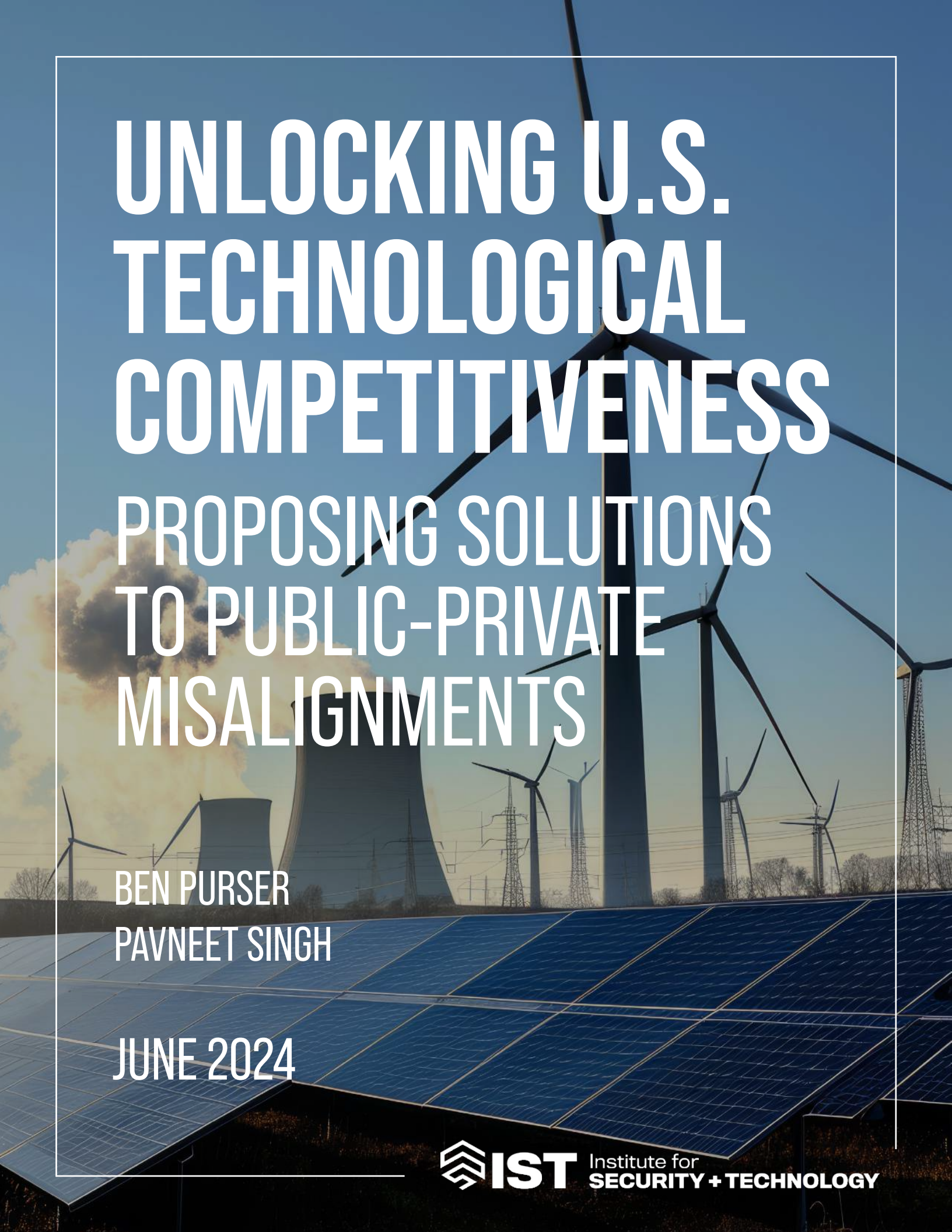


UNLOCKING U.S. TECHNOLOGICAL COMPETITIVENESS

PROPOSING SOLUTIONS TO PUBLIC-PRIVATE MISALIGNMENTS

BEN PURSER
PAVNEET SINGH

JUNE 2024

IST Institute for SECURITY + TECHNOLOGY

Unlocking U.S. Technological Competitiveness: Proposing Solutions to Public-Private Misalignments

June 2024

Authors: Ben Purser, Pavneet Singh
Design: Lillian Ilsley-Greene
Copy Edits: Jennifer Tang, Sophia Mauro

Cover image is AI-generated and depicts solar energy panels, wind turbines, and a nuclear power plant.

To avoid even the perception of a potential conflict of interest, IST is disclosing that one of the authors of this concept paper, Ben Purser, has an immediate family member employed by a nuclear power company. The terms of this arrangement have been reviewed and are in accordance with IST's Intellectual Independence Policy, but this relationship is being disclosed in the spirit of full transparency.

Printed in the United States of America

IST

About the Institute for Security and Technology

Uniting technology and policy leaders to create actionable solutions to emerging security challenges

Technology has the potential to unlock greater knowledge, enhance our collective capabilities, and create new opportunities for growth and innovation. However, insecure, irresponsible, or exploitative technological advancements can threaten global security and stability. Anticipating issues and guiding the development of trustworthy technology is essential to preserve what we all value.

The Institute for Security and Technology (IST) is a 501(c)(3) critical action think tank that stands at the forefront of this imperative, proactively convening policymakers, technology experts, and industry leaders to identify and translate discourse into impactful action. Our unique problem-solving approach proactively addresses risks of emerging technologies and advances national security and global stability.

Our portfolio is organized across three analytical pillars: **Geopolitics of Technology**, anticipating the positive and negative security effects of emerging, disruptive technologies on the international balance of power, within states, and between governments and industries; **Innovation and Catastrophic Risk**, providing deep technical and analytical expertise on technology-derived existential threats to society; and **Future of Digital Security**, examining the systemic security risks of societal dependence on digital technologies.

Learn more: https://securityandtechnology.org/

Acknowledgements

We are grateful to the members of the Biotechnology, Energy, and Quantum Working Groups for sharing their time and expertise. This work would not be possible without their invaluable insights.

About the Strategic Balancing Initiative (SBI)

The Strategic Balancing Initiative (SBI) at IST works to overcome public-private misalignments in the technology development ecosystem to accelerate American and likeminded technological strength. This is especially important in light of the People's Republic of China's (PRC's) focus on leading in emerging technology domains and utilizing the resulting technological capabilities to pursue its authoritarian interests at home and abroad. Ultimately, SBI aims to gain understanding, raise awareness, shape behavior, and deliver solutions to this set of strategic challenges.

Table of Contents

Executive Summary

Launched in 2023, IST organized this particular SBI effort into separate working groups on three key technologies: *biotech, energy, and quantum*—each composed of public- and private-sector experts and stakeholders in those respective fields. Over the research period, each working group convened three times, building and iterating from the previous work and generating concept papers after each round. The process will culminate in a final gathering of input from a plenary convening and then a comprehensive analytical synthesis and set of actionable recommendations for public-private collaboration.

The February 2024 paper, Unlocking U.S. Technological Competitiveness: Public-Private Misalignments in Biotechnology, Energy, and Quantum Sectors summarized the first round of discussions and research, which identified and explored a selection of the most significant misalignments. The March 2024 paper, Unlocking U.S. Technological Competitiveness: Evaluating Initial Solutions to Public-Private Misalignments, explored potential solutions to those most significant concerns—capturing both what was revealed in the second round of discussions and the research that the SBI team performed on those options.

This concept paper, the third and last working paper in the series, lays out how a third round of working group meetings further explored those initial solutions, building out specific ways to operationalize them, identifying specific questions that need to be addressed to achieve these goals, and suggesting potential mechanisms for achieving them.[1] Each sector-specific section explores what was newly identified in this third round of work and conducts a "deep dive" into how to unlock biotech, energy, and quantum progress, respectively. In short, IST suggests that the U.S. government set up a new biotech data repository, provide a demand-side mandate for green energy, and facilitate a mapping of the quantum sector. These proposals would address the misalignments we found most pressing—as identified in the first paper—and reflect IST's recommendations for how to be most impactful, including the data limitations in the biotech sector, the political uncertainty in the energy sector, and the sprawling quantum domain (where different companies, departments, and agencies are struggling to align, even on vocabulary). If the U.S. government could take these steps, the companies developing innovative technologies would be able to make significant progress in the next several years—helping the United States and its like minded economic partners win the technology competition with China.

1 As noted in the conclusion, a final report will summarize and interpret the breadth of all rounds of working group discussions and present policy recommendations to facilitate public-private alignment on technological competitiveness.

Significantly, all three working groups found that the U.S. government should develop a public capital framework to help guide the injection of non-dilutive government capital into innovation, with a focus on identifying where such government funds are not redundant with private capital (e.g., from venture capital funds), but unique solutions to innovation efforts that would fail without such funds.

Biotech

Access to bio data, de-risking supply chains from China, and the considerations around building a framework for public capital in biotechnology present opportunities for impactful action. As a result, and as initially explored in the aforementioned first concept paper, IST proposes that the U.S. government develop a commercial data repository. SBI research and analysis expands on this suggestion by providing an assessment of the relevant operational and policy questions—as detailed in the appendix—that the U.S. government must address for this tool for biotech innovation to succeed. Such a repository would allow biotech companies to benefit from existing, privately-funded research that they would otherwise not know about or be able to use. By unlocking these biotech opportunities, the U.S. government could keep these data safe but still unlock opportunities for biotech progress.

Energy

Building on previous working group sessions, this concept paper explores how the United States might implement a mandate for consumption of new energy solutions, public financing tools for energy technology, and the energy sector's business decisions related to diversifying away from China (e.g., for gasification technology). As initially proposed in the second paper, IST recommended that Congress consider legislation that creates a long-term demand-side mandate for green energy. This paper both further explores the prospect of long-term, demand-side mandates for green energy and encourages Congressional movement on any feasible demand-side mandate, no matter how narrow—including laws around sustainable fuels and nuclear power for new data centers. Notably, some participants suggested that the Renewable Fuel Standard (RFS) be amended so that it benefits the agriculture lobby while simultaneously increasing mandates for consumption of alternative fuels over an extended period of time.

Quantum

A lack of understanding of the quantum ecosystem and misalignments between current public capital frameworks and the funding rounds of private quantum companies pose significant and

interrelated challenges to the U.S. quantum sector's ability to thrive. Building on the previous work done by the Working Group, IST recommends that the Department of Commerce's Industry and Analysis Unit conduct a mapping of the overlapping and currently opaque ecosystem. Also, should a quantum reauthorization bill move in Congress, IST encourages that it incorporate a requirement for this sector mapping; similarly, IST suggests that the authorization bill include more definitional work, building on efforts from the "Sandbox" bill (e.g., defining "near-term use case" as less than two years).

Geostrategic Currents: Evaluating the Present State of Play

New developments in the U.S.-China relationship are accelerating existing patterns in both the bilateral economic relationship and the broader state of techno-industrial competition with China. The challenges of the U.S.-China relationship—and the relationship that China has with the democratic world—are becoming increasingly acute.

Key Developments in the U.S.-China Relationship (April - June 2024):

» **Bilateral AI Meeting**: The United States and the PRC followed through on a promised deliverable from the Biden-Xi November meeting at the edge of Silicon Valley: senior U.S. and Chinese officials conducted their first AI dialogue.[2] The fact that this occurred at all is significant, given China's historical and recent refusals to engage bilaterally. In a background briefing before the talks, a U.S. official explained that the focus of the talks was not on "promoting any form of technical collaboration" because the PRC "is rapidly deploying capabilities across civilian as well as military, national security sectors, and in many cases in ways that we believe undermines both US and allied national security." Afterwards, the White House spokesperson confirmed that American officials had "raised concerns over the misuse of AI" by the PRC. Although the fact that the talks occurred at all was a positive sign, it is important to note that the U.S. government overtly used the event to criticize China's problematic AI behavior.

2 This was not the first completed deliverable: the Pentagon and the PRC military resumed military-to-military contacts.

» **Executive Branch Action Against China**: The U.S. administration took trade-related actions against China. These actions are both rhetorically and substantively a response to Chinese "unfair trade practices regarding technology transfer, intellectual property, and innovation;" the steps reflect a broader embrace of both industrial policy, as well as new escalation in the "trade war" with China. The U.S. Trade Representative announced an investigation into unfair trade acts, policies, and practices of the PRC's maritime and shipbuilding sectors; similarly, the White House announced new tariffs on Chinese advanced batteries, solar cells, steel, aluminum, medical equipment, and electric vehicles. Experts at CSIS noted that "these sectors are key to the Biden administration's plans to reshore manufacturing to increase supply chain resilience and improve the political economy of the energy transition." Notably, the Chinese response to the May 2024 actions was more muted than reactions to the previous administration's trade actions, possibly due to receiving advance warning from the White House. Regardless of messaging, these developments demonstrate the ways that the administration feels compelled to act against Chinese business actions.

» **Legislative Branch Action Against China**: For context, the U.S. legislature has historically played a particularly significant role in the U.S.-China relationship (e.g., the Taiwan Relations Act). In the context of a legislature that is increasingly partisan and dysfunctional, the fact that they continue to find bipartisan alignment against China speaks volumes to the problematic nature of the U.S.-China relationship. Some analysts have recently suggested that Congressional action on China could even be destabilizing, saying that the rare common ground could lead to a rapid escalation in tension. In April 2024, Congress passed legislation that will require TikTok to be either sold or banned in the United States. ByteDance has nine months to divest, with a three-month grace period.[3] Notably, this was not the only China-related bill that moved recently, helping illustrate how elected legislators are likely to keep applying pressure to the PRC—affecting international and American businesses who might rely on those Chinese entities.[4]

» **Hardening Public Opinion**: The Pew Research Center released their fifth annual report on American attitudes about the PRC with findings that match what IST is hearing from stakeholders. Much like last year's Pew report, this year's found that most Americans see China negatively. In 2024, Pew finds that 81% of Americans have at least an "unfavorable" opinion of China, many of whom in fact hold a "very unfavorable" opinion. Unfavorable

3 There have already been both legal challenges and discussions of American offers to acquire TikTok.

4 Although not passed into law, the Senate also moved a bill out of committee that would ban the U.S. government from contracting directly with WuXi AppTec and other companies of concern. According to Reuters, the bill would also prevent "the government from entering contracts with companies that use their equipment or services." With only Senator Paul voting against it, the bill will next need to face a Senate-wide vote, either on its own or attached to must-pass legislation, voted on in the House, where there is a counterpart bill, and signed by the president.

views toward China largely stem from concerns over China's behavior, including its territorial disputes with neighbors in the Indo-Pacific and interactions with other nations, as well as over China's impact on the U.S. economy more broadly. Only 6% of Americans reported seeing the PRC as a "partner," with exactly 50% seeing China as a "competitor" and 42% seeing it as an "enemy." As Pew notes, "[m]any see China as increasingly influential and consider limiting its power a top priority." These findings illustrate that the cascading effects that increasing tensions and trade actions are exerting on how populations see each other—broadening the nature of the competition and deepening the perceived needs for progress.

Taken together, these developments indicate a continuation of the geopolitical and economic trends highlighted in previous SBI publications regarding the state of the U.S.-China relationship. Despite recent diplomatic efforts to ease tensions, or at least maintain the status quo (e.g., the aforementioned bilateral AI meeting), the Biden administration's efforts to protect America's most advanced technologies from China and the Congressional efforts to create unambiguous timelines and consequences (e.g., the legislation requiring ByteDance's divestiture of TikTok) make it unlikely that the bilateral relationship will become less contentious or competitive. As SBI papers have highlighted, this is not limited to the bilateral: the PRC's strategic relationship with democratic governments, in general, will likely get worse—putting greater pressure on the U.S. and allied business communities at-large, particularly in the technology space.

Biotech

Stakeholder Analysis

In the third Biotech Working Group discussion, participants explored three interrelated topics of access to data, de-risking supply chains from China, and the considerations around building a framework for public capital in biotechnology.

DE-RISKING

The importance of innovating at the data layer is magnified when it comes to prototyping and manufacturing drug compounds. Currently, China remains an integral link in the global supply chain.

Notably, there are currently active Congressional considerations of a federal ban on contracts with WuXi AppTec, a pharmaceutical and biotechnology company headquartered in Wuxi, China. The company provides a range of services to the pharmaceutical, biotechnology, and medical device industries, including contract research, development, and manufacturing services. These services effectively underwrite drug discovery, development, and commercialization and WuXi has grown to become a global leader in this field.

The House Select Committee on China has identified WuXi and the BGI Group, among others, as threats to U.S. national security (e.g., given how they could allow the Chinese government access to Americans' health and genetic data) and has proposed legislation that prohibits federally funded medical providers from providing genetic information about Americans to these firms. A Senate counterpart to the bill also moved out of committee; according to Reuters, the bill would also prevent "the government from entering contracts with companies that use their equipment or services." With only Senator Paul voting against it, the bill will next need to face a Senate-wide vote, either on its own or attached to must-pass legislation.. Meanwhile, companies and even some U.S. national labs lack alternative options to WuXi and BGI Group for manufacturing of small molecules or biologics, or even in accessing technology platforms such as CRISPR and other gene sequencing technologies. Thus, American leaders in this space are left in the uncomfortable position of pursuing prototype advancements with WuXi while running the risk of political criticism - or more. Some large pharmaceutical companies are already hedging their bets as a result; AstraZeneca, for example, separated its drug supply chains for its U.S. and Chinese markets. However, bifurcating supply chains will likely increase costs and delays in drug development and distribution. Further, replacing Chinese manufacturing capacity could take upwards of five years and incur substantial costs for biotech startups in particular, a move that would ultimately be at odds with policymaker efforts to lower drug prices.

The current state and dynamics of U.S. competitiveness in drug discovery and manufacturing is sobering. While U.S. industry is competitive in early drug discovery and has demonstrated efficiency and cost-effectiveness in its R&D, and as U.S. companies progress into clinical trials and consider manufacturing, the current landscape presents a dilemma. Companies and researchers can either opt for costlier but more secure options in Europe or North America (where prices are three times higher than options located in China), or navigate the uncertainties of continuing to manufacture in China and/or rely heavily on cheaper Chinese supply chains. The latter option, while economically advantageous, raises red flags regarding national security and intellectual property (IP) integrity. As U.S. firms navigate this complex landscape, the U.S. government needs to explore innovations in both drug discovery and manufacturing while addressing the broader implications for business and the economy. Balancing cost considerations with IP protection and national security interests is paramount as the United States charts a course forward in the biotech domain.

The United States must make clear policy decisions as a result. If Congress or the executive branch decides to enact an outright prohibition in biotechnology and/or data engagement with China, this would severely curtail U.S. ability to innovate and produce small molecule drugs and biologics. Prior to or in tandem with any final decision, policymakers must provide accessible financial and manufacturing alternatives.

PUBLIC CAPITAL FRAMEWORK

There are different ranges of capital that biotechnology companies require at each stage of development, and public capital can catalyze private investment into otherwise risky investments.

In an effort to consolidate knowledge of the capital needed for companies in the biotech space, SBI drew on stakeholder input and research to develop a notional set of funding ranges required in each phase (*Figure 1*). Working group participants generally agreed that these notional funding ranges accurately reflect the current financial environment.

Figure 1: Biotechnology Startup Notional Funding Ranges per Round

Series	Funding Range	Phase of Company
Seed	$3 - $8 million	Early R&D/Discovery
A	$27 - $54 million	Discovery
B	$45 - $60 million	Preclinical trials (Phase 0)
C	$50 - $400 million	Clinical Trials (Phases I, II, III)
D	$200 million+	Commercialization

Early development phases, from the Seed to Series A rounds, are the most critical for a company and present the highest level of risk for investors. Seed and Series A rounds could benefit significantly from public capital and other public resources, which could provide science and technical risk mitigation and significantly catalyze private investment. Once a company reaches the late A stage and enters into its B round of financing, private investors are looking to the Seed and early A rounds for indications of successes and milestones.

In the current funding environment, however, private investors are reluctant to take the Seed or Series A risk, making it challenging for companies to find financing to fill the gap. Furthermore,

the traditional Small Business Investment Research (SBIR) grant, which generally tops off in the $1 to $3 million range, also does not approach the levels of what is necessary for the full A round of financing. An intermediate stage of funding via public funds, if tailored correctly, could play an important role by bridging the gap between the Seed stage and A stage. For example, a non-dilutive capital source available in the range of $5 to $12 million–an amount that would not take over the whole funding round but does meaningfully de-risk the amount raised–could ease several constraints.

- It would allow company founders to maintain more equity in the company, a big concern for biotech founders who, as compared to founders in software or other sectors, tend to be largely diluted by the time the company reaches commercialization.
- For investors, such a non-dilutive capital source could significantly alter the overall financing process, as they are no longer taking a huge bet on an unproven technology, particularly as the entrepreneurs are trying to get to early discovery data or pre-clinical data.
- While the ecosystem as a whole would welcome more funding, it would be especially useful in this intermediate stage between Seed and A in the range of $5 to $12 million.

In light of current national capital stack offerings, the biotech ecosystem needs a novel form of capital that can bridge the gap between the SBIR grant and the larger dollars available through ARPA-H or the Defense Production Act funds, which range from $10 million to $50 million or more.

The public capital framework as it relates to the biotech startup ecosystem is largely under-researched. Participants were supportive of further SBI efforts to identify existing sources of non-dilutive capital and translate how they fit into the funding lifecycle of venture-backed companies.

DATA REPOSITORY

There is unequivocal value of a new and expansive data repository that would house pre-competitive data and more mature data sources. Biotechnology is one of the more prominent sectors that is experiencing rapid advances, in large part due to the introduction of generative AI tools which expedite techniques such as phenotypic screening and the expeditious testing of hypotheses. As a result, significant amounts of new, AI-generated data can be stored and combined with existing troves of historical data. Such a data repository offers numerous potential benefits, including:

- Accelerate drug discovery and the invention of bespoke medical devices;

- Reduce the costs for existing companies conducting research and development;
- Increase the number of companies in the sector;
- And most importantly, introduce novel public health solutions.

However, in order to make such a repository viable, several tactical and policy questions remain that require intensive research and policy development.

From a policy development perspective, a guiding framework for a data repository must recognize that the majority of bio-relevant data has yet to be created, much less collected. Moreover, many traditional pharmaceutical companies and researchers are not trained to process the volume of data that is now possible to generate. The existing drug discovery policy and technical regime is not designed to understand the data nor build the appropriate models to properly exploit the data.

Furthermore, officials lack an understanding of the range of unintended consequences brought about by granting different actors access to the data. Biotechnology operates in a different economic and policy space than general AI companies, yet in the marriage of the two technologies, it is the AI companies that are developing the protocols around model security. Given the absence of biotechnology expertise at those AI companies, participants cautioned that there will be many failure modes in this space until AI companies hire bio experts and build for biotech use cases - which due to the speed at which those AI companies are moving may not occur until well past when it is critically important to do so.

Finally, from the perspective of investors, many thorny questions remain on the control over IP and the monetization structure for the data. As one participant noted, in today's environment, investors are already reluctant to partner with the U.S. government because of complexities with government rights of use. Any data regime that would attract private sector actors and satisfy investors would have to clearly articulate IP ownership policies and the potential commoditization of data; in particular, it would need to contemplate and resolve key issues around licensing, data provenance, and compensation, particularly in a scenario in which one entity creates data and another modifies it to use in a commercial context. Given SBI team members' conversations with other experts in the critical and emerging technology space, these questions of IP seem particularly salient.

Although much remains to be examined, ultimately, the need (at least conceptually) for a "platform" for storing and enabling a company's interaction with biotech data remains abundantly clear. While the contours of such a platform remain nebulous, at a minimum it would start with public-private investments in large scale foundries and automation capabilities to develop public datasets that match the pace and needs of private sector developments. Key to

the repository is not only the ability to store data,[5] but to extract, transform, and load the data so that it is searchable, consistently formatted,, and ready to be analyzed. From the perspective of industry, the United States funds high volumes of disparate research from which insights can be cross-pollinated. However, at present, the data being produced is siloed and lacks standardized formatting and hygiene.

The ability to provide such a platform would significantly reduce costs for private companies. As one participant noted, upon initiating a drug discovery experiment, companies are looking at several dimensions of a compound at once: biology, chemistry, Absorption, Distribution, Metabolism, and Elimination (ADME) and toxicology, just to name a few. The ability to identify red flags early would allow the companies to pivot in their research, allowing for faster innovation and lower manufacturing costs.

Deep Dive: Moving Towards A Data Repository

Given the strong signals about stakeholder interest in a federal biodata repository for commercially useful biodata, as well as its broad utility and applicability, IST suggests that the U.S. government develop such an initiative. Specifically, after review of existing authorities, IST recommends that the White House Office of Science and Technology Policy (OSTP) establish a task force for building out the protocols and policies for such a data repository.

As initially identified in the second SBI concept paper in March 2024, a U.S. government-led effort to create a biotech data repository would not be at odds with longstanding "public access" mandates. Yet, as described above—and as identified in follow-up conversations with additional subject matter experts and in IST's own research—multiple factors require deep, careful, and potentially sensitive (e.g., for dual-use concern) analysis.

Accordingly, IST recommends that the U.S. government establish an executive branch office, committee, or task force to develop a plan for developing such a repository. In the Appendix, IST identified some of the key questions that would need to be addressed. Accordingly, IST recommends that the White House establish an effort, preferably in partnership with industry, to develop answers to these questions, identify any other related questions, answer those questions, and otherwise develop such a commercial repository.

5 Working group participants noted that in 2011, the federal government launched several initiatives to make government data widely available. These include Data.gov, where federal departments and agencies publish unclassified data sets.

Energy

Stakeholder Analysis

Three critical topics raised in previous sessions were sharpened during the final discussion: how the United States might implement a mandate for consumption of new energy solutions, why–and to whom–a mandate is important, and whether there is a credible path to providing a mandate in the United States. This discussion was closely followed by the related topic of public financing tools, particularly regarding the unique nature of a private energy company's lifecycle, the varying needs at different stages, and the role of public capital in buttressing a company at each stage. Beyond investment capital, participants were bullish on the need to utilize tools such as advanced market commitments and milestone payments on contracts to create a healthy ecosystem of novel energy solutions. Finally, stakeholders addressed the current business climate in China and different options and considerations for diversifying into other geographies.

CONSUMPTION MANDATES AND PRODUCTION INCENTIVES

Production incentives without a consumption mandate are an incomplete solution to achieving the twin goals of decarbonization and resuscitating the U.S. clean energy industry. Incentives alone, such as those provided through the Inflation Reduction Act (IRA), target domestic production and only marginally affect demand creation. However, if the United States were to pursue a two-pronged approach–akin to Europe's current strategy–first by fostering an environment more conducive to energy innovation, the U.S. government could collaborate with industry to create a functional market that keeps production domestic while also promoting decarbonization.

From the perspective of entrepreneurs, if the United States were to employ a combination of consumption and production policy tools, the framework would need to gain support from three key audiences: business owners, investors, and lenders. Business owners tend to be more risk-tolerant and are thus inclined to take a different view of the policy environment and what the future will hold. As a result, they will initiate new businesses, leveraging the credits and subsidies that the U.S. government has to offer. Investors are a bit more skeptical, but look for opportunities where policy frameworks exist and where signals of policy shifts might provide either a time or market advantage. In Europe, the investor class is generally positive

on the policy direction and are investing in novel energy opportunities. By contrast, lenders are generally the most skeptical and least likely to want to take risk, particularly when there is no existing policy regime or a signal of policy longevity.

Against this backdrop, some of the policy tools most closely resembling that of Europe in the U.S. context are the recently announced Sustainable Aviation Fuels Grand Challenge and the decades-old Renewable Fuels Standard (RFS). Reflecting on the Grand Challenge, notable skepticism arose regarding the enforceability of the current roadmap targets and their longevity to reassure the various actors in the ecosystem, attributed to a lack of political certainty in the U.S. system and the general partisan divide over the need for clean energy production.

On the RFS, however, participants offered a modicum of optimism and provided some thoughts on a possible, yet admittedly imperfect, path forward. Namely, amending the RFS to benefit the agriculture lobby while simultaneously increasing mandates for consumption of alternative fuels over an extended period of time. The underlying logic comports with the realities of the U.S. political system: the bioethanol industry, unwilling to lose its subsidies, could take advantage of the generally bipartisan support for the U.S. agriculture industry. The key to unlocking a productive mandate, then, is to figure out how to ramp up subsidies for bio-related fuel production while ensuring that there are reasonable guardrails that prevent climate unfriendly activities. For example, instead of growing soybeans to make fuel, farmers can extract value by converting their waste products. Perhaps most importantly, given the longevity of the RFS, the amendment would reassure business owners, investors, and lenders.

FRAMEWORK FOR PUBLIC CAPITAL

Complementing the policy discussion, participants then took on the critical challenge of further conceiving a framework for public financing options in the new energy industry. Given the significant public outlays through the Departments of Energy, Defense, Commerce, and others, the aim is to provide an organizing principle for how executive branch departments and agencies can structure, communicate, and execute public investment programs to align with the unique phases of a startup energy technology company's lifecycle.

The U.S. government has historically been quite comfortable providing grants, either for basic research or sometimes for more advanced technology maturity levels. However, given the dynamics around first of its kind emerging technology solutions that are largely cultivated in the private sector and more reliant on private investment, there is a need to be more tailored and targeted in deploying U.S. capital for maximum effect.

Participants offered context into how entrepreneurs think about public capital offerings. For starters, entrepreneurs view public capital through the prism of how it might encourage the next batch of private investment. Ultimately, the government does not have to carry all the water, but instead act as a catalyst for private funding. Instead of trying to line up public funding with a startup's funding series (i.e., series A, B, C, etc), the government should structure its capital so it accommodates what a company is trying to do at different stages. In the first stage, for example, the company is likely conducting its basic research and development and potentially creating a prototype or proof of concept. At this stage, a grant is still relevant. In the second stage, the company is building its minimum viable product (MVP) and seeking product market fit. The company needs non-trivial capital injections to de-risk its technology, but is unlikely to take debt because repayment risk is still high. As such, some form of grant money that far exceeds a traditional SBIR grant is appropriate here. While the DOE currently offers some opportunities through the Seeding Critical Advances for Leading Energy technologies with Untapped Potential (SCALEUP) program, they are not without certain complications. As one participant noted, the money is frequently structured as a cost-share, which implies that the company must still raise up to fifty percent of the money in private funding order to be eligible for public money. And finally, the third stage is about achieving commercial replication and growth; at this stage, the company has removed its technology risk, has an articulated market, and has identified an associated pathway to revenue: the company is likely comfortable with loans and other project-finance type debt instruments that the DOE Loan Program Office can provide.

Beyond grants and debt, the U.S. government, and particularly the Departments of Energy, NASA, and the Department of Defense can also leverage tools like advanced market commitments and milestone-based payment contracts. These instruments can initiate positive feedback loops for companies in first of its kind technology markets, where investors are more risk-averse but will follow if there is a credible path to revenue. Accordingly, IST recommends that the U.S. government develop a more developed and tailored approach to providing startups access to non-dilutive government capital (as explored more in the Conclusion).

BUSINESS CLIMATE IN CHINA: OPPORTUNITIES FOR DIVERSIFICATION

Probing deeper into the complexities of the global supply chain, particularly with respect to dependencies on China, three prominent insights were further explored. First, as noted in the second concept paper, China maintains certain technology and cost advantages (e.g., gasification). This is a result of its commitment to setting and executing national strategic priorities of leading in energy technology and manufacturing, as well as a result of its ability to leverage large-scale infrastructure, low-cost labor, and to innovate in the manufacturing process for much of the previous two decades.

For U.S. companies straddling the desire to produce domestically and avail themselves of IRA benefits while also exploiting Chinese economies of scale, many companies are reaching the conclusion that they will continue to engage in business with China, but only for Asian markets. The cost of attempting to leverage these advantages in the U.S. context are too high, largely because of different rules, different codes, and other regulatory barriers. Second, the overall business climate for Western energy companies (and potentially others) in China is becoming increasingly difficult. One participant noted that whereas over the previous decade, Chinese interlocutors would welcome the chance of forming joint ventures with Western technology companies, today, counterparts are less enthused and the business environment is becoming increasingly anti-Western. Finally, reflecting on the global supply chain, Western energy companies are finding success in diversifying supply chain and manufacturing options with other countries, including Singapore, India, Mexico, Malaysia, and Indonesia, but making these transitions is not always quick, easy, or cheap. While none of these offer infrastructure and a business climate that is nearly as advanced as those in China, they can offer better intellectual property protections and at a national level are actively fostering stronger ties with the United States.

Deep Dive: Creating Political Stability via Demand-Side Mandates

As proposed in the second concept paper, IST suggests the creation of demand-side mandates as a tool for unlocking innovation, as this type of policy would foster long-term stability—allowing businesses to recruit capital, develop new technologies, build out supply chains, create jobs (as they did in the EU), and generate positive environmental effects.

Specifically, IST proposed both general mandates as well as more narrowly-scoped ones, such as by expanding the Renewable Fuel Standard.

- **Broad Mandate**: An effort to pass a broader set of mandates would pose various legislative and practical difficulties. A stand-alone bill, for example, would likely face significant hurdles, particularly given the current political climate as the United States approaches an election in a hyper-partisan climate.
- **Narrow Mandate**: However, careful development of legislation that could increase subsidies for bio-related fuel production, as noted above, while ensuring that there are reasonable guardrails that prevent climate-unfriendly activities, could find bipartisan support. If such a text could then be attached to a must-pass bill as an amendment, the energy innovation community could benefit from demand-side mandates before the

end of the year. It is noteworthy that this year already saw the introduction of bipartisan legislation to expand the RFS in exactly such a way. Notably, if such a bill were to have an extremely long horizon—something that would make its passage significantly more likely—business would still benefit from being able to point to those targets, no matter how distant, as bankable constants.

Another narrowly focused opportunity for an impactful demand-side mandate would be one that did not emerge from the Energy Working Group itself, but from related conversations with both some of those participants and some additional stakeholders: the potential for providing demand-side clarity related to the co-location of power production and compute. Although professionals in the data space have long been seeking greater power for their operations (and exploring nuclear power as the ideal), the meteoric rise of generative AI–given its high energy demands–has sharpened the public-private conversation about how to provide power to such facilities. For example, Amazon Web Services has announced an agreement to locate a facility beside a nuclear power plant. AWS is not unique in identifying that nuclear power is likely the best answer to powering not just traditional data centers, but also next-generation AI centers. Notably, it is not only analysts who are making these connections: the head of OpenAI invests in both near-term fission company Oklo, a company that recently signed long-term power provision agreements with large- and small-scale data center companies alike, as well as fusion company Helion. More broadly, the Washington Post has examined how data centers, in general, and generative AI, in particular, are overtaxing an already stressed power grid, noting that "[t]he soaring demand is touching off a scramble to try to squeeze more juice out of an aging power grid while pushing commercial customers to go to extraordinary lengths to lock down energy sources, such as building their own power plants." One specific way to address this is with a demand-side mandate that new compute centers be colocated with not just power production, but green power production, such as with small modular reactors. Yet, nuclear power still faces challenges in the public space (with some states maintaining moratoria on new nuclear power facilities); this complicates both the work of energy innovation and those seeking to partner with those power providers for green energy. Accordingly, the movement of legislation in Congress, or even the passage of a resolution that supports the collocation of compute with nuclear power, would be an impactful step. Given domestic and international energy crises (e.g., in Germany), such an endorsement would likely help make public sector leaders feel more comfortable enabling such private-sector decisions.

Whether via a narrowly-scoped mandate around sustainable fuels, new compute centers, or something else, IST recommends that the U.S. government move some sort of legislation that provides the long term value of a political mandate for the energy sector and the innovative technologies that American and economically like minded firms are working to develop in real time.

Quantum

Stakeholder Analysis

In the third Quantum Working Group, participants provided more specifics on the interrelated challenges of mapping the quantum ecosystem and developing a framework for aligning public capital with the funding rounds of private quantum companies.

MAPPING THE QUANTUM ECOSYSTEM

Building on the previous findings about the sprawling nature of the quantum sector and the need for an effort that helps everyone communicate and collaborate, participants reiterated the importance of a third-party mapping exercise, to include: identifying the different parts, components and potentially the suppliers required at each stage of development for different qubit architectures; providing transparency to investors, and companies on the potential demand for specific parts and components, allowing potential vendors to make informed decisions about investments in manufacturing; and identifying where vulnerabilities in a supply chain might exist in the future and how the U.S. government could make targeted interventions either through financial or regulatory policy to mitigate those risks.

Most quantum companies are currently at the stage where they are investing in bespoke solutions up and down their individual supply chain to prove out their core quantum capabilities. As the solutions mature and become commercialized, the companies will look for ways to work with third-party suppliers to commoditize the parts and components that are not core to their solutions. In order to do that, however, these companies require a third party to convene quantum industry representatives to better understand individual supply chains, areas of potential overlap, and where there should be a convergence on non-core technologies.

The U.S. government is uniquely situated to support this nascent ecosystem but it is not clear which offices across the government have the capacity to support such analyses. To date, primary government interlocutors for quantum are at the Department of Defense due to the national security importance of the technology. However, these officials are generally not responsible for tracking current market trends in the quantum ecosystem, particularly at the detailed level of supply and demand or pricing of components such as wiring, lasers, or photonic integrated circuits.

The SBI team suggested that the Department of Commerce, through the Industry and Analysis Unit, would be a good place to engage, given that supply chain mapping and industry engagement are key pillars of their mandate. Participants were all receptive to the idea of working with the Department of Commerce and noted enthusiastically that quantum should not be limited to the Department of Defense, as it will have wide-reaching societal effects. Going forward, however, participants from private companies recognized the many remaining open questions they need to answer internally with respect to what information they can share (i.e. what is critical to their intellectual property), under what conditions they would be willing to share (i.e., under a non-disclosure agreement) and ultimately, how intensively they want to work with the U.S. government.

This discussion and the two previous working groups revealed that there is a target of opportunity to pull together officials from the U.S. government, namely from the Department of Defense, Department of Commerce, and the Department of Energy, and representatives across the spectrum of the U.S. quantum industrial base, with the goal of developing a framework for a dynamic quantum ecosystem analysis. While several open questions remain on the execution of such an analysis, none of them seem insurmountable. Importantly, given the criticality of U.S. competitiveness in quantum, there is appetite from both the public and private sectors to collaborate.

PUBLIC CAPITAL FRAMEWORK

Similar to the deliberations in the Biotechnology and Energy Working Groups, participants were universally enthusiastic about the idea of developing a public capital framework that aligned government offerings with the needs of companies at different quantum company funding rounds. However, as with most technology areas, the devil is in the details. Quantum companies will take many forms, from software as a service providers to quantum sensor hardware manufacturers. As such, the funding profiles will differ, and generally speaking, quantum companies building software products may not require as much public funding support (as the hardware development requires physical infrastructure that is significantly more costly).

Furthermore, motivations driving company officials versus the demands from investors varied. Companies at Series B or even Series C rounds are still wanting to build out a technical roadmap; in this case, non-dilutive funding from the government would be a tremendous boost in these efforts. However, investors at this stage expect the company to have fine tuned a commercial system, to come up with a product that is ready to be market tested, and to demonstrate how the company will make revenue at scale going forward. As one participant noted, the investors “don’t really care about the technical stuff that needs to happen in five

years;" they believe that any additional dollar spent at this time should be spent on refining the market approach.

Additionally, public money for quantum currently ends up being competitive with U.S. industry, as opposed to additive. This is likely due to the fact that the U.S. government wants certain in-house capabilities to test weapon systems or perform other classified activities (e.g., decryption of adversary communications) that private sector companies in quantum might not want to facilitate. However, if a substantial amount of public dollars are going towards the development of redundant technology capabilities, the U.S. government needs to identify a better way of licensing or otherwise sharing the IP developed within its labs.

Public officials and private sector participants would benefit from a complete understanding of the innovation landscape, and the creation of a public capital framework that can complement or augment private investment dollars. Participants in the SBI Working Group are eager to work with the U.S. government, and the quantum ecosystem represents a relevant sector where the U.S. government can better align its grants, contracts, and debt tools to ensure U.S. competitiveness going forward.

Deep Dive: Mapping the Quantum Sector

Given strong support for a U.S. government-led effort to map the quantum ecosystem, this concept paper proposes two ways to pursue this approach.

First, the Department of Commerce's Industry and Analysis office could perform this work. For context, the White House recently empowered this office to host the first-of-a-kind Supply Chain Center; the expertise that this office holds, paired with its connections "across government, industry, academia, labor, and civil society" position it to perform the cross-cutting analysis necessary for this proposed mapping. Given that agency's remit, authorizations, and resources, they could begin this work on their own; upon completion, the White House would then ideally issue guidance to require departments and agencies to comply with the findings.

Second, Congress could pass legislation to support a mapping effort. Within the quantum legislation space, the 2018 National Quantum Initiative Act (NQIA) directed the President to implement a National Quantum Initiative Program, develop long-term quantum strategies, and required that certain departments and agencies play specific roles (e.g., have NIST establish a consortium to develop quantum-specific standards). Notably, the NQIA has been supplemented by other legislation, including multiple NDAAs as well as the CHIPS and Science Act.

However, the NQIA expired in September 2023. Shortly afterwards, Representatives Frank Lucas and Zoe Lofgren—the bipartisan leadership of the House Science, Space and Technology Committee—introduced a reauthorization bill last fall. Within the month, the committee voted unanimously in favor of moving the legislation to the House floor (but has not been moved since). This reauthorization increases the budget for quantum work, funds new centers and institutes, recognizes the need for international cooperation (while banning funds from going to any entity that works with any Confucius Institutes), and adds emphasis commercial applications (e.g., states that members of the National Quantum Advisory Committee should include end users likely to benefit from the technologies). Notably, the bipartisan, bicameral "Quantum Sandbox for Near-Term Applications Act of 2023" has not been considered by committee and now seems to have taken a backseat to the Lucas-Lofgren text. This helps illustrate both the broad interest in ensuring American success in quantum and the difficulty of moving quantum legislation right now.

The development and implementation of the NQIA itself was also far from simple. A chart in the National Quantum Initiative Supplement to the President's FY 2024 Budget illustrates the seven-year process *(Figure 2)*.

As that document makes clear, the absence of a quantum authorization bill does not preclude federal work on quantum. But if a quantum reauthorization bill does make its way through Congress, IST encourages lawmakers to include a requirement directing the federal government to provide the sector mapping as outlined in the second concept paper. Similarly, we suggest that the authorization bill include more of the sort of definitional work done in the "Sandbox" bill (e.g., defining "near-term use case" as less than two years).

Figure 2: Establishing and Implementing the National Quantum Initative

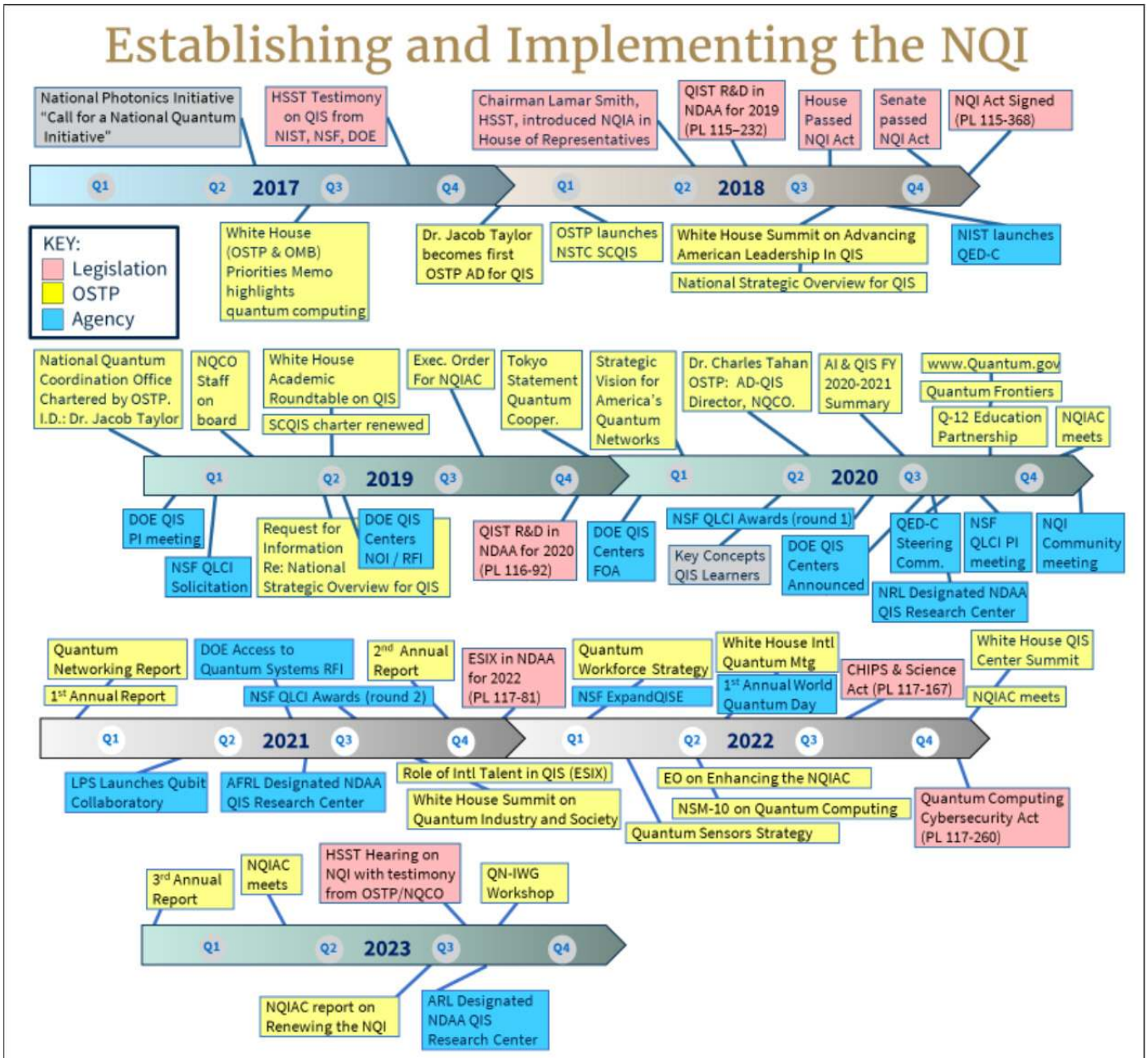


Figure 5.1: Timeline of actions establishing and implementing the NQI. Color-coding shows legislative process in red; OSTP and NSTC actions in yellow; agency actions in blue. The NQI was introduced in Congress, passed in the House, passed in the Senate, and signed into law by the President, reflecting bipartisan support. The NDAA for FY 2019 and FY 2020 are shown on the timeline because they authorize QIST R&D supported by DOD. Selected actions led by the White House OSTP and the NSTC SCQIS and ESIX are highlighted in yellow. Agency actions on QIS R&D have been ongoing during this time. Selected NQI-authorized activities are highlighted here in blue, notably to establish consortia and centers called for by the NQI Act.

Figure 2 from: Subcommittee on Quantum Information Science, Committee on Science, National Science and Technology Council, "National Quantum Initiative Supplement to the President's FY 2024 Budget," December 2023, https://www.quantum.gov/wp-content/uploads/2023/12/NQI-Annual-Report-FY2024.pdf.

Conclusion

The members of the SBI working groups were instrumental in further elucidating challenges to the quantum, biotech and energy sectors. In each, there are clearly sector-unique misalignments between the needs of the private sector innovators and the development of the policy and programmatic apparatus of the U.S. government. However, there are a range of policy challenges that are cross-cutting and, if addressed systematically, can make the most efficient use of U.S. government resources and build a base for supporting technology competition as even newer technologies emerge.

In this light, stakeholders were resounding in their recommendation that the U.S. government needs a public capital framework to provide some level of discrimination in its decisions on where to invest. A key insight in the most recent set of discussions is that as a precondition for understanding public capital allocation, program officials need to understand where public money is absolutely necessary – i.e., without public investment, the technology or R&D will not be funded by the private sector – and where public investment is currently redundant with the private sector. This can allow for reallocation of funding to go towards the highest and best use in the context of a technology competition. Further, policy makers should build a better understanding of the different funding cycles of the private companies, particularly in these sectors. Key questions to answer include: the types of funding the companies need, the uses for the funds, and the speed at which the capital is required. Informed by the answers to these preliminary questions, the U.S. government can organize its various offerings to better partner with industry.

SBI will continue to engage with stakeholders on issues around public capital, data management, and more agile regulatory policy development.

Next Steps

The SBI team is working on both producing a final report that will summarize the key findings and suggestions for what can be done to improve public-private collaboration and thus accelerate technology innovation and scheduling an event to discuss those findings and opportunities for progress. If policymakers can incorporate any of these recommendations into future legislative or executive agenda, those steps would help overcome misalignments

in the public and private sectors and thus accelerate American and like-minded country competitiveness vis-à-vis the PRC.

Feedback, both on what is included here and new concepts for consideration, would be welcome and incorporated into future events and efforts.

Appendix

Questions to Consider in Establishment of Biotech Data Repository

Questions include, but are not limited to:

- Incentivizing participation:
  - What incentives are best for getting researchers and private-sector enterprises to contribute data to such a depository?
  - How do those incentive structures need to be different for pre-competitive versus other types of data?
  - How can those incentives be structured so as to reward the entities which hold the intellectual property (e.g., when startups develop proprietary data but cannot find another commercially viable use)?
  - What commercial arrangements are best for managing different types of data usage? For example, is the mental model the Apple Store, where music can be purchased for unlimited use? Or is it Spotify, where users pay under a different model? (More on this below.)
  - What, if any, legal changes are necessary, including with respect to intellectual property rights?
- Scope, scale, and format:
  - What sorts of data can be included? (What exceptions cannot be included?)
  - What are the appropriate formats?
  - What are the regulatory limitations for each type of data?
  - What are the mechanisms for uploading data (e.g., what sort of upload filters should or could be in place)?
  - Who can access the repository?
  - Who can upload data?
  - Can any work be performed inside the repository?
  - Who can download data?

- What API or other options should be available, including for the training of AI?
- How can data be identified inside the repository?
- How much access to data sets is allowable without purchase? (For example, the Apple Store allows users to listen to a portion of a song before purchase.)

» Uses

- What are appropriate policies and protocols to facilitate commercial progress without inappropriate use? For example, what would allow for the recombination of data sets in ways that respect national and personal security but also enable value to be captured?
- What sort of broad use cases are always, never, and sometimes appropriate?
- How should AI versus human uses vary?
- What sort of specifics need to be carefully considered, crafted, and developed in partnership with subject matter experts?
- What sort of training is necessary, possible, and best for researchers who want to contribute and/or use data? What is the process for developing and providing that training so that this repository becomes well performing?

» Enforcement

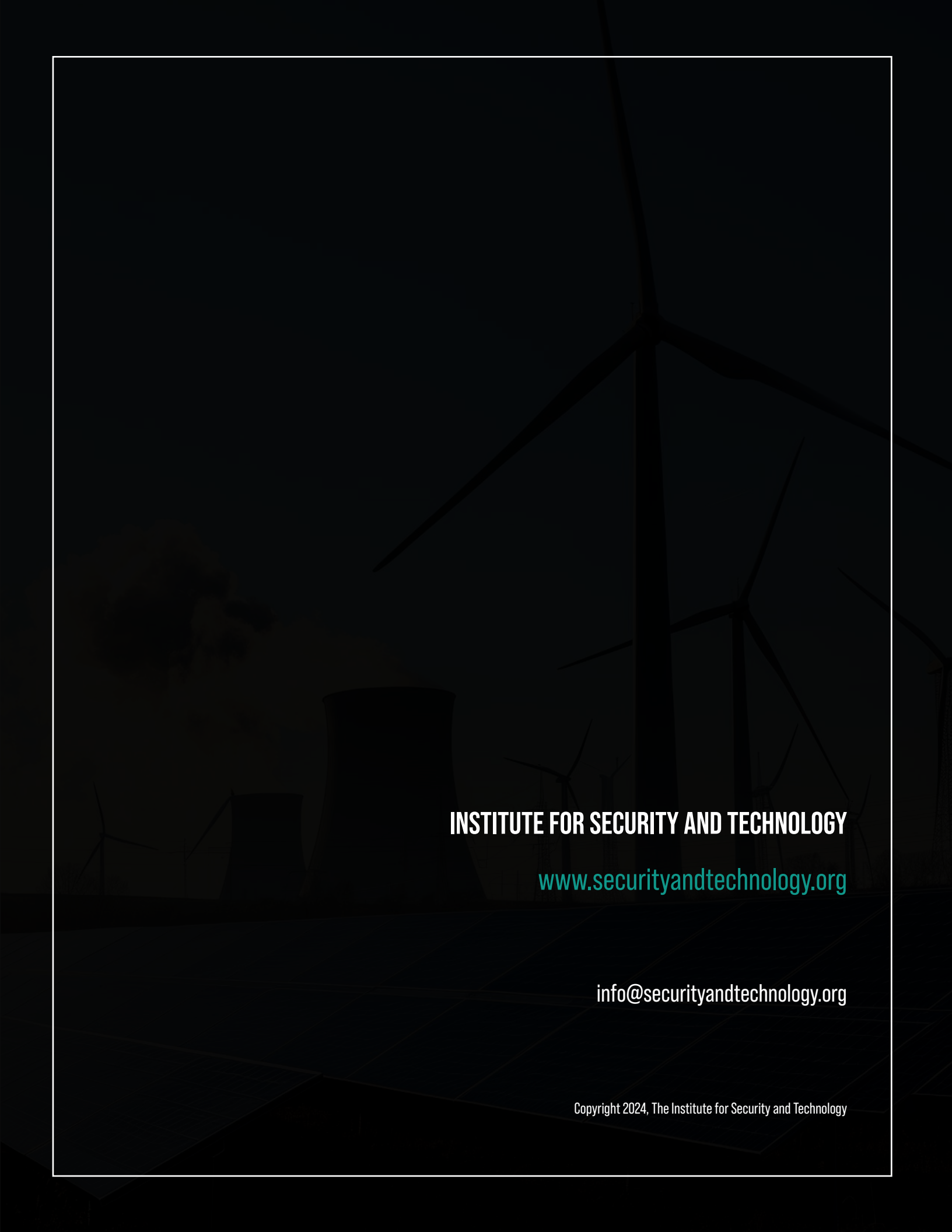
- What mechanisms can positively affirm that the terms of use for the repository are being honored? For example, how can the government ensure that unauthorized users or uses are not being enabled?
- What regulatory or legislative steps are necessary for developing those mechanisms?

» Additional factors:

- What sort of test program might be possible for exploring this initiative at a smaller scale? For example, where could such a repository be piloted (i.e. tied to a specific oncologic process, diagnosis, and source of data) that has a realistic pathway from pre-competitive data to commercially valuable data?
- When it comes to data provenance, what is a solution that employs federated learning technologies and solutions (e.g., blockchain-based auditing) that can provide better resolution for licensing and security monitoring purposes?
- What sort of IT and other protective measures will this data repository receive? How will the sensitive data be identified and protected? For example, how will the system limit access to more sensitive data to certain types of users ? Will there be geographic bounds on respiratory access? Which part of the federal government will have the

funding, capability, and authority for protecting this repository?

- What sort of Congressional engagement would facilitate progress with this initiative, including hearings and potential legislation?
- To what degree could or should this repository be an international effort? If it includes foreign partners, which ones? How does their integration affect this?
- If this is for solely American use, how does that apply to international teams of researchers based in America? Or to American companies' research teams based abroad?



INSTITUTE FOR SECURITY AND TECHNOLOGY

www.securityandtechnology.org

info@securityandtechnology.org