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REPORT

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*A Companion
to NDIA's Annual
Vital Signs Report*

Defense Industrial Base Vitality Outlook 2023

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TECHNOLOGY MAGAZINE

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VITAL SIGNS

2023 EXECUTIVE SUMMARY

BY JENNIFER STEWART AND ROBBIE VAN STEENBURG

The National Defense Industrial Association has issued *Vital Signs* over the last three years to encourage conversations at all levels of government and among Americans interested in national defense about the necessary policies and investments required to maintain the superior readiness of the U.S. defense industrial base.

The defense industrial base readiness policy goal is straightforward: to ensure warfighters have the platforms, services and technologies they need so they never engage in a fair fight against any competitor.

This goal is personal for many working in industry. From the largest defense contractors to the smallest defense technology start-ups, many either served in the U.S. military or have family and friends who are serving, and therefore see their work to ensure U.S. industrial readiness as national service from a different angle.

Unfortunately, from a public policy perspective, the gap is widening between the intentions and the outcomes of current policies and processes to improve defense industrial readiness. The capacity of the U.S. defense industrial base to grow its output and to fulfill a surge in military demands stands as a key test of its health and readiness.

Currently, U.S. public policy is not oriented to support a defense ecosystem built for peer conflict. This was a troubling truth during the last 20 years of asymmetric conflict against nonstate actors. In the return of great power competition, this is an unsustainable dynamic.

While the United States talks about the re-emergence of great power competition, China is advancing its

military capabilities and harnessing the power of strategic industrial policy. In 1985, China's GDP was only 15 percent of U.S. GDP. In 2016, China surpassed the United States, and by 2021, China's GDP was 118 percent of US GDP, adjusted for purchasing power.

From this position of economic strength, the People's Republic of China is taking a disciplined approach to re-order the international system — its rules, norms, standards and values — on terms favorable to itself. It is steadily increasing its military capabilities and capacity, including modernizing its nuclear capabilities; honing sophisticated strike, space and cyber capabilities; and building out its navy in “one of the most remarkable and strategically disruptive global defense spending trends in the last two decades,” according to the “Fiscal Year 2020 Industrial Capabilities Report to Congress” issued by the Defense Department.

The goal of China's industrial policies, according to the Defense Department report, “2022 Military and Security Developments Involving the People's Republic of China,” is to expand “the private sector's participation in the PRC's defense industrial base and supply chains as well as improving the efficiency, capacity and flexibility of defense and civilian industrial and manufacturing processes.”

Conversely, current U.S. defense spending is not reflecting the stability and sufficiency required to prevail in great power competition. Over the last 14 years, the Defense Department's budgets have been subject to significant disruption and delays. In addition, from 1985 to 2021, national defense spending dropped from 5.8 percent to 3.2 percent of U.S. GDP.

Uneven and unpredictable budget demand signals consistently fail to produce the results bipartisan policy-

makers in the executive and legislative branches want because they prevent proper planning for optimized capital investments and supply chains. In addition, the parts of the budget most crucial to reorient the department to prepare for, deter and — if necessary — respond to peer conflict are the accounts most vulnerable to being cut or squeezed during budget instability: research and development; operations and maintenance, including funding for crucial training, military exercises and sustainment of platforms and equipment; and procurement.

One of the biggest challenges will be aligning and sequencing resourcing priorities for peer conflict over the next 15 years. For the last 40 years, the United States has benefited from a technological competitive advantage that afforded it unimpeded logistics and power projection as well as military dominance in every operational domain. A return of great power competition changes these dynamics.

Conflict with one or more near peer competitors will likely involve asymmetric attacks on U.S. critical infrastructure, contested and degraded logistics and communications and dispersed U.S. units fighting directly against adversaries with platforms, systems and munitions of roughly technical parity. This means the department needs to balance resourcing requirements for the future character of war by integrating and scaling emerging disruptive technology with resourcing requirements necessitated by the inherent nature of war.

That requires consistent, steady policy and financial investments to increase the capacity and modernization of our defense infrastructure and to accelerate advancements in the capabilities of our nuclear triad; major air, land and sea platforms; and precision-guided munitions.



Serious policy disagreements over balancing the pacing and sequencing of the department's finite resources are significant macro-level challenges for industry to navigate.

Compounding these challenges, the U.S. defense industrial base resiliency required to sustain the United States in great power conflict was sacrificed as part of the federal budget cuts of the 1990s. The return of great power competition necessitates that the United States rebuild its strategic deterrence. The 2022 National Defense Strategy emphasizes deterrence by resilience and defines resilience as “the abil-

ity to withstand, fight through, and recover quickly from disruption.”

The powerhouses of industrial readiness — an experienced workforce; stable and predictable budgets; diversified and modern infrastructure; manufacturing innovation; and sufficient, including idle, capacity — have all atrophied under the combined transition to a services-based economy with a premium on just-in-time commercial supply chains. This is the result of a worldview that no longer contemplated peer conflict nor wanted to resource an industrial footprint required to prevail in one.

In addition, the U.S. macro-economic industrial conditions required to support another national level military build-up do not exist. In modern history, the United States has consistently responded after conflict erupts. Furthermore, during the major defense industrial base build-ups before World War II and during the Carter and Reagan administrations, the American economy was able to surge the capacity of its commercial industrial base to augment the specialized expertise of the defense industrial base.

This is not currently a viable option. The U.S. defense industrial base lost 2.1 million workers from 1985 to 2021. In addition, the Defense Department bluntly reported in the “Fiscal Year 2020 Industrial Capabilities Report to Congress” that the “[m]achine tool industry laid the groundwork for the mobilization miracle of World War II ... [and] America has allowed its machine tool sector to turn from a national asset into a national security vulnerability.”

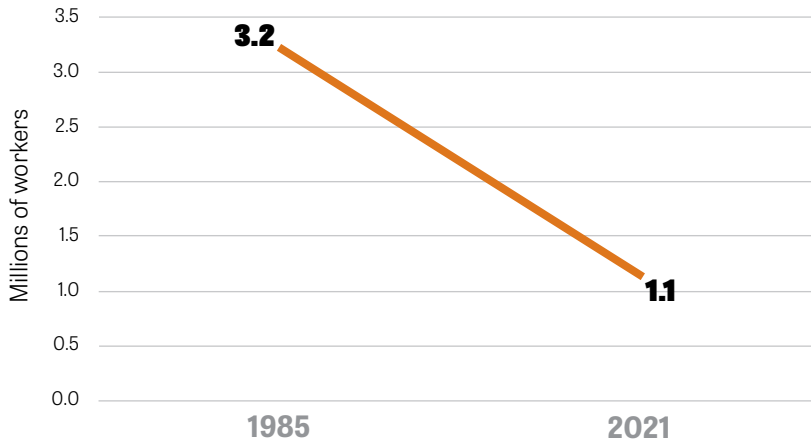
In this operating environment, NDIA member companies have a more pessimistic view about defense contracting business conditions improving in 2023 compared to general business conditions. U.S. defense industrial base companies must operate under the same conditions as any other company in the global economy.

Vital Signs 2023 survey results showed that while 22 percent thought general business conditions could get better in 2023, only 14 percent thought defense contracting business conditions could improve. This is pointed feedback from an industry currently responding to surge demand signal due to the illegal invasion of Ukraine and quietly preparing against the darkening security environment in the Indo-Pacific.

Vital Signs 2023 survey results are unambiguous regarding industry's pain points. Specifically, NDIA member companies are emphasizing to government policy makers and external audiences that: the federal acquisition process is growing more — not less — cumbersome; the lack of budget stability is breaking companies and causing significant workforce uncertainty; and the challenges of finding and retaining talent are impacting even the most strategic defense programs.

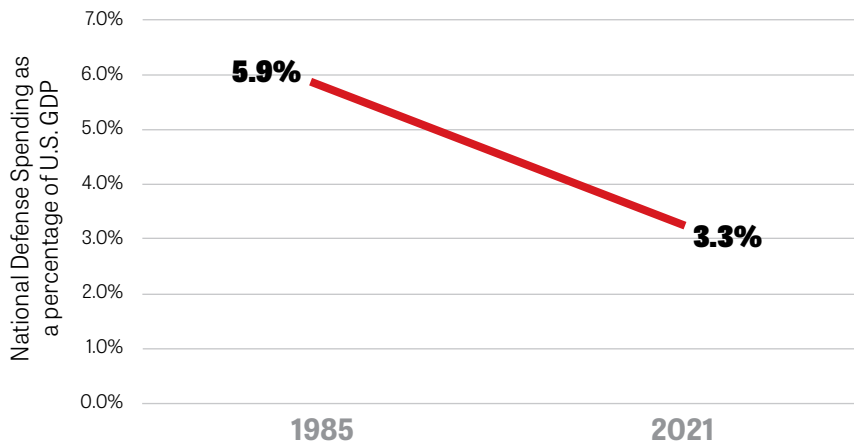
In addition, inflation was specifically highlighted as a pressing issue. This was anticipated with inflation rates at the highest levels in 40 years and interest rates at the highest lev-

The DIB Workforce is 1/3 of its Previous Size



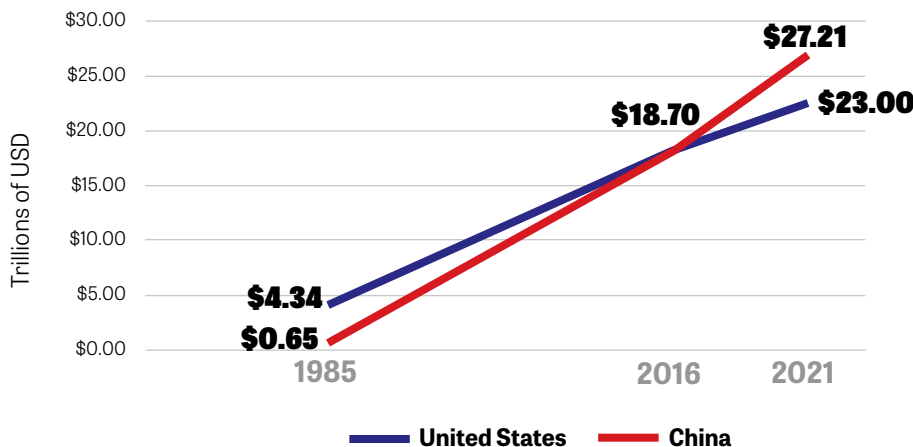
Source: U.S. Bureau of Labor Statistics

National Defense Spending Has Declined Significantly as a Percent of GDP



Source: Office of Management and Budget

China's Purchasing Power Parity Adjusted GDP Has Surpassed the U.S. Adjusted GDP



Source: Internal Monetary Fund

els in 15 years, with the potential for additional increases in 2023. High inflation rates increase the cost of capital, restrict both demand and supply for commercial loans and heighten the specter of recession conditions.

Of special note, 72 percent of *Vital Signs* survey respondents noted the continued negative impact inflation is having on labor costs, and NDIA member companies also highlighted inflation would exacerbate their challenges with hiring and retaining skilled workers.

Most NDIA member companies — 86 percent — believe nothing is going to change. Over the next year, 57 percent believed defense contracting business conditions would be about the same and 29 percent reported business conditions would worsen. Put another way, 86 percent believed that despite the sense of urgency to restructure the defense industrial base to deter and, if needed, decisively prevail in peer conflict, nothing is going to change.

NDIA and its Emerging Technologies Institute believe change can happen and will therefore spend the next year working with its members through divisions, conferences and chapter events on solutions to priority policies that will move the needle for industry.

In 2023, NDIA is committed to working on securing budget stability and sufficiency; advancing Defense Department digital modernization; facilitating foreign military sales modernization and technology integration; restoring industrial readiness, capacity and infrastructure; and supporting the development of more resilient supply chains.

NDIA will also integrate acquisition reform and workforce development as cross-cutting issues into each of these policy priorities.

The current U.S. defense industrial base is not postured to be resilient in great power competition. Whether the United States is successful in deterring conflict for five years, 15 years or longer, when conflict erupts — as world history tells us it will — national leaders will either have credible or constrained response options from the U.S. defense industrial base based on the policy, authorities and resourcing investments they inherit from this current generation of leaders serving in the executive branch, the congressional branch and industry. **ND**

Jennifer Stewart is executive vice president for strategy and policy, and Robbie Van Steenburg a regulatory policy associate, at NDIA.

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Talent Troubles

Post-Pandemic Workforce

Shortages Continue *BY JOSH LUCKENBAUGH*

It's been three years since the initial COVID-19 outbreak upended the global economy, and the defense industry is still struggling to attract and retain key talent on both the production line and in offices, according to a new study.

The 2022 Aerospace & Defense Workforce Study — released in October 2022 by the Aerospace Industries Association and the American Institute of Aeronautics and Astronautics in collaboration with Ernst & Young LLP — revealed that overall turnover in aerospace and defense companies has risen to 7.1 percent, marking more than a 2 percent increase since 2020.

The study noted a specific shortage for workers with skills in engineering and “strong digital capabilities” — such as data, analytics and automation. The push for a defense workforce with these digital skills is a relatively new phenomenon, said Steve Fuller, partner in Ernst & Young's people advisory services division.

“There's really an evolution in the types of skills that are needed today as well as in the future, and it's being exacerbated by multiple factors,” Fuller said.

One factor causing the talent shortage is academia's inability to keep up with the defense industry's changing needs, he said.

As part of the 2021 edition of the survey, companies were asked how far in advance they conduct workforce planning. More than half of the respondents said they only plan 18 months into the future, Fuller said.

This timeline for workforce planning can cause shortfalls as it doesn't always align with contract periods and doesn't factor in the time universities and trade schools need to update their curriculums, he said.

“There's a disconnect between what the professionals in the industry are doing and those in the academic space are doing,” Fuller added.

“The entire landscape of manufacturing; both in the makeup of the workforce and in the inter-

national supply chain, has vastly changed since the initial days of the COVID-19 pandemic,” Mark Lyall, senior sales manager-defense at Cummins-Meritor, said in an email.

“Our supply chain has [to] continue innovating, finding efficiencies, accelerating process improvements, and investing in the workforce to find new ways to operate under the new normal conditions,” he added.

Another company looking to bridge this gap between academia and the professional industry is Lockheed Martin. The company has established apprenticeship programs — including one in partnership with the College of Central Florida — which are “instrumental in developing a sustainable pipeline of highly skilled talent for our future operations,” a Lockheed Martin spokesperson said in an email.

Creating these pathways for younger candidates will be important as the defense industry has an “aging workforce” that needs to be replenished, Fuller said.

As defense companies look to attract the next generation of key talent, they must also improve compensation practices such as adjusting faster to inflation, he added.

“One of the things we find is that companies typically only benchmark their pay annually at best,” Fuller said. “The reality is with inflation, if you're doing it annually, you've already lost the people that [are] sensitive around pay. So that's something that I think we would like to see a little bit more.”

According to the study, 78 percent of employers cited workers seeking higher pay as a factor for the high attrition rate. Additionally, 75 percent of employers listed workers seeking better career advancement as a factor.

“What really matters to employees is really what their situation is like at work,” Fuller said. “What kind of experiences are they getting, and do they have opportunities for career growth? And that's a real opportunity for this industry: to identify how they can create more career paths and also learning opportunities so that



people can access those career paths.”

Companies have also faced retention challenges at the executive level, he added, with the fluctuation of the stock market causing many to consider other opportunities if their incentive compensation targets aren't met.

Another factor is the dual nature of many companies that serve both commercial and defense customers, said Raman Ram, the aerospace and defense leader for Ernst & Young Americas. As the commercial side of these businesses struggled during the pandemic, many of their defense executives left as well, he noted.

The workforce challenge in the defense industry is a structural and long-term issue rather than a temporary one, Ram said.

“I think it's an inflection point, because now we're seeing defense companies actually having the inability to meet the revenue, because direct labor translates to revenue for defense companies,” he said. “Program performance [is] slipping, supply chain performance [is] slipping — not only at the primes, but also all the way throughout the chain ... it's a call for action for defense companies to act, even though they've



HELP
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to other industries, Fuller said. The study noted that 84 percent of respondents said they provide remote working options, with 81 percent responding they provide flexible working hours to employees.

Increased flexibility has been a focus for Lockheed Martin when looking to attract and retain talent, the company spokesperson said.

“During the pandemic, we implemented a hybrid workforce model to continue meeting our customer commitments, while maintaining flexibility to help our employees thrive,” the spokesperson said. “This flexibility extends to when, where and how Lockheed Martin employees work — including the majority of our employees working a flexible four-day workweek.”

Lockheed Martin has also created skill development programs for employees, including micro-degrees, advanced skills development courseware and access to business development content, the spokesperson said. The micro-degree program has resulted in a 400-plus percent return on investment “with employees engaged in building skills for future opportunities,” they added, citing an analysis done in the company’s 2021 business impact report.

One company that achieved strong growth during the pandemic was American Rheinmetall Vehicles, or ARV, a subsidiary of German-based company Rheinmetall AG.

Established to increase the company’s presence in the United States, ARV began with six employees in January 2020 and now has more than 100 employees, said Mike Milner, ARV’s director of business development and strategy.

Unlike larger companies, ARV can offer prospective employees the chance to build something

from the ground up, Milner said.

“That’s one of the intangibles that we get ... [and] see [in] a lot of the folks that we do recruit,” he said. “It’s that opportunity to be part of that ground floor and establish a company versus, ‘I’m just going to be one cog in the 100,000-person machine.’”

Companies must continue to be adaptable and flexible as working remotely is likely to become “a permanent part of the United States service industry,” Milner said. While manufacturing itself requires in-person labor, digital design capabilities are now allowing more workers “to do a lot of the stuff remotely from our own houses if we have to, [and] that enables us to provide a better work environment for the employees,” he said.

Along with increasing employees’ digital skill sets, many companies are investing more in leadership training at all levels, Fuller said. The study found that 66 percent of respondents had made significant investments in helping workers develop leadership skills.

“This industry really needs to develop the next generation of leaders,” Fuller said. “[There are] significant needs for succession purposes at the top of these organizations.”

Defense companies must develop leaders at the lower levels of their organization as well, he added.

“That’s really going to dictate the culture, it’s going to dictate your employee satisfaction, it’s going to dictate your ability to retain employees,” Fuller said. “I think it’s good that it’s recognized. I think now it’s a matter of how are you going to take action in order to really develop leadership across the industry?”

To attract key talent and foster future leaders, defense companies must clearly articulate to candidates and employees their purpose as an organization, he added.

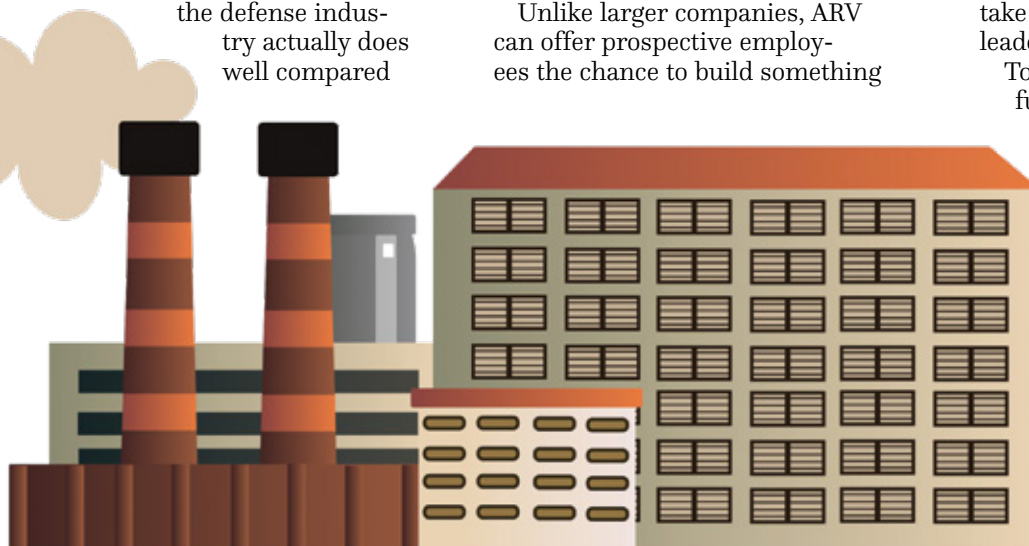
“That’s really what today’s workforce is really looking at: ‘What’s the bigger reason of why I’m going to work? It’s not just to do my job. It’s not just to earn money. It’s how am I making an impact on the world?’” Fuller said. “And I think there’s a lot of opportunity for this industry to better define the why.” **ND**

been talking about this for 20 years.”

One action companies can take is to better articulate their unique “value proposition” to current and potential employees, Fuller said.

“Why should someone want to work at your organization, whether they’re a candidate or an employee?” he said. “A lot of these organizations actually have some very beneficial things that they just don’t articulate well.”

One example would be offering flexibility on when people work, which the defense industry actually does well compared





Essential Imports

Tapping Into High-Skilled Foreign Workers Talent Pool *BY SEAN CARBERRY*

China's growing might and control over critical supply chains has prompted the United States to invest billions into "reshoring" the manufacturing of semiconductors and defense-related technologies.

To fill new high-tech jobs that investment will create, the United States must reform cumbersome immigration policies to bring in skilled foreign talent — it's a matter of national security, according to defense, immigration and congressional experts.

The \$280 billion CHIPS and Science Act of 2022 is projected to create 30,000 to 100,000 jobs, according to analyses by academic, industry and research organizations. Even with recent layoffs in the tech sector, there isn't a standing supply of U.S. workers ready to jump into new semiconductor or defense manufacturing jobs, analysts say.

"We see that there's a huge labor crunch," said Jeremy Neufeld, a senior immigration fellow at the Institute for Progress. "Something like 80 percent of firms within the defense industrial base are reporting having a hard time filling job vacancies as it is." And the shortage is more pronounced for sectors like semiconductors where much of the expertise is outside the United States, he added.

Neufeld and other experts say the United States needs to continue developing the domestic talent pool and get more Americans into sci-

ence, technology, engineering and math fields, but that's a longer-term endeavor that will take years to pay off.

"If we want to be serious about developing a workforce that can compete with China, we need to use whatever is in our toolbox," Neufeld said. "I think both the immigration lever and the domestic training lever shouldn't be thought of as totally separate, but they actually reinforce one another."

That's because building up industries like semiconductor manufacturing in the United States requires instruction and mentorship from the Taiwanese and South Koreans who are the leaders in the field, he said.

And to fill workforce gaps in the short run, the United States needs to tap more deeply into the global supply of high-skilled workers, he said.

"We've passed the CHIPS Act. We're increasing our defense spending," said Charles Wessner, who teaches global innovation policy at Georgetown and serves as an advisor to the Renewing American Innovation Program at the Center for Security and International Studies.

"We recognize the existential threat that China is posing to a rules-based system and to potentially our own safety. And we won't bring in the people that we need to compete with them," he said.

He and others noted that the United States has never been self-sufficient and has always immigrated, borrowed or poached the world's sci-

ence and technology talent.

"When we were desperately trying to do the Manhattan Project — and I think AI and quantum may be comparable — we didn't say, 'We can do this with Americans, we just have to train them and find them,'" he said. "We took the best minds we could find in the world and brought them together," he said.

Richard Freeman, an economics professor at Harvard and research associate at the National Bureau of Economic Research, said the United States needs to look beyond the workforce implications and see high-skilled immigration through a national security lens.

For example, Chinese scientists are doing a lot of "cool stuff" with artificial intelligence, he said. Yet in recent years the United States has been discouraging potential students or scientists from China from coming to the United States.

"There's got to be some thinking that if we're going to do more of this stuff at home, we're going to need more people, and that's the time to also get the best people away from our competitors," he said. "Let's have them do their good stuff in the United States."

For that matter, he and others argued that the United States should create a program to bring in Russian scientists who fled after Russia invaded Ukraine.

"I hope we have a scheme of how to turn those into our allies and friends ... for national security," he said. "It's a notion [that] America is appealing in general ... and we've got to think more about, how do we use that to undermine the bad guys?"

The current options for bringing

foreign tech talent into the United States are limited to a few programs. Foreign students are welcome in U.S. universities, but once they complete their degrees, there are no easy paths for them to remain in the United States, Freeman noted. They have one to at most three years to find an employer willing to sponsor a visa.

The H-1B visa for skilled workers is capped at 65,000 slots per year, with another 20,000 available for immigrants who have earned an advanced degree in the United States. There is so much demand that the visas are awarded through a lottery rather than prioritizing the most needed or highest valued candidates.

So, while it would seem there would be compelling reasons to reform the H-1B system to bring in the best talent, there is strong opposition in Congress and provisions to increase visas for tech workers routinely get stripped from legislation like the CHIPS Act or annual defense bills, Neufeld said.

Opponents argue that giving out more visas increases the potential for espionage, drives down wages, crowds out domestic talent and reduces incentives for Americans to study STEM fields.

Experts who spoke with *National Defense* agreed those are demonstrated impacts of the current system.

"I think it's important to be cognizant of the risk that Chinese nationals play," Wessner said. "You can't look for perfect ... it's not the world we're going to find," he added, noting that companies who hire foreign workers have strong incentives to monitor risk and prevent intellectual property theft.

Then there is the question of finding the right level of imported talent that meets workforce needs without crowding out citizens. That is almost impossible to calculate, Neufeld and Freeman said. There are some available data points such as the approximate size of the tech and defense workforces and the number of Americans who graduate with STEM degrees.

However, other than having tech employers raise wages until the potential pool of American workers is exhausted, there is no practical mechanism to determine how many of the nation's STEM grads could be lured into tech jobs rather than positions

in business or finance where they see more economic opportunity, they said.

"If we raise the pay, we can get more people from the United States. We can give more scholarships for fellowships or whatever we want, we can do that," Freeman said.

But it isn't a matter of a three to five percent increase in wages or in stipends for advanced degrees, it would take 20 to 40 percent more, he said. "That's a pretty costly way for us to do it when ... smart people really want to come here," he continued.

The other constraint on determining the ideal immigration flow is that the H-1B system's lottery structure doesn't generate useful data on industry salaries and the level of need for different skill sets, Neufeld said.

"If for instance, the H-1Bs were allocated to the highest earners among the applicants, then you could look at what is the minimum wage that is getting an H-1B each year," he said. "And if it's going down and we're getting less qualified workers each year, then that would be an argument for potentially lowering the cap.

"And if it's going up drastically, that would be a real sign that there's a significant shortage of visas and you could actually use that data to estimate the size of the increase," he said. "It would give lawmakers better information about the effect on the margin of increasing the H-1B."

Eliminating the lottery and prioritizing visas for high-paid/high-skilled workers is one measure in the "H-1B and L-1 Visa Reform Act" that Sen. Chuck Grassley, R-Iowa, and Sen. Richard Durbin, D-Ill., have been sponsoring the last few years. The bill seeks to protect wages and U.S. jobs by preventing outsourcing companies from abusing the lottery system and by prioritizing high-skilled immigrants in the H-1B pool.

"In the last Congress, the progressive caucus in the House ... endorsed this idea of replacing the lottery and making sure that visas are going to the good-paying jobs," Neufeld said, adding that he sees hope for passage in the new Congress. "It seems like the kind of thing that should have bipartisan support."

Arun Seraphin, deputy director of the Emerging Technologies Institute at the National Defense Industrial Association, said while immigration is needed in the short- to medium-term to fill the gap, it shouldn't be viewed as the "easy button" at the expense of continu-

ing to invest in growing the domestic STEM workforce. That's in part why he advocates for small-scale reforms.

"We've been trying for the last few years to do something based on this legislation called National Security Innovation Pathways," he said.

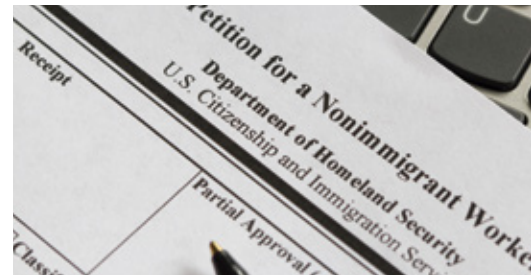
That legislation "aims to establish a pathway to permanent residency for students and professionals engaged in fields such as artificial intelligence, quantum information sciences, biology, robotics, and hypersonics," according to a 2020 press release from Rep. Elise Stefanik, R-N.Y.

The idea of the program is modeled on the Military Accessions Vital to National Interest program. That was designed to recruit legal immigrants with special skills — medical or language abilities — and fast-track their citizenship in exchange for military service.

The tech pathway program would start with 100 slots as a pilot to see if it works and could expand from there, he said.

"Every year, we're getting closer, and we're smoking out another objection and then addressing it," he said. "And that's why I'm hopeful that within the next few years, we will get a program like this going."

Progress is also a result of "more and more people framing this as an anti-China national security issue," he said. Still, the measure keeps getting caught up in committee politics and "the right wing-left wing crossfire," over a comprehensive immigration package, he said.



That's the problem with making progress on high-tech visa reform, Wessner said. "We're not treating the issue with the urgency that it needs," he said.

"We need to pull out this urgent need from the morass of family reunification and different quotas for different countries," he said. "We just need to recognize the urgency that is there." **ND**



Balance Needed for High Skills Immigration Reform

The U.S. defense industrial base faces a critical science, technology, engineering and math talent shortage, exacerbated by an outdated immigration system.

As has been highlighted previously in this space and reiterated by national security experts in many fora, increasing “high skills immigration” is a critical national security issue. While the government and defense contractors struggle to hire new STEM employees, caps on available visas force thousands of foreign-born graduates of U.S. universities to return home rather than remain here.

Responding to calls for reform, advocates have proposed legislation to exempt all foreign citizens who have earned an advanced STEM degree at a U.S. university from numerical visa caps. However, a similar reform effort failed last summer when a nearly identical measure was left out of the China-focused competition bill, the CHIPS and Science Act.

Advocates are right to continue pushing for high skills immigration reform — but if these efforts do not address concerns raised during previous debates on this issue, new legislative attempts will likely fail as well.

Given the complex and sensitive nature of today’s immigration debate, a broad reform design would be unlikely to succeed. A pragmatic look at immigration and the political context suggests that a more measured proposal, which navigates security and labor concerns, offers a better chance of successfully moving forward.

Some of the more sweeping reform attempts have failed to address legitimate growing apprehension about the Chinese Communist Party’s attempted influence on, and espionage in, U.S. society. In the current political climate, a significant increase in the number of visas allowed without a corresponding expansion in robust security procedures is likely to fail as it does not present the sort of balanced approach that gathers consensus.

For example, some opponents of last summer’s bill raised concerns that the Chinese government could use the additional visas to bring spies into the United States.

Some have even called for a total ban on admitting Chinese students to U.S.

universities due to perceived systemic weaknesses in the vetting system, even though most Chinese students would remain in the country after graduation and provide much-needed high caliber support to our talent-strapped defense industrial base.

There is also skepticism in some circles about the value of cooperation between U.S. and Chinese companies. For example, several prominent lawmakers sought to increase security in the Small Business Innovation Research program due to worries about the Chinese government gaining access to technology. Other lawmakers have sought to prevent potential Chinese influence on U.S. consulting companies and universities.

Security-focused decisionmakers in Congress and the Pentagon are unlikely to support any program they deem ripe for Chinese exploitation. Thus, a politically successful high skills immigration proposal must be limited in size and scope and include explicit protocols and institutional capacity for identifying and preventing potential espionage.

While limiting the size of a STEM talent program is not ideal, advocates for reform can take solace that some foreign talent is better than no foreign talent, and increased security will help prevent other nations from exploiting U.S. openness and avoid incidents that would threaten the program’s long-term political viability.

Previous reform measures have also failed because their broad scope invited criticism from an economic populist perspective. In some circles, immigration reform is attacked as an opportunity for “executives ... to easily hire grateful, lower-wage foreign graduates,” displacing U.S. workers. Similar criticisms have been made against increases in HB-1 visas to fill domestic labor shortages. Regardless of the STEM talent shortage, some segments of the political spectrum will be wary of an increase in the number of visas connected to high-paying jobs that could otherwise go to domestic workers.

Reform advocates should recognize these concerns and craft

future proposals accordingly. To mitigate allegations of an overt “Big Tech” influence on the effort, advocates must clearly articulate that an increase in foreign talent will fill a gap critical to national security.

One option could be to require direct government or industry service in exchange for acceptance into the visa program. Such a system would help not only support national security but



would make the program part of efforts to bolster industrial base capabilities rather than an attempt to depress domestic wages.

Similar programs, such as the Military

Accessions Vital to the

National Interest “service-for-citizenship” program, have been successful in the past. To that end, lawmakers recently introduced a similar program within the STEM Corps Act of 2020.

Advocates must also recognize that high-skilled immigration reform exists as part of a larger immigration debate. Some detractors argued the issue should be addressed in a broader immigration-related bill, suggesting that agreement might be crafted with some tradeoffs on other immigration policy issues. While safeguards against Chinese Communist Party exploitation and domestic wage depression are a good start, advocates may benefit from developing ideas for policy trades that are politically tenable for all concerned parties.

Despite the sensitivities that exist in today’s political environment, policymakers can create a bipartisan proposal that leverages foreign talent for U.S. national security.

One of America’s great strengths has been that the best and the brightest from around the world want to come here to study, and ultimately join, its free society. Absent a strong STEM talent pool, the nation will have increasing difficulties in its competition with China. High-skilled immigration reform must be pragmatic and bipartisan. **ND**

Ben Ackerman is an Emerging Technologies Institute research intern and an undergraduate student at Brown University.

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Critical Elements

U.S. Tackles Rare Earth Supply Chain Conundrum **BY MIKAYLA EASLEY**

MOUNTAIN PASS, California — From the smartphone in your pocket to magnets powering a growing number of electric vehicles on the road, rare earth elements are the foundational components for some of the most commonly used technologies today.

But over the last three decades, Beijing has held an iron grip on the world's supply chain for rare earth elements such that nearly all materials — no matter where in the world they are mined — travel to China for refinement before they can be used in technologies.

Currently, the country controls nearly 60 percent of rare earth mining operations, more than 85 percent of processing capacity and more than 90 percent of permanent magnet production, according to the U.S. Department of Commerce.

It's an issue that poses a vulnerability within the United States' supply chain and poses potential national security risks, considering Washington's strained relations with Beijing. As demand signals for technologies that rely on these elements are projected to skyrocket, both industry and government are investing in methods that aim to secure a domestic rare earth supply chain.

Despite being labeled as “rare,” the 17 different elements known as rare earths are relatively abundant in the Earth's crust. The Biden administration considers them one of the strategic and critical materials and minerals for their use in several modern commercial and defense technologies — including smartphones, medical equipment and highly specialized magnets used in electric vehicles, jet fighters and drones.

But since the chemical properties of rare earth elements are nearly indistinguishable from one another, individually separating and refining them so they can be used to make magnets and other technologies is a complex process, said Linda Chrisey, program manager at the Defense Advanced Research Projects Agency.

“Two different rare earth elements may be fractions of an angstrom dif-

ferent in diameter — that means it's very difficult to separate using physical means. The processes that are used right now ... can be 100 steps,” Chrisey said, also noting that the procedure can be very expensive and environmentally hazardous due to the chemicals used to separate and purify the metals.

“These are all reasons why it has been difficult to sustain that kind of operation in the United States,” she added.

However, on top of a mountain in the Mojave Desert at the United States' largest rare earth mine, MP Materials is trying to reverse that trend.

With the scale and capability of their facilities, MP Materials is trying to become a “magnet champion” in the Western Hemisphere, said Matt Slouster, MP Materials' senior vice president of communications and policy.

“What we're trying to do is build a full magnetic supply chain, and we want to be able to make all the necessary materials and recycle the necessary materials to have that magnetic supply chain,” he said.

Since acquiring the Mountain Pass mine in 2017, MP Materials has revitalized the site's production of rare earth elements and produces a mixture of rare earth concentrate that contributes around 15 percent of the rare earth minerals consumed each year, according to the United States Geological Survey.

And soon, MP Materials will no longer have to ship this mixture overseas to China for the lengthy process of separating and refining the rare earth elements. After two years of construction, the company announced in November that it is on the cusp of opening the first rare earth refinement facility within the United States at the Mountain Pass facility.

First it must commission assets for the new facility for the second stage of production, which is a process of stress testing the facility's equipment to ensure it is performing at the rate it was designed for, Slouster said during a tour of the ongoing construction at the Mountain Pass mine. The procedure will unfold over the course of 2023, he added.

“We're months away from pro-

ducing refined products,” he said. “It's really exciting.”

The second stage of production starts with a process of drying, roasting, leaching and purifying the mixture of rare earth concentrate, he explained. Then, the rare earths are fed into one of several towering tanks located in a building longer than an American football field. In these vats, a solvent extraction process separates the mixture into individual rare earth oxides, he said.

Although it's just one refinement facility competing against multiple in China, its opening marks a crucial step in the United States' effort



Mountain Pass Rare Earth Mine and Processing Facility

to address its vulnerable rare earth supply chain. In 2020, the Department of Defense invested \$10 million into the \$200 million project, according to a Pentagon press release.

MP Materials will focus on refining a compound of neodymium and praseodymium — one of the most common materials used to make rare earth magnets — as well as lanthanum and cerium, Slouster noted. These elements are classified as “light rare earths.”

The government is also pushing for domestic production of “heavy rare earths,” which are more difficult to refine but also used to make more specialized magnets. For

example, heavy rare earths terbium and dysprosium are needed to make rare earth permanent magnets that can operate in high temperatures, while samarium is used to produce samarium-cobalt magnets found in aerospace and defense applications.

“If you don’t have separated rare earths domestically, there’s a point of failure in the supply chain for magnets,” he said.

The Defense Department awarded MP Materials a \$35 million contract in February 2022 to build a facility specifically designed to process heavy rare earth elements at the Mountain Pass mine. Sloustcher said the heavy rare earths will be refined in a different building, adding that the project is just getting started.

To fully domesticate the magnet supply chain, MP Materials also began construction on the United States’ first rare earth magnetics factory in

According to a report by independent research firm Adamas Intelligence, the global demand for rare earth oxides is forecasted to triple from \$15 billion in 2022 to \$46 billion in 2035.

“The world is electrifying on every front possible — electric vehicles, wind turbines, drones, robots, everything,” Sloustcher said. “So the demand picture is very bright, and the supply just isn’t there relative to what most analysts project demand will produce.”

MP Materials has already entered an agreement with General Motors to produce rare earth alloys and magnets for the automobile manufacturer’s electric vehicle programs beginning in late 2023, he said.

“Defense demand alone can’t even stand up a modestly sized magnetics facility,” Sloustcher said. “We want to be able to stand up and be able to supply GM and other companies

in order to survive, she said.

“Because they were exposed to these extreme environments, they were using the rare earths as cofactors for enzymes and they’ve evolved transport systems to pick the elements up from the environment and bring them into the cell and store them until they were needed,” she explained. “Maybe we can figure out how the cells are doing this and exploit that for our purposes.”

EMBER will use biomining to mimic this naturally occurring phenomenon. The technique uses microbes to help break down or separate an element of interest from a larger mixture, Chrisey explained. The process isn’t fully developed for rare earths due to “poor specificity and selectivity of the microbes” for the elements, the agency said.

In October, the program announced it had selected teams from the Lawrence Livermore National Laboratory, the Battelle Memorial Institute and San Diego State University to participate in phase one of the four-year program.

Each team will take a different source material that contains at least eight different rare earth elements, separating and refining each element from one another using different microbes and biomining techniques, Chrisey said. The three groups are using a unique combination of source material, microbe and biomining, she added.

For example, two teams are starting with mineral sources that can be partially processed from ore dug out from the ground, while the third is looking at mined waste. And while one group is focusing on microbes because they are naturally found in extreme environments, another team is using a class of microbes that grow on methane and feed on greenhouse gas.

“We’re thinking about many different levels and how biology could give an advantage in this overall process,” she said.

Phase one of EMBER is expected to wrap up around January 2024, after which DARPA will make a decision whether or not to continue with the second phase, Chrisey said. If it does, the next phase will focus on improving the efficiency and scale of separating rare earths from source rocks, and then phase three will end in a pilot-scale rare earth biomining demonstration. **ND**



April 2022. Located in Fort Worth, Texas, the facility will be able to annually produce around 1,000 tons of neodymium-iron-boron magnets from rare earth elements mined and refined at the Mountain Pass facilities, according to the company.

Because the defense market accounts for just a fraction of the United States’ total demand for rare earths — around five percent — the company is looking to address needs within the commercial industry first, Sloustcher noted.

Demand signals for rare earths are projected to rise as the world electrifies with machines that require highly specialized rare earth magnets.

... and if we succeed in doing that, defense demand can be satiated.”

Meanwhile, Chrisey and her team at DARPA are researching ways to secure a domestic rare earth supply chain using a different kind of method — biomining.

The Environmental Microbes as a BioEngineering Resource, or EMBER, program is a DARPA initiative to use microbial and biomolecular engineering techniques to separate and purify rare earth mixtures like the ones produced at the Mountain Pass mine, Chrisey said. The program was inspired by microbes found living in harsh, volcanic environments that were using rare earth elements

INDUSTRY PERSPECTIVE

U.S. Needs Industrial Policy for Critical Minerals

BY GREGORY D. WISCHER

The United States needs a secure supply of critical minerals to protect its national security.

Minerals like cobalt, gallium and rare earths are vital elements in superalloys, semiconductors and permanent magnets. These components, in turn, are essential for advanced technologies such as jet engines, quantum computing and military radars.

In short, critical minerals form the foundation of America's digital economy and modern military.

However, the United States relies heavily on critical mineral supply chains controlled by China. For example, according to the U.S. Geological Survey, the United States produces zero percent of the world's refined cobalt while China produces 72 percent; the United States produces zero percent of the world's gallium while China produces 98 percent; and the United States produces zero percent of the world's refined rare earths while China produces 85 percent. The list continues.

The United States lacks a secure supply of critical minerals, relying dangerously on its top geopolitical adversary. The government, so far, has pursued piecemeal actions that have insufficiently incentivized domestic mining and refining of critical minerals. Moving forward, the government needs a comprehensive industrial policy that allows U.S. companies to maximally mine the nation's critical minerals and make America domestically self-sufficient in refining critical minerals.

"Industrial policy" refers to "policies that stimulate specific economic activities and promote structural change," as defined by Harvard economics professor Dani Rodrik in his article "Industrial Policy: Don't Ask Why, Ask How."

The White House has indeed tried to grow U.S. capacity for mining and refining critical minerals. The effort began most vigorously in the previous administration when President Donald Trump invoked the Defense Production Act to make purchases and

purchase commitments for samarium cobalt magnets.

Trump then signed Executive Order 13953, which ordered agencies to bolster domestic mining and refining capacity, as well as accelerate federal permitting for critical mineral projects.

Most notably, the Trump administration's Department of Energy issued a rule making critical mineral projects eligible for the Advanced Technology Vehicle Manufacturing Direct Loan Program and Title XVII Innovative Energy (Section 1703) Loan Guarantee Program. This updated rule unlocked substantial loans for domestic critical mineral projects. Currently, the vehicle manufacturing program has \$55.1 billion available in loan authority, and the Title XVII program has \$42.5 billion available in loan authority.

The Biden administration continued efforts by invoking the Defense Production Act to make purchases and purchase commitments of minerals necessary in large-capacity batteries. The invocation specifically targets domestic production of cobalt, lithium, manganese, nickel and graphite.

Additionally, the State Department established the Minerals Security Partnership: 10 U.S.-aligned countries seeking to mobilize investment in critical mineral supply chains, including production in resource-rich developing countries.

Congress has taken steps as well. For instance, the Infrastructure Investment and Jobs Act appropriated \$7 billion for battery supply chains, including critical mineral production. Most recently, the Inflation Reduction Act included a 30 percent tax credit for investments in battery material projects and a 10 percent tax credit for critical mineral production costs. Furthermore, Congress has sought to incentivize domestic critical mineral projects through the annual National Defense Authorization Act.

The above efforts will surely bolster some parts of the critical mineral supply chain. Yet, the United States will remain dependent on



China unless the U.S. government adopts an industrial policy for critical minerals. The White House and Congress should take the following actions to increase domestic mining and refining of critical minerals.

First, the White House should withdraw federal public lands for critical mineral exploration. Public lands often include mineral-rich areas like national parks, forests and wilderness areas. For example, the Idaho Cobalt Belt crosses the Salmon-Challis

National Forest and Frank Church-River of No Return Wilderness. Federal lands, however, have mining regulations that prolong the permitting timeline and expose mineral leases to bureaucratic cancellation.

To expedite permitting, the White House should withdraw public lands to survey for critical minerals and then award government contracts to private entities for mining in these areas. This action has precedent. In the 1950s, the secretary of the interior withdrew public lands for government surveying of uranium deposits, and then the Atomic Energy Commission awarded mining contracts to private entities. The result was domestic uranium production increasing dramatically, according to the U.S. Energy Information Administration. Today, the White House should do the same for critical minerals.

Second, the White House should reinterpret loan statutes, making domestic critical mineral projects eligible for more programs. For instance, the International Development Finance Corp., which has a \$60 billion lending cap, does not invest in domestic projects. However, it should have domestic investment authority because projects like domestic refineries will help catalyze mine production in resource-rich developing countries, effectuating its mission of overseas economic development.

Notably, the White House expanded the corporation's domestic authority by having the agency run a domestic loan program via the Defense Production Act during the coronavirus pandemic.

The White House should also reinterpret statutes to allow loans for U.S.-led mining projects in countries like the Democratic Republic of the Congo. As justification, overseas mining projects should be eligible for Department of Transportation loans because more mines are necessary to reach U.S. adoption targets of clean energy vehicles.

The International Development Finance Corp. should also prioritize overseas mining projects because mines are often located in countries needing economic development.

Third, the White House should make purchase commitments for U.S.-mined and refined critical minerals. Purchase commitments — like those authorized by Biden's Defense Production Act invocation — will support domestic mines and refineries by guaranteeing a large-scale buyer, which private entities value in volatile mineral markets. Again, this action has precedent. During the Cold War, government purchase commitments for cobalt spurred cobalt mining and refining in Idaho. Today, purchase commitments for critical minerals would similarly incentivize domestic production.

The White House can make purchase commitments via several funds. For example, the Defense Department can direct a portion of the \$448 million in the National Defense Stockpile Transaction Fund and \$914 million in the Defense Production Act Fund toward critical mineral purchases. Such purchases would help replenish and grow the National Defense Stockpile. Therefore, purchase commitments would both spur domestic production of critical minerals and bolster critical mineral reserves in the National Defense Stockpile.

As for Congress, it should first implement expedited deadlines for federal permitting of critical mineral projects. According to analysts SNL Metals and Mining, U.S. mine permitting takes seven to 10 years. This timeline dissuades many companies from building critical mineral projects, like mines, because the companies must invest significant capital and then wait years before receiving returns on those investments.

Congress specifically needs to reduce the permitting timeline for mining on federal lands. Section 40206 of the Infrastructure Investment and Jobs Act requires the Bureau of Land Management and the Forest Service to report on the average timeline for each permitting step. After receiving this report, Congress should pass a bill requiring the relevant agencies to comply with expedited deadlines for each step. Such deadlines will reduce the regulatory risk for mining investors.

Next, Congress should allocate grants and loans to critical mineral projects. These projects face not only significant upfront capital costs but

also limited private financing due to regulatory and supply chain risks. Congress can alleviate these financial burdens with grants and loans.

For grants, Congress should authorize and appropriate specific Defense Production Act funds for critical mineral projects. For loans, Congress should provide more authority to the Energy Department and specify a percentage of those loans for critical mineral projects.

Congress can also allocate grants and loans for critical mineral projects by reallocating unused pandemic relief funds or specifying uses for general funds.

For instance, Rep. Byron Donalds, R-Fla., introduced the "Cobalt Optimizes Batteries and Leading Technologies Act," which authorizes \$800 million from already appropriated funds for the acquisition of domestically refined cobalt for the National Defense Stockpile. Congress can use this bill as a template to target other already appropriated funds and other critical minerals.

Congress should offer tax credits and deductions for domestic critical mineral projects. Tax credits should include production tax credits based on a company producing certain amounts of critical minerals, and investment tax credits based on a company investing in critical mineral projects. These incentives would most benefit established companies since they are already producing minerals and likely have capital to invest.

Notably, the Inflation Reduction Act included a clean vehicle credit, featuring two tax credits totaling \$7,500 for clean vehicles with a percentage of critical minerals from the United States or free trade partner and battery components assembled in North America. Consequently, electric vehicle companies like Tesla are seeking to domestically source their critical minerals and battery components to access these tax credits. Congress should include similar domestic content requirements for critical minerals in future electric vehicles and renewable energy tax legislation.

While the government has long implemented industrial policy, some people may question whether the recommended

actions will increase domestic production of critical minerals.

As noted above, the U.S. government has previously taken most of these actions to good effect. Moreover, in an article entitled "Industrial Policy and Competition," a National Bureau of Economic Research team found that "industrial policies — subsidies or tax holidays — that are allocated to competitive sectors ... or allocated in such a way as to preserve or increase competition, have a more positive and significant impact on productivity or productivity growth."

Others may note the risk for fraud, waste and abuse in the recommended actions. Such concerns are valid. Yet, these risks accompany any government program, including existing subsidies for airlines, agriculture and defense. Therefore, the government must diligently vet companies and projects receiving government funds and release funds in an incremental process — versus all at once — as project goals are met.

People may also argue that the recommended actions do not sufficiently constitute a comprehensive industrial policy. They are correct. The above actions are solely initial actions that the government should take to increase domestic mining and refining of critical minerals. Other actions include import tariffs on refined critical minerals, bans on foreign companies mining on federal lands and domestic content requirements — not preferences — for government purchases of critical minerals.

In conclusion, robust critical mineral supplies are vital to national security, especially America's high-tech economy and advanced military. Yet, the United States depends heavily on critical mineral supplies controlled by China. The United States should maximally mine its domestic critical minerals and become domestically self-sufficient in refining critical minerals. **ND**

Gregory D. Wischer is vice president of government affairs at Westwin Elements, an American company poised to build and operate the first major cobalt refinery in the United States.



Gallium stone

Critical Mineral

U.S. Seeks Alternatives to Chinese Cobalt *BY SEAN CARBERRY*



The Periodic Table is packed with elements of critical importance to U.S. economic and national security. From lithium to iron to uranium, the nation needs a steady diet of minerals and metals, and few are as challenging to source as number 27: cobalt.

The bluish-gray metal's widest use today is in the cathodes of lithium-ion batteries, which proliferate in commercial and military devices. Cobalt also serves the Defense Department in temperature-resistant alloys for jet engines, in magnets — used for things like stealth technology and electronic warfare — and alloys used in munitions.

And like so many materials and commodities today, China controls the bulk of the global cobalt supply.

“What makes this a really significant challenge is China could use this the same way Russia can use oil, or in the same way that the world is impacted because of grain supply,” said Brad Martin, director of RAND Corp.’s institute for supply chain security. China’s ability to deny access to cobalt “creates a national security vulnerability,” he added.

Studies by minerals analysts and the U.S. government say that 70 percent of mined cobalt comes from the Democratic Republic of Congo, a politically unstable country with a well-documented history of poor labor and environmental practices in its mining sector. Almost all the cobalt mined there — usually as a byproduct of nickel or copper mining — heads to China for refining and processing. Currently, China processes about 80 percent of the world’s cobalt.

“The big issue is China and its influence over the DRC, and the fact that China understands better than the United States the need to have access to strategic materials,” said Martin. “China has not only been finding

sources, it’s also been stockpiling, and that is just not something the United States has successfully done.”

On the contrary, the United States has sold off large amounts of its critical materials stockpile like cobalt over the last few decades.

According to “Revitalizing the National Defense Stockpile for an Era of Great-Power Competition,” a Heritage Foundation report released in January, the supply contained \$22 billion worth — in today’s dollars — of critical materials in 1989. It’s now down to \$888 million.

Still, the stockpile isn’t designed to be a solution. Rather, it’s a stopgap in case there is a conflict with China or some other shock that interrupts the supply chain.

However, Martin pointed out that China doesn’t need to resort to military means to get what it wants because of its control over cobalt and other critical materials.

“If China is in a position of being able to demand political concessions, diplomatic concessions because it has a hammerlock over some set of commodities, it doesn’t need to go to war,” he said. “It already has all the instruments of influence it needs to prevail.”

In the short run, the supply chain risk isn’t that significant unless there is a situation where China is incentivized to cut off cobalt supplies, he added. Plus, China would lose revenue if it stopped the cobalt supply.

“The main mitigation is just the overall state of relations is such that nobody really benefits from cutting off supplies within the supply chain, because the supply chains are so interdependent,” he said.

However, that’s not a durable solution. Hence, during the last five years, successive administrations have made supply chain resilience for critical materials a priority through executive orders and policy guidance.

Technically, the Defense Depart-

ment does not rely on Chinese cobalt. “For many years, the ‘specialty metals clause’ (10 USC 4863) has required defense contractors and their suppliers to purchase cobalt-base alloys and steel products — with greater than 0.25 percent cobalt — that is melted or produced in the United States or other close U.S. allies,” Pentagon spokesperson Jessica Maxwell said by email.

“This provides some protection for the defense industrial base for defense-unique items, but this clause does not apply to commercial products or electronics, among other exceptions,” she added.

And with the Defense Department looking to transition vehicles and bases to renewable sources, that means growing demand for large batteries, which do rely on Chinese cobalt.

In March, the Biden administration invoked the Defense Production Act to address the problem of sourcing cobalt and other critical materials.

According to the memorandum: “The United States depends on unreliable foreign sources for many of the strategic and critical materials necessary for the clean energy transition — such as lithium, nickel, cobalt, graphite and manganese for large-capacity batteries. Demand for such materials is projected to increase exponentially as the world transitions to a clean energy economy.”

The United States shall secure materials such as cobalt “through environmentally responsible domestic mining and processing; recycling and reuse; and recovery from unconventional and secondary sources, such as mine waste,” the memorandum states.

Domestic mining will be a challenge, according to experts and the U.S. Geological Survey. Its analysis finds that more than 120 million tons of cobalt have been identified on the planet. Of that, 1 million tons reside in U.S. territory. However, the latest USGS cobalt report estimates that only 69,000 tons can be “economically extracted or produced,” compared to 3.5 million tons in the Democratic Republic of Congo.

Companies such as Jervois, Glencore, Electra and U.S. Strategic Metals have mining projects in various stages of development in the United States, with Idaho being an area of major focus. The U.S. government is working to streamline the permitting process for new mining activity. But experts are skeptical that mining will solve much



Stock illustration

of the cobalt supply chain conundrum.

“There are some real challenges with trying to bring mining back into the United States in a big way,” said Martin. “And for the damage it causes, it’s not necessarily clear it’s going to yield all that much.”

Caspar Rawles, chief data officer with Benchmark Mineral Intelligence, agreed that mining within the United States is a low-yield proposition. Canada and Australia are better prospects, although right now Indonesia looks to be the next big source of cobalt, he added.

“That could stack up to be quite considerable volume — let’s say the next 5 to 10 years,” he said. “But the challenge ... through the lens of national security is that the vast majority of investment that’s going into Indonesia is coming from Chinese companies.”

However, the United States could compete for

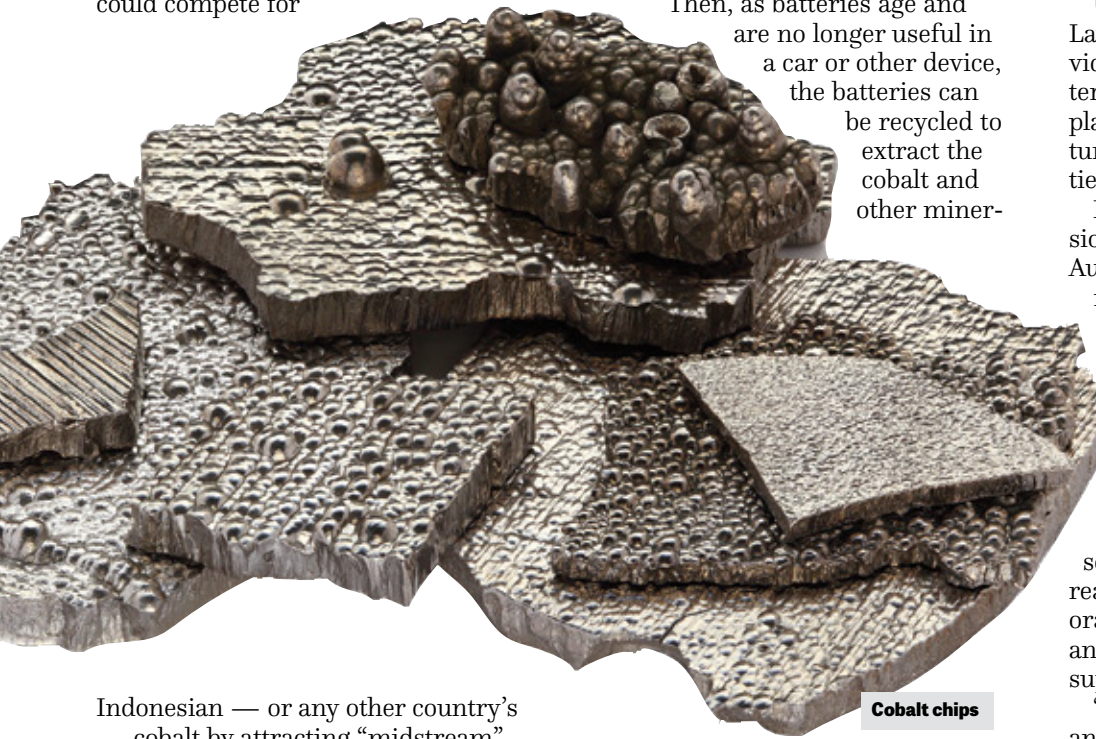
inventories of that material in place.”

The Canadian company Electra is constructing a refinery that is scheduled to open later in 2022. Next year, they will begin refining 5,000 tons of battery-grade cobalt per year, according to the company’s website. However, that’s a small fraction of the 160,000 tons of cobalt mined annually.

Where analysts see greater potential to kick the Chinese cobalt habit is by producing the metal through the recycling of batteries and production scrap and waste.

“It could potentially be a very big source of raw material in the near term,” Rawles said. “What you’re looking at is what we call ‘production scrap’ or ‘batteries scrap.’ And so that’s just either off-spec or just off-cuts of production of battery materials that will then get fed back into the battery supply chain.”

Then, as batteries age and are no longer useful in a car or other device, the batteries can be recycled to extract the cobalt and other miner-



Cobalt chips

Indonesian — or any other country’s — cobalt by attracting “midstream” businesses, said Rawles. “So, by that I mean like refiners and cathode producers, because those are commercial entities that will go out into the market, and they will secure raw materials via commercial contracts.”

In other words, they will cut the Chinese refiners and producers out of the loop.

“It’s not like direct control of the raw material,” he added. “But you’re getting access via proxy, because if you have a refining company in your country ... that company is going to be looking to sell its products domestically and will have feedstocks and

als back out to create new batteries.

It will be about 10 years before the recycling market takes off, he added. “Then, of course, you have big volumes, and you definitely want to ensure that you can retain that, regionally process it and put it back into your own ... battery supply chain.”

There are several companies and projects ongoing to recycle scrap and spent batteries.

Canadian company Li-Cycle has three operational recycling facilities in Kingston, Ontario, Rochester, New York and Gilbert, Arizona.

According to a company spokesperson, those facilities are currently processing 20,000 tons of lithium-ion battery material per year.

The company is constructing new facilities in Alabama, Ohio, Germany and Norway that will increase production to 65,000 tons by the end of 2023, the spokesperson added.

The U.S. company Redwood Materials has formed partnerships with Ford and Toyota to create closed-loop battery recycling and production supply chains.

Redwood expects to produce anode and cathode components by 2025 to power more than 1 million electric vehicles and to expand to 5 million vehicles by 2030, a company statement said.

Under the Bipartisan Infrastructure Law, the Department of Energy is providing nearly \$3 billion “to fund battery materials refining and production plants, battery cell and pack manufacturing facilities, and recycling facilities,” a department press release said.

Both the House and Senate versions of the 2023 National Defense Authorization Act include provisions requiring the Defense Department to recycle spent batteries.

Government funding will be essential in scaling up recycling in the United States, said RAND’s Martin. Establishing collection and transportation networks to get materials to recyclers could be cost-prohibitive for the private sector, he said. That’s one of the reasons he argues for a more collaborative relationship between industry and government to identify potential supply chain vulnerabilities early on.

“As companies design products and ... supply chains are erected, everybody needs to be much more aware of where things come from and account for these types of things up front and not just stroll into a vulnerability,” he said.

“So, a medium-term impact or requirement is for the government and for industry to do a better job of working together to figure out where their vulnerabilities are going to be, and where that can be met with private action and where it’s going to require collective action, require the government to do something over and above what individual industries can do,” he added. **ND**

ANALYSIS

U.S. Shipyards Struggle To Keep Up with Demand

BY MEREDITH ROATEN

While U.S. military leaders exchange fire over what the next-generation of naval fleets will look like, the shipbuilding industrial base is treading water.

Since 2016, the Navy has been working toward a 355-ship fleet goal as outlined in its long-term force structure plan.

But Navy ambitions have been complicated by the Marine Corps' modernization strategy, prompting back-and-forth between service leadership and lawmakers regarding future fleet size and structure.

In addition, China's more aggressive moves in the Indo-Pacific — especially considering Taiwan — is elevating the need for greater shipbuilding and maintenance capacity to meet demand, naval power experts said.

Retired Adm. Phil Davidson, former commander of Indo-Pacific Command, predicted in 2021 that the following six years would see China's threat to naval forces reach its height.

An October report entitled "A Modern Naval Act to Meet the Surging China Threat" from the conservative think tank the Heritage Foundation called for legislation to increase shipbuilding capacity and action within what policymakers have begun to call "the Davidson window."

Brent Sadler, senior research fellow at the Heritage Foundation's Center for National Defense, said in the report: "A war with China would be decided at sea, and an American victory will depend on having adequate naval forces."

While the Navy has planned to keep the fleet greater than 300 ships, the service has averaged 10 ships below its own procurement plans since 2017 and has sustained fewer than 300 warships since 2003, Sadler noted. During the same time, China has increased its fleet capacity by about 150 ships, according to the report.

Sadler estimates that it would take two to three years to expand shipbuilding capacity due to the

vendor selection process — which is why Congress should pass legislation in the next session if the Navy wants to be ready by 2027.

Marine Corps Commandant Gen. David Berger said that China is far behind in capability but is expanding rapidly in capacity.

"They're building an amphibious force so they can project power, and I don't see that trajectory stopping," he said during a Defense Writers Group event in December. "So capability wise [they are] way behind us. Capacity wise, we should pay absolute attention to [it]."

Some lawmakers support increasing maritime capacity, especially those who represent constituents who stand to benefit from a boost to the local economy.

In July, House Armed Services Committee members Rep. Elaine Luria, D-Va., and Rep. Jared Golden, D-Maine, introduced a \$37 billion National Defense Authorization Act amendment that would have appropriated more than \$4 billion for ship procurement and maintenance. Virginia and Maine are home to two of the United States' four public shipyards.

Luria warned a reduction in fleet size would decrease capability "in the timeframe when the threat from China is the greatest," she said in a press release at the time. The amendment asked for funding to invest in public and private shipyards crucial to maintaining the fleet, build one additional Arleigh Burke-class destroyer this fiscal year and restore five littoral combat ships along with other research



and development investments.

The authorization bill, including the amendment, was signed into law in December, charting a course for Congress to fund the additional destroyer. That brings the total to three ships in the next fiscal year.

Lawmakers also passed language in the legislation that could help the Marine Corps' bid to increase amphibious ship production.

The legislation authorizes \$32.6 billion in spending for Navy shipbuilding, including one amphibious ship. However, it clarifies that the Navy cannot enter into a contract without consulting with the Marine Corps first.

As for maintenance of existing ships, Adm. Daryl Caudle, the commander of U.S. Fleet Forces Command, said the lack of capacity "is placing a large and unsustainable strain on our [Optimized Fleet Response Plan], our operational availability and our forward presence options."

The Navy currently has four

public shipyards designated for maintenance and overhauls.

When asked if there's an argument to be made for opening a fifth public shipyard, Caudle replied: "Of course, I mean ... I need six."

The Navy has stated that because of maintenance costs and delays, it could move to decommission several amphibious ships, including four amphibious dock landing ships, in the coming years counter to the Marine Corps' modernization plan, known as Force Design 2030.

However, the Navy commissioned a study that has yet to be released that would provide analysis of how many amphibious ships would make up the final count. The service has a requirement for 31 ships, but Berger said the NDAA enables the service to move beyond that.

Regardless of the distribution of ships across the services, the Marine Corps and Navy are more aware of the precarious position that shipyards

are in than ever before, Berger added.

"I think the Department of Defense leadership, civilian and uniformed, is a lot more aware of — even if we're not smart enough on — the industrial base than we were five years ago," he said.

He noted shipbuilding mergers have cut down the number of shipyards significantly, reducing capacity and competition.

"Industrial capacity, diversity — this is a discussion like every week, and it never was before," he said.

In November, Bollinger Shipyards acquired ST Engineering subsidiary VT Halter Marine, the shipyard that has a contract for the Coast Guard's new Polar Security Cutter. It will be the first icebreaker built in the United States since the 1970s.

The program has pushed back its delivery date to the Coast Guard from 2025 to about 2026, Coast Guard Vice Adm. Peter Gautier, deputy commandant for operations, told the House Transportation and Infrastructure Subcommittee on Coast Guard and Maritime Transportation in December.

Berger noted labor is the "main limiting factor" for shipyard capacity, as workforce retention has taken a hit across industries because of the COVID-19 pandemic. But he also said the uncertainty of business in the shipbuilding industry has made it even more challenging to keep workers.

"We got to keep that active, warm producing all the time," he said. If production goes cold, it makes it "harder and harder to bring that factory back, harder to bring those workers back."

He added competition could help cut costs in the long run.

"I think if the CNO had his drawers, he would double the number of shipyards tomorrow because we need capacity and we need competition," Berger said. "We need both to get the citizens a good price on their ships, right?"

Caudle said: "I need enough capacity in our shipyards to drive down the [maintenance] backlog to zero," he said. "We just continue to stack ships up [and] not get them back into the fight. So ... yes, we need to be thinking about what we do to increase that capability." **ND**

— Additional reporting by Josh Luckenbaugh

Navy photo



Valley of Death

Pentagon Makes Moves to Speed Up Tech Transition *BY STEW MAGNUSON*

SIMI VALLEY, California — It's a well-documented problem in the world of defense technology development.

Small businesses, universities or startups received a couple million dollars to develop an innovative new technology that warfighters could use.

The project comes to fruition, but when the startup delivers the prototype as promised, the funding to incorporate the technology into the force isn't available.

This is the so-called "Valley of Death," and the "death" is usually the small business that doesn't have the cash flow to stay in business while the Defense Department agency winds through its laborious budget process.

The lack of funding doesn't mean a lack of interest, said Heidi Shyu, undersecretary of defense for research and engineering.

The Army, Air Force, Navy or Marines might want the technology it invested in badly, but it takes too long to secure the funding, she said.

"Small companies can't twiddle their thumbs for two to three years waiting for a contract," she said during a panel discussion at the Reagan National Defense Forum held at the Reagan Presidential Library in Simi Valley, California.

The worst-case scenario is when a Chinese company swoops in to invest in the small business and then takes the technology out of the country.

Shyu said her office is actively trying to tackle the Valley of Death problem, along with implementing other programs with a goal of putting innovative, new technologies into the hands of warfighters more quickly.

"We are on the path of innovative solutions," she said.

One concrete move to bridge the Valley of Death came earlier in the day at the forum when Defense Secretary Lloyd Austin and Small Business Administrator Isabella Casillas Guzman signed a letter of intent to partner on the recently established Office of Strategic Capital.

The Defense Department office will seek to serve as a go-between connecting venture capital funds and the startups seeking the funding to wait out the Pentagon's notoriously slow budget process.

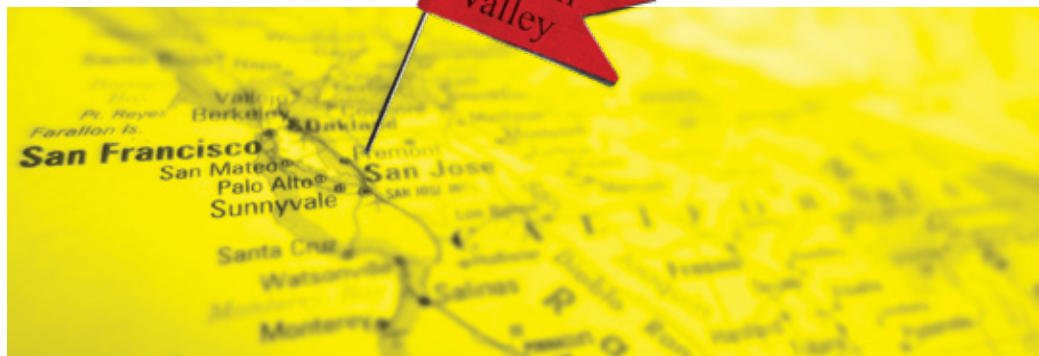
The SBA, for its part, will propose a new regulation that introduces a new financial instrument called the "accrual debenture."

This instrument is designed to align with the cash flow patterns of startups and supports the long duration often required to incubate and scale technology invest-

as Silicon Valley has been a long-standing Pentagon goal dating back to the late Defense Secretary Ash Carter, who made it his mission to create bridges between the nation's innovative private sector companies that don't normally do business with the military and the Pentagon.

He created what would become the Defense Innovation Unit and set it up in Silicon Valley to serve as a Pentagon liaison to startups. It has since opened satellite offices in tech hubs around the nation. The services followed with their own versions such as the Air Force's AFWERX and the Navy's Tech Bridges.

Air Force Chief of Staff Gen. Charles "CQ" Brown Jr. said at the forum that he had visited several Silicon Valley companies in the fall and saw increased interest in working with the Defense Department, but more needs to be done to speed



ments, a joint statement released after the deal was inked stated.

Guzman said: "This new mission-driven office will continue to build and align incentives for private investment in innovators who are producing frontier technologies that advance America's security and economic competitiveness."

Austin said: "This partnership will help secure funding for critical areas for national defense — and ensure that our warfighters get the capabilities they need, before they need them."

Shyu said the best aspect of the office is that it will take relatively little funding to operate since its purpose is to convince the venture capitalists to invest their money in the startups. It will also seek to tap into Small Business Administration and other government funding streams to help the startups stay on life support until the contracts roll in, she said.

Tapping into the innovation found in America's innovation hubs such



up the processes.

“We need to start picking some winners and nurture them. We need to look at companies that have capabilities today that we will need in the future,” he said.

History has shown that the armed forces can quickly do innovative things if there is a crisis, he said.

A recent example is the Air Force helping Ukraine install the U.S.-made AGM-88 HARM, the High-Speed Anti-Radiation Missile, on Russian-built MiG-29s jet fighters.

If there were no crisis, the bureaucracy would push back and slow down the process, he said.

“What we want to do is not wait until there a crisis to actually move at a pace and a sense of urgency to do some things,” he said.

Theodore Colbert III, president and CEO of Boeing Defense, Space and Security, said there is disconnect between the fast-paced world of startups and the Defense Department and its traditional contractors.

Startups “work on processes that are about delivering products on a consistent ongoing basis. Our industry is really designed around programs, and there is not a natural coming together of those two approaches,” he said.

Companies such as Boeing that understand the world of government contracting need to help these small businesses pull their technologies

through the Valley of Death, he said.

A warfighter familiar with defense technology, a representative of a major contractor and one from a small business should all be sitting together in the same room to solve major problems for the Defense Department, he added.

Meanwhile, major defense contractors such as Boeing have long lamented the focus on Silicon Valley startups. They have plenty of innovation in their laboratories as well, they have said.

Colbert said new digital engineering practices are speeding up the development of Boeing’s new T7-A Red Hawk jet aircraft trainer.

“We just need to do that over and over and over again on many different platforms,” he said. “I think the whole system is working toward that objective. We just need to do it more,” he said.

Shyu said the office of research and engineering has a program in place that is taking advantage of these new technologies such as “digital twins,” that allow developers to experiment on computers without having to take the time and expense to create real-world models.

That approach is developing physics-based simulators that are tied into a campaign-level model. Researchers can experiment on the computer with several different technologies to see which ones are more effective. She can then know which technology would make the bigger difference in the outcome on a battlefield.

“That helps me to invest,” she said.

Another program Shyu helped to kickstart along with Bill LaPlante, undersecretary of defense for acquisition and logistics, is the Rapid Defense Experimentation Reserve, or RDER.

The idea is to take promising prototypes out of labs and — in partnership with the services — put them in real-world experiments simulating contested environments to see how well they actually work.

The concept will be to come up with three “scripts,” or scenarios, then try about four technologies to see how well they perform within the construct, she said.

Whether or not the technologies are at a high technology readiness level is beside the point, she said.

“It doesn’t have to be 100 percent solution, which takes a decade, right? But if it’s a 78 percent solu-



tion that solves a problem that we have within the joint warfighting concept, let’s push it out,” she said.

Rep. Rob Wittman, R-Va., said startups often have good ideas that can help the military, but they run into the classic push-verses-pull problem. Defense acquisition personnel are not set up to procure technologies unless they have a requirements document that justifies a need.

“What you see today is a structure that puts everything towards the concept of the requirement. So, companies say, ‘I have a great idea and I can do it less expensively.’ The Pentagon goes, ‘I would love to do that but guess what? I don’t have a requirement to do that, so we’re not going to do that,’” Wittman said.

Congress and the Defense Department have put forth some alternative acquisition processes such as mid-tier acquisition rules and other transaction authorities to circumnavigate the red tape, but those are the exceptions rather than the rule, Wittman said.

The Pentagon needs to “level the playing field” when it comes to useful technologies that have documented requirements and those that don’t, he said.

And the people who decide what innovative ideas are useful should be the same personnel who are using the technology on an everyday basis, he added.

“It’s great to have the Joint Chiefs of Staff and others say, ‘It’s good to have that great technology applied,’ but it has to start with that Marine lance corporal, with that Army private, with that third-class airman and that third-class seaman, and work from there on up because those individuals are incredibly talented, incredibly insightful and they know ... and what we learn from them is invaluable,” he said.

As for the new Office of Strategic Capital, Wittman said the Defense Department must ensure that these companies have the funding needed to scale up. For example, a \$100 million pot may sound like a lot, but split among 10 companies, it may not be sufficient, he added.

The office should complement organizations such as the Defense Innovation Unit, not compete against it, he also stated. **ND**

Heidi Shyu

