

STEPS

SCIENCE, TECHNOLOGY, ENGINEERING, AND POLICY STUDIES

ISSUE 8 2023

Robert (Bob) Hummel, PhD
Editor-in-Chief



POTOMAC INSTITUTE PRESS

IN THIS ISSUE

**Values, Strategy, and America's
Competitive Posture**

*The Honorable Alan R. Shaffer;
Moriah Locklear, PhD; and Tim Welter, PhD*

**Want US Semiconductor Leadership?
Fix the Tax Code**

Brian Shirley

**Reinvigorating Innovation for
National Security**

*Bob Hummel, PhD in collaboration with
Potomac Institute for Policy Studies Staff*

**The Concept of an Economic
Warfare Operations
Capability (EWOC)**

*Tim Welter, PhD in collaboration with
staff members of the
Potomac Institute for Policy Studies*

**Prospects for US Sources
of Energy**

*Bob Hummel, PhD and
Moriah Locklear, PhD*



STEPS is published by Potomac Institute Press of the Potomac Institute for Policy Studies.

Disclaimers: The Publisher, Institute, and Editors cannot be held responsible for errors or any consequences arising from the use of information contained in this publication; the views and opinions expressed do not necessarily reflect those of the Publisher, Institute, Editors, or any Government Agency. The Potomac Institute is non-partisan and does not take part in partisan political agendas.

Copyright Notice: It is a condition of publication that articles submitted to this magazine have not been published and will not be simultaneously submitted or published elsewhere. By submitting an article, the authors agree that the copyright for their article is transferred to the Potomac Institute Press if and when the article is accepted for publication. The copyright covers the exclusive rights to reproduce and distribute the article, including reprints, photographic reproductions, microfilm, or any other reproductions of similar nature and translations.

Access to this publication is available free online at: www.potomacinstitute.org/steps.

All images Shutterstock.com, unless otherwise credited.



Cover image:

The cover is from a collection of photographs made by the late David Kay. He was a Senior Fellow of the Potomac Institute, a nuclear weapons expert, and had worked for the International Atomic Energy Agency and for the US intelligence community as an expert on Iraqi programs of weapons of mass destruction. His findings from a 2003 search in Iraq led to the Robb/Silberman independent commission on intelligence failure, published in 2005. David Kay was also an accomplished photographer, and shared that interest with the founder of the Potomac Institute, Michael Swetnam. David Kay died in August 2022 at the age of 82.



David Kay

About *STEPS*

STEPS: Science, Technology, and Engineering Policy Studies magazine is the technical publication of the Potomac Institute for Policy Studies, where scholarly articles of broad interest are published for the policy community. We welcome original article submissions including, but not limited to the following:

- Discussions of policies that either promote or impede S&T research
- Articles that address implications and/or consequences of S&T advances on national or international policies and governance
- Articles that introduce or review a topic or topics in science, technology, or engineering, including considerations of potential societal impacts and influences
- Articles that cover historical developments in science, technology, and engineering, or related policies, and lessons learned or implications going forward
- Non-partisan opinion pieces concerning policies relevant to S&T, to include S&T research trends or research opportunities, and the role of national policies to promote or modify those trends and opportunities

STEPS promotes the mission of the Potomac Institute for Policy Studies, which fosters discussions on science and technology and the related policy issues. Policies are necessary to advance scientific research toward achieving a common good, the appropriate use of human and material resources, and significant and favorable impacts on societal needs. At the same time, the creation of effective policy depends on decision makers being well-informed on issues of science, technology, and engineering, including recent advances and current trends.

Societal changes arising from technological advances have often surprised mainstream thinkers—both within technical communities and the general public. *STEPS* encourages articles that introduce bold and innovative ideas in technology development or that discuss policy implications in response to technology developments.

We invite authors to submit original articles for consideration in our widely-distributed publication. Full articles should be between 2,000 and 5,000 words in length, and should include citations and/or references for further reading. Contributions will undergo in-house review and are subject to editorial review. Short articles of less than 2,000 words, such as notes, reviews, or letters are also welcome.

Please submit articles to steps@potomacinstitute.org

or contact us if you wish to discuss a topic before completing an article. Please refer to the **Instructions for Authors** for complete information before submitting your final manuscript.

Editorial and Production Staff

Editor-in-Chief
Robert (Bob) Hummel, PhD
Email: rhummel@potomacinstitute.org

Director, Potomac Institute Press
Website + Imaging
Alex Taliesen
Email: ataliesen@potomacinstitute.org

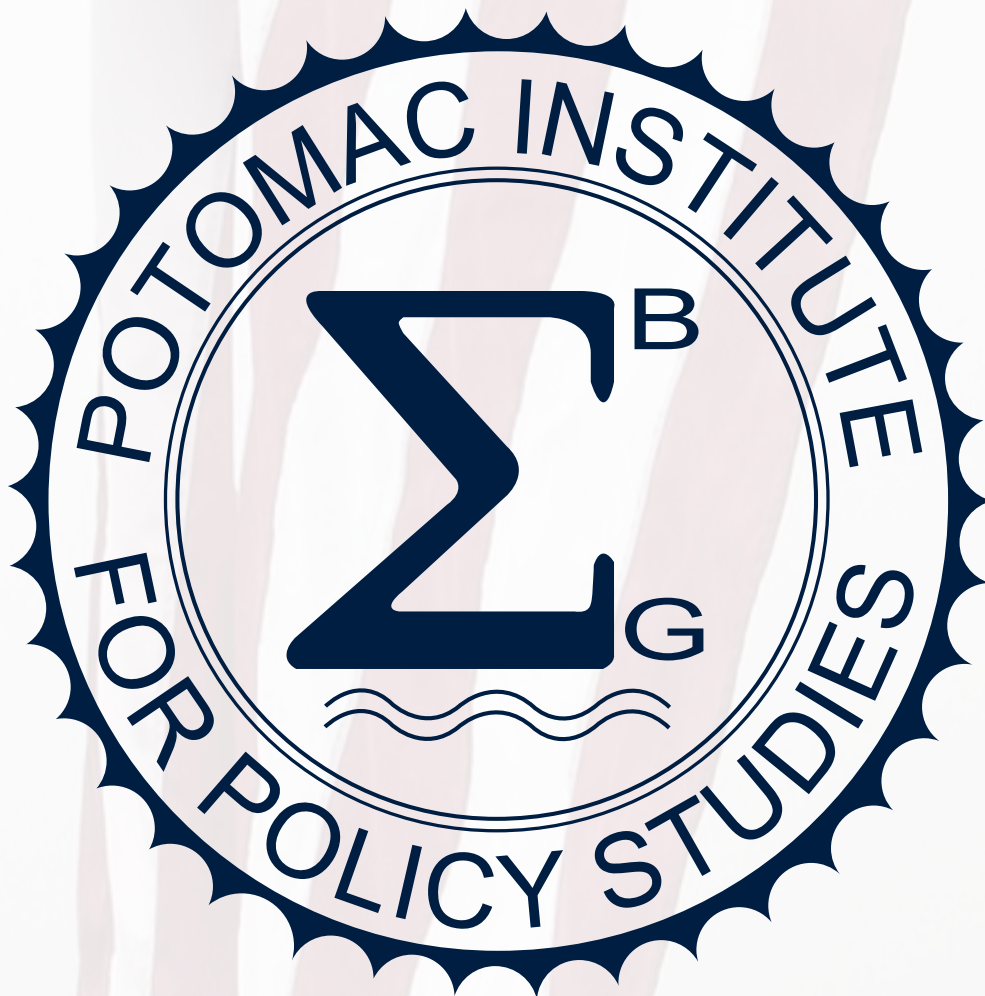
Editing + Design
Sherry Loveless
Email: sloveless@potomacinstitute.org

Potomac Institute for Policy Studies Board of Regents

Gen. Alfred M. Gray, USMC (Ret.), Chairman	Francis Landolf
Yonah Alexander, PhD	Hon. Zachary J. Lemnios
Jeffrey Allen "Skunk" Baxter	Hon. Arthur L. Money
Hon. Maj. Gen. Charles F. Bolden Jr., USMC (Ret.)	Brian J. Morra
Hon. H. Lee Buchanan, PhD	Alden V. Munson Jr.
Peter F. Byrrow, PhD	Adm. Robert J. Natter, USN (Ret.)
Terry L. Collins, PhD	Gordon Oehler, PhD
Hon. Rita R. Colwell, PhD	Robie Samanta Roy, PhD
Peggy Evans	Timothy R. Sample
Lt. Gen. Timothy G. Fay, USAF (Ret.)	Howard K. Schue
Raul Fernandez	Hon. Alan R. Shaffer
Lt. Gen. George Flynn, USMC (Ret.)	Brian Shirley
Rear Adm. John E. Gordon, JAGC, USN (Ret.)	George A. Spix
Melissa Hathaway	Lt. Gen. Keith J. Stalder, USMC (Ret.)
John C. Johnson	Hon. Kathryn D. Sullivan, PhD
Hon. Donald M. Kerr, PhD	Hon. William McClellan
Kathleen Kiernan, PhD	"Mac" Thornberry
Jerry Krassner, PhD	Rand Waltzman, PhD
	Doug Wolfe
	Lt. Gen. Donald C. Wurster, USAF (Ret.)
	Hon. John J. Young Jr.

About the Potomac Institute for Policy Studies

The Potomac Institute for Policy Studies is an independent, nonpartisan, not-for-profit, science and technology (S&T) policy research institute. The Institute identifies and leads discussions on key S&T and national security issues facing our society, providing an academic forum for the study of related policy issues. Based on data and evidence, we develop meaningful policy recommendations and ensure their implementation at the intersection of business and government.





STEPS

SCIENCE, TECHNOLOGY, ENGINEERING, AND POLICY STUDIES

CONTENTS

About STEPS.	3
About the Potomac Institute for Policy Studies	4
From the CEO	6
<i>Jennifer Buss, PhD</i>	
From the Editor	7
<i>Robert (Bob) Hummel, PhD</i>	
VALUES, STRATEGY, AND AMERICA'S COMPETITIVE POSTURE.	8
<i>The Honorable Alan R. Shaffer; Moriah Locklear, PhD; and Tim Welter, PhD</i>	
WANT US SEMICONDUCTOR LEADERSHIP? FIX THE TAX CODE	18
<i>Brian Shirley</i>	
REINVIGORATING INNOVATION FOR NATIONAL SECURITY	30
<i>Robert (Bob) Hummel, PhD in collaboration with Potomac Institute for Policy Studies Staff</i>	
THE CONCEPT OF AN ECONOMIC WARFARE OPERATIONS CAPABILITY (EWOC).	42
<i>Tim Welter, PhD in collaboration with staff members of the Potomac Institute for Policy Studies</i>	
PROSPECTS FOR US SOURCES OF ENERGY	56
<i>Robert (Bob) Hummel, PhD and Moriah Locklear, PhD</i>	
FEATURED AUTHORS	67

From the CEO

Jennifer Buss, PhD

The Potomac Institute has always centered its mission around four factors: national security, science and technology, US industry, and government policy. The Institute's goal is to find ways to create or improve government policy to propel the technology engine that drives benefits to the nation and to enact policies that are well-informed by sound science and technology.

Articles in *STEPS* reflect our priority to sound research and recommendations for science and technology policies. The publication of *STEPS* is where we try to elevate the discussion and provide big ideas to address the complexity of the nation's wellbeing and national security. Complementing the work we do for customers, discussions are fostered from information gleaned from our studies and our interactions with affiliates, to address big issues from a bold policy perspective. They allow us to step back from the specific concerns of government agencies and bureaucratic issues, to emphasize our role as a think tank that can mix technology expertise with government and business experience to confront some of the nation's most difficult problems.

The articles in this issue draw on lessons from our Global Competition Project to address ways that the US can prevail in a competition with other nation states in areas of primary national importance. From recommendations on how to organize an Economic Warfare Operational Capability to finding common values to achieve a unity of effort in global competition, these articles combine thoughts and ideas from discussions involving Potomac Institute for Policy Studies staff, affiliates, and guests.

I hope you find the ideas expressed in these articles useful.

Jennifer Buss, PhD
Chief Executive Officer, Potomac Institute
jbuss@potomacinstitute.org



From the Editor

Robert (Bob) Hummel, PhD

This issue of *STEPS* includes articles that are inspired by the Potomac Institute's Global Competition Project. During the project, which is ongoing, the Institute holds symposia with invited experts to discuss societal-level issues associated with competition between nations on varying dimensions of economic, military, and political sectors.

The culmination of the first phase of the project is summarized in an article with lead author Al Shaffer calling for a renewal of American commitment to enduring values and development of strategies to ensure constancy to those values. In this way, America can maintain a competitive posture that positions the nation for economic and military security.



The Institute has long focused on microelectronics as an enabler of technological advances and a competition among nations for dominance in supplies of semiconductors. An article by Brian Shirley points out that while the CHIPS Act intends to bolster the US position in supplying semiconductors for our needs, the tax code inhibits R&D that is vital to the development of a domestic production capacity. A change to tax treatment of R&D that became effective in 2022 is being considered for recission, and this article points out the need for that change as soon as possible.

One of the dimensions of competition involves innovation for national security interests. Other nations, particularly China, have learned that technological innovation is important in military affairs, and are competing with the US tradition of innovation in development of defense systems. The Institute conducted a major study for the Department of Defense, as directed by a previous act of Congress, looking at sixteen different areas of impact to the capacity of the national security innovation base. I compiled a selection of the work of a large number of researchers at the Institute to highlight three areas for action where the US could reinvigorate innovation for national security.

The Global Competition Project, from its inception, has considered national security to involve competition in military, economic, and political spheres. Yet our tools for combatting punitive economic measures against the US are uncoordinated and limited. Tim Welter and colleagues discuss the concept of an economic warfare operations capability, detailing the structure and missions that such an organization might entail.

One of the thorny issues that the Global Competition Project considered was the competition for energy sources, which are currently dominated by oil and gas deposits. These are unevenly distributed throughout the world, causing geopolitical and economic competitions. Independent of the issue of carbon emissions, the Institute considered the prospects for other energy sources to supply US economic and military goals. Dr. Moriah Locklear and I compiled some of the thoughts in an article on those prospects for future supplies.

STEPS welcomes submissions for future issues, whether by affiliates of the Potomac Institute, or others, on topics related to science and technology policy. As with this issue, *STEPS* is published in pdf form online, and widely disseminated electronically to policy-makers and stakeholders. Enjoy this and future issues.

Robert (Bob) Hummel, PhD
Editor-in-Chief, *STEPS*
Chief Scientist, Potomac Institute
rhummel@potomacinstitutione.org

A large, vertical American flag with red and white stripes and a blue field with white stars, positioned on the right side of the page.

Values, Strategy, and America's Competitive Posture

*The Honorable Alan R. Shaffer;
Moriah Locklear, PhD;
and Tim Welter, PhD*

"The supreme art of war is to subdue the enemy without fighting.... When you surround an army, leave an outlet free. Do not press a desperate foe too hard."

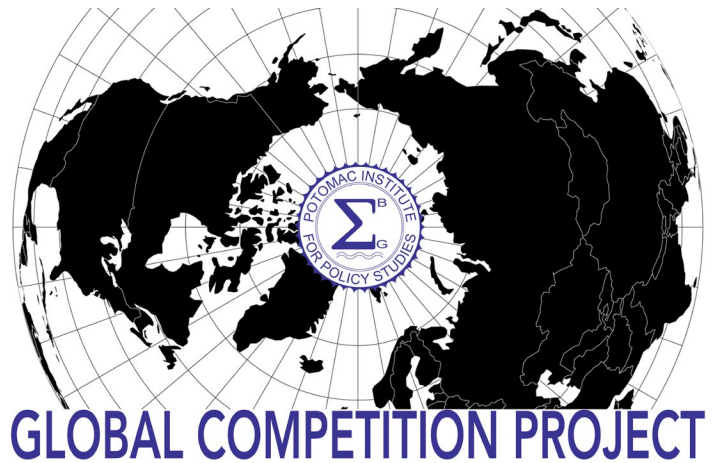
—Sun Tzu
The Art of War

"One has to understand the Chinese intellectual game, which is what we call 'Go' [and] they call 'weiqi'. ...it's a game of strategic encirclement... our intellectual game is chess. Chess is about victory or defeat. Somebody wins."

—Former Secretary of State Henry Kissinger
CNN, 2010

Across the 2021-2022 academic year, the Potomac Institute conducted the Global Competition Project (GCP) as a foundation to identify, elevate, and examine some of the most consequential aspects of the globally competitive environment in the modern era. Among transitions that the US strategic community faces, maintaining a competitive advantage among peer rivals is arguably the most influential. While shifting from a focus on counterterrorism, which remains a vital concern, the US confronts a societal-level competition that challenges US dominance in military, economic, and political spheres.

The project's study makes clear the interdependency of these spheres and the complex nature of the competition. For example, a flourishing economy is essential for government funding of a strong national defense, which in turn is needed to deter attacks that could impact other important national interests.¹ Competition to lead in the development and employment of technology impacts businesses and thus the health of the nation's economy. Especially for the United States, technology is historically consequential to the fielding of military might that renders required deterrent effects and operational capabilities to keep the nation safe and prosperous. More broadly, a continuous supply of scientists and engineers is the critical enabler for technology leadership, which is driving the development of a more competitive environment across STEM education.² Competition in certain sectors, such as food, microelectronics, metals and minerals, pharmaceuticals, and petrochemicals, can have profound impacts when global supply chains are interrupted. Each area requires a strategy for the US to remain competitive, so that the US can remain dominant in the interlocking vectors of national power.



However, we pose the question: Is there a grand strategy to preserve the competitive posture of America in the "international order"? What are the goals and purposes of the strategies addressing individual competitive domains? What is a universal strategy on which the multi-dimensional competitions can unite in a common effective position?

We posit that to ensure a secure and prosperous future as a world leader, the US needs to adopt a grand strategy based on a contemporary conception of our shared American values. Such a strategy should be tied to the fundamental ideals that Americans have sought throughout US history; a continuous journey toward "life, liberty, and the pursuit of happiness" for all, as in the Declaration of Independence. Or, as codified in the preamble to the US Constitution, the ideals of the foundation of the nation still apply as doctrine that Americans can support: "To form a more perfect union, establish justice, ensure domestic tranquility, provide for the

common defense, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our posterity."

The current global and domestic environments challenge our ability to realize a strategy based on shared values. Somewhere over the past several decades, the United States has seemingly lost its unity of purpose: the shared vision of what the country is and its role in the world. In the 1990s, the concept of "illiberal democracies" was discerned,³ with concern that democracies worldwide might willingly abandon the fundamentals of liberalism (not in the sense of liberal politics, but rather the norms of individual rights and freedoms and rule by laws and constitution). In September 2018, *The Economist* decried that champions of the liberal democratic ethos have turned their backs on the very tenets of liberalism they espoused (see excerpt). Those tenets (liberal democracies, not left or right political ideologies) had helped deliver immeasurably positive outcomes for the quality of life of an entire era of humanity.⁴ The forewarned potential for illiberal democracies to abandon those tenets seems to be an accelerating trend.⁵

The world, it seems, is turning away from liberal democratic values—the basis for the greatest improvement in quality of life in the history of humanity, experienced by billions across the globe. This adverse trend has been most notably embodied in the rise of populist political movements and increasingly autocratic governments. Less controversially, there is a global erosion of international norms and institutions that America helped establish in the post-World War II era—those norms and institutions that led to unbridled growth and prosperity, not to mention America's posture as a global leader, in ensuing decades.

Excerpt from *The Economist*, "A manifesto for renewing liberalism," Sept 13, 2018.

"LIBERALISM made the modern world, but the modern world is turning against it. Europe and America are in the throes of a popular rebellion against liberal elites, who are seen as self-serving and unable, or unwilling, to solve the problems of ordinary people. Elsewhere a 25-year shift towards freedom and open markets has gone into reverse, even as China, soon to be the world's largest economy, shows that dictatorships can thrive."

American Exceptionalism

A review of the origins of American exceptionalism might elucidate the kind of shared values on which a contemporary strategy for ensuring our enduring security and prosperity should be rooted.

Immediately following victory in World War II, the US emerged as a beacon for liberal democracy. The United States guided the post-World War II international order by promoting free enterprise and democracy while adopting a strategy of containment to deal with the Soviet Union; ultimately providing a competitive edge that drove an arguably peaceful and prosperous era. American values were generally admired and often emulated during the Cold War when compared with those who empathized with the primary ideological rival of Western democratic values—communist dictatorships, as exemplified by Stalin's Soviet Union.

The notion that the principles guiding American society were "unique" among the world's nations dates back to 1835 when Alexis de Tocqueville wrote about America's "exceptional" nature. Tocqueville defined American exceptionalism as "based on liberty, equality before the law, individual responsibility, republicanism, and laissez-faire economics."⁶ Over the years, some have interpreted American exceptionalism to mean American superiority. This was never the intent. Rather, America was an exception to the general rule that nations throughout history were primarily established around things like shared ethnicity, religious beliefs, or natural geographic boundaries, and not on a set of principled ideals.

The revolutionary idea in the founding of the American democracy was that all should be viewed as equals under the law. The foundational ideals were unique and exceptional at their time, in prioritizing individual liberty and equality as the cornerstones for governance.

After the Great Depression and World War II, America was confident and optimistic, embracing an ethos of exceptionalism and liberal democratic values. The US was a hegemonic great power among the world's nations, unified in sharing a common enemy in the Soviet Union. In establishing a "Strategy of Containment,"⁷ the US posited that Soviet demise was inevitable if they continued to elevate the communist state over individual liberty, fraternity, and free enterprise, as practiced in the US and free Europe.

Containment meant that competition amounted to maintaining deterrence, for example through the creation of the North Atlantic Treaty Organization, and the Marshall Plan to rebuild Europe and create a strong economy across Europe to resist the spread of communism.

When the USSR was dissolved in 1991, it was widely recognized that the Soviets simply did not have a grand strategy that could compete with the West, economically or otherwise. Top-down, state-driven Soviet economics could not compete with the flourishing free-market approach of the West. The latter provided the means to field and sustain a long-term military buildup while the Soviets could not compete financially to sustain their military capabilities. Perhaps more importantly, the US embraced an approach of investing in technology that subsequently enabled that military superiority (the "offset strategy"⁸) while also vastly benefiting the growth of commercial markets.⁹ The US focus on R&D resulted in the US leading the world in development of the semiconductor, the computer, imaging sensors, the information technology revolution, the mapping of the human genome, and the development of quantum science among other technology leaps. It was an approach that inherently reflected shared American values of the time and the weighty aspirations that influenced the nation's birth.

To the world, the United States exemplified freedom and possibilities. President Kennedy had proposed a set of challenges, including a lunar mission, that was a characterization of the nation's persona: "We choose to go to the Moon in this decade and do the other things, not because they are easy but because they are hard."¹⁰ Despite the strife in the US of the sixties, doing the "hard" things were embraced by Americans and envied by other nations. They transcended the fray of short-sighted political whims. Across administrations, they unified the country on shared principles that helped maintain competitiveness on the global stage both economically and militarily. In turn, they helped secure an enduring means for Americans to flourish and lead for decades thereafter.

The Competitive Landscape Today

The competitive landscape has changed. Today, both Russia and China pose particular challenges to the US national wellbeing.

Russia has shown an ability to field sophisticated weapons, albeit a remarkable inability to dominantly utilize them in their Ukrainian conquest. However, Russia remains a challenge in their ability to divert supplies of oil and gas, meddling in and exploiting regional conflicts, and in manipulating information and emerging technologies for their exploits.

The US now perceives China as its greatest competitive challenge. Following in the footsteps of his immediate predecessors, President Xi of China has led a very focused effort to increase China's stature in specific areas that will advance their national interests, both domestically and abroad. China is using economic, military, and other levers of influence.¹¹ In rolling out China's 14th five-year plan covering 2021 to 2026, Xi cited the need for China to develop an independent means for innovation that drives economic growth and influence, with advanced technology at the center of the plan. A translation of a portion of Xi's remarks is in the accompanying box.¹²

Xi's observations present aspirations that could well have reflected continued US research goals. The Chinese plan further targets "New Generation AI, Quantum Information, Integrated Circuits, Brain Science and Brain-Inspired Research, Genetics and Biotechnology, Clinical Medicine and Health, and Deep Space, Deep Earth, Deep Sea, and Polar Exploration."¹³ It also pledges Chinese leadership to pursue basic research, talent development, and focused research for strengthened industrial output.

Previously, in 2018, President Xi had established a goal for China to become the dominant power in AI by 2030, documented in a speech to the Politburo: *"that China must develop, control and use artificial intelligence (AI) to secure the country's future in the next technological and industrial revolution."*¹⁴ At the time, it was noted that China would invest more money in AI by 2030 than the value of the entire Australian economy.¹⁵ In 2014, China had established a goal to be the dominant producer of microelectronics by 2030. The goal was reiterated in 2016, when President Xi said "the fact that core technology is controlled by others

"New-generation information technologies, represented by artificial intelligence, quantum information science, mobile telecommunications, the Internet of Things, and blockchain are accelerating breakthrough applications. The realm of life sciences, represented by synthetic biology, gene editing, brain science, and regenerative medicine is giving birth to new changes. The new manufacturing technologies of integrated robotics, digitalization, and new materials are accelerating the manufacturing industry's shift toward intelligent systems, focusing on services, and eco-friendliness. The development of clean, high-efficiency, and sustainable energy technologies is accelerating and will usher in a global energy revolution. Space and maritime technologies are expanding the frontiers of where humans can live and work. In sum, creative breakthroughs in areas such as information technology, life sciences, manufacturing, energy, space, and maritime are supplying ever more well-springs of innovation for cutting-edge and disruptive technologies."

President Xi Jinping
Peoples Republic of China

is our greatest hidden danger."¹⁶ Vice Premier Ma Kai reinforced Xi at the 2018 National People's Congress by stating, "We cannot be reliant on foreign chips."¹⁷ Reflecting a competitive posture of technology development, the 14th five-year plan states that the People's Republic of China will "formulate an action agenda for becoming an S&T powerhouse...and successfully fight tough battles for key and core technologies." One hears echoes of Kennedy's "Moon in this decade" speech.

China has an established comprehensive vision for its future with tangible goals and strategies to achieve those goals. Portions of this plan are exemplified in the "Made in China 2025" document.¹⁸ While their success is not guaranteed, China has taken deliberate steps toward achieving those goals with measurable progress. In contrast, the United States pursues technologies ad hoc, driven by fads and competitive pressure, with little or no strategy. Some say that this is preferable, as it comports with the character

of an open, liberal democratic, free-market society. Others say that technologically, the US is essentially standing still, if not regressing.

Impediments to America Securing its Future

A secure and prosperous future will require America to rally behind a coherent, societal-level strategy that reflects our values and can address the challenges China and others present in a competitive global environment. The strategy must acknowledge impediments and provide a means to mitigate them while also capitalizing on our strengths across the most pertinent areas of the global competitive environment. Arguably, the recently released 2022 National Security Strategy opens a window to the complexities of that discussion.¹⁹

Drags on Economic Growth

The US can remain competitive by investing resources, human and capital, in productive assets that create value for the populace. The value of such investments should be guided by the aspirations of the aforementioned preamble to the Constitution: to “provide for the common defense, [and] promote the general Welfare.” This is distinctive from business, wherein the bottom line is literally the bottom line in an accounting spreadsheet.²⁰ For society, the bottom line is found in its shared values.

The problem with the national debt, which for the US exceeds \$30 trillion, is that the interest paid on the debt can end up being invested in unproductive or less desirable assets, as opposed to those reflective of shared values. Arguably, much of the roughly \$400 billion spent on interest on the national public debt,²¹ and some of the \$1.7 trillion currently spent per year by the US government on social safety net programs, fails to wholly answer societal expectations (and really, its needs). Moreover, the US government deficit has increased steadily over the past 20 years with a sharp uptick during the COVID-19 pandemic.²² The last time the US had a budget surplus was 2001.²³ Total national debt as a percent of GDP is the highest in US history,²⁴ and carries the implication that deficit spending is the norm rather than a tool reserved for deliberate strategic stimulus. A strategy that helps the US realize and maintain a viable competitive posture and a leadership role on the international stage includes getting the government’s financial house in order.

Individuals and consumers have a role to play in determining investments made for prosperity. Economic theory says that demand will drive efficient investments, but such is less the case as income inequality rises. Income inequality in America has skyrocketed over the past four decades. As of this article’s writing in 2022, only 0.1% of Americans wielded 18% of the nation’s wealth.²⁵ The US ranks 98th of 169 countries in income inequality, as measured by the Gini Index,²⁶ which is worse than most peer nations.

Income inequality is correlated with decreased social cohesion, increased polarization, and overall depressed economic growth.²⁷ Worse than simply promoting unproductive investments, a nation will find it hard to be competitive on the global stage if it is at war with itself.

Polarization

Numerous studies show that America has become increasingly polarized, which presages a scenario that can reduce the country’s competitiveness.^{28,29} In his 2004 book “The Paradox of Choice: Why Less is More,” Barry Schwartz lays out a compelling hypothesis, supported by data, that anxiety and polarization increase as the number of available choices increase.³⁰ Consider Schwartz’s hypothesis as it relates to the availability of news in the United States. In the 1970s, Walter Cronkite was hailed as “the most trusted man in America,” and people got their news primarily from one of three networks (CBS News, Cronkite; NBC, Huntley and Brinkley; ABC News, Peter Jennings) supplemented by the local newspaper. Each were trusted to report professionally and objectively. Today, there are many more news channels and pathways for information,³¹ and there is no universal “trusted agent.” Instead of a comfortable middle ground, America now has a thoroughly divided left and right. “News” channels (really “news commentators”) compete by finding niches that allow consumers to reinforce their views by self-selection to sources motivated to sell their product. Politicians and political profiteers often pour gasoline on the fire by hyperbolizing and caricaturing minor policy differences for political and monetary gain. Elected leaders who compromise are all too frequently endangered.

Polarization ultimately detracts from the ability to define a common set of contemporary American values upon which to base a strategy to compete effectively on the global stage.

Appreciation of US Civics

Yet another impediment to coalescing on shared values is a decline in knowledge of, and respect and appreciation for, US civics. A robust civics education helps motivate citizens to engage productively on the issues of the day, it broadens the base of those involved (and therefore invested) beyond the interests of a small political elite. Civics classes elucidate how government works while providing the opportunity to debate, understand, and work through all sides of challenging issues with civility and respect for the process.³² However, in 2016, only 26% of Americans could name the three branches of government.³³ Flatly, Americans no longer understand how government works, let alone feel an obligation or sense of duty to participate in traditional civic responsibilities. In the absence of a common external villain (e.g., the USSR), political debate and policy prescriptions are increasingly based on opinions of others who tend to reinforce personal views, as opposed to the collective wisdom of an educated society.

Devising the Next Grand Strategy—Where Should We Go Now?

It is not a stretch to say that “inherent American values”—individual rights, an open democratic society, and free enterprise—made the nation and the world a stronger place. People have enjoyed major improvements in living standards, growth in personal wealth, the ability to explore and communicate with the rest of the world more easily, and, in spite of internal squabbling, greater individual freedoms. Said another way, the principles of “American exceptionalism” remain a noble goal for the betterment of humanity. This is true for America, and for all who embrace liberal democratic ideals.



Despite daunting challenges, America can regain and enhance its competitive posture and rally around a strategy that unifies our engagement with the rest of the world by acting along three directions, presented here as recommendations.

RECOMMENDATION 1

Regain wide appreciation for government's purpose and active civil discourse that strengthens our institutions and society.

A well-functioning government requires the active participation of citizens compromising and holding each other accountable via civil debate and tough deliberation on the formulation of policy. Mindless partisan brinkmanship is wholly destructive for all involved. Americans should be able to name the three branches of government, understand models of governance, and appreciate the value of checks and balances.

The federal government could start by providing incentives and policies to expand civics instruction at the local level. Objective curricula could be promulgated through trusted channels, possibly stood up for the purpose. Reinvigorating an understanding for how government works and establishing an appreciation of civic duties, is a first step in securing America's competitive posture for the future.

RECOMMENDATION 2

Establish and enforce standards of accountability that ensure efficacy of information used in media and policy deliberations without abridging the freedom of speech and of the press.

The nation needs access to news based on authoritative, factual data. The Society of Professional Journalists have agreed on a code of ethics, which begins:

“... public enlightenment is the forerunner of justice and the foundation of democracy. Ethical journalism strives to ensure the free exchange of information that is accurate, fair and thorough. An ethical journalist acts with integrity.”

These are sound principles. “News” networks need to be transparent about who has (or, has not) adopted such standards.

As an analogy, the American Meteorological Society certifies weathercasters who meet similar professional standards. Most professions require lifelong learning with tests to hold them accountable. This is true of lawyers, doctors, professional engineers, accountants, and many others. Identification of who is and is not a professional journalist would be a step toward rooting out malfeasance. Radical views should not be suppressed, but viewers should have the right to know if the on-air person is a true journalist or an entertainer.

A further step would be to have a federally funded apolitical organization, an ombudsman, to conduct fact checking and provenance discovery, using authoritative sources, to illuminate those “news bits” that are really just conspiracy theory or memes not based on facts. Once again, the idea is not to suppress speech, but to illuminate truth from falsehood using verifiable data and contextual explanation. The US government collects mounds of data on countless issues and has done so since its earliest days. Leveraging that data as a foundation for accountability would help reinvigorate an appreciation for the value of our institutions while also distinguishing truth from entertainment. Revitalizing an allegiance to data in policymaking will be a significant step in developing a coherent strategy for competition on the global stage.

RECOMMENDATION 3

Assess and divulge America’s contemporary values, and formally commit to them as a basis for a strategy to compete with near peers on military, economic, and political levels.

America’s competitive posture for the future requires us to identify a coherent set of values from which to develop a strategy. Too often, Americans get bogged down in the minutia of daily life or caught up in the passion of a politically charged debate. In doing so, they lose sight of the uniquely exceptional values Tocqueville first wrote about that are still accepted by most Americans. A joint panel, made of Executive and Legislative Branch members of varying age, race, experience, and regional origin should be appointed with that express mission. Once agreed upon, the panel should incorporate their findings into the basis of a draft strategy document.

It would be difficult to argue against continued dedication to life, liberty, and the pursuit of happiness and the ideals of the US Constitution. Modern economic analysis could justify capitalism and a market economy over a Stalinist command economy.

Such a panel was constituted in 1996 and listed American national interests of that day.³⁴ An update is needed and would have to be ratified as a representative statement of American values. While not written in stone, it would serve as the foundation of common contemporary principles and ideals in addressing the global competitive environment.

To Sum Up

To assure a secure and prosperous future wherein America thrives as a world leader, the US must adopt a grand strategy based on a contemporary conception of our shared American values. Such a strategy should connect current day global and domestic challenges to the base ideals Americans have pursued since the dawn of our nation. To do so, Americans must act to regain a wide appreciation for government’s purpose and a dedication to active civil discourse that strengthens our societal institutions. We must also seek to develop and adopt the means to hold accountable efficacy in information used in media and policy deliberations while holding true to First Amendment principles. Finally, we should commission a diverse panel to assess and divulge America’s contemporary values, and formally commit to them as basis for a strategy to address the challenges of the globally competitive environment.

Endnotes

- 1 Hon. Alan R. Shaffer, “Standing Tall: Maintaining US Economic and Military Competitive Posture During Turbulent Times,” *STEPS* Issue 6, April 2022, <https://potomac institute.org/steps/featured-articles/april-2022/standing-tall-maintaining-us-economic-and-military-competitive-posture-during-turbulent-times>.
- 2 Andreas Schlwicher. “Programme for International Student Assessment 2018.” OECD Press. 2020.
- 3 Fareed Zakaria. “The Rise of Illiberal Democracy.” *Foreign Affairs* Nov/Dec 1997. <https://www.foreignaffairs.com/world/rise-illiberal-democracy>.
- 4 “A Manifesto for Renewing Liberalism.” *Economist* September 13, 2018. <https://www.economist.com/leaders/2018/09/13/a-manifesto-for-renewing-liberalism>.
- 5 Sean Illing. “Fareed Zakaria Made a Scary Prediction about Democracy in 1997 – And It’s Coming True,” *VOX Magazine* July 4, 2017, <https://www.vox.com/conversations/2017/1/18/14250364/democracy-liberalism-donald-trump-populism-fareed-zakaria-europe-fascism>.

- 6 Martin Lipset. *American Exceptionalism: A Double Edged Sword* New York, N.Y.: W.W. Norton & Co., Inc. 1996.
- 7 X, (George Kennen), The Sources of Soviet Conduct. *Foreign Affairs* Jul 1947, <https://www.foreignaffairs.com/articles/russian-federation/1947-07-01/sources-soviet-conduct>.
- 8 Edward Keefer, Harold Brown: Offsetting the Soviet Military Challenge 1977-1981, Mar 2017, webHaroldBrownProgram2018.pdf (defense.gov).
- 9 William Leavitt. Toward New Horizons. Theodore von Karmen, A Memorial. *Air Force Magazine* June 1963.
- 10 John F. Kennedy, "Address at Rice University on the Nation's Space Efforts," 12 Sept. 1962, transcript available at <https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-at-rice-university-on-the-nations-space-effort>.
- 11 Ben Murphy, Rogier Creemers, Elsa Kania, Paul Triolo, Kevin Neville, and Graham Webster, Stanford Cyber Policy Center, "Xi Jinping: 'Strive to Become the World's Primary Center for Science and High Ground for Innovation,'" March 18, 2021.
- 12 Xi Jinping: 'Strive to Become the World's Primary Center for Science and High Ground for Innovation.'
- 13 Taken from the translation of the 14th 5-year Plan by the Center for Security and Emerging Technology.
- 14 "Develop and Control: Xi Jinping Urges China to use Artificial Intelligence in Race for Tech Future." *South China Post* Oct 31, 2018.
- 15 Made in China 2025: Xi Jinping's Plan to Turn China Into the Ai World Leader. ABC News.
- 16 Speech at the Work Conference for Cybersecurity and Informatization <https://chinacopyrightandmedia.wordpress.com/2016/04/19/speech-at-the-work-conference-for-cybersecurity-and-informatization/>.
- 17 China's Next Target: US Microchip Hegemony, *Wall Street Journal*, July 27, 2017, <https://www.wsj.com/articles/chinas-next-target-u-s-microchip-hegemony-1501168303>.
- 18 Made in China 2025 Archived 2018-12-29 at the Wayback Machine. CSIS, June 1, 2015, Made in China 2025 | Center for Strategic and International Studies (csis.org).
- 19 2022 US National Security Strategy, <https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf>.
- 20 Paul Krugman, "Competitiveness: A Dangerous Obsession," *Foreign Affairs* Mar/Apr 1994.
- 21 Fiscal Data Treasury.gov, "Interest Expense on the Public Debt Outstanding," <https://fiscaldata.treasury.gov/datasets/interest-expense-debt-outstanding/interest-expense-on-the-public-debt-outstanding>.
- 22 Fiscal Data Treasury.gov, "What is the National Debt?" <https://fiscaldata.treasury.gov/americas-finance-guide/national-debt/>.
- 23 Fiscal Data Treasury.gov, "What is the National Debt?"
- 24 National Debt in the United States in Relation to Gross Domestic Product from 2017 to 2020, with a Forecast to 2027." Statista. 2023. <https://www.statista.com/statistics/269960/national-debt-in-the-us-in-relation-to-gross-domestic-product-gdp/>.
- 25 Ember Smith and Richard V. Reeves. "Class Notes: Rising Income and Wealth Inequality, Parent Spending, and More." Brookings. December 9, 2020. <https://www.brookings.edu/blog/up-front/2020/12/09/class-notes-rising-income-and-wealth-inequality-parent-spending-and-more/>.
- 26 Ventura, Luca. "World Inequality Ranking by Country 2022." *Global Finance* February 17, 2022. <https://www.gfmag.com/global-data/economic-data/world-inequality-ranking>.
- 27 "Introduction to Inequality." International Monetary Fund. 2022. <https://www.imf.org/en/Topics/Inequality/introduction-to-inequality#What%20are%20Consequences%20of%20Inequality?>
- 28 "Political Polarization in the American Public." Pew Research Center. June 12, 2014. <https://www.pewresearch.org/politics/2014/06/12/political-polarization-in-the-american-public/>.
- 29 "Is Political Polarisation in America Really Rising?" *Economist*. October 5, 2021. <https://www.economist.com/the-economist-explains/2021/10/05/is-political-polarisation-in-america-really-rising>.
- 30 Barry Schwartz. *The Paradox of Choice*. Harper Perennial. 2004.
- 31 Barry Schwartz. *The Paradox of Choice*.
- 32 Edward Fiske. "With Old Values and New Titles, Civics Courses Make a Comeback." *New York Times* June 7, 1987.
- 33 Shapiro, Sharon and Catherine Brown. "A Look at Civics Education in the United States." Department of Education. 2018. <https://files.eric.ed.gov/fulltext/EJ1182087.pdf>.
- 34 "America's National Interests." The Commission on America's National Interests. July 1996. https://www.belfercenter.org/sites/default/files/legacy/files/america_interests.pdf.

Want US Semiconductor Leadership? Fix the Tax Code

Brian Shirley

*Member of the Board of Regents
Potomac Institute for Policy Studies*



Image credit: Alex Taliesen

Article first published online as the white paper: *Want US Semiconductor Leadership? Fix the Tax Code*



Introduction

Recent events starkly highlighted the importance of semiconductors to the US economy and the fragility of the US semiconductor supply chain. These shortages were estimated to have cost over a full percentage point of 2021 US GDP,¹ prompting Congress to pass the 2022 CHIPS and Science Act to level the playing field for onshore semiconductor manufacturing after decades of decline.

However, unrelated tax code changes are threatening to unravel any benefit from the CHIPS Act. New 2022 regulations that disallow the same-year expensing of investments in research and development (R&D) have perversely made the already-uncompetitive US tax code even more punitive to innovation. These disincentives to R&D risk harming US competitiveness across all high-tech fields, including those sectors where the US currently leads.

The impact is especially great to the semiconductor industry. In every corner of the semiconductor ecosystem, R&D costs are rising dramatically due to the challenges of the slowing of Moore's Law and increasing international competition, forcing all companies to run even faster on existing product roadmaps, while simultaneously investing in higher-risk technology. The semiconductor industry has always depended on large R&D expenditures, but today the pressures are even greater due to the exploding complexity of technology.

Such pressures have already driven many companies to focus on existing "cash-cow" product lines rather than investing in the requisite R&D to stay current. By slashing R&D funding and giving up on maintaining the cutting edge, companies can increase near-term profitability and return cash to shareholders. These companies run the risk, however, of obsolescence and demise within a few years.

For companies in other sectors where large R&D spending is mandatory, the risk of underinvestment in R&D is larger today than ever, especially with the headwinds of a potential economic downturn. Declining revenues usually mean that cuts must be made, and R&D investment in future products is often the only available lever. However, long development pipelines mean the gaps will not be obvious for years, at which point they will be too large to remedy.

In this environment, the 2022 tax code changes are uniquely damaging. While meant to help pay for lower overall corporate tax rates, the changes punish the nation's high-tech industries by penalizing the very innovation that drives progress and growth. Research-intensive industries are paying for lower tax rates for larger but less R&D-dependent industries. The beneficiaries are industries such as financial, service, and retail. The result will be perverse harm to the high technology industries of the US.

New 2022 regulations that disallow the same-year expensing of investments in research and development (R&D) have perversely made the already-uncompetitive US tax code even more punitive to innovation.

Such policies stand in stark contrast to those of Asian countries (including China)—all of whom have realized the importance of innovation, erecting favorable R&D tax policies to promote technology development. The US is risking national security due to an anticompetitive tax code that penalizes innovation.

Semiconductor R&D

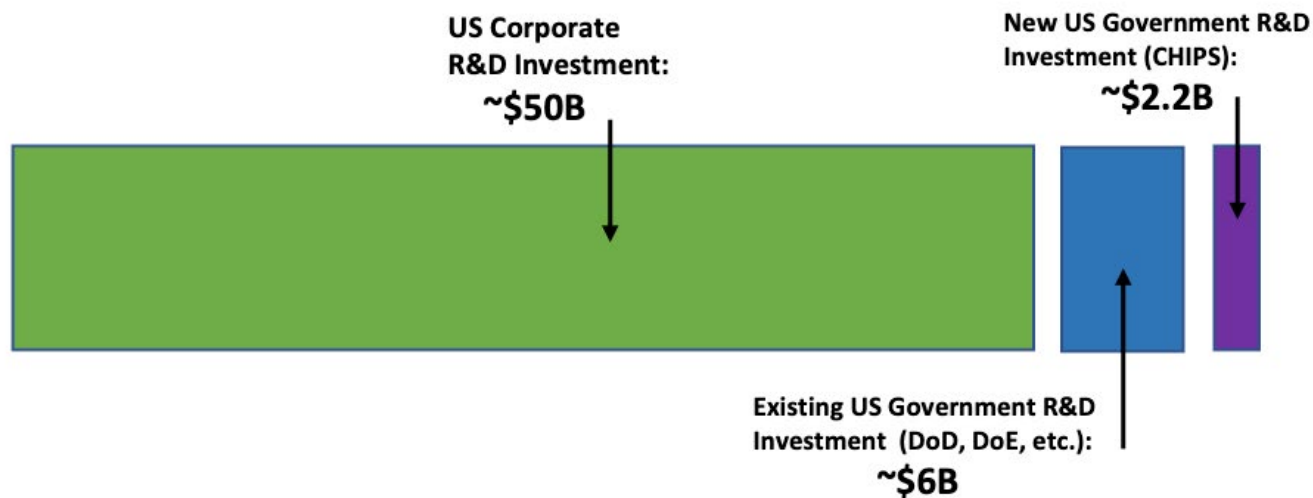
Modern semiconductor devices are appropriately recognized as the most complex mass-produced products in history, as documented by Chris Miller's 2022 book *Chip War*.² A vast ecosystem of specialized engineering domains erected over decades feeds a progression of ever-more-complex new chips, governed by the drumbeat of Moore's Law. Devices such as processors, memory devices, sensors, and communication chips help make usable information out of the mountains of raw data that inundate us daily. Novel architectures enable new applications such as artificial intelligence (AI). Moreover, as recent military news makes clear, our critical defense systems are also critically dependent on secure access to semiconductors.³

The costs to fuel these innovations have skyrocketed. Costs are driven in tandem by manufacturing and design complexity. While Moore's Law has delivered the capability to form trillions of shapes no larger than the width of a small molecule, future advancements require new techniques using the most precise manufacturing gear ever created (and thus the most expensive). Specialized multi-billion-dollar development fabrication facilities (fabs) are staffed with large teams of R&D engineers working on a pipeline of next-generation processes.

This R&D may start up to a decade before transfer to manufacturing. Investigations begin with basic research of new materials, then move to applied research to prove basic production capability, and finally on to development of prototypes to ensure high-volume repeatability. This progression is necessary to establish readiness for the high stakes of prime-time manufacturing, with costs and urgency rising with each step. The results of every project must be evaluated carefully to justify further investment, with only the most promising approaches allowed to continue. A company that stumbles will require even greater investments in R&D to attempt to catch up. Intel's recent delays introducing 10nm and 7nm manufacturing nodes highlight the inherent risks in the development and deployment of cutting-edge manufacturing processes.⁴

Design teams face similar challenges, often mobilizing 1000+ member teams to craft complex chips. Modern "System-on-Chip" (SoC) designs are filled with thousands of synchronized sub-systems, including hundreds of processors, memory blocks, and interface circuits—all on one chip. Ensuring these pieces work together flawlessly requires hundreds of thousands of simulations using the latest electronic data automation (EDA) tools, resulting in multi-year design efforts that can cost well over \$500 million in non-recurring engineering (NRE) charges. Once the design is complete, initial manufacturing runs may take the better part of a year, making "first-time-correct" methodology a must. Finding a design problem in silicon can add catastrophic delays, risking a missed market window and a significant reduction in the ability of the project to pay back its development costs.⁵

Figure 1. Annual US Semiconductor R&D Investment Sources



Notes: Figures represent estimates for FY2023. CHIPS R&D Investment of \$11B total over the five years of FY2023-27, annualized as \$2.2 billion per year. Sources: "American Semiconductor Research: Leadership Through Innovation," Semiconductor Industry Association (SIA); John VerWey, "Betting the House: Leveraging the CHIPS and Science Act to Increase US Microelectronic Supply Chain Resilience," CSET, January 2023.

This work transpires before a single chip is sold and amounts to a crushing R&D burden. But now a larger specter has emerged: Moore's Law is bumping up against the fundamental laws of physics. More than five decades of exponential physical scaling progress are at risk of ending, forcing a competition to discover new avenues for progress. For companies to expect to remain competitive, they must now pursue completely new disruptive innovations, known as "post-Moore" technologies. Such approaches include pushing structures into three dimensions, employing new elements, and finding new approaches to package multiple chips together.

These challenges require semiconductor manufacturers to invest a larger percentage of R&D into basic research, further straining budgets oversubscribed with nearer-term projects in more traditional corporate areas of applied R&D.

These same "post-Moore" challenges are driving design teams to employ new architectures, custom-built for the application, reminiscent of the "application-specific-integrated-circuits" (ASICs) products of the past. While offering significant performance gains, this in turn drives the need for more designs while incurring large development

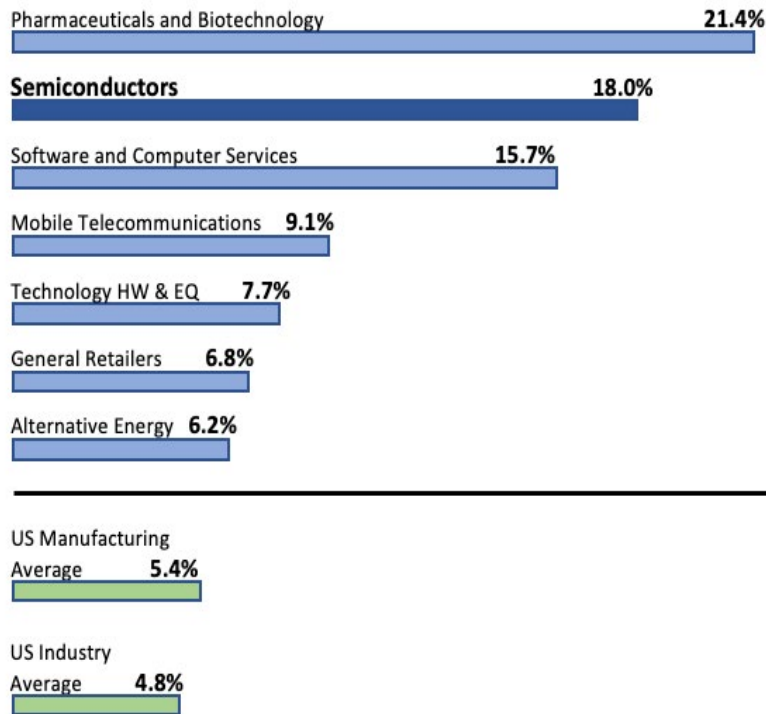
costs that are amortized over significantly fewer units in future sales, further straining R&D budgets.

Basic research, while perhaps offering significant new opportunities, is even more fraught with long lead-time and risk, and thus historically has been the domain for government-sponsored investment. However, US government spending in semiconductor R&D has declined drastically since the 1960s, with recent estimates near \$6 billion, compared to annual corporate investment of about \$50 billion. This spending has also been disproportionately focused on specialized Department of Defense and Energy needs with less commercial industry relevance.⁶

The CHIPS and Science Act of 2022 attempts to reverse this decline, by investing \$11 billion in government-funded semiconductor R&D to be spent over five years on commercially relevant technology areas.⁷ While a welcome infusion, corporate-funding of R&D will still strongly dominate in the semiconductor field, as Figure 1 illustrates.

The cost of innovation has pushed average US semiconductor R&D intensity (R&D as a percentage of revenue) to 18% in 2021. Semiconductors, together with pharmaceuticals (with an average R&D intensity of 21%) and

Figure 2. R&D Expenditures as a Percentage of Sales, Select Industries



Sources:
 "2022 State of the
 US Semiconductor
 Industry,"
 Semiconductor Industry
 Association (SIA);
 Raymond M Wolfe,
 "InfoBrief NSF
 22-343," National
 Center for Science and
 Engineering Statistics,
 October 2022.

software (at 16%), are the only US industrial sectors with R&D intensity over 10%.⁸ For these types of high-tech sectors, R&D is the lifeblood essential to maintaining a business—not a minor sideline expense for product improvement, as in many other industrial sectors.

Of note, US semiconductor R&D intensity is the highest in the world, effectively double that of China, Taiwan, Japan, or South Korea.⁹ R&D intensities for several notable US sectors are shown graphically in Figure 2.

High R&D intensity is essential to the long-term competitiveness of semiconductor companies in every segment, including those in fabless design, equipment, and EDA software. For advanced semiconductor manufacturers, annual R&D investment must be paired with even larger annual capital expenditures (capex) in manufacturing capacity. This investment in production fabs and equipment is necessary to transform new technology into usable manufacturing capability. However the combined costs are staggering. For comparison, the top five largest US pharmaceutical companies invested 22% of revenue in the sum of R&D and capex in 2021 (18% and 4%, respectively); the

comparable figure for the advanced semiconductor manufacturing industry is 50%, broken down as 14% R&D and 36% capex.¹⁰ The crushing combination of annual investments required to stay competitive in advanced semiconductor manufacturing is not found in any other industry.

This cost burden has fueled the decision by most manufacturers to exit advanced semiconductor manufacturing, typified most recently by Global Foundries' announcement stopping all R&D and manufacturing investment in 7nm and smaller nodes.¹¹ The result is that in state-of-the-art logic and memory manufacturing, only a small handful of worldwide companies remain, down from dozens in each field three decades ago.

These costs have also fueled shareholder pressure to minimize R&D, given short-term concerns on expenses, risk, and payback time, pushing instead for either an acquisition strategy¹² or a return of cash to shareholders. Other companies in cyclical sectors have been forced to cut core R&D at the bottom of the cycle, as the only discretionary lever available for survival, incurring large risk of technology development gaps that will not be obvious for years.

The International Playing Field

Spurred by decades of globalization and an understanding of the importance of semiconductors, multiple Asian countries have sought and attained leadership positions in advanced semiconductor production. Companies in these countries have felt the same rising R&D cost pressure as semiconductor firms everywhere. The respective national governments have responded by offering significant R&D incentives, for example:

- South Korea, home to Samsung Electronics and SK Hynix (the semiconductor arms of two of the largest South Korean chaebol), passed a bill offering R&D tax credits for indigenous semiconductor firms of up to 50%, as part of the “K-Belt” initiative announced in 2019. This initiative proposed upwards of \$150 billion in government aid to local producers for both manufacturing and R&D assistance.¹³
- Taiwan, home to Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC), likewise approved a bill in November of 2022 instituting a full 25% R&D tax credit, of notable help to TSMC in particular, with annual R&D expenditures of \$4 billion.¹⁴
- China’s semiconductor efforts were highlighted most notably with 2014’s “Made-In-China” initiative, featuring not only tax credits but also direct subsidization of R&D.¹⁵ More recently, in December 2022, China approved additional subsidies worth \$143 billion to the nation’s semiconductor producers.¹⁶ Extension of broad-based R&D “super-deductions” offer all Chinese high-tech industries the opportunity for effectively “free” R&D.^{17,18} The unfortunate ease with which high-volume commercial semiconductors can be reverse-engineered and copied has further accelerated the development efforts of China’s companies, as well as notable cases of outright intellectual property (IP) theft (most recently, for example, in the cases of ARM,¹⁹ ASML,²⁰ and Micron).²¹

US Tax Policy

In the US, tax treatment of R&D has moved in the opposite direction. Changes to the tax code starting in 2022 require R&D to be amortized over a five-year period (fifteen years, if performed offshore) rather than deducted immediately (i.e., expensed). This modification to R&D tax treatment is part of the 2017 Tax Cuts and Job Act. The change was instituted putatively to help offset revenue loss from a reduction in US corporate top tax rates. The practical effect however was to punish R&D-intensive industries such as semiconductors, while benefitting industries with minimal R&D.

The transition from immediate deduction to a delayed depreciation schedule results in direct taxation of R&D. Companies moving to a five-year schedule will pay one-time federal and state taxes on the equivalent of 200% of their annual R&D expense (see box, below). This additional tax is of minimal concern for financial or retail companies, but a potentially multi-billion-dollar impact for R&D intensive companies. The financial hit is never recouped. Although accompanied by a reduced top federal corporate tax rate, the exposure of R&D spending to taxation—which is unique to the US among all OECD countries—is a powerful deterrent to R&D investment.

Under steady-state R&D annual investment, the transition from immediate deduction to a five-year depreciation schedule implies additional tax basis in year 1 (2022) of 80% annual R&D, followed by 60% in year 2, 40% in year 3, and 20% in year 4, totaling to a one-time increase to the cumulative taxable base of 200% of annual R&D.

The transition of R&D to a depreciation schedule causes more than a one-time financial hit. Because today’s R&D is not fully deductible until five years hence, inflation means that R&D investment will never be fully deducted due to the decline in time-value of money. Effectively, some percentage of R&D must be paid out of profit, which means that for tax purposes, R&D in the US is now treated worse than manufacturing expenses. (For manufacturers and retailers, non-capital costs, such as cost of goods sold, are deducted quickly in the quarter the product is sold).



The financial impact is not confined to the semiconductor industry. In October 2022, 178 CEOs across a broad base of R&D-intensive sectors signed a letter to Congress seeking repeal of the R&D deductibility change, with multiple firms reporting hits to 2022 profitability of greater than \$100 million. Raytheon’s CEO noted a 2022 impact of over \$1.5 billion.²² The effective penalization of R&D will hurt innovation in the US, causing more harm than simple economic losses.

The timing of the change could not be worse for the semiconductor industry, currently mired in a deep cyclical downturn (with multiple firms now reporting losses).²³ While any tax code change has winners and losers, selecting R&D-intensive industries to pay for an overall corporate tax reduction runs perversely counter to the stated US goals of increasing national R&D investment.

The US has featured a R&D tax credit since 1981; however, due to original design and subsequent revisions, it is quite limited in benefit to semiconductor companies. The credit only applies to 14% of the incremental increase in R&D spending over a rolling three-year average and is further limited to just R&D labor and supplies, specifically excluding all R&D capital.²⁴ Given long technology horizons and business cyclicity, the R&D budgets for most

semiconductor companies, while massive, typically do not grow much year to year. R&D budgets for advanced semiconductor manufacturers are also very capital intensive, specifically for R&D fab shells and new, next-generation equipment. The value of the US tax credit is negligible to the semiconductor industry.

In contrast, the tax credits of South Korea, Taiwan, and China all apply to the entire R&D annual expense for semiconductor development (not just incremental increases), which provides in those countries significant ongoing subsidization of R&D investment.²⁵

The CHIPS legislation of 2022 provided incentives for semiconductor manufacturing as well as funds for government-directed R&D. However, no incentives were provided for corporate R&D. The government-directed R&D funds, while welcome, pale in comparison to annual corporate R&D. Therefore, the government must leverage corporate R&D infrastructure (helping to avoid the cost and risk of a centralized national R&D fab such as Sematech but placing an even larger burden on healthy corporate R&D investment).

On a positive note, the CHIPS Act’s manufacturing investment tax credits are already helping drive a resurgence in

US semiconductor fabs. Investment tax credits have the added feature of driving corporate “skin-in-the-game,” as companies must invest their own capital first to receive a downstream proportional credit in return. Thus, companies affirm the viability of projects through their own financial commitments before receiving any taxpayer-funded benefit. However, the CHIPS Act investment tax credits are not applicable to R&D (nor capital purchases for R&D), thereby disparaging the value of R&D and undercutting the very intention of the CHIPS Act with respect to the semiconductor industry.

Prognosis

Surveying the semiconductor landscape, the US maintains the lead or is strongly competitive primarily in those segments with modest capital requirements, including EDA software, wafer equipment, and fabless design. In other critical areas however, such as semiconductor manufacturing, packaging, and compound semiconductors, the US has fallen behind. The US today is responsible for just 12% of global semiconductor manufacturing, falling from 37% in 1990 (and with the percentages for certain critical state-of-the-art technologies rounding to zero).^{26,27}

Even in areas the US leads in today, the combination of skyrocketing semiconductor R&D cost, cyclical and systemic investment limitations, activist investor pressure, subsidized international competition, and state-sponsored IP theft are challenging US firms like no other time in history. On top of these already significant challenges, the US tax code’s incentives for innovation have now moved from uncompetitive to anticompetitive. As many nations expand R&D tax credits and offer super-deductions, the US tax code’s disallowing of immediate R&D deductions (therefore directly taxing R&D investment in the transition) poses a very real threat to US semiconductor companies’ ability to afford adequate R&D to remain competitive.²⁸

Proposals

The US depends on a sustainable and secure semiconductor industry, as acknowledged in the CHIPS and Science Act of 2022. The US Secretary of Commerce acknowledged in recent remarks that the “stakes couldn’t be higher,” and that “our success [with CHIPS] will be short-lived if we focus only on manufacturing.”²⁹ Given the challenges that the industry now faces, we offer a set of proposals to help re-establish the US as a competitive home for semiconductor R&D:

1. **Immediately rescind (retroactively) the provision of the Tax Cut and Jobs Act of 2017 that forced qualified R&D to be depreciated over a minimum of five years.** This change has thrust the US into a unique level of punitive R&D tax treatment as the only nation disallowing immediate R&D expensing, just as the semiconductor industry is fighting through a downturn. Inflation makes delayed expensing even more painful. In 2022, both branches of Congress acknowledged significant bipartisan agreement on the damage resulting from this provision; however, resolution in the final Omnibus spending bill was forestalled.
2. **Expand CHIPS’s Investment Tax Credits to be applicable to R&D capital expenses.** No other industry requires R&D capital at the scale and expense of semiconductor manufacturing, where development fabs must be built and equipped before R&D can start. A tilted R&D playing field means the newest tools are often shipping to Asian companies ahead of those in the US.³⁰ Expanding the investment tax credits to apply to R&D equipment would ensure that the latest cutting-edge equipment can be purchased competitively and timely by US producers. The cost of this extension would be a relatively minor increase of the CHIPS’s tax credit costs, yet it would immediately improve the odds of CHIPS success by helping ensure the US is competitive in semiconductor manufacturing R&D.

"Innovation distinguishes between a leader and a follower."

— Steve Jobs

3. Update the R&D tax credit to be competitive with all other nations competing in semiconductors: A permanent, non-incremental, 25% tax credit applied to all qualified R&D performed in the US. The US R&D tax credit has minimal value to US semiconductor manufacturers and other R&D-intensive sectors. Asian countries have used significantly larger R&D tax credits and subsidies to catch up to the US, often hiring students trained by leading US universities. To be competitive, the US needs to simplify, expand, and make permanent a US R&D tax credit, incentivizing US companies to continue investing their own skin-in-the-game in significant ongoing domestic R&D operations.

4. Aggressively prosecute nation-sponsored IP theft. While tax treatment of R&D is important, all will be for naught if large-scale nation-sponsored IP theft is allowed to continue. No company can rationalize R&D investment when the results are used to weaponize their competitors. Companies in the US invest over \$500 billion in R&D, annually. Recent estimates place the annual theft of US IP by China at an identical \$500 billion, illustrating the appalling scope of the issue, now acknowledged by both US political parties.³¹ The solution will most assuredly rely on US government assistance, stronger coalitions of US allies, commitment to principles of IP protection, and aggressive and rapid prosecution of theft.

These actions would help the US recover as a thriving home to corporate R&D necessary for semiconductor leadership and would benefit other R&D-intensive fields critical to national security. The actions would provide incentives not only to large, established companies but also to startups pursuing disruptive blue-sky innovation. Current semiconductor challenges require massive and bold investments in innovative solutions and new technologies. The passage of CHIPS by the US acknowledges this need; however, the success of CHIPS is predicated on a thriving corporate R&D ecosystem to deliver these solutions.

No tax policy discussion should ignore legitimate concerns of US deficits. We note, however, that R&D investment is universally acknowledged as one of the best levers to drive long-term growth in future tax-paying businesses and jobs. We also note that in recent years, corporate tax revenue in total has amounted to no more than 6% of all US annual tax receipts.³² Quite simply, considerations around lost revenue from R&D tax treatment should be of vanishingly small priority relative to the larger concern of properly incentivizing the nation's technological competitiveness.

As Steve Jobs once noted, "Innovation distinguishes between a leader and a follower." The geopolitical competition in which the US finds itself will be won or lost based on the strength of our nation's technology base. Leadership in semiconductor design, fabrication technology, and next-generation technologies is a non-negotiable requirement for economic and national security. We cannot afford an anticompetitive R&D tax policy that acts to drive technology development offshore. Let's fix the US tax code to incentivize large, ongoing, onshore, corporate R&D investment to help ensure our future security.

Acknowledgements

The author thanks reviewers and contributors Michael Fritze, Al Shaffer, Dan Marrujo, and Joe Parrish. He is also grateful to Bob Hummel and Sherry Loveless for editorial support and further contributions.

Endnotes

- 1 "FACT SHEET: Biden-Harris Administration Bringing Semiconductor Manufacturing Back to America," US White House Briefing Room – Statements and Releases, January 21, 2022 <https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/21/fact-sheet-biden-harris-administration-bringing-semiconductor-manufacturing-back-to-america-2/>.
- 2 Chris Miller. *Chip War: The Fight for the World's Most Critical Technology* (New York: Scribner) 2022.
- 3 Alan Patterson. "Experts: U.S. Military Chips Supply Is Dangerously Low," *EETimes* January 6, 2023. <https://www.eetimes.com/experts-u-s-military-chip-supply-is-dangerously-low/>.
- 4 Chris Fox. "Intel's Next-Generations 7nm Chips Delayed Until 2022," *BBC News* July 24, 2020. <https://www.bbc.com/news/technology-53525710>.
- 5 Harald Bauer, et al. "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities," McKinsey&Company, August 20, 2020. <https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities>.
- 6 "American Semiconductor Research: Leadership Through Innovation," Semiconductor Industry Association (SIA), pages 12-13. <https://www.semiconductors.org/wp-content/uploads/2022/11/American-Semiconductor-Research-Report-FINAL1.pdf>.
- 7 "American Semiconductor Research: Leadership Through Innovation," Semiconductor Industry Association (SIA). <https://www.semiconductors.org/wp-content/uploads/2022/11/American-Semiconductor-Research-Report-FINAL1.pdf>.
- 8 "American Semiconductor Research: Leadership Through Innovation," Semiconductor Industry Association (SIA).
- 9 "2022 State of the U.S. Semiconductor Industry," Semiconductor Industry Association (SIA), page 24. https://www.semiconductors.org/wp-content/uploads/2022/11/SIA_State-of-Industry-Report_Nov-2022.pdf.
- 10 Data compiled from publicly available 2021 SEC Form 10K's for Johnson & Johnson, Eli Lilly, Merck, Abbvie, Pfizer, Micron, and Intel, and 2021 SEC Form 20F for TSMC. Note the semiconductor industry no longer has five advanced semiconductor manufacturers with which to compare.
- 11 Anton Shilov and Ian Cutress. "GlobalFoundries Stops All 7nm Development: Opts To Focus on Specialized Processes," *AnandTech* August 27, 2018. <https://www.anandtech.com/show/13277/globalfoundries-stops-all-7nm-development>.
- 12 Krystal Hu and Jane Lanhee Lee. "How Broadcom CEO Tan Shaped a Tech Giant Through Acquisitions," *Reuters* May 27, 2022. <https://www.reuters.com/markets/us/how-broadcom-ceo-tan-shaped-tech-giant-through-acquisitions-2022-05-27/>.
- 13 Song Su-hyun. "Seoul Sets Out to Protect Chip Prowess," *The Korea Herald* May 13 2021. <https://www.koreaherald.com/view.php?ud=20210513000820>.
- 14 Dan Robinson. "Taiwan Rolls out Tax Credits for Chipmakers to Keep R&D Local," *The Register* January 9 2023. https://www.theregister.com/2023/01/09/taiwan_chip_tax_credits/.
- 15 "Taking Stock of China's Semiconductor Industry," Semiconductor Industry Association (SIA), July 13, 2021. <https://www.semiconductors.org/taking-stock-of-chinas-semiconductor-industry/>.
- 16 Julie Zhu. "Exclusive: China Readying \$143 Billion Package for its Chip Firms in Face of U.S. Curbs," *Reuters* December 13, 2022. <https://www.reuters.com/technology/china-plans-over-143-bln-push-boost-domestic-chips-compete-with-us-sources-2022-12-13/>.
- 17 "75% R&D Super Deduction Extended, Raised to 100% for Manufacturers," KPMG, May 7, 2021. <https://kpmg.com/cn/en/home/insights/2021/03/china-tax-alert-07.html>.
- 18 "R&D Coalition CFO Letter to House and Senate Leadership," R&D Coalition, November 4 2022. <https://investinamericasfuture.org/wp-content/uploads/2022/11/RD-Coalition-CFO-Letter-FINAL-11.4.2022.pdf>.
- 19 Dylan Patel. "The Semiconductor Heist of the Century; ARM China Has Gone Completely Rogue, Operating as an Independent Company with In-house IP / R&D," *SemiAnalysis* August 27 2021. <https://www.semianalysis.com/p/the-semiconductor-heist-of-the-century>.
- 20 Jordan Robertson and Michael Riley. "Engineer Who Fled Charges of Stealing Chip Secrets Now Thrives in China," *Bloomberg* February 15, 2023. <https://www.bloomberg.com/news/articles/2022-06-06/engineer-who-fled-us-charges-of-stealing-chip-technology-now-thrives-in-china?leadSource=verify%20wall>.
- 21 Deb Wu. "Engineers Found Guilty of Stealing Micron Secrets for China," *Bloomberg* June 12, 2020. <https://finance.yahoo.com/news/engineers-found-guilty-stealing-micron-142809629.html>.
- 22 Jennifer Williams-Alvarez. "U.S. CFOs Ask Congress to Repeal Change to R&D Tax Rules," *Wall Street Journal* November 7 2022. https://www.wsj.com/articles/u-s-cfos-ask-congress-to-repeal-change-to-r-d-tax-rules-11667845533?st=903afah7d79iz8h&reflink=desktopwebshare_permalink.
- 23 Ian King. "Micron to Cut 10% of Workforce as Demand for Computer Chips Slumps," *Bloomberg* December 21, 2022. <https://www.bloomberg.com/news/articles/2022-12-21/micron-gives-weak-sales-forecast-will-cut-headcount-by-10?leadSource=verify%20wall>.
- 24 Alex Muresianu and Garrett Watson. "Reviewing the Federal Tax Treatment of Research & Development Expenses," Tax Foundation, April 13, 2021. <https://taxfoundation.org/research-and-development-tax/>.
- 25 As noted at Muresianu et. al. "Reviewing the Federal Tax Treatment...", only the US, Mexico, Spain, Portugal, and the Czech Republic limit R&D tax credits to incremental R&D investment.
- 26 "2022 State of the U.S. Semiconductor Industry," Semiconductor Industry Association (SIA). https://www.semiconductors.org/wp-content/uploads/2022/11/SIA_State-of-Industry-Report_Nov-2022.pdf.
- 27 Brian Shirley. "Don't Forget About Memory," Potomac Institute for Policy Studies, September 2022. <https://potomac institute.org/steps/featured-articles/september-2022/don-t-forget-about-memory>.
- 28 Harald Bauer, et al. "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities," McKinsey&Company, August 20, 2020. <https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities>.
- 29 "Remarks by U.S. Secretary of Commerce Gina Raimondo: The CHIPS Act and a Long-term Vision for America's Technological Leadership", U.S. Department of Commerce, February 23, 2023. <https://www.commerce.gov/news/speeches/2023/02/remarks-us-secretary-commerce-gina-raimondo-chips-act-and-long-term-vision>.
- 30 Reuters Staff. "TSMC Starts Volume Production of Most Advanced Chips in Taiwan," *Reuters* December 29, 2022. <https://www.reuters.com/technology/tsmc-starts-volume-production-most-advanced-chips-taiwan-2022-12-29/>.
- 31 Lee Edwards. "China's Grand Theft," The Heritage Foundation, June 4, 2021. <https://www.heritage.org/homeland-security/commentary/chinas-grand-theft>.
- 32 Daniel Bunn and Cecilia Perez Weigel. "Sources of U.S. Tax Revenue by Tax Type," Tax Foundation, February 27, 2023. <https://taxfoundation.org/publications/sources-government-revenue-united-states/>.





Reinvigorating Innovation for National Security

*Robert (Bob) Hummel, PhD
in collaboration with
Potomac Institute for Policy Studies Staff*





Introducing the National Security Innovation Base (NSIB)

The United States has a long tradition of innovative research and development (R&D). Innovation has been particularly important for national security, with the development of advanced weapons systems, superior reconnaissance and surveillance systems, and sensors and detectors intended to help the military defend the nation. Many innovations for national security purposes spill over into benefits for the commercial sector. Sometimes, commercial innovations and products spill over into benefits for national security.

Lately, much has been discussed about the “national security innovation base.” The term appears to derive from the 2017 US National Security Strategy¹ but was not formally defined there. Instead, the term has evolved and is generally considered a network of individuals, companies, and institutions that transforms ideas into capabilities to benefit US national security. The “national security innovation base” should not be confused with the intersecting but distinct concepts of “national security industrial base” or “defense industrial base.”

There is concern that the US network of innovation for national security is not performing as well as in the past. The basis for this concern is two-fold: 1) innovators within the US are more intent on commercial products and less devoted to national security issues; and 2) other countries, particularly China, have learned to be innovative in their national security and military affairs and, in some cases, are outstripping US innovations.²

The fascination with Silicon Valley jobs and startups has economic roots. The promise of large salaries and anticipation of instant wealth has caused university graduates and talented researchers to migrate to companies specializing in commercial activities, which takes resources away from more direct support to national security objectives.

In military systems, both China and Russia have claimed new weapon systems that show innovative capabilities that outperform and counter US defenses. Particularly, the development of highly maneuverable hypersonic vehicles demonstrates innovative invention and advanced systems development that extend beyond technologies that the US can field.³

None of these developments imply that the US is incapable of innovation for national security. However, concerns exist over limited capacity (i.e., the availability of human and monetary resources) for continued national security innovation. But confidence remains in the ability of American ingenuity. The Department of Defense continues to take actions to increase the capacity by finding new sources and improving engagement with the innovation ecosystem—sometimes with surprising results. Congress, too, has supported initiatives such as the CHIPS and Science Act of 2022, aimed at reinvigorating US innovation capacity for both commercial and defense purposes.

So, it is unfortunate that certain laws and policies negate the benefits of these initiatives by “shooting the US in the foot” and thwarting the capacity of the national security innovation base (the NSIB). This article examines the main inhibitors.

The NSIB includes governmental agencies and organizations, public and private research centers, academia, the traditional defense industry, the broader commercial sector, financial institutions, and the innovation ecosystems of America’s allies and partners abroad (whenever those entities directly or indirectly contribute to US national security). The NSIB includes the Department of Defense (DOD) agency DARPA (Defense Advanced Research Projects Agency), all its contractors and agents, and other DOD elements that fund and perform research. The NSIB is thus a large apparatus, fully capable of creating capabilities from innovative ideas and new technologies. At issue, however, is its capacity to bring new ideas to fielded capabilities.

Is the NSIB Capacity Sufficient?

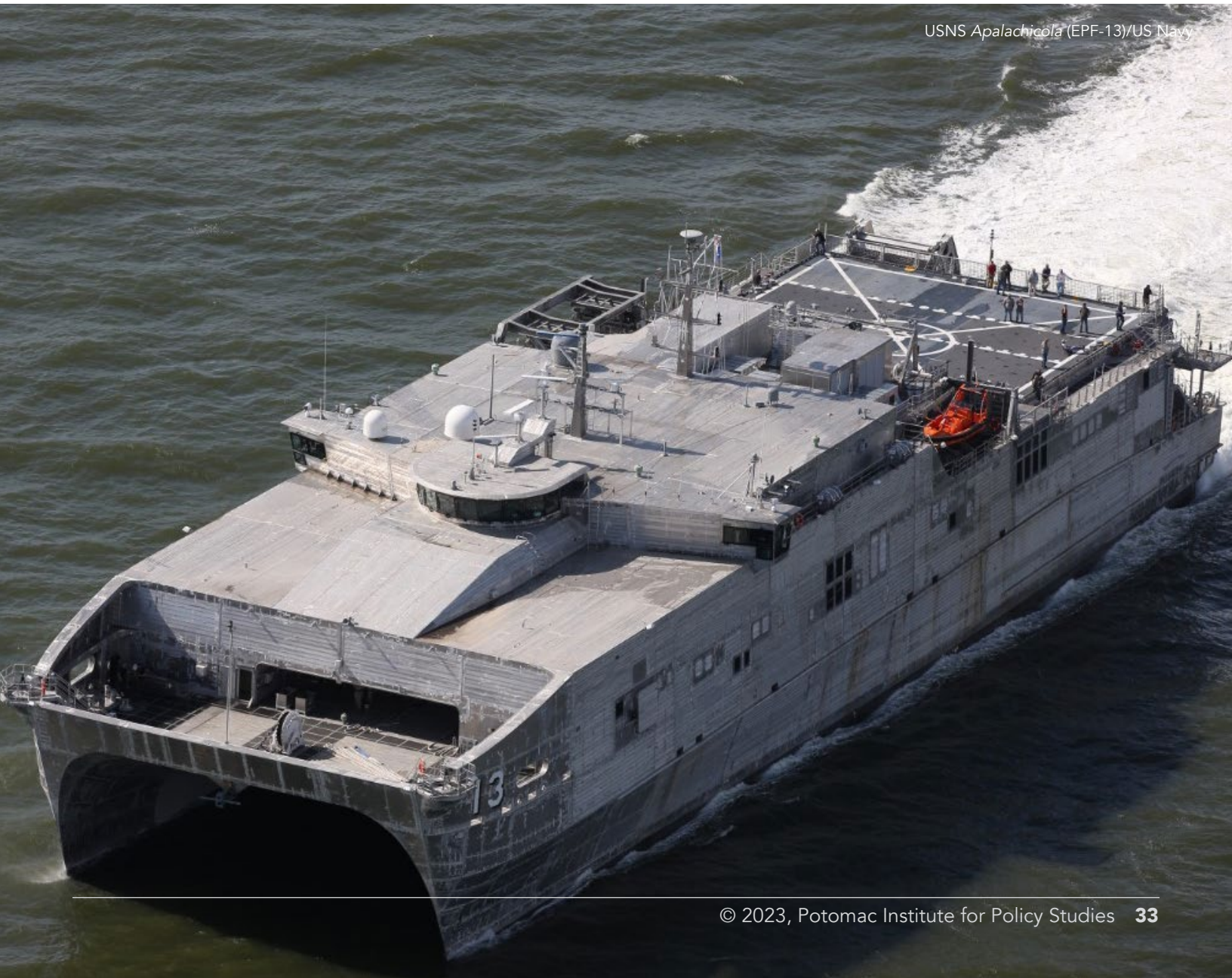
Not everyone agrees that there is a need for more innovation—why develop new weapons when we already have the finest equipped force in the world? The US is in fact deploying new weapon systems. The Army announced 24 new systems for deployment in 2023,⁴ the Air Force has the B-21 bomber with an open systems architecture about to be fielded, and the Navy has taken delivery of the *Apalachicola*, a drone ship.⁵ New space-based surveillance systems and airborne intelligence, surveillance, and reconnaissance (ISR) systems also silently testify to US innovation capacity. Many upgrades to existing systems managed by program executive offices, often with

classified capabilities, show further evidence of great innovation in the national security sector.

But concern remains, expressed in a variety of other sources. A recent report from the Information Technology and Innovation Foundation titled “Wakeup America: China is Overtaking the United States in Innovation Capacity,”⁶ claims that by 2020, China’s output of innovation in absolute terms (not per capita) was already 139% of the US innovation output. An article by the Alliance for American Manufacturing remains skeptical that recent laws such as the Inflation Reduction Act and the CHIPS and Science Act will succeed in their intent to reverse the US decline in innovation capacity.⁷ The implication is that the United States can innovate for defense and commercial needs but is not innovating enough.

Thus, the debate over NSIB capacity sufficiency is inconclusive.

Section 889 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year 2021 directs the DOD to assess the “economic forces and structures shaping the capacity of the national security innovation base (NSIB) and develop policies to address such forces and structures.”⁸ The assessment includes reviewing various elements “as they pertain to the innovative and manufacturing capacity of the national security innovation base.” The authors of the legislation sought areas where Congressional action could help the NSIB, separate from policies of departments and agencies that the executive branch can enact.



USNS Apalachicola (EPF-13)/US Navy

The Ronald Reagan Institute, the think tank that manages the Reagan Library, initiated a task force in 2019 to address US competitive advantages in technology and innovation, and subsequently presented findings and recommendations at their 2023 National Security Innovation Base Summit.⁹ In 2022, the DOD commissioned the Potomac Institute for Policy Studies to research the topic areas outlined in Section 889, in light of NSIB needs. In March of 2023, the Potomac Institute for Policy Studies delivered a report on the 16 elements named in the legislation, as listed below.

1. A detailed description of the entities comprising the NSIB and how they currently interact.
2. Competition and antitrust policy.
3. Immigration policy, including the policies germane to the attraction and retention of skilled immigrants.
4. Education funding and policy.
5. Demand stabilization and social safety net policies.
6. The structure and incentives of financial markets and the effects of such on the access of businesses to credit.
7. Trade policy, including export control policy and trade remedies.
8. The tax code and its effect on investment, including the Federal R&D tax credit.
9. Regulatory policy, including with respect to land use, environmental impact, and construction and manufacturing activities.
10. Economic and manufacturing infrastructure.
11. Intellectual property policy.
12. Federally funded investments in the economy, including investments in R&D and advanced manufacturing.
13. Federally funded purchases of goods and services.
14. Federally funded investments to expand domestic manufacturing capabilities.
15. Coordination and collaboration with allies and partners.
16. Measures to protect technological advantages over adversaries and to counteract hostile or destabilizing activity by adversaries.

A glowing lightbulb is positioned in the upper left quadrant of the page. From its base, a thick, billowing plume of white smoke or steam rises diagonally towards the bottom right corner. The background is a solid, vibrant blue. The lightbulb itself is white and appears to be illuminated from within, with a warm yellow glow emanating from its base where the smoke originates.

Each of these 16 areas contains recommendations and policy changes that can enhance or support NSIB's capacity and improve the nation's ability to field innovative technologies for national security considerations. Many of the concepts for enhancement are well known in government and policy communities. Examples include acquisition reform, faster contracting, increasing and enabling "Other Transactions" for research without cost shares,^{10,11} and better interactions between industry and government. Improvements to the Small Business Innovative Research (SBIR) and related Small Business Technology Transfer (STTR) programs are significant to the small business community. Most importantly, recommendations discuss "bridging the Valley of Death" so that innovations and prototypes developed for defense capabilities transition into fielded capabilities more rapidly and frequently.

This article does not rehash these many well-known complaints and suggested reforms. Many other sources provide lengthy analyses. Instead, the concern is what the government does to promote the NSIB and the three truly imaginative, absurd, and ridiculous ways we undercut those benefits.

Investments in the NSIB

The government and society support the NSIB in many ways for the nation's benefit. In 2021, US R&D spending from all sources, government and non-government, was estimated at \$792 billion.¹² US government funding for R&D amounted to \$138 billion in 2020.¹³ The US government tends to fund more in the innovation space, whereas non-government sources focus on development and product evolution. However, over the past two years, the big social media Silicon Valley companies and venture capital investments have added billions in R&D for artificial intelligence research. Much of this financing supported the development of fundamental large language models to drive text, imagery, and software generation.

Within government funding, the DOD is responsible for the largest share of R&D funding, amounting to \$123 billion in 2022. Of that amount, \$18.8 billion was in the 6.1 to 6.3 budget categories, often collectively characterized as "science and technology," which included a large portion of the DOD R&D innovation.¹⁴ One analysis indicates that DOD funding of "early stage R&D" totaled \$34 billion in 2022, with an expected increase to \$40 billion in 2023.¹⁵ The National Science Foundation, the National Institutes of Health, the Department of Energy, the Department of Agriculture, and other agencies fund the remaining government support for R&D.

The government supports the NSIB in ways that go beyond providing funds by encouraging small businesses to research topics in the national security space in the SBIR/STTR programs.¹⁶ The DOD has other avenues to fund innovative R&D, such as AFWERX and SpaceWERX, the Defense Innovation Unit, and the latter's National Security Innovation Network.¹⁷ More recent initiatives include the Rapid Defense Experimentation Reserve (RDER), with appropriated funding of \$278 million in 2023,¹⁸ and the Office of Strategic Capital, which has requested \$115 million for FY 2024.¹⁹ These units aim to accelerate the transfer of technologies to national security capabilities through attracting or delivering funding that resembles venture capital investments. As part of the Science, Mathematics, and Research for Transformation (SMART) scholarship-for-service program, the US government offers free tuition and stipends to selected, qualified students for science, technology, engineering, and mathematics (STEM) post-secondary study in exchange for a commitment to work for a DOD institution an equivalent number of years.²⁰ The SMART program is thus a scholarship and workforce development program for the NSIB. In these and other ways, the government is engaged in efforts that boost innovation for national security purposes, leveraging the talents and capabilities of the nation and its institutions.

In addition, recent legislation has directed new R&D funding in particular industry sectors based on national interests. The CHIPS portion of the CHIPS and Science Act of



2022 appropriates about \$5 billion per year for the next five years in microelectronics research, and additional funds to increase domestic manufacturing. The Science portion of the Act authorizes \$174 billion over five years for science, technology, and workforce development. This funding dramatically increases the National Science Foundation (NSF) budget through a Technology, Innovation, and Partnerships (TIP) directorate that focuses on the transition of technologies for commercial use. The Inflation Reduction Act of 2022 improves the R&D tax credit for startup businesses and incentivizes specific sectors of manufacturing that should increase demand for R&D in those sectors. The NSIB will certainly benefit.

Do Not be Innovatively Stupid

With all this effort and funding for innovation in national security systems, it would not make sense that the government has policies and laws that directly and needlessly inhibit the NSIB.

But we do.

We undo many of the US programs and advantages in support of NSIB by thwarting innovation in three key ways:

- 1) Taxing R&D.
- 2) Throwing away talent.
- 3) Discouraging STEM talent development.

Do Not Tax R&D

A common assumption is that R&D gets preferential tax treatment, through deductions (26 CFR § 1.174, called Section 174) and credits (26 U.S. Code § 41, called Section 41). The truth is complicated, reflecting the complexity of the law and the common confusion between Section 174 and Section 41. The culture reflected in the tax code is one that treats R&D suspiciously, viewing R&D like entertainment and not essential to making a profit. This attitude is harmful to the nation's security and wellbeing.

Section 174 provides for the deductibility of "research and experimental expenditures," which are defined in excruciating detail in Section 1.174-2, including a discussion about "expenses incurred in the taxpayer's trade or business

which represent R&D costs" and a discussion of the discovery of information "that would eliminate uncertainty concerning the development or improvement of a product."²¹ Certain expenses are excluded, such as quality control testing, efficiency surveys, management studies, and consumer surveys,²² which are essential aspects of commercial product development. For defense applications, these activities could also be beneficial to defense R&D transition but are discouraged by their tax status.

To further help explain research and experimental expenditures, Section 174 gives ten examples with further cases concerning "expenditures with respect to land and other property."²³ Further complicating the situation, Section 41 provides for a 20% tax credit for incremental increases in "qualified research expenses" (QREs) over a base amount. For certain kinds of QREs, Section 41 allows for partial credits that are not necessarily incremental over a base level. The definition of QREs relates to "qualified research," which is defined according to a four-part test and certain exclusions to each business component.²⁴ Although related, QREs are defined separately from the Section 174 definition of research and experimental expenditures that provide for the deductibility of expenditures.

The upshot is that for-profit companies often have legions of lawyers and accountants to ensure their research is deductible. As well, for-profit companies are often discouraged from conducting unsponsored research, lest the expenses be taken from after-tax profit (capital accounts). Further, an entire consulting industry is devoted to assisting companies in taking advantage of Section 41 tax credits,²⁵ which provides a hidden burden on successful small businesses and startups.

Add to this the change that occurred in the Tax Cut and Jobs Act of 2017. This Act amended Section 174 to require that deductible research and experimental expenditures be depreciated over at least five years starting in 2022, as opposed to being expensed as a deduction in the year in which they occur. The change effectively imposes a tax on two years' worth of R&D in for-profit businesses that previously expensed their R&D costs. For example, a business would have to count as profit 80% of 2022 R&D expenses (even though it was already spent), and pay taxes on that "phantom profit." Additionally, the business will have to pay taxes on phantom profits at 60% of FY 2023 R&D expenses, 40% of FY 2024 R&D expenses, and 20% of

FY 2025 R&D expenses. This added tax (which, if R&D expenses are held constant, amounts to two years' worth) is an ideal way to discourage R&D. For some businesses, the tax due (21% of profit) will be greater than revenue over expenses, thus bankrupting the company. Even if this provision is repealed,²⁶ the message to US businesses is that R&D is not valued as a cost of doing business but rather as a depreciable asset.

Tax treatment of R&D in the US is a prime example of the "death of common sense," as articulated by Philip Howard in his book decrying "how law is suffocating America."²⁷ Identifying legitimate and reasonable R&D expenses should not require detailed legal specifications. Legitimate R&D by for-profit companies should be considered a cost of doing business and deductible as a business expense necessary and reasonable for competing in the global goods and services marketplace and beneficial to national security.

Do Not Throw Away Talent

The demand for talent in STEM is global. The US is in a growing global competition for talent and employees who can contribute to commercial and defense capabilities. In 2019, the US STEM workforce consisted of over 36 million workers, of whom about 8.6 million have post-secondary degrees and were considered scientists and engineers.²⁸ As well, roughly one-fifth (19%) of all STEM workers in the US were foreign born and nearly half (45%) of the STEM workers

with doctoral degrees were foreign born.²⁹ International students make up over 70% of the graduate students in computer and information science, electrical engineering, and petroleum engineering and over 50% in many other STEM fields.³⁰ According to the American Immigration Council, "professional STEM workers" in the US amounted to 10.8 million in 2019,³¹ of whom 23% were foreign born.

The number of professional STEM individuals that the US is expected to need will increase by more than 10% from 2020 to 2030 above and beyond replacing retirements.³² This demand can only be met with increased numbers of foreign-born individuals recruited to professional STEM occupations in the US.³³

International students on F or J visas are non-immigrants, meaning they have promised and are expected to leave the US eventually. International students who receive PhDs in the US tend to manage to stay for long periods of time—a recent report states that 77% of international STEM PhD graduates from 2000 to 2015 are still living in the US,³⁴ indicating long-term stay rates among PhD graduates. Transitioning from non-immigrant visa status to legal permanent residency involves a sequence of visa transitions including optional practical training (OPT), H1-B visa candidacy and award, and green card and eventually US citizenship application.³⁵ The process can take decades, during which time the foreign national is subject to international traffic in arms (ITAR) technical information restrictions and other



impediments. Moreover, the individual is ineligible for a US security clearance until after receiving citizenship.

Through the years, there have been proposals for a special STEM visa,³⁶ adjustments to the H1-B visa numbers, and modification of the OPT program. There are also a limited number of “employment-based” (EB) visas for extraordinary talent that will not displace US workers. The problem remains that the nation and the educational system, particularly graduate programs at research universities, rely on a stream of international students, but visa policies treat these students as temporary.

These proposals and policies are viewed as immigration issues, when the real issue is export control. In most cases, the foreign person is already here, has been educated and trained, and is the subject of investment by the US. By encouraging them to leave through continued temporary visa status, we encourage the export of knowledge and talent to foreign countries that are often in competition with the US.

There is a very real concern about theft of intellectual property and technology, and foreign agents sent to collect information at universities, startups, and companies in the US. However, vetting should be done prior to the investment in their participation or education in the US and should be based on the intentions of the candidate. Instead, for those students and graduates who are in the

US for their own educational purposes, we should want to capture and retain them, and utilize their talents for economic and defense benefit in the most efficient manner. The long route of temporary visas together with the ITAR restrictions on information sharing is anathema to proper export control and efficient use of resources. Proper export control means that we do not return graduates to further develop technologies to compete with US business and defense industry. Efficient use of resources means that we give these individuals the means to contribute with knowledge in technical areas of importance to national security, once they are vetted to ensure that their intentions are not on the side of adversaries.

Do Not Discourage STEM Talent Development

Getting a STEM degree and maintaining STEM skills is a daunting task. In the US, a degree from a private university, in a STEM field, generally takes at least five years of study (despite the notion of a four-year college degree) and generally requires incurring substantial debt (or an ability to pay hundreds of thousands of dollars).³⁷ Undergraduate tuition, fees, and housing is currently \$82,730 per year.³⁸ Scholarships that “meet need” without substantial borrowing through loans are rare, limited in number, and ineffective in removing the deterrence of all candidates except for the independently wealthy. Minorities and females are underrepresented in STEM degree programs, reflecting evidence of their discouragement from pursuing STEM



education in high school years and suggesting that help and intervention is appropriate as early as possible along the education ladder.³⁹

The DOD SMART program made 482 awards in 2022.⁴⁰ This is an excellent way to encourage and support STEM talent development to benefit the NSIB, but the NSIB is likely to need thousands of entrants per year to satisfy the workforce needs. An expansion of the SMART program would be welcome. However, there also must be ways to reduce the impediments that discourage minorities, women, and those without sufficient independent resources from pursuing STEM degrees and further STEM training—for the overall benefit of the NSIB and economic benefit of the nation. The current US advantage of excellent private universities and research institutions is, in part, squandered by economic factors and education funding policies.

Summary

The ability of the US to produce innovations for defense and economic purposes remains strong. However, competition with the rest of the world dictates that the US cannot afford to be foolish in maintaining its technological edge through innovation. This article has identified three areas in which US policies are indeed stupid.

First, the tax policy is not conducive to supporting research and development, except at not-for-profit institutions that do not worry about being taxed on R&D expenditures. But for-profit companies have a lot to offer in innovation for national security purposes. Tax policy should encourage for-profit company participation in the NSIB and not discourage R&D.

Then, international students are an essential aspect of the US education system, particularly in STEM fields, and their talents should be captured for the benefit of the US economy and the NSIB. Instead, today, out of fear of exporting technologies, we enforce the barriers between the NSIB and talent among international students that we have educated. By suspecting all, we encourage the export of their knowledge and abilities through the uncertainties of

temporary visas. While international students using our institutions to collect knowledge for the benefit of adversaries should be prevented, this is not a good reason to discard a large pool of talent that could be persuaded to stay and work for US national security.

At the same time, we need to find ways to encourage the development of STEM talent to benefit the NSIB and maintain those talents through careers. We need measures to level the inducements to the study of STEM topics compared to other fields, by adjusting costs. Today, we unnecessarily discourage STEM education. To the extent that STEM education remains a draw, too often that draw is to lucrative commercial endeavors whose benefit to US national security is limited. The NSIB needs to compete for the development of talent that drives careers to benefit US national security and productive economic industries.

The US has a tremendous advantage in its ability to innovate, especially for national security purposes. It behooves the nation to undo the unnecessary impediments to using those advantages.

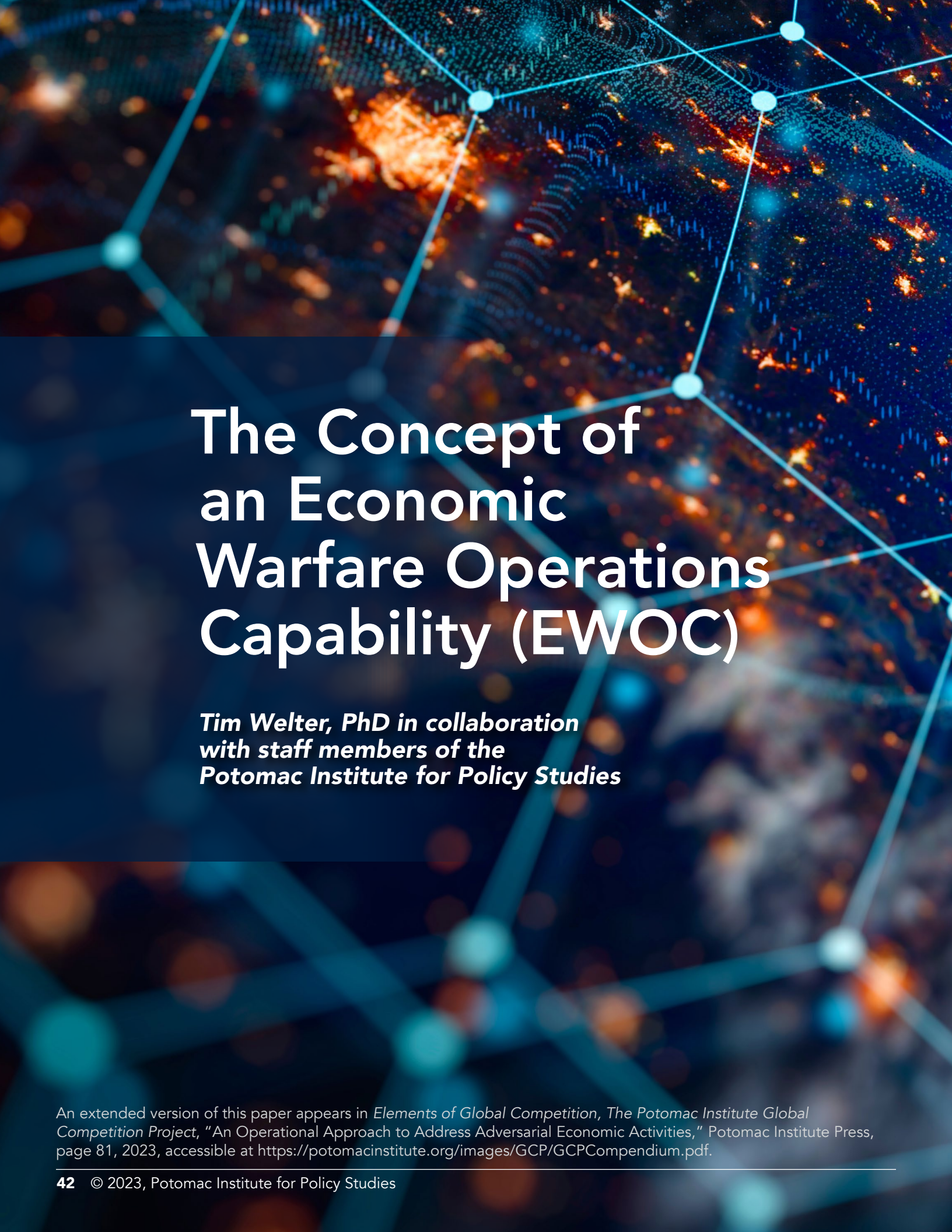
Acknowledgements

This document was made possible by a large team of researchers at the Potomac Institute for Policy Studies. The author is especially grateful to Curtis Pearson and Ryan Lewis for their guidance.

Endnotes

- 1 Nadia Shadlow. 2017. National Security Strategy of the United States of America. Online: Trump White House Archives. <https://trumpwhitehouse.archives.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>.
- 2 Prarthana Prakash. 2023. As America Obsesses over ChatGPT, it's Losing the Race with China on Tech in 37 out of 44 Key Areas. Study funded by the State Department says. *Fortune*. State Department-funded Study: China is Beating U.S. in Tech | *Fortune*.
- 3 BluePath Labs. 2017. *An Exploratory Analysis of the Chinese Hypersonics Research Landscape*. Alabama, China Aerospace Studies Institute. 2022-12-05 Hypersonics Landscape.pdf (af.edu).
- 4 Jenna Biter. 2022. From Rifles to Robot Tanks, Here are the 24 New Weapons the Army is Fielding in the Next Year. *Coffee or Die Magazine*. <https://coffeeordie.com/army-24-weapons-systems/>.
- 5 Navy Public Affairs. 2023. Navy Accepts Delivery of USNS Apalachicola. Alabama: America's Navy. <https://www.navy.mil/Press-Office/News-Stories/Article/3300920/navy-accepts-delivery-of-usns-apalachicola/>.

- 6 Ian Clay and Robert D. Atkinson. 2023. *Wake Up America: China is Overtaking the United States in Innovation Capacity*. Hamilton Center on Industrial Strategy. <https://itif.org/publications/2023/01/23/wake-up-america-china-is-overtaking-the-united-states-in-innovation-capacity/>.
- 7 Elizabeth Brotherton-Brunch. 2023. *The United States is Losing Its Innovation Edge Over China, a New Report Warns*. Online: Alliance for American Manufacturing. <https://www.americanmanufacturing.org/blog/the-united-states-is-losing-its-innovation-edge-over-china-a-new-report-warns/>.
- 8 William Thornberry. 2021. *William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021*. District of Columbia: Public Law. <https://www.congress.gov/116/plaws/publ283/PLAW-116publ283.pdf>.
- 9 National Security Innovation Base. 2019. *Peace through Strength*. District of Columbia: The Ronald Reagan Presidential Foundation & Institute. <https://www.reaganfoundation.org/reagan-institute/centers/peace-through-strength/national-security-innovation-base-program/>.
- 10 Legal Information Institute. 2021. *10 U.S. Code § 4022 - Authority of the Department of Defense to carry out certain prototype projects*. New York: Cornell Law School. <https://www.law.cornell.edu/uscode/text/10/4022>.
- 11 Legal Information Institute. 2021. *10 U.S. Code § 4022 - Research projects: transactions other than contracts and grants*. New York: Cornell Law School. <https://www.law.cornell.edu/uscode/text/10/4021>.
- 12 Francisco Moris and Brandon Shackelford. 2023. *Businesses Invested \$32.5 Billion in Assets to Support Their R&D Activities in the United States in 2020*. Online: National Center for Science and Engineering Statistics. <https://nces.nsf.gov/pubs/nsf23327>.
- 13 Congressional Research Service. 2022. *U.S. Research and Development Funding and Performance: Fact Sheet*. District of Columbia: CRS Reports. <https://crsreports.congress.gov/product/pdf/R/R44307>.
- 14 Congressional Research Service. 2022. *Defense Primer: RDT&E*. District of Columbia: CRS Report. <https://crsreports.congress.gov/product/pdf/IF/IF10553>.
- 15 Eric Chewning, Will Gangware, Jess Harrington, Dale Swartz. 2022. *How will US funding for defense technology innovation evolve?* McKinsey & Company. <https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/how-will-us-funding-for-defense-technology-innovation-evolve>.
- 16 Congressional Research Service. 2022. *Small Business Research Programs: SBIR and STTR*. District of Columbia: CRS Report. <https://crsreports.congress.gov/product/pdf/R/R43695>.
- 17 American Institute of Physics Number 9. 2023. *FY23 Budget Outcomes: Department of Defense*. Maryland: AIP. <https://www.aip.org/fyi/2023/fy23-budget-outcomes-department-defense#:~:text=DARPA,representing%20a%20%2440%20million%20drop>.
- 18 Eric Lofgren. 2023. *Rapid Defense Experimentation Reserve*. Online: Acquisition Talk. <https://acquisitiontalk.com/2023/01/rapid-defense-experimentation-reserve-rder-fy-2023-update/>.
- 19 Sydney J Freedberg Jr. 2023. *Pentagon teams up with SBA to sweeten the pot for tech investments*. Online: Breaking Defense. <https://breakingdefense.com/2023/03/pentagon-teams-with-sba-to-make-key-tech-investments-dod-cant-legally-do-itself/>.
- 20 Department of Defense. 2023. *Scholarship. Stipend. Internship. Career. Build Your Future with SMART*. District of Columbia: Scholarship for Service Program. <https://www.smartscholarship.org/smart>.
- 21 26 CFR § 1.174-2 (a)(1).
- 22 26 CFR § 1.174-2 (a)(6).
- 23 26 CFR § 1.174-2 (a)(11) and (b)(5).
- 24 26 U.S. Code § 41 (d).
- 25 Specialty Tax Professionals. 2020. *What Qualifies as an R&D Expenditure?*. Online: Tri-Merit. <https://tri-merit.com/qualifying-research-expenditures/>.
- 26 Sen. Margret Wood Hassan. 2021. S.749 - American Innovation and Jobs Act. District of Columbia: Senate (Congress.gov). <https://www.congress.gov/bills/117th-congress/senate-bill/749>.
- 27 Philip K. Howard. 2011. *The Death of Common Sense: How Law Is Suffocating America*. New York: Random House.
- 28 Amy Burke, Abigail Okrent, Katherine Hale. 2022. S&E Higher Education in the United States. Online: National Science Foundation. <https://nces.nsf.gov/pubs/nsb20221/u-s-and-global-stem-education-and-labor-force#s-e-higher-education-in-the-united-states>.
- 29 Abigail Okrent, Amy Burke. 2021. "The STEM Labor Force of Today: Scientists, Engineers, and Skilled Technical Workers." The National Science Foundation. <https://nces.nsf.gov/pubs/nsb20212>.
- 30 Stuart Anderson. 2021. International Students Remain A Primary Source Of U.S. Tech Talent. Online: *Forbes*. <https://www.forbes.com/sites/stuartanderson/2021/08/19/international-students-remain-a-primary-source-of-us-tech-talent/>.
- 31 American Immigration Council. 2022. Foreign-born STEM Workers in the United States. District of Columbia: American Immigration Council. <https://www.americanimmigrationcouncil.org/research/foreign-born-stem-workers-united-states>.
- 32 U.S. Bureau of Labor Statistics. 2022. *Employment in STEM occupations*. District of Columbia: U.S. Bureau of Labor Statistics. <https://www.bls.gov/emp/tables/stem-employment.htm>.
- 33 National Center of Education Statistics. 2022. Total fall enrollment in degree-granting postsecondary institutions, by attendance status, sex of student, and control of institution: Selected years, 1947 through 2031. https://nces.ed.gov/programs/digest/d22/tables/dt22_303.10.asp.
- 34 Corrigan, Jack, James Dunham, Remco Zwetsloot. 2022. The Long-Term Stay Rates of International STEM PhD Graduates. District of Columbia: CSET. <https://cset.georgetown.edu/wp-content/uploads/CSET-The-Long-Term-Stay-Rates-of-International-STEM-PhD-Graduates.pdf>.
- 35 Stacy Phu. 2022. International Students' Pathway to US Citizenship. Online: International Student Insurance. <https://www.isoa.org/international-students-pathway-to-us-citizenship>.
- 36 Congressional Research Service. 2012. Immigration of Foreign Nationals with Science, Technology, Engineering, and Mathematics (STEM) Degrees. District of Columbia: CRS Reports. <https://crsreports.congress.gov/product/pdf/R/R42530/14>.
- 37 Board of Science Education. 2014. *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways*. New York: The National Academies of Sciences-Engineering-Medicine. <https://www.cuny.edu/wp-content/uploads/sites/4/page-assets/about/administration/offices/undergraduate-studies/coordinated/CUEUpdated-Barriers-ReportFINALOUS.pdf>.
- 38 Student Financial Services. 2022. Cost of Attendance. Massachusetts: MIT. <https://sfs.mit.edu/undergraduate-students/the-cost-of-attendance/annual-student-budget/>.
- 39 Dina Ghazzawi, Donna Pattison, and Catherine Horn. 2021. Persistence of Underrepresented Minorities in STEM Fields: Are Summer Bridge Programs Sufficient? *Texas: Frontiers in Education*. <https://www.frontiersin.org/articles/10.3389/feduc.2021.630529/full>.
- 40 Department of Defense. 2022. *DOD SMART Scholarship Award Statistics*. District of Columbia: Scholarship-for-Service Program. https://www.smartscholarship.org/smart?id=program_stats.



The Concept of an Economic Warfare Operations Capability (EWOC)

***Tim Welter, PhD in collaboration
with staff members of the
Potomac Institute for Policy Studies***

An extended version of this paper appears in *Elements of Global Competition*, The Potomac Institute Global Competition Project, "An Operational Approach to Address Adversarial Economic Activities," Potomac Institute Press, page 81, 2023, accessible at <https://potomac institute.org/images/GCP/GCPCompendium.pdf>.



Introduction

The US enjoyed the benefits of a relatively unmatched monopolar position on the global stage in the immediate aftermath of the Cold War. That position has been challenged in recent years by rivals, such as China and Russia, working to shift the geopolitical and global economic environment in their favor.¹ To do so, both nations have employed asymmetric “gray zone” tactics, actions below the threshold of war, but which still vitally threaten the economic and security interests of the US and others.²

Gray zone operations include propaganda, media misinformation and disinformation, deliberate supply chain disruptions, and economic manipulation and coercion, along with other more traditional military equipping activities.³ Economic warfare activities are the most concerning, as such activities are focused on destabilizing and diminishing the vitality of the US economy⁴ and interfere directly with the United States’ ability to acquire, secure, and field capabilities required to defend the nation.

The industry and supply chains that the US government relies upon for weapons, technology, infrastructure support, and other factors of vital importance are at risk—highlighted recently by the PPE and other shortages experienced during the early days of the COVID-19 pandemic.⁵ Subsequently, factors limiting US access (deliberate or not) to critical technologies and other products and commodities vital to a healthy population and economy have become a growing concern for national leaders.

An emphasis of the 2022 National Security Strategy (NSS) was to invest in and partner with the commercial sector to strengthen the US national security posture—a societal-level approach to addressing the threats and realities of a dynamic global competitive environment. The approach carries over from the 2017 NSS and 2018 National Defense Strategy (NDS). Both emphasized the need for a strong, resilient defense industrial base as an integral part of national security, as the 2017 NSS stated, “...a vibrant domestic manufacturing sector, a solid defense industrial base, and resilient supply chains [are] a national priority.”⁶ The policy guidance across two administrations is encouraging, but there is still much to be acted upon.

Prior to the COVID-19 pandemic, US government efforts to combat asymmetric “gray zone” attacks were more reactive, fragmented, and siloed. The pandemic inspired US government agencies to re-evaluate how to identify, support, and maintain industrial base elements vital for US national security. However, the nation still lacks the strategy (2022 NSS aside), workforce skillsets, and business operations to properly address the scope of the challenge at hand.

The US government’s approach to countering the infusion of adverse capital and other asymmetric economic activities that directly impact DOD missions has also been limited and disparate. While policymakers have acted,⁷ the remaining challenge demands a fundamental shift in statecraft. Remedies will likely be constrained by the inertia of long-established institutional processes, cultures, and norms inside and outside the government. An evolution in thought and approaches to new threats come historically with a debate over the balance between liberty and security (e.g., post 9/11). Change, if effective, drives uncomfortable organizational and cultural shifts away from the status quo. In this case, a shift from 20-plus-years of the big “M” military as America’s primary lever of national power toward others in the “DIME”—diplomacy, information, military, and economy—is necessary.

Ultimately, a US government entity must be designated to “own the supply chain and industrial base problem,” responsible to orchestrate the development and employment of a suite of options to protect and defend the US industrial base from asymmetric economic attack. The Office of Economic Warfare and Competition (OEWC), as proposed by David Rader* is a tenable conception of such an entity, as is the Economic Warfare Operations Capability, a more operationally focused approach outlined in this article.⁸

Vulnerabilities resulting from conflict escalation, kinetic or otherwise, will be more manageable if there is a government entity with the authority and tools to identify, orchestrate, and address fundamental risks to the industrial base and supply chains. This would require strengthened

* Former Deputy Director of the Office of Foreign Investment Review at the DOD.

partnerships between the US government and the private sector to expose and examine threats to domestic and foreign companies. Moreover, it would require an exchange of information on risks, potential responses, and drivers—both political and economic—and their interdependencies with supply chains and national security. Ultimately, gray zone economic assaults must be addressed by the US government in collaboration with the private sector and partners and allies.

Until the problem is addressed, the US government's ability to carry out its core duties to "insure domestic tranquility, provide for the common defense, promote the general Welfare, and secure the Blessings of Liberty," is at risk. This paper provides a proposed solution to that end: The Economic Warfare Operations Capability (EWOC).

Background

Understanding the Problem

The US government is not well organized for societal-level competition against adversaries. The 2023 Select Committee on the *Strategic Competition Between the United States and the Chinese Communist Party* in the US House of Representatives has the opportunity to address these

issues. "Gray zone" tactics, employed by China but also by Russia and others, operate below the threshold of open kinetic warfare but still threaten US national security. This is a reality of the character of competition and conflict in the 21st century. America is just starting to awaken to this reality and challenge traditional conceptions of the spectrum of war. Remedies will require a societal-level response that actively fuse operational savvy with economic and business acumen. They will also require authorities to swiftly decide and act on, or elevate threats and vulnerabilities for action, at appropriate levels across the US government and industry.

According to *Special Warfare*:⁹

"Gray zone security challenges, which are competitive interactions among and within state and non-state actors that fall between the traditional war and peace duality, are characterized by the ambiguity about the nature of the conflict, opacity of the parties involved, or uncertainty about the relevant policy and legal frameworks."

Gray zone warfare is thus a way to weaken a rival nation's position outside the realm of conventional armed conflict and can be used to allow a competitor nation to achieve its



political goals. The ancient Chinese military philosophy of Sun Tzu articulated its practices and tactics. The People's Republic of China uses gray zone tactics to pursue the geopolitical goals of the Chinese Communist Party (CCP). Russia is also well-practiced in gray zone tactics.¹⁰

Gray zone tactics are delineated in China's People's Liberation Army (PLA) doctrine of "Unrestricted Warfare." The PLA emphasize combining all elements of national power to achieve national objectives, with tactics that reportedly include: "military intimidation, paramilitary activities [maritime militia and maritime law enforcement over disputed territories breaking norms of good seamanship], co-opting of state-affiliated businesses, manipulation of borders... lawfare and diplomacy, and economic coercion, and strategic investments in, and venture capital funding of, cutting-edge technology companies."¹¹ Gray zone economic activities are also referred to as predatory or asymmetric economics, adversarial investment, or as adversarial economics. They are designated in this paper as "economic warfare."

Ultimately, China and Russia have each been openly accused of destabilizing and diminishing the vitality of the US economy by using gray zone operations. Both have sought influence and advantage using adversarial economics. The defense industrial base has been a consistent target, through IP theft, infiltration of supply chains, and other gray zone activities.¹²

To ensure America's security and continued prosperity, the US government needs a coherent operational framework to identify, monitor, prioritize, and coordinate (across US government and DOD entities) the mitigation of vulnerabilities to the industrial base. To accomplish this, trust and agility must be central to working relationships between the public and private sectors. Concurrently, the government's acquisition vehicles and practices must evolve to address contemporary competitive challenges at a relevant pace.

Economic Warfare

Beginning in 1953, China has used a series of "Five-Year Plans" to set strategic goals, focus government work, and guide the activities of market and non-market entities in China.¹³ In 2021, China started on its fourteenth Five-Year-Plan, which set an ambitious agenda to "promote

high-quality development in all aspects, including the economy, environment, and people's livelihood and well-being, and realize the rise of China's economy in the global industrial chain and value chain."¹⁴ To that end, the CCP has employed adversarial economic activities to undermine US economic and technological advantages to pursue its own strategic objectives on the global stage.¹⁵

China's grand strategy of economic warfare is enhanced by state ownership of industries and businesses. State-owned enterprises (SOEs) receive significant investments from their owners (the Chinese government), allowing them to invest with less risk than that which investors in private commercial companies experience. In contrast, US businesses rarely receive government subsidies in the way and extent that Chinese SOEs receive government funding.¹⁶

China also uses their own venture capital¹⁷ funding to access innovative technologies in free-market economies. The Chinese government gains access to technologies (especially by investing in small and medium size Western enterprises) and then shares those technologies with their SOEs. China's venture capitalists have been monitoring innovation hubs like Silicon Valley for investment opportunities in early-stage startups in fields deemed essential to its future military dominance (AI, Fintech, etc.).¹⁸

Coercive loss of intellectual property (IP) can occur when a US company "partners" with a foreign company for "mutual benefit" in a joint venture or major stock purchase.¹⁹ China, for example, can require a partnership for access to its market.²⁰ IP-intensive industries account for over 45 million US jobs and the loss of IP erodes US technological supremacy, the cornerstone of its economic prosperity and military hegemony since World War II.

Intellectual property theft by China is said to cost the US between \$225 billion and \$600 billion annually.²¹ Malintended foreign direct investment and the use of cyber espionage to steal IP from US companies has resulted in the proliferation of technologies and capabilities once exclusive to the US military.²² Chinese IP theft has allowed the PLA to fill gaps in its research programs, shortening R&D timelines for fielding advanced military platforms and identifying vulnerabilities in US systems to develop countermeasures.^{23,24} It also allows China to bolster its own economy, cornering advantage in competition with the US.

Current Efforts to Combat Asymmetric Economic Activities?

While the US has laws to protect companies from predatory foreign direct investment (FDI), loopholes always exist in a proper free-market economy. The Committee on Foreign Investment in the United States (CFIUS) is supposed to prevent threats to national security from FDI in US businesses. The Foreign Investment Risk Review Modernization Act (FIRRMA), passed in 2018, attempted to provide more authority, scope, and latitude to CFIUS. However, CFIUS reported to Congress in 2022 that it only reviewed a “small percentage of the total number of... foreign direct investment flows into the United States”²⁵ Given the scale and adaptability of investments throughout the US economy, the challenge to CFIUS is simply too great.

To counter asymmetric economic threats, including threats to national security, a different approach is needed. The 2022 NSS talks of an “integrated defense,” calling for the use of all instruments of national power to address subversive gray zone activities and other contemporary threats.²⁶

The CHIPS and Science Act in August 2022 represents an effort to combat economic threats in the microelectronics and high technology fields. The law allots tens of billions of taxpayer dollars to invest across industry, government, and academia for R&D, manufacturing, and workforce development critical to gaining (or recovering) an economic and security posture for the United States, in particular in semiconductor manufacturing.²⁷

The Office of Strategic Capital (OSC) was established in December 2022 within DOD’s Office of the Undersecretary for Research and Engineering. The OSC is a turning point for DOD in publicly recognizing the need to counter the gray zone economic threats. Their mission is to “develop, integrate, and implement proven partnered capital strategies to shape and scale investment in critical technologies.” Criticality, here, would refer to military needs.

At least two dozen other US government and nongovernmental organizations, including the FBI, and the Treasury, Commerce, and Defense Departments, have initiatives focused specifically on countering adversarial

economics. However, these efforts are too disparate and tactically-focused to adequately address or deter the comprehensive gray zone strategies currently deployed against the United States. No single US entity, public or private, is calling the shots overall (let alone has the authority to do so) to counter adversarial economic challenges at the societal level. Subsequently, the government needs an orchestrated operational approach.

An Operational Approach: The EWOC

What sort of organization could address a solution set informed by the global economic, political, and security environment?

Designated the *Economic Warfare Operations Capability (EWOC)*, the concept outlined in this section is a proposed means by which the US government can operationally address the threats and challenges posed by adversarial economic activity.²⁸ This capability is an imperative if the US expects to remain operationally relevant on the global stage. It is envisioned as agile and responsive to the dynamics of the global economic, political, and security environments to support the strategic posture of the United States.

The overall mission of the EWOC is to ensure access to the industrial base and supply chains critical to preserving operational advantage across the full spectrum of conflict, to include economic warfare. As envisioned, the EWOC will do so by building and leveraging enduring partnerships and operational capacity across the interagency and industry.

The EWOC will bring disparate efforts together, prioritized and orchestrated under one umbrella—a scalable operational approach for decision and action.

The EWOC approach operationalizes the concept of “integrated deterrence” (a key principle of the 2022 National Defense Strategy), providing coordination with the private sector, as well as with vetted allies and partners, to address economic threats across domains and instruments of national power. The EWOC will help deter kinetic conflict with adversaries by virtue of using economic dependencies as a lever of national power, i.e., economic statecraft.

The EWOC has three core mission areas that fuse inputs from across the government, industry, and DOD:

Mission Area 1: Fused Observation and Analysis. Prioritize and conduct observation and analysis of global markets, the industrial base, and supply chains critical to the US government.

Mission Area 2: Industry-Government Partnerships. Shepherd enduring, agile partnerships between industry and the government.

Mission Area 3: Integration and Orchestration for Operations: Decide, Act, Elevate. Provide options to decide and act or elevate action to address threats and risks.

The synchronization of the EWOC's three mission areas is key to addressing the primary challenge: Assurance the US government has enduring, secure access to the industrial products and supply chains vital for success across the spectrum of conflict while maintaining competitive advantage.

The diagram and following section describe each mission area in greater detail, to include explanations of how they work together.

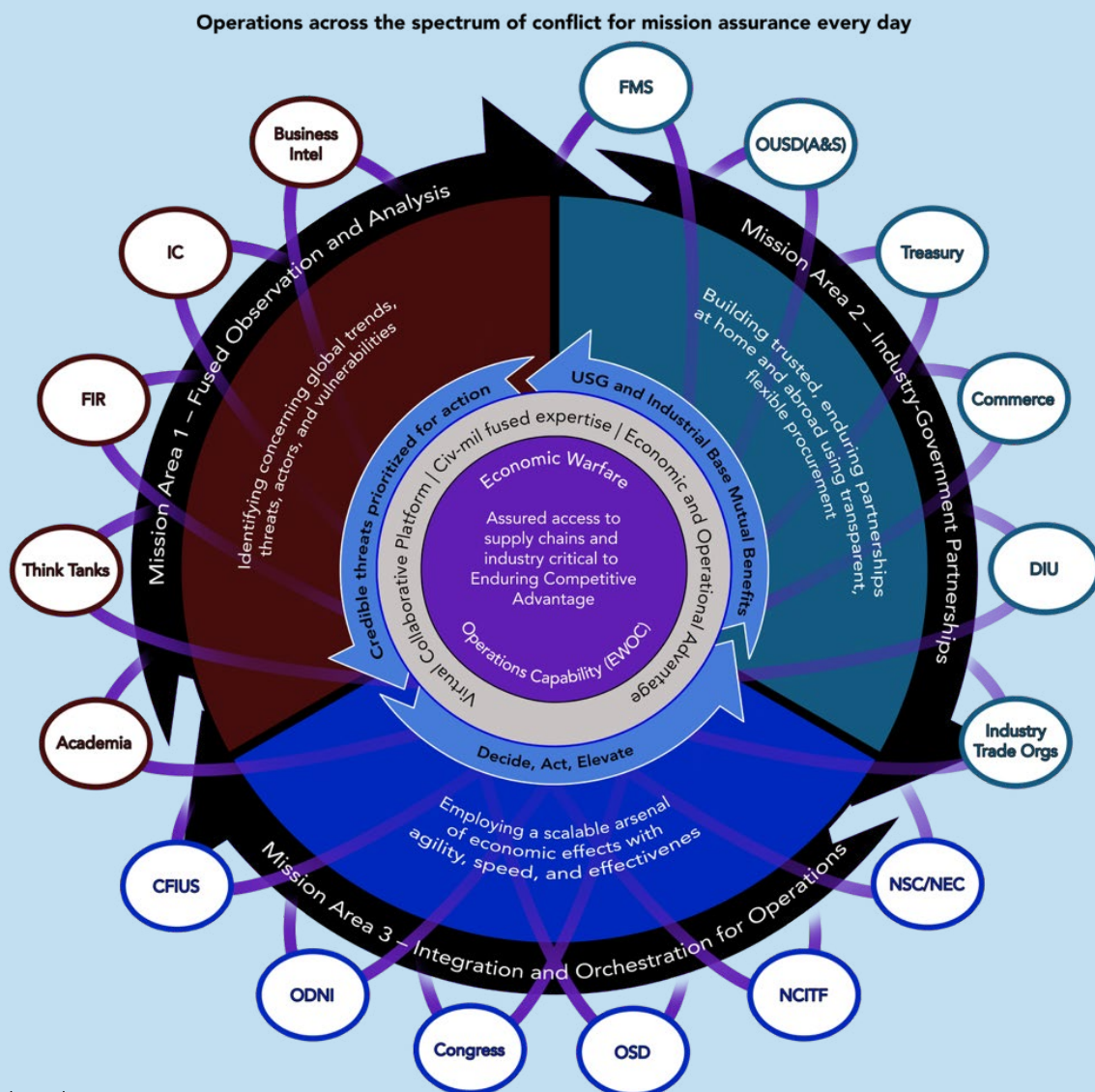


Image credit: Alex Taliesen

Mission Area 1: Fused Observation and Analysis—*Identifying Concerning Global Trends, Threats, Actors, and Vulnerabilities*

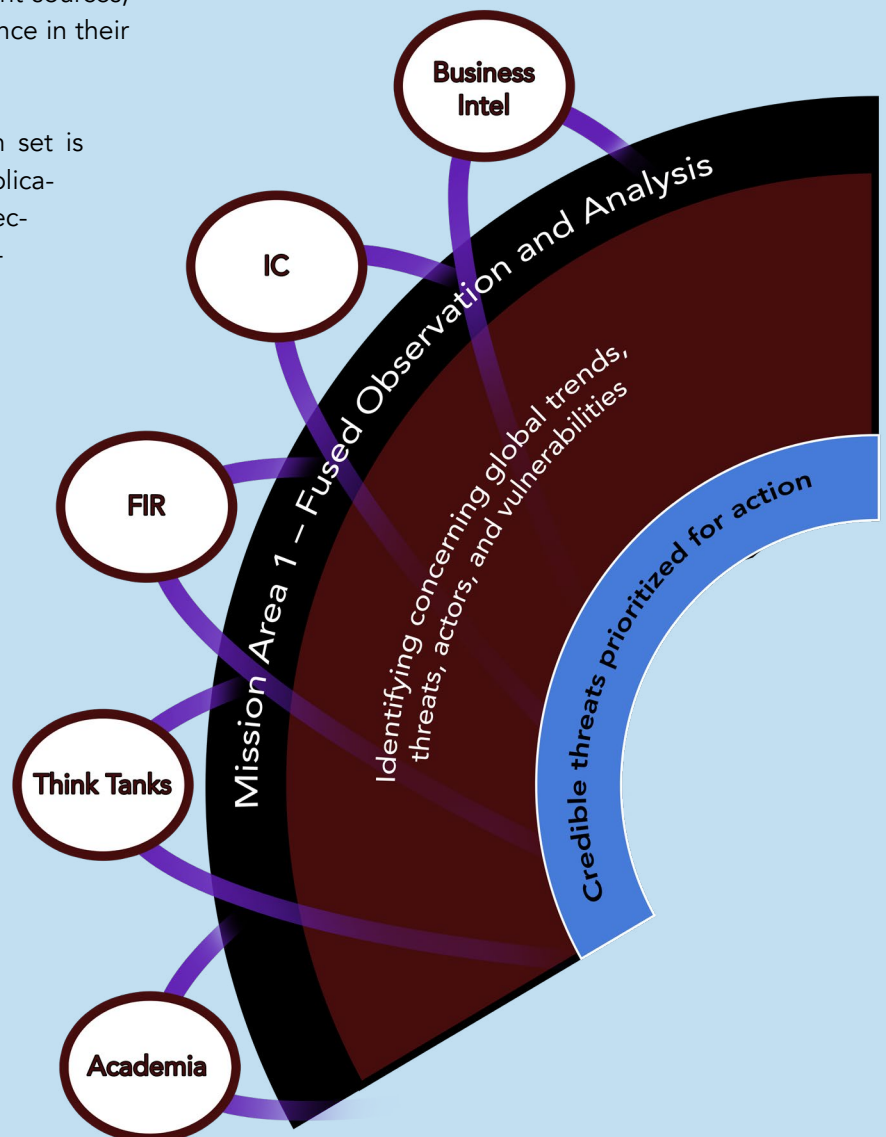
Mission Area 1 of the EWOC provides prioritized market intelligence and analysis for decisive operational action. The EWOC will have a dedicated workforce deeply steeped in both business intelligence and military operations, tasked to understand risks and vulnerabilities in supply chain networks impacting the US government.

Mission success will require continuous deep knowledge of global economic trends, investments, and markets and the identification of innovation and technologies vital to national security and US economic wellbeing. Intelligence will be collected from open sources, government sources, and businesses that develop their own intelligence in their respective market sectors.

Currently, information relevant to the problem set is scattered across the private sector, trade publications and associations, various areas of the executive branch and military services, and the intelligence community. Often, the government's awareness of useful information is limited and intelligence fusion capabilities are lacking that could provide comprehensive analytical products to inform decision makers. Therefore, an overarching role of the EWOC is to fuse disparate intelligence analyses together to provide prioritized, actionable options.

The EWOC will help identify sectors worth protecting and the nodes of influence. Analysis of the resulting network will provide critical points of vulnerability and risks in supply chains, driving further focused intelligence collection, sharing, and fusion among industry and government stakeholders.

The key to EWOC's Mission Area 1 is development of a workforce with expertise in researching, analyzing, and using economic market-based intelligence. The workforce would include experience across the financial services, intelligence, and operational national security realms. Expertise would be required in international finance and business, and global logistics coupled with national security savvy. Operators must be able to identify and understand risks and vulnerabilities in supply chain networks impacting US interests and readily leverage a deep knowledge of global economic trends, investments, markets, innovations, and technologies vital to national security and enduring competitive advantage.



Mission Area 2: Industry-Government Partnerships—Building Trusted, Mutually Beneficial Enduring Partnerships at Home and Abroad Using Transparent, Flexible Procurement

Mission Area 2 of the EWOC is focused on developing and harnessing mutually beneficial relationships between the government and industry. It provides a virtual collaborative platform for consistent engagement between the two—domestically and with allies and partners—rendering enduring partnerships built on countering common gray zone economic threats. This mission area is fueled by assuring that businesses are properly

incentivized and sufficiently equipped to identify and share information about economic threats for assistance from the US government.

Fusing the efforts of extant organizations, the EWOC will help orchestrate a cohort of invested parties from within the government and across industry to establish a distributed public-private partnership. It aims to transcend transaction-focused relationships through the sharing of information to benefit economic sectors while also preserving individual industry's competitive advantages over their competitors. In many cases, the EWOC will fuse products from multiple anonymized entities to inform operational decisions for action against adversarial economic activities. The partnerships will enable businesses to succeed in their endeavors, while also serving national interests in providing for common defense and security, to include economic security.

The trust established by collaborating to counter adversarial economic activities will strengthen relationships. Industry can be incentivized to participate through more transparent and flexible acquisitions practices, sharing of business intelligence, and broader access to government needs and resources.

The EWOC's role is to serve as an information clearinghouse between the government and industry. The EWOC should be the venue for sharing information on emerging economic threats so nefarious actors or suspicious activity may be identified, deterred, and countered with decisive action. Participants would gain market and industry insights unavailable elsewhere. The outcome will be a protected and strengthened industrial base critical to national interests while addressing the pace and character of security challenges of the global competitive environment.

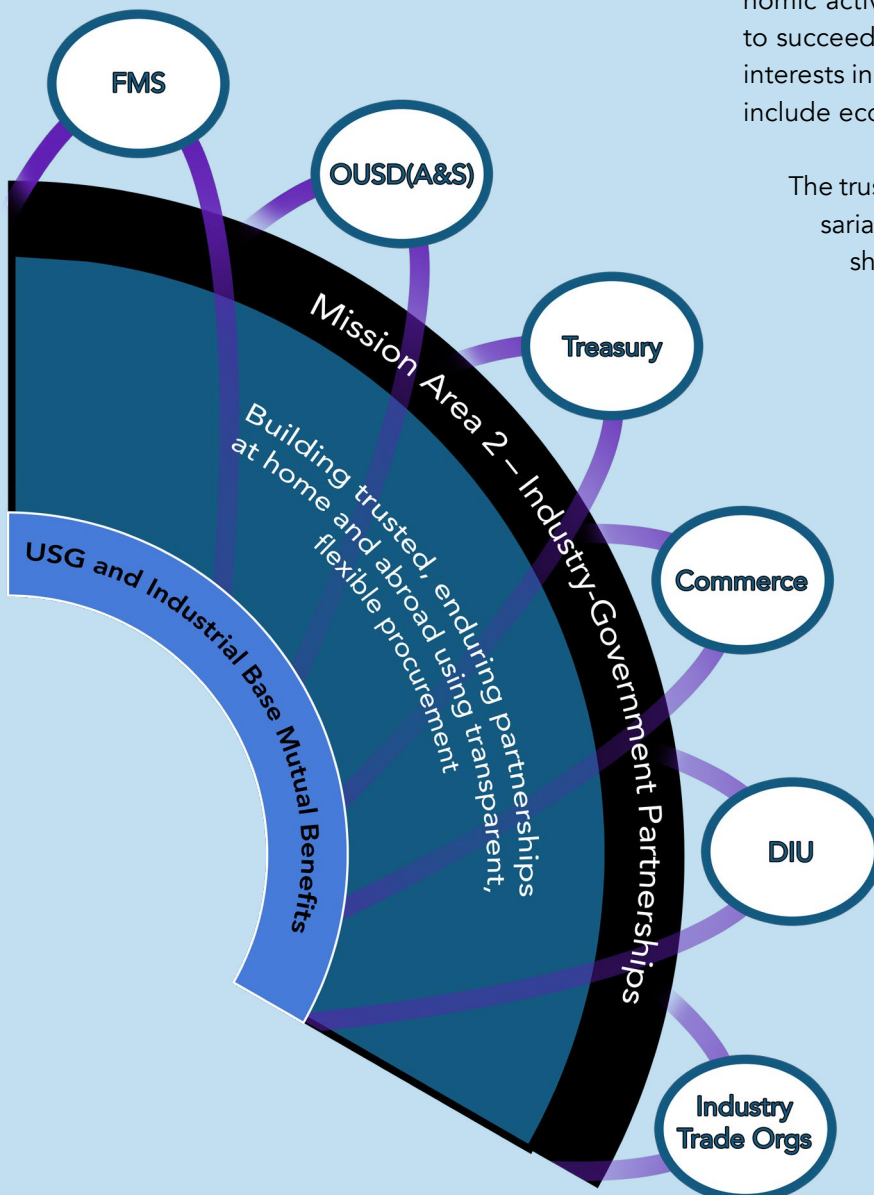


Image credit: Alex Taliesen

Mission Area 3: Integration and Orchestration for Operations: Decide, Act, Elevate— *Employing a Scalable Arsenal of Economic Effects With Agility, Speed, and Effectiveness*

Mission Area 3 of the EWOC is the operational arm. It will develop and recommend actions from an arsenal of economic levers to act on the market intelligence and fused analysis from Mission Area 1, in concert with the partnerships established by Mission Area 2. Actions may be recommended to the executive branch, to be orchestrated by departments and agencies at the direction of the chief executive (the president), or National Security Council, or the legislative branch through proposed legislation. The EWOC itself might have limited operational authorities by virtue of association with interagency stakeholders. With integrated information, integrated deterrence is possible. Effects will be used to address threats with agility, speed, and impact, ultimately assuring competitive and decision advantage across the spectrum of conflict—from competition to crisis.

The US government currently employs various levers to identify, analyze, and address mission critical industry and supply chain vulnerabilities. Trade controls are typical capabilities employed in this domain. However, no agency currently takes an orchestrated operational approach to their employment, bringing disparate efforts together for decision and action. Identifying an arsenal of gray zone economic levers will enable an operational decision framework to be developed. The framework would include guidance on when to make decisions based on analysis of threats, when and how to act upon threats, and when to elevate actions to higher levels of authority for further actions. The arsenal would include a suite of effects to create specific desired outcomes in both defensive and offensive operations.

Defensive measures might be designed to protect companies from malign foreign influence. Defensive operations include changes to policy, regulations, and procedures that make it easier for industry partners to work with the US government, as opposed to working with entities beholden to



rival governments. They might involve reducing hurdles for companies to accept US government funding (as with the DoD's OSC). It could also be manifested in the creation of tax incentives for US companies to remain in the US or it could facilitate the availability of services that enable small companies to better compete.

Offensive operations generally involve asymmetric effects that negatively impact an adversary's global economic enterprise. For example, introducing capital investments in an alternative to rare earth elements (REEs) could disrupt China's dominant share of the world's processing capability, (which they exploit to threaten supply chains).

Summary

Development and employment of a scalable arsenal of economic effects that leverage market intelligence and analysis, as well as government-industry partnerships, will support the new reality of national security. Fusion of these elements provides a means for government leaders to decide to act on looming threats in a deliberately orchestrated, operational manner. The US needs an effective whole-of-government approach to countering adversarial economic activity across domains and instruments of national power.

National interests are vulnerable to unchecked adversarial economic activities. While there are efforts underway to

identify and analyze those threats, such information is not prioritized, fused, and orchestrated across the entirety of the government for decision and action. When an action is taken it is usually at the tactical level, disconnected from a broader strategy and from industry partners. Here, we have outlined the concept of an Economic Warfare Operations Capability, an EWOC, to provide a unique but mutually beneficial opportunity for industry and government to strengthen their relationships and work together with partners to counter threats and serve the common good.

Development and fielding of an EWOC-type capability will help preserve the ability of the US government to carry out its core missions at the most basic level—by securing the industrial base and supply chains they depend upon—while providing the opportunity to build enduring partnerships and operational capability to assure competitive advantage on the global stage.

Acknowledgements

The author declares that the views expressed in this article reflects the author's personal thoughts and do not represent the position of the Department of the Air Force or the Department of Defense, with whom the author is also affiliated. He is grateful to the many contributors of the staff of the Potomac Institute for Policy studies, and thanks the editors of Potomac Institute press for their assistance in the preparation of this article.



Endnotes

- 1 "Fact Sheet: The Biden-Harris Administration's National Security Strategy." The White House. October 12, 2022. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/12/fact-sheet-the-biden-harris-administrations-national-security-strategy/>.
- 2 John Knefel. "The 'Gray Zone' Is the Future of War: Ongoing, Low-level, and Undeclared." *Inverse*. December 7, 2015. <https://www.inverse.com/article/8838-the-gray-zone-is-the-future-of-war-ongoing-low-level-and-undeclared>.
- 3 Center for Strategic and International Studies. "Competing in the Gray Zone: Countering Competition in the Space between War and Peace." CSIS. 2023. <https://www.csis.org/analysis/competing-gray-zone-countering-competition-space-between-war-and-peace>.
- 4 "How China's Economic Aggression Threatens the Technologies and Intellectual Property of the United States and the World." The White House. June 2018. <https://trumpwhitehouse.archives.gov/briefings-statements/office-trade-manufacturing-policy-report-chinas-economic-aggression-threatens-technologies-in-tellectual-property-united-states-world/>
- 5 Will Weissert. "DHS Report: China Hid Virus' Severity to Hoard Supplies." *AP News*. May 4, 2020. <https://apnews.com/article/us-news-ap-top-news-international-news-global-trade-virus-outbreak-bf685dcf52125be54e030834a-b7062a8>.
- 6 "National Security Strategy of the United States of America." The White House. December 2017. <https://history.defense.gov/Portals/70/Documents/nss/NSS2017.pdf?ver=CnFwURrw09pJ0q5EogFpwg%3d%3d>
- 7 US Mission Japan. "Remarks by Secretary of Commerce Gina Raimondo on US Competitiveness and the China Challenge." US Embassy and Consulates in Japan. November 30, 2022. <https://jp.usembassy.gov/commerce-secretary-raimondo-on-us-competitiveness-and-chinas-challenge/>.
- 8 David Rader. "Dollars, Tanks, and Banks: Modernizing the Economic Warfighting Domain." *The Hamiltonian*. 2022. <https://hamiltonian.alexanderhamiltonsociety.org/security-and-strategy/dollars-tanks-and-banks/>.
- 9 Philip Kapusta. "The Gray Zone." *Special Warfare*. October 2015. <https://www.proquest.com/trade-journals/gray-zone/docview/1750033789/se-2>.
- 10 Ben Connable, Stephanie Young, Stephanie Pezard, Andrew Radin, Raphael S. Cohen, Katya Migacheva, and James Sladden, *Russia's Hostile Measures: Combating Russian Gray Zone Aggression Against NATO in the Contact, Blunt, and Surge Layers of Competition*. Santa Monica, CA: RAND Corporation, 2020. https://www.rand.org/pubs/research_reports/RR2539.html. Also available in print form.
- 11 Elisabeth Braw. "The Defender's Dilemma: Identifying and Deterring Gray Zone Aggression." American Enterprise Institute. 2022. <https://www.aei.org/the-defenders-dilemma/>.
- 12 Christopher Wray. "Countering Threats Posed by the Chinese Government Inside the US" Federal Bureau of Investigation. January 31, 2022. <https://www.fbi.gov/news/speeches/countering-threats-posed-by-the-chinese-government-inside-the-us-wray-013122>.
- 13 Per Covington, a firm providing legal and policy advice to those seeking to do business in China.



- 14 Kaja Ashwin, Sean Stein, and Ting Xiang. "China's 14th Five-Year Plan (2021-2025): Signposts for Doing Business in China." *Global Policy Watch*. April 6, 2021. <https://www.globalpolicywatch.com/2021/04/chinas-14th-five-year-plan-2021-2025-signposts-for-doing-business-in-china/>.
- 15 Remarks by U.S. Secretary of Commerce Gina Raimondo on the U.S. Competitiveness and the China Challenge, November 30, 2022, <https://www.commerce.gov/news/speeches/2022/11/remarks-us-secretary-commerce-gina-raimondo-us-competitiveness-and-china>.
- 16 Elisabeth Braw. "The Defender's Dilemma: Identifying and Deterring Gray Zone Aggression." American Enterprise Institute. 2022. <https://www.aei.org/the-defenders-dilemma/>.
- 17 The Defender's Dilemma: Identifying and Deterring Gray Zone Aggression.
- 18 The Defender's Dilemma: Identifying and Deterring Gray Zone Aggression.
- 19 Christopher Wray. "Countering Threats Posed by the Chinese Government Inside the US" Federal Bureau of Investigation. January 31, 2022. <https://www.fbi.gov/news/speeches/countering-threats-posed-by-the-chinese-government-inside-the-us-wray-013122>.
- 20 Lucie Béraud-Sudreau, David Brewster, Christopher Cairns, Roger Cliff, R. Evan Ellis, April Herlevi, Roy Kamphausen Mr., Roderick Lee, Paul Nantulya, Meia Nouwens, Rebecca Pincus, and Joel Wuthnow, Enabling a More Externally Focused and Operational PLA – 2020 PLA Conference Papers (Carlisle Barracks, PA: US Army War College Press, 2022), <https://press.armywarcollege.edu/monographs/951>.
- 21 "Executive Summary: China: The Risk to Corporate America." Federal Bureau of Investigation. 2022. <https://www.fbi.gov/file-repository/china-exec-summary-risk-to-corporate-america-2019.pdf>.
- 22 Sakshi Tiwari. "Chinese 'Stealth' Espionage! How Beijing-Backed Hackers 'Acquired' Sensitive US Tech Used In Its F-35 Fighter Jet?" February 3, 2022. <https://eurasianimes.com/chinese-stealth-espionage-us-tech-used-in-its-f-22-f-35-fighter/>.
- 23 Ellen Jones. "China Steals US Designs for New Weapons, and It's Getting Away with 'The Greatest Intellectual Property Theft in Human History.'" *Business Insider*. September 24, 2019. <https://www.businessinsider.com/esper-warning-china-intellectual-property-theft-greatest-in-history-2019-9#the-plas-j-20-looks-extremely-similar-to-the-us-air-forces-f-22-raptor-1>.
- 24 Jeff Jones. "Confronting China's Efforts to Steal Defense Information." Harvard Kennedy School's Belfer Center for Science and International Affairs. May 2020. <https://www.belfercenter.org/publication/confronting-chinas-efforts-steal-defense-information>.
- 25 "Annual Report to Congress: Report Period: CY 2021." Committee on Foreign Investment in the United States. 2022. <https://home.treasury.gov/system/files/206/CFIUS-Public-AnnualReporttoCongressCY2021.pdf>.
- 26 Meredith Roaten. "AFA News: 'Integrated Deterrence' to Drive National Defense Strategy." *National Defense Magazine*. September 22, 2021. <https://www.nationaldefensemagazine.org/articles/2021/9/22/integrated-deterrence-to-drive-national-defense-strategy>.
- 27 "Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China." The White House. August 9, 2022. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/>.
- 28 Distinct from, but not unrelated to the independently proposed Office of Economic Warfare and Competition (OEWC).

Prospects for US Sources of Energy

***Robert (Bob) Hummel, PhD
and Moriah Locklear, PhD***





The US national security and economy depend on reliable and long-term access to abundant energy sources. Historically, the US has benefited from easy access to energy resources, including coal, oil, gas, wind, solar, and hydro power. Access to energy resources includes oil importation. Events in the 1970s demonstrated that a lack of self-reliance could lead to vulnerabilities. As a result, the US endeavored to achieve “energy independence,” to become a net exporter of energy resources. For the US, that goal was first achieved in 2020.

Energy independence is a noble goal, but it does not eliminate vulnerabilities. Malicious actors, cyberattacks on energy infrastructure, turbulence from climate change, an aging electrical grid, and unsecured supply chains pose threats to America’s competitive edge and economic wellbeing. Sudden increases in the price of energy could destabilize the population by making essential goods and services unaffordable. Residential heating and air conditioning, transportation, and commercial real estate rely on cheap energy sources. Industry depends on large supplies of energy, because, for example, manufacturing typically involves massive consumption of energy. The military requires prodigious supplies of energy in the form of jet fuel, gasoline, and nuclear power—for wartime and peacetime operations. The supply of energy resources is important, but its distribution is also essential to the population, the economy, and the military. Even when sources of energy are based on indigenous domestic supplies, disruptions can occur that put America’s national security and economy at risk.

Being a net exporter of energy resources does not mean that the US does not depend on imports. A major complication is that oil must be refined, and there are different types of oil for different kinds of refineries. The United States imports certain types of oil for which it has refinery capacity and capabilities and exports other types of oil for refining elsewhere. Should imports be disrupted, the US would confront supply deficiencies because current exports could not be converted quickly to domestic use. Moreover, domestic supplies of oil are limited.

Distribution requirements cause other vulnerabilities. Oil and gas pipelines can be sabotaged through physical and cyberattacks. Power grids for electricity distribution require maintenance and are vulnerable to weather or other disruptions.

In addition to threats from geopolitical adversaries, whether wartime or gray zone, there is also a competition for resources. Supply and demand are typically in a very delicate balance globally, and nations need and want access to sufficient energy resources. Any disruption can lead to a scramble and competition for resources globally. This scenario occurred in 2022 due to the reduction and redirection of supplies of oil and gas from Russia.

There are multiple other competitions that take place with respect to energy. In wartime, a typical target of an adversary’s infrastructure and warfighting capabilities involves local energy supplies. There is also a competition for affordable energy, as oil-rich states benefit from high oil prices, whereas major consuming nations benefit from low prices. Today, there is even competition for the installation of renewable energy resources, as there is increasing global interest in reducing atmospheric carbon emissions and thus reducing or eliminating the use of fossil fuels.

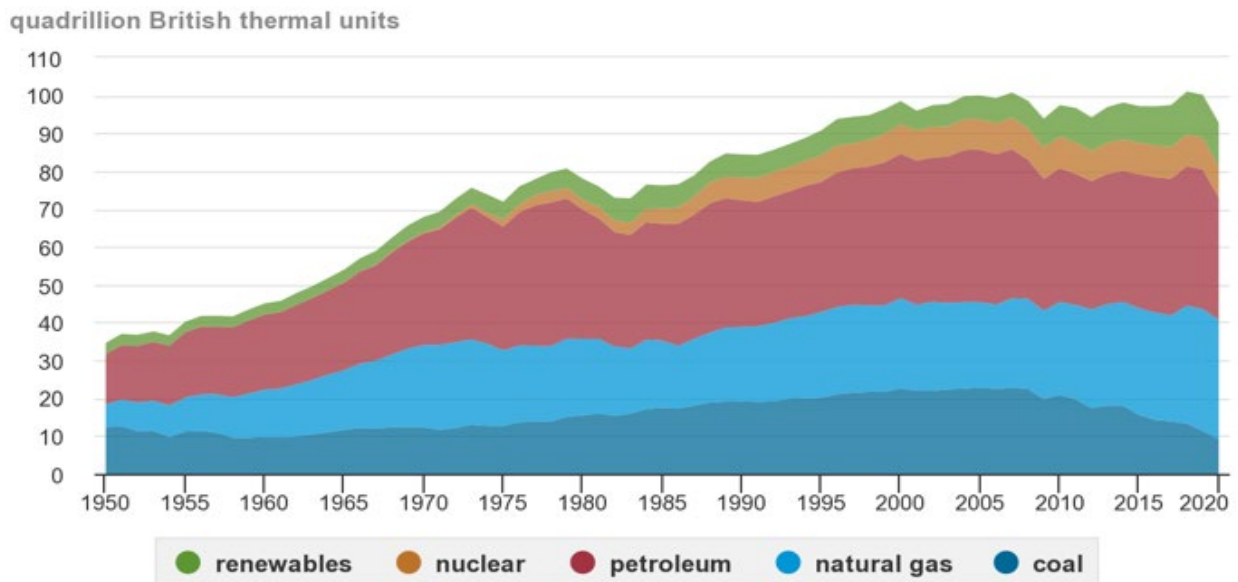
Because energy is so important to prosperity and security, the overarching requirement is for reliable access to energy resources. This necessitates sources of energy, production, and distribution, with reserve capacity in all areas. Even then, vigilance is required in recognizing potential threats, both natural and deliberate. This sets up a relentless pursuit of a competitive advantage in access to sources, production, and distribution of energy for the US population, industry, and military needs.

Sources of Energy

To a limited extent, energy resources are fungible. Natural gas can be used in place of gasoline derived from oil; solar power can generate electricity in place of fossil fuel power plants. For resilient and stable access to energy resources, it is advisable to have a mix of available energy sources. We begin by considering the current mix of sources for US energy consumption.

Petroleum, natural gas, and coal (fossil fuels) provide for the majority of the US power needs: 79%, as shown in Figure 1. Renewables account for 12% of US energy consumption, which includes wind, solar, hydroelectric, geothermal, and biomass sources. Nuclear energy comes in third after fossil fuels and renewables, contributing 8% to the total domestic energy portfolio.¹

Figure 1. US Primary Energy Consumption by Major Sources, 1950-2020



Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3, April 2021, preliminary data for 2020

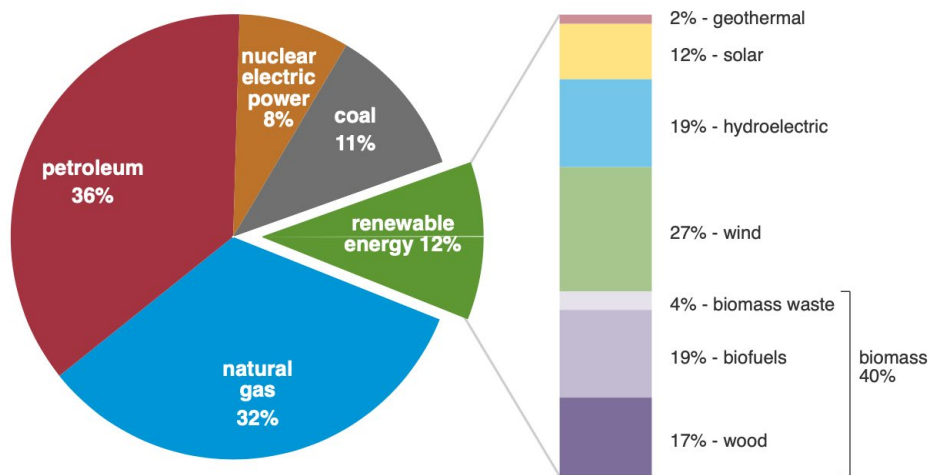


Note: Petroleum is petroleum products excluding biofuels, which are included in renewables.

Figure 2. US Primary Energy Consumption by Energy Source, 2021

total = 97.33 quadrillion
British thermal units (Btu)

total = 12.16 quadrillion Btu



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2022, preliminary data



Note: Sum of components may not equal 100% because of independent rounding.

From <https://www.eia.gov/energyexplained/us-energy-facts/>.

Measured in “quads” representing the equivalent of a quadrillion British thermal units (Btu), total US consumption is a little less than 100 quads per year, which is roughly one-sixth of worldwide consumption. In the US, roughly a third comes from petroleum, a third from natural gas, and 11% of energy production from coal. Roughly 3.2 quads come from wind turbines, and 1.5 quads from solar.² Bio-fuels (including ethanol from corn) contribute less than a quad.³ Thus, wind, solar, and biofuels are still relatively minor sources. The US continues to increase renewables while generally decreasing reliance on coal, although the use of coal in the US increased in 2021.

Today, and for some years to come, oil and gas will remain the predominant sources of energy in the US. The US produces around 11 million barrels of crude oil per day, which is supplemented with hydrocarbon gas liquids and biofuels to effectively produce 18.6 million barrels per day in 2021. (Hydrocarbon gas liquids come from both natural gas and from the process of refining crude oil.) Consumption stood at around 19.9 million barrels per day in 2021, with the difference made up in imports.⁴ Oil consumption in 2021 accounted for 31.3 quads of energy in the US.

The US Strategic Petroleum Reserve (SPR) holds at maximum about 750 million barrels of oil,⁵ which is a roughly 40-day supply for the US, or 100 days of imports at current rates. It is useful for wartime supplies, but also can be used to stabilize prices to absorb or make up for over- and under- capacity of the world’s supplies. It is being drawn down in 2022 at a rate of a million barrels a day to make up for reduced Russian supplies of oil.

Natural gas production in the US in 2021 was a total of 34.5 trillion cubic feet (TCF),⁶ of which the US consumed 30.3 TCF⁷ and exported the remainder. Natural gas contributed 31.3 quads to US needs in 2021; coal contributed 10.5 quads.⁸

Petroleum products (which technically include both liquid oil products as well as natural gas) are uniquely important due to their high energy content per unit weight and volume. The military is vitally dependent on refined oil products and uses large quantities of natural gas. For certain military uses, it would be hard to replace petrochemicals with any other form of energy production. Aircraft, for example, need jet fuel for long-duration or high-velocity flights. Armored vehicles typically need diesel fuel to

generate sufficient power. Many naval vessels rely on petrochemicals for propulsion.

Accordingly, for now and for the foreseeable future, the US requires a stable supply of petrochemicals. Our dependence arises both from common usage of oil and gas for residential, industrial, transportation, and other common uses, as well as from the military’s need for large energy supplies. Total US consumption of energy is not expected to decrease, nor should it. This begs the question: to what extent should US energy supply be based on oil and gas, and are alternatives required?

The fact that the US is a net exporter of energy belies the observation that domestic oil and gas are increasingly difficult to extract. Today, oil and gas are found in abundance in the Middle East and other parts of the world but are highly concentrated in small pockets.

Uneven Distribution

The fact that fossil fuels are not evenly distributed throughout the world makes for a complicated marketplace with inequalities in competition. Moreover, production and demand are in close balance at any given time, mediated by prices. Excess production, or excess production capacity, requires excess infrastructure and is thus inefficient. Over production capacity suppresses prices, which is not favored by the relatively few producers. The other problem is that as time goes on, oil and gas that is easy to recover has already been recovered. While there is plenty left, that which is left becomes more difficult to extract. New technologies enhance the ability to recover more difficult petrochemical sources, but also require significant investment.

Oil is concentrated into thousands of oil fields scattered throughout the world. Roughly 500 “giant” and 40 or so “super-giant” oil fields each contain over a half a billion barrels of ultimately recoverable liquid oil (5 billion, in the case of super-giant fields).⁹ The largest, the Ghawar field, is in Saudi Arabia, is said to have contained nearly 100 billion barrels of liquid oil when first tapped in 1951, now contains an estimated 58 billion barrels equivalent, and continues to produce nearly four-million barrels of oil per day.¹⁰ Most of the other giant fields, such as Prudhoe Bay in the north slope of Alaska, produce a few hundred thousand barrels per day. Thus, most fields produce a small fraction of the world’s consumption of nearly 100 million



barrels per day. The giant fields and super-giant fields provide for 60% of the world's total consumption.¹¹

If one looks at "proven reserves," and divides by current consumption rates, the world will run out of oil and gas in 47 years. The same computation for US proven reserves versus US consumption results in about 5 years of oil and 15 years of natural gas remaining.^{12,13} In the US, the primary sources of oil and gas come from the north slope of Alaska containing the Prudhoe Bay fields, the East Texas Oil Field, and the West Texas "Permian Basin" fields. There are many other smaller sources, such as fracking in Pennsylvania and West Virginia, and many other potential sources, such as oil shale of western Colorado (which has seen multiple boom and bust cycles, due to the lack of profitability of oil extraction).

However, computations of years remaining are naive for multiple reasons: For one thing, proven reserves can rise or fall over time, depending on the price of oil and gas and the development of new recovery technologies. New discoveries are made all the time. Proven reserves do not fully account for abundant oil shale, tar sands, and other sources that can provide oil and gas using advanced technologies, and

"unproven reserves." Fracking, when performed safely and responsibly, can free up natural gas supplies that are not envisioned in the simple computation. Natural gas can be used in place of oil for many purposes, but in many places is "flared" (i.e., burned on the spot) because it is not profitable to capture and distribute. These amounts are often not included in proven reserves.

Nonetheless, at this point, total oil and gas supplies are limited. For the US to maintain its rate of energy use, and continue to depend on oil and gas, there will need to be new supplies soon. There could be new domestic discoveries, but it is likely that much will have to come from imports. Most of the rest of the world's oil is in oil fields located in the Middle East, namely Saudi Arabia, Iran, Iraq, and United Arab Emirates. There are other super-giant and major fields in Mexico, Venezuela, Brazil, Russia, and Kazakhstan, as well as that which remains in the US. With more than 90% of the world's supply (along with the US), these nations have outsized influence due to the concentration of oil reserves and super-giant fields in their territorial borders. There will be a competition for access to these resources.

Possible Future Sources

The issue becomes: Is there a way to reduce dependence on oil and gas, in whole or in part, to ensure that there are sufficient supplies for uses that require them? The concern over greenhouse gas emissions and global climate change only adds considerable additional pressure to the interest in new supplies (but only for renewables.)

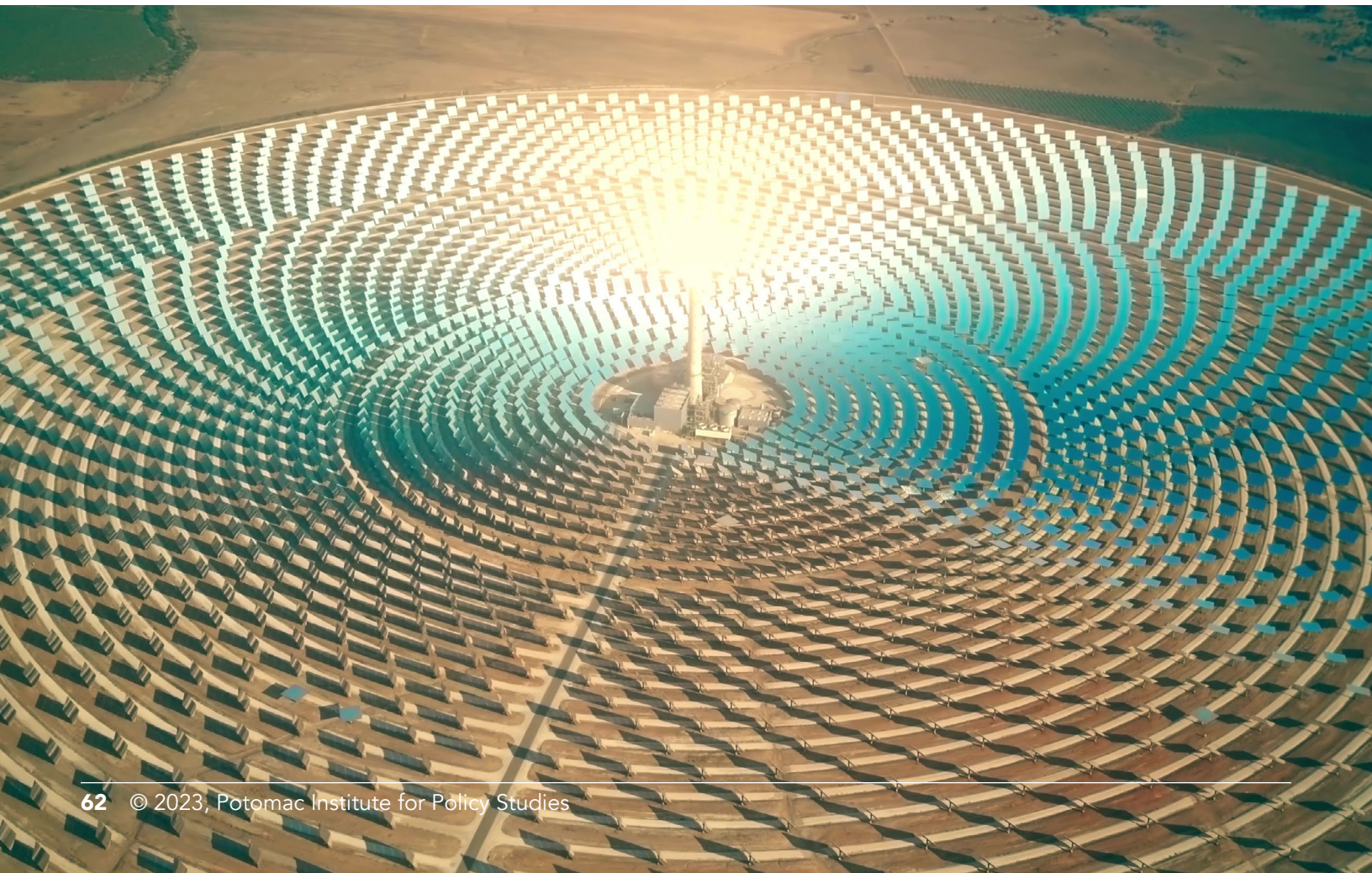
Significant headroom is available for expanding the use of solar production of electricity in the US. The current installed base is around 100 Gigawatts (GWs), which generates 1.5 quads per year.¹⁴ An optimistic Department of Energy study posits 1,000 GWs installed by 2035,¹⁵ which might generate 15 quads per year. However, many issues would need to be resolved, including storage and distribution.

Similarly, wind energy production offers enormous potential, from the current installed base of 135 GWs,¹⁶ which produced a little less than 10% of all electric power generated in the US in 2021.¹⁷ One vision predicts wind providing 35% of US electricity needs by 2050.¹⁸ Wind generators operate at night as well as day, which is a big advantage. However,

they rely on a smart grid, as most of the US production is in the Midwest (and some offshore), and so must be distributed. As demand increases for electric power, it is possible that wind turbines could supply much of the increase. Storage is a problem for wind power as well as solar, as total electrical power generation becomes more dependent on sources that can be episodic. A robust distribution system with spare capacity can lessen storage needs.

Nuclear power accounts for about 20% of all electricity generation in the US. There are 93 reactors in 55 plants throughout the US, down from a peak of 104 reactors in 2012.¹⁹ The reactors are old, and many are operating past their expected life span. Significant research is ongoing on the design and construction of new forms of nuclear power plants,²⁰ which would provide greater safety and higher returns on investment (as nuclear power plants are very expensive and take a long time to build).

Perhaps the best prospects for increased nuclear power generation is through development of “small modular reactors” (SMRs).²¹ The Department of Energy sponsors an advanced R&D program on the development of SMRs, and



considers them a key to the US energy future.²² Each SMR would produce a few tens or hundreds of megawatts, and so hundreds or thousands would be envisioned to contribute to a percentage of the million megawatts of electricity generation capacity of the US. Although there is an aversion to the expansion of nuclear power, there are those who believe that the time for nuclear power dominance has come, especially for SMRs.²³

US road, rail, and boat transportation accounts for around 20 quads of annual energy consumption in the US (down from around 24 quads in 2015).²⁴ Air transportation consumes only around one quad. If all transportation other than air could be converted to electric vehicle power, then it would be easy to replace the power generation from non-fossil fuel sources (such as wind, solar, or nuclear, feeding into electrical grids for onboard storage or immediate consumption).

Notably, the military uses small nuclear power plants for energy production, particularly for aircraft carriers and submarines. We might ask whether the military could eliminate its dependence on petrochemicals by converting to all-nuclear power production. But concepts for nuclear-powered aircraft are distant dreams. Nuclear power plants for armored vehicles are undoubtedly a bad idea.

Each of these enhancements (wind, solar, nuclear) as well as any others will require significant investment, not just in the production infrastructure, but also in distribution and control systems, and eventually an electric storage infrastructure. Return on investment computations depend heavily on the future cost of energy, which in turn depends on the price of a barrel of oil.

Exotic Sources to Reduce Competition for Energy

A variety of more exotic energy sources might become available in the future. Some involve oil and gas from new sources, which would nonetheless relieve pressure on the competition for resources by providing large new reservoirs of energy supplies. In all cases, the new sources envision near-infinite supplies that could supply energy globally.

Potentially abundant supplies of natural gas are available, albeit difficult to extract, and creating greenhouse gas emissions. The frozen methane hydrates in the deep

ocean fuse ice and natural gas into formations that exist under high pressure, but with deep sea mining techniques could be used to extract gas.²⁵ Separately, there is concern that global warming could cause a tipping point with existing methane hydrates, causing the uncontrolled release of methane into the environment, over a period of centuries or millennia.²⁶ So it would behoove the world to secure the resource before they melt.

The other suggestion is that the mantle of the Earth, located below the Earth's crust and typically 100 kilometers below the surface, is replete with methane, according to models of chemical processes.²⁷ It might be possible to tap into these supplies, which might be viewed as essentially infinite, although bore holes have rarely descended beyond 10 kilometers. Locations where the crust is thin, however, might provide locations where large supplies of methane could be extracted. Whether this is advisable or feasible is problematic.

Even more exotic is the idea of retrieving methane from outer planets and their moons, such as from Saturn's moon Titan. Note that bringing resources back to Earth is "down-hill" relative to the sun's gravity well. We would also want to bring new supplies of oxygen to Earth.

Eventually, controlled fusion reactors might be able to supply power to electrical grids. International programs for the development of controlled fusion continue, and progress continues to be made. Practical power plants, however, remain many years, and perhaps decades, hence.

A less dangerous way to obtain energy might be to use giant solar cells in space, to beam energy to Earth. The concept of space-based solar power has been around for a long time, but only recently have practical experiments been conducted.²⁸ A major impediment is the cost of getting material into space from the Earth.

Summary

Necessity might drive invention in one or more of these directions, or in other directions. The world has had the luxury, as well as the consequences, of abundant fossil fuel resources over the past couple centuries. This will continue, but extraction will be increasingly difficult and costly, and will likely still be competitive as resources are unevenly distributed. Further, dislocations due to global

climate change may also force the more aggressive pursuit of alternatives.

Energy resources are so vital to national economies and security that the competition for energy may be central to most other competitions. International investments into resources may be driven by a need to secure future sources of energy. Resources that depend on energy include food from agriculture products, and industrial production capacity, and residential resources for heating and cooling.

In the near term, it is a safe prediction that oil and gas will remain the predominant sources, and that most supplies will come from a handful of countries that have remaining easily available resources. Thus, a competition for resources will continue, and success depends on either being one of the handful of countries, economic dominance, or military might.

The approach is not sustainable long term. Military conflicts are likely to occur in the interim over energy supplies, which could include kinetic wars as in Ukraine, and cyber wars to disrupt or divert supplies. They can also engender investment wars, as oil companies and nations vie for the rights to emplace infrastructure in territories that are not traditionally under their own control. Until inexhaustible supplies are found and secured, the competition for energy and especially for oil and gas will become an increasing driver of human activity.

So, what should the US do to prevail in the competition for energy resources? The answer is undoubtedly "all of the above." That is, the nation needs to be strong militarily, economically, and politically, to secure domestic sources and maintain access to foreign sources. The US needs a diversity of sources of energy, to include current fossil fuels and other energy sources derived from domestic supplies, supply chains from overseas sources, and future sources, all including wind, solar, nuclear, renewables, and more exotic sources. Reports of recent improvements in controlled fusion, and other potential inexhaustible supplies, provide for a hopeful future, but cannot be relied upon in the short term. One of the keys will be continued R&D and investments in demonstration and pilot plants. The US has the ability to lead in respect to R&D, and thus could control not only its own destiny, but the destiny of the world in access to energy sources.

Endnotes

- 1 "Energy Facts Explained." Energy Information Administration. 2022. <https://www.eia.gov/energyexplained/us-energy-facts>
- 2 US energy facts explained - consumption and production - US Energy Information Administration (EIA).
- 3 "Biofuels Explained: Ethanol." U.S. Energy Information Administration. 2022. <https://www.eia.gov/energyexplained/biofuels/ethanol-supply.php>.
- 4 "Frequently Asked Questions." U.S. Energy Information Administration. 2022. <https://www.eia.gov/tools/faqs/faq.php?id=33&t=6#:~:text=In%202021%2C%20the%20United%20States,day%20over%20consumption%20in%202020>.
- 5 "U.S. Ending Stocks of Crude Oil in SPR." U.S. Energy Information Administration. 2022. <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCSSTUS1&f=M>.
- 6 "Where Our Natural Gas Comes From." U.S. Energy Information Administration. 2022. <https://www.eia.gov/energyexplained/natural-gas/where-our-natural-gas-comes-from.php>.
- 7 "Use of Natural Gas." U.S. Energy Information Administration. 2022. <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>.
- 8 OJG Editors. "Fossil Fuels Made Up 79% of 2021 US Primary Energy Consumption." *Oil & Gas Journal*. July 1, 2022. <https://www.ogj.com/general-interest/economics-markets/article/14279046/fossil-fuel-sources-made-up-79-of-2021-us-primary-energy-consumption>.
- 9 Gina Cohen. "Giant Oil Field; Super Giants." *Hebrew English Energy Dictionary*. 2022. <https://www.hebrewenergy.com/giant-oil-field-super-giants/>.
- 10 "Largest Oil Fields in the World." *Stacker*. Updated November 2022. <https://stacker.com/stories/3860/largest-oil-fields-world>.
- 11 Op cit. Cohen, Gina. "Giant Oil Field; Super Giants." *Hebrew English Energy Dictionary*. 2022. <https://www.hebrewenergy.com/giant-oil-field-super-giants/>.
- 12 "United States Oil." *Worldometer*. 2022. <https://www.worldometers.info/oil/us-oil/>.
- 13 "U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2020." U.S. Energy Information Administration. January 13, 2022. <https://www.eia.gov/naturalgas/crudeoilreserves/>.
- 14 Anmar Frangoul. "U.S. Solar Capacity Passes 100 Gigawatts After Strong First Quarter, but COVID Challenges Persist." *CNBC*. Updated June 17, 2021. <https://www.cnn.com/2021/06/17/us-solar-capacity-passes-100-gigawatts-but-challenges-persist.html>.
- 15 Solar Energy Technologies Office. "Solar Futures Study." U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. 2022. <https://www.energy.gov/eere/solar/solar-futures-study>.
- 16 Wind Energy Technologies Office. "Wind Market Reports: 2022 Edition." U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. 2022. <https://www.energy.gov/eere/wind/wind-market-reports-2022-edition>.
- 17 "Electricity: Electric Power Monthly." U.S. Energy Information Administration. 2022. <https://www.eia.gov/electricity/monthly/>.
- 18 "Wind Vision Detailed Roadmap Actions: 2017 Update." U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. 2017. https://www.energy.gov/sites/prod/files/2018/05/f51/WindVision-Update-052118-web_RMB.pdf.
- 19 "Nuclear Explained: What Is the Status of the U.S. Nuclear Industry?" U.S. Energy Information Administration. 2022. <https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php>.
- 20 Renee Cho. "The State of Nuclear Energy Today-and What Lies Ahead." *Columbia Climate School*. November 23, 2020. <https://news.climate.columbia.edu/2020/11/23/nuclear-power-today-future/>.
- 21 "Small Nuclear Power Reactors." *World Nuclear*. Updated May 2022. <https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx>.
- 22 Office of Nuclear Energy. "Advanced Small Modular Reactors (SMRs)." U.S. Department of Energy Office of Nuclear Energy. 2022. <https://www.energy.gov/ne/advanced-small-modular-reactors-smrs>.

- 23 "Small Modular Reactors: Challenges and Opportunities." OECD. 2021. https://www.oecd-neo.org/upload/docs/application/pdf/2021-03/7560_smr_report.pdf.
- 24 "Energy Consumption by Transportation Mode in the United States, 1960-2020." *Transport Geography*. 2021. <https://transportgeography.org/contents/chapter4/transportation-and-energy/energy-consumption-transportation-unit-ed-states/>.
- 25 Zack Colman. "Should the World Tap Undersea Methane Hydrates for Energy?" *Scientific American*. August 1, 2017. <https://www.scientificamerican.com/article/should-the-world-tap-undersea-methane-hydrates-for-energy/>.
- 26 David Archer, Bruce Buffett, and Victor Brovkin. "Ocean Methane Hydrates as a Slow Tipping Point in the Global Carbon Cycle." *Proceedings of the National Academy of Sciences of the United States of America*. December 8, 2009. <https://www.pnas.org/doi/10.1073/pnas.0800885105>.
- 27 Zeeya Merali. "Earth's Mantle Can Generate Methane." *Nature*. September 14, 2004. <https://www.nature.com/articles/news040913-5>.
- 28 Leonard David. "Space-based Solar Power Getting Key Test aboard US Military's Mysterious X-37B Space Plane." *Space.com*. April 8, 2021. <https://www.space.com/x-37b-space-plane-solar-power-beaming>.





A wireframe globe is centered on the Atlantic Ocean, showing the continents of North and South America. The globe is composed of a white wireframe mesh. Overlaid on the globe is a network of white dots connected by thin white lines, creating a global connectivity pattern. The background is a deep blue with a subtle bokeh effect of light spots.

Featured Authors

Robert (Bob) Hummel, PhD

STEPS, Editor-in-Chief

Chief Scientist, Potomac Institute for Policy Studies

Dr. Robert Hummel serves as the Chief Scientist of the Potomac Institute for Policy Studies. He is Editor-in-Chief of the Science, Technology, Engineering, and Policy Studies (STEPS) journal/magazine (this publication), and the author of over a hundred academic articles and Potomac Institute reports. He completed a four-year IPA assignment to the National Geospatial-Intelligence Agency in 2020. Prior to joining the Potomac Institute, he served as a program manager at DARPA for nearly nine years, managing and initiating projects in information exploitation, computer science, and sensor design. Prior to joining DARPA, he was a tenured faculty member at NYU's Courant Institute of Mathematical Sciences in the Computer Science Department, where he did research in computer vision and artificial intelligence. Dr. Hummel has a PhD in mathematics from the University of Minnesota, and he holds a B.A. in mathematics from the University of Chicago.



Jennifer Buss, PhD

Chief Executive Officer, Potomac Institute for Policy Studies

Dr. Jennifer Buss serves as the CEO of the Potomac Institute for Policy Studies. The Institute develops meaningful science and technology policy options through discussions and forums and ensure their implementation at the intersection of business and government. She has extensive experience examining policy issues in support of NASA, and has been involved in their strategic planning processes for astronaut medical care and cancer diagnostics and therapeutics. She manages a variety of OSD programs including an outreach effort for the Department of Defense to the start-up community across the country to find innovative technologies to meet the challenges faced by the Services and Government agencies. Dr. Buss performs science and technology trends analysis and recommends policy solutions to some of the country's most pervasive problems. She has also directed and assisted research on numerous government contracts, including systematic reviews and gap analyses. Dr. Buss is an authority in her scientific field with national recognition in her area of expertise. She is responsible for major projects requiring integration/coordination across multiple scientific disciplines.



Moriah Locklear, PhD

Arizona State University, Office of VP Research Development, Washington Center

Dr. Moriah Locklear was a Research Fellow at the Potomac Institute for Policy Studies. She has since joined Arizona State University's Washington D.C. Barbara Barrett and Sandra Day O'Connor Washington Center, to provide upstream intelligence to faculty and leadership regarding large funding opportunities and other avenues for advancement. Prior to joining the Potomac Institute, Dr. Locklear obtained her PhD in organic chemistry from University of Nebraska at Lincoln where her graduate research focused on the study of peroxides for the construction of drug-related functionalities. Simultaneously, Dr. Locklear served as a legislative intern in the Nebraska State Legislature focusing on a variety of issues related to veteran affairs, technology policy, and green energy. She received her bachelor's degree in pharmaceutical sciences with minors in chemistry and comparative religion at Ohio State University.



The Honorable Alan R. Shaffer

Board of Regents Member, Potomac Institute for Policy Studies

The Honorable Alan R. Shaffer assumed his current position as the director of Washington operations for MIT Lincoln Laboratory in April 2022. Since January 2021, he has been a member of the Board of Regents of the Potomac Institute. Previously, he was Deputy Under Secretary of Defense for Acquisition and Sustainment (A&S), confirmed in January 2019. He served as the Director, NATO Collaboration Support Office in Neuilly-sur-Seine, France after serving as the Principal Deputy Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) from 2007–2015, with two stints as acting assistant secretary. In these capacities, he is known for his service as the Executive Director of the Mine Resistant Ambush Protection (MRAP) Task Force, where he was responsible for oversight, fielding, and employment of 27,000 MRAPs across the Department of Defense. Before entering the federal government, Mr. Shaffer served 24 years as a commissioned officer in the United States Air Force and retired in the grade of Colonel. While serving, he held positions in command, weather, intelligence, and acquisition oversight with assignments in Utah, California, Ohio, Honduras, Germany, Virginia, and Nebraska. He holds a Bachelor of Science degree in Mathematics from the University of Vermont and a Bachelor of Science in Meteorology from the University of Utah, a Master of Science in Meteorology from the Naval Postgraduate School, and a Master of Science in National Resource Strategy from the Industrial College of the Armed Forces.



Brian Shirley

*Member, Board of Regents and Senior Fellow,
Potomac Institute for Policy Studies*

Brian Shirley is a senior executive and advisor with over 34 years of broad-based experience in the semiconductor industry, including fourteen years as an executive officer of Micron Technology, a US-based Fortune 500 leader in semiconductor memory. He has been a senior consultant to the US government on topics related to the semiconductor industry and US national security. He is listed as an inventor on 82 US patents and helped drive Micron's expansion into specialized memory for servers, and mobile and networking solutions. At Micron, he drove DRAM diversification, product expansions in NAND solid-state memory and related SSD product lines, and productization of multiple emerging memory technologies. He has served on the boards of numerous joint ventures and industry organizations. Mr. Shirley retired from Micron in December 2019. In 2020, Mr. Shirley joined CTC Aero consulting with multiple departments of the US government. In addition, he is serving as a senior advisor and board member to multiple semiconductor startups, as well as serving as a member of the Board of Regents and Senior Fellow of the Potomac Institute.



Tim Welter, PhD

Senior Fellow, Potomac Institute for Policy Studies

Tim Welter conceived and led the Potomac Institute's Global Competition Project (GCP). Having worked in the private sector, the military, and on Capitol Hill, Tim Welter brings valuable experience in national security and defense policy to the Institute. After serving on active duty in the Air Force for several years, he worked on Capitol Hill as Legislative Director for two different Members of Congress and later as a Professional Staff Member with the House Veterans Affairs Committee. Upon leaving the Hill, Tim worked with the foreign and defense policy research team at the American Enterprise Institute. He later completed a research fellowship at the National War College during which he finished his PhD dissertation in Political Science with the University of Missouri, writing about the political nature of defense policy in Congress. A US Air Force Academy graduate, Tim holds Master's degrees in political science, national security strategy, and management. Just prior to joining the Institute, Tim served at the Pentagon where he helped stand up an organization dedicated to future force design and the development of capabilities and concepts required to meet emerging national security challenges.





STEPS (Print)
STEPS (Online)

ISSN 2333-3219
ISSN 2333-3200

