THE TECHNO-INDUSTRIAL POLICY PLAYBOOK

2025

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Contents

NATIONAL SECURITY

America's Techno-Industrial Crossroads

The Foundation for American Innovation, American Compass, Institute for Progress, and New American Industrial Alliance Foundation are proud to present the Techno-Industrial Policy Playbook, a collection of detailed policy proposals written by senior domain experts. Our playbook targets three central areas—industrial power, national security, and frontier innovation—the systemic vulnerabilities of which have been exposed by recent crises and geopolitical competition.

Is America still the world's leading technological and industrial power? As late as 2011, when China first surpassed the United States in manufacturing output, the answer would have been an unqualified *yes*. Today, the picture is far less clear.

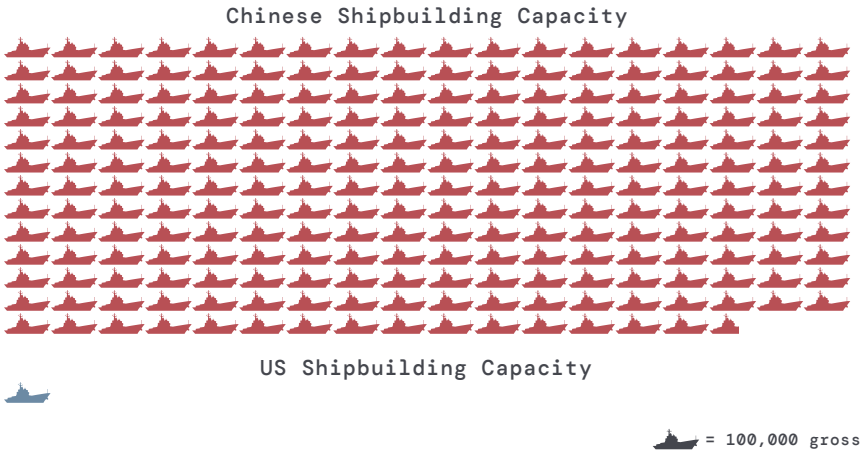
As China's industrial might ascended in recent decades—last year reaching a manufacturing surplus almost equivalent to Britain's entire GDP—we decided to let ours decline. For too long, our political leadership trusted an "invent here, make there" model that neglected the profound connection between innovation and production. This mistake has cost us dearly.

America is wholly unprepared for wartime production needs. With current manufacturing capacity, it would take at least eight years to replenish major defense program inventories at surge production rates. Nearly all Navy ship construction projects are years behind schedule. Decades of consolidation have reduced the number of defense prime contractors from more than 50 during the Cold War to 6 today, the number of surface ship suppliers from 8 to 2, and the number of tactical missile producers from 13 to 3. Ninety percent of all missiles come from three sources, creating inefficient oligopolies and inflated prices. While our defense industrial base slumbers in peacetime, China's operates on wartime urgency, generating 23,000 percent more shipbuilding capacity; its Jiangnan Shipyard alone surpasses all US shipyards combined.

These problems are exacerbated by failing energy infrastructure across our country. US grid capacity is already reaching the breaking point in many areas. Yet it is getting increasingly costly and difficult to build basic electric infrastructure: annual transmission line construction has fallen nearly 90 percent since 2013. Rapidly growing demand from industrial projects and technological innovation, particularly artificial intelligence, will require much greater supply to come online, in amounts that can only be met with a combination of traditional and alternative sources. China, recognizing this reality, is currently building 23 next-gen nuclear reactors, compared to zero in America, where nuclear plants cost 6 to 12 times more to construct today than in the 1960s. Last year, a single Chinese company, Tongwei, installed nearly the same amount of solar capacity as all of America combined.

Meanwhile, China leveraged its superior production capabilities to scale up whole new industries and surpass America in a growing portfolio of critical technologies. From 2007 to 2018, its contributions to value-added manufacturing of the iPhone—one of the most complex pieces of hardware on earth—grew from 4 percent to 25 percent. Deepseek's R1

SHIPBUILDING CAPACITY: CHINA VS. US



Source: The War Zone/Office of Naval Intelligence

model, released during President Trump's second inauguration, exceeded OpenAI's most advanced model on multiple benchmarks at 10 percent of the cost. China dominates global markets for rare earths refinement, 5G networks, consumer drones, and lithium-ion batteries. In recent years, China achieved global firsts in quantum-encrypted satellite communication and landing spacecraft on the far side of the moon, proving its ability to push technological frontiers. Its industries are supported by a vast technical workforce: in 2020, China graduated 3.5 million STEM students (4x the US total) and roughly 50,000 STEM PhDs (2.5x the US total, excluding international students).

These successes result from a deep, unified seriousness among Chinese elites that the leading techno-industrial nation will win the 21st century. From Deng Xiaoping to Xi Jinping, the Chinese Communist Party's top brass have consistently stated that we are in the midst of a techno-industrial revolution—and that "seizing this rare opportunity" is the "decisive factor for national strength," the "foundation for a world power," and a requirement to achieving the "great rejuvenation" of the Chinese nation. This seriousness has allowed China to repeatedly defy American expectations about its technological capabilities, from the Semiconductor Manufacturing International Corporation's 7nm semiconductors to Deepseek's V3 and R1 models, despite stringent export controls.

For too long, many in Washington have lacked the same degree of seriousness. This does not imply imitating China, as US innovation does not depend on top-down economic mandates, forced tech transfers, or intellectual property theft. What America must take from China is not its methods but *its attitude*. A serious country would not allow overbearing red tape to hamper hundreds of billions of critical infrastructure investments. It would not educate the world's brightest only to kick them out shortly thereafter—often into the arms of our adversaries, with disastrous consequences.

It would not have fetishized financialization—neutering industrial capacity and leaving communities hollow. It would not allow its students to hit all-time-low math scores just last year, at a time when such foundations are most critical.

Such mistakes undermine America's tradition of technological progress—a tradition that history shows is the foundation of our national prosperity. It was the First and Second Industrial Revolutions that catapulted Britain, then America, to global superpower status. For 20th-century Americans, nuclear bombs, industrial machines, and space shuttles secured existential military victories, widespread economic growth, and national pride. In recent decades, democracies such as Israel, South Korea, Taiwan, and Japan all became techno-industrial envies of the world by force-multiplying free markets with strategic state action.

Fortunately, the tide has begun turning. Continued failures at home, emerging threats abroad, and an intensifying arms race over emerging technologies such as AI have sparked a resurgent bipartisan awakening that drastic actions are needed to secure America's techno-industrial future. Both the Trump and Biden administrations have taken bold steps—the former has initiated a sweeping agenda to reincentivize private investment in domestic industry, while the latter emphasized historic supply-side investments into chip factories, energy, and infrastructure.

However, neither approach is sufficient in isolation. Take American shipbuilding, which suffers from immensely inflated costs due to parts of the Jones Act, aging infrastructure, lack of modern tooling, labor shortages, and persistent shifting requirements from the Navy. Public subsidies without structural reform cannot fix these chronic inefficiencies. Likewise, private-sector incentives alone cannot close the funding gap to rebuild naval capacity, let alone on strategic timelines like a 2027 Taiwan scenario. America's techno-industrial challenges are not just about trade or spending—they re-

flect deeper structural bottlenecks and insufficient state capacity.

Policymakers must pursue an all-of-the-above strategy. No single policy lever is enough. The scale, urgency, and complexity of today's techno-industrial challenges require coordinated action across public investment, regulatory reform, and private mobilization. TSMC's US expansion highlights the potential of such an approach—initially drawn by CHIPS Act subsidies to start a fab in Arizona, the company recently announced a further $200B investment, spurred by tariff pressure and accelerated permitting promises.

Despite our headwinds, America retains significant assets that, if strategically harnessed, can unleash a new century of prosperity. We still boast the world's most advanced military, capital markets, and research ecosystem. We still lead many of the world's emerging technologies, from AI to hypersonics to quantum computing (although the gap is shrinking fast). The world's best and brightest still flock to us. The "spirit of enterprise" that Tocqueville saw as America's most distinctive feature remains strong. Public policy should therefore seek to complement these forces, not replace them.

THE TRUMP—VANCE ADMINISTRATION AND THE 119TH CONGRESS have a historic opportunity at their feet. A generational leadership transfer in Congress, the ongoing bipartisan realignment, and the arrival of bold outsiders in Washington have given America a chance to rebuild its techno-industrial leadership.

From the citizenry's perspective, technology—like other pursuits—should support economic growth, national security, and community flourishing. Effective policy requires discerning which innovations to privilege and the most effective ways to support them. After all, not all technology is equally valuable for the good of the nation. Anduril's arsenal is far more critical to American interests than Netflix, even though the latter is worth 15 times as much.

The road ahead will not be easy. The realities of American labor costs, permitting burdens, and cultural clashes reveal a stark reality: reindustrialization requires not just the ability to make things, but to make them cost-competitively. TSMC's failed 1998 Oregon plant and the 2019 documentary *American Factory* exemplify these challenges. In contrast, China reduces unit costs by deploying more industrial robots annually than the rest of the world combined, alongside exploiting low wages, lax safety standards, and forced labor.

Our values rightly dissuade us from competing on those terms. Instead, we must beat them the same way we achieved industrial dominance in the past: through investing (both public and private) and adopting productivity-enhancing technologies. The War Finance Corporation and Reconstruction Finance Corporation were instrumental public institutions that catalyzed American industry during WWI and WWII, respectively. Many pillars of modern manufacturing, including CNC machining and CAD/CAM software, originated from joint Air Force/MIT research. Scaling industrial innovation, investing in a skilled domestic workforce, and easing regulatory restraints on development are the keys to improving the economics of industrial power to reduce immutable costs and make reindustrialization financially feasible.

Weak industrial capacity poses a grave risk to national security. Industrial power in peacetime, even if it is dedicated to commercial goods, can be quickly converted to meet surge production needs. This was our overwhelming strategic advantage in World War II. As one British analyst observed, "The Battle of Waterloo was won on the playing fields of Eton, but World War II was won on the drawing boards of Detroit." Our success ramping 155mm artillery shell production in the past two years is a reminder of what American industry can achieve at its best.

The industrial base is not the only defense-relevant arena for innovation. Military

supremacy—as shown in American domination during the Gulf War, ongoing conflicts in Israel and Ukraine, and wargames for a potential Taiwan Strait conflict—is largely due to technological asymmetries. As AI, quantum computing, biotech, and other emerging technologies continue to advance, we must ensure they are adapted for offensive and defensive advantage—and that they get into the hands of warfighters as quickly and efficiently as possible. Their requisite supply chains must remain stateside or in allied nations.

Finally, we must not forget the foundation of technological supremacy: frontier research, both basic and applied. Although China's research ecosystem still lags behind America's, it is rapidly closing the gap in dozens of areas. America, meanwhile, continues to struggle with the infamous "valley of death" problem, where promising technologies stall in R&D and fail to reach production. As a 2023 Department of Defense report on the topic aptly urged, "the need for reform is immediate."

To that end, the proposals in this collection offer swift tactics for restoring America's industrial power, national security, and frontier innovation. We hope that policymakers find these materials useful, and join us in advancing innovation towards our national interest. ■

Kelvin Yu

Kelvin Yu is a Fellow at the Foundation for American Innovation.

A version of this foreword containing hyperlinks can be found at www.rebuilding.tech/foreword.

Declarations of Urgency

American leaders are united: restoring our techno-industrial might is of paramount importance.

TODD YOUNG

Senator (R-IN)

"Tech power—in AI, biotech, quantum, drones, and more—is fundamentally transforming our economy, security, and the very nature of global power. America must seize on the opportunities this dynamic technological revolution presents through thoughtful and sustained policies that promote freedom and prosperity."

TRAE STEPHENS

Chairman & Co-Founder, Anduril Industries

"America's defense industrial base is in crisis. If we don't rebuild it now, we will lose the ability to deter and win wars—full stop."

BERNIE MORENO

Senator (R-OH)

"Politicians enabled businesses to gut our industrial sector for decades. The result was a total assault on our middle class. The imperative to repair that damage has never been greater."

KATHERINE BOYLE

General Partner, a16z American Dynamism

"Building is core to our American cultural fabric and there is no greater mission than building in the national interest. We must invest in the entrepreneurs creating a new industrial base to secure this future."

CHRIS MILLER

Author, *Chip War*

"America has tolerated industrial stagnation driven by bureaucratic sclerosis for too long. This playbook delivers a welcome set of new ideas—at a time when fresh thinking has never been more needed."

JAKE AUCHINCLOSS

Congressman (D-MA)

"America needs to build. From housing to ships, medical laboratories to nuclear power, the United States must build at scale. These proposals point the way to an economy of builders & doers, not NIMBYs & middlemen. An economy that works like Legos, not Monopoly."

JACK SHANAHAN

Founding Director, Joint AI Center (Department of Defense)
Air Force Lt. General

"This playbook delivers the bold industrial policy America needs to lead the world through the seismic shift from the industrial age to the digital revolution."

DANNY CRICHTON

Head of Editorial, Lux Capital
Fellow, Manhattan Institute

"Washington can't allow the hardest working people on Earth to lose the greatest wealth creation machine that humanity has ever devised."

JASON HSU

Senior Fellow, Hudson Institute

"A strong US industrial base and defense tech ecosystem are essential for Indo-Pacific stability."

STEVE BOWSHER

CEO, IQT

"America's life blood is its entrepreneurial spirit. Our national security priority should be to empower innovators to tackle our nation's greatest technology challenges."

JOHN JAMES

Congressman (R-MI)

"Strategic investment in the defense industrial base—particularly within opportunity zones—drives innovation, strengthens national security, and fuels economic growth. By harnessing the automotive industry's proven expertise in scaling complex, high-precision manufacturing at competitive costs, we can revitalize domestic production, enhance supply chain resilience, and position the industrial Midwest as a hub for next-generation defense and technology advancements."

AARON SLODOV

CEO, Atomic Industries

"America stands at a crossroads. We must invest in our industrial base today to secure an abundant future for generations to come."

MIKE GALLAGHER

Head of Defense, Palantir

fmr Congressman and Chair of Select Committee on the CCP

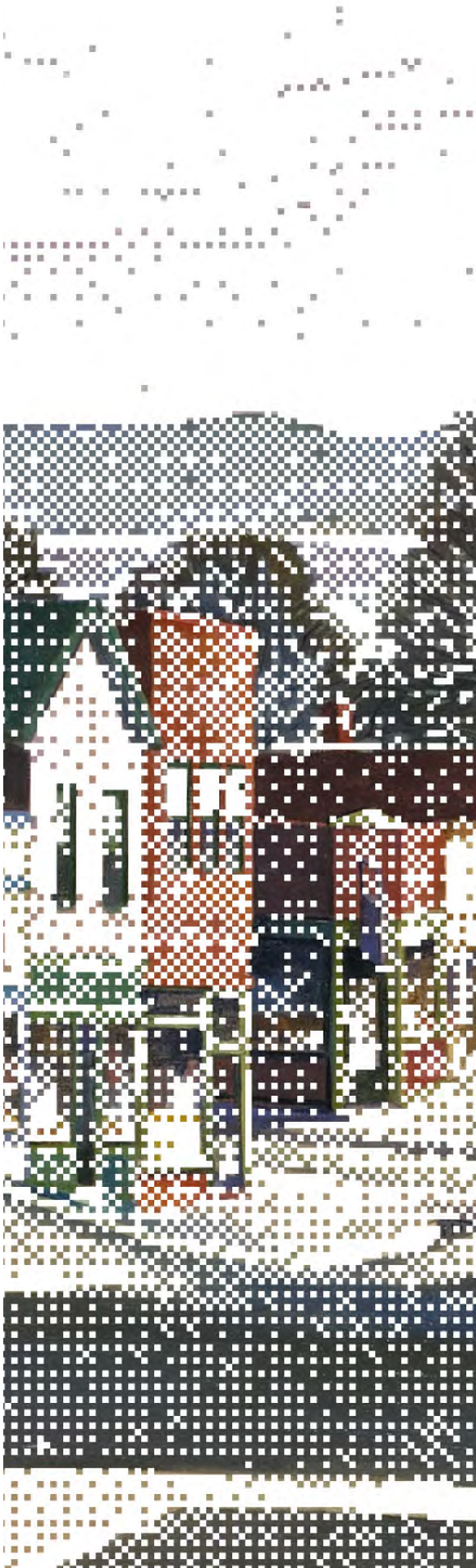
"Xi Jinping fears two things above all others: (1) his own people and (2) that the sleeping giant of American industry awakens. These essays provide the playbook to awaken the giant and strike fear into Xi's heart."

Declarations do not imply endorsement of any particular policy in the playbook.

Frontier Science & Technology

Launching X-Labs for Transformative Science Funding

Caleb Watney



SUMMARY

The traditional, university-driven science funding model that has dominated our research landscape over the last 75 years is beginning to show its age. To maintain US scientific leadership, the White House should coordinate the launch of 20 new "X-Labs" by 2026, each funded at $10 million to $50 million per year through reallocated National Science Foundation (NSF), National Institutes of Health (NIH), and Department of Energy (DOE) budgets. These labs would be independent research institutions selected through a competitive review process, designed to accelerate team-based, high-risk, high-reward, basic science in fields such as biotechnology, materials science, next-generation energy, and chronic disease research—addressing research problems that university-imposed structures and private markets are not well-suited to solve.

X-Labs would address a critical gap in federal funding by providing long-term, flexible block grants to innovative organizations outside of traditional academic settings. Existing insti-

tutional funding mechanisms, such as NSF Science and Technology Centers, NIH P Series (Program Project Grants/Center Grants), and DOE Energy Innovation Hubs, have primarily functioned as loosely connected collaborations of principal investigators rather than unified research institutions. In contrast, X-Labs would support organizations with clear leadership, dedicated full-time teams, and visionary scientific goals.

Unlike ARPA-H and ARPA-E, which back short-term applied projects led by rotating program managers, X-Labs would fund independent research organizations with long-term missions—many focused on fundamental science, others on building critical tools and infrastructure—and the freedom to evolve their work over time, with only the most successful renewed.

Drawing inspiration from the NIH's established system of grants, including the R Series (Research Grants), K Series (Career Development), and U Series (Cooperative Agreements), the X Series would include four distinct award categories:

- **X01 (EXCELLENCE):** Breakthrough basic science institutions.
- **X02 (EXECUTION):** Focused nonprofits building critical tooling with startup-like agility.
- **X03 (EXPERIMENTATION):** Portfolio-based regranting organizations.
- **X04 (EXPLORATION):** Planning grants to test a proof of concept.

This initiative could be implemented immediately using Other Transaction Authority (OTA), allowing agencies to establish X-Labs without new legislation. Each participating agency would retain control over its own awards while coordinating within a unified X-Labs framework. Congressional appropriations could further expand the program's scale, and philanthropic matching funds could amplify its impact through public-private partnerships.

PROBLEM

For the last 75 years, US science funding has relied on project-based grants awarded to individual investigators at universities. While this model has delivered significant discoveries, it is poorly suited for research requiring large-scale infrastructure, focused interdisciplinary collaboration, or long-term investment.

However, advancing the scientific frontier increasingly depends on precisely these features. We are seeing a rise in "team science," where contributing to the frontier of knowledge in nearly every field requires larger and more specialized groups of people. In other words, the future of scientific research looks less like a lone genius working at a chalkboard and more like a team operating in a startup-like environment. For example:

EVO 2 MODEL: At the Arc Institute, researchers developed an advanced AI model trained on over 9 trillion nucleotides from 128,000 genomes across all domains of life. This model enables accurate prediction and design of genetic sequences, facilitating the identification of disease-causing mutations and the development of novel biological tools. Its development required extensive computational resources, interdisciplinary expertise in genomics and machine learning, and sustained infrastructure funding far beyond the scope of traditional NIH grants.

ALLEN BRAIN ATLAS: At the Allen Institute for Brain Science, researchers built the first comprehensive gene expression map of the mouse and human brain, creating a publicly available resource used worldwide. This required industrial-scale data collection and analysis, which would have been infeasible under the fragmented structure of traditional academic grants.

LIGHT-SHEET MICROSCOPY: At the Janelia Research Campus, scientists developed an advanced imaging technology enabling real-time, high-resolution 3D visualization of living tissues. This required multi-year engineering and computational development, which traditional NIH grants rarely support.

All of these projects succeeded because they had dedicated institutional support from philanthropic funders beyond the constraints of university-based NIH or NSF grants. Similar efforts that are publicly funded remain the exception rather than the rule, if they can get funded at all. Large-scale initiatives that succeed, like the Brain Initiative Cell Census Network, have required extensive coordination across multiple NIH institutes, with funding cobbled together from U19, U01, and R01 grants.

Meanwhile, NIH P-Series "program project" grants and the NSF's Science and Technology Centers (STCs), which nominally support large, multi-project efforts, have a variety of issues:

- They require applicants to specify in advance the exact research projects they will pursue. This rigid structure eliminates the flexibility that makes institutional block grants so effective.
- Within the university structure, these grants often function as administrative umbrellas for groups of individual Principal Investigators (PIs) and their preexisting research agenda rather than as independent organizations with clear leadership and a coherent vision.

Beyond structural funding limitations, the broader science funding system has become increasingly bureaucratic. Researchers face wait times of up to 20 months for grant funding—crippling in fast-moving fields like synthetic biology. The burden of securing funding is also enormous: scientists report spending nearly half of their time on grant-related paperwork instead of doing research. This system's preference for incremental, fundable projects over ambitious, high-risk work means that younger scientists struggle to pursue bold ideas. The average age for receiving a first NIH R01 grant is now 43, delaying career independence and discouraging risk-taking.

Some elite research universities have pioneered semi-autonomous centers and cross-disciplinary institutes that partially overcome these issues—but these are exceptions, often reliant on external philanthropy or special administrative carveouts. X-Labs would institutionalize the ability to operate with this kind of autonomy by default.

Taken together, these structural issues mean that large-scale, interdisciplinary, and infrastructure-intensive research remains chronically underfunded and organizationally constrained. Our traditional scientific funding institutions have, without a doubt, generated enormous returns for society overall and will remain essential in the future. But without a dedicated funding mechanism for independent, high-risk, team-driven research, the US risks falling behind in the next generation of scientific breakthroughs.

SOLUTION

The X-Labs Initiative

X-Labs (organizations awarded an X01, X02, or X03) would be selected through a competitive federal award program, with at least 20 institutions funded at levels of $10 million to $50 million per year, depending on their scope. Each award would run on a seven-year cycle, with a hard cap on renewals: no more than 70 percent of labs would continue into a second term. This deliberate churn would keep the portfolio dynamic—rewarding excellence while continuously making room for new entrants and fresh ideas.

To support new entrants, the program would also offer two-year "Exploration" grants (X04), providing early-stage teams with $1 million to $3 million to refine their vision and build scalable institutional plans before applying for full funding.

By providing long-term, flexible funding to institutions rather than individual projects, X-Labs would fill a structural gap in the federal research portfolio—enabling team-based science that is difficult to support through standard mechanisms—with an overall budget equivalent to roughly 1 percent of the combined NSF, NIH, and DOE science budgets.

To structure this new ecosystem, the X Series would include four distinct award types:

X01 (EXCELLENCE) AWARDS would support cutting-edge basic science institutions with flexible research environments modeled after organizations like the Janelia Research Campus, the Arc Institute, the Broad Institute, and the Allen Institute. These institutions would focus on foundational scientific discovery with stable, long-term support. The core bet behind X01s is on people, not projects—the goal is to assemble the best team in the world to pursue open-ended scientific inquiry with minimal bureaucratic constraint.

X02 (EXECUTION) AWARDS would fund scientific entities dedicated to solving critical infrastructure, tooling, or data challenges. Similar to Focused Research Organizations, these labs would be designed for time-limited, high-impact interventions and use multi-year block grants with milestone-based evaluations. Eligible institutions could include purpose-built entities working on platform technologies—such as improved instrumentation, open datasets, or scalable experimental methods—or mission-driven AI labs like early OpenAI or DeepMind, to the extent that they operate with nonprofit structures and public-interest mandates. The fundamental selection principle is the challenge: funding a talented group with a nimble organizational structure to execute against a clearly defined bottleneck in the scientific ecosystem.

X03 (EXPERIMENTATION) AWARDS would fund portfolio-based regranting and incubation organizations, acting as alternative funding institutions outside of the traditional government grant selection process, with models such as Convergent Research, Speculative Technologies, and Science Angels serving as potential inspiration. Some projects would be required to integrate metascience experiments to study and improve science-funding methodologies. The animating principle behind X03s is to empower scientific scouts: individuals or organizations with the insight, network, and conviction to identify high-potential ideas, talent, or research directions long before they become consensus picks.

X04 (EXPLORATION) AWARDS would provide seed funding of between $1 million to $3 million over a few years to support the formation and planning of new scientific institutions, enabling teams to refine their vision, build key partnerships, and develop initial proof-of-concept work before applying for full X01, X02, or X03 funding.
To ensure the success of X-Labs, the relevant agency heads should:

- Expand eligibility beyond academia, explicitly allowing and encouraging independent research organizations to apply. This shift would incentivize the creation of new models of scientific institutions and reduce dependence on traditional university structures.
- Use a deliberately selective process that prioritizes scientific vision, execution ability, and institutional leadership. Unlike traditional grant programs that must process thousands of proposals, X-Labs would evaluate a relatively small number of institutional candidates—enabling agencies to recruit elite reviewers with deep domain knowledge and judgment. While track record should matter, the process should emphasize the novelty, significance, and feasibility of the proposed scientific agenda—and whether the team has the capacity to realize it.
- Leverage OTA authority to launch X-Labs immediately while utilizing existing funding streams within the agencies, bypassing the need for specific action from Congress. Other Transaction Authority (OTA) is a flexible funding mechanism that allows agencies to sidestep traditional grant constraints. The NSF TIP Directorate and the NIH Director's Office both have access to OTA and should lead implementation within their agencies. Each agency would retain oversight of its portfolio while coordinating under a shared X-Labs framework.
- Encourage public-private partnerships with federal agencies exploring philanthropic matching funds to potentially double the impact of government investment.

Congress could expand appropriations if the model proves successful. While the initial X-Labs program would represent roughly 1 percent of total NSF, NIH, and DOE science budgets, it should be structured for scalability. If early institutions demonstrate transformative impact, Congress could authorize dedicated appropriations to grow the program, potentially to 5 or 10 times its initial size. The goal is not to constrain X-Labs to 1 percent but to establish a high-performing pilot that earns the right to scale.

JUSTIFICATION

Reducing Administrative Burden and Improving Efficiency

A key advantage of X-Labs is the ability to consolidate administrative overhead within research institutions, freeing scientists from the excessive burden of grant writing and reporting. X-Labs would centralize award administration within institutions, allowing individual researchers to specialize and focus on discovery rather than bureaucracy.

For NIH and NSF, this shift could also streamline the internal review process. Instead of evaluating hundreds of individual project-based proposals, relevant program officers could assess a portfolio of research opportunities at the institutional level. This approach could reduce workload while enabling better-informed funding deci-

sions—enabling program officers to pursue quality over quantity in the selection of peer reviewers.

While DOE already funds institutional science through its National Laboratories, the current lab system suffers from entrenched structural constraints. These labs are weighed down by inflexible governance models, antiquated procurement and HR systems, and a narrow interpretation of mission that disincentivizes scientific risk-taking. Their emphasis skews toward applied and mission-specific work, leaving limited room for curiosity-driven or exploratory research. X-Labs would provide a distinct institutional complement—supporting startup-like research organizations that are smaller, faster-moving, and less encumbered by bureaucratic or political inertia. Rather than duplicating the labs' existing role, they would offer a sharper instrument for enabling high-risk, high-reward basic science.

X-Labs would shift federal funding toward a portfolio-based approach—selecting institutions with a demonstrated capacity to manage and prioritize breakthrough science. This model acknowledges that while it is difficult to predict which specific projects would succeed, it may be easier to identify research organizations with strong leadership, a history of transformative impact, and the ability to allocate resources strategically.

Venture capital firms, for example, are evaluated based on their overall track record of investment success, not on the projected outcomes of a single investment. Similarly, X-Labs would allow agencies to renew research organizations that have shown they can generate high-impact discoveries over time, rather than attempting to predict which specific projects would succeed in isolation. ■

FURTHER RESOURCES

- Ben Reinhardt, "Fund Organizations, Not Projects: Diversifying America's Innovation Ecosystem with a Portfolio of Independent Research Organizations," Institute for Progress, January 19, 2022
- Adam Marblestone et al., "Unblock Research Bottlenecks with Non-Profit Start-Ups," *Nature*, January 11, 2022.
- Michael Nielsen and Kanjun Qiu, "A Vision of Metascience," *Scienceplusplus*, October 18, 2022.
- Ben Reinhardt, "Unbundling the University," *Speculative Technologies*, February 2025.

Caleb Watney is the co-founder and co-CEO of IFP, an innovation policy think tank. His research focuses on policy levers the US could use to rebuild state capacity and increase long-term rates of innovation.

■ Frontier Science & Technology

Securing Access to Foreign Data Flows for AI

Tim Hwang and
Joshua Levine

SUMMARY

For the United States to remain on the cutting edge of artificial intelligence (AI) development, model developers need access to novel, high-quality, and underused data sets. This is true for frontier model advancement, but even more so for ensuring that models can be effectively fine-tuned for accomplishing specific tasks such as industrial operations, drug development, and climate prediction that contribute to scientific discovery, economic dynamism, and national security. This policy should be advanced by directing the United States Trade Representative (USTR) within the Department of Commerce to prioritize working with foreign governments, particularly those the US already has strong relationships with, to establish a policy of licensing crucial data to be used to train AI models. The USTR should also work with Congress when crafting new trade agreements or treaties to include language that expressly calls for data sharing and unencumbered cross-border data flows for the purpose of training AI models.

PROBLEM

Now that leading AI model developers have scraped the web and have incorporated most, if not all, publicly available data to train their models, they are increasingly seeking access to high-quality proprietary datasets to drive system improvements. The US government has an opportunity to secure the nation's technological advantage in AI by negotiating and securing access to key data flows on behalf of US industry. Specifically, access to data from allies in areas of strategic importance will support continued building and fine-tuning of AI models to support diffusion domestically, while also establishing mutually beneficial relationships globally around a key input for future AI model development. Where possible, the US may also aim to secure these arrangements on an exclusive basis, denying access to geopolitical rivals as they attempt to catch up in AI.

Exclusive agreements are particularly important in the context of competition with China. Presently, Chinese model developers enjoy the benefit of a domestic legal framework that facilitates firm access to information, as well as efforts by regional governments, such as those in Shanghai and Shenzhen, to collect and curate datasets to spur AI development. The federal government should promote these exclusive agreements to mitigate potential data shortages in the near term, while extending existing norms related to cross-border data flows and AI model training over the medium to long term. Such agreements could be a critical plank of Western collaboration around the sharing and use of key inputs for training AI models as a counter to the techno-authoritarian ecosystem being developed by the People's Republic of China and its collaborators.

Pursuing these agreements would establish a clear vision for US trade policy specifically as it relates to AI development, and broadly to other technologies. Ensuring that such data is accessible for training can build upon existing norms related to cross-border data flows for the AI era. Such a posture would strengthen collaboration on a critical technology with allies and support America's own domestic AI industry.

SOLUTION

Executive

- The president should direct the USTR to include, when amending or initiating new trade agreements, specific language to promote and protect the sharing of data for domestic AI model training. Such a directive should instruct USTR to prioritize securing access to high-value, hard-to-access data sources surrounding scientific research, health data, and industrial tasks and operations. Datasets specifically focused on heavy industry and manufacturing, telecommunications network operations, geospatial and environmental areas, labor force participation, and transportation flows could all support US policy objectives domestically and around the world.
- The president should form a Presidential Commission on Data Acquisition (PCDA) that would bring together key model developers to advise the White

House and USTR on the evolving data needs within the AI industry and help prioritize targets for acquisition and data flow agreements.
- The president should direct the Director of the Office of Science and Technology Policy (OSTP) to produce a report identifying opportunities to create broader data alliances to facilitate and incentivize exchange of key types of data between the US and its allies to create mutual acceleration for each nation's respective AI industries. This would result in a report identifying the global landscape of "critical" data flows and offering potential trade agreement structures. The report should also explore opportunities to deny geopolitical rivals access to crucial datasets as a means of preserving US advantage.
- The president should direct the USTR and the Bureau of Industry and Security within the Department of Commerce to study and propose a framework for securing data access between the US and allies to mitigate cyberespionage threats that arise when data is acquired, transferred, and accessed by firms in the US, if deemed necessary. Such a framework could also provide an opportunity to update existing frameworks used for current agreements for cross-border data flows.

Congressional

- The Senate Finance Committee and House Ways and Means Committee are the committees of jurisdiction for the USTR. As part of their oversight authority, they should conduct hearings with the USTR focused on improving relationships between the US and allies with regard to digital trade and pursuing agreements to support access to training data for AI models.

JUSTIFICATION

The idea for facilitating access to data for the specific purpose of training AI models has not been tried, but it should be seen as a continuation of existing policies for cross-border flows present in multilateral organizations such as the Organization of Economic Cooperation and Development and the Indo-Pacific Economic Framework for Prosperity, and in trade agreements the US is party to, such as the United States-Mexico-Canada Agreement, the US-Japan Data Transfer Agreement, and an agreement between the US Department of Commerce and the Kenyan Ministry of Information, Communication, and the Digital Economy. What this new policy adds is specific language to protect the transfer and use of data from foreign countries to the United States for the express purpose of training AI models. This could include exceptions to local privacy and intellectual property rules that hinder private acquisition of key data flows. It could also include specific acquisition and licensing of key data sources by the government to accelerate the US AI industry. While it is likely that existing agreements that facilitate cross-border data flows have supported the construction of data sets for AI model training, adding explicit language would add an additional layer of protection for the domestic AI industry. ■

FURTHER RESOURCES

- Frank Schweitzer and Ian Saccomanno, "The Rise of Artificial Intelligence, Big Data, and the Next Generation of International Rules Governing Cross-Border Data Flows and Digital Trade," White & Case, 2024
- Department of Commerce, Joint Statement on Harnessing Artificial Intelligence, Facilitating Data Flows and Empowering Digital Upskilling Between the United States Department of Commerce and the Kenyan Ministry of Information, Communication and the Digital Economy, 2024
- OECD, Fostering Cross-Border Data Flows with Trust, 2022
- GSMA, Cross-Border Data Flows: Realising Benefits and Removing Barriers, 2018

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■ Frontier Science & Technology

Reforming Federal Hiring for Tech Policy Talent

Sophia Brown-Heidenreich and Remco Zwetsloot

SUMMARY

The American government's strength increasingly depends on its technological capabilities, yet its hiring processes actively prevent it from hiring essential technical talent. While private sector companies can quickly hire skilled workers, federal agencies' bureaucratic processes deter qualified candidates, particularly in critical areas like artificial intelligence, semiconductor policy, and cybersecurity.

We propose reforming federal hiring through improved assessments and streamlined authorities. These changes would enable agencies to build the technical workforce needed to effectively implement defense, innovation, and industrial policy. By modernizing its hiring practices, the US government can position itself to lead through the technological revolutions that will define this century.

PROBLEM

The US government's technological capabilities increasingly determine its global competitive-

ness and national security, yet current processes actively prevent it from hiring the technical talent it needs.

While private sector technology companies can hire skilled workers in weeks, federal agencies often take six to nine months to fill critical technical roles. This bureaucratic process particularly hurts high-priority programs in artificial intelligence, semiconductor policy, and cybersecurity.

In hiring for technical talent, the US government faces several institutional disadvantages. It often cannot offer competitive compensation and its bureaucracy—including long security clearance timelines—repels technologists accustomed to the entrepreneurial culture of Silicon Valley. Rigid job classifications and specialized experience requirements limit the candidate pool, as does the federal practice of posting obscurely titled positions that may not be legible to technologists (e.g. calling a technical AI policy role "IT Specialist"). In short, too many tech professionals overlook federal opportunities or are turned off by the process.

Nevertheless, many brilliant private-sector individuals would be interested in making the leap into public sector work, if only the government's hiring process selected them. But impediments to smooth hiring have meant that even willing candidates are left untapped.

Currently, 90 percent of open positions are evaluated by government human resources professionals with no background in the subject-matter for which they are hiring. Office of Personnel Management (OPM) guidelines require candidates to complete questionnaires about their abilities, and OPM advances candidates who self-report expertise in all domains, without verifying such self-reports. Human resources then looks for similarities between the job description and a candidate's resume to determine whether the applicant is advanced to the next stage. This process selects for those savvy enough to know that government resumes succeed when they closely match the original job description, even if the candidate does not in fact possess the desired skill. After all that, veterans' preference is applied and only the top three resumes are passed on to the hiring manager for consideration—if the hiring manager does not see any resumes suitable for the role, their only hope is to restart the process. The system, designed to foster meritocracy, has turned into a box-checking exercise.

The current system functions so poorly that only 51 percent of the jobs posted on USAJobs lead to hires (and of course not all of those hires are of truly qualified applicants).

Innovation, industrial, and national security policy rely on talented staff. Capable government employees can be the difference between American techno-industrial leadership and billions of dollars of wasted funds. In many cases, qualified staff are the bottleneck.

A February 2025 report from the Government Accountability Office found that workforce challenges were at the heart of many of the "high-risk" challenges to the federal government. Areas for improvement included improving capacity for weapons acquisitions—where the Department of Defense (DOD) struggles to source software engineers and procurement specialists with experience in software—identifying staffing gaps in cybersecurity, and hiring nuclear safety specialists and electrical engineers at the Department of Energy.

Other examples abound. Analysts have identified talent as a critical bottleneck to the success of export controls, the Food and Drug Administration's (FDA) ability to

approve rollouts for AI medical devices, safe adoption of AI in the airline industry, the implementation of the CHIPS and Science Act (the National Institute of Standards and Technology was chosen as the bureau to run the program "because of its deep technical expertise"), and even the security of the southern border.

The United States is undertaking its largest-ever investment in technical and industrial capabilities through programs like CHIPS and AI integration in defense systems through initiatives like the Chief Digital and Artificial Intelligence Office's (CDAO) AI Rapid Capabilities Cell. These massive investments will succeed or fail based on the government's ability to bring on qualified personnel to implement them effectively.

Solutions are within reach. Programs like Subject Matter Expert Qualification Assessments (SME-QA)—initiated during the first Trump administration—demonstrated significant improvements in federal hiring, without hiking salaries. These proven models could be scaled immediately across federal agencies, transforming technical hiring from a liability into a competitive advantage. Early data shows that reformed hiring processes reduced the average selection timeline from 45 to 16 days at the Department of Interior (DOI) while simultaneously improving the quality of hires. With President Trump's return to office, there's a unique opportunity to expand these successful pilots across the federal government while remaining consistent with cost-cutting initiatives.

This combination of urgent need and validated solutions creates a unique window for reform. The government has committed unprecedented resources to technical initiatives—now it must ensure it has the talent to implement them effectively. Without immediate hiring reform, billions in federal investment risk being mismanaged or ineffectively deployed. The tools for improvement exist; they simply need to be deployed at scale.

SOLUTION

Executive

- Process: Agencies should expand the use of pooled hiring to allow hiring managers to share the same certs. While each federal agency currently has the authority to run pooled hiring grounds, the practice should be systematically encouraged, supported, and tracked by OPM.
- Assessment: Agencies, in partnership with OPM, should scale up use of Subject Matter Expert Qualification Assessments (SME-QA) to critical hiring rounds for roles requiring significant subject-matter expertise, both political and programmatic.
- Review: OPM should launch an audit of the Delegated Examiners Operating Handbook to identify further efficiencies.

Congressional

- Oversight: Exercise thorough oversight over the 2024 Chance to Compete Act to ensure agency compliance with intent to streamline hiring.

JUSTIFICATION

The proposed reforms build on proven successes while addressing known implementation gaps.

PROCESS: Pooled hiring transforms federal hiring by allowing multiple agencies to tap into a single, high-quality candidate pool simultaneously. When agencies share a certificate of eligibles or "cert" for qualified applicants, they dramatically expand their access to talent while reducing administrative burden. In early 2024, OPM set a goal of facilitating 28 pooled hiring rounds which it hopes will lead to 700 new hires by September 2025. That would be a 25-fold increase in the number of hires for each position listed, massively reducing administrative overhead for each individual hire. But the real power of pooled hiring lies in its network effects: as more agencies participate, the talent pool becomes larger, and qualified individuals are more likely to find a spot across any number of jobs. These dynamics create a virtuous cycle which in turn makes government service more attractive to top candidates. Agencies can also share assessment costs and best practices, making the entire federal hiring system more efficient.

ASSESSMENT: Pilot programs at HHS and DOI demonstrated SME-QA's effectiveness in improving technical hiring. Though the process surfaced fewer total qualified candidates, it dramatically increased the proportion of qualified applicants reaching hiring managers (from 0 percent to 52 percent). Meanwhile the hiring time decreased by 63 percent. Most importantly, the process eliminated the problem of unqualified candidates gaming keyword systems—every candidate reaching final review had been vetted by technical experts. These results suggest SME-QA could transform government technical hiring if implemented more widely.

SME-QA is specially useful for pooled hiring, where the returns from up-front investment in the hiring process can pay out for tens of hires at once. Additionally, SME-QA should be considered for individual technical hires when a critical hiring need exists. For even broader adoption, agencies should consider increasing their recruitment capacity (see the Defense Innovation Board's recommendation for SME tech hiring).

REVIEW: At 318 pages, the Delegated Examining Operations Handbook exemplifies the bureaucratic complexity that plagues federal hiring. While some procedures are statutorily required, many are self-imposed executive branch policies that prioritize process over outcomes. A thorough audit could identify numerous opportunities to streamline hiring while maintaining merit principles and fairness. For example, simplifying position classification requirements, reducing documentation burdens, and modernizing assessment tools could significantly accelerate hiring without compromising quality. The handbook should be reimagined as a tool for enabling effective hiring, rather than a barrier to it.

OVERSIGHT: The 2024 Chance to Compete Act marks a crucial shift toward skills-based hiring by requiring agencies to prioritize technical assessments over self-reported qualifications. However, implementation will determine its impact. Transitioning to a new assessment system will require upskilling existing HR staff and adopting new systems. Congress should establish clear metrics for success—including on success rates

in hiring and proportion of hires made through skills-based assessments—and require quarterly progress reports from agency hiring leads. Additionally, oversight should focus on identifying, celebrating, and scaling successful assessment practices across agencies. By maintaining consistent pressure for reform while highlighting wins, Congress can accelerate the transformation of federal technical hiring. ■

FURTHER RESOURCES

- United States Digital Service, "Understanding the SME-QA Process"
- Jennifer Pahlka, "What on Earth Is SME-QA and Why Should You Care About It?" *Medium*, 2021
- Beyond the Checkbox: Modernizing Federal Hiring and Assessments, Niskanen Center [forthcoming].
- Peter Bonner, "Better Hires Faster: Leveraging Competencies for Classifications and Assessments, Federation for American Scientists, 2024
- Merit Systems Protection Board, "Direct-Hire Authority Under 5 U.S.C. § 3304: Usage and Outcomes," 2021
- Office of Personnel Management, *Delegated Examining Operations Handbook*, 2019
- Office of Personnel Management, OPM Time to Hire Dashboard

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■ Frontier Science & Technology

Reforming the SBIR Program

Lars Erik Schönander

SUMMARY

The Small Business Innovation Research (SBIR) program, established in 1982, is a powerful tool for the federal government to commercialize innovative research and assist in turning startups into major companies. But despite meaningful reforms in recent years, problems persist that limit its ability to commercialize critical technologies. Companies earn hundreds of awards despite being mediocre at commercializing research, and malign foreign actors continue to take advantage of the SBIR program. Both harm the program's effectiveness at enhancing American competitiveness.

Senator Joni Ernst (R-IA), Chair of the Senate Small Business Committee, which oversees the SBIR program, has introduced S. 853, the INNOVATE Act, to reauthorize the SBIR program and address these problems. The bill enhances commercialization requirements to ensure that companies with dozens of awards do not rely on SBIR dollars as their principal source of revenue, strengthens the due diligence process that agencies undertake to evaluate SBIR companies for foreign risk, and reforms SBIR awards to increase the applicant pool and help companies cross the "valley of death."

PROBLEM

At the inception of the program, Congress intended SBIR to provide early-stage seed funding to help the best startups attract private capital. The SBIR program counts among its success stories companies such as Qualcomm and Anduril, both of which used SBIR awards to scale up their operations.

There are three tiers of SBIR awards. Phase I awards are approximately $200,000 to test if a technical idea has commercialization potential. Phase II awards are approximately $1,000,000 (though some agencies such as the Department of Defense (DOD) award larger awards) to turn ideas into products. To receive a Phase II award, a company must generally have received a Phase I award (or completed equivalent work outside of the program), as the Phase II award follows up on the work done in the Phase I award. Finally, a Phase III award is a term for a contract that is derived from a Phase II contract or through prior SBIR work, funded by an agency's general R&D or acquisition budget. There are several traits of Phase III contracts that are unique compared to other kinds of government contracts.

The SBIR program has two major problems. First, many Phase I and Phase II SBIR awards go toward a few unproductive companies rather than companies creating bold new technologies. These are colloquially called "SBIR mills." According to the author's calculations, from 2010 to 2023, 25 companies received 9 percent of all SBIR award dollars, out of 17,563 companies that received SBIR awards in total. Concentration is worse in some agencies. For example, 25 companies received $3.2 billion percent of all DOD SBIR awards from 2010 to 2023. Many of these companies are not effectively commercializing their Phase I/II SBIR awards. Only four of the top 25 DOD SBIR companies generated more in DOD Phase III contracts than they received in Phase I/Phase II awards from FY 2012 to FY 2021.

The second problem is the SBIR program's vulnerability to China's attempts to steal American research. Some SBIR companies maintain employees tied to Malign Foreign Talent Recruitment Programs in China. In some cases, researchers received SBIR awards while actively doing research for Chinese universities.

Large-scale collaborations can pose a risk to SBIR-funded research. SBIR companies have conducted joint research or joint ventures with entities known to have ties to foreign adversaries. Even more troubling are cases in which an SBIR company has had a branch in China that became the primary beneficiary of the SBIR funds. The 2022 reauthorization of the SBIR program made some progress on these problems, creating new foreign ownership, control, or influence due diligence programs within SBIR programs. But the problem continues: companies with risky backgrounds are still receiving SBIR awards.

The mill problem weakens the SBIR program's ability to help companies cross the "valley of death"—the gap in funding that companies with advanced technologies face when trying to transition research from an idea to a product. The current structure of the SBIR program, with inadequate funding available at later stages of commercialization and tolerance of large firms exploiting program dollars for perpetual R&D, creates a struggle for motivated companies to transition from SBIR awards to regular contracts. The foreign influence problem, meanwhile, weakens America's ability to benefit

from SBIR-funded technologies, as the program remains vulnerable to technological theft by China and other adversaries.

SOLUTION

Congressional Recommendations

Senator Ernst, as Chair of the Senate Small Business Committee, has introduced S. 853, the INNOVATE Act, to reform the SBIR program as part of the fiscal year 2025 reauthorization of the program. The bill would make three major reforms.

First, the legislation would strengthen commercialization requirements:

- It would implement a lifetime cap on how many SBIR award dollars a company can receive. While the vast majority of companies receive fewer than five SBIR awards, SBIR mills over the lifetime of the program have received hundreds or even thousands of awards. The program should be structured as an initial investment to grow companies, as Congress intended when creating the program in 1982, instead of letting companies rely on SBIR awards as a perpetual source of revenue.
- It would strengthen commercialization benchmark requirements associated with SBIR companies that win hundreds of awards. The bill would require agencies to check how much revenue a company has received from SBIR awards versus from other sources of revenue. The goal is to ensure that companies that receive SBIR awards grow and graduate from the program.
- It would make SBIR and Small Business Technology Transfer (STTR) contracts fixed-price contracts by default. A fixed-price contract is one in which the dollar amount paid is set in advance. Some SBIR contracts are currently cost-plus contracts, whereby the government pays the contract winner negotiated overhead fees associated with the project. Restructuring these contracts as fixed-price rather than cost-plus would incentivize companies to deliver what they promised quickly and efficiently. Fixed-price contracts ensure taxpayers are not spending money on corporate cost overruns.

Second, the bill would improve agency due diligence programs:

- It would enact a stronger definition of foreign risk to ensure that federal agencies take a standardized approach in analyzing SBIR applicants from a research security perspective. One area for improvement from the provisions in the 2022 SBIR reauthorization is that federal agencies have the latitude to evaluate foreign risk differently. This has resulted in cases where a company that was denied a SBIR award by one agency on the basis of foreign ties could potentially receive a SBIR award from a different agency.
- It would require agency due diligence programs to consult applicants' relationships to entities on a common set of established lists of sanctioned and adversary-linked entities when checking if a company has dangerous foreign ties. An applicant company could not be affiliated with a corporation, research insti-

tution, or other entity on one of the federal government's many Chinese military-industrial complex lists and still remain eligible for award dollars.

Finally, the legislation aims to attract new entrants and help the best companies cross the "valley of death":

- It would simplify the process of getting SBIR awards. Agencies would be required to create a simply one-time-only Phase I SBIR award focused on commercialization potential. This would increase the amount of technologies agencies could choose from for targeted investment.
- It would help DOD scale companies through SBIR awards by creating a new transition-focused Phase II allocation with 0.25 percent of the DOD SBIR-STTR budget. The allocation would be reserved for high-dollar awards to small businesses that best improve the effectiveness of the warfighter with a focus on scaling the production of new technologies. This proposal is inspired by the success of the Air Force's STRATFI/TACFI (see appendix).
- These reforms would help agencies pick the best companies and make targeted investments to accelerate their technology. The streamlined Phase I award would make it easier for companies with worthy technology to get their foot in the door with federal agencies that have SBIR programs. The transition-focused Phase II awards would enable agencies to choose technologies with the best commercialization potential and rapidly scale them.

JUSTIFICATION

The SBIR program expires at the end of fiscal year 2025, and its reauthorization offers an opportunity to reform the program. Several senators have pursued SBIR reform, with mixed success.

In 2019, the Chair of the Senate Small Business Committee, Senator Mark Rubio (R-FL), introduced the SBA Reauthorization and Improvement Act of 2019, which would have reauthorized the Small Business Administration (SBA). Section 205 would have created a Phase III SBIR contracting authority education program; Section 206 would have required SBIR program officers to more heavily weigh commercialization potential when choosing companies to award. The SBA reauthorization bill containing these SBIR reforms stalled in 2019 because of differences between the Republican majority and Democratic minority on regulatory reform.

The SBIR program was most recently reauthorized in 2022. While the reauthorization bill passed and contained key reforms to the SBIR program, including foreign ties due diligence, a requirement for the Government Accountability Office (GAO) study on multiple award winners, and enhanced commercialization benchmarks for multiple awardees, these reforms did not go far enough.

Given a narrow number of firms subject to new standards and relatively lenient standards to escape penalty, the 2022 reauthorization's commercialization benchmarks did not meaningfully affect the role of SBIR mills in the program. A 2024 GAO study showed that new commercialization standards only affected six multiple awardees (a broader

group of companies of which SBIR mills are a subset). Further, while the legislation requires a foreign ties due diligence program at participating agencies, some now have disparate due diligence practices and varying evaluations of adversarial influence in potential awardees, which can lead to companies with malign ties continuing to receive awards. The 2025 reauthorization presents an opportunity to fix these flaws in the program. ■

FURTHER RESOURCES

- Amanda Bresler, "Assessing the Effectiveness of Defense-Sponsored Innovation Programs as a Means of Accelerating the Adoption of Innovation Forcewide," Acquisition Research Program, 2023
- Defense Innovation Board, "Terraforming the Valley of Death: Making the Defense Market Navigable for Startups," 2023
- Protecting the National Security Innovation Base Study Group and OSE/Factor 8 Program, "Survey of PRC State-Sponsored Technology Transfers Affecting SBIR Programs: A DoD Case Study," 2021
- Government Accountability Office, "Increased Performance Standards Likely Affect Few Businesses Receiving Multiple Awards," 2024
- Ben Van Roo, "Are a Few Dozen SBIR Mills Sucking the Air Out of Small Business Innovation?" Beyond Visual Range—AI, Defense, and Policy, 2022
- Ben Van Roo, "Congress Renews SBIRs. Yay!?" Beyond Visual Range—AI, Defense, and Policy, 2022

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APPENDIX

Small Business Technology Transfer contracts: STTR contracts are SBIR awards whereby a small business cooperates with colleges or universities, Federally Funded Research and Development Centers (FFRDCs) or qualified non-profit research institutions to commercialize research from those institutions.

Strategic Funding Increase/Tactical Funding Increase (STRATFI/TACFI) Programs: SBIR funding programs run through AFWERX, the innovation arm of the Department of the Air Force. STRATFI/TACFI award larger than usual SBIR Phase II awards ($3–15 million and $375,000–$2 million) with a combination of SBIR and non-SBIR government dollars. The Air Force uses STRATFI/TACFI awards to help companies cross the gap between receiving SBIR awards and entering long-term, larger government contracts.

Establishing Special Compute Zones

Tim Fist

SUMMARY

Maintaining American leadership in AI will require an infrastructure project at a scale this country has not seen in decades. We must build many gigawatt-scale (GW) clusters,[1] each requiring the energy equivalent of multiple nuclear power plants. To achieve this, US policymakers must unleash America's industrial capacity. They must radically reduce timelines for environmental permitting and help developers take on the technical risks involved in scaling next-generation energy technologies such as small modular reactors (SMRs) and enhanced geothermal.

However, huge investments in AI infrastructure will count for little if the products of these investments—systems that could both form the basis of the US economy and reshape the global balance of economic and military power—can easily be sabotaged, stolen, or used against us by our adversaries. The AI and computing industry is underinvesting in the level of security required to successfully secure and defend their technologies against nation-state-level actors, if

1 A "cluster" is an interconnected group of computers that can be used together to train AI models. Today's largest clusters span multiple data centers.

the situation demands it. We must ensure that the future of AI is both built in America, and good for America.

We propose that the federal government establish "Special Compute Zones"—regions of the country where AI clusters at least 5 GW in size can be rapidly built through coordinated federal and private action. Within Special Compute Zones, the government should use federal authorities to accelerate permitting and solve supply chain bottlenecks, and unlock financing for next-generation power plants. In return, the government should require security commitments from AI and computing firms—making nation-state-grade investments in AI security a sensible commercial decision, rather than one which puts a firm at a disadvantage relative to its competitors.

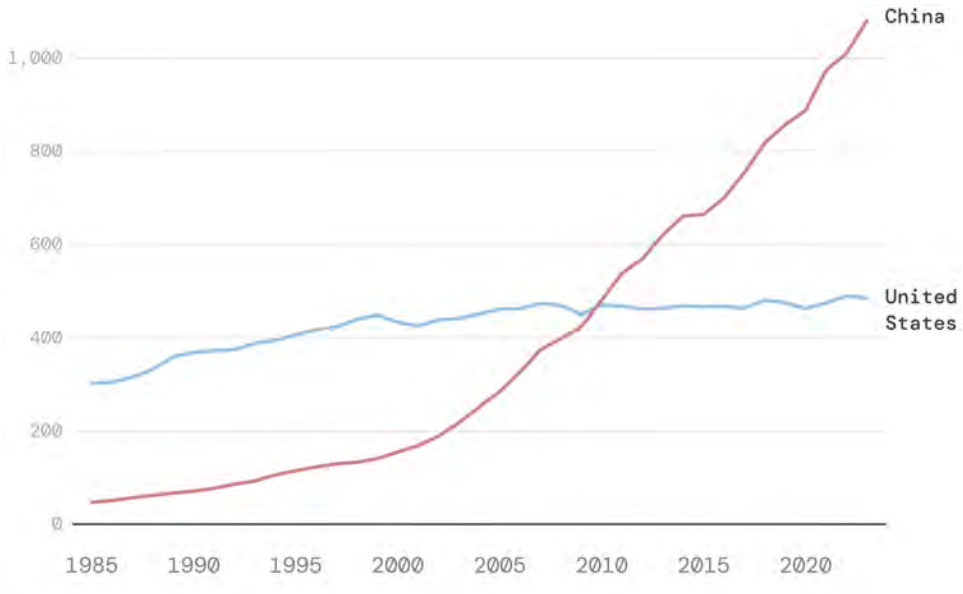
PROBLEM

Ensuring the most advanced AI data centers are built in America will yield two large advantages. Economically, it means American firms can capture the immense value created by cutting-edge AI development and secure priority access to frontier models. Developing frontier models here also means that we have the option of withholding their capabilities from our adversaries. This may become necessary in worlds where the predictions of those at the frontier of AI development turn out to be correct: massive AI-driven workforces achieving cyber-dominance through rapid software development, hacking, and digital reconnaissance; mass-persuasion campaigns and elaborate forms of espionage; and dramatic acceleration of weapons design and military autonomy.

Success requires overcoming two major obstacles.

ELECTRICITY GENERATION CAPACITY

in GW, baseload-equivalent*



* "Base load equivalent" power generation refers to the average base case power required to sustain a particular level of total electricity generation, for both intermittent and non-intermittent sources.

First, our existing energy system is simply not able to compete. American power generation growth has lagged far behind China's over the last 25 years.

To reverse this trend, policymakers must first address the burdens imposed by regulations. More than 70 percent of energy projects in the queue to connect to the grid are withdrawn due to long wait times, which have doubled since 2005. In 2013, around 4,000 new miles of transmission lines were built in America. Today, this figure is close to 500 miles, and it takes 10 years on average to build a new line.

A number of more technology-specific issues also plague any large-scale US energy buildout:

- Existing capacity is not enough. 74 US coal plants totaling 35 GW of generation capacity are due to be retired by the end of 2029. As has already started to happen, these plants could be kept online to power AI data centers, but they are a highly polluting source of energy, and will not be sufficient to power the entirety of the AI data center buildout.
- Thanks to issues with licensing, permitting, and supply chains, building new large-scale clean firm capacity using proven technologies takes a long time: the last US nuclear plant to come online was 7 years late and $17 billion over budget. Hydropower is in a similarly dire state—it takes an average of 7 years to obtain a license for a new project, and a further 5 to 10 years for construction.
- Large-scale generation projects require equipment such as electrical transformers, which are often custom-built for projects. However, transformers have a lead time of one to two years, which has increased by two to four times over the last five years.
- While natural gas plants can be built relatively quickly, supply chains have little capacity. GE Vernova, the world's largest manufacturer of gas turbines, is reportedly sold out beyond 2030. New gas plants also face uncertain long-term economics due to rapidly improving alternatives, regulatory risk, and corporate decarbonization commitments.
- Next-generation technologies like advanced geothermal and small modular reactors show immense promise, but face financing challenges due to cost and timeline uncertainty during the early stages of development.

To hit aggressive timelines, policymakers must help reduce the burdens on industry imposed by regulation and help developers take on the financial and technical risks involved in scaling quickly.

COMPARISON OF PROMISING POWER GENERATION TECHNOLOGIES FOR AI DATA CENTERS

A comparison of key characteristics for non-intermittent power generation technologies that can be deployed behind-the-meter.

Source	Min. construction time (years)*	nth-of-a-kind cost per MWh (LCOE)**	first-of-a-kind cost per MWh (LCOE)	Emissions (gCO_2 per kWh)***
Natural gas with carbon capture and storage	3	$63	$99	49
Next-generation geothermal	4	$45	$146	7
SMRs (light-water)	6	$66	$109	5

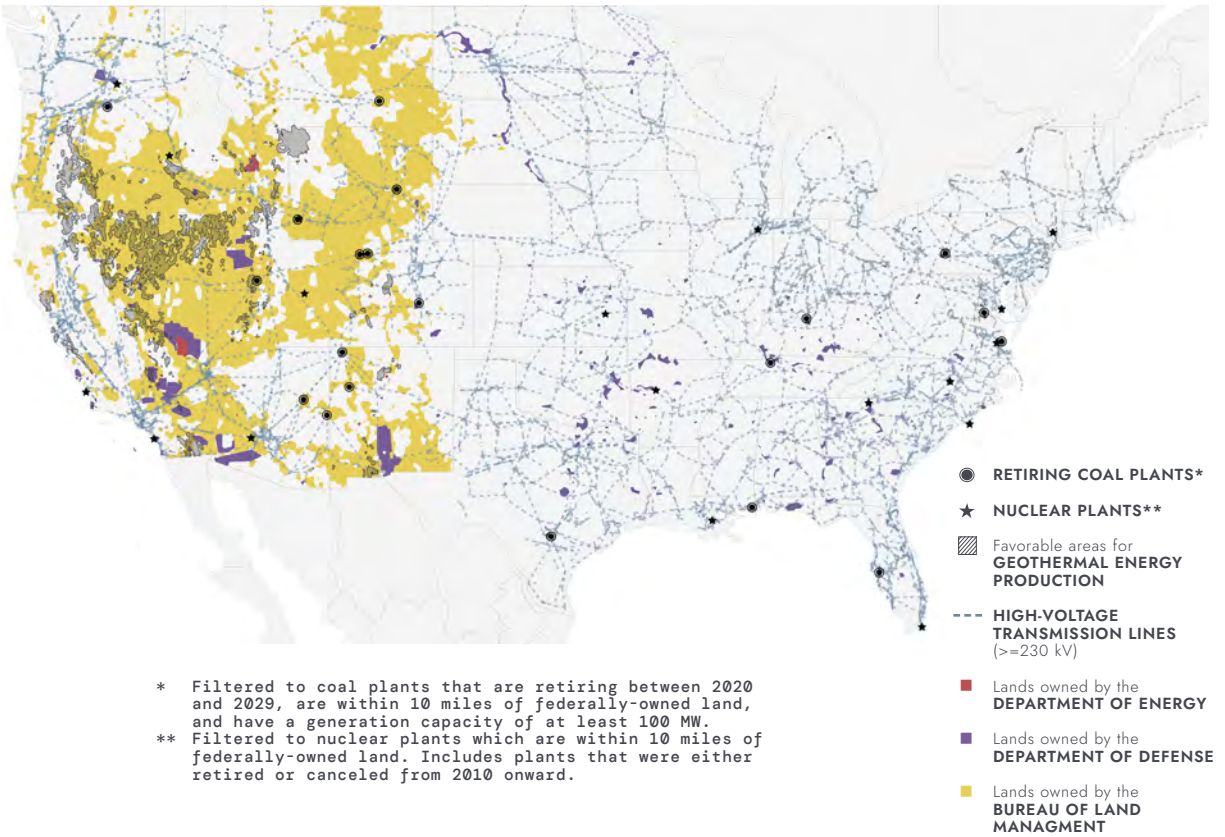
The second major obstacle: the benefits of a massive AI data center buildout will count for little if our ability to secure breakthrough AI systems lags behind our adversaries' ability to sabotage, steal, and use them against us. At present, the AI and computing industry is underinvesting in the level of security required to adequately secure their technologies against nation-state-level actors. This represents a clear market failure: we are looking at a future where American science and industry will depend on powerful AI models. It is in the American public's interest to ensure that powerful models are not sabotaged or used against us by our adversaries. Still, American AI developers and computing firms are locked in a race with each other to build ever more powerful models. If they invest in sufficient security to protect their systems from top Chinese state-backed hacking groups, they risk falling behind.

SOLUTION

We propose an ambitious federal program to accelerate the AI data center buildout within particular geographic regions of the United States–"Special Compute Zones." Focusing attention on specific areas reduces the number of stakeholders who need to coordinate to build quickly, and allows for targeted public and private investments

MAPPING SPECIAL COMPUTE ZONES

A map of energy resources and federal lands relevant for building large-scale AI data center infrastructure in America



* Filtered to coal plants that are retiring between 2020 and 2029, are within 10 miles of federally-owned land, and have a generation capacity of at least 100 MW.
** Filtered to nuclear plants which are within 10 miles of federally-owned land. Includes plants that were either retired or canceled from 2010 onward.

in shared electricity infrastructure costs. Because AI training clusters can be flexibly located based on power availability, Special Compute Zones can be planned around areas where it is possible to build quickly: including federal lands where local control is limited, areas with existing nuclear capacity or soon-to-be-retired coal sites (where large-scale energy support infrastructure already exists), areas with substantial and consistent sunlight for solar energy production, and areas with high potential for next-generation geothermal production.

The program should include the following measures:

Establish strong and effective leadership

The President should appoint an AI infrastructure czar to coordinate the establishment of Special Compute Zones, with executive branch experience, a deep understanding of energy infrastructure, and the ability to work closely with industry on ambitious security initiatives.

Identify and prioritize Special Compute Zones

The czar should lead a comprehensive interagency review to identify the most promising Special Compute Zones, focused on:

- Compiling an inventory of federal lands suitable for AI infrastructure development.
- Identifying existing energy assets (such as retired coal sites) that could be upgraded or repurposed under the Department of Energy's Loan Programs Authority—Section 1706 of Title XVII of the Energy Policy Act of 2005. Many of these sites reside on or near federal land, with existing infrastructure that can meet the scale for AI training clusters while tapping into existing rights-of-way, reducing permitting hurdles and project timelines.
- Identifying "previously disturbed lands" that qualify for categorical exclusion from environmental review to help lower regulatory uncertainty.
- Identify land available for acquisition under Section 161g of the Atomic Energy Act, and utilize that authority to support nuclear energy infrastructure for AI data centers.

Use federal authorities to accelerate construction

Once Special Compute Zones are identified, the czar should work with the interagency to streamline permitting and unlock financing for AI infrastructure within the zones, including:

- Using DPA Title I authorities to prioritize orders for critical equipment essential for AI infrastructure to the top of suppliers' order books, including gas turbines, high-voltage transformers, and switchgear. Title I can also be used to prioritize not just end products, but also component parts and materials, including silicon steel for transformer cores and specialized cooling systems.

- Using DPA Title III authorities to provide loans for next-generation energy infrastructure, alongside requirements for firms to invest in security measures that protect the AI technologies they are developing from sophisticated attackers and coordinate with the US government on their implementation, following the precedents set by the 2009 Smart Grid Investment Grants program and the CHIPS and Science Act.
- Using DPA authorities to streamline permitting and environmental review, including using NEPA's emergency circumstances provision (40 C.F.R. § 1506.11) to avoid following the conventional, time-intensive process, using legal protections under NEPA for classified and sensitive information to shield projects from legal challenges (40 C.F.R. § 1506.11), invoking Section 7(j) of the Endangered Species Act to obtain national security exemptions, and using the DPA Title III "without regard" clause to waive NEPA requirements for high-priority facilities.
- Establishing new categorical exclusions to NEPA for activities that don't have material impacts, such as design, site characterization, and materials acquisition. This would allow the disbursement of federal loans to accelerate non-disruptive activities, whose expense would normally have to be fronted by developers. Following the 2023 Fiscal Responsibility Act, agencies can adopt categorical exclusions issued by other agencies.

Tie federal assistance to security requirements adequate to protect American AI technology against our adversaries.

The czar should launch new initiatives to radically improve the security of American AI infrastructure, enlisting DOD, DOE, NIST, NSA, CIA, FBI, CISA, and USCYBERCOM. This should include:

- Rapid development of improved security specifications to defend against sophisticated attacks on supply chains, hardware, and networks.
- Creating points of contact in the intelligence community to advise the builders and operators of AI data centers on vulnerabilities to exfiltration, sabotage, and denial operations
- Assisting with the design of secure data centers and inter-data center network infrastructure.
- Establishing a red team to conduct penetration testing of AI infrastructure, and establishing a fast and effective background screening process for roles that involve access to sensitive hardware or data at advanced AI data centers.
- Providing tracking and physical security for shipments to AI data centers, and assistance with screening devices entering data centers to detect and prevent supply chain attacks.
- Launching new research programs to radically advance the state-of-the-art in security for AI hardware devices, including cluster-scale confidential computing and protection from invasive and non-invasive physical attacks.

Parts of this agenda have already begun through the Biden administration's AI Infrastructure Executive Order. However, the executive order has three important gaps:

1. While it makes federal lands available for AI data centers, it doesn't contain a comprehensive plan to speed up the permitting issues this creates.[2] Nor does it provide tools to resolve the looming supply chain shortages, particularly in gas turbines, that energy infrastructure for AI data centers will experience. Both these problems can be addressed through the use of the Defense Production Act.
2. It requires that AI data centers be powered exclusively with clean energy. This neglects the reality that while next-generation clean energy technologies such as enhanced geothermal and small modular reactors offer a longer-term energy solution, natural gas turbines must form a large part of the near-term solution.
3. While it introduces an initial set of security requirements for AI and computing firms, these requirements are not sufficient to adequately protect strategically critical American AI technologies from being stolen by our adversaries.

The Trump administration should issue a new Executive Order to fix these issues, ensuring that increasingly powerful AI systems are both built in America and good for America. ■

FURTHER RESOURCES

- Tim Fist, Arnab Datta, and Brian Potter, "Compute in America," Institute for Progress, 2024
- Thomas Hochman, "Federal, State, and Local Regulatory Barriers to Data Center Energy Infrastructure," Foundation for American Innovation, 2024
- Konstantin F. Pilz, Yusuf Mahmood, and Lennart Heim, "AI's Power Requirements Under Exponential Growth," RAND, 2025

Tim Fist is the Director of Emerging Technology at IFP. He is also an Adjunct Senior Fellow at the Center for a New American Security.

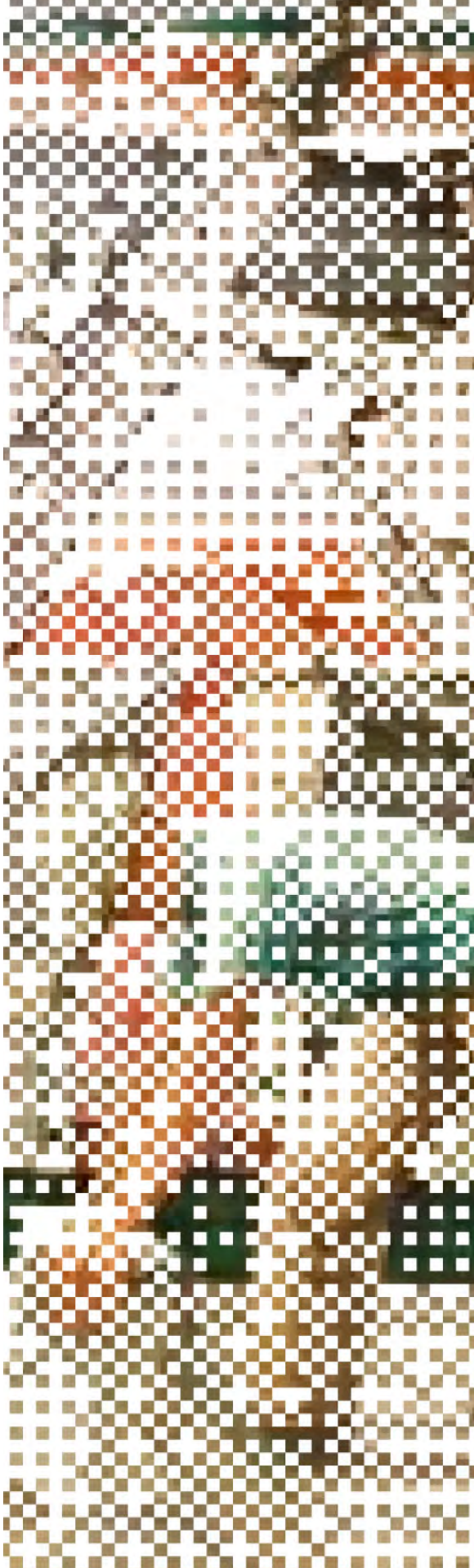
2 NEPA Automatically Applies

APPENDIX

MEASURE	BIDEN EO	OUR PROPOSAL	WHY IS IT IMPORTANT?
Earmarks federal land for AI data center and energy project development ("Special Compute Zones")	✓	✓	Many federal lands have promising energy assets and can have development fast-tracked by the federal government.
Conducts a comprehensive interagency review to identify high-priority Special Compute Zones and relevant supply chain issues	✓	✓	Not all federal lands will be equally easy to build on. We need to prioritize regions for development based on available energy assets, agency authorities, and potential supply chain issues.
Modest AI security requirements (sufficient to protect top AI models against well-organized criminal hackers)	✓	✓	There is a market failure in AI security. Linking energy/permitting assistance to initial security requirements will make security investments a sensible commercial decision, rather than putting a firm at a disadvantage relative to its competitors.
Appropriate AI security requirements (sufficient to protect top AI models against routine operations by top state-backed hacking groups)	X	✓	Within a few years, AI systems developed by American firms could have capabilities that will reshape the economic and military balance of national power. Greatly improved AI security will be required to adequately defend American AI technology against our adversaries.
Enables an "all of the above" energy strategy	X	✓	Deploying gigawatts of new, non-intermittent power generation within 2 years will initially require the use of natural gas turbines.
Appoints an AI data center czar	X	✓	Meeting ambitious timelines will require a leader who is empowered to coordinate and oversee industry, federal agencies, and individual projects and quickly resolve issues.
Uses DPA authorities to solve AI data center supply chain issues	X	✓	Order books for critical components such as electrical transformers and gas turbines are mostly booked out for years. DPA authorities can be used to move orders for AI infrastructure to the top of the queue.
Uses DPA authorities to provide lending and permitting assistance for AI data centers	X	✓	Building on federal lands automatically triggers NEPA review, which can dramatically slow down projects. DPA can be used to fast-track or exempt projects.
Establishes categorical exclusions to NEPA that accelerate federal financing	X	✓	Federal loan assistance for new energy projects is normally only available once NEPA review is complete. Disbursing funds earlier to assist with pre-build activities will accelerate project timelines.

Reforming the National Semiconductor Technology Center

Brady Helwig and
Arrian Ebrahimi



SUMMARY

The semiconductor industry faces mounting challenges as traditional chip fabrication processes approach their physical limits. Novel materials, devices, and computing paradigms could drive future progress, but gaps in the US semiconductor innovation ecosystem—namely, access to prototyping lines, expensive equipment and tooling, and scarce capital—make commercialization challenging. The CHIPS and Science Act established the National Semiconductor Technology Center (NSTC) as a public-private partnership to address these gaps. To date, however, the NSTC has adopted a cautious, consensus-driven approach.

To realize the NSTC's potential, three reforms are needed:

- The administration and Congress must commit to ensuring that the NSTC succeeds beyond the organization's initial five-year appropriation. Cutting semiconductor R&D programs now would jeopardize US competitiveness in next-generation chip technologies and future AI systems.

- The NSTC must prioritize disruptive innovation by maintaining an independent, moonshot-focused research agenda and positioning the NSTC investment fund as an anchor investor, augmented by a fund-of-funds to stretch capital further.
- Prevent industry capture by tweaking the NSTC's financial and intellectual property (IP) structure, incentivizing greater participation by startups and academic researchers.

PROBLEM STATEMENT

In 1965, Intel co-founder Gordon Moore famously predicted that cramming more transistors onto flat silicon wafers would result in regular doublings of computing power. This remarkable prediction, which later became known as Moore's Law, sparked the personal computing revolution and gave rise to the digital world. Today, however, traditional chip fabrication is reaching its atomic limits, resulting in ballooning technical complexity, rising costs to design and fabricate chips, and increasing industry concentration. What Moore termed the "day of reckoning" has arrived.

The core technical problem facing the semiconductor industry today is heat dissipation. When chips perform computations, they release excess energy as heat. For decades, the power consumption of a chip scaled down alongside Moore's Law, allowing for remarkably energy-efficient computing. But this linkage broke in the mid-2000s. The result has been a massive spike in energy consumption, made much worse by the recent explosion in compute demand for large-scale AI systems. Novel materials, devices, and compute paradigms exist which could improve AI energy efficiency by several orders of magnitude; picture the creation of energy-efficient supercomputers that could fit in a closet, not a warehouse. This novel hardware could power future large-scale AI systems and offer outsized geopolitical leverage to the first nation to develop them.

The CHIPS and Science Act established the NSTC as a forward-looking innovation hub that would drive true breakthroughs. Former Commerce Secretary Gina Raimondo explained that the NSTC would "ensure the US leads the way in the next generation of semiconductor technologies—everything from quantum computing, materials science, and AI to the future applications we haven't even thought of yet." But in the two and half years since the passage of the CHIPS Act, the NSTC has moved too slowly, opting for an industry-led, consensus-driven approach. The organization must move faster, and it must prioritize disruptive innovation.

SOLUTION

To ensure that the NSTC reaches its full potential, policymakers should reach for a scalpel, not a sledgehammer. Starting over would waste valuable time. Several promising initiatives are already underway—especially expanded access to prototyping, packaging, and tooling—which will lower barriers to entry for startups. However, additional resources and targeted reforms will be needed across three areas.

First, sustained congressional funding will be necessary to keep the NSTC financially viable. Past successful research consortia discussed below received steady gov-

ernment funding for their first decade of work, and Congress should ensure that its existing investment in the NSTC does not go to waste by issuing a second five-year appropriation. The corollary to sustained government investment is fiscal discipline; the NSTC must limit the number of technology verticals it attempts to pursue and regularly trim research programs that do not yield results.

Second, Natcast—the nonprofit consortium running the NSTC—is in the process of standing up an investment fund, as authorized by Congress. Yet key decisions about how the fund operates have yet to be made. For example, in the semiconductor industry, investment arms of large chip companies typically lead funding rounds for startups they believe will complement their existing research agenda. But the NSTC fund could play a key role by leading its own funding rounds, serving as an anchor investor and crowding in capital for projects that do not necessarily benefit one existing firm. In addition, the investment fund should compensate for its relatively modest size of $500 million by distributing a portion of its capital as a fund of funds.

Third, the NSTC's internal R&D agenda should prioritize disruptive innovation by commercializing breakthroughs rather than subsidizing industry-led research. Natcast should model its research program off the Defense Advanced Research Projects Agency (DARPA)'s approach, hiring program managers from industry and academia on a revolving basis to execute an internal research agenda free from industry bias.

Congressional

- Congress should fund the NSTC for an additional five years after the initial appropriation expires in 2027. Successful semiconductor-focused public-private partnerships have relied heavily on public funding for the first decade of their lives, which prevented industry capture, as explained below.
- The House Committee on Energy and Commerce and Senate Committee on Commerce, Science, and Transportation should require mission agencies to issue annual reports on public funding for microelectronics-related research. Policy makers need updated estimates of current spending on strategic technologies to make funding decisions, but properly cataloguing relevant R&D programs has proved difficult. Policymakers could model this initiative on successful efforts to estimate federal AI R&D, which aligned with national-level strategic planning.

Executive

The White House should issue an executive order on the CHIPS R&D program to do the following:

- Protect programs and staff related to microelectronics R&D and immediately rehire key CHIPS R&D Office staff. NIST recently dismissed two-thirds of the staff responsible for overseeing CHIPS R&D programs. Small savings through staff reductions could jeopardize the efficient allocation of $11 billion in R&D funding.

- Accelerate provision of tooling, facility access, and prototyping to Natcast member companies. Delays in standing up the NSTC have cost valuable time, but ensuring access to existing infrastructure and tooling could compensate while new R&D facilities are built, and fast-tracking permitting and construction of R&D facilities could make up for lost time.
- Institute a regular review period for NSTC research programs. Literature on public-private partnerships suggests that successful efforts ruthlessly prune projects, without penalizing program managers for risk-taking.
- Direct the NSTC investment fund to lead funding rounds and solicit fund-of-funds proposals from qualified venture investors. These actions would allow the fund to crowd in additional private capital while drawing on the expertise of existing deep-tech investors, increasing the odds of success.

JUSTIFICATION

Federal research funding has historically moved the needle at critical points in the semiconductor industry's development, offering outsized benefits to the US economy. Since 1978, every dollar invested by the federal government into semiconductor research has increased US GDP by approximately $16.50. These returns are the result of a series of breakthroughs in the chip industry which were catalyzed by federal R&D spending. For example, DARPA's Very Large-Scale Integrated Circuits (VLSI) program was pivotal to overcoming the Moore's Law scaling challenges of the 1970s and 1980s. Other examples of breakthroughs that received federal support include Extreme Ultraviolet Lithography (EUV) tools and FinFET, the chip industry's first 3D transistor.

Balancing the goals of government with the interests of industry has been key to the success of R&D programs, both in the US and abroad. As a research consortium funded with both government and industry contributions, the NSTC has been established as a public-private partnership, but the success of these programs hinge on designing the right funding models and IP-sharing structures. The Interuniversity Microelectronics Center (Imec) in Belgium provides the closest example for the structure the NSTC needs. Imec is best known for its role in developing EUV tools; today, the center offers researchers access to facilities for developing new, full-stack, complementary metal-oxide-semiconductor (CMOS) paradigms. Imec's facilities also offer pilot wafer runs for startups in sensors and telecommunications.

Imec's early budget independence was key to its success. For the first decade of its existence, Imec received over half of its funding from the Flemish government. Even as it transitioned away from subsidies, Imec refused to become an outsourced research service for industry. Avoiding reliance on a membership-based funding structure proved crucial: Imec's Industrial Affiliation Program established IP as participants' "currency" for contribution and reward, offering open IP sharing for early-stage R&D while tightening sharing for mature research. This arrangement incentivizes established firms to contribute to Imec long-term while allowing startups and researchers to reap early-stage benefits.

Pursuing a membership fee funding structure would likely relegate NSTC to being an outsourced research service for industry. Instead, NSTC must pursue ambitious projects whose IP results will incentivize established firms (and Congress) to sustain its funding. Constructing unique prototyping facilities which industry or academia alone cannot provide is an example of such ambitious projects. ■

FURTHER RESOURCES

- Arrian Ebrahimi and Jordan Schneider, "How to Make the NSTC a Moonshot Success," Institute for Progress, 2024
- Brady Helwig and PJ Maykish, "National Action Plan for U.S. Leadership in Compute & Microelectronics," Special Competitive Studies Project, 2023
- John Shalf, "The Future of Computing Beyond Moore's Law," Philosophical Transactions of the Royal Society, 2020
- Hassan Khan, "Scaling Moore's Wall: Existing Institutes and the End of a Technology Paradigm," Carnegie Mellon University, 2017

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Arrian Ebrahimi is a JD candidate at Georgetown Law and the author of the Chip Capitols *newsletter. He previously worked at the Semiconductor Industry Association and TSMC.*

■ Frontier Science & Technology

Experimenting with NIH Funding

Stuart Buck

SUMMARY

At the National Institutes of Health (NIH), reform is coming, but many questions remain about what a more effective NIH should look like. A Center for NIH Innovation should routinely roll out new ideas for how to structure science funding, how to do peer review, and how to find the best "high-risk" research, and it should then run experiments on those ideas.

PROBLEM

It is time for serious NIH reform. All of the relevant congressional committees issued major white papers in 2024 detailing ideas for NIH reform, and incoming NIH director Jay Bhattacharya has indicated strong interest in reform. Even establishment figures have written that NIH's "research enterprise has become sclerotic, cautious, focused on doing what it has always done and withdrawing from clinical research," and that NIH "needs to shake off its doldrums and embrace the very traits that are essential in generating outstanding science—creativity, persistence, and courage."

But we know surprisingly little about the best science funding approaches. Open questions include:

- Is it better to give more funding to the person, not the project?
- Are 10-year grants more effective than 3- or 4-year grants?
- Is peer review the best system for grant allocation?
- Should we "red-team" scientific fields in which funded grants all seem to follow one particular theory?
- Should NIH program officers have more discretion to overrule or even bypass peer review?
- What's the optimal method of scientific training and education? Top athletes, musicians, and CEOs almost always have personal coaches; is there a way that we could provide "personal trainers" to top scientists so as to broaden their impact?
- What would happen if we demanded that all scientific grants publicly report at least one "failure?" Would we encourage more risk-taking and/or truth-telling?
- What's the best way of funding "high-risk, high-reward" research?
- What's the best way of recruiting top talent to biomedicine, given the long and uncertain pathway to an NIH-funded career?

Although many reform ideas have been proposed, there is little rigorous evidence as to what works and when. For example, the Canadian government recently commissioned an international expert panel on scientific funding, led by former Princeton President Shirley Tilghman. The panel found that across the world: "Many funding practices seem promising but are not substantiated by rigorous evaluations." As another major report pointed out, "research funders . . . rarely systematically experiment with different ways to design and run their funding programmes. As a result, research funders are missing out on opportunities to achieve their goals in a cost-effective way, and to further accelerate the progress of science."

In short, we don't know very much. That's why we need to "turn the scientific method on ourselves." We hand out billions of dollars every year to scientists who are expected to follow rigorous principles of observation and experimentation, but we do not use those same principles to study how we hand out the money in the first place.

The most important priority for NIH should therefore be to start a more deliberate process of internal experimentation and evaluation. That way, we will learn from many reform ideas (which ones to keep, which ones to discard, and which ones to modify), thus leading to improved scientific innovation over time.

Running randomized experiments within government, however, can be seen as high-risk. The last thing any NIH official wants is to be called in front of Congress to answer complaints from famous scientists upset about how funding was handed out. If we want NIH to experiment with new approaches to peer review, etc., policymakers should empower a specific team with the responsibility, mandate, and budget to do so.

SOLUTION

Executive

HHS should establish a Center for NIH Innovation (CNI), preferably by following the statutory process of invoking the Scientific Management Review Board (see 42 U.S.C.

§ 281) and producing a report with the appropriate notice to Congress. Alternatively, Congress could create CNI directly through authorizing legislation or through appropriations. The current statutory framework limits the number of Institutes and Centers to a total of 27: see 42 U.S.C. § 281(d). Congress would either have to raise this number to 28, or else HHS/Congress could agree on eliminating another Institute/Center (IC) (most people would suggest the National Center for Complementary and Integrative Health).

CNI's mission would be to develop pilot experiments as to how NIH hands out funds, evaluate the results, and promote more widespread adoption of successful programs. Several key features would ensure CNI's success:

- CNI should be funded directly by Congress as an independent Center or as a line item within the Director's Office, and should be guaranteed funding on at least a 3-5 year time scale so that it can take up longer-term experiments.
- CNI should be able to require the participation of other NIH ICs in ongoing experiments. For example, if CNI wants to imitate the National Science Foundation in performing an experiment with peer review, the Center for Scientific Review should be required to participate in that experiment in good faith.
- CNI should be empowered to waive statutory requirements that otherwise apply to NIH, such as the requirement that all grants be approved by a majority of peer reviewers (see 42 U.S.C. § 289a-1). Waiver authority is important to ensure that CNI doesn't constantly need to return to Congress to get special permission to engage in an innovative experiment, such as allowing program officers to use a "golden ticket" or a limited lottery.
- Finally, CNI should be empowered to take approaches that work, and scale them up into NIH-wide policies, so that the rest of NIH benefits from experimental learnings.

JUSTIFICATION

The idea of regular experimentation, evaluation, and feedback loops has become popular throughout government over the past decade or more. Several other federal agencies have been creating offices to engage in regular experimentation and testing, including the Center for Medicare and Medicaid Innovation, the Office of Investor Research at the SEC and its POSITIER initiative, the Office of Healthcare Innovation and Learning at Veterans Affairs, and the Office of Evaluation Sciences at the Government Services Administration (which grew out of the White House Social and Behavioral Sciences Team). Collectively, these offices and centers have launched well over 150 experiments within government, including everything from a cardiovascular disease risk reduction tool to improving a suicide prevention hotline to changing how we pay for end-stage kidney disease.

While experiments with science funding are rare to date, NIH did run an experiment several years ago on whether blinding peer reviewers to an applicant's identity would reduce racial disparities. More recently, the National Science Foundation (NSF) in partnership with the Institute for Progress has launched an experiment with the so-called "golden ticket" approach, in which a grant can get funded if one peer reviewer

loves it (and deploys a metaphorical "golden ticket") even if the other reviewers dislike it. The idea is that some truly breakthrough ideas go unappreciated at first, and we might find more such ideas if we looked for cases where one reviewer saw the potential. That said, NSF's pilot experiment is being conducted on a private basis, and the results may not be public. NIH should be required to make all results public, absent a very compelling reason (such as a serious risk of compromising patient privacy). But NSF's willingness to try different peer review approaches is hopefully the first of many experiments that will improve the effectiveness of science funding in spurring American innovation. ■

FURTHER RESOURCES

- Stuart Buck and Kushal T. Kadakia, "Investing in the Science of Science: What Medicare Can Teach the NIH About Experimentation," *Health Affairs*, 2022
- National Academies of Sciences, Engineering, and Medicine, "Experimental Approaches to Improving Research Funding Programs: Proceedings of a Workshop," 2024
- Research on Research Institute, *The Experimental Research Funder's Handbook* (2nd ed.), 2023

Stuart Buck is the Executive Director of the Good Science Project. As Vice President at Arnold Ventures, he helped launch the Center for Open Science, Vivli, the Meta-Research Innovation Center at Stanford, the Stanford Center for Reproducible Neuroscience, the Yale Collaboration on Research Integrity and Transparency, and the Evidence-Based Medicine DataLab at Oxford.

APPENDIX

Sample Legislative Text:

Section 401 of the Public Health Service Act (42 U.S.C. § 281) is amended by inserting the following new subsection (g) after subsection (f) (with the current subsections (g) and (h) being renamed (h) and (i) respectively):

"(g) CENTER FOR NIH INNOVATION.

(1) IN GENERAL—There is hereby created a Center for NIH Innovation ("CNI") at the National Institutes of Health to carry out the duties described in this section, with the overall goal of accelerating the pace of biomedical advancement. The purpose of CNI is to work with other NIH Institutes and Centers to test new ways of sourcing, reviewing, and funding grants and contracts; measure the impact of pilot projects and experiments; and scale up innovations that are successful.

(2) DEADLINE—The Secretary of HHS shall ensure that CNI launches and is able to carry out its statutory mission by [date].

(3) Organization—The CNI Director shall be appointed for up to two 5-year terms by the NIH Director. The Office of Evaluation, Performance and Reporting and the Office of Portfolio Analysis are hereby consolidated with CNI and shall report to the CNI Director.

(4) Consultation with Advisory Council—CNI shall create an Advisory Council with 5 or more representatives from other NIH Institutes/Centers, 5 or more representatives from universities, and 3 or more researchers with expertise in meta-science. This advisory council shall meet at least twice each calendar year, and shall provide CNI with expert advice on ideas for experimentation and evaluation of NIH's processes. CNI shall also make an email address available to the public for suggesting other ideas and relevant submissions shall be considered by CNI and its Advisory Council at the biannual meetings.

(5) Selection of Ideas to Be Tested—CNI shall select ideas to test by gathering evidence as to promising methods for improving science funding from other national science funders, the advisory council, the academic literature, or other submissions of ideas.

(6) Evaluation—

(A) Where possible, CNI shall attempt to use randomization or cutoff-based methods to pilot new science funding models and to determine their effects.

(B) CNI shall evaluate the success of alternative scientific funding models by a diversity of outcomes, including qualitative evidence, citations, patents, prominence of new discoveries, and other signals of scientific achievement. CNI shall additionally explore funding external meta-scientific work to determine how best to measure the outcomes of scientific funding, and whether various short-term outcomes are indicative of longer-term outcomes.

(C) The results of any pilot, experiment, or other evaluation shall be made fully public and transparent (absent good cause, such as patient privacy).

(7) Waiver Authority-CNI may waive the requirements of the Public Health Service Act as regards peer review or any other issue as may be necessary for purposes of carrying out its mission with respect to testing new models of NIH funding;

(8) Limitations on Review—There shall be no administrative or judicial review of -

(a) The selection of NIH funding models for testing or expansion under this section;

(b) The selection of organizations, sites, or participants to test those models; or,

(c) The elements, parameters, scope, and duration of such funding models.

(9) PARTNERSHIP WITH OTHER NIH INSTITUTES AND CENTERS—Other NIH Institutes and Centers shall work under CNI's leadership to test new ideas for performing peer review, sourcing scientific ideas, funding innovative research, and the like. If an Institute or Center does not wish to participate in a CNI-led study or evaluation, its objection may be overruled by a majority vote of the Advisory Council described in subsection (4).

(10) PARTNERSHIP WITH OUTSIDE EXPERTISE-CNI should regularly work with outside scholars to share NIH's internal data on proposals and peer review scores, and to partner with them on pilots and experiments. CNI should also investigate a partnership with the Office of Evaluation Sciences (OES) at the Government Services Administration, and should report back to Congress within one year of enactment on a possible partnership with OES.

■ Frontier Science & Technology

Modernizing Civilian Defenses Against Biological Threats

Jacob Swett and
Aman Patel

SUMMARY

America faces a growing risk of biological threats. The confluence of emerging biotechnology and unstable geopolitics means that there may soon be more adversaries with the capability and intent to use biology to attack the US.

To protect our population, we need a potent civilian biodefense enterprise that can rapidly develop and deploy countermeasures against changing future threats. America's current version of this enterprise, the Public Health Emergency Medical Countermeasure Enterprise (PHEMCE), is burdened with artificial constraints on some of its resources that tie them to (primarily pharmaceutical) countermeasures against an outdated list of threats.

First, PHEMCE leadership should regularly identify technology areas beyond pharmaceuticals where additional innovation would help the US maintain protection dominance, and second, Congress should remove the requirement that ties Project BioShield funding to a specific list of "material threats." If implemented, these two changes will ensure that the PHEMCE will have the dexterity it needs to address future biological threats.

PROBLEM

Progress in synthetic biology and artificial intelligence has opened a vast new territory of innovations that could transform American health—but it may also provide bad actors with new capabilities to launch biological attacks against the people of the United States. In the current moment of global turbulence, it is more important than ever that we establish and retain security against both state and non-state adversaries.

If they materialize, the biological threats of the next 20 years and beyond could be potent and spread rapidly. To defend against these threats, America will need scientific prowess to engineer detection mechanisms and countermeasures. We will need manufacturing and logistical muscle to produce and deploy these defenses. And we will need a lean, efficient, and speedy government to coordinate this response.

Our current civilian biodefense apparatus, led by an interagency coordinating body called the Public Health Emergency Medical Countermeasure Enterprise (PHEMCE), did its job well for the known threat agents of the 2000s and 2010s. To ensure that it continues to achieve its mission of "enhancing the nation's capabilities to prepare for and respond to national health security threats," the PHEMCE and its components must be unburdened and re-equipped with a modernized arsenal of abilities and tools.

FIRST, THE PHEMCE MUST BE ABLE TO ADAPT ITS RESOURCE TARGETING TO A RAPIDLY-MOVING THREAT LANDSCAPE. As it stands, there are hundreds of millions of dollars spent every year under PHEMCE's direction—Project BioShield —that are statutorily limited to address a narrow, outdated list of threats that the Department of Homeland Security has issued "material threat determinations" for. This bureaucratic process has historically been sluggish at issuing new threat determinations, so a large chunk of the nation's biodefense funding has been locked up on programs that may not address the threats of the future. We need to clear this unwieldy procedure and enable the PHEMCE to target taxpayer dollars more efficiently.

AND SECOND, THE PHEMCE MUST BE ABLE TO PURSUE INVESTMENTS IN WHATEVER TECHNOLOGICAL COUNTERMEASURES ARE NEEDED TO DEFEND AGAINST FUTURE THREATS, WHETHER PHARMACEUTICAL IN NATURE OR NOT. In the past, the PHEMCE has focused most of its budget on pharmaceutical countermeasures under the "one bug, one drug" paradigm, requiring an entirely new product development cycle for each countermeasure. These product development cycles often take years and cost billions of dollars over their lifetime.

One example of a class of innovations that the current PHEMCE process is largely unequipped to capitalize on: physical transmission-suppression interventions, like air filtration, far-UVC, glycol vapors, and next-generation respirators. These interventions could be much more cost-effective to deploy than pharmaceuticals and prevent pathogen exposure in the first place, obviating the need for treatment. However, they don't currently have a home in the federal advanced research and development (R&D) portfolio. If we let these potential innovations flounder in the Valley of Death, our adversaries may capitalize on them before we do —which would make us differentially more vulnerable to a biological attack. To avoid this outcome, we should remove

burdensome and unnecessary limitations on the solution space that PHEMCE's R&D components are allowed to deploy their resources to tackle.

SOLUTION

Executive

- The Administration for Strategic Preparedness and Response (ASPR), acting as the chair of the PHEMCE, should regularly survey innovative non-pharmaceutical, pathogen-agnostic technologies that could enhance US biological threat preparedness and identify R&D, procurement, advanced manufacturing, or industrial warm-basing investments that PHEMCE components could make to accelerate their readiness for civilian biodefense.

Congressional

- The Senate Health, Education, Labor, and Pensions (HELP) Committee and House Energy and Commerce (E&C) Committee should remove the limitation that Project BioShield Special Reserve Fund appropriations are to be used only for countermeasures against agents that have received material threat determinations. A reauthorization of the Pandemic and All-Hazards Preparedness Act (PAHPA) would be an appropriate vehicle to make these changes, but given the increasing importance and necessity of biological defense, these changes may warrant their own legislative vehicle.

JUSTIFICATION

The Defense Advanced Research Projects Agency's (DARPA) evolution is a case study of the benefits of removing straightjackets on an R&D agency's programs. In the early days of ARPA, after its establishment in response to Sputnik, it focused nearly exclusively on space technologies. Over time, as strategic competition moved beyond the domain of space, DARPA's core mission of "preventing technological surprise" required it to undertake projects in a wider range of fields, from computing to biology. Had DARPA been statutorily limited to space-based threats, the US may not have been the first to invent and deploy stealth aircraft, mRNA technology, or many other innovations that proved critical to our national security and strategic dominance.

DARPA's history also shows the potential downsides of a stiflingly narrow institutional focus. The Mansfield Amendment of 1973 strictly constrained ARPA's focus to defense-related research. This restriction generated additional paperwork for the agency and hindered its ability to invest in basic R&D with long-term payoffs—including computing projects like ARPANET. Had the 1973 Mansfield Amendment been in place just a few years earlier, the development of the internet would likely have been slowed or crippled entirely.

Like DARPA's liberation beyond a single technology domain—and unlike the Mansfield Amendment's limiting effect on ARPA—we should aim to remove the constraints that impede the PHEMCE as it strives to achieve its mission. ■

FURTHER RESOURCES

- "Public Health Emergency Medical Countermeasures Enterprise (Multiyear Budget: Fiscal Years 2023-2027)," Office of the Assistant Secretary for Preparedness & Response, US Department of Health & Human Services, 2024
- BARDA Broad Agency Announcement Active Areas of Interest
- Willy Chertman, "Creating Advanced Market Commitments and Prizes for Pandemic Preparedness," Institute for Progress, 2022

Jacob Swett, PhD is the Executive Director and founder of Blueprint Biosecurity, a US nonprofit organization focused on debottlenecking technologies that could defend against tomorrow's biological threats.

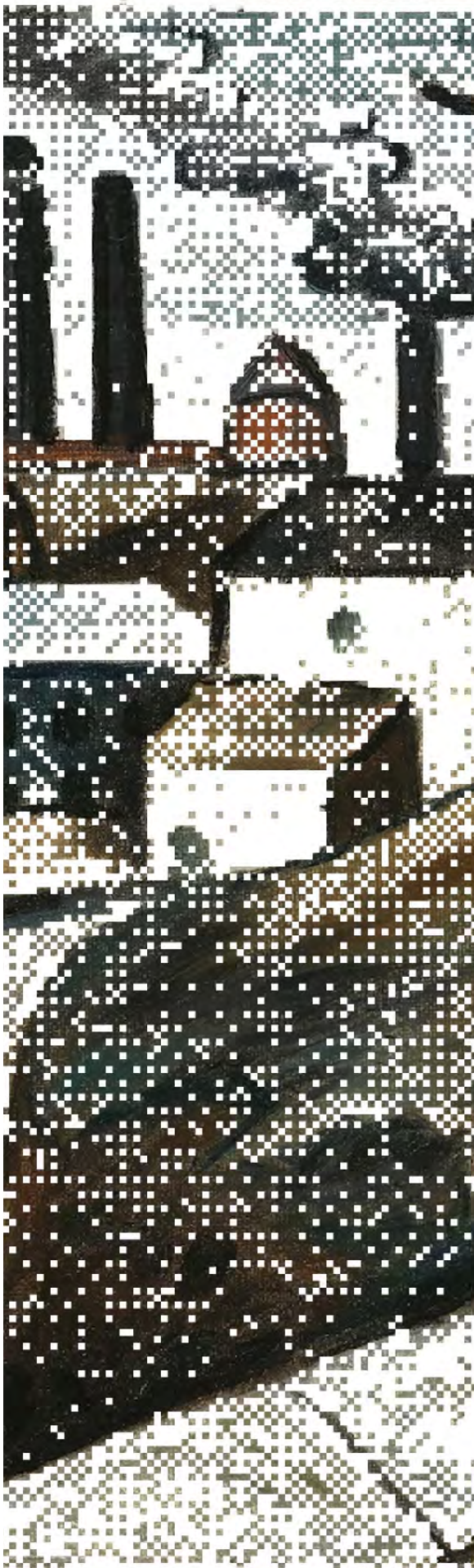
Aman Patel is the Deputy Director for PPE at Blueprint Biosecurity.

Industrial Power

■ Industrial Power

Reforming the Advanced Manufacturing Institutes

William B. Bonvillian, Michael Szczupak, and David Adler



SUMMARY

The 17 US Manufacturing Institutes are public-private partnerships that bring together key actors in industry, universities, and government to accelerate domestic advanced manufacturing innovation. The Institutes have had significant success, but the model needs enhancements to achieve its stated vision of promoting "US global leadership in advanced manufacturing through the development and transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities." This requires networking the Institutes for better technology integration and improved private-sector take up, better linking the Institutes to the Manufacturing Extension Partnership programs in each state, improving the workforce education offerings, and supporting stronger scale-up capabilities. This proposal will outline how.

PROBLEM

The US Lacks Manufacturing-Led Innovation

The manufacturing productivity rate in the US has been stagnant or declining for 15 years, a signal of our failure to innovate and compete in production. By the end of World War II, the US innovated mass production and was the clear global leader in manufacturing. But after the war, the US failed to prioritize manufacturing in its innovation system. American research and development (R&D) agencies such as the National Science Foundation (NSF), the Department of Energy's Office of Science, the National Institutes of Health (NIH), national labs, and military research centers have made important discoveries and innovated new technologies, but with few exceptions (such as DARPA's support of Sematech) these agencies have not developed R&D portfolios around manufacturing technologies and processes. The assumption was that basic R&D would lead to new critical general purpose technologies, and that those might evolve into manufacturing improvements, but there was no organized effort to undertake this translation.

Industry did not fill the gap, focusing on development rather than longer-term research where the risks are too long-term and advances difficult for the originating firm to appropriate. The financial sector, demanding quarterly returns, pushed firms into a "core competency" model, requiring them to go "asset light," divesting, outsourcing, and offshoring manufacturing. These have been major disincentives for industry investment in manufacturing R&D.

By contrast, other countries such as Germany, Japan, Korea, and now China have developed "Manufacturing-Led" innovation strategies focused on manufacturing technologies. Japan invented its quality production model in the 1970s and 1980s and the technologies and processes behind it; the US had to play catch up, losing leadership in auto and consumer electronics sectors as a result. China has developed a rapid production scale-up approach using connections across regional firms that has allowed it to develop dominance of production in numerous sectors; the US has not. The US is 7th in the world in adopting industrial robotics, far behind Germany, Korea, and China. Too often a technology invented in America is scaled in other countries more focused on production. Lithium ion batteries, drones and solar panels were invented in the US, but production is now dominated by China.

Apart from R&D and product development, the US also faces a problem with adoption of new production technologies. Small- and medium-sized manufacturers (SMMs) struggle to adopt new technologies and processes, owing to the high cost and risk of implementing new technologies, low R&D capability, lack of technology expertise, and lack of qualified workers, among other challenges. Foreign counterparts outpace them. There is a pyramid of manufacturing firms beneath critical technology firms: every high-end product produced in the US requires dozens (sometimes hundreds) of critical tier 2 and 3 components and products. Making sure those suppliers can compete is essential for critical technology leadership.

The Manufacturing Institutes

To help tackle this challenge, starting in 2012 the US formed 17 advanced manufacturing institutes (called "Manufacturing USA") funded initially at around $50 million each from the Commerce, Defense and Energy Departments for a term of five years. Each focuses on a particular technology, from 3D printing to digital production and robotics. These are industry-led, public-private partnerships for late-stage development of advanced manufacturing technologies. The Institutes were formed to help close the gap between R&D innovation and production innovation, and involve the critical actors required for developing advanced manufacturing technologies: industry, universities, community colleges, and federal, state, and local government. They match federal funding with industry and state and local government investments, in order to:

- Connect small and large firms in collaborative innovation to restore the thinned-out manufacturing ecosystem;
- Relink innovation and production through collaborations between firms and universities;
- Pursue advanced manufacturing technologies and processes that improve manufacturing efficiency and productivity;
- Provide shared facilities to support scale-up of promising technologies; and
- Train a skilled workforce to use advanced manufacturing technologies

In 2023, the 17 institutes had 2,500 reported members, including 1,177 small manufacturers; undertook over 400 applied R&D projects with 85 percent meeting key project goals; and enjoyed federal funding matched by industry and state funding at a ratio of 2.6 to 1. Nevertheless, US manufacturing has not been implementing advanced manufacturing at the scale required. China, for example, has a much larger network of over 40 comparable institutes and hubs, with much larger funding. This is a meaningful part of its rise from 5.7 percent of world manufacturing output in 2000 to 31 percent in 2024.

SOLUTION

The Manufacturing Institutes need to be enhanced to meet these long-term challenges. There are steps the administration can take.

The Departments of Commerce, Defense and Energy: Network the 17 Manufacturing USA Institutes

- The Manufacturing Institutes are organized around particular technologies, but manufacturers need integrated packages of fully coordinated new technologies to achieve maximum production efficiencies. New robots should be integrated with digital production technologies and 3D printing systems, for example. Integrating varied new technologies requires a mechanism to achieve it; there is no such mechanism now. The Manufacturing USA program describes itself as a

"network" but has never been funded to integrate across these technologies. They should be incentivized to pursue joint development among a group of institutes and provide packages of technologies that can be readily introduced by industry—particularly for small and mid-sized manufacturers that face the greatest productivity challenges. Groups of institutes should compete for a separate fund to undertake this networking and receive additional funding for packaging their various technologies together.

- Manufacturing Institute federal funding levels should be restored to at least the levels of their initial five-year terms to enable greater small firm participation and workforce education programs, and to support networking. Successful institutes meeting their technology adoption roadmaps should receive this additional funding. Manufacturing is a $2.3 trillion sector; to transform it requires additional investment. This will require smarter executive branch budgeting; if additional Congressional appropriations are required, agencies must take the lead in requesting these funds.

The Commerce Department: Tie the Manufacturing Extension Partnership (MEP) and the Manufacturing Institutes Together

- MEP has programs in every state, funded by the states with federal seed funding, to bring the best manufacturing processes to SMMs. Each MEP program has teams of engineers and experts with substantial manufacturing experience that work with SMMs to adopt new processes. The program's overall success has been validated in National Academies reports.
- MEP was created to help bring the quality manufacturing models developed in Japan to American firms (a process known as LEAN manufacturing in the US). But manufacturing technologies have evolved. The technologies resulting from the Institutes' work, as well as best practices in technology areas like robotics and digital production, need to get onto SMM factory floors.
- A much closer alliance with MEP is required. Institute funds (or alternatively National Institute of Standards and Technology funds) should back joint collaborations between MEPs and Institutes to help SMMs achieve a measurable increase in productivity and profitability by adopting Institute-supported technologies. (For more on how to improve the MEP, see "Upgrading the Manufacturing Extension Partnership to Be an Engine of Reindustrialization.")
- Part of this funding should be used for Institutes to enable SMM access to technology demonstration centers where they can test and learn new technologies with Institute help and expertise. Once new technologies are validated, MEP staff should be trained on them so they can help spread best technologies and practices to additional SMMs.
- MEPs also support workforce education programs for small manufacturers, which are most in need of them. Institute funds can support bringing advanced manufacturing skills from Institute programs to SMMs through MEPs, in addition to expanding the Institutes' own workforce efforts. (Both the Institutes

and SMMs generally will also benefit from broader workforce development improvements; see "Building a Techno-Industrial Workforce" for an example of such a proposal.)

The Departments of Defense, Commerce, and Energy: Support Scale Up of Technologies Emerging from the Manufacturing Institutes

- Manufacturing Institutes were designed to operate at Technology Readiness Levels 4–7, that is, from development through prototyping stages. However, moving the technologies they prototype into the follow-on stages of testing, demonstration, technology validation and initial production design (Technology Readiness Levels 8–9) remains a major challenge.
- Many companies, particularly SMMs, are not equipped to take prototypes and move them through these next stages themselves. While a number of Institutes have basic demonstration facilities, building these out so that the Institutes can carry out full demonstrations and technology validations is becoming increasingly important to achieve their mission. Lacking that, new technologies will too often not be adopted, particularly by smaller firms. The three agencies supporting the Institutes should direct that part of the Institutes' federal funding be directed to these later stages of technology readiness. Institutes could compete for this funding, with awards going to the best Institute proposals for scale up facilities. The Institutes could also collaborate with national labs so that their facilities could assist in the technology validation process.

JUSTIFICATION

The great majority of US manufacturing sector firms are small and mid-sized that, despite producing some 46 percent of US output, perform little in-house R&D and often have difficulty accessing the production innovation they need to compete. The Institutes can address these challenges and needs by acting as test beds, providing a range of industries and firms with opportunities to collaborate on, test, and prove prototypes for advanced production technologies and processes. The Institutes also help fill manufacturing talent gaps, training technical workers to use advanced technologies and to develop processes and routines for introducing advanced technologies into established production systems.

Many nations have been contending with these issues for the past three decades. There are ample case studies from Germany (the Fraunhofer institutes and manufacturing competence centers), the Netherlands (Smart Industry Labs), Israel (the Advanced Manufacturing Institute and Resource Efficiency Center), China (its advanced manufacturing institutes), and the UK (Catapult Centre) that show that other nations are finding value in an institute approach.

The UK's Catapult Centre, for example, rather than farming out its R&D projects to companies and universities (as the American Institutes must do), has created substantial expertise in-house. As of 2023 the Catapult has reached over 5,000 SMMs in

its over 2,800 commercialization projects. The Fraunhofer Institute system (with over 70 institutes) takes advantage of the respected Fraunhofer Laboratory to undertake full technology performance evaluations and certifications for technology prototypes emerging from the Institutes. The US has not used its labs in this way. A study of German firms with Fraunhofer engagements suggests after a year they experienced a nearly 10 percent increase in sales and a corresponding 7 percent increase in employment. China adopted and built on the US institute model; its 45 centers and hubs are operating at much larger scale, have much deeper funding, and are located in regional manufacturing ecosystems so that their technologies can move more quickly onto factory floors with substantial government assistance. The US Manufacturing Institutes must catch up. ■

FURTHER RESOURCES

- Michael Szczupak, "Lessons from Israel's Advanced Manufacturing Institute," *American Affairs*, 2024
- David Adler and William B. Bonvillian, "America's Advanced Manufacturing Problem—and How to Fix It," *American Affairs*, 2023
- David Adler, "Why 'Economic Security' Became Magic Words in Japan," *Foreign Policy*, 2023

William B. Bonvillian is a Lecturer at MIT teaching science and technology policy, a Senior Advisor to the Manufacturing-at-MIT Initiative, a former senior advisor in the US Senate, and an author of six books on technology policy and workforce development.

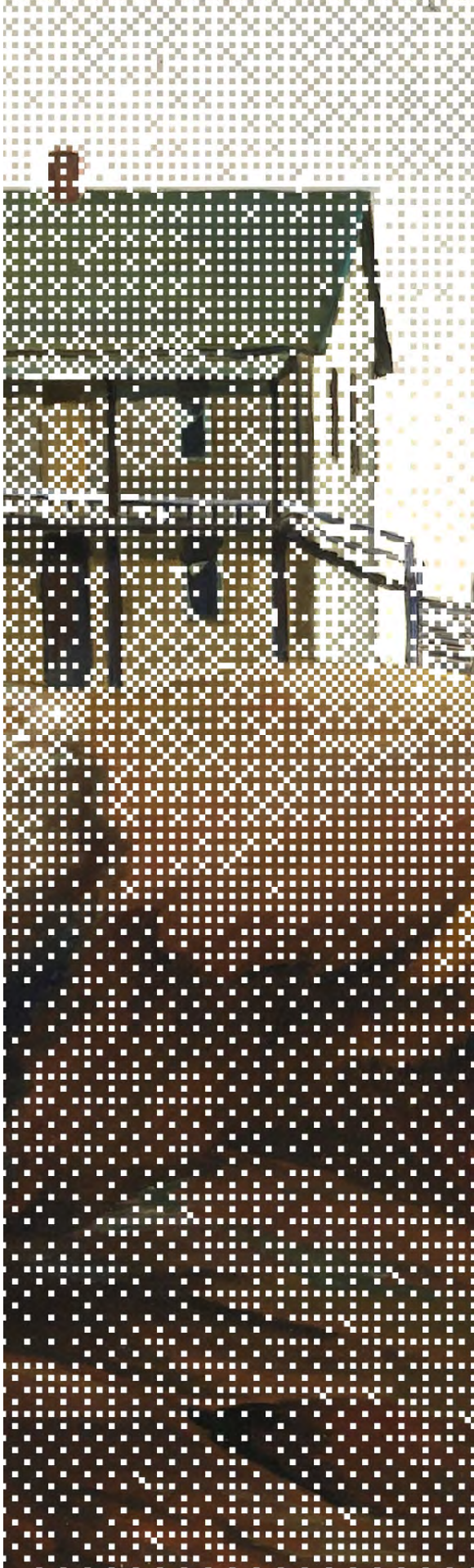
Michael Szczupak served in Israel's Ministry of Economy and Industry for six years as senior director of manufacturing policy.

David Adler is author of the monograph The New Economics of Liquidity and Financial Frictions *and coeditor of the anthology* The Productivity Puzzle. *He is also a contributing editor of* American Affairs.

■ Industrial Power

Taxation for Techno-Industrialization

Oren Cass



SUMMARY

The economists who believe that it does not matter what America makes, or whether America makes anything at all, have traditionally celebrated tax reform as an optimal tool for promoting economic growth without "picking winners and losers." Their timeworn goal is to broaden the tax base and lower the tax rate, reducing distortions that might favor some business activities over others while granting to the business owner a higher share of each marginal dollar of profit regardless of its provenance.

Tax policy to promote technological innovation, real investment, and reindustrialization would do the opposite. The corporate tax code should privilege the profits derived through the kinds of high-risk research, development, and capital investment that have the greatest social and economic value.

PROBLEM

The "invisible hand" works, according to Adam Smith, when it directs "industry in such a manner as its produce may be of the greatest value." But in the modern American economy, the

capitalist intending only his own gain is more likely to pursue financial engineering that generates greater cash flow from existing assets, or business growth that requires the least possible deployment of long-term capital. If the United States is to reassert itself as the world's leading technological and industrial superpower, it will need to use public policy to alter the return profiles of various business strategies in favor of those that drive technological innovation and build industrial capacity.

SOLUTION

Expiring provisions of the Tax Cuts and Jobs Act of 2017 (TCJA) necessitate substantial tax legislation in 2025. The House Ways and Means Committee and the Senate Finance Committee should make permanent modifications to the corporate tax code that:

- Raise the corporate tax rate from 21 percent to 25 percent
- Permit immediate expensing of all capital expenditures
- Permit immediate expensing of all R&D expenditures
- Expand eligibility for the Qualified Small Business Stock capital gains tax benefit

JUSTIFICATION

Congress erred in lowering the corporate tax rate all the way to 21 percent, far below the 25 percent that had traditionally been the target of congressional Republicans and the corporate lobby based on a desire to match the rate in other developed economies. The much lower rate produced a windfall for profitable corporations and investment firms, and larger federal budget deficits, but not the promised supply-side boom. Indeed, using the metrics chosen by Kevin Hassett, chair of the White House Council of Economic Advisers at the time of TCJA's passage, the $1.7 trillion package had no positive effect on either business investment or economic growth.

Investment may have increased in those firms that received more favorable tax treatment relative to those that did not, but that relative effect did not translate into an absolute one. In aggregate, concludes the Brookings Institution's William Gale, "TCJA changed which firms did the investing but did not necessarily affect the overall level of investment." TCJA did lead to higher corporate profits and enormous repatriations of cash from overseas, but these appear to have been channeled into stock buybacks rather than productive activity.

Perversely, the cost of the lower corporate rate led Congress, seeking revenue elsewhere, to raise the effective tax rate on research and development by requiring amortization of those expenditures. The lower corporate tax rate also weakened useful investment incentives like the immediate expensing of capital investment, because a lower rate on a marginal dollar of income reduces the value of deductions from that income. That incentive was itself made temporary to reduce its cost, and will expire in 2025 absent new legislation.

Reversing course on those decisions would sharply alter returns on investment in favor of real spending on R&D and physical assets. The tax rate on profits derived ab-

sent such spending would rise, while the rate on profits in the techno-industrial sector would fall. Evidence suggests that such incentives have dramatic impacts on behavior. For instance, prior reforms allowing for immediate expensing of capital expenditures, or "bonus depreciation," yielded double-digit percentage increases in affected forms of investment. Less research has been conducted on R&D expensing because that model was standard prior to TCJA. But analyses of R&D tax credits like the one first introduced in President Reagan's 1981 tax reform have found elasticities of 1.0 or higher, meaning a 1 percent reduction in the effective cost of the spending leads to at least 1 percent increase in the amount of spending.

A drawback of immediate expensing is that it benefits only firms with taxable profits against which to deduct expenses. Start-ups in their growth phase can benefit, if at all, only by carrying forward a credit against profits at some point in the future. Thus, policymakers should also consider targeted tax measures that address the challenges facing manufacturers at the critical scale-up phase—companies that often struggle to raise investor capital to build production facilities.

One way to do this would be to amend the Qualified Small Business Stock (QSBS) capital gains tax benefit to remove what amounts to an unintentional disadvantaging for asset-intensive, "hard tech" companies. QSBS is a tax incentive used mainly by tech start-ups, which allows investors to exclude capital gains on certain smaller companies from taxation. Relevant here, a company cannot have more than $50 million in gross assets prior to or immediately after the qualifying investment. But while $50 million is a quite high threshold for software and services companies, building a factory often costs more than that. Investors in a hard-tech company's first factory, for instance, typically cannot benefit.

Congress should amend the QSBS asset test by increasing the asset limit to $500 million where the majority of a company's assets are in property, plant, and equipment (a figure already reported by companies in their ordinary tax filings). Such a provision would have dramatic effect for the particular class of start-ups focused on scaling industrial capacity in the United States, but the overall budget impact would be modest. According to the National Venture Capital Association, out of approximately $150 billion of total VC investment in 2023, less than 10 percent went to hardware. Even if the policy succeeded in doubling hard tech investment from around $15 billion to, say, $25 billion annually, the annual cost of amending QSBS would likely remain in the single-digit billions.

Tax reform alone will not bring about a techno-industrial renaissance, but it can play an important role in creating the right conditions, if policymakers will abandon the pretense of a neutral tax code in favor of one that advances the national interest. ■

Oren Cass is the founder and Chief Economist of American Compass.

■ Industrial Power

Redesigning NEPA Regulation to Unleash American Energy

Thomas Hochman

SUMMARY

President Trump's "Unleashing American Energy" executive order, which rescinded the Council on Environmental Quality (CEQ)'s regulatory authority, has created a generational opportunity to streamline the National Environmental Policy Act (NEPA). To achieve the president's energy dominance goals, the administration should implement three core reforms: narrow the set of actions that trigger NEPA, expand categorical exclusions, and narrow the set of actions that require an environmental impact statement. These changes would significantly reduce the scope and number of environmental reviews under NEPA, leveraging existing statutory authority and recent court decisions to accelerate infrastructure development without requiring new legislation.

PROBLEM

CEQ, established under NEPA in 1969 as the White House's environmental policy office, oversees NEPA implementation across all fed-

eral agencies. Over decades, CEQ regulations have expanded NEPA's reach far beyond its original mandate, creating substantial barriers to infrastructure development and technological innovation. Projects face years of delays and litigation risk due to overly broad interpretations of key statutory terms. The recent DC Circuit's decision in *Marin Audubon Society v. FAA* invalidating CEQ's regulatory authority, combined with the Fiscal Responsibility Act (FRA)'s statutory changes, creates a unique window for reform. The FRA included significant amendments to NEPA's core definitions, creating a statutory basis for streamlining environmental reviews and reducing regulatory burden. Without action, infrastructure projects will continue facing unnecessary delays and costs, hampering America's ability to build critical infrastructure and maintain technological leadership. With these reforms, agencies could focus resources on truly significant environmental impacts while accelerating approvals.

SOLUTION

NEPA's review framework operates through three key decision points. The first filter determines what constitutes a "major Federal action." When an activity qualifies as a "major Federal action," it enters the NEPA review process, while activities falling outside this definition bypass NEPA requirements entirely. The second filter addresses categorical exclusions. Actions with environmental impacts that "normally" aren't "significant" can be categorically excluded, allowing these actions to skip detailed review and proceed with minimal documentation. All other actions require at least an Environmental Assessment (EA). The third filter distinguishes between Environmental Assessment and Environmental Impact Statement (EIS) requirements. For actions requiring review, the "reasonable foreseeability" of significant impacts determines the level of scrutiny. Actions with impacts that aren't "reasonably foreseeable" need only an EA, while only those with "reasonably foreseeable" significant impacts require the comprehensive EIS process.

This three-filter structure creates distinct opportunities for streamlining. Federal agencies should redefine these three pivotal terms—"major Federal action," "normally significant," and "reasonably foreseeable." By implementing these definitional changes, agencies can substantially reduce unnecessary environmental reviews.

The FRA provides statutory language that supports narrower interpretations of all three terms compared to CEQ's historical approach. CEQ's new guidance should advance three core reforms:

Reinterpret "Major Federal Action" Using a Two-Part Test

Federal agencies should adopt a clear, two-part test to determine which actions trigger NEPA review. First, the action must involve meaningful agency discretion that can genuinely shape project outcomes beyond basic compliance checks. This would ensure that NEPA is only applied where federal agencies can actually influence environmental outcomes. Second, the action must demonstrate substantial federal involvement through at least one of three criteria: federal funding representing a significant per-

centage (e.g., greater than 25 percent) of total project costs, essential federal capabilities that are critical to the outcome of the action, or the use of federal eminent domain powers. This approach would explicitly exclude actions with minimal federal involvement, allowing projects with limited federal connection to proceed without unnecessary environmental review processes.

Expand Categorical Exclusions Using the FRA's "Normally" Threshold

The administration should establish a data-driven approach to categorical exclusions by setting a 70 percent threshold—actions would qualify for categorical exclusion if more than 70 percent of similar projects historically received findings of no significant impact (FONSIs). To determine what constitutes a "significant effect," agencies should apply three criteria: substantial magnitude that goes beyond routine environmental changes, high likelihood of occurrence supported by empirical evidence, and inadequate existing mitigation measures. Additionally, certain types of projects should automatically qualify for baseline categorical exclusions, including projects under five acres in size, facility expansions under 20 percent of existing footprint, and development on previously disturbed lands. This expansion of categorical exclusions would dramatically reduce the burden of environmental reviews for projects with minimal environmental impact.

Narrow the Set of Actions Requiring an Environmental Impact Statement

Federal agencies should redefine "reasonably foreseeable" impacts to require three elements: a meaningful or substantial possibility of occurring under normal conditions, proximate causation between the federal action and the environmental effect, and legal responsibility of the lead agency for the effect. This narrower interpretation should rely on existing data and standard models rather than requiring extensive new research, which often causes significant delays. Agencies should also eliminate the practice of modeling worst-case scenarios without a data-driven basis, focusing instead on likely outcomes based on empirical evidence.

Implementation

CEQ and the NEPA Implementation Working Group, established by President Trump's executive order to "coordinate the revision of agency-level implementing regulations," should play the critical role of issuing new guidance and coordinating all reforms. Agencies should review historical NEPA outcomes within six months to identify new categorical exclusion opportunities, compare existing actions against the new "major Federal action" criteria to determine which actions should trigger NEPA, and generally move aggressively to develop and issue new NEPA regulations. The administration should encourage regular progress reporting and best practice sharing across agencies.

JUSTIFICATION

A comparison between the FRA's amendments and NEPA's original text shows that the proposed reforms represent a straightforward implementation of the statutory changes. The FRA explicitly modified key NEPA definitions to reduce regulatory burden, and these reforms directly translate these statutory changes into actionable policy.

The proposed reforms align with the FRA in three significant ways. First, the FRA's definition of "major Federal action" explicitly requires "substantial Federal control and responsibility," creating a statutory basis for the proposed two-part test. This marks a significant departure from NEPA's original text, which left the term undefined, and CEQ's expansive interpretation, which defined "major Federal action" as an action "potentially subject to Federal control." Therefore, the proposed criteria for substantial federal involvement provides clear, quantifiable standards that align with Congress's intent to narrow NEPA's scope.

Second, the FRA's categorical exclusion language specifically directs agencies to identify classes of action that "normally do not significantly affect" the environment. This represents a meaningful shift from CEQ's historical approach, which initially only allowed categorical exclusions for actions that "do not individually or cumulatively have a significant effect on the human environment," and even after the passage of the FRA required consideration of cumulative effects when making determinations. The proposed 70 percent threshold for categorical exclusions directly operationalizes the FRA's use of "normally," creating an empirical standard that agencies can apply consistently. This data-driven approach would ensure that categorical exclusions remain grounded in actual environmental outcomes rather than speculative concerns.

Third, the FRA's emphasis on "reasonably foreseeable" effects provides clear authority to focus EISs on concrete, demonstrable impacts. This standard supplants CEQ's previous "context and intensity" framework, which encouraged speculation about indirect and cumulative effects. The proposed reforms would implement this change by requiring direct causation between the federal action and the significant effect and eliminating analysis of speculative impacts, ensuring that agency resources focus on meaningful environmental review.

These reforms would stand in stark contrast to CEQ's historical approach of expanding NEPA's reach beyond its statutory foundations. By returning to the plain language of NEPA as amended by the FRA, these changes would create a more efficient, legally defensible framework for environmental review that better serves both development needs and environmental protection. ■

FURTHER RESOURCES

- Thomas Hochman, "How the White House Can Reform NEPA," Foundation for American Innovation, 2025
- Thomas Hochman, How to Rewrite an Environmental Law in 30 Days," *Green Tape*, 2025

- Thomas Hochman, Rewriting NEPA: The Guidance is Out," Green Tape, 2025
- White House, Executive Order 14154: Unleashing American Energy, 2025
- DC Circuit Court, Marin Audubon v. FAA, 2025
- North Dakota District Court, Iowa v. Council on Environmental Quality, 2025
- CEQ, Initial Guidance, 2025
- CEQ, Pre-Publication Interim Final Rule, 2025

Thomas Hochman is the Director of Infrastructure policy at the Foundation for American Innovation, where he works on regulatory reform and infrastructure policy.

APPENDIX

Mock CEQ Guidance

[Date], 2025

MEMORANDUM FOR HEADS OF FEDERAL DEPARTMENTS AND AGENCIES

FROM: XXXXXX, Chair, Council on Environmental Quality
SUBJECT: Guidance on Implementing the Fiscal Responsibility Act of 2023 Amendments to the National Environmental Policy Act

1. Purpose and Overview

The Fiscal Responsibility Act of 2023 (FRA), Public Law No. 118-5, introduces targeted amendments to the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4347. These amendments are intended to streamline the NEPA process by ensuring environmental reviews focus on truly major Federal actions and genuinely significant environmental effects. This document sets forth the Council on Environmental Quality's (CEQ) interpretive guidance on the FRA's changes.

The CEQ issues this guidance to federal agencies to clarify and streamline National Environmental Policy Act (NEPA) implementation in accordance with the reforms enacted by the FRA. The FRA amended NEPA for the first time in decades, with the goal of focusing environmental review on truly significant federal actions and effects and speeding up the review process. This guidance provides CEQ's official interpretation of key terms and procedures—specifically "major Federal action," "categorical exclusion," "significant effect," and the scope of "environmental impact statements" (EIS)—consistent with the FRA's amendments.

Agencies may use the recommendations herein to update and administer their NEPA processes, with the aim of improving efficiency, maintaining legal soundness, and targeting analyses toward substantial environmental risks. Federal agencies may integrate this guidance into their NEPA implementing procedures to ensure efficient, legally sound environmental reviews

that concentrate resources on substantial environmental risks while expediting actions with minimal environmental impact.

2. Authority, Background, and CEQ's Advisory Role

2.1 Authority and Background

The National Environmental Policy Act (42 U.S.C. §§ 4321-4347), as amended by the FRA, provides the statutory framework for federal environmental reviews.

Historically, CEQ promulgated binding regulations governing NEPA implementation (40 C.F.R. parts 1500-1508). However, in light of President Trump's Executive Order (E.O.) 14154, *Unleashing American Energy*, and recent judicial decisions (see *Marin Audubon Soc'y v. FAA* (D.C. Cir. Nov. 12, 2024) and *State of Iowa v. CEQ* (D.N.D. Feb. 3, 2025)), CEQ may no longer have the authority to issue binding NEPA regulations. However, CEQ retains its advisory role and authority to issue interpretive guidance that federal agencies may adopt to help fulfill statutory obligations.

2.2 Purpose of this Guidance

The guidance below aligns with the FRA's intent to reduce unnecessary analysis of minor impacts and expedite federal decision-making.

It articulates CEQ's recommended interpretations of key FRA provisions—particularly in clarifying "major Federal action," defining "significant effects," and streamlining the scope of EISs.

Agencies remain responsible for their own NEPA procedures and retain flexibility to implement the FRA's requirements in a manner consistent with their statutory mandates and the changed legal landscape.

3. Clarifying "Major Federal Action"

3.1 Statutory Changes

The FRA defines a "major Federal action" as "an action that the agency carrying out such action determines is subject to substantial Federal control and responsibility" (42 U.S.C. § 4336e(10)). This statutory language replaces the prior broad standard and expressly excludes from NEPA review:

- Projects with no or minimal Federal funding
- Projects with no or minimal Federal involvement where a Federal agency cannot control the outcome of the project
- Loans, loan guarantees, or other forms of financial assistance where a Federal agency does not exercise sufficient control and responsibility over the subsequent use of such financial assistance or the effect of the action
- Activities or decisions that are non-discretionary and made in accordance with the agency's statutory authority

These amendments make clear that NEPA is not triggered for projects with only a trivial federal nexus.

3.2 Two-Part Test for Substantial Federal Control and Responsibility
CEQ advises agencies to employ a two-step inquiry:

Part A—Agency Discretion
Drawing on the FRA's exemption for non-discretionary actions (42 U.S.C. § 4336e(10)(B)(vii)), agencies should determine whether they have genuine decision-making authority (e.g., whether they can impose conditions or select among alternatives). If the agency's role is ministerial or solely advisory without the ability to alter the project outcome, NEPA does not apply.

Consistent with the FRA's statutory language, CEQ interprets "major Federal action" to require meaningful discretionary authority over the action. If the agency's role is non-discretionary or purely advisory with no decision-making control, the action fails this prong and is not subject to NEPA. For example, "activities or decisions that are non-discretionary and made in accordance with the agency's statutory authority" fall outside NEPA's scope. Agencies should first confirm that a federal decision is required and that the agency has the legal ability to choose among alternatives or impose conditions—if not, NEPA review is not required.

Part B—Substantial Federal Involvement
If Part A is satisfied, determine whether federal involvement is "substantial" rather than incidental. CEQ interprets this distinction as follows:

1. Significant Federal Funding: Federal funding comprises a significant portion of the project's financing—approximately 25 percent or more of total project costs may serve as a benchmark. This threshold is suggested as a practical indicator of a substantial federal stake, consistent with other regulatory contexts using 25 percent to denote substantial control. (Notably, the 25 percent figure aligns with ownership thresholds in corporate law equivalent to "substantial control" (see 31 CFR § 1010.380(d)). Agencies retain discretion to adopt a different benchmark, supported by appropriate data and analysis, but should ensure any chosen percentage meaningfully distinguishes "substantial" from incidental federal influence over the project's outcome.
2. Critical Federal Expertise or Operational Control: The federal agency provides unique, essential capabilities or plays an indispensable coordination role that is crucial to the project's outcome. This may include, for example, determining key design or siting parameters, or other support without which the scope or nature of the project would substantially change. If the project's scale or impact would remain largely the same in the absence of federal involvement, the federal role is considered incidental under 42 U.S.C. § 4336e(10)(B) and the action is not a major Federal action.
3. Exercise of Unique Federal Authorities: The action involves use of distinctly federal powers, such as federal eminent domain or other sovereign authorities, to enable the project. Exercising federal eminent

domain on behalf of a project demonstrates a high level of federal control and responsibility, meeting this prong regardless of funding percentage.

CEQ's interpretation is that both Part A (discretionary agency action) and Part B (substantial involvement as indicated by one or more factors above) are required for the proposed undertaking to qualify as a "major Federal action" under NEPA. CEQ interprets the FRA to exclude from NEPA review those activities that fail either prong (e.g., where the federal contribution is minimal and no project control exists). Agencies should document their application of this two-part test in the administrative record to support their determinations. By clearly delineating when Federal involvement crosses from minimal to substantial, this test focuses NEPA compliance on projects truly under federal control, as intended by the FRA.

3.3 Functional Equivalence as an Alternative to NEPA Review

Agencies should continue to apply the long-recognized "functional equivalence" doctrine where compliance with another environmental statute effectively meets NEPA's core requirements (i.e., meaningful analysis of environmental effects, consideration of alternatives, and opportunity for public participation) and thereby precludes the need for NEPA review. Courts have upheld functional equivalence for decades in situations where the statutory scheme provides essentially the same review and disclosure benefits as NEPA. See, e.g., *Portland Cement Ass'n v. Ruckelshaus*, 486 F.2d 375 (D.C. Cir. 1973); *Env't Def. Fund, Inc. v. EPA*, 489 F.2d 1247 (D.C. Cir. 1973); *Alabama v. EPA*, 911 F.2d 499 (11th Cir. 1990); *Merrell v. Thomas*, 807 F.2d 776 (9th Cir. 1986).

When invoking functional equivalence, agencies should:

1. Identify the underlying statute and procedures that serve NEPA's purposes
2. Document how these procedures address environmental impacts, alternatives, and public involvement
3. Show that no added NEPA documentation is needed because the relevant issues are fully considered under the other statute.

This approach remains a practical way to avoid duplicative reviews while preserving robust environmental oversight. The Fiscal Responsibility Act's emphasis on streamlining is consistent with these established principles; functional equivalence simply continues to provide an existing avenue for efficient compliance where agencies already meet NEPA's objectives through other statutory programs.

4. Expanding and Streamlining Categorical Exclusions

The FRA also codified and reinforced the use of Categorical Exclusions (CEs) as a tool for expediting reviews of minor projects. By statute, a "categorical exclusion" is defined as "a category of actions that a Federal

agency has determined normally does not significantly affect the quality of the human environment." (42 U.S.C. § 4336e(1)). The statutory term "normally" is central to this definition and requires interpretation.

4.1 Empirical Basis for "Normally"

CEQ interprets "normally" to refer to the typical or usual outcome for a category of actions based on empirical evidence rather than theoretical possibility. This interpretation follows the plain meaning of "normally" as conforming to a type, standard, or regular pattern. It also aligns with judicial expectations that categorical exclusions be based on reasoned analysis rather than unsupported assumptions (see *Alaska Center for the Environment v. U.S. Forest Service*, 189 F.3d 851 (9th Cir. 1999)).

Under this interpretation, CEQ advises agencies to use an empirical, data-driven approach to determine when a category of actions "normally" has no significant effects. In practice, this means examining the agency's own NEPA track record and other relevant data for that category of action. If the vast majority of past projects of that type have resulted in Findings of No Significant Impact (FONSIs), the action category can be deemed to normally lack significant effects.

CEQ recommends a "substantial majority" threshold as a guide: for example, if over approximately 70 percent of comparable actions (agencies may tailor this figure based on their particular record and experience) historically concluded with a FONSI, the action category should qualify for a categorical exclusion. This threshold is grounded in empirical observation (as opposed to an arbitrary value)—it reflects a meaningful confidence level that most such actions do not have a significant effect. Indeed, government-wide statistics show that an overwhelming proportion of Environmental Assessments (EAs)—on the order of 95-99 percent—result in FONSIs rather than findings of significant impact. In light of this reality, many actions currently subjected to EAs can and should be reclassified as CEs, so long as appropriate conditions are in place to ensure unusual cases are caught. Using data on past NEPA outcomes to define "normally" will make CE determinations more objective and accurate.

This interpretation provides agencies with a practical framework for implementing the statutory language while ensuring categorical exclusions remain grounded in empirical reality. The 70 percent threshold is not presented as a rigid requirement but as an interpretive guideline that agencies may adapt based on their particular circumstances, provided they maintain fidelity to the statutory concept of "normally."

4.2 Extraordinary Circumstances and Documentation

CEQ interprets the FRA's categorical exclusion provisions as requiring empirical support. This interpretation aligns with judicial precedent requiring a rational basis for agency categorical determinations. See, e.g., *Ca. ex Rel. Lockyer*, 575 F.3d 999 (9th Cir. 2009).

Therefore, agencies should document the analysis supporting any new or

expanded CEs. This includes quantifying the percentage of past actions in the category with no significant impacts, and explaining why future actions are expected to follow the same pattern. Factors to cite may include:

- The use of standard mitigation measures
- Permit requirements
- Best practices that have consistently prevented significant effects in that category
- Rationale for concluding these patterns will continue for future actions

CEQ also emphasizes that agencies should maintain "extraordinary circumstances" review—i.e., screening for site-specific red flags (such as critical habitat) that would merit a fuller review despite the general category being excluded. By taking these steps, agencies can confidently expand their CE lists to cover more routine activities, in turn freeing up resources to focus on proposals with genuinely significant environmental effects.

5. Refining the Definition of "Significant Effect"

A crucial companion to the above is clarifying what types of effects count as "significant" in the NEPA context. The original text of NEPA never provided a precise definition of "significant effect," while CEQ's regulations historically added color to the term through broad "context and intensity" factors that invited consideration of speculative or minor effects (e.g. controversy or cumulative impact considerations), contrary to the plain meaning of "significant." With the new FRA text drawing the threshold for requiring an EIS for actions as "a reasonably foreseeable significant effect on the quality of the human environment," 42 U.S.C. § 4336(b)(1), a plain interpretation of the term is necessary.

5.1 Criteria for Significance

Drawing from the statutory context and Supreme Court precedent, CEQ interprets "significant effect" as encompassing three essential elements (for CEs, EAs, and EISs alike). An effect should be deemed "significant" under NEPA only if it meets all three of the following criteria:

1. Substantial Magnitude: The expected environmental change or impact is appreciable. The plain meaning of "significant" supports this interpretation, and establishes an inherent substantiality threshold. In other words, the effect is more than minimal or routine in context—it involves a measurable alteration of environmental conditions (e.g. exceeding defined thresholds such as a certain acreage of habitat disturbed, pollutant emissions above a set level, etc.). Minor changes or temporary/transient effects do not satisfy this element.
2. Inadequately Mitigated by Standard Measures: The effect is of a type or severity that would not be prevented or mitigated by routine, well-es-

tablished measures or that is not already regulated by an existing law. This criterion derives from the Supreme Court's holding in *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 351-52 (1989), which held that NEPA "merely prohibits uninformed—rather than unwise—agency action" and recognized mitigation measures as central to NEPA's analytical framework. See also *Cabinet Mountains Wilderness v. Peterson*, 685 F.2d 678 (D.C. Cir. 1982) (holding that the adoption of mitigation measures that reduced an action below the significant threshold voided the need for an EIS). If the impact can be effectively avoided or reduced to minor levels through commonly employed mitigation (or if it falls below regulatory significance thresholds set by other environmental laws), then the impact should not be considered significant for NEPA purposes. This criterion ensures that effects already addressed by other environmental requirements (such as permits under the Clean Air Act, Clean Water Act, etc.) are not double-counted as "significant" if those processes will mitigate the impact to an acceptable level.

3. High Likelihood and Proximate Causation: There must be a high probability of the effect occurring as a result of the federal action, based on credible evidence and a direct causal relationship. This criterion directly implements the Supreme Court's holdings in *Department of Transportation v. Public Citizen*, 541 U.S. 752, 767 (2004), where the Court explicitly held that "a 'but for' causal relationship is insufficient to make an agency responsible for a particular effect under NEPA" and instead required a "reasonably close causal relationship" comparable to proximate cause in tort law, a principle the Court previously established in *Metropolitan Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766 (1983). Speculative or uncertain impacts—those based on unlikely chains of events or dependent on numerous contingencies—do not meet this threshold. The effect should have a reasonably close causal connection to the proposed action, rather than being an attenuated consequence. In essence, this incorporates the "reasonably foreseeable" standard (discussed further below) and the legal doctrine of proximate causation into the significance determination: an impact that is not probable and proximately caused by the action should not elevate an action to EIS-level significance.

CEQ interprets the statutory concept of "significant effect" as requiring all three of the above elements. This approach remains faithful to NEPA's language (ensuring "significant" impacts get attention) and judicial precedent while providing clearer, more objective standards that agencies can apply in practice. Only once an agency determines, using available data (see 42 U.S.C. § 4336(b)(3)(B)), that a reasonably foreseeable significant effect exists should an EIS be prepared. Agencies are encouraged to update their NEPA procedures to reflect these factors—for example, by establishing quantitative thresholds or clear qualitative benchmarks for what constitutes

a "substantial" change in their specific resource contexts—and to explain in decision documents how an impact was evaluated against these criteria.

6. Focusing EIS Analysis on Direct and Reasonably Foreseeable Effects

Consistent with the FRA's amendments, CEQ interprets the definition of EISs to focus on the effects that are reasonably foreseeable and proximately caused by the proposed federal action. The FRA explicitly codifies that an EIS should discuss "the reasonably foreseeable environmental effects of the proposed agency action" (as well as a reasonable range of alternatives and any unavoidable effects). This statutory language reinforces longstanding CEQ regulations and case law, and reflects Congress's intent to focus NEPA analysis on probable, proximate effects rather than speculative or attenuated possibilities.

Under this guidance, agencies should ensure that NEPA review (particularly in EISs) remains proportional to the agency's decision at hand, concentrating on effects that can be confidently predicted and are closely linked to the action, while streamlining or omitting analysis of effects that are remote, indeterminate, or beyond the agency's control.

6.1 "Reasonably Foreseeable" Defined

CEQ interprets "reasonably foreseeable" effects as those effects which are likely enough to occur that a person of ordinary prudence would take them into account in decision-making, and which have a reasonably close causal relationship to the federal action. This means an effect should:

1. Have a substantial probability of occurring under typical circumstances (not a mere theoretical possibility), and
2. Follow directly from the action (or via a short, clear chain of cause and effect) without too many intervening factors.

A "but for" causal link alone is insufficient—in other words, just because an effect could be traced back to the project in a broad sense does not automatically make it an effect that the agency must consider. There must be a direct or proximate causal connection, analogous to the concept of proximate cause in tort law, for the effect to be attributed to the action for NEPA purposes.

Effects that are geographically or temporally distant, or that depend on unpredictable future actions by other parties, generally fail this test of reasonable foreseeability. For example, if an agency's action enables some subsequent private or state decisions that are not yet planned or are beyond federal control, the downstream impacts of those subsequent decisions may be too attenuated to be deemed reasonably foreseeable effects of the initial federal action. Agencies should focus their analysis on impacts that will likely occur as a direct result of the proposed project or its immediate alternatives, based on reliable data or experience, and need not engage in speculative "worst-case" scenario analysis for improbable outcomes (see *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 356 (1989)).

This interpretation is in line with Supreme Court precedent in Metropolitan Edison and Public Citizen and the statutory text of the FRA. If an agency has no legal authority to prevent or regulate a particular consequence of its action, or if the effect would occur regardless of the federal action, then that effect is outside NEPA's scope. NEPA does not require analysis of environmental impacts outside the agency's jurisdiction or control, or more properly under another agency's purview. By the same token, indirect effects that are highly speculative or dependent on a string of uncertain events should not consume extensive study. CEQ's 2020 rulemaking clarified that a "close causal relationship" is required and that effects occurring via a "but-for" chain of causation alone (without proximity) are not NEPA effects. The FRA now embeds the "reasonably foreseeable" limitation in statute, giving agencies a clear mandate to trim back analyses of remote possibilities and keep EIS documentation focused on likely, actionable impacts.

6.2 Application in Practice

When preparing EISs (or determining whether an EIS is necessary under an EA), agencies may:

1. Focus analysis on likely effects that the agency is legally responsible for: Concentrate on evaluating the environmental impacts that are likely and within the scope of the federal action's influence. These effects may be considered only to the extent they are reasonably foreseeable, have a close causal connection to the proposal, and are most properly under the deciding agency's legal purview.
2. Document briefly why more distant or uncertain impacts are excluded from detailed study: Agencies can briefly describe why more speculative effects are not analyzed in detail, to show they were considered but ruled out as beyond NEPA's requirements.
3. Consider providing a concise discussion of potential but uncertain effects for informational purposes: CEQ encourages a pragmatic approach—for instance, if an energy infrastructure project may facilitate some downstream use that in turn results in emissions, the agency may assess those emissions if they can be reasonably forecast with available tools and are proximate (e.g. directly enabled by the project). However, if quantifying or predicting such effects would require undue speculation about market conditions or policies outside the project, the agency can delineate those uncertainties and refrain from exhaustive analysis.

Analyses may emphasize direct project impacts (e.g., land disturbance, direct emissions, water usage of the project itself) and well-understood indirect impacts, while acknowledging but not deeply analyzing highly uncertain or indirectly linked effects. This focused approach will produce clearer EIS documents that inform decision-makers on the significant likely consequences of their actions, consistent with NEPA's core purpose, and will reduce delay caused by attempting to evaluate every conceivable ripple effect.

Agencies should also be mindful of the litigation context: A reasonable bounding of the EIS scope to foreseeable direct effects is supported by the FRA and case law, but agencies may make a robust record of why more distant effects are not reasonably foreseeable. In some cases, it may be prudent to include a concise discussion or quantification of a potential effect for informational purposes only, even if the agency deems it not legally required, as a "belt and suspenders" measure to demonstrate that considering those effects would not change the decision.

CEQ's interpretation allows such flexibility. The primary analysis may reflect the streamlined, focused scope, but a short appendix or sidebar analysis of a contentious indirect effect (such as upstream or downstream greenhouse gas emissions, in aggregate) can be included to preempt claims that the agency ignored an impact. The overarching principle, however, is that NEPA documents are not required to go beyond what is reasonably foreseeable or to analyze speculative scenarios. By adhering to that principle, agencies can implement NEPA efficiently and in line with the updated statute.

7. Effective Date, Next Steps, and Implementation

This guidance is effective immediately. Agencies may:

1. Review their NEPA Procedures to conform to the FRA amendments and this advisory guidance.
2. Incorporate Revisions: For instance, update definitions of "major Federal action," revise CE lists based on historical data, and clarify significance thresholds.
3. Provide Feedback: CEQ welcomes data and suggestions regarding these benchmarks (e.g., the approximately 25 percent and 70 percent figures), which may be refined over time.

Since CEQ functions in an advisory capacity post-Marin Audubon, agencies are not legally bound to adopt these recommendations. However, CEQ believes these interpretations will enhance efficiency and clarity while complying with NEPA's core requirements under the FRA.

7.1 Alignment with FRA 2023

The interpretations and recommendations in this guidance are firmly rooted in the amended NEPA statutory text and are intended to carry out Congress's intent in the FRA to improve the timeliness and effectiveness of environmental reviews. By narrowing the definition of "major federal action" to exclude trivial federal involvement, expanding the use of categorical exclusions through evidence-based determinations, and focusing EISs on effects that are reasonably foreseeable and causally direct, federal agencies can fulfill NEPA's requirements in a way that protects environmental values without unnecessary delay. This guidance provides a framework that agencies can incorporate into their NEPA procedures (per 40 C.F.R. § 1507.3) and apply immediately to pending and future actions.

7.2 Agency Discretion

In implementing this guidance, agencies should note that the numerical thresholds and criteria provided (such as the 25 percent funding benchmark for substantial involvement and the 70 percent FONSI rate for categorical exclusions) are grounded in rational precedent. They are offered as presumptive safe harbors to enhance clarity and consistency, not as inflexible rules. Agencies have discretion to depart from these benchmarks as befits their particular case, but should consider providing appropriate justification in the administrative record.

For example, if an agency's experience indicates a different percentage of federal funding is more appropriate to define incidental vs. "substantial" involvement for a certain program, the agency may adopt that threshold—provided it explains the reasoning (e.g. citing historical project data or analogous standards). Similarly, the "substantial majority" test for CEs should be anchored by data; while roughly 70 percent is a generally reasonable guide, an agency could establish a higher confidence requirement for very sensitive resource areas, or a slightly lower percentage if supplemented by other indicia of low impact (like stringent permit requirements that apply to all actions in the category). The key is that any such threshold should be justified by facts or logic, thereby avoiding arbitrariness.

CEQ finds that the 25 percent and 70 percent figures, in particular, have strong justification—25 percent being a level of ownership/control commonly recognized in law as significant, and 70 percent being a conservative definition of "most" or "normally" based on NEPA outcomes—but agencies remain free to refine these values with proper support. CEQ will monitor implementation and welcomes feedback from agencies on the practical efficacy of these standards.

Next Steps

Agencies should review their NEPA implementing regulations and guidance in light of this CEQ guidance. Where immediate conflicts exist (for instance, if existing agency NEPA procedures define "major Federal action" more broadly than the FRA statutorily allows), agencies should promptly update or clarify their procedures to be consistent with the FRA.

CEQ also notes that the FRA introduced other process improvements (such as page limits for NEPA documents and timelines for completion) that, while outside the scope of this document, complement the substantive clarifications provided here. Taken together, these modifications aim to refocus NEPA on its core purpose—informing decision-makers and the public about significant environmental effects of major Federal actions—rather than creating unnecessary barriers to needed projects. CEQ will continue to assist agencies in implementing these changes and will consider further guidance or rulemaking as necessary to ensure NEPA reviews are effective, efficient, and faithful to the law.

Agencies may apply these principles to ongoing NEPA processes to the extent practicable, especially where doing so can streamline analysis without undercutting environmental protection. CEQ stands ready to provide technical assistance as agencies integrate this guidance. By adhering to the clarified definitions and focused analytical scope outlined above, agencies will improve NEPA's functionality and better serve both environmental stewardship and the expeditious development of infrastructure and other federal actions, in alignment with the FRA and NEPA's goals.

8. Disclaimer

Following Executive Order 14154 and judicial decisions such as *Marin Audubon Soc'y v. FAA* (D.C. Cir. Nov. 12, 2024) and *State of Iowa v. CEQ* (D.N.D. Feb. 3, 2025), CEQ recognizes that it may lack authority to issue binding regulations governing NEPA implementation. However, CEQ retains its role as the expert agency on NEPA matters and continues to have authority to issue interpretive guidance.

This document represents CEQ's interpretations of key statutory provisions in the FRA amendments to NEPA. These interpretations reflect CEQ's specialized expertise and institutional experience with environmental review processes. While they lack the force of law that binding regulations would carry, they may prove persuasive to agencies and courts based on the thoroughness and validity of their reasoning, their consistency with judicial precedent, and their grounding in CEQ's expertise.

Federal agencies remain responsible for their own NEPA procedures and retain ultimate authority to interpret statutory requirements within their jurisdictions. Agencies may adopt, adapt, or develop alternative approaches to the interpretations presented here, provided those approaches comply with the statutory text and relevant judicial precedent.

This guidance does not create or confer any legal rights, impose legally binding requirements, or mandate particular outcomes. It represents CEQ's expert judgment on implementing the FRA amendments in a manner that advances NEPA's fundamental purposes while respecting the FRA's streamlining objectives.

CEQ will continue to evaluate the effectiveness of these interpretations and may issue updated guidance as implementation experience accumulates. CEQ welcomes feedback from agencies on their experiences implementing the FRA amendments.

■ Industrial Power

Advancing Nuclear Energy with the Loan Programs Office

Emmet Penney

SUMMARY

To unleash a nuclear renaissance, the US needs to leverage the Department of Energy's Loan Programs Office (LPO)'s ability to de-risk and finance nuclear investments.

PROBLEM

Headlines claim that America and China are in a race for computational dominance, but this can obscure the hard reality of the industrial challenge datacenter energy demand poses for America. The real race is for thermodynamic supremacy. If America wants to win, it needs to invest in radically expanding its nuclear fleet.

However, the nuclear industry has been trapped in a vicious cycle. Anemic supply chains have increased financing costs, since new builds must establish said supply chains from scratch. As a consequence, supply chain development has been stultified, which has led to delayed deployment and cost overruns, which then discouraged further investment in nuclear, thus perpetuating the brittleness of its supply chains. As a result, private capital looks askance at nuclear financing.

To break out of this cycle, the Department of Energy's Loans Program Office, an office dedicated to providing vital energy projects with financial assistance, has a unique opportunity to offer robust, long-term financing for traditional and advanced reactors that can de-risk nuclear development and fortify its supply chains. This will enable the economy of repetition needed to drive down reactor costs and open up new avenues for innovation.

SOLUTION

Through the Loans Program Office, the Department of Energy can ignite a nuclear renaissance in America through three programs aimed at the near, medium, and long term.

Operation Full Tank (Near Term)

PREMISE: Deploying already proven nuclear technology at power plants with open reactor spots is the lowest-hanging fruit for a fleet-scale nuclear build.

OPPORTUNITY: America has 18 empty reactor spots large enough for gigawatt-scale nuclear reactor slots in various nuclear power plants across the country. This represents around 20,000 megawatts of power capacity, enough to serve 22 million people.

PROGRAM: The LPO can coordinate with hyperscalers (i.e., datacenters hungry for electricity), utilities, independent power producers, or a consortium thereof, to provide project financing a fleet-scale build of proven nuclear technology at sites that possess: a) an owner with a nuclear operating license; b) a grid connection; and c) space for at least one additional reactor unit. The LPO should direct $10 billion in low, fixed-interest construction loans through credit subsidies for such projects. This will allow the LPO to unlock more funding for these projects by an order of magnitude. Additionally, it should offer $10 billion in long-term, fixed-rate loans post-completion to protect these projects from refinancing risk when construction loans come due. Additionally, the LPO should establish an Offtake Contract Authority similar to the Department of Energy's Transmission Facilitation Program. In the way that the TFP provides financing tools that help shovel-ready transmission line projects establish a customer base, the OCA would help these nuclear projects secure long-term Power Purchase Agreements.

Operation Atomic Heartland (Medium Term)

PREMISE: America's coal fleet teeters on the brink of extinction. A bleak future awaits the communities that host these plants. Rarely, if ever, does a community economically recover from a plant closure. Losing these plants is a tragedy not just for these communities, but for the industrial commons of our power grid, which is starved of firm capacity. Providing these coal plant owners and their communities with the chance to flourish in perpetuity while stabilizing our most essential piece of infrastructure needs to be a national priority.

OPPORTUNITY: Given that the bevy of coal plants set to retire in the 2030s are of varying sizes, both small modular reactors and traditional gigawatt-scale reactors are eligible to replace their spot in the grid. There are 85 coal plant sites slated to retire in 28 states that could serve as sites for new nuclear reactors.

PROGRAM: The LPO should establish a program whereby host communities for coal plants, their respective utilities, and their respective workforces apply to host a nuclear reactor of appropriate size for their site. The LPO will provide $15 billion in financial assistance for site cleanup and conversion, $5 billion for workforce retraining, and $20 billion in low, fixed-interest construction loans for reactor construction via credit subsidies. Lastly, these projects should be eligible for the long-term PPA procurement through an Offtake Contract Authority as stated above.

Operation Eternal Dominance (Long Term)

PREMISE: America not only wants to master traditional nuclear, but to become a prime mover in nuclear innovation.

OPPORTUNITY: Our national lab system is already robust and ready to help advanced nuclear companies prototype their designs so that they can troubleshoot technical challenges before dealing with the added pressure of commercialization.

PROGRAM: The Department of Energy needs to use its network of national labs to create a commercialization pipeline. Advanced nuclear companies could apply to build a commercial reactor prototype at a national lab site with a reduced regulatory burden. For the companies that successfully debut a reactor for commercial power production at a lab, the LPO can offer a total of $10 billion in cost insurance to ease their deployment in a commercial setting by covering budgetary outlays for regulatory expenses (e.g., Nuclear Regulatory Commission safety compliance), environmental compliance, interconnection fees, etc. It should also offer $10 billion in offtake loans post completion for the reasons stated above.

To fund these missions, Congress will need to appropriate the requisite $80 billion. To put this amount in broader context, China has committed nearly half a trillion dollars to building 100 new reactors premised on Westinghouse's AP-1000 design. They plan to switch one on every five years. The race is on.

JUSTIFICATION

Fleet-scale builds in practice and theory

The most famous nuclear build in history took place in France during the 1970s, when Marcel Boiteux, then head of the national utility, Électricité de France, brute-forced a fleet-scale nuclear deployment of 56 reactors over 15 years. By committing to the same reactor design, France sped up deployment times as their experience with the technology increased. Standardization was the lynchpin of France's successful nuclear deployment.

America pursued a variety of reactor designs following the dawn of nuclear power in the late 1950s. A fateful combination of regulatory shifts, a flatlining of load growth, and a lack of standardization stymied the industry by the 1980s. To avoid this pitfall, the US needs to incentivize the deployment of already proven technology.

Moreover, reports from both the Massachusetts Institute of Technology and the Department of Energy reveal that -nth-of-a-kind plants (i.e., successive plants of the same type) can deliver cost reductions more assuredly than first-of-a-kind plants. Both Russia and China have pursued this strategy, which has allowed them to reduce costs and deployment time, while providing them with the expertise to experiment with advanced reactor types.

Learning from our northern neighbors

Ontario achieved one of the most seamless and robust energy scale-ups in human history by phasing out its coal fleet and replacing it with nuclear reactors. Even more impressive, the province retained its coal workforce by retraining them to operate nuclear reactors. While the American experience will involve less central planning (Ontario's power system is a publicly owned utility), Canada's achievements in this regard serve as a general proof of concept for a transition from coal to nuclear power.

Reactor Park: an old debate made new

In the early years of nuclear development, the Atomic Energy Commission and America's utilities debated how best to proceed when it came to developing nuclear power. Utilities wanted the national labs to experiment with several different reactor types to see which held the most promise, a desire the power industry held onto even after Admiral Hyman Rickover debuted the first civilian power reactor in 1957. However, the national labs were more interested in scientific experimentation than practical commercialization. The idea of leveraging the national labs to prototype commercial reactors therefore never took off.

Today, with an already established fleet and a burgeoning advanced reactor sector, the picture looks much different. Now, the national labs can play a unique role in helping the private sector cultivate deeper technical proficiency in producing cutting-edge nuclear technology for commercial purposes. By demonstrating prototypes at the various labs, small modular reactor companies trying to build innovative designs that can be "snapped together" like LEGOs on site will be able to work the kinks out in their designs before they take on the risk of debuting commercial reactors. As a result, their deployments will go more smoothly while American nuclear engineering discipline simultaneously accrues, which will allow the US to pull ahead of the current industry leaders, China and Russia. ■

FURTHER RESOURCES

- Department of Energy, "Pathways to Commercial Liftoff: Advanced Nuclear," 2024
- Idaho National Lab, "Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants," 2022
- Idaho National Lab, "Evaluation of Nuclear Power Plant and Coal Power Plant Sites for New Nuclear Capacity," 2024
- Idaho National Lab, "Opportunities for AP1000 Deployment at Existing and Planned Nuclear Sites," 2024

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■ Industrial Power

Regaining Control over Critical Mineral Production

Dean Woodley Ball

SUMMARY

The United States faces a severe strategic vulnerability in its critical minerals supply chain, with complete import dependence for 15 critical minerals and over 80 percent import reliance for an additional 11 minerals. China dominates the global supply chain, producing 95 percent of US rare earth elements supply. This dependence threatens America's technological capabilities and national security. President Trump's recent executive order on critical minerals is a strong start, but following through on execution will be the harder part. This paper proposes a two-pronged approach: federal funding for domestic mining and refining ventures, and the establishment of a strategic mineral reserve, supported by environmental permitting reform.

PROBLEM

The United States finds itself in a precarious position, dependent on China—its primary strategic competitor—for the essential minerals

that power modern civilization. The US produces the majority of only 13 of the 63 critical minerals domestically. For "rare earth elements," a term used to describe elements that are in fact common but difficult to extract, China produces 95 percent of the US supply. Without these critical minerals, semiconductors cannot function, batteries cannot operate, and both basic and advanced military systems cannot be produced. China has deliberately achieved market dominance in these minerals through decades of industrial policy, while US policy choices have led to the offshoring of domestic production capacity. This vulnerability has moved beyond theoretical concern to active threat: China has already begun using critical mineral export controls in retaliation for US technology restrictions, demonstrating both the willingness and ability to weaponize this dependency. Market forces alone cannot correct this imbalance, as Chinese firms have repeatedly demonstrated their ability to flood markets and destroy the economic viability of new Western mining ventures. With US-China tensions escalating and the defense industrial base exposed to potential supply disruptions, establishing secure critical mineral supply chains has become an urgent national security imperative.

SOLUTION

Departments of Defense and Energy

America has a pre-existing statutory framework with which to solve this problem: the Defense Production Act (DPA). Title I of the DPA is more widely known and allows the government to rapidly procure national security-related supplies and equipment from existing industrial capacity. This is the authority that was used, for example, during the height of the COVID pandemic to secure emergency supplies of ventilators and personal protective equipment (PPE). Title III, on the other hand, is less commonly invoked and is aimed at addressing gaps in the American industrial base. In short, DPA Title I is meant to alleviate near-term supply constraints, while Title III focuses on adding new or expanded domestic manufacturing capabilities in the long term. Together—and with sufficient congressional appropriations—Title I and Title III allow ample statutory powers to address America's critical minerals vulnerability.

Title III requires that a specific industry (or in this context, class of critical mineral) be designated by the president or by agencies as eligible for funding. Funding can be deployed to provide grants to domestic mining and refining operations. Given Title III's explicit allowance for the scaling of emerging technologies, the Departments of Defense and Energy should seek to include projects with technologically differentiated approaches to minerals exploration, mining, and refining. For example, while finding new deposits of critical minerals has become more challenging, new technologies, such as hyperspectral satellite imagery combined with machine learning algorithms, have the potential to accelerate our rate of discovery.

When used in concert with the Departments' "Other Transaction Authority," which bypasses many of the burdensome rules in the traditional federal procurement process, Title III can quickly allocate funding to promising minerals ventures. Funding can take a variety of forms, such as purchase commitments, loans, loan guar-

antees, and direct grants. Direct purchase agreements under Title III, or purchases made under Title I, can be used to guarantee demand at a specific price for these minerals, which will be essential for these businesses to be viable. If these minerals are stockpiled, this can be a pilot version of the proposed Strategic Minerals Reserve, discussed below.

Congressional Actions

Congress should appropriate funds to authorize expanded grantmaking for critical minerals under DPA Title III. In addition to providing the funding, Congress should consider expanding the list of countries where Title III funding can be allocated. Currently, it is restricted to the US and a handful of close allies (Canada, the United Kingdom, and Australia, the latter of which was added only in 2023). Title III eligibility could be strategically expanded to include, for example, Greenland—ideally to provide support for American-backed mining ventures.

Another essential step is to relax, and ideally repeal, procedural environmental regulations that delay important industrial projects of all kinds. Chief among these is the National Environmental Policy Act (NEPA). NEPA introduces delays to essential construction while providing very few tangible environmental benefits. Short of repeal, Congress should provide clear pathways for expedited approval of critical minerals projects, particularly those with Title III support.

Finally, Congress should consider the creation of a formal Strategic Minerals Reserve, modeled on the Strategic Petroleum Reserve (SPR). Existing statutory authorities allow the executive branch to purchase minerals, but absent congressional action there will be few purpose-built physical locations in which to stockpile them. Furthermore, a Mineral Reserve would allow the federal government to act as both a buyer and seller of minerals, creating a potential long-term buffer against price volatility, as is the intended purpose of the SPR. (See “Secure Energy, Stable Prices: A Strategic Petroleum Reserve for Industrial Resilience” for more on this idea; see also “Demand-Side Financing for Critical Minerals” for more on stabilizing the critical mineral market.)

JUSTIFICATION

America must respond to China’s strategic dominance of critical mineral mining and refining. Preserving and expanding domestic supply chains of strategic goods like critical minerals is a matter of national and economic security. Market-based solutions, on their own, are unlikely to work, because China regularly seeks to lower prices in specific markets when Western sources of supply appear likely to be developed. To counteract this, the federal government, on its own or in concert with allied countries, must develop an independent supply chain for the discovery, mining, and refining of critical minerals necessary for key technologies. ■

FURTHER RESOURCES

- Dean Ball, "Restoring Leadership in Critical Minerals," *American Compass*, 2025 (this piece offers an expanded version of this proposal)
- US Geological Survey, Mineral Commodity Summaries, 2025
- Erin Dumbacher, "Closing the Critical Mineral Gap," In-Q-Tel, 2023
- Arnab Datta and Daleep Singh, "Reimagining the SPR," Employ America, 2024

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Financing for Critical Industries

Julius Krein

SUMMARY

American techno-industrial strength cannot be restored without fundamental changes to how we finance industrial innovation and scale-up production. The existing policy paradigm does not provide sufficient incentives for investment in critical industries, which has resulted in the erosion of the defense industrial base, fragile supply chains, and unsustainable macroeconomic imbalances. An American sovereign wealth fund can fill this critical gap by using public funds to activate private investment.

PROBLEM

For decades, corporate and financial market incentives favored the separation of "techno" and "industrial." Business models such as "designed in California, made in China" divorced intellectual property rents from capital- and labor-intensive parts of the value chain. Software was "eating the world" because the highest-margin revenue streams could now be harvested without return-eroding investments in hardware and physical infrastructure. On top of that, foreign subsidies and industrial policies made cap-

ital-intensive sectors less attractive domestically and more attractive abroad. Today, the definition of "tech" itself is usually applied only to businesses with low marginal costs of expansion. Although policymakers often assumed that lofty valuations demonstrated US "tech" dominance, in reality, American companies were dominating a narrow, asset-light approach to innovation while our techno-industrial prowess—from Intel to Boeing to GE to the Detroit automakers and beyond—steadily declined. The result of this decline is not only our deteriorating capability to produce submarines, artillery shells, and other military materiel in sufficient quantities. This trend also contributes to increasingly fragile and inflation-prone commercial supply chains, as well as the erosion of quality middle-class jobs, inflated asset prices, and the macroeconomic imbalances and financial precarity witnessed since 2000.

Restoring America's techno-industrial leadership therefore requires fundamental changes to investor incentives. Making America great again requires making investments in critical capital-intensive sectors attractive again. While efforts to address this challenge encompass everything from environmental permitting reform to trade policy to tax policy, these will not be enough without one of the most important approaches to investment promotion: government-supported financing.

According to conventional economic theory, industrial policy investment vehicles will always be inefficient, value-destructive, and a drag on growth because they interfere with market-driven capital allocation. If private-sector actors require government support or prodding to make an investment, the theory goes, then it must be a poor investment, even if necessary for non-economic reasons such as defense.

These models assume, however, a form of economic rationality in which firms operate to maximize profits. In reality, firms operate to maximize shareholder value. The two may occasionally overlap, but they are not identical. As a result, firms often maintain hurdle rates well in excess of their cost of capital, and pursue financial engineering strategies instead of capital investment. This behavior is often eminently rational for maximizing short-term equity valuation. The net result is chronic national underinvestment, particularly in capital-intensive sectors where foreign industrial and trade policies drive down domestically produced returns. This is one reason why the relationship between financial returns and productivity breakthroughs has always been more tenuous than standard models would predict, and why smart industrial strategy can spur economic development by dislodging financial rentierism.

Government investment promotion can therefore enable investments whose returns, while below high private-sector hurdle rates, are still positive. These investments, in turn, can form the basis of new companies, technologies, and industries, as the many historical examples of successful industrial policies attest, from Korean autos to Taiwanese semiconductors to early Silicon Valley.

Tax incentives and deregulation, while certainly needed in some areas, will not be enough to bridge the gap between investor hurdle rates and the capital-intensive realities of critical techno-industrial sectors, particularly those facing foreign-subsidized competition. Proactive state investment plays an important role in these areas, and a development-oriented sovereign wealth fund is the most effective way to structure it.

SOLUTION

A Sovereign Wealth Fund

Channeling private capital into America's critical techno-industrial sectors will require more robust government investment authorities. President Trump has ordered the Secretaries of Treasury and Commerce to offer a plan for the creation of a US sovereign wealth fund, a bipartisan idea also explored by the Biden administration and previously by now-Republican Senator David McCormick (R-PA). Such a fund could be the key investment engine of American techno-industrial revival.

President Trump's executive order of February 3, 2025 stated that the purposes of a sovereign wealth fund should include "establish[ing] economic security for future generations, and promot[ing] United States economic and strategic leadership internationally." Neither of these purposes can be met unless the financing deficits confronting critical industries are addressed. The order also directs the Treasury and Commerce Departments to investigate the necessary legal considerations, including whether legislation is needed.

Fortunately, the legislative structure for such a fund—and, realistically, Congress will have to appropriate funds for a vehicle of any size to take shape—has already been outlined by Vice President Vance during his time in the Senate. In 2024 Senator Vance was about to cosponsor a bipartisan bill to establish the Industrial Finance Corporation of the United States (IFCUS). (Vance became the vice-presidential nominee shortly before the bill was introduced). IFCUS would be a development bank focused on critical, capital-intensive industries, such as the defense industrial base, advanced manufacturing, energy, and biotech production.

The administration should recommend that Congress establish a sovereign wealth fund as a government-owned investment vehicle, along the lines of the IFCUS model, to support:

1. Robust and resilient supply chains in critical sectors and industries
2. US manufacturing and the economic development it drives
3. Domestic commercialization of advanced technologies
4. Small- and medium-sized manufacturers, especially in critical sectors
5. Critical industries facing systematic underinvestment or unfair trade and industrial policies from other nations

This kind of sovereign wealth fund could leverage $50 billion in capital to generate hundreds of billions of dollars of private-sector financing. Following the ICFUS model, its tools should include the ability to issue and guarantee loans, issue bonds, take equity stakes, acquire assets, establish investment facilities and enterprise funds, and securitize its investments.

A key advantage of a development bank, or sovereign wealth fund, for techno-industrial policy is its budgetary efficiency. Unlike government grants (as in the CHIPS Act), a $50 billion appropriation to a development fund would be leveraged to produce a much larger multiple of deployable assets. Moreover, the fund would earn returns on its loans and investments, which could be redeployed without requiring future appro-

priations. Additionally, unlike a onetime grant program (such as CHIPS), the fund's permanent, portfolio structure allows for greater experimentation, adaptation, and customizability in financing models.

It is worth noting that the US currently has not one but two development banks for foreign investments: the International Development Finance Corporation and the Export-Import Bank of the United States. Entrepreneurs looking to build factories often find it easier to raise US government funds to build abroad than at home. The Trump administration's proposed sovereign wealth fund would correct this policy omission.

The US government also maintains a raft of programs aimed at de-risking early-stage technologies across multiple departments. But these agencies have very limited resources to support scale-up production, even as foreign subsidies target precisely this area. Too often, then, US government-supported technology companies end up locating production abroad. At precisely the moment when these companies could begin hiring employees, generating tax revenue, and producing at scale, they must shift production out of the US for lack of financing. Because of our failure to finance scale-up production, existing US technology investments often function to subsidize rivals, who reap the rewards of US R&D and often use their production capabilities to seize intellectual property leadership as well. This story has played out across critical sectors, from semiconductors, to batteries, to nuclear technologies and beyond. A sovereign wealth fund to invest in scale-up development is a critical missing piece in the US techno-industrial ecosystem.

JUSTIFICATION

The combination of a development-oriented sovereign wealth fund with good tax policy (and along with the other proposals outlined in this collection) could supercharge investment in America's techno-industrial future. The timing for the Trump administration is also propitious. The pressure to compete in AI has driven software companies to undertake previously unthinkable capital expenditures. Firms like Microsoft, Google, and Meta, whose business models defined the "fissured economy" of asset-light services separated from physical investments, are now investing in vertically integrated energy generation and securing hardware supply chains. At the same time, novel combinations of private equity, private credit, and insurance structures open new avenues for financing capital-intensive projects. Apollo Global Management, for instance, led multiple investments in chip manufacturing, in some cases in tandem with CHIPS Act funding. This model has also been proven internationally. The European Investment Bank achieved a 15:1 ratio of private to public capital deployment in its "Juncker Plan."

During the last several decades, Americans found a way to financially engineer seemingly everything except for investments in critical techno-industrial capabilities. Today, that may be changing, and prudent, proactive government investments offer a unique opportunity to finally mobilize the private capital needed for techno-industrial revival. ■

FURTHER RESOURCES

- American Compass, "A Domestic Development Bank: Financing American Industrial Development," 2023
- David Adler, "Financing Advanced Manufacturing: Why VCs Aren't the Answer," *American Affairs*, 2019
- David Adler and William B. Bonvillian, "America's Advanced Manufacturing Problem—and How to Fix It," *American Affairs*, Fall 2023.
- David McCormick, *Superpower in Peril: A Battle Plan to Renew America*, Center Street, 2023, 2019
- Senator Marco Rubio, "American Investment in the 21st Century," 2019

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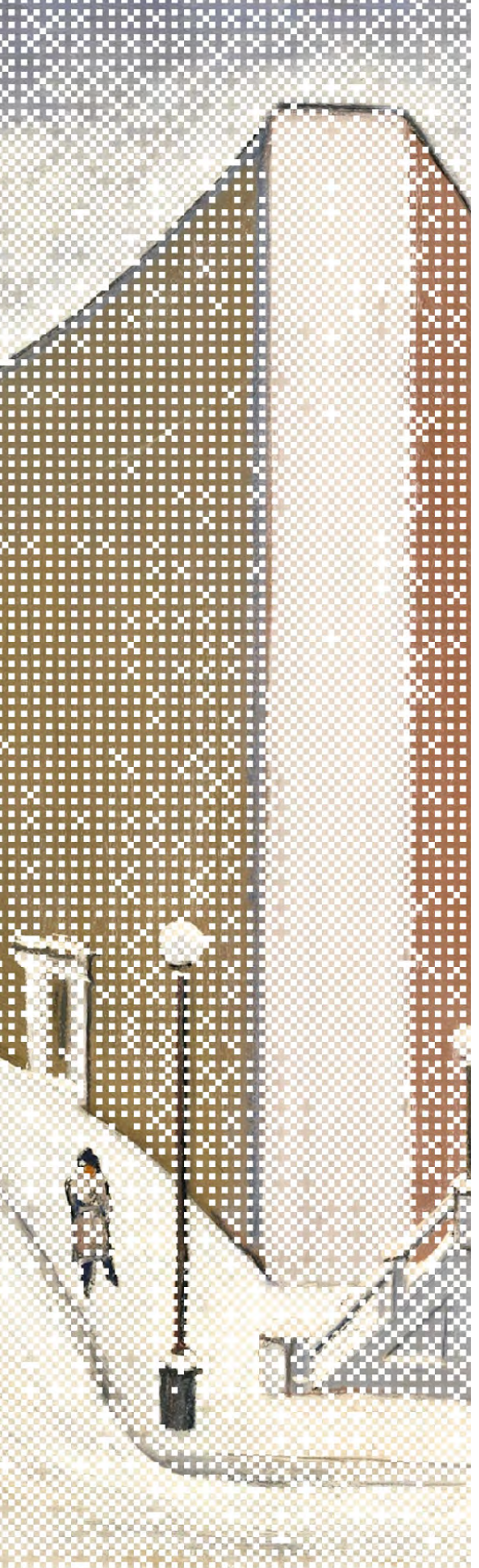

■ Industrial Power

Accelerating Strategic Place-Based Investments

Connor O'Brien

SUMMARY

Congress has made a down payment of nearly $1 billion toward place-based innovation programs since 2021 through four programs:

- The Department of Commerce's Regional Technology and Innovation Hubs, which aim to seed globally competitive hubs across a range of emerging technologies;
- The National Science Foundation's Engines program, which seeks to build R&D clusters in parts of the country that are not home to cutting-edge scientific research;
- The Small Business Administration's Regional Innovation Clusters, which support accelerators, incubators, and technical assistance for startups in 10 geographic regions; and
- The Department of Defense's Microelectronic Commons Hubs, which seeks to expand manufacturing capacity and talent pipelines in the semiconductor industry across the country.

Such investments recognize the role federal investments in R&D and commercialization ecosystems have historically played in reinforcing American industrial might, and have focused on "hubs" and "clusters." Clusters refer to tight concentrations of specialized talent and firms vital to spurring innovation. Hubs are typically centered around economic development organizations (often nonprofits) that make workforce development investments, provide mentorship and technical assistance to startup founders, and run testbeds for companies to experiment with low-volume production of new technologies.

But awards through the Tech Hubs, Engines, and other such programs are a first step. The ultimate goal of these investments is to seed self-sustaining agglomerations of profitable firms in industries that matter for US national and economic security, such as semiconductors, critical minerals, biotech, and energy production. Yet firms participating in these programs enjoy no regulatory relief alongside federal awards. "Hub" designations indicate that Congress and the administration view the success of such projects as critical. While there is value in convening regional stakeholders through clustering policies, designations themselves do not solve practical problems for associated firms or founders trying to build.

Congress and the administration should pursue broad deregulation over the next few years to make American industry more competitive, including deep overhauls of environmental and permitting laws like the National Environmental Policy Act. In the meantime, the president should establish a new task force with a mission to accelerate permitting and regulatory waivers for firms participating in critical place-based consortia. The task force should work to the maximum extent allowable under the law to accelerate tech hubs' progress as they begin to mature into full industrial ecosystems.

PROBLEM

Agglomeration effects—the productivity benefits from highly specialized workers and firms being in close proximity to each other—are an important driver of American innovation. "Superstar cities" such as San Francisco and New York generate a disproportionate share of the country's most promising startups, even as they fall short in other areas of governance, because they forge dense networks of talent and expertise.

An American industrial strategy should carefully foster such clusters to compete with China in key technologies. Place-based investments in the CHIPS and Science Act have seeded organizations coordinating hubs across the country. The Nevada Tech Hub, for example, aims to build a "lithium loop" near Reno that includes the entire electric vehicle battery supply chain. Its seven-pillar strategy has a goal of spurring the creation of 3,000 new businesses and 50,000 new jobs by 2029, largely by expanding workforce development pathways. Such plans have already secured a commitment from Lyten to build "the world's first lithium-sulfur gigafactory."

The Nevada hub has the potential to transform the state into a mining and battery manufacturing powerhouse, as do other hubs in other states, but only if participating firms ultimately receive permission to build quickly and affordably. Tens of millions of dollars in workforce training subsidies from the state or federal level will be for naught

if the status quo gauntlet of permitting, environmental reviews, local procurement rules, and more continues to slow down builders and raise costs. As President Trump designates more tech hubs across an array of programs, perhaps focused on reinvigorating our defense industrial base or energy supply chains, these barriers will continue to snag projects of strategic value.

Individual agencies tasked with designating, managing, and supporting innovation hubs are limited in how they can help. While the Small Business Administration manages Regional Innovation Clusters in areas ranging from underwater drones to speculative agricultural technology, for example, the agency has neither subject matter expertise nor legal authority to overcome participating firms' regulatory obstacles. Strong leadership from the White House, however, can cut through divisions between agencies and force solutions.

SOLUTION

Mission

The president should issue an executive order establishing a Task Force for Accelerating Strategic Investments to directly interface with firms, economic development agencies, local governments, and nonprofits affiliated with Tech Hubs, Engines consortia, and other place-based economic development clusters designated as strategically significant by the President. The president should delegate to the task force the authority to order agencies to accelerate and give priority to any environmental, security, or permitting reviews associated with such investments.

Activity

The task force should proactively survey firms, researchers, and local officials participating in Tech Hubs or Engines clusters. Its members should investigate any regulatory barriers actively impeding or slowing private or non-profit research initiatives or the construction or operation of commercial facilities tied to the consortia's areas of focus. The task force should function as "bottleneck detectives," identifying all practical steps within existing legal authorities to waive relevant discretionary rules, regulations, or processes likely to raise costs or delay production for facilities directly tied to federal, place-based policy investments. Once identified, it should order agencies to carry out those steps. Such authorities might include, but should not be limited to, national security exemptions under the National Environmental Policy Act, Endangered Species Act, Clean Air Act, or Defense Production Act.

While executive agencies in conjunction with the Office of Management and Budget (OMB) are working to reduce the reach of the regulatory state pursuant to E.O. 14192 (with its "1 in, 10 out" rule), the task force prescribed in this memo should focus on simultaneously maximizing the use of authorities under *existing* regulations. Both efforts can happen concurrently. President Trump, in his first term, issued E.O. 13927, which ordered agencies to maximize the use of emergency and discretionary

authority under the National Environmental Policy Act, Endangered Species Act, and other authorities to accelerate infrastructure projects to the "fullest extent possible and consistent with applicable law." The White House should draw on the language of this executive order when setting up the task force.

Structure

Federal hubs represent a wide range of industries, from quantum computing to aerospace manufacturing. Paired with centralized decision-making authority, the task force's membership should reflect the breadth of the hubs it's designed to assist, with a broad membership useful for sourcing ideas. The task force should include representatives from the following:

- White House Office of Science and Technology Policy;
- National Science Foundation;
- Department of Commerce;
- Environmental Protection Agency;
- Department of Defense;
- Department of the Interior; and
- Department of Energy

Transparency

The task force should issue reports every 90 days disclosing its contacts with innovation hub members. It should also issue an annual report recommending legislative reforms for Congress and disseminating best practices at the state level.

JUSTIFICATION

Regulatory carve-outs for projects critical to national or economic security are nothing new. In 2023 Congress passed the Building Chips in America Act, which exempted the semiconductor projects that the bill funded from federal reviews under the National Environmental Policy Act and the National Historic Preservation Act. Congress passed this law on a bipartisan basis, recognizing that while disagreements remained on the proper extent of broad-based permitting reform, the national security imperative to reshore leading-edge semiconductor manufacturing was too urgent to let such debates get in the way.

The Task Force for Accelerating Strategic Investments should be viewed as a temporary measure. The US needs deep reforms to permitting, environmental law, and manufacturing policy more generally if it is going to reindustrialize in sectors critical to economic and national security. But such an overhaul will be subject to lengthy debate, while investments in regional tech clusters will succeed or fail on a much shorter time horizon.

One model to draw on is the "regulatory sandbox." States across the country have experimented with the sandbox concept, which allows participating firms to tempo-

rarily operate under a looser regulatory regime, subject to close monitoring and consumer protection and environmental safeguards. Utah became the first state to adopt an all-industry sandbox in 2020, administered by the Office of Regulatory Relief. Sandboxes' discretionary model is attractive, but its temporary relief has limited participation to only a handful of companies in the Utah experiment. The task force recommended here should instead provide ongoing relief. In the case of tech hubs, the sandbox model would have two benefits. First, it would provide immediate relief to firms making strategically significant investments. Second, such experiments could serve as useful models for broader regulatory reforms.

There are a number of relevant precedents for this task force from prior administrations. In 1981, President Ronald Reagan established his Task Force on Regulatory Relief (E.O. 12291), taking *de facto* centralized control of the administration's regulatory agenda and settling disputes between agencies and OMB. This effort did slow the cadence of new regulations, as well as loosen proposed rules from agencies; the number of pages in the *Federal Register* fell nearly 40 percent in President Reagan's first five years in office. President George H.W. Bush built on this model with the White House Council on Competitiveness, which served a similar function of surveying industry and steering agencies' proposed rules. The president may also be able to draw on authorities within the National Emergencies Act unlocked by E.O. 14156, which declared a "national energy emergency." ■

FURTHER RESOURCES

- Caleb Watney, "Clusters Rule Everything Around Me," *Works in Progress*, 2020
- Robert D. Atkinson, Mark Muro, and Jacob Whiton, "The Case for Growth Centers: How to Spread Tech Innovation Across America," Brookings Institution and Information Technology and Innovation Foundation, 2019
- Eric Carlson, Adam Ozimek, and Kenan Fikri, "CHIPS off the Federal Funding Block: Using Data to Inform the Location of the 20 New Regional Innovation Hubs," Economic Innovation Group, 2022
- Thomas Hochman, "So You Want to Ignore an Environmental Law," *Green Tape*, 2025

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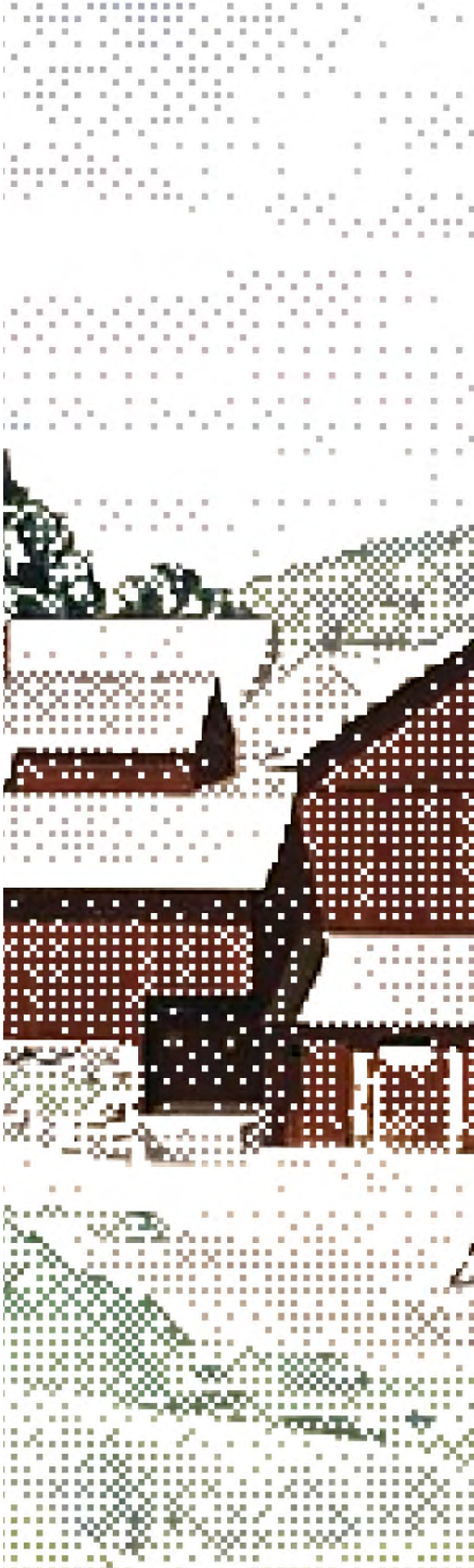
■ Industrial Power

Reforming the Small Business Administration

Samuel Hammond



SUMMARY

The Small Business Administration (SBA) possesses uniquely strong and underutilized authorities for supporting innovative American manufacturers. Congress has not passed legislation reauthorizing SBA since 2004, presenting an opportunity for a future reauthorization to leverage SBA's loan and investment authorities toward manufacturing and hard tech startups. Congress should reform the Small Business Investment Companies (SBIC) program to streamline fund applications and enhance the leverage available for investments in key manufacturing sectors; create an Innovation Growth Loan program to provide innovative manufacturers with scaling capital; and modify SBA's small business criteria to make it easier for manufacturers to expand beyond their "small" status without an abrupt loss in eligibility.

PROBLEM

Rebuilding America's industrial base will require growing a robust ecosystem of small and

medium manufacturers, as even the largest manufacturers in the United States rely on smaller manufacturers and parts suppliers throughout their supply chain. However, the patient forms of debt and equity financing best-suited to manufacturing are chronically undersupplied in the US context. Rich nations with resilient manufacturing sectors, such as Israel and Germany, address these gaps in financing with industrial development banks.

While the US could adopt a similar approach by creating its own development bank, leveraging the latent authorities of the SBA offers a simpler path forward. Indeed, as an offshoot of the Reconstruction Finance Corporation, the SBA already has many if not most of the authorities associated with a development bank, from loan guarantees to equity issuance. The SBA's long-overdue congressional reauthorization thus provides an opportunity to redirect these authorities toward bolstering and scaling innovative small and medium manufacturers, including the sorts of hard-tech startups that venture capital has traditionally overlooked.

SOLUTION

Congress should reauthorize the SBA and include the following reforms:

- Streamline eligibility rules and licensing timelines for SBICs, while expanding the leverage available for investments in advanced manufacturing with specialized "Innovation Debentures."
- Establish a new Innovation Growth Loan program to provide scaling capital to R&D-intensive manufacturers seeking to ramp up production.
- Align the SBA's suite of policies with manufacturing priorities, including by amending and extending the criteria and review period for small and medium manufacturers, making it easier for firms to grow beyond their "small" status without an abrupt loss in eligibility.

JUSTIFICATION

These proposed reforms to the SBA are largely drawn from the SBA reauthorization proposed by the Senate Small Business Committee in 2019 under then-Chairman Marco Rubio. Inspired by analogous policies in Israel and Germany, the reforms seek to leverage SBA's existing authorities in debt and equity financing to serve as a quasi-development bank for advanced manufacturers. While the reauthorization was derailed by the COVID-19 pandemic, many of its core proposals are worth revisiting, and have the benefit of existing legislative text and background research.

Small Business Investment Companies

SBICs are privately owned and operated investment funds licensed and regulated by SBA that provide long-term debt and equity capital to small businesses. Created in

1958, the program operates as a unique public-private partnership where SBICs use their own capital plus funds borrowed with an SBA guarantee to make leveraged investments in qualifying small businesses.

SBICs have been credited with helping spur America's robust venture capital sector, but have since become overshadowed by private funds. This partly owes to cumbersome and outdated licensing regulations that privilege professional fund managers with a track record of realized returns. This disadvantages emerging VC funds and tech investors who may have gained substantial relevant experience as founders or in corporate development. Additionally, the focus on realized returns is out of step with the realities of modern early-stage venture financing, where returns may take longer to realize or come from alternative deal structures.

By streamlining and modernizing licensing processes and establishing clear timelines for SBA decisions, existing VCs could be induced to establish an SBIC on the side. The creation of specialized "Innovation Debentures" for advanced manufacturing investments would then enable the strategic and technical acumen contained with America's top VC funds to turn towards identifying investment opportunities in advanced manufacturing and hard-tech. Innovation Debentures would come with a revenue-based repayment structure to better match manufacturing's growth patterns, and include incentives to maintain US production, such as penalties for offshoring.

Innovation Growth Loans

The Innovation Growth Loan program is a proposal to create a new SBA loan category for R&D intensive advanced manufacturing seeking to scale their production. As detailed in the markup of the SBA Reauthorization Act of 2019, Innovation Growth Loans would:

- Provide loans of up to $50 million for scaling US-based manufacturing (defined by industry code and R&D intensity).
- Require at least 50 percent of funds to go toward productive capital assets
- Use tranched disbursement tied to growth benchmarks.
- Feature a revenue-based repayment structure.

The high-powered scaling capital and revenue-based repayment structure provided by Innovation Growth Loans are designed to allow advanced manufacturers to escape the "valley of death"—the $15–40 million funding gap that often forces innovative manufacturers to either relocate production overseas or sell to foreign acquirers. In exchange, tranched disbursements, growth benchmarks, and the requirement that funds be immediately put toward productive capital assets help to align incentives toward scaling while ensuring accountability.

Modernizing SBA definitions and review periods

Supporting these major initiatives would benefit from strategic reforms to SBA's overall approach to manufacturers. Such reforms would include:

- Extending manufacturers' size standard review period to five years to give firms more runway to grow before losing small business status.
- Increasing loan caps across existing programs like 504 loans to recognize manufacturing's higher capital requirements.
- Increasing SBA's coordination with the Manufacturing Extension Partnership program to help integrate technical assistance with capital access.

Taken together, these reforms would transform the SBA into a more effective partner for innovative manufacturers at all stages of growth, from early stage startup and initial scale-up through to maturation into large manufacturing enterprises. Rather than creating new agencies or authorities from scratch, the proposal leverages SBA's existing capabilities while redirecting them toward rebuilding America's industrial commons.

FURTHER RESOURCES

- SBA Reauthorization and Improvement Act of 2019
- SBA markup section-by-section, 2019
- Samuel Hammond and Connor O'Brien, "How Congress Can Address America's Startup Shortage," *National Review*, 2019

Samuel Hammond is Chief Economist at the Foundation for American Innovation. He previously worked as the Director of Social Policy for the Niskanen Center and as an economist for the Government of Canada specializing in regional economic development.

Upgrading the Manufacturing Extension Partnership

Ryan Kelly

SUMMARY

The Hollings Manufacturing Extension Partnership (MEP) is a nationwide network that serves as a cornerstone of America's manufacturing ecosystem. Anchored at the National Institute of Standards and Technology (NIST) with centers in every state and Puerto Rico, MEP connects small and medium-sized manufacturers (SMMs) with the expertise and resources they need to innovate, improve productivity, and compete globally. Through this unique public-private partnership, federal, state, and private support are combined to deliver high-impact services—from technology adoption and process improvements to workforce training and supply chain optimization. For over three decades, MEP's proven model has empowered thousands of manufacturers, delivering strong returns on investment for taxpayers while fueling growth in local economies.

Today's volatile economic and security environment demands that MEP intensify its role in bolstering American manufacturing. This proposal calls for a comprehensive upgrade of

MEP to serve as a true engine of reindustrialization, in support of urgent national priorities such as building resilient supply chains, enhancing defense industrial capabilities, and driving breakthrough manufacturing innovation. MEP is not currently optimized to fill this function; the following measures will unlock MEP's full potential as a dynamic driver of national industrial strength.

PROBLEM

Current Challenges

DECENTRALIZED DELIVERY: MEP's network of 51 centers operates with significant autonomy, resulting in variable service quality, limited scale, and inconsistent impact across regions.

LACK OF STANDARDIZATION: There are no uniform national benchmarks for evaluating technology adoption and productivity gains. Without these tools, improvements in productivity, supply chain resilience, and job creation are difficult to track.

BROAD INDUSTRY GAPS: US SMMs face fierce global competition, persistent supply chain vulnerabilities, technology adoption gaps, and workforce shortages that compound the challenges MEP is meant to address.

Why It Matters

DEFINING STRATEGIC PRIORITIES: A modernized MEP should be laser-focused on boosting productivity, promoting reshoring, and securing critical supply chains in strategic sectors. Uniform benchmarks—set by NIST under broad guidance from the White House—should define key outcomes like technology integration, productivity gains, and supply chain resilience, ensuring all centers work toward the same national priorities.

FOCUSING ON OUTCOMES: This proposal recommends shifting the evaluation focus from how MEP centers report their activities to the tangible improvements in manufacturers' operations. Prioritizing outcomes—such as increased productivity, accelerated technology adoption, and strengthened supply chains—MEP can ensure that its policy and practice is focused on the foundation for a unified measurement system geared to national strategic goals.

IMPROVING MEASUREMENT AND ACCOUNTABILITY: Uniform metrics enable direct comparisons across regions, highlight best practices, and reveal gaps where further support is needed. This approach allows policymakers to make data-driven decisions, refine performance-based funding, and ensure that every federal investment translates into meaningful, measurable progress toward national industrial goals.

Urgency

RAPID TECHNOLOGICAL ADVANCEMENTS: With technologies evolving at a breakneck pace, American manufacturers must rapidly adopt advanced methods to remain competitive. An enhanced MEP is ideally positioned to assist by serving as a central hub that disseminates cutting-edge manufacturing practices. By providing expert assistance, training, and digital toolkits, MEP can accelerate adoption of automation, AI, and cybersecurity, helping manufacturers quickly capitalize on new innovations.

SUPPLY-CHAIN DISRUPTIONS: Global shocks have exposed significant vulnerabilities in US production systems, underscoring the need for robust, coordinated responses. An enhanced MEP can play a vital role in strengthening supply chains by offering targeted technical assistance in risk management, digital connectivity, and resiliency planning. Integrating regional expertise with best practices, MEP can help manufacturers quickly respond to disruptions.

SOLUTION

Executive

NIST, the Department of Commerce's agency dedicated to promoting national industrial competitiveness, should do the following.

EXPAND MEP CAPACITY: Increase federal matching grants and establish centrally determined performance targets focused on national industrial goals as set by the White House, acting through a designated Manufacturing Council or other appropriate office.

CREATE UNIFIED BENCHMARKS AND TOOLKITS: Develop national benchmarks that all MEP centers must implement to consistently measure and guide improvements. Benchmarks should focus on:

- Advanced Technology Utilization: Metrics might include data integration levels, adoption of "digital-twin" simulations, cybersecurity preparedness, and cross-factory collaboration. Germany's Industrie 4.0 initiative successfully used similar standardized benchmarks (like the RAMI 4.0 reference architecture) to accelerate technology adoption and standardization nationwide. Though the framework is nearly 15 years old, it still serves as an effective model for structured guidance.
- Supply Chain Responsiveness and Resilience: Benchmarks like Manufacturing Critical Path Time (MCT)—measuring the total duration from order placement to delivery—can help identify and eliminate production bottlenecks, enhancing agility and responsiveness. MCT complements lean manufacturing by pinpointing process bottlenecks and opportunities for faster, more agile production. Additionally, measuring on-time delivery rates, supplier diversification (with particular emphasis on increasing domestic suppliers), and Time-to-Recovery (TTR) after disruptions can reveal how well MEP-assisted firms withstand shocks—an increasingly vital metric in today's volatile environment.

- Productivity Gains and Quality Improvement: Operational outcomes such as increased output per worker, reduced defects, and higher first-pass yields are useful measures of productivity gains. If MEP assistance boosts productivity by enabling manufacturers to achieve higher output with existing resources, these metrics can directly demonstrate modernization's economic impacts.

Given the rapid pace of technological change, a structured, collaborative review process—engaging manufacturers, industry groups, and technology experts—should regularly update these benchmarks. NIST should align these metrics closely with national industrial priorities set by political leadership, focusing on strategic objectives. Standardized toolkits, based on updated benchmarks, will then provide practical, actionable guidance for manufacturers and MEP centers nationwide, accelerating digitization, productivity gains, and enhanced supply chain resilience.

State Economic Development Agencies

STREAMLINE COORDINATION: States should formalize partnerships via MOUs among MEP centers, state agencies, and financial institutions, clearly outlining roles and ensuring timely access to financing and training. For example, states could establish a joint advisory board that links MEP centers with local banks to facilitate referrals and monitor outcomes. Successful models include New York's integration of MEP with state economic development and Maryland's Manufacturing 4.0 program.

Workforce Development Offices

INTEGRATE TRAINING PROGRAMS: Workforce Development Offices should establish formal partnerships with MEP centers and local educational institutions—through agreements such as MOUs—to embed advanced manufacturing and cybersecurity training into community college curricula and apprenticeship programs. This approach would create a seamless pipeline of skilled talent tailored to modern manufacturing needs. For example, New Jersey MEP's Pro-Action Education Network achieved 100 percent job placement rates through partnerships embedding manufacturing and cybersecurity training into local curricula. (Such an approach will benefit from broader workforce development improvements as well.)

Congress

The relevant committees (e.g., House Committee on Science, Space, and Technology , Senate Committee on Commerce) should:

FOCUS ON PERFORMANCE-BASED FUNDING AND ACCOUNTABILITY: Legislation should tie federal matching funds to measurable outcomes (e.g., productivity, technology adoption, resilience). Enhanced matching grants rewarding states exceeding baseline contributions will drive accountability.

INCENTIVIZE STATE AND PRIVATE CO-INVESTMENT: Legislation should promote state matching and private-sector co-investment through challenge grants (similar to those used in Manufacturing USA institutes) and formal public-private partnerships that recognize in-kind contributions and fee revenues (as seen in the Department of Agriculture Cooperative Extension's matching approach).

JUSTIFICATION

Established in 1988, the MEP supports SMMs, generating significant economic benefits. However, to sustain these outcomes amid escalating global competition and rapid technological changes, MEP's current structure requires modernization.

Global competitors significantly outpace US investments in manufacturing support programs. Germany's Fraunhofer Institutes receive approximately $1 billion annually, far surpassing MEP's 2025 federal budget request of $175 million. Recent global disruptions—from Covid-19 to geopolitical tensions—have highlighted US supply chain vulnerabilities, underscoring the urgency of empowering small manufacturers to swiftly adopt advanced technologies and localize critical production.

MEP currently serves only a fraction of the nation's approximately 246,000 small and medium-sized manufacturers, reaching about 36,000 firms in 2023. Limited federal funding and inconsistent service capabilities constrain centers' ability to support widespread, transformative technology adoption. While decentralization fosters local responsiveness, it also leads to uneven service quality and incremental rather than comprehensive technological upgrades. As manufacturing technology advances rapidly, MEP's capacity to deliver advanced support in automation, AI, and cybersecurity remains limited, hindering national competitiveness.

Without MEP modernization, the US risks ceding technological leadership and manufacturing capacity in its SMM sector to international competitors such as China, which direct vast resources toward dominating high-tech industries. Continued reliance on foreign suppliers jeopardizes national security, especially during crises. Competitive small- and medium-sized manufacturers play a critical role in advancing American industrial strength. An upgraded MEP can help more of them step into the role America needs them to. ■

FURTHER RESOURCES

- Government Accountability Office, "Manufacturing Extension Partnership," 2019

Ryan Kelly is Vice President of Technology at the Association For Manufacturing Technology (AMT), a 120-year-old nonprofit dedicated to strengthening the US industrial base through advanced manufacturing solutions.

■ Industrial Power

Securing Energy and Stabilizing Prices Through the Strategic Petroleum Reserve

Arnab Datta and
Skanda Amarnath

SUMMARY

The US economy requires stable commodity supplies, with current markets suffering from harmful volatility cycles that damage industrial suppliers and end-users. While storage facilities typically stabilize oil markets, critical market deficiencies undermine this function.The Strategic Petroleum Reserve (SPR) has become misaligned with today's energy landscape, focusing on heavy sour crude while domestic production and marginal refining capacity have shifted to light sweet crude, and lacking effective market engagement mechanisms.

This proposal recommends: (1) appropriating at least $4 billion for future purchases to stabilize the market; (2) expanding SPR with a new cavern at Richton, Mississippi, connected to the WTI Cushing market; and (3) reauthorizing an expansion of the SPR to establish a "Strategic Resilience Reserve" (SRR) that can actively manage market volatility for other industrial commodities.

This approach builds on successful recent initiatives and would employ both preventative measures (long-term contracts, contracting for

inventory minimums) and reactive interventions (strategic releases, market operations) to ensure stable, resilient commodity markets critical to US economic security.

PROBLEM

Stable and resilient commodity supplies are critical for the US economy. In 2022, 27.5 percent of petroleum used in the US was allocated to industrial and manufacturing sectors, not inclusive of fuel use in transportation. Unfortunately, commodity markets are inherently volatile, following "boom and bust" supercycles that impose painful costs on industrial users and, ultimately, consumers through inflation shocks and supply scarcity.

In effectively functioning commodity markets, storage can serve as a crucial shock absorber, dampening price spikes and preventing price crashes. During downturns, buyers "of last resort" can purchase and store until the market recovers and then sell the product at a profit. One mechanism through which this occurs is the West Texas Intermediate (WTI) crude oil financial contract, a contract bought and sold via the New York Mercantile Exchange (NYMEX). At the predetermined delivery date, the purchaser takes ownership of the crude oil, which delivers to a physical location in Cushing, Oklahoma, which has approximately 90 million barrels of oil storage capacity. Located at the heart of North America's oil pipeline network, the Cushing location provides producers, refiners, and traders ready access to purchase, sell, and transport oil barrels as needed. When demand softens or prices drop, participants can utilize Cushing's storage tanks rather than selling at unfavorable rates, helping to stabilize spot prices. Additionally, pipeline infrastructure connecting Texas production to Cushing enables rapid oil inflows when local prices rise, dampening the pace of price spikes.

However, two market deficiencies undermine this stabilizing function.

First, building sufficient storage capacity requires substantial investment that private market participants find economically unjustifiable. This results in limited storage capacity that proves inadequate during tail-risk scenarios. In March 2020, when Covid-19 and the Russia-Saudi Arabia price war crashed oil prices, insufficient storage capacity pushed WTI to negative prices. The 2020 price crash led to bankruptcies in the oilpatch. Even as the economy (and oil prices) recovered, domestic oil investment lagged. The parsimonious investment response ultimately set the stage for the price shock of late 2021 and 2022. This price shock was incredibly harmful for all consumers of petroleum products, including industrial users. The manufacturing sector experienced a sharp increase in costs between 2021 and 2022 for petroleum-based inputs such as lubricants, rubber, and plastics and transportation costs, weakening profitability. In the second quarter of 2022, Caterpillar Inc. reported that manufacturing costs had decreased their operating profits largely reflecting higher material and freight costs.

The second market deficiency emerges during precipitous price increases. Insufficient storage means private inventories may lack adequate product to keep prices at tolerable levels for consumers during severe shortages. Moreover, in certain extreme scenarios with supply uncertainty, such as following the Russian invasion of Ukraine, firms will engage in precautionary stock building rather than release product to relieve price pressure

These are both entirely logical business decisions—it is not the private industry's job to prevent tail risks, it is to operate and deliver returns for shareholders. But the resulting price shocks hurt all consumers of petroleum products. While the American media typically centers the individual gassing up their automobile, major industrial users suffer as well.

Sound policy is critical to avoiding the oilpatch bankruptcies and the attendant commodity cost dynamics that harm industrial producers and end-users. Unfortunately, long-duration storage facilities are particularly uneconomical for private investment, requiring significant capital expenditure with limited return potential.

Enter the Strategic Petroleum Reserve. Established in 1975 in wake of the Arab oil embargo, the SPR was traditionally valued for the quantity of crude oil stored, but the US energy landscape has evolved. As the US has become the world's largest producer and a net exporter, vulnerability to crude supply shortages has diminished. Instead, risks have shifted. The vulnerability of the American shale sector to price crashes is significant, and the American economy is typically more strained by the supply of refined products and critical minerals essential for industrial and energy applications. The SPR's infrastructure is not optimally configured to balance statutory requirements with the production mix of the market and its infrastructure.

Recent SPR acquisitions have been for sour, heavy crude oil, the grade of unrefined oil typically produced offshore in the US Gulf Coast and more heavily aligned with our domestic refining capabilities. However, this approach overlooks the significant shift in domestic production toward shale-derived light sweet crude over the past decade. These short-cycle wells are more responsive to policy influence than deepwater operations. Unfortunately, since grades cannot be commingled, there is not sufficient SPR storage capacity for sweet, light crude, limiting the government's ability to be a "buyer of last resort" to protect investment in the shale patch. Furthermore, because SPR acquisitions occur outside the liquid market for WTI contracts, the price stabilizing effect is somewhat muted. From a legal perspective, the Department of Energy is not only permitted but mandated to find a solution. The SPR's authorizing statute requires the Secretary to acquire petroleum in a manner that, among other things, minimizes cost, promotes competition, maximizes domestic production, and avoids excessive cost or appreciably affecting the price of petroleum products to consumers.

SOLUTION

- Congress should appropriate at least $4 billion to the Department of Energy to stabilize the market and protect the US shale sector in the event that prices crash precipitously.
- Congress should reauthorize and appropriate for the expansion of a new SPR cavern at the Richton, Mississippi site that previously received NEPA approval. Congress should additionally authorize the exploration and construction of a pipeline to connect it with Cushing (directly, or indirectly through the Nederland terminal), allowing intake of excess crude when existing private storage terminals reach capacity. Further infrastructural improvements are also needed to expand

intake capacity at existing caverns, which have deteriorated from poorly structured congressionally mandated sales.

- Finally, Congress should expand the Strategic Petroleum Reserve's authority to establish a Strategic Resilience Reserve to support market resilience for critical industrial and energy commodities beyond oil.

JUSTIFICATION

The proposed Richton, Mississippi SPR expansion addresses critical infrastructure limitations that have hindered the SPR's effectiveness in today's energy landscape, and allows SPR facility alignment with domestic production and marginal refining capacity that has shifted dramatically toward light sweet crude from shale formations. The Richton site received NEPA approval in 2007, making it an expedient choice for expansion. (The expansion plan was effectively terminated during the Obama administration; the Trump administration can remedy this mistake). Furthermore, connecting this facility to the Cushing, Oklahoma hub—the delivery point for WTI crude contracts—would create a direct mechanism for government intervention in the benchmark crude market. This connectivity would enable direct price stabilization of excess crude when private storage terminals reach capacity, as happened catastrophically during the 2020 market collapse when WTI prices went negative due to storage limitations. In the future, such a price-stabilizing mechanism could prevent a subsequent price shock that harms industrial users.

The proposed evolution from the SPR to a broader Strategic Resilience Reserve (SRR) builds on successful precedents while addressing the limitations of past approaches. The post-2008 financial systemic risk framework offers an instructive model, combining preventative measures with reactive tools to intervene when markets destabilize. Similarly, an SRR would deploy both preventative tools (long-term fixed-price contracts, inventory minimums) and reactive measures (strategic releases, market operations) to ensure commodity market stability.

The SRR would significantly improve upon current mechanisms by enabling direct intervention through market channels. Compared to the aforementioned clunky SPR acquisition process, an SRR trading physically cleared, financial benchmark contracts tied to storage facilities could act more quickly to stabilize market disruptions engineered by adversaries, and provide the necessary foundation for market infrastructure less vulnerable to external shocks and localized supply disruptions.

Furthermore, broadening the SRR's scope beyond petroleum to include critical minerals and other essential commodities would strengthen US economic security in an era of increasing supply chain vulnerabilities. Recent energy market turbulence has demonstrated that strategic intervention is necessary and justified to prevent harmful price shocks that weaken our manufacturing sector. ■

FURTHER RESOURCES

- Arnab Datta, Alex Williams, and Skanda Amarnath, "Contingent Supply: The SPR Is More Equipped Than Ever to Stabilize Oil Prices," Employ America, 2022
- Daleep Singh and Arnab Datta, "Reimagining the SPR," *Financial Times*, 2024
- Arnab Datta and Alex Turnbull, "Contingent Supply: The Federal Government's Interest in a Liquid Lithium Benchmark," Employ America, 2023

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APPENDIX

Glossary

LIGHT SWEET CRUDE: A type of unrefined oil with low sulfur content that is easier and cheaper to refine, and often produced from shale formations.

NEW YORK MERCANTILE EXCHANGE (NYMEX): A commodity futures exchange where WTI crude oil contracts are traded.

SHORT-CYCLE WELLS: Oil wells that can be quickly brought online or offline, are typically associated with shale oil production, and can provide more immediate responsiveness to market changes.

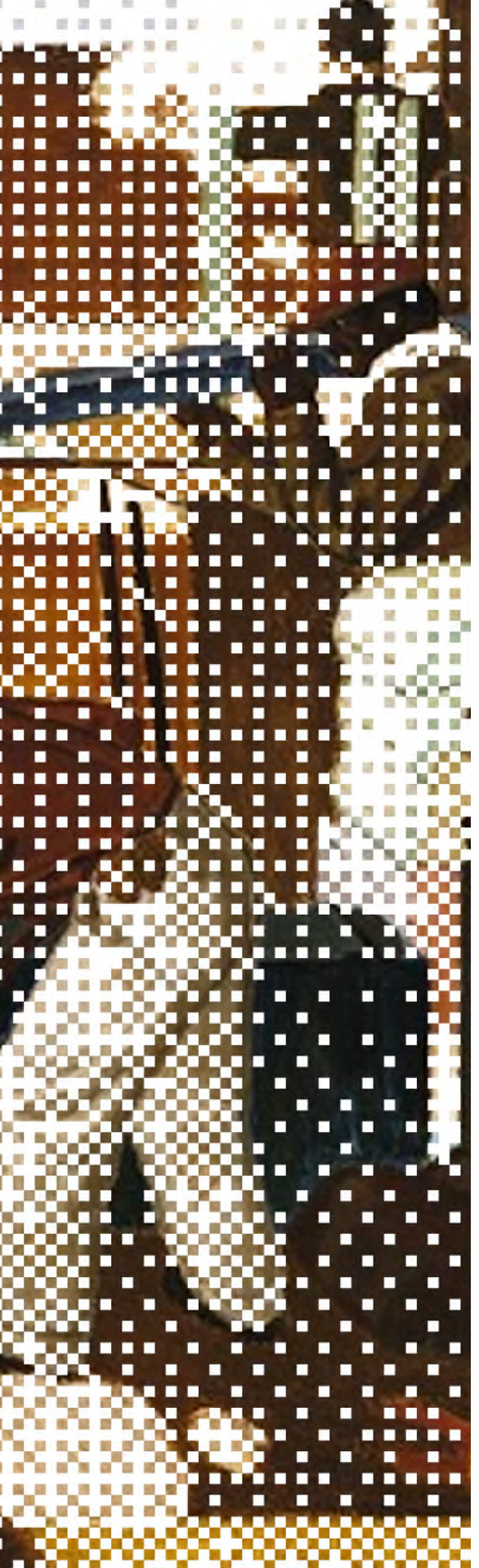
SOUR HEAVY CRUDE OIL: A type of crude oil characterized by high sulfur content (making it "sour") and high density or viscosity (making it "heavy"). It is more challenging and costly to refine compared to lighter, sweeter crudes because its higher sulfur levels require additional processing steps to remove impurities, and its heavier nature often yields lower proportions of high-value products like gasoline and diesel. Sour heavy crude is commonly produced in regions such as the Gulf Coast and certain parts of the Middle East. US refining capacity is currently oriented more towards sour crude than with light, sweet crude produced in the shale regions.

SPOT PRICES: The current market price at which a commodity can be bought or sold for immediate delivery.

STRATEGIC PETROLEUM RESERVE (SPR): A government-controlled reserve of crude oil, established to provide emergency supply during shortages or price spikes. It consists of a set of storage facilities across four sites on the gulf coast; the storage itself is a

series of salt caverns where up to 714 million barrels of crude oil can be stored for extended periods.

WEST TEXAS INTERMEDIATE (WTI): A benchmark grade of crude oil used in trading and pricing, typically delivered and stored at the Cushing, Oklahoma hub.



■ Industrial Power

Building a Techno-Industrial Workforce

Chris Griswold

SUMMARY

A deficit of willing and qualified workers is a serious obstacle to American industrial revitalization. Yet American education and workforce development policy shunts the great majority of federal dollars to a broken higher education system that is not producing the workforce that national industrial strength requires.

Congress should create a workforce training grant of $10,000 per worker trained per year, designed to make high-quality on-the-job training economically viable for both employers and trainees. This grant should be paid for by an endowment tax and by repurposing a portion of existing federal education dollars. The Department of Labor should launch a pilot version of this approach using unspent H-1B visa fee funds.

PROBLEM

A deficit of willing and qualified workers is a serious obstacle to American industrial revitalization. The United States has allowed its education and workforce development system to atrophy, diverting the vast majority of Ameri-

can education dollars to a broken higher education system that only serves a minority of students well.

Yet it is employers, not universities, who not only can often provide the most valuable training, but also have a far better grasp of what cutting edge skills industrial work and innovation requires. In many cases it is employers who are best suited to provide (either directly, or in concert with other entities like industry associations, trade unions, and community colleges) the most useful and relevant training. It is also employers who ultimately hire and deploy high-skilled workers, yet the higher education system is not in touch with employer needs.

SOLUTION

Congress

Congress should create a workforce training grant of $10,000 offered to employers per year for each trainee engaged in on-the-job training, to be administered by the Department of Labor. Such a grant program should:

- Clearly define what constitutes "trainee" status. Workers' time should be split between formal training and on-the-job work.
- Establish clear parameters that employers must define and communicate for training programs, including the program's length, an overview of its curriculum, what wage and job placement outcomes are expected, what formal certifications will be earned (if any), and what entities are responsible for delivering the training (the employer directly, a trade union, an industry consortium or trade group, a community college in concert with the employer, etc).
- Certify programs that meet eligibility requirements.
- Provide employers with an annual grant of up to $10,000 per trainee employed per year.
- Define strict and clear quality controls, and swiftly decertify training programs that underperform.

The American Workforce Act, reintroduced in 2024 by Senator Tom Cotton (R-AR), then-Senator JD Vance (R-OH), and Congressman Max Miller (R-OH), is an example of this approach. Such legislation could be paid for by expanding the university endowment tax, by rebalancing some existing federal education spending away from higher education towards this program, or a combination of both.

Department of Labor

The Secretary of Labor should establish a pilot program that field-tests this approach in select states that apply to participate. Such a program should receive applications from states willing to invest their own funding. The Department of Labor can offer matching funding by allocating unspent guest-worker visa processing fees for this purpose. For example, the H-1B skills training fee, first authorized by the American

Competitiveness and Workforce Improvement Act of 1998, is intended "to prepare Americans for high-skill jobs, reducing dependence on foreign labor." $217 million in unspent visa fee funding was rescinded for FY 2025 alone, for example. This is enough to fund 21,700 $10,000 grants—more than the number of registered apprentices in Michigan or Illinois. If states matched this funding, 43,400 grants could be funded—more than the registered apprenticeships in any state other than California.

JUSTIFICATION

American policymakers have long seen the wisdom in investing public money in education and workforce development, but for too long they have entrusted that duty—and those funds—predominantly with colleges and universities. This hyper-focus on higher education as the primary provider of workforce development is misplaced. Fewer than one in five Americans move smoothly from high school to college to a job that requires a college degree.

Policy must acknowledge the vital role employers can play in workforce development, especially in the context of the global race for technological and industrial dominance. Rectifying this is urgent, but higher education spending is currently badly mismatched with employer needs. The American economy is producing college graduates at more than twice the rate it is producing jobs that require college degrees, leading not only to great frustration and economic stress on working Americans but to a workforce underprepared for what America's leading companies require.

Fixing this requires acknowledging that employers face specific challenges in providing the training our technological progress clearly needs. While many employers do offer training, they are constrained by market pressures that heavily-subsidized colleges and universities do not face. A trained and now-more-productive employee can either command higher pay from that employee (a good outcome for the worker, but a potential negative return on investment for the employer), or else take those skills elsewhere, leaving their initial employer holding the bag for having trained someone else's upskilled worker. Noncompete agreements could mitigate the latter concern, but many conservatives have rightly objected to their heavy use, both because they are unjust to workers and because—of special importance to techno-industrial strategy—they stifle innovation and technological advancement.

American industry will struggle to meet the moment without the workforce it needs. Decades of atrophy and misallocation of funds have left the American workforce development systems unable to adequately provide that workforce. The push to swiftly (re)develop American semiconductor production is a case in point. The CHIPS and Science Act, while broadly working well, has faced implementation challenges due to the lack of sufficiently trained and interested American workers. Chip companies have sought fixes, for example by working with labor unions and by making use of guest worker programs. But no industry is equipped to solve a national problem of this scale on its own. In the long run, the American economy's ability to be globally competitive and to prompt large-scale, ambitious, and forward-looking investment in innovation and industrial strength depends in large part on getting workforce development policy

right. That means resolving the disconnect and misalignment between the workforce needs of American industry, what entities we trust to provide those needs, and how we spend our federal education and workforce dollars.

FURTHER RESOURCES

- Oren Cass, "The Workforce Training Grant," American Compass, 2022
- Senator Tom Cotton, Senator JD Vance, Representative Max Miller, American Workforce Act, 2024

Chris Griswold is the Policy Director at American Compass and a Louis O. Kelso Fellow at the Rutgers University School of Management and Labor Relations. He was formerly a senior advisor in the US Senate.

National Security

■ National Security

Reforming Naval Shipbuilding

Brian Potter and
Austin Vernon

SUMMARY

The US Navy persistently sees ship construction delays and cost overruns. Over 80 percent of ships exceed initial budgets, and all recent lead ships delivered behind schedule. We propose three interconnected reforms to address these issues: simplifying ship designs to focus on core capabilities, rebuilding the Navy's in-house design capabilities, and ensuring designs are completed before construction begins. These changes would enable faster ship delivery, reduce costs, and maintain fleet capabilities while increasing hull count—all without requiring substantially more resources.

PROBLEM

The Navy's shipbuilding program is plagued by systematic cost overruns and schedule delays that hamper fleet modernization and capability. According to a 2018 Government Accountability Office (GAO) report, more than 80 percent of ships exceed their budgets, sometimes by 100 percent or more, while every recent lead ship has been delivered years behind schedule. These issues stem from overcomplexity in de-

sign, outsourced design capabilities, and concurrent design-build processes. The Navy creates high-level requirements for complex, multi-role ships, and it outsources the design of these ships to third-party contractors.

Once a design is selected, it is then turned into production drawings (a so-called detail design), which are used to produce the ships. In an effort to reduce the time it takes to deliver a ship, ship construction is often started before ship design is complete. However, this strategy frequently backfires: as design work is completed, changes to under-construction ships are often required, resulting in costly and time-consuming rework.

For an example, see the Constellation-class frigate, a guided missile frigate currently under development. Unlike earlier frigates (such as the Oliver Perry-class), which were designed for narrower roles, the Constellation is designed to fulfill multiple roles, including "air warfare, surface warfare, antisubmarine warfare, and electromagnetic warfare operations." The contract for the Constellation-class was awarded to Fincantieri Marinette Marine (FMM), based on a parent design for a European FREMM frigate. However, the Navy and FMM struggled to turn the Navy's extensive list of specifications into a completed design. Contrary to best practices, the construction of the lead ship began before the design of the ship was finalized in an attempt to avoid schedule delays, and design continued for years after construction began. This strategy has backfired: the program is now significantly over budget and three years behind schedule.

Without reform, the Navy will continue to receive fewer ships, later than needed, at higher costs than budgeted, directly hurting national security capabilities.

SOLUTION

We propose three interconnected changes to naval shipbuilding that would fundamentally transform how the Navy designs and acquires new vessels. These changes work together to create a more efficient, predictable, and cost-effective shipbuilding process.

First, the Navy should return to simpler, more focused ship designs. Current vessel designs attempt to pack multiple missions into single platforms, resulting in compromises that reduce effectiveness while increasing complexity and cost. For example, the Littoral Combat Ship's attempt to fulfill multiple roles through modular mission packages proved unworkable, while the Ford-class carriers incorporate expensive radar systems that duplicate destroyer capabilities without clear operational benefit. Instead, ships should be optimized for specific primary missions, with clear priorities and minimal feature creep. This approach allows for faster design cycles, more efficient production, and ultimately better-performing vessels.

Second, rebuilding the Navy's in-house design capabilities at Naval Sea Systems Command (NAVSEA) is crucial for controlling both costs and outcomes. The current practice for ship design is for the Navy to specify high-level ship requirements, and for third-party contractors to use those requirements to create the design of the ship. With the Littoral Combat Ship, for instance, both General Dynamics and Lockheed each created distinct ship designs based on the Navy's high-level requirements for the

ship. This practice of outsourcing design work creates barriers between those setting requirements and those creating designs, and makes it difficult to both determine requirements and to modify them as cost and capability knowledge evolve during the design process. It also makes it difficult to maintain the pool of shipbuilding expertise necessary to produce quality designs, since commercial shipbuilders typically can't afford to keep a large design staff employed full-time. By bringing design back in-house, the Navy can better evaluate tradeoffs, respond to changing needs, and maintain the deep expertise needed for successful naval architecture. This change would also allow for faster iteration and more efficient communication between designers and end-users.

Third, the Navy must adopt commercial best practices by completing its designs before beginning construction. Our concurrent design-build practices, while intended to speed delivery, actually result in costly changes and delays when inevitable design modifications must be made to partially-built ships. Waiting for design maturity before starting construction ultimately results in faster delivery of better ships at lower cost.

These three changes reinforce each other—simpler ships are easier to design, in-house design teams can better focus on core requirements, and completed designs enable smoother construction. Together, they would enable the Navy to deliver more capable ships, on time, and on budget.

Executive

- Naval Sea Systems Command (NAVSEA) should rebuild in-house naval architecture and ship design capabilities by increasing naval architect staffing from current 300 to the historical level of more than 1,200. It should also implement strict design completion requirements before authorizing construction.
- The Office of the Secretary of Defense should revise the ship requirements process to emphasize focused, single-role platforms over multi-role vessels. It should establish clear guidance prioritizing design simplicity and production efficiency. And it can and should mandate substantial design completion before construction is authorized.

Congressional

- The House and Senate Armed Services Committees should authorize increased funding for NAVSEA's ship design capabilities. They should propose modified acquisition regulations to require demonstrated design maturity before construction, and they should establish oversight mechanisms for those design completion requirements.
- The House and Senate Appropriations Committees should fund an expansion of NAVSEA's naval architecture staff, and in return should require progress reports on design completion before releasing construction funds.

JUSTIFICATION

The Navy's historical success with focused ship designs like the Perry-class frigate, the original Burke-class destroyer, and the T-AGOS-19 surveillance ship demonstrates the effectiveness of simpler, specialized vessels. The proposed return to in-house design reflects proven past practice: before the post-Cold War downsizing, NAVSEA successfully designed most Navy vessels internally. It also reflects best practices in other domains of large, government-funded, semi-unique construction projects, such as mass transit and high-speed rail construction. Commercial shipbuilding already follows the principle of completing design before construction, achieving better cost and schedule performance. These reforms build on demonstrated successful practices while addressing the specific challenges of modern naval construction. ■

FURTHER RESOURCES

- Government Accountability Office, "Navy Shipbuilding: Past Performance Provides Valuable Lessons for Future Investments," 2018
- Robert G. Keane, Barry F. Tibbitts, and Peter E. Jacquith, "The Navy's Ship Design Factory: NAVSEA—The 'Golden Goose,'" *Naval Engineers Journal*, 2019
- Ronald O'Rourke, "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress," Congressional Research Service, 2024

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■ National Security

Streamlining Defense Procurement to Bridge the Valley of Death

Arun Seraphin

SUMMARY

The congressionally mandated Planning, Programming, Budgeting, and Execution (PPBE) Commission made a number of specific recommendations that would streamline the process by which the Department of Defense (DOD) funds technology development and innovation activities. Adopting these recommendations would reduce the time for the development and deployment of innovative national security capabilities.

PROBLEM

The Pentagon's antiquated budgeting processes is one of the key impediments to speeding up the adoption of emerging technologies for use in national security missions. For most new ideas to obtain funding, the PPBE process is essentially a two-year effort to go from idea to actual available budget. The department-wide PPBE enterprise requires the efforts of thousands of people and the participation of count-

less defense organizations, costs hundreds of millions of dollars to run, and results in the annual Pentagon budget plan delivered to Congress each year.

This set of processes was originally established in early 1961 to give the Pentagon a way to make strategic and cost-effective decisions on force structure and budget decisions, based on then-best commercial practice. More than half a century later, the current PPBE process lacks agility, limiting DOD's ability to respond quickly and effectively to evolving threats, unanticipated events, and emerging technological opportunities. The bureaucratic processes also serve as a barrier to small businesses and commercial companies from entering the national security innovation base. This is highly problematic, given America's technological competition with China, the rapid development and deployment of new technologies by Russia in Ukraine, and DOD's struggles to keep pace with and adopt commercial technologies, especially in critical areas such as AI, biotechnology, advanced software, and cybersecurity. The US needs a system that is more responsive to technological advances and emerging threats, and more aligned with the innovative commercial technology sector. Streamlining Pentagon budgeting and spending processes will be one important part of achieving such a system.

In response to these concerns on the Pentagon's budget processes, Congress mandated that the PPBE Commission undertake a study and make recommendations "to improve such process and practices in order to field the operational capabilities necessary to outpace near-peer competitors, provide data and analytical insight, and support an integrated budget that is aligned with strategic defense objectives." The resulting blue-ribbon commission of experts from DOD, Congress, academia, and industry developed a comprehensive final report delivered in 2024, including numerous recommendations to improve PPBE processes.

SOLUTION

The Commission made many recommendations, but the below reflect ideas specifically focused on enhancing the Pentagon's ability to rapidly develop and deliver innovative warfighting capabilities. The government should adopt a number of these PPBE Commission recommendations focused on enhancing the Pentagon's capacity to develop and deliver innovative capabilities to help it win the global technological competition in national security and address emerging threats from China, Russia, Iran, and other adversary nations.

Executive

- DOD should review and consolidate budget line items. These line items reduce DOD's ability to reallocate funds to address current needs and increase the complexity of the overall budget for the public, industry, and Congress. The Committee argued that the consolidation of budget lines, if done transparently and in accordance with existing acquisition best practices, has the potential to save time and resources in the development and review of the defense budget. (pp. 82–83)

- DOD should revise the Financial Management Regulations (FMR) to provide guidance that funding requested for software refreshes or upgrades is available to develop, prototype, test, field, troubleshoot, redevelop, procure, and sustain in a complete cycle regardless of whether the funding is requested as Operations and Maintenance (O&M), Procurement, or Research, Development, Test and Evaluation (RDT&E) funding. (pp. 84–85)
- DoD should consolidate RDT&E Budget Activities (subaccounts by which the RDTE budget is allocated and managed) to reflect current technology development paradigms and improve agility for programs. This recommendation would grant program managers greater flexibility to transition programs in a more dynamic and responsive manner to changing threats, enabling faster capability delivery to the field and warfighter. (pp. 64–66)

Congressional

- The House Armed Services Committee, Senate Armed Services Committee, House Appropriations Subcommittee on Defense, or Senate Appropriations Subcommittee on Defense should direct DOD to undertake the Budget Activity consolidation activities discussed in the PPBE report. This would entail reducing the current set of eight budget activities into a more realistic set of four, more accurately reflective of technology development processes. This would also include using specific budget line items (called "program elements") that are more reflective of the work being undertaken with the funding to improve transparency and accountability. (pp. 64–66)
- The House Appropriations Subcommittee on Defense and Senate Appropriations Subcommittee on Defense should include report language in the next appropriations bill to increase Below Threshold Reprogramming levels based upon the nominal growth of the appropriation account. These levels set DOD's ability to independently and quickly reallocate resources after receiving appropriations from Congress based on new threats, technology developments, program execution issues, or operational realities, without seeking congressional pre-approval for the change. This would increase DOD's flexibility in addressing emergent budgetary needs, without significantly reducing congressional oversight and control. (pp. 86–87)
- The House Appropriations Subcommittee on Defense and Senate Appropriations Subcommittee on Defense should include report language in the next appropriations bill to simplify new start notifications by increasing the notification threshold, which is the size of new activity that Congress needs to be notified about before its initiation. This recommendation, if adopted, should also send the message to non-traditional contractors and other private sector innovators that DOD is "open for business" and able to respond rapidly to opportunities and fund new technologies when they are proven to meet national defense needs effectively and efficiently. (pp. 81)

- The House Appropriations Subcommittee on Defense and Senate Appropriations Subcommittee on Defense should include legislative language that permits DOD to use O&M funds for hardware improvements in the sustainment phase, after systems have been delivered to the field and are being used and maintained by operators, even in cases where the improvements result in an increased capability. This simple fiscal management improvement would avoid the current situation where different types of funding need to be used for system upgrades versus systems repair and maintenance in the field, which are further compounded by the speed of hardware development and the current ability for industry to deliver upgrades much more rapidly than in the past. This would also allow new industry partners to bring new capabilities to a system without having to go through the traditional RDT&E and Procurement budgeting and program development process, opening the possibility of delivering emerging technologies through the sustainment process, which is already more flexible and in the control of operational forces. (pp. 86–87)

JUSTIFICATION

These recommendations were developed by a two-year blue-ribbon commission supported by an expert staff. The commissioners were appointed by both congressional and DOD leaders and brought an extensive set of experiences representing industry, government (executive and legislative), budgeting and appropriations, technology and innovation, acquisition, and oversight experiences. The recommendations reflect a knowledge of the roles and interest of the principal organization players in developing and executing financial management, budgeting, and appropriations processes and were designed to be both consistent with the needs of the different organizations and executable based on the significant professional experience of the commission staff and members.

A number of these initiatives have been tried as pilot efforts in DOD's smaller innovation organizations including the Defense Advanced Research Projects Agency, Defense Innovation Unit, the Space Force, and US Operations Command. Many of them have been proposed in some format by Congress, such as the Software Budget Activity 8 pilot. ■

FURTHER RESOURCES

- PPBE Commission Report, "Defense Resourcing for the Future," 2024
- DOD, Financial Management Regulations, 2022

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■ National Security

Demand-Side Financing for Critical Minerals

Charles Yang

SUMMARY

Critical minerals are a key upstream resource for building a competitive industrial base. However, Chinese oversupply, particularly in midstream processing of critical minerals, has created a volatile price environment that is difficult for American companies to compete in. Traditional industrial policy focuses on supply-side public capital to support the construction of mining and processing facilities. These tools are important, but do not address the fact that domestic processors are often unable to secure offtake of their products to domestic manufacturers. This proposal outlines how demand-side financing mechanisms can support offtake agreements between domestic processors and manufacturers, while reducing the amount of risk to taxpayer dollars.

PROBLEM

China's use of critical mineral export controls against the US—on gallium, germanium, graphite, rare earths, and antimony, for example—viv-

idly illustrates its chokehold on the processing of critical minerals. For over half of the US Geological Survey's designated critical minerals, China holds the majority of global processing and refining capacity. China has achieved this chokehold over upstream critical minerals through government-encouraged over-subsidization, which has led to price volatility and prices below cost of production in certain markets. This market manipulation threatens the viability of a domestic critical mineral processing industry, as they struggle to sell their products into a market with deflated prices.

The US has already leveraged a number of offices, agencies, and authorities to support a domestic critical mineral processing industry, including the Department of Defense (DOD)'s Defense Production Act, the Department of Energy (DOE)'s Loan Program Office, 45X production tax credits for critical minerals, and grants for battery materials processing facilities. More can and should be done in this vein (see Dean Ball, "Regaining Control over Critical Minerals"). However, while this kind of federal support is necessary to support a nascent critical mineral industry, these tools are variations of supply-side capital that provides funding to support the construction of facilities to increase domestic capacity. But supply-side capital does not address the volatile market dynamics that make it difficult for domestic processors to sign offtake agreements with manufacturers and create a domestically integrated supply chain.

Supply-side capital solutions face several challenges. One of them is that even if a facility is successfully stood up and operationalized, it is unclear if its operating costs will be sufficiently competitive in a volatile price environment, or if it will be able to secure domestic offtake to feed into a broader supply chain. Demand-side financing tools, such as contract-for-differences and forward contracts, can help support the formation of a mature US critical mineral market.

SOLUTION

The US government can use public capital to support backstop offtake agreements between domestic critical mineral processing facilities and manufacturers, providing certainty for domestic manufacturers to buy American critical minerals while reducing their exposure to Chinese price manipulation. This flexible financing also reduces government risk and overhead. It is important to note that while demand-side financing can be complemented by broader tariff actions, demand-side financing also provides an important level of certainty and direct domestic support for a nascent critical mineral industry.

The Department of Energy and the White House

DOE has approximately $725 million in remaining grant funding for battery manufacturing and battery materials processing. DOE should leverage these funds to support demand-side financing, either through a grant-based funding opportunity or by using DOE's more flexible Other Transaction Authority (OTA). DOE has already used an OTA to create a hydrogen demand-side consortium, which could be repurposed for critical minerals as well. Germany has pioneered a similar demand financing ap-

proach to hydrogen, which has helped shift its industrial energy sector away from Russian-sourced natural gas.

DOE has several different kinds of tools to provide demand-side financing support. For instance, DOE could backstop a contract-for-difference between a domestic critical mineral processor and a domestic manufacturer. The contract for difference would include an agreed-upon offtake contract price, benchmarked against a given market index. If the index price floats above the market index price, the offtaker would pay the higher market index price. If the index price drops below the offtake contract price, DOE would make up the difference between the contract price and the index price. Alternatively, a forward price contract would effectively set a price floor at which DOE would accept offtake from critical mineral processors. The price floor could be based on spot price indices or through reverse auctions from domestic critical mineral processors. While this scheme could be used to support the National Defense Stockpile, DOE could also act as a "virtual offtaker" and simply resell critical minerals to domestic manufacturers, which would significantly reduce the logistical burden.

The White House National Security Council (NSC) can also play an important coordinating role in building an integrated critical mineral supply chain with robust domestic offtake agreements. NSC can set the priorities for various federal critical mineral funding streams to ensure coverage of support for domestic critical mineral processing supply. Relevant programs could include, but are not limited to, DOE battery grants, DOE loan program office, DOD Defense Production Act for critical minerals, State Mineral Security Partnership, and Commerce CHIPS funding. In addition, the NSC can use the White House's "bully pulpit" to present the national security case for sourcing offtake domestically to auto and defense manufacturers.

Congress

Congress should pass the bipartisan Critical Minerals Future Act, which authorizes a pilot program for DOE to use innovative financing tools, such as Other Transaction Authority, Contracts for Difference, Forward Contracts, and Advanced Market Commitments, for critical minerals. These proposed actions for the executive branch, which repurpose existing funding and use existing grant structures, complements the proposed legislation, which authorizes additional new funding and explicitly allows for the use of a full suite of flexible financing tools.

These efforts should focus on mineral markets where the US has a viable technological path to market competitiveness. While long-term support may be necessary to counteract Chinese subsidies, this program is not necessarily suited for that purpose. Instead, DOE should award developers on the basis of competitive domestic pricing and innovative critical mineral processing technology with a path to global competitiveness. Similarly, awards should be sufficiently capitalized to provide full coverage of downside price volatility risk for projects, which may limit the number of markets or projects this program is able to cover.

JUSTIFICATION

There is an increasing recognition that supply-side capital, such as grants, are important but blunt instruments for industrial policy, and that more flexible financing tools that directly address price volatility are needed. The bipartisan House Select Committee on CCP Critical Mineral Policy Working Group published a report in December 2024 recommending further exploration of flexible financing price support mechanisms. The Biden administration considered a potential critical mineral price support program in the closing days of the administration. Other nations have also started experimenting with flexible financing to support liftoff of nascent industries, such as Germany's demand-side contract-for-difference market mechanism for hydrogen production for heavy industries. The United States must take action and use new demand-side tools to support the critical mineral industry, or risk the continued vulnerability of dependence on China. ■

FURTHER RESOURCES

- Department of Energy, Office of Manufacturing and Energy Supply Chains, "Preliminary Results from DOE's Critical Materials Market Dynamics Request for Information," 2024
- John Jacobs, "Resilient Resource Reserve: A Plan to Catalyze the American Critical Mineral Processing Industry," Bipartisan Policy Center, 2024
- Arnab Datta, Alex Williams and Skanda Amarnath, "Contingent Supply: The SPR in The Current Moment," Employ America, 2022

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■ National Security

Launching Project Paperclip 2.0 to Recruit Top Scientists

Jeremy Neufeld

SUMMARY

The destinations of just a few superstar talents can make the difference in determining which countries develop cutting-edge technology. Recruiting the top scientists or engineers in a field can let a country secure leadership in that field; denying a rival just a few top minds can reduce that rival's competitiveness.

A new Office of Talent Assessment, housed under the Department of Defense or Department of State, could systematically identify top researchers poised to make important defense-relevant contributions in critical fields like AI, quantum computing, and semiconductors where China seeks dominance. This office would identify talent for targeted recruitment, deploy talent scouts, evaluate candidates, recruit vetted targets, and bring them to the US, with a limited quota of 80 green cards per year for principal targets.

PROBLEM

China is making aggressive moves through programs such as Qiming to recruit researchers in critical technologies. After long targeting its recruitment initiatives on the return of Chinese talent from abroad, China is beginning to target international talent without origins in China. In 2021, President Xi Jinping announced to the Central Committee the goal that "by 2035, the country will have competitive advantages in talent competition in many areas."

Meanwhile, the United States relies primarily on universities and companies for recruitment in a decentralized approach that, for all its successes, misses key talent necessary for defense-related industries and technologies. For example, the United States could very well have denied China leadership in 5G technology if it had recruited MIT PhD Erdal Arikan. Instead, he returned to Turkey, where his invention of polar codes was exploited by Huawei and secured 5G dominance for China.

We've successfully run targeted talent recruitment before. Project Paperclip brought to America transformative scientists who won the space race, while the Soviet Scientists Immigration Act denied crucial expertise to rogue states after the USSR's collapse and exploited that expertise for the United States. To maintain America's lead in defense and innovation, we must revive and modernize a proven strategy: proactively recruiting the world's best scientists and engineers in critical and emerging technology fields.

SOLUTION

The United States needs a comprehensive system to identify and recruit the very top foreign technical scientific and technical talent working on technologies critical to national defense. Launching a Project Paperclip 2.0 could be accomplished by a new and independent Office of Talent Assessment, housed in the Department of Defense (DOD) or the Department of State (DOS) to oversee and manage a US talent program.

While establishing a new independent office to coordinate talent identification and recruitment efforts would be the gold standard for a proactive recruitment effort, the US government need not wait for legislative authorization to begin taking meaningful steps. Existing authorities and resources allow agencies to start building the capacity for proactive identification and recruitment today, even before Congress authorizes and funds a permanent institutional home.

The strategy has two major phases: building a talent identification capacity, then beginning a talent recruitment and acquisition process.

Phase 1: Talent Identification

Success begins with systematically mapping the global talent landscape and identifying key researchers who could advance US technological leadership. A prerequisite to any effective proactive recruitment program is effective talent identification to produce targets for recruitment efforts.

The executive branch should immediately establish a strategic talent assessment network using existing authorities to start identifying potential recruiting targets:

- Instruct federally funded research and development centers (FFRDCs) to build or expand on existing predictive methodologies for identifying talent poised to make meaningful technical contributions after a move to the United States.
- Create a formal process at DOD to regularly solicit principal investigators at DOD Laboratories, the Office of Army Research, the Office of Navy Research to report on the leading foreign researchers working in defense-related fields on critical and emerging technologies. This process should also include principal investigators at National Laboratories and partner universities working on defense-relevant work.
- Maintain a regularly updated database of identified talent. A classified report identifying the top scientists and technologists, along with details from screening and vetting on the identified talent, should be made available to Congress.

Congress can assist the executive branch in expanding its talent assessment capacity with funding and new authorities. At a minimum, Congress should mandate and fund agencies to contract with FFRDCs to continue work on identifying the top researchers who should be recruited to the United States. This work could augment the database produced by a talent assessment network described above by developing standardized evaluation criteria to evaluate both technical expertise and security considerations. These criteria should include:

- metrics for measuring research impact in defense-related fields
- observable characteristics that predict future success
- observable characteristics that predict when researchers pose security risks

Congressional authorization for an Office of Talent Assessment to oversee these efforts (along with any eventual recruitment campaign) would coordinate the new talent identification efforts, grant authority to coordinate with the intelligence community, fund and manage the development of assessment methodologies, launch pilot programs for experimentation in talent evaluation, create secure systems for maintaining and updating talent databases, and establish any additional supporting infrastructure. Ultimately, an office would provide the accountability to ensure that identification is conducted and completed thoughtfully.

Phase 2: Talent Recruitment

With targets identified, the US would then deploy a coordinated recruitment strategy. Like talent identification, recruitment efforts can begin through existing authorities while building toward more comprehensive capabilities that require congressional support.

After identifying targets, the executive branch should begin to play a part in the recruitment of those targets with the following existing authorities:

- DOD should fully use its allotment of H-1B2s, a special set-aside of 100 visas for researchers working on a DOD cooperative research and development project or

a coproduction project under a reciprocal government-to-government agreement administered by DOD. In recent years, DOD has used only approximately 30 percent of its H-1B2 allotment. It could immediately work to use remaining visa slots by placing eligible targets in eligible projects using remaining visa slots if they want to work on those projects.

- DOD should act as an interested government agency to submit findings to the US Citizenship and Immigration Service about a target's work, or otherwise offer an inter-governmental letter explaining a target's eligibility for an O-1 visa and/or a National Interest Waiver.
- DOD should request expedited processing for identified targets.
- DOD and/or DOS can train officials abroad (for example, DOS EducationUSA advisories and Global Innovation through Science and Technology Initiative officials) to better inform targets of available immigration options under existing laws.

Ultimately, however, existing authorities are insufficient for a successful recruitment campaign to secure US leadership. Proactive recruitment by the government will require congressional support in the form of new authorities and some small but designated funding.

Congressional authorization for an Office of Talent Assessment should include:

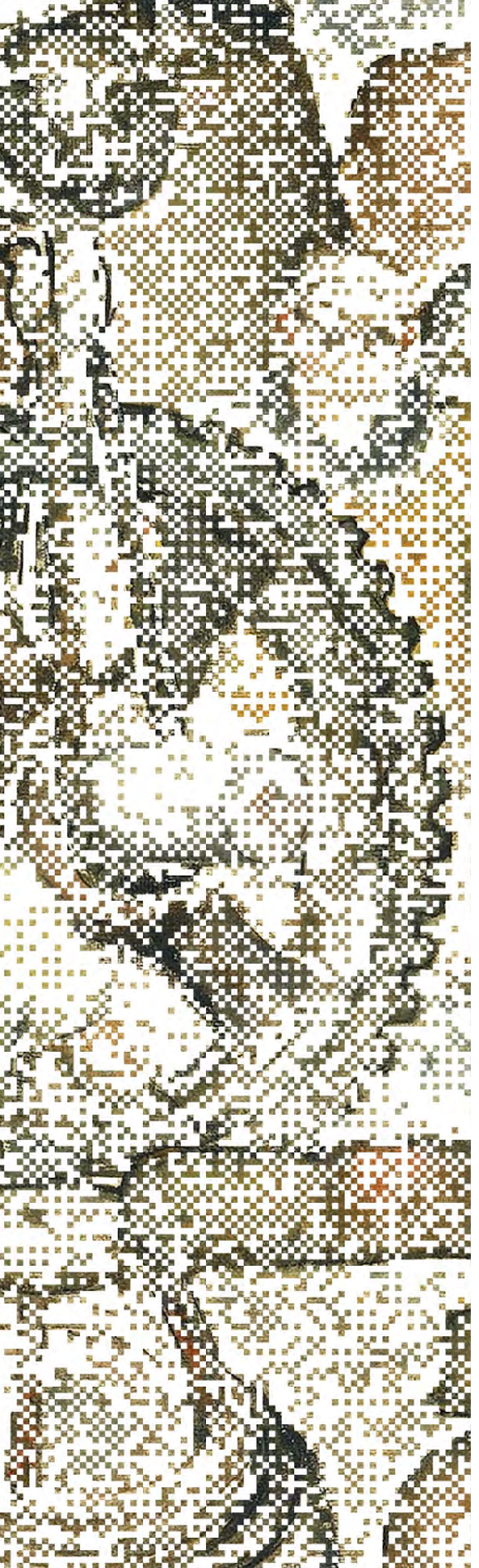
- Authorization and funding for an independent office. A fully empowered and independent Office of Talent Assessment would require new authorities and resources to execute its mission effectively. Placement would likely make sense under the DOD Under Secretary of Defense for Research and Engineering, or under the DOS Under Secretary of State for Economic Growth, Energy, and the Environment.
- Resources and authority for experimentation in real-world recruitment. To determine what actually works to persuade top scientists to move to the United States would require experimentation and learning-by-doing. During Project Paperclip, US recruitment suffered until it learned to emulate some of the recruitment techniques used by the other allies' recruitment efforts (for example, by approaching German scientists with German recruiters). What techniques, pitches, and incentives will work best today will not be known until recruiters are empowered to try different methods.
- Reserved visas. At the outset, the Office could be launched with a small quota of immigrant visas for targets (e.g., 80 green cards per year for principal targets). Green cards should also be made available for their families to increase the likelihood of a successful recruitment.
- Coordination with the Departments of Homeland Security, State, and Labor to expedite the visa processing for identified targets.
- Authorization for Public-Private Partnership Programs. Targets will likely want to know they will have access to good jobs, housing, and schools for their children upon moving. The Office should coordinate with the private sector to find jobs and possibly even housing before a move. Further, partnerships could help provide cultural orientation to help new arrivals generally navigate their new country. In many cases, private sector or civil society partners may be better poised to successfully approach and/or recruit a target than the Office itself.

- Authorization for designated counterintelligence resources and/or cooperation with the Intelligence Community. Proactive recruitment would allow US authorities to choose targets who pose a low risk of espionage. Nevertheless, some counterespionage capacity is prudent, though special care must be taken not to deter targets with a culture of suspicion. ■

FURTHER RESOURCES

- Jeremy Neufeld, "The Immigration Advantage in the US-China Strategic Contest for STEM Talent," *Asia Policy*, 2024
- Jeremy Neufeld and Hamidah Oderinwale, "The Talent Scout State," Institute for Progress, 2024
- National Academies of Sciences, Engineering, and Medicine, "International Talent Programs in the Changing Global Environment," 2024
- Wilson Miles, Jeremy Neufeld, and Jordan Chase, "Strengthening the National Security Innovation Base Requires International STEM Talent," National Defense Industrial Association Emerging Technologies Institute, 2024

Jeremy Neufeld is the Director of High-Skilled Immigration Policy at the Institute for Progress.



■ National Security

Reviving the Medical Industrial Base

Daniel Bring

SUMMARY

Guarding the health of Americans is a national security imperative. Yet within weeks of a global conflict or another pandemic, Americans could lose access to many of their most essential medicines and medical supplies. Worse still, the US medical industrial base is so atrophied that it would struggle to scale up to meet demands even in the direst circumstances. Recognizing this risk, policymakers have charged the Department of Health and Human Services (HHS)'s Administration for Strategic Preparedness and Response (ASPR) with rebuilding the medical industrial base. ASPR, however, lacks the capabilities to fulfill this mandate and reinvigorate this base.

The Trump administration and Congress should remedy this problem by increasing ASPR's autonomy and expanding its capabilities to kickstart and sustain domestic production. Likewise, legislative reform should grant ASPR permanent, independent access to funds and allow it to use more forward-looking contracting and procurement avenues. The result of these reforms would be a civilian medical preparedness agency that can take swift, decisive, and

proactive action to rebuild the medical manufacturing base and secure Americans' healthcare against biomedical and geopolitical risks.

PROBLEM

The US healthcare system's dependence on fragile medical supply chains—which often lead back to China—threatens the health and security of the American people in the event of a global conflict or another pandemic. Securing medical supply chains requires an effective industrial policy to expand domestic production capacity. Policymakers have assigned this responsibility to ASPR, which oversees the Biomedical Advanced Research and Development Agency (BARDA) and manages the Strategic National Stockpile (SNS) of medical supplies and countermeasures. Though ASPR may have the mandate to expand the medical industrial base, it lacks the methods and means to do so.

Despite its critical responsibilities, ASPR remains entangled in a bureaucratic morass and suffers from piecemeal funding and procurement. The clearest example of this failure is that ASPR cannot make independent stockpiling decisions for the SNS and instead must defer to the Public Health Emergency Medical Countermeasures Enterprise (PHEMCE), an interagency body that is technically subordinate to ASPR. PHEMCE's recommendations have often prioritized countermeasures for very rare threats, such as a smallpox outbreak, over basic supplies for civilian medical preparedness. Likewise, ASPR relies on case-by-case Department of Defense (DOD) approvals to use Defense Production Act (DPA) Title III funds for medical base expansion.

Beyond these bureaucratic complications, ASPR lacks the tools necessary to forge each link of a secure, domestic supply chain, from raw material production to advanced manufacturing at scale. ASPR cannot enter into pre-purchase agreements or automatic contracts with trusted suppliers to keep stockpiles filled; its use of expedited procurement pathways, such as Other Transaction Authority (OTA), is limited to BARDA funding for specific medical countermeasures. ASPR's procurement is largely subject to Federal Acquisition Regulation (FAR) constraints. Its funding depends on yearly appropriations, limiting its ability to plan ahead or make long-term commitments to American producers.

SOLUTION

Policymakers should empower ASPR to make swift decisions and execute a successful medical industrial policy to scale up domestic production and reshores supply chains. Many crucial actions would require only HHS directives, internal ASPR policy changes, and limited White House action. Only Congress, however, can give ASPR the resources and authorities it needs to consistently and proactively develop the medical industrial base.

Executive

- The White House should take action to streamline interagency coordination. The White House should issue an executive order requiring ASPR to integrate its Inventory Management and Automated Tracking System (IMATS) with DOD and Department of Homeland Security inventory systems.
- HHS should reduce bureaucratic redundancies, expand funding options, and authorize long-term funding flexibility. First, HHS should order ASPR to disregard PHEMCE's stockpiling recommendations and establish its own internal procurement board on an interim basis. HHS should also issue a directive extending ASPR's Other Transaction Authority for Advanced Research (OTAR), mostly reserved to BARDA, to IBMSC and the SNS for research contracts. Critically, HHS should ask the Office of Management and Budget to reclassify ASPR's entire budget as no-year funds, allowing the agency to carry over appropriations indefinitely and plan to make longer-term contracts and funding commitments. Finally, HHS should direct the Center for Medicare & Medicaid Services to reimburse hospitals for the purchase of 100 percent domestically sourced and manufactured medical supplies, and to phase in a requirement that at least 25 percent of all supplies be domestic products.
- ASPR must continue to improve data collection and modernize its internal systems. ASPR should allocate current SNS funds for further IMATS modernization with the express purpose of achieving real-time inventory tracking capability. Furthermore, ASPR should request proposals for an AI-based analytics platform to enable predictive inventory management and inform proactive stockpiling. Lastly, ASPR should begin to develop a preapproved vendor system and qualification process to expedite contracting when Congress authorizes new procurement pathways.

Congressional

- The House Energy and Commerce Subcommittee on Health should clarify ASPR's relationships in and outside of government and authorize agility in procurement and industrial base expansion. Congress should permanently relegate PHEMCE (or a reconfigured successor body) to an advisory capacity and impose a fixed structure for the new ASPR internal procurement board. Most importantly, Congress should empower ASPR to use a robust arsenal of non-traditional procurement processes, including Advance Market Commitments, milestone-based contracts, and pre-purchase agreements, and allow for the automatic activation of these contracts. Each of these pathways can support specific segments of the domestic supply chain and enable ASPR to replenish the SNS automatically as products expire. Lastly, Congress should create a permanent, independent OTA for ASPR that can be used to procure novel medical countermeasures as well as critical inputs produced domestically using new methods.
- The House Oversight and Accountability Committee should formally authorize ASPR's creation of a pre-approved vendor list and enact a permanent FAR waiver for vendors that meet the agency's criteria.

- The House Appropriations Committee Subcommittee on Labor, Health and Human Services, and Education should establish a long-term funding stream for ASPR's industrial base expansion projects. Adequate resourcing for an industrial base build-up requires the creation of a dedicated Medical Industrial Base Resilience Fund to support the SNS and ASPR's Office of Industrial Base Management and Supply Chains on a basis of 5–10 years.
- The House Financial Services Committee should amend Section 303 of the Defense Production Act to grant ASPR permanent access to DPA Title III authorities without the need for case-by-case approvals from DOD and the White House.

JUSTIFICATION

Decades of offshoring left America's medical industrial base unable to meet the Covid-19 pandemic's immediate demands for medical supplies—and unable to scale up production in time to mitigate most shortages, despite significant government investments. Instead, the healthcare system relied on tenuous overseas supply chains, which led to surging imports from China, the only country with the industrial capacity to meet the scale of US demand. At the pandemic's peak, China's share of all US personal protective equipment (PPE) and durable medical equipment imports exceeded 50 percent, up by over 20 percentage points from 2019. China still remains dominant in the global PPE supply chain, having cornered the market during the pandemic through hoarding, nationalizations, and an aggressive industrial build-up. Today, Chinese producers supply 91 percent of medical gloves and 83 percent of surgical textiles imported to the United States.

Dependence on foreign supply chains has become deeply entrenched. Today, the US imports up to 60 percent of active pharmaceutical ingredients (APIs) from China and India. Imports also represent 71 percent of biologics and 43 percent of medical devices sold in the United States, while 78 percent of active pharmaceutical ingredient (APIs) manufacturers are based overseas. China supplies many critical inputs, such as precursor chemicals, to other overseas producers of medical goods; for example, it supplies 80 percent of the chemicals that India uses to produce pharmaceuticals.

Dependence and vulnerability have worsed amid a failed US government response. Historically, ASPR has functioned more like the "Administration for Response," reacting to public health emergencies rather than proactively preparing for them. Even when reacting to a crisis, ASPR and other public health agencies failed to complete industrial base expansion projects. Many of the industrial projects funded during the pandemic stalled entirely after emergency funds and short-term appropriations lapsed. In 2022, ASPR was elevated to full agency status within the department and endowed with the Office of Industrial Base Management and Supply Chains. But even as it has grown, ASPR has failed to demonstrate progress in adding medical manufacturing capacity.

Preparing for medical risks must be taken as seriously as preparing for defense, and America cannot afford to be reactive any longer. Amid a potential confrontation, China could cut off the American healthcare system from its most essential supplies and disrupt its supplies. At that point, the US would have no time to build up medical

industrial capacity before a public health disaster ensued. America's national security depends on rebuilding the medical industrial base—and reforming ASPR in order to do so. ■

FURTHER RESOURCES

- Garrett Murch and Scott Maier, "Medical Manufacturing: A Critical Supply Chain at Risk," *American Affairs*, 2025
- Janika Schmitt and Jake Swett, "The Triple Rapid Framework for Pandemic Diagnostics," Institute for Progress, 2024
- Olivia Webb Kosloff, "A National Defense Strategy for Generic Drugs," *American Affairs*, 2024
- Michael Lind, Jon Camola, and Anita D'Souza, "Leveraging Federal Procurement Policy to America's Supply Chains," *American Affairs*, 2022
- Nikki Terran, "Explaining Biden's Pandemic Preparedness Budget: ASPR," Institute for Progress, 2022
- Nikki Terran, "Why BARDA Deserves More Funding," Institute for Progress, 2022

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■ National Security

Closing the Hypersonic Testing Loop

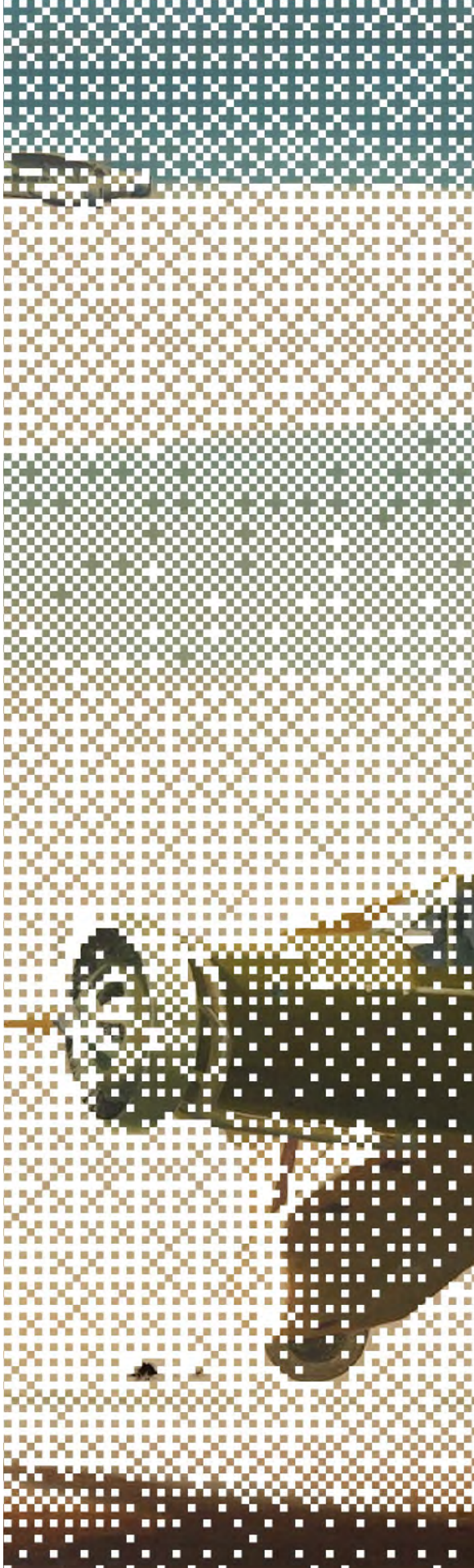
Masao Dahlgren

SUMMARY

It is now common knowledge that successful hardware enterprises win by testing early and often. Whether at Toyota or SpaceX, testing creates critical feedback for early engineering decisions, uncovering mistaken assumptions before they become costly.

This virtuous cycle is often unrealized for priority defense projects. While the Department of Defense (DOD) has invested nearly $12 billion in new hypersonic weapons since 2018, hypersonic engineers still contend with yearslong waiting periods to test designs in wind tunnels or in flight.

The US is now racing to fix hypersonic testing, with more dollars for workforce development and plans to increase the number of flights from five to more than 50 a year. But Congress and the new administration should do more to build hypersonic test infrastructure and integrate nontraditional testing approaches.



PROBLEM

As China multiplies its naval, air, and missile forces to threaten its neighbors, the US needs standoff weapons to defeat targets from outside the range of Beijing's missile arsenal. It is difficult to concentrate and project traditional forms of power on the future battlefield. Raising the cost of an attack on Taiwan, while surviving massed air and missile attack, simply demands more and better missiles.

Hypersonic weapons will be a key piece of these cost-imposing strategies. Their combination of speed, maneuverability, and low altitude not only make such weapons challenging to intercept; they may one day be more affordable than subsonic cruise missiles, replacing complex turbomachinery for engines without moving parts. These reasons are why China has raced ahead in hypersonic development, and why they have now become a DOD priority.

Why has China outpaced the US? Setting aside the cyclical pattern of US hypersonic research funding, China has learned lessons from successful US procurement efforts, echoing Aegis mastermind Wayne Meyer's dictum to "build a little, test a little, and learn a lot." China's advantage in hypersonic testing—20 times more frequently than in the United States—enables its staggering progress in designing and deploying novel weapons.

Shortfalls in testing hypersonic systems bottlenecks America's race to catch up. In 1959, NASA and the Air Force performed nearly 200 tests to develop the X-15, the first manned hypersonic aircraft. But today, the cadence of hypersonic flight testing barely exceeds once every quarter. The rate of hypersonic flight testing simply does not keep pace with the priority accorded to building hypersonic systems.

Monthslong, or even yearslong, wait times are common for hypersonic wind tunnel and flight test opportunities, with industry participants stating that "nearly every wind tunnel facility suitable for hypersonic testing is booked a year or more in advance." Opportunities for flight test compete with established programs of record for limited space and resources, safety analyses and instrumentation can take months to prepare, and permitting challenges can threaten capacity increases. Worse still, these delays are self-reinforcing: faced with long and uncertain wait times, contractors are incentivized to cross-shop different ranges, creating duplicate review processes that further bog down the system.

Equally challenging is the shortfall in US ground test capacity. A strategy of flying full test articles without proving individual parts increases the risk of "dumb mistakes"—basic fin separation, booster duds, and other banal failures—that have wasted costly flight tests. There is a tidal wave of heat shields, thermal tapes, sensor windows, and other subsystems that need validation before moving from science experiment to weapons system.

Yet the roughly 40 ground test facilities suitable for hypersonic development—wind tunnels, thermal chambers, and test tracks—are often decades old, with minimal production bases for replacement parts and outdated data collection infrastructure. More strikingly, the number of operational arcjet wind tunnels, crucial for confirming hypersonic weapons' heat shielding and basic shape, can be counted on one hand. Instead of using flight tests to demonstrate basic lessons on component performance, design-

ers should use them as SpaceX does: to prove new and immature systems and push the engineering envelope. Doing so will necessitate a manyfold increase in US hypersonic ground test capacity.

There is momentum to build on. Beginning in 2025, the DOD's Test Resource Management Center (TRMC) plans to increase flight tests to roughly 50 yearly for its Multi-service Advance Capability Hypersonics Test Bed (MACH-TB) project, largely with more flexible commercial testing platforms. It is replacing its "string of pearls," a series of range instrumentation ships that take days to emplace, with Skyrange, a network of rapidly deployable drones. And collaboration with Australia through AUKUS Pillar II (SCIFiRE) and the preceding HIFiRE program have unlocked more basic research, wind tunnels, and a test range larger than Pennsylvania. Yet more can be done.

SOLUTION

Executive

- Expand TRMC's gap survey to include an updated review of major hypersonic tunnel facilities, and instrumentation; survey data on hypersonic flight test and tunnel wait times; and final recommendations for Congress on specific facility and budgetary needs.
- In the Government Accountability Office's review of Federal Aviation Administration (FAA) licensing processes, assess FAA's capacity for reviewing commercial hypersonic launches, including an analysis of modeling and simulation needs.
- Issue requests for information on new technical and contracting approaches to building arcjet and quiet tunnels at scale.
- Conduct a NASA-led study on next-generation autonomous flight termination systems (AFTS), for the purpose of enhancing the safety of overland flight testing.

Congressional

- After evaluating outcomes in fiscal year 2025, resource the MACH-TB effort as a program of record.
- Resource the construction of a second hypersonic test track at Holloman Air Force Base.
- Fund infrastructure modernization on Kwajalein Atoll to the extent identified in the forthcoming National Defense Authorization Act-mandated Defense Science Board study on Kwajalein infrastructure challenges.
- Request a TRMC report on the cost of constructing a new high-speed flight corridor at White Sands Missile Range.
- Request and fund a study on novel approaches and leapfrog technologies for hypersonic ground testing.

JUSTIFICATION

These recommendations would extend Congress's recent directive to "address deficiencies and capacity constraints with the existing hypersonic test infrastructure."

First, if TRMC's MACH-TB and Skyrange pilots prove successful, Congress and the administration should work to establish MACH-TB as a formal program of record with a dedicated funding line in the defense budget. Such a designation is crucial for acquisition success—not only for ensuring stable funding for flight tests, but for nudging industry to make long-lead investments in hypersonic workforces and supply chains.

Second, policymakers should explore less traditional methods to accelerate the flight test cadence. Given their cost, hypersonic flights typically happen after the DOD pays for them: the Pentagon issues prototyping contracts to firms, which then search for sponsorship at a DOD test range, contracting them for the safety analyses needed for final approval. But with the influx of private capital into defense firms, the hypersonic enterprise should examine where to emulate the commercial space industry, where companies develop prototypes on their dime and profit from the results. To that end, the administration should consider how FAA licensing processes used in commercial space launches could be adapted for commercial hypersonic flight tests. Firms willing to stake their capital on hypersonic testing should not face higher licensing barriers than those that do not.

Third, the administration should expand its efforts to collect data on hypersonic test capacity. Some studies are straightforward—updated data on test delays, institutions, or wind tunnel infrastructure would create the evidence base needed for smart budget decisions. Others are less obvious, but still impactful: potential upgrades to flight termination systems or simulation software could make preflight safety calculations more precise, shrinking the keepout zones needed to conduct tests.

Lastly, Congress must directly resource test infrastructure. As emphasized by the Senate Armed Services Committee, it will be necessary to repair aging facilities, housing, and hospitals on Kwajalein Atoll, one of the few sites equipped for supporting long-range hypersonic, ballistic missile, and missile defense tests. Construction of a second hypersonic test track, meanwhile, would not only support the hypersonic enterprise but a wide variety of defense applications, from ejection seat testing to nuclear modernization. The nation would similarly benefit from new flight test corridors, wind tunnels, and instrumentation—the literal airspace and equipment needed to increase test capacity. ■

FURTHER RESOURCES

- Fiscal 2025 President's Budget for USAF Hypersonics Prototyping
- Fiscal 2025 President's Budget for ONR
- Fiscal 2025 President's Budget for TRMC
- Fiscal 2025 National Defense Authorization Act
- House Armed Services Committee: US and Adversary Hypersonic Capabilities, 2024

- Congressional Research Service, "Hypersonic Weapons: Background and Issues for Congress," 2024
- NDIA, Hypersonics Supply Chains: Securing the Path to the Future, 2023
- USAF: An Exploratory Analysis of the Chinese Hypersonics Research Landscape, 2022
- CSIS: "Hypersonic Strike and Defense: A Conversation with Mike White," 2021
- Hudson Institute, "The Future of US and Allied Hypersonic Missile Programs," 2024
- CSIS, "Complex Air Defense: Countering the Hypersonic Missile Threat," 2021
- CSIS: "Getting on Track: Space and Airborne Sensors for Hypersonic Missile Defense," 2023
- Stratolaunch: "Introduction to Hypersonic Flow," 2021
- NASA, "Facing the Heat Barrier: A History of Hypersonics," 2007
- US–China Economic and Security Review Commission, Hearing on China's Pursuit of Defense Technologies, 2023

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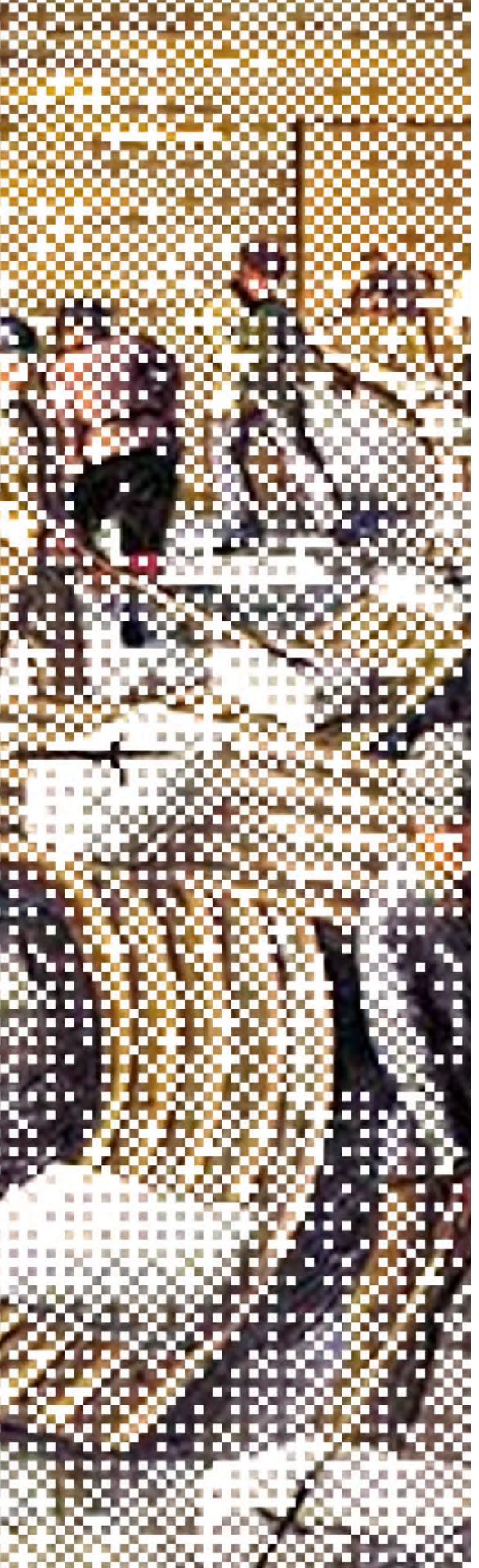


■ National Security

Conditional Export Controls on AI Chips

Tao Burga

SUMMARY

The Bureau of Industry and Security (BIS) implements US export controls on dual-use technology. To be effective at preventing misuse and smuggling, some of these controls, such as those on AI chips, must restrict exports to dozens of countries. Although this blanket-ban approach weakens US industry's competitiveness in the short and long term, current oversight and enforcement mechanisms leave little alternative.

Conditional export controls offer a more effective approach within BIS's authorities. This approach allows BIS to specify the conditions under which export restrictions apply, increasing restrictions on technologies that are easy to smuggle or misuse, but not on those that include security features to enable better oversight or reduce misuse potential. This would incentivize AI chip firms to develop more secure versions of their chips in order to avoid tougher export restrictions.

Using the pressing case of AI chips, BIS should reform the Low Processing Performance (LPP) license exception to lower the yearly cap of AI chip exports to single firms, while allowing chip firms to use LPP's current (higher) cap for chips that

include security features to help detect or prevent smuggling and/or hinder their misuse. By linking export access to security features, conditional export controls would enhance national security, help sustain US technological leadership, reduce smuggling, and drive security-focused innovation—all without additional government spending.

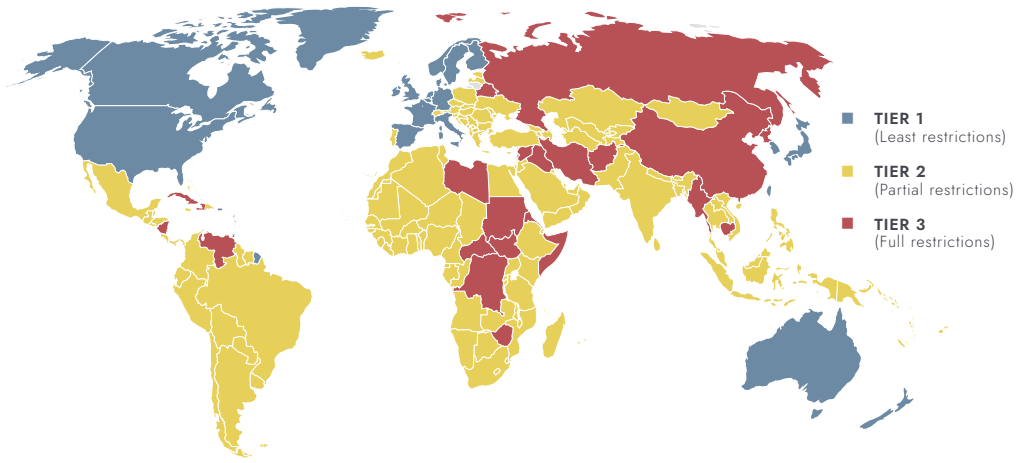
PROBLEM

Conditional export controls follow two principles:

1. Export controls should be *conditional*: restrictions should vary based on how effectively technologies can be protected against misuse or smuggling.
2. This conditionality should be *forward-looking*. BIS should not take the set of currently existing technologies as fixed; instead, it should specify which properties a technology would need to have to face lower restrictions, and let US industry innovate to meet this security requirement.

Although applicable to any technology that can be modified to decrease its misuse potential, this piece focuses on AI chips. Extensive smuggling shows that AI chip export controls are being easily circumvented. This mounting evidence is in part responsible for prompting BIS to repeatedly expand the scope of its controls on AI chips, from merely restricting exports to China and a few other arms-embargoed countries in 2022 to extending some form of AI chip export restrictions to all but 18 countries in the world in 2025.

AI CHIP EXPORT RESTRICTIONS AFTER JANUARY 2025



Map: Tao Burga. Source: Bureau of industry and security

To be effective, blanket bans on exports must be far-reaching, covering not only target countries but also every country suspected of facilitating smuggling. But these broad export restrictions come at a cost: in the short term, they weaken the competitiveness of American firms, and in the long term, they risk pushing global supply chains away from US technology. By driving demand toward foreign alternatives, they create room

for the emergence of foreign competitors and incentivize the deliberate "designing out" of American components. Moreover, blanket bans cannot address the underlying dual-use problem of AI chips themselves; once a chip has been smuggled, export controls do nothing to lower the chips' misuse potential.

By clearly specifying the conditions under which export regulations will vary, the US government can incentivize industry to develop products with built-in safety and security features that reduce misuse potential. These incentives would accelerate defensive innovation, spurring a "race to the top" among firms competing for increased market access in allied or neutral countries (though not in adversarial countries such as China or Russia, given the risk of circumventing security measures (see appendix)). Conditional export controls would thus allow the US to maintain foreign market access for its firms while achieving stronger national security outcomes, all without additional government spending.

BIS recently made progress by making access to National Validated End User (NVEU) authorizations conditional on the applicant's ability to verify that chips have not been moved from the intended destination country, explicitly including delay-based location verification as a potential mechanism. This is the most concrete and recent case of BIS implementing a conditional export control policy. Despite this, AI chip export controls continue to have major gaps: BIS's LPP license exception allows "Tier 2" countries (those facing partial restrictions) to receive up to 1,700 advanced AI chips (NVIDIA H100 or equivalent total processing performance) per firm per year with no country-wide limit or export license requirements, amounting to $42.5 million worth of chips today. LPP will likely prove to be the weakest link in today's chip export control regime, since smugglers can set up shell companies online for as little as a few thousand dollars in a matter of hours or days and take advantage of LPP.

SOLUTION

BIS should strengthen existing export controls on AI chips by amending the LPP license exception. Specifically, BIS should lower the annual import cap per firm in "Restricted LPP Destinations" from 1,700 to 200 H100-equivalent chips. This new quantity would be low enough to make large-scale smuggling much more difficult while not restricting smaller transactions, and is equal to the current reporting threshold for single shipments under LPP. Restricted LPP Destinations would be those in Tier 2 countries that are less trusted or suspected of being chip diversion hotspots (see appendix for the proposed list and detailed implementation recommendations).

Additionally, BIS should permit exports of additional chips—up to the original 1,700 limit, although it could be higher or lower—conditional on these chips having a new "High Security" (HS) certification granted by BIS and interagency partners. This does not roll back current export controls; it expands them *only* for less-secure chips.

The security goals for HS certification and example hardware-enabled mechanisms to achieve them should include:

1. Effective oversight: Knowing whether the chips have been moved to restricted regions, are being used by prohibited entities, or are being used for prohibited

uses. Possible mechanisms include privacy-preserving location verification to detect smuggling and metering to detect policy violations without revealing sensitive data.

2. Rule enforcement: Enforcing export restrictions by limiting the usefulness of the chip when in restricted regions or used for prohibited uses. Possible mechanisms include selling AI chips in fixed sets and bandwidth bottlenecking to prevent unauthorized dual-use AI model training, and offline licensing to enforce end-user or location-based export restrictions.

Some of these mechanisms, like delay-based location verification, can be implemented with little delay by leveraging functionality already present on advanced chips. Others may require years of R&D to be implemented securely. BIS should therefore consider a staged compliance delay (see appendix).

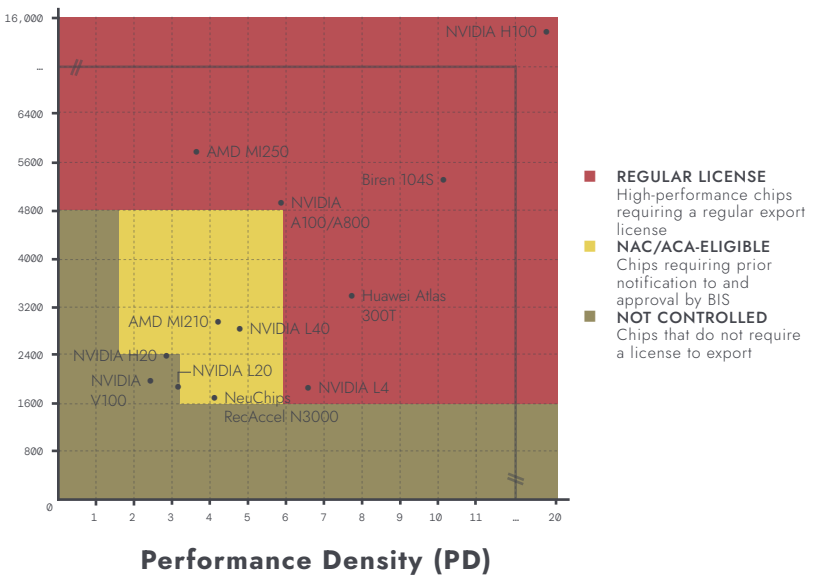
All these mechanisms should incorporate robust hardware security, tamper resistance, and privacy protections to prevent circumvention while maintaining trust in American technology. To ensure continued compliance, exporters should be required to submit regular reports to BIS detailing whether HS chips are still compliant with the terms of HS certification.

JUSTIFICATION

Precedent

BIS is authorized to set conditions for accessing export licenses under the Export Control Reform Act of 2018. Blanket export controls are already routinely implemented conditionally based on the technical characteristics of the items—indeed, current AI chip export controls apply only on chips above specific performance parameters, as shown below.

DATACENTER CHIPS



Source: Center for Security and Emerging Technology

What BIS has done comparatively less is make these conditions forward-looking to create incentives to adopt safer technologies. Still, this has precedent: In 2016, BIS created the "encryption carve-out," which exempts sensitive or dual-use data from normal export restrictions if stringent cryptographic security requirements are met. At the time, consultants advised companies to ensure adherence to this high security standard to simplify compliance and be able to serve customers that need to transfer sensitive data overseas. The success of BIS's 2016 encryption carve-out later prompted the amendment of the International Traffic in Arms Regulations (ITAR) to likewise create a successful encryption carve-out for the export of sensitive data within its jurisdiction. Today, all major US cloud computing providers offer data storage and transfer services that comply with the security standard set by BIS, even touting it as a feature to attract users.

Challenges to implementation and recommended solutions

If BIS has the authority and successful precedent to implement conditional export controls, why doesn't it do so more often? The most important challenges to overcome are:

- Specification: BIS's conditions for lowering export restrictions need to be well specified, which is harder to do for technologies that do not yet exist or have not been widely adopted.
- Credibility: Given the specification problem described above, BIS may be reluctant to take on the task of testing the on-chip security mechanisms in-house. This would take time, money, and expertise that BIS may not have.
- Unintended consequences: BIS may fear that on-chip mechanisms for governance could be tampered with and circumvented post-export, reducing their efficacy.
- Capacity constraints: BIS has already expressed interest in conditional export controls and implemented one in their NVEU program, but it has not had capacity to scope and implement more such changes because it is chronically underfunded and understaffed.

The proposed solution addresses these concerns by recommending:

- A discretionary (yet minimally burdensome) approach to give BIS flexibility in adjudicating applications, thus eliminating the risk of negative outcomes from bad early specifications.
- Placing the burden of proof for HS applications on US chip firms, since they have the required technical knowledge and capacity to run or fund these evaluations.
- Conditionally expanding, not reducing, export controls. This means little downside risks to national security, even if the on-chip mechanisms are circumvented. If US chip firms choose not to apply for HS licenses, the effect will merely be a reduction in the number of chips that can be sold without a license to less trusted Tier 2 countries. In the worst-case scenario, if HS-certified chips are sold but are later found out to be easy to skirt their security mechanisms, the level of effective restrictions on chip exports will still be no higher than they are currently. ■

FURTHER RESOURCES

- Tim Fist, Tao Burga, and Vivek Chilukuri, "Technology to Secure the AI Chip Supply Chain: A Working Paper," Center for a New American Security, 2025
- Asher Brass and Onni Aarne, "Location Verification for AI Chips," Institute for AI Policy and Strategy, 2024

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APPENDIX

How to implement HS certification

To implement an HS certification for AI chips and qualify them for lower export restrictions, BIS, in collaboration with interagency partners, would adjudicate applications on a per-model basis, granting HS certification automatically to all identical chips with the same security-enhancing modifications. Chips with previously approved security mechanisms could also be fast-tracked for certification.

This discretionary adjudication process could be modeled after that of the Notified Advanced Computing (NAC) license exception, reducing set-up costs. But unlike for NAC, HS certification should only require one blanket approval for all identical chips or security mechanisms. This would differ from NAC's per-shipment process, which has proven cumbersome for BIS and industry alike.

A non-formulaic approach is important because creating precise technical specifications may be difficult for BIS to do in advance. Instead, discretionary approaches would allow BIS to specify security goals, and let US chip firms choose the best ways to meet them. A precise, formulaic process could still be used for some better-understood mechanisms like delay-based geolocation.

Because BIS is chronically underfunded and understaffed, it is unlikely to be able to conduct the relevant evaluations fully in-house. That is why it should, first, rely on its interagency partners, including the Department of Defense and the National Institute of Standards and Technology, for technical assistance, and, second, advise private industry that they are responsible for meeting the burden of proof and showing the functionality and robustness of their hardware security mechanisms.

The draft rule text below (alongside a more detailed application form) could be used to establish HS Certification:

> *(a) HS Certification.* Exporters may apply for HS certification on a per-model basis (i.e., separate certification is needed for items with different designs or technical specifications), to show that the item meets the security requirements (as specified in subparagraph (a)(i)), to the satisfaction of the Bureau of Industry and Security and its interagency export control partners.

(i) Security requirements. To be eligible for HS certification, exporters must show that the item has features which:

(1) (starting 60 days after [PUBLICATION DATE]) Enable the exporter and the Bureau of Industry and Security to continuously (e.g., monthly) and easily verify that the item has not been moved to an ineligible destination (e.g., from ping times to nearby secure servers) with a focus on avoiding false negatives (the item does not appear to be in a restricted region, but it is), as specified in paragraph [PARAGRAPH] of this section, AND/OR

(2) (starting 10 months after [PUBLICATION DATE]) Significantly decrease the item's usefulness for some activities described in part 744 of the Export Administration Regulations, and especially for dual-use AI model training, by significantly throttling performance (e.g., by revoking an operating license and bottlenecking interconnect bandwidth), especially if the item is moved to ineligible destinations as specified in paragraph (b)(i) of this section; AND

(3) Are tamper-resistant or tamper-evident and costly to circumvent, for example by requiring significant time or cost proportional to the number of items from which security features are removed.

(ii) Incident reporting requirement. Exporters with knowledge of incidents or evidence that suggest that the added security of an HS-certified item is being successfully tampered with or circumvented must immediately report these incidents to BIS.

(iii) Revocation of certification. HS Certification may be revoked, at the discretion of BIS, if an HS-certified mechanism or model of an item is found to no longer satisfy the security requirements specified in paragraph (a)(i) of this section.

Proposed amendments to License Exception LPP

BIS should amend 15 C.F.R. § 740.29 as follows:

1. Add a new subparagraph to paragraph (d) to read as follows:

(d)(1) Notwithstanding paragraph (d), any ultimate consignee that is located in, headquartered in, or has an ultimate parent company headquartered in a "Restricted LPP Destination" (as defined in paragraph (h)(3) of this section) may receive no more than 3,200,000 TPP per calendar year under License Exception LPP, unless the exported or reexported items are HS-certified (as defined in paragraph (h)(4)). If the exported or reexported items are HS-certified, the standard 26,900,000 TPP limit in paragraph (d) applies.

2. Modify subparagraph (f)(ii) by deleting "*26,900,000 TPP*" and replacing it with "*3,200,000 TPP for non-HS certified items or 26,900,000 TPP for HS-certified items (as defined in paragraph (h)(4))*"
3. Modify subparagraph (g)(2) by deleting "*26,900,000 TPP*" and replacing it with "*TPP set forth in paragraph (d)*"
4. Add two new definitions in paragraph (h) to read as follows:

(h)(3) Restricted LPP Destination. *For purposes of paragraph (d)(1) of this section, a "Restricted LPP Destination" means any destination specified in Country Group D:1 or Country Group D:4, as well as India, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. [See justification below.]*

(h)(4) HS-certified item. *For purposes of this license exception, an "HS-certified item" is an item that has been granted a High Security (HS) certification by BIS, in consultation with its interagency export control partners, upon a determination that such item incorporates on-chip security measures designed to facilitate post-export oversight (e.g., geolocation from the ping times to nearby secure servers) or to reduce misuse potential, including dual-use AI model training and large-scale inference (e.g., offline renewable licensing to enforce end-use agreements) and that the item's security mechanisms cannot be easily bypassed (e.g., by relying on robust hardware security to make tampering costly and/or easy to detect).*

The justification for "Restricted LPP Destinations" is that Country Groups D:1 and D:4 were already export-controlled in October 2023 as the result of concerns about national security and missile technology proliferation. The other countries are added because of modeling that indicates they may be hotspots for AI chip diversion (e.g., to China). This excludes Taiwan, a key strategic ally. The list should be amended as AI chips with geolocation capabilities increase our insight into which countries are responsible for most chip diversion.

Frequently asked questions

Q: Does this approach roll back current export controls?

A: No. Conditional export controls are a tool with a broad range of possible implementations. The goal is to have higher restrictions for less secure technology compared to more secure versions of that same technology. For example, this proposal achieves this goal by increasing export restrictions *only* on less-secure chips. Alternative approaches could seek to decrease net restrictions by creating broader carve-outs for more secure chips.

Q: Would it be safe to export AI chips with security and oversight-enhancing mechanisms to adversarial countries such as China and Russia?

A: No. All such mechanisms carry some risk of circumvention, especially by motivated nation-state-level actors. If conditional export controls are used to facilitate exports of more secure chips, this should only be done for currently restricted allies or neutral countries. Some of these are countries that faced no AI chip export restrictions before January 2025, many of which are US allies or strategic partners, such as Poland, Iceland, Turkey, Colombia, and others that are neither suspected of widespread misuse or chip diversion.

Q: Why not just require US chip firms to modify all their export-grade chips to make them more secure?

A: Blanket requirements could backfire by forcing industry to implement security mechanisms that are not yet commercially viable. While such requirements would be reasonable for well-understood mechanisms implementable with functionality already present in chips, such as delay-based location verification, many promising security features still require substantial R&D to ensure that they are effective without compromising performance or adding prohibitive costs. Conditional export controls offer a balanced approach by creating strong incentives for innovation in chip security while allowing flexibility in implementation. This reduces the risk of unintended consequences and prevents potential harm to US industry's competitiveness if certain mechanisms prove difficult to implement.

Q: Should conditional export controls only be applied to AI chips?

A: No. Although this proposal focuses on AI chips, other export-controlled technologies would be good candidates for conditional export controls. In general, conditional export controls should be targeted at modifiable dual-use technologies in areas where the US is ahead of the competition. In this context, "modifiable" means that it could be made safer to export with technical alterations.

Another technology where conditional export controls seem particularly valuable is benchtop DNA synthesizers. A report from the Institute for Progress investigated technical mitigations that should be implemented on these devices, which could serve as a tentative list of potential security-enhancing modifications that would lead BIS to implement less restrictive export controls.

Q: Is delay-based location verification fully privacy preserving?

A: Yes. Delay-based geolocation can identify only the broad area (tens to hundreds of miles) where a chip may be located, and it does so without communicating any private or sensitive information. This is because it relies on sending a simple "ping" to AI chips and calculating the time it takes to return to the server of origin. This can already be implemented with cutting-edge AI chips' existing functionality.

Q: Is delay-based location verification easy to circumvent?

A: No, not easily and without raising alarms. There are two broad ways it could be circumvented: taking the chips offline and spoofing. Taking chips offline is comparatively easy, but would raise red flags: although the chip wouldn't positively attest that it has been smuggled, it would stop positively asserting that it hasn't. This would alert BIS to potential smuggling, allowing it to focus its enforcement efforts on these cases

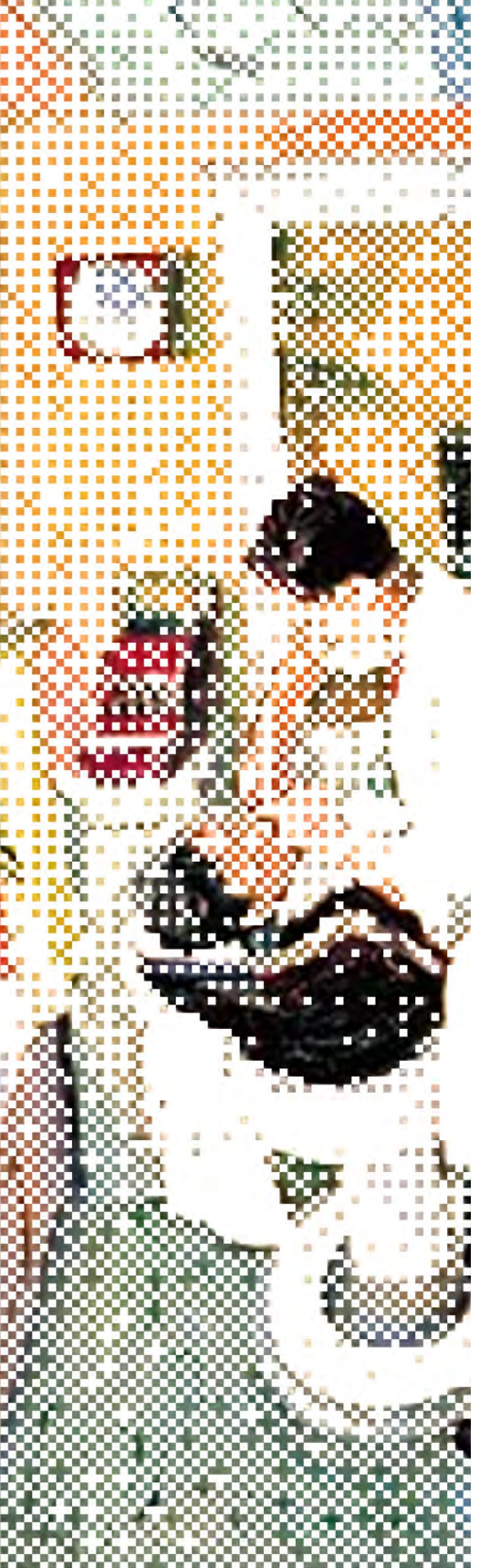
while not worrying about chips that continue to provide consistent location data. That is, even if some motivated actors are able to stop transmitting location data, having this functionality is an immense improvement over BIS's current oversight capabilities.

The second approach, spoofing, could be actively misleading (e.g., showing a location outside of China when the chip is actually in China). However, this would be very difficult to accomplish at scale. It may require per-GPU private key extraction (potentially through complex side-channel attacks) and forging responses for thousands of GPUs with precise timing. This may only be feasible for openly adversarial state-backed actors with physical access to the chips. Even then, it would cost significant resources, slow down smuggling, catch failed circumvention attempts, and significantly narrow down potential smuggling routes.

Therefore, while no security measure is perfectly foolproof, delay-based location verification would significantly enhance BIS's monitoring capabilities and act as a strong deterrent against AI chip diversion.

Q: How could US chip firms meet their burden of proof for HS certification?

A: Firms could meet their burden of proof by subjecting their modified products to adversarial testing or red-teaming, potentially launching bug bounty programs and hiring independent evaluators; demonstrating post-export oversight mechanisms, such that they would know if a certain solution has been circumvented; adhering to existing rigorous hardware/cybersecurity standards when applicable; and gradually rolling out new solutions to test them under real-world conditions.



■ National Security

Accelerating the Defensive Deployment of Pathogen Sequencing

Simon Grimm

SUMMARY

America's inability to quickly detect new biological threats endangers national security. US biosurveillance could be improved through the use of metagenomic sequencing, a technology that would allow the detection of unknown pathogens. But although American companies dominate the sequencing market, no government program uses metagenomic sequencing at scale, and the use of sequencing in clinics remains low.

To remedy this, the United States should accelerate the deployment of sequencing through i) increased adoption of metagenomic biosurveillance by the Centers for Disease Control and Prevention (CDC), ii) investment by the Advanced Research Projects Agency for Health (ARPA-H), and iii) improved regulation of clinical metagenomics by the Food and Drug Administration (FDA). Specifically:

1. The CDC should establish public-private partnerships to run metagenomic sequencing on 10-20 percent of samples collected through its federal wastewater and international traveler surveillance programs.
2. To increase the adoption of clinical metagenomic sequencing, the FDA should release a public update of its 2016 draft guidance on the regulatory approval of sequencing-based pathogen diagnostics.
3. ARPA-H should stand up a program for the development of faster and more robust sample processing methods for metagenomic sequencing.

PROBLEM

America is vulnerable to biological threats. No major government program has the goal of continuously monitoring the emergence of new pathogens, whether they are natural, accidentally leaked, or intentionally released. Common-sense improvements to disease surveillance have yet to be implemented: monitoring of well-known pathogens like H5N1 is often delayed by months, and data sharing remains slow or incomplete. All the while, biological risks are increasing, as malicious actors can use new technologies to engineer biology for nefarious ends.

If we want to reliably mitigate new pathogen outbreaks, aggressive steps to improve biosurveillance are required. The key technology enabling better pathogen detection is metagenomic sequencing: a method for reading out all genetic material in a sample, allowing the identification of both known and unknown biological threats (Appendix 1).

The United States has the technological capacity to use metagenomic sequencing for nation-scale pathogen monitoring. American companies provide more than half of global sequencing capacity and comprise the majority of the sequencing market. But metagenomic sequencing is not routinely deployed in America's biosecurity architecture. No FDA-cleared sequencing-based diagnostics exist, leaving both hospitals and military bases with few tools to reliably detect unknown pathogens. Similarly, though CDC monitors incoming international travelers and wastewater for known viruses, the agency does not use metagenomic sequencing to get ahead of unforeseen biological threats.

The administration's interest in government reform and its embrace of private sector innovation both provide an opportunity to strengthen American biosurveillance. Through improved FDA guidance, companies could develop and sell more affordable sequencing-based pathogen diagnostics. By working with the private sector, the CDC could pilot metagenomic sequencing within federal biosurveillance programs. And US government research and development (R&D) bodies like ARPA-H could further the development of sequencing-based pathogen detection. These changes would both strengthen America's security against future biological threats, and further US companies' lead in sequencing technology.

SOLUTION

The Centers for Disease Control and Prevention

The CDC has entered into multiple public-private partnerships to build biosurveillance systems: the National Wastewater Surveillance System (NWSS), launched in 2020, collects wastewater across the US, covering more than 100 million citizens. Meanwhile, the Traveler-based Genomic Surveillance (TGS) Program collects nasal swabs and airplane waste from thousands of international travelers each month.

- Working with private companies, both of these programs should pilot metagenomic sequencing of collected samples.
- Under the PREVENT Pandemics Act, CDC is allowed to use more flexible Other Transactional Authority awards (OTA) for biosurveillance purposes. OTA awards should be used for pilot public-private partnerships that trial sequencing of 10 to 20 percent of samples from NWSS and TGS.
- For NWSS, samples should be taken from a set of five to ten major metropolitan areas.
- For TGS, nasal swab samples and airplane wastewater should be collected from three or more major international airports and pooled before sequencing to maintain anonymity.

After removing human data, the resulting sequencing data should be shared in real-time (less than a day after data generation) to allow analysis by actors beyond CDC.

Currently, programs like TGS squander the value of uploaded data by omitting crucial information like flight or airport origin. This should be changed; following guidance on metagenomic sequencing data sharing released by HHS (see below), metagenomic sequencing data should always be linked to precise contextual metadata.

Following actions by the Department of Government Efficiency (DOGE), CDC will likely undergo structural reform. Instead of cutting NWSS or TGS, agency reform should create space to make these pathogen-agnostic monitoring platforms a centerpiece of infectious disease surveillance.

The Department of Health and Human Services (HHS) should provide data sharing guidance for metagenomic sequencing data. This guidance would establish how human genomic material should be removed prior to upload and clarify that pooled sequencing samples that had human genomic material removed do not fall under Health Insurance Portability and Accountability Act (HIPAA) privacy rules. Additionally, the provision of precise contextual metadata should be mandatory (Appendix 2).

The Food and Drug Administration

The FDA originally released draft guidance on the approval of sequencing-based diagnostics in 2016. Given rapid technological advances, the agency decided to not further develop this guidance. However, sequencing technology has now become cheaper and more precise, allowing the development of sample-to-answer sequencing devices in the next 5-10 years. Based on these developments, FDA should publish updated draft guidance:

- This guidance should clearly specify that metagenomic pathogen diagnostics must demonstrate very high specificity, while allowing moderate sensitivity. Additionally, FDA should clarify under which conditions metagenomic detection methods can be used to detect newly emerging pathogens without additional regulatory review.
- Finally, the guidance should outline conditions under which sequencing-based diagnostics would qualify for reimbursement by the Centers for Medicare & Medicaid Services (CMS).

ARPA-H

ARPA-H should set up a new program to develop faster and more robust sample processing methods for clinical metagenomic sequencing.

- At present, getting clinical metagenomic results takes anywhere from twelve hours to several days, with sample preparation as the primary bottleneck.
- Building on the Biomedical Advanced Research and Development Authority's (BARDA) DRIVe's Agnostic Diagnostics work, a new ARPA-H program should focus on technologies that prepare heterogeneous clinical samples for sequencing more quickly.
- The ultimate aim should be to get different sample types onto a sequencer in under two hours, at less than $50 per sample, while maintaining detection capability for pathogens at clinically relevant concentrations.

JUSTIFICATION

The status quo will leave us exposed to new biological threats. Routine metagenomic sequencing has only become viable in recent years, as the cost of sequencing has plummeted. Despite these technological advances, it remains uncertain whether the government will adopt metagenomic sequencing anytime soon.

The CDC's failure to look beyond known threats is explained by its fragmented structure. Founded in 1946 with a specific mandate for disease surveillance and epidemiology, the agency has splintered into subunits dedicated solely to specific known pathogens. This structure makes it challenging for the CDC to incorporate technologies like metagenomic sequencing, which detect many pathogens at once, including unknown ones. Similarly, it remains unclear if the CDC will fully integrate new biosurveillance programs into its disease surveillance apparatus, despite their affordability and effectiveness. Together, TGS and NWSS public-private components cost just $37 million a year—less than half a percent of the CDC's 2024 budget—and reduce reliance on state public health labs, many of which struggle to share timely data or adopt advanced detection methods.

The FDA's past approach to regulating diagnostics is a similarly bad fit for modern detection technologies. To approve diagnostics, companies need to show reliable performance for detecting specific pathogens. This approach makes little sense when

evaluating diagnostics that can detect as-of-yet unknown pathogens. With preliminary guidance released nearly a decade ago, the FDA has left regulatory uncertainty unresolved. As a result, only companies with close relationships to the FDA understand the agency's expectations for approving metagenomics-based diagnostics, slowing innovation and adoption.

Adopting metagenomic sequencing

Both domestically and abroad, more actors are exploring metagenomic sequencing for pathogen detection. In the United Kingdom, the National Health Service has launched an ambitious sequencing-based pathogen detection system, partnering with Oxford Nanopore Technologies to diagnose severe respiratory illness. Next door, the European Union has committed €24 million to develop a rapid point-of-care metagenomic sequencing diagnostic.

The US has taken some small steps to embrace sequencing-based pathogen detection. The Department of Defense's Defense Innovation Unit launched the ANTI-DOTE project, a program for detecting engineered pathogens in military base wastewater, and BARDA DRIVe spent $3–4 million dollars on developing metagenomic sequencing tools through its "Agnostic Diagnostics" program. However, these initiatives remain too limited in scope and scale to enable the United States to reliably detect unknown or engineered pathogens in the near future.

Through the actions outlined in this policy brief, HHS agencies can make large improvements to American pathogen early detection. The combination of cheaper sequencing, established sampling infrastructure, and increasing biological risks make the current moment well-suited for accelerating the deployment of metagenomic sequencing, both in clinics and within the federal government's biosecurity infrastructure. ■

FURTHER RESOURCES

- CDC, "SARS-CoV-2 Sample Positivity in Travellers Can Predict Community Prevalence Rates: Data from the Traveller-Based Genomic Surveillance Programme," 2024
- National Wastewater Surveillance System, "About CDC's National Wastewater Surveillance System (NWSS)"
- FDA, "Infectious Disease Next Generation Sequencing Based Diagnostic Devices: Microbial Identification and Detection of Antimicrobial Resistance and Virulence Markers," *Federal Register*, 2016
- Defense Innovation Unit, "DIU Demonstrates Capability To Find Novel Threats in High Complexity Wastewater Data," 2025
- Simon L. Grimm et al. "Inferring the Sensitivity of Wastewater Metagenomic Sequencing for Pathogen Early Detection," medRxiv, 2023
- Charles Y. Chiu and Steven A. Miller, "Clinical Metagenomics," *Nature Reviews Genetics*, 2019

- Nava Whiteford et al., "Towards Ubiquitous Metagenomic Sequencing: A Technology Roadmap"
- Arielle D'Souza and Janika Schmitt, "Mapping America's Biosurveillance," Institute for Progress, 2024

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APPENDIX

1. A primer on metagenomics

Unlike targeted approaches such as antigen tests or quantitative polymerase chain reaction (qPCR), metagenomic sequencing works by breaking up all genetic material (DNA and RNA) in a sample into short fragments, reading the sequence of DNA/RNA bases in each fragment, and then matching these reads against reference databases to determine which organisms they came from.

The cost of sequencing has dropped precipitously in recent years, making it likely that metagenomic sequencing will become cost-competitive with targeted pathogen detection approaches in three to ten years. In the mean-time, there is already research showing that metagenomic sequencing is viable for both detecting a large number of pathogens in wastewater and in a large swath of clinical sample types.

2. Barriers to metagenomic data sharing

There are three main concerns around the generation and sharing of metagenomic data.

First, metagenomic datasets can be noisy, increasing the risk of false-positive findings. Even for more simple types of data, a concern about false positives has traditionally made CDC averse to data-sharing. However, quickly resolved false positives are much less harmful then not identifying a new biological threat as fast as possible. Public health agencies should thus move toward more data sharing, rather than less. This would allow a larger number of actors to review public health data, increasing transparency and accelerating threat detection.

A second concern is that metagenomic sequencing data can contain human genomic material. Uploading large amounts of human genomic data could both pose privacy risks, and could enable exploitation by US adversaries. However, researchers have developed robust methods to remove human reads from sequencing material. For instance, data that gets uploaded to the National Center for Biotechnology Information's Sequence Read Archive (SRA) can be run through its Human Read Removal Tool (HRRT), or researchers can use many publicly available tools to remove human data before any further analysis takes place.

Finally, CDC's wastewater and international traveler programs routinely omit large amounts of raw data and crucial metadata due to fears that associating pathogens with

specific counties or origin countries encourages discrimination. However, these omissions harm transparency and significantly reduce the value of publicly-funded biosurveillance data. To not have this happen with metagenomic sequencing data, fast data sharing and provision of appropriate metadata should become mandatory within federal biosurveillance programs.

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