PARTNERSHIPS TO ACCELERATE ADVANCEMENT OF PRIORITY S&T

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1. Introduction

The United States stands at the convergence of multiple inflection points within science and technology (S&T) advancement:

- We're in the beginning stages of having a handful of technologies fundamentally change what is possible and thus significantly influence our national security and economic prosperity for the next few decades.
- New programs, with significant financial resources, are being established to increase the federal government's investments in translational or use-inspired research[1] (while maintaining its historical focus on basic research).
- There is a growing understanding that the United States must operate in a different, more collaborative manner on critical topics than we have in the past if we're to be successful within the modern international S&T competition.

This convergence of inflection points provides a unique opportunity, provided we approach them strategically and collectively. Providing additional resources to a technology community doesn't magically meet the nation's objectives. Neither does creating and nurturing an unprioritized variety of innovation-centric partnerships. But providing additional resources and enabling specific public-private collaboration *at the right time and with the right focus* within the technology lifecycle can rapidly accelerate S&T development and its application across a variety of use cases.

This paper provides guidance to national S&T thought leaders on how to do this, leveraging and combining the authors' insights in managing federal research and development (R&D) programs, establishing national S&T strategies, investing as part of the venture capital community, and leading a variety of public-private partnerships (PPPs). Section 2 provides an overview of the technology lifecycle, identifying the levers that can best accelerate advancement. Section 3 provides the basics of successful partnerships including public-private partnerships (PPPs). Section 4 then brings the two fields together, providing actionable recommendations for focused collaboration at specific points in the technological lifecycle that would significantly accelerate S&T advancement.

In summary, MITRE acknowledges that technology and market maturation is often measured in decades and previous methods are insufficient to accelerate U.S. S&T to win the global competition. MITRE recommends that government, industry, academia, and others co-design the optimal set of partnerships to accelerate the advancement of S&T. By partnerships, we mean collaboration among interested parties that engage together at the right time in technology/market lifecycles to address some specific purpose or challenge for mutual benefit. MITRE expects that cross-sector collaboration that aligns our nation's strengths will enable the U.S. to cross chasms that single entities could not cross on their own and to move faster to achieve national economic and security imperatives.

2. The S&T Landscape, Its Future, and Its Acceleration Levers

Governments from around the world have recognized the nascent multi-technology revolution, particularly the United States and the People's Republic of China, which are engaged in a strategic competition.[2] "The epicenter of the competition is the quest for leadership and dominant market share in a constellation of emerging technologies that will underpin a thriving society, growing economy, and sharper instruments of power. At stake is the future of free societies, open markets, democratic government, and a world order rooted in freedom not coercion."[3]

Various public and private entities have identified lists of critical technologies, leadership of which in the global marketplace will greatly define a nation's future security and economic prosperity. While there is some variation across these lists, for the most part they are very similar. Figure 1 provides an easily digestible assessment.[4]

China is taking an approach that aligns with its normal philosophies: "rapidly increasing funding for research and development, implementing a dictatorial approach requiring all Chinese parties to collaborate for the national good, and ignoring international science and technology

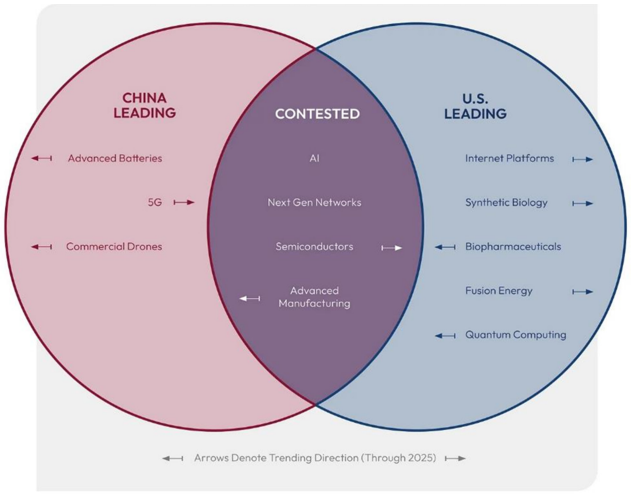

Figure 1. U.S.-China Leadership in Key Technologies (SCSP: Mid-Decade Challenges to National Competitiveness)

norms in order to achieve objectives."[5] The U.S. government has thus far taken steps that align with its normal philosophies: increasing R&D funding and creating new bureaucratic entities to specifically focus on the international technology revolution, as well as initiating an uncommon activity—focused collaboration to accelerate S&T.

The aspect that both governments have thus far missed is the philosophy of the venture capital community: targeting investments and supporting activities at strategic points in a technology's developmental lifecycle to accelerate its development and application, thus maximizing return on investment. Adding this focus on select technologies will have a greater impact on international competition than the current "a rising tide lifts all boats" approach.

S&T Futures

To be able to understand the evolution of technologies and markets, it is helpful to first establish a definition of vertical technologies and horizontal markets. Artificial Intelligence (AI) and blockchain are examples of verticals that include multiple related technologies. These technologies create opportunities for solution providers to develop new goods and services based solely on that technology, which enable new solutions to address a known challenge. In a technology vertical, companies created around the technology are attuned to the specialized needs and generally do not solely serve a broader market, but rather enable broader groups of related solutions to address a larger business area or challenge. A market is an institution where goods and services are exchanged or traded in transactions.[6] A market is often composed of multiple vertical technologies, is horizontal in nature, and is usually addressing or solving a challenge area or business problem. An example of a market is digital health, which may draw on several vertical technologies such as AI, personalized medicine, internet of things, and cybersecurity. The U.S. S&T priorities have both vertical technology enablement and broader market components that are made up of many related verticals addressing the same challenge.

The financial community (e.g., venture capital, market planners and analysts) has developed a series of signposts that can be used to assess future opportunities of different technologies and maturing markets. These entities traditionally invest in a market or in a technology when they see

value and promise based on adoption. One signpost used is the Compound Annual Growth Rate (CAGR). CAGR is used to assess risk and manage volatility of solutions entering or affecting markets by looking at adoption and revenue growth over time. CAGR is created out of a series of mathematical calculations that have proven to be an accurate way to assess and forecast the rise and fall of new solutions, markets, and companies. It is also a signpost that can reflect the interdependency between a market and underlying infrastructure or enabling technology. This tool has traditionally been used by the investment community and product planners as a way to gain a quick understanding, and compare a peer group, of companies, markets, or technologies.

CAGR analysis can be used in understanding a new or mature market—whether it is in a growth, stable, or declining phase. For example, for an early-stage market that has been around for only three to five years, a CAGR of 10% to 20% is a strong indicator of its growth/potential, while a CAGR of 8% to 12% is a good indicator of stability for a solution, technology, or company that has more than 10 years of experience. A market in growth may show a CAGR of 25% whereas one in decline may see a CAGR of only 1% to 3%. When a market hits a CAGR of 8% to 13% it is mature and stable.

Emerging technologies that are focused within a single market will have a CAGR similar to that single market. Whereas a technology that is critical to multiple markets will routinely have a CAGR over 30%.

Table 1 provides a summary of CAGR analyses of markets and technologies often discussed as part of the international S&T competition. Note the technologies shown in the table all have a CAGR greater than or equal to 25%.[7]

In looking at these projections, there are several markets with both stable CAGR percentages and projected annual revenue over a trillion

FOCUS	Emerging Markets	2023	2030/35	CAGR
Market	Biotechnology	$1.02T	$3.2T	12%
Market	Microelectronics	$573B	$1.3T	12%
Market	Cybersecurity	$173B	$780B	13%
Market	Digital Health	$195B	$780B	16%
Market	Advanced Manufacturing (Materials)	$65.2B	$167.5B	20%
Market	Intelligent Domains	$1.2T	$7.1T	24%
Market	Future Connectivity	$109B	$300B	25%
Market	Climate, Energy, & Environment	$335B	$2.77T	29%
	Deep and Emerging Tech - 2022 / Q2 2023 – 2030/35 – aggregated from multiple sources	2023	2030/35	CAGR
Technology	Internet of Things (IoT) 2030	$662B	$3.335T	26%
Technology	Quantum	$1.013B	$50.22B	33%
Technology	Augmented/Extended Reality	$40.12B	$1.423T	34%
Technology	Artificial Intelligence	$150B	$1.3T	42%
Technology	WEB3	$2.2B	$89B	45%
Technology	Blockchain	$10.2B	$169B	60%
Technology	2030-2035 // 6G (Transition to 7G)[8]	$7.47B	$159.54B	127%

Table 1. CAGR Analysis of Select Markets and Technologies

dollars, plus there is a set of technologies showing significant growth well above any single market, indicating they are critical to those markets. This all points to 2035, when key emerging technologies will exceed 30% annual growth, enabling several multi-trillion-dollar markets to emerge. These markets are expected to be enabled by seven underpinning infrastructure technologies: 7G, internet of things, AI, quantum technologies, augmented reality, next generation internet (WEB3), and blockchain. These seven technologies, with full-scale converging availability expected between 2033 and 2035, will set the global technology standards and will establish global economic dominance.

S&T Evolution

Many models exist that attempt to explain the lifecycle of technologies and markets, such as the Gartner Hype Cycle and Roger's Model on the Diffusion of Innovation. Figure 2 shows how any given technology's adoption over time—in this case, AI—starts slow, rapidly accelerates once a critical point is reached, then levels off as it approaches maximum market penetration. Using the example of AI, we see how the lifespan of technologies is often measured in decades, from the inception of the idea, through basic research (invention), applied research (innovation), early entrepreneurism, and maturation. The specific adoption curve for a given technology depends on the technology itself, when resourcing (including attention) is applied to it, and how the potential market responds. We see here that AI is just recently taking off in terms of substantial investment and adoption, despite the original scientific idea occurring some 70 years ago.

While the typical U.S. practice provides some focused resourcing on basic and applied R&D, typically it is not until an idea emerges from the lab as a prototype application with a viable path to commercialization (e.g., begins to become productized) that substantial investment is brought to bear (e.g., angel investment, venture capitalization, acquisitions). Inventors, innovators, and entrepreneurs do have a role in technology adoption (as enthusiasts transitioning it from discovery/idea to product). Yet it is not until an idea enters the market (as some product or service) that we see end-user adoption begin to get traction, first among early adopters, then the

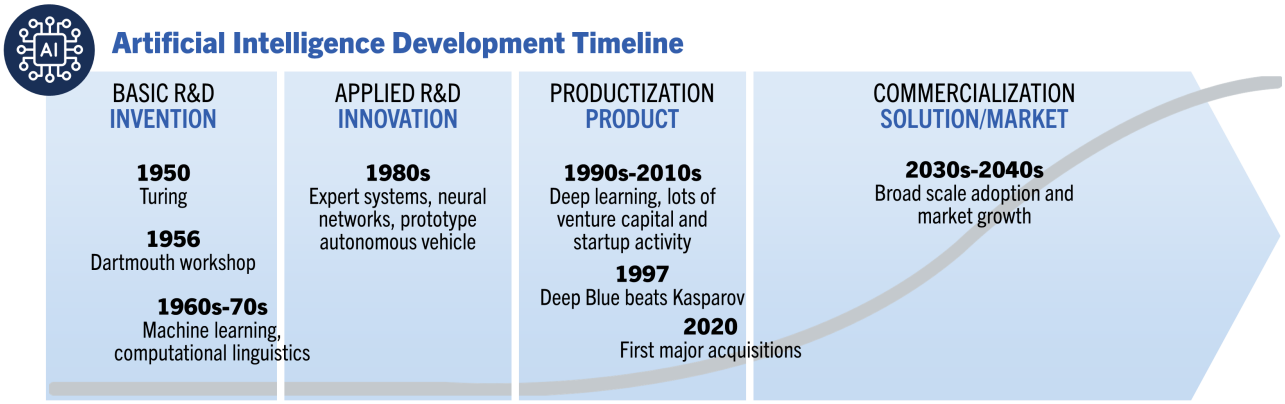

Figure 2. Timeline of AI Advancement, Which Is Representative of Most Technological Evolution

early majority, late majority, and finally laggards, until finally the technology reaches maximum market penetration (if it is so lucky).

Understanding the long timeframes associated with maturation or adoption of a technology, as well as the entities acting at different phases (and the relative levels of resourcing they bring to advance the technology/market), is a first step toward realigning those actions to accelerate S&T.

S&T Acceleration Levers

The critical S&T acceleration that our nation desires is squarely focused on realigning actions and related resourcing at critical points in a technology's early evolution.

Figure 3 shows how strategically targeting more resourcing and purposeful partnerships at specific points earlier within this timeframe will yield greater return on investment and accelerate S&T innovation and adoption compared to the historical approach.

MITRE's innovation acceleration researchers have identified four levers that can best catalyze advancement of a technology or market during the earlier stages of its lifecycle:

1. Stimulating research and creating interest
2. Mobilizing a network (active ecosystem)
3. Demonstrating impactful solutions
4. Increasing business/industry engagement (e.g., establishing routes to market for emerging tech)

Each of these levers can individually help, although their influence is muted if the other levers aren't also embraced. An orchestrated and continued focus on all four as a technology evolves enables more rapid advancement and new routes to market, thus creating competitive advantage for U.S. product and service providers, corporate mergers and acquisitions, investors, and academic institutions. All actors need to time where they align their resources, enter the market at the appropriate juncture, and then surgically focus on activities that will optimize their time to market and return on investment.

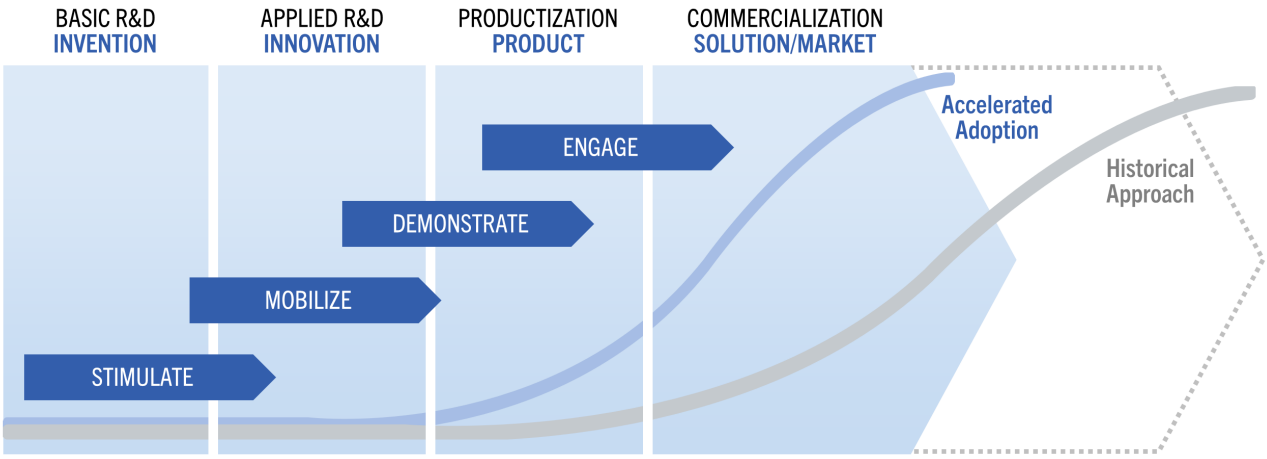

Figure 3. Focused Attention on Four Levers Earlier in a Technology's Evolution Can Accelerate Its Adoption and Market Growth

Lever 1:
Stimulating Research and Creating Interest

This lever is where new ideas are born, but the time from initial concept to adoption may normally be 15–20 years. Deep tech investment,[9] collaboration-building forums, non-dilutable grants, and community challenge problems are the primary partnership approaches to move this lever. These activities are long-term investments, as they produce little revenue up front and there is often not a defined market. This lever is about bringing potentially interested parties together to increase situational awareness.

Lever 2:
Mobilizing a Network (Active Ecosystem)

This lever is the critical transition phase from fundamental research to applied research (i.e., solving business problems and challenges). This lever is most notably characterized by academic engagement, deep tech startups, joint R&D ventures, angel investment,[10] and the first-market predictions. Example partnership approaches include workshops, specialty conferences, collaboration accelerators with technology focus, and initiating silo markets. This phase can normally last up to 10 years.

Lever 3:
Demonstrating Impactful Solutions

This lever occurs when the market is emerging, and product companies are looking for key features they can acquire to complete solution sets or new and enhanced features based on technology enablement or market needs. It is generally accepted that it takes five to seven years from the time a product or solution is acquired to when it is market ready. It is in this time frame when standards and frameworks emerge that enable faster adoption of innovative solutions spanning multiple markets.

During this lever, innovators are looking for ways to accelerate time to market by:

- Validating the capability of, raising value awareness of, building support ecosystems for, and communicating the unique qualities of their technology, solution, or new product
- Demonstrating value by solving challenges through comparing emerging competitor approaches, collecting feedback, and demonstrating value to end users looking for solutions
- Understanding who can derive the most value from their solution and how the solution can support problem solving

This lever also sees an increase in partnering as industry and government work together to:

- Create frameworks and standards that can be leveraged across broad markets to speed up time to market by providing rapid development and iteration.
- Reduce risk by sharing risk with multiple parties that can best manage it.
- Validate market interest and opportunity as partnerships promote understanding of what the private sector and potential customers need and how to scale solutions.

Lever 4:
Increasing Business /Industry Engagement

The final lever of acceleration and adoption occurs when markets become stable or enter transition. Public policy is being developed and standards are established leading to consistent industry models, large-scale integration, and interoperability of technology—all of which enable more complex operational capabilities to emerge. Broad public adoption is underway and additional business incentives are needed to make

it easier for companies to get new innovations to market. These elements of technology maturity help streamline innovation-centric partnership formation and enhance the speed and integrity of these initiatives. In turn, these partnerships can support government and commercial opportunities to accelerate key standards, address major challenges, scale solutions, and establish new policies.

This lever is the major inflection point in market growth, technology adoption, and diffusion of innovation, which can last 15 years. In the later stages of the market lifecycle, a transition of legacy technology is needed to support changing business conditions and partnerships, and industry incentives are needed to smooth the transition within a market or when a new feature-rich technology emerges. This will be seen in the shift, for example, from 5G to 6G to 7G cellular technology, where at each transition, partnerships are expected to emerge to accelerate technology transition and promote solution stability.

3. Basics of Successful Partnerships

Introduction to Partnerships

MITRE generally considers three categories of partnerships—where interested participants collaborate on some shared purpose—all of which can be leveraged to accelerate S&T:

1. **Innovation-centric partnerships** are focused on applications of research or motivating markets and competitiveness (e.g., incubators, test labs, consortia to cross the technology innovation valley of death). They often come about in circumstances where solutions and markets do not exist, or significant investment is required to bring technology to maturity.
2. **Information-centric partnerships** exist where the problem space is complex and there are many stakeholders who realize that sharing information is the only way to obtain needed insights and/or coordinate action. These partnerships are also typically constantly learning and adapting to address emergent challenges with data-driven actions.
3. **Infrastructure-centric partnerships** focus on finding ways for communities to co-design and finance infrastructure that is required for advancement but isn't feasible or appropriate for any one entity to undertake on its own. PPPs for large-scale public infrastructure projects (roads, bridges, etc.) are the most common example, but partnerships can also provide other kinds of shared capabilities (such as the National AI Research Resource).

PPPs are working arrangements based on a mutual commitment between a public sector organization and any other organization(s) outside the public sector to achieve some mutually beneficial outcome. They are collaboratives in which the goals, structure, governance, roles, and responsibilities are mutually determined, and decision making is shared. PPPs are distinct from traditional contractual arrangements and are rooted in co-creation, co-design, and co-resource mobilization. Regardless of a particular collaborative's membership—public-private, cross-sector, or involving some other combination of government, business, academia, and other entities—the most successful collaboratives typically have the following 10 characteristics:[12]

1. **Multi-Dimensional Thinking** – A shared understanding of each party's needs, concerns, and perspectives that enables parties to define the challenge from multiple angles and co-develop novel solutions

2. **Shared Vision** – A co-created North Star for the initiative that provides direction to and inspires participation from the parties needed to solve complex, at-scale challenges

3. **Mutual Trust** – The safe space needed for risk taking and collaboration that is established through parties agreeing to norms and expectations, working together in good faith, managing expectations, and following through on commitments (shared accountability)

4. **Unique, Mutual Benefit** – A clear and tangible value proposition from collaborating, which cannot be achieved in any other way, that justifies each party's voluntary investment and participation

5. **Co-Created Model** – The mutually determined operational model, including the core business deal and necessary support functions, that enables the delivery of value to parties and the public

6. **Transparency** – The practice of proactive communication, openness, and sharing visibility into the basis of decisions and operations that strengthens trust and efficiency

7. **Shared Resourcing** – Each party's fair commitment to provide the necessary resources (financial and/or in-kind contributions) that enable operation of the collaborative and progress toward the vision

8. **Co-Decision Making** – The practice of collaborative decision making and dispute resolution that allows parties to make progress together, balancing (loss of) control and (gain of) buy-in and mutual benefit

9. **Appropriate Safeguards** – The co-designed controls—including binding agreements, verifiable protocol, and information technology solutions—for mitigating security, privacy, intellectual property, business, legal, and other risks that enable the safe space and support the imperative for impactful collaboration and innovation

10. **Collaborative Environment** – The suite of proven methods and tools for working together along with the optimal, situation-tailored usable, secure IT services/products that support effective and efficient collaboration

Americans can benefit when federal agencies use PPPs to advance service delivery and mission success by:

- Extending the proven model of PPPs in public works to other government-provided services and critical national problems—for example, advancing transportation safety
- Emphasizing the use of PPPs and other collaborative approaches when acquiring solutions
- Embracing trusted third parties, free from conflicts of interest, to facilitate or operate PPPs when appropriate
- Engaging with stakeholders to design and execute PPPs to address whole-of-nation challenges

Congress and the executive branch can foster public good via PPPs by:

- Providing safe harbor-style protections for PPP members so that industry can more confidently participate and share proprietary data with less concern about liability or about competitors gaining advantage as a result of their participation
- Removing barriers to PPP effectiveness and burdens on partners; for example, they can streamline the collection of PPP data under the Paperwork Reduction Act
- Encouraging the appropriate use of PPPs by agencies to deliver innovative, widely beneficial solutions in the public interest

Technology-Focused Partnerships

Partnerships that mobilize research and innovation across sectors can generate economic value and competitive resilience. Fueling innovation across this ecosystem generally requires incentives and accelerants to:

- Stimulate innovative research that both creates market opportunities for the partners (or networks of partners) and increases the competitive advantage and high-value returns.
- Mobilize a diverse network of research organizations, academic programs, industry, government, and the startup community to co-create solutions that address issues impacting the whole-of-nation.
- Champion new approaches that accelerate innovative solutions adoption and foster technologies transitioning from deep tech into the applied startup world.
- Demonstrate impactful solutions by using an agile approach to prototype and creating a safe space to experiment.
- Develop business acumen as a core competency, enabling a new workforce to continually seek and translate into useful application more innovative approaches and technologies.

Partnerships are best applied in the challenge/solution space when government, industry, and academia work together to:

- Invest in and accelerate the development of deep tech such that viable inventions addressing the shared problem are developed.
- Connect innovators to markets, such as through joint ventures and other partnerships, to develop specific technology applications that have value to customers and/or create new markets.
- Develop working products based on user feedback and real-world testing while building the customer base and ensuring access to capital.
- Obtain real-world insights on the performance of early-stage or mature technologies to guide further development, investment, policy, etc.

National-Level Network of PPPs: Insights from the GEAR Center

While PPPs have existed in many forms for quite some time, strategically establishing a collection of them to support broad national-level endeavors remains quite novel. A couple of years ago, MITRE helped the White House study this macro-level approach as it was designing its proposed GEAR Center concept,[13] which was envisioned as a collection of cross-disciplinary PPPs to help the federal government advance and better leverage innovative technologies and business practices in federal operations.

At a high level, there are many similarities between the GEAR Center activities and the national S&T collaboration model currently being envisioned:

- Public-private scanning of needs and opportunities
- Collaborative development of strategies
- Joint research and pilots against those strategies

The collaborative operating model for the GEAR Center consisted of three primary groups: the federal government, a network of PPPs/networks to both forecast possibilities and collaborate on R&D, and an operator entity that serves as both a strategic and tactical coordinator and as a trusted third party between government and the private sector. It involved seven major ecosystems of related entities, including federal agencies, state and local governments, industry, academia, research organizations, non-profit organizations, and investors.

Each of these ecosystems has different qualities, and thus brings different insights and capabilities to the joint endeavor. MITRE's analysis showed that the ultimate success of the GEAR Center would depend on reaching large groups of thought leaders within each of these ecosystems quickly and systematically. The most feasible approach was to identify and focus on the entities within each ecosystem that had existing networks (with diversity of thought and experiences) that could easily be leveraged. We also recognized that each participant's role would vary based on their level of commitment and involvement within the GEAR Center:

- Governance (lowest number of participants)
  - Shape the strategic direction of the GEAR Center.
  - Represent the interest of respected ecosystem networks.
  - Determine activities of the PPPs.
- Resource Providers
  - Contribute capital investments and assets such as facilities, data, tools, and human capital to facilitate execution.
- Knowledge Providers (highest number of participants)
  - Provide experts to aid in strategic planning and to lead or participate in collaborative research.

Much like the national S&T collaboration models being considered today, the GEAR Center was envisioned as a volunteer collaboration. Each participating organization must therefore feel sufficient value is returned to justify their investments, and there can be a great range of value propositions that could entice participants:

- **Reach decision makers:** Connect with leaders shaping technology and operations strategy. Have a voice in the exchange of ideas.
- **Develop insight into federal government needs:** Hear directly from federal agencies regarding current and future challenges or priorities, given their role as major customers and influencers.
- **Extend professional engagement:** Participate in thought leadership helping to identify trends, find solutions, and address national needs.
- **Increase market visibility:** Enhance visibility to government and industry. Announce corporate accomplishments and share research news throughout the community.
- **Expand market and economic opportunities:** Build knowledge and intellectual property. Tap into data, deployment/testing opportunities, and potential funding streams. Optimize solutions for various markets.

- **Connect with and foster new business relationships across sectors**: Create research opportunities. Participate in interagency and public-private problem solving.
- **Empower, educate, and energize:** Access and contribute to educational workshops and networking events. Create curriculum and direction to reskill the workforce. Gain knowledge from network partners.

The federal government's role within the GEAR Center is also very closely aligned to what is needed in national-level S&T collaboration. Even though the government would not be directing activities solely on its own—rather, working in collaboration with other stakeholders—it still has a critical role to play in catalyzing collaborative research. The federal government has the most influence on setting national priorities, is the nation's largest sponsor of research, and has the largest/widest audience for publicizing those activities and their impact. Additionally, it is an unprecedented convener with huge data assets and a breadth of piloting opportunities.

The final GEAR Center insight that's useful within this S&T context is the need to measure the impact and value of each effort using success metrics that reflect both its individual purpose and its role in meeting the higher-level goal(s) that it supports. These metrics will need to evolve over time. During the early stages the emphasis will be on crafting a working infrastructure, developing key processes, and building a network of partners. Measures during this period need to correspond to those efforts (i.e., focus on process and outputs). As the PPPs mature, capability enhancements and operationally tangible benefits will start to be seen. Measures during this period should assess PPP impacts not only individually but also in how they help progress toward the ultimate national objective (i.e., focus on near-, mid-, and long-term outcomes).

4. Accelerating Advances in S&T

The prior two sections provide foundational insights on S&T advancement and different types of partnerships. A high-level summary of proposed partnership activities advancing each stage of technology innovation is provided in Figure 4.

This section more directly and strategically brings the two prior sections together to provide actionable insights. For each of the four identified levers, key questions include: what are the appropriate forms of partnerships; how do we properly assess the partnership's impact on economic and national security imperatives; and what needs to be the benefit for each constituency to participate? Early levers tend to see greater benefit from innovation-centric partnerships and specific forms of infrastructure partnerships, while later levers tend to see benefit from those partnerships as well as information-centric partnerships.

Lever 1: Stimulating Research and Creating Interest

Lever Objective & Supporting Partnerships

This lever aims to reduce institutional risk in undertaking R&D that is high-risk, that wouldn't provide near-term revenue, or for which no clear application (or market) exists. Typical approaches are incentivizing investment (e.g., by providing tax benefits), increasing supporting grants, conducting research moonshot challenges, and making it easier for academia and startups to engage with federal agencies to explore research priorities and potential application gaps they could address. A primary focus of partnering at this stage is generating situational awareness about the research need and/or emergent ideas.

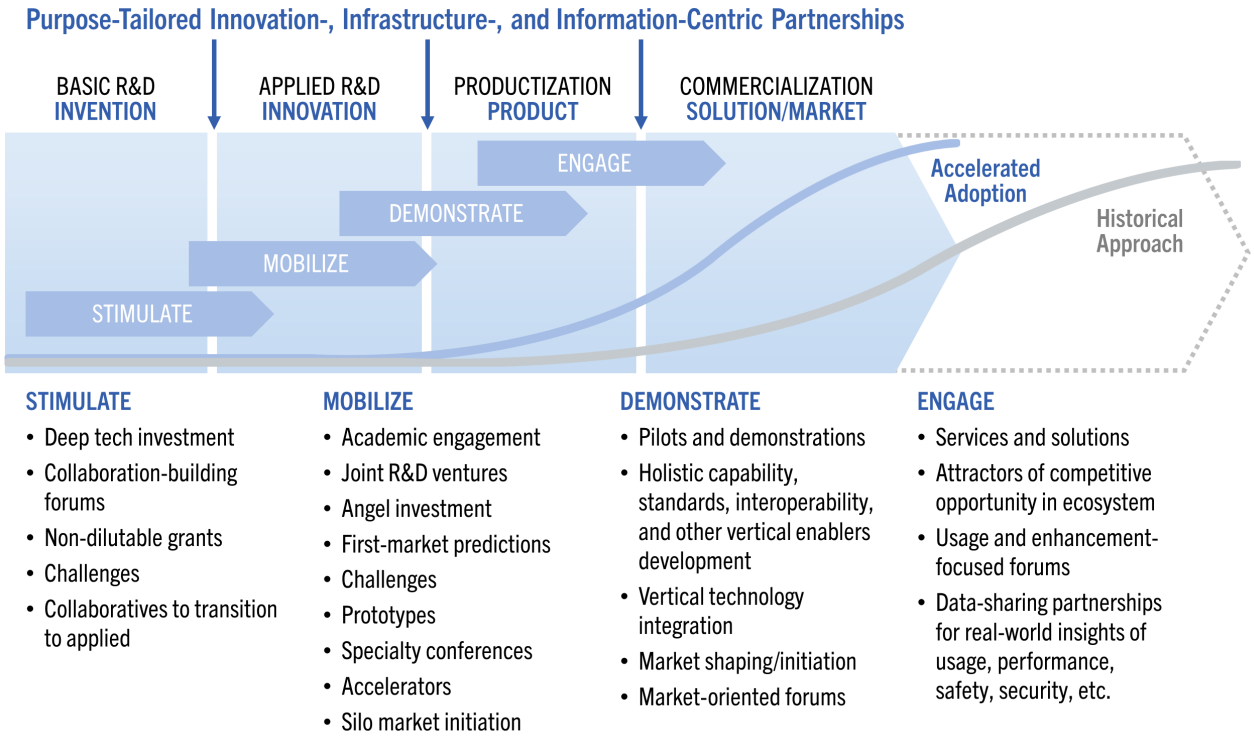

Figure 4. Examples of Collaborative and Partnership Activities Supporting Each Lever

Conferences, workshops, and invitationals (e.g., calls for papers, research moonshot challenges) that provide structure for information and idea exchange in an otherwise nebulous environment, as well as consortia and ventures that support the transition from deep tech environments to use-inspired research, are typically the most effective forms of partnerships at this stage.

Measuring Progress & Impact

Metrics for conferences/workshops that support this S&T advancement level will evolve as the effort matures. Initially the key focus will be on participation, although more toward ensuring the right entities are participating rather than overall participant counts (which is also important, but secondary). Supporting this initial metric is participant feedback: are they seeing value in participating and are they taking away insights that will be useful for them?

In cases of partnerships, such as consortia and joint ventures, to transition ideas from pure research to practical/applied research, metrics can include counts of involved parties, patents, or licensing deals, as well as the level of investment in lab environments and R&D pipelines (where possible, considering successful exits). This leads to the next assessment phase: are we seeing evidence that the partnership is driving changes in subsequent decisions and behaviors? This supports the ultimate metrics for the lever itself: fundamental research that is appropriately targeted and resourced, strong sponsor-researcher alignment, and an increase in supportive risk taking by corporations.

Value Propositions

- **Federal Agencies**: Insights into what collectively needs to be done for the nation to successfully accelerate advancement using this lever and how the federal government needs to support it.
- **Industry & Capital Community:** Insight into pending capabilities and future use cases. Identification of thought leaders and most-promising researchers. Risk identification and mediation concepts.
- **Academia & Research Organizations:** Awareness of new discoveries and insights. Identification of potential collaboration partners. Early stages of establishing an ecosystem that their discoveries can transition into.

Lever 2: Mobilizing a Network (Active Ecosystem)

Lever Objective & Supporting Partnerships

The objective for this lever is to bolster situational awareness and accelerate the transition of a new general S&T capability into solving real-life problems and challenges by getting potential users engaged with innovators earlier in the development process.[14] That is, creating ecosystems where transition possibilities are exposed to increased real-world situational awareness of the problem sets or the emerging tech, thus creating new opportunities to simulate and prototype potential solutions with increasing fidelity and consideration of the end user's needs and constraints. This is usually done by identifying major emerging trends, creating inventories of communities of thought, aligning with the venture capital and investment community, and providing a bridge into industry (and associated markets/user communities). Efforts should focus on creating and actively promoting active networks that coordinate activities across government, industry, and academia, as well as methods of accessing capital.

From a partnership perspective, the key is to convene ecosystems of like minds and emerging companies and give them access to the broader environments that lead to accelerated solutions. Continuation of conferences/workshops will still benefit this lever, but to truly accelerate advancement other innovation-centric partnership approaches such as challenges,[15,16] demonstration programs, and other types of clearinghouses that connect business challenges with emerging technologies will be required. Moreover, certain early-stage S&T can benefit from concerted and collaborative efforts to bring it to market—this invokes innovation-centric partnerships such as joint ventures and other undertakings to develop specific applications and derivative IP that are commercially viable. Infrastructure-centric PPPs that connect innovators and entrepreneurs with capability providers (e.g., computational, simulation, and at-scale testing environments) also provide benefit by facilitating access to needed capabilities and related support at lower cost (due to co-resourcing yielding something greater than the sum of its parts).

Metrics for Assessing Progress & Impact

Metrics at this stage include:

- To what extent are specific partnerships accelerating time to market, enhancing the viability/usability of S&T applications in products, and connecting businesses to capital and markets?
- How robust and useful are the knowledge inventories?
- How is the partnership and related infrastructure being routinely leveraged to aid in knowledge sharing, productizing the S&T solution, and fostering fit-to-market (or market creation)?

- To what extent are innovators beginning to understand potential users' operational desires and factoring that into their product development—and users beginning to understand a new technology's opportunities and tradeoffs (i.e., creating demand)?
- To what extent are regional hubs, communities of practice, or other similar partnerships sufficiently being created/grown to establish an active ecosystem?

Value Propositions

- **Federal Agencies:** Insights into what collectively needs to be done for the nation to successfully accelerate advancement using this lever and how the federal government needs to support it.
- **Regional Innovation Hubs:** Easy-to-obtain awareness of potential impacts of the new technology, the key local players, and how to shape investments and activities to achieve maximum benefit.
- **Industry & Capital Community:** Accelerated time to market and enhanced product-market fit. Exposure to future operational opportunities across a variety of use cases and potential alignment with various innovative approaches. More insightful trend analysis and enhanced access to technologies and representative users.
- **Academia:** Transition of intellectual property (with associated licensing revenue and spin-offs).
- **Research Organizations & Nonprofits**: Insights on opportunities and issues sufficient to drive their early-stage endeavors in standards, best practices, systems engineering, and policy or regulation.

Lever 3:
Demonstrating Impactful Solutions

Lever Objective & Supporting Partnerships

The objective for this lever is to accelerate time to market (and market stabilization) so that new innovations create meaningful impact. Community-wide standards and frameworks will need to emerge to enable faster adoption of new solutions within and across multiple markets. There are two subtypes of partnerships for this lever, which have different (yet mutually supporting) objectives: foundational stability and solution demonstration.

Partnerships supporting this lever will tend to focus on issues where there are well-defined challenges that need integrated attention (and possibly pooled resources). These infrastructure-centric partnerships enhance foundational stability by drawing on the broad community ecosystem to create holistic solutions that enable greater effectiveness, efficiencies, and performance that wouldn't be possible independently. Individual partnerships will generally focus on developing needed capabilities/artifacts (e.g., standards, risk management and other frameworks, software development kits, application programming interfaces, and other means of fostering related ecosystem innovation and interoperability) that undergird the growing opportunity space around a particular S&T solution. Successful partnerships invoke a virtuous cycle or network growth dynamic, attracting more and more entities to build a foundation of related capabilities and services for the particular S&T focus.

To accelerate via this lever even further, a community can create an environment to demonstrate new capabilities in the context of priority use cases. Partnerships that do so not only accelerate technology transition but also highlight opportunities for acquisitions and

mergers, which can strengthen individual entities and the overall market. These partnerships facilitate opportunities to pilot S&T products to benefit the technology's owner directly, the potential customers of that technology, and the broader ecosystem via sharing insights gained throughout the community. Again, a virtuous cycle forms wherein these pilots show something is real, attracting other attention and investment and promoting maturity of the product through continued refinement as well as greater exposure in the customer base.

Federal government efforts at accelerating innovation should focus on encouraging demonstration projects. The government has a breadth of piloting environments and opportunities across a variety of operational contexts, direct access to voluminous amounts of data, and an unprecedented ability to convene entities to participate. The federal government also doesn't need to worry about demonstration projects impacting its financial bottom line like private sector entities do and has a much larger audience and ability to publicize the activities and their lessons learned. The government should also prioritize creating and supporting any other critical yet high-risk partnership endeavors at this stage.

Metrics for Assessing Progress & Impact

Metrics for partnerships focused on foundational stability should address the generation rate (e.g., number created, how many entities are involved in the creation) and penetration rate in actual usage of the most important artifacts. Metrics for partnerships focused on demonstration projects should address how well new capabilities impact operations in the most important use cases, and how well lessons learned from those pilots are shared throughout the remainder of the community and incorporated into maturing the product. Related, information-centric partnerships should provide participants unique insights into how their S&T solutions are performing in the real world, enabling more effective and efficient allocation of resourcing to ongoing product development and delivery/support channel optimization.

Value Propositions

- **Federal Agencies:** Ability to target early-stage demonstrations and technology transfer toward issues of greatest impact to the nation's future security and economic prosperity.
- **Regional Innovation Hubs:** Establishing their region as an early adopter and thought leader in leveraging a new technology within specific domain(s).
- **Industry:** Community-wide foundations lower any individual organization's cost and risk, open avenues for new applications, and accelerate time to market. Demonstration projects provide insight into operational considerations so that they can enhance their future products while helping to establish a user base while also reducing barriers for transitioning research to practice. Overall, this lever provides the foundation for new companies, increases exposure to emerging solutions, and accelerates emerging routes to market—all of which are critical in delivering solutions faster and more effectively than current approaches.
- **Research Organizations:** Demonstration projects initiate their rapid ascent in importance within the community, as their systems-level work begins to take precedence. These projects also provide insights and evidence to guide their efforts in developing supporting artifacts.

- **Non-Profits:** Demonstration projects provide evidence on which to base their investigations into policies, regulations, and best practices.
- **Capital Community:** Supporting artifacts signal community maturation and nearer-term growth, while the demonstration projects fine-tune their assessments of which technologies and use cases they should focus on.

Lever 4: Increasing Business/Industry Engagement

Lever Objective & Supporting Partnerships

This late-stage lever occurs when markets, standards, and policies begin to stabilize, thus allowing more complex operational capabilities and broad adoption to occur. Partnerships can be instrumental in filling critical informational and infrastructure gaps, assessing performance of solutions in the real world (e.g., safety, cybersecurity), as well as informing public policy and awareness. Partnerships can increase awareness and adoption of solutions, which serves to attract other ecosystem services and solutions that complement or extend the solution in the market. Interestingly, conference and workshop-style forums again begin to take priority due to the need for cross-community information sharing to uncover remaining hurdles. In particular, information-centric PPPs can play a substantial role in this timeframe, as they allow participants to obtain data-driven insights not otherwise possible due to the complexity and scale of the ecosystem and related challenges. They also can allow participants to provide for a common response to known or emerging challenges in the product's ecosystem, such as countering the asymmetry of bad actors/cyber threats and detecting or predicting rare events affecting public safety or economic growth.

Metrics for Assessing Progress & Impact

Partnership metrics in this stage can be harder to establish and assess due to the sheer size of the community compared to the partnership itself. Yet partners with shared interests have showed they can co-define metrics specific to their partnership that are resonant and achievable. Examples may include the number of potential safety incidents detected or proactively avoided, the number and severity of cyber vulnerabilities or threats addressed, or the tangible economic value of those insights to the participants and the economy as a whole as partners take action on them. Simple metrics on conferences and workshops, such as participation rate of key community players, also remain useful.

Value Propositions

- **Industry:** Maximizing utility and usability of products. Early stages of setting up transition of legacy technology to next-generation (or superseding) technologies (e.g., 4G to 5G to 6G).
- **Government:** Obtaining insights into the effects of technology adoption on the population and mitigating related risks in collaboration with industry (e.g., complementing or supplanting traditional public-interest regulation by agencies with voluntary, partnership-defined standards and expectations).
- **Research Organizations & Nonprofits:** Insights to fine-tune systems engineering and policy activities.

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For more information about the Center for Data-Driven Policy, contact policy@mitre.org.

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[1] Translational or use-inspired research refers to the process of leveraging new discoveries from basic research to develop new techniques, methods, or technologies that are useful in practical applications. It can be thought of as bridging the gap between basic research and applied and advanced research.

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[6] See e.g., G. Haeringer (2017) Market Design: Auctions and Matching. MIT Press.

[7] Data within this table comes from a variety of sources, updated over time, including: Grandview Research; Inside Ace Analytics (2030-2035); Fortune Business Insights; Bloomberg Research; Markets and Markets Research; Research Nester; Future Market Insights; Acumen Research and Consulting; Electronics Media Research; and Pitchbook Research.

[8] The 7.47B number represents 6G only; $159.54B number represents both 6G and 7G.

[9] "Deep tech" is a term that generally refers to scientific innovations and cutting-edge technologies that can potentially impact industries and economies significantly. The term is also used to classify a startup company's area(s) of focus.

[10] Angel investors, typically individuals rather than a venture capital firm, provide startups with their initial funding and strategic guidance, often in return for some equity in the activity. Angel investors are instrumental in helping startups gain traction before the startup is mature enough to successfully seek larger funding investments.

[11] The National Artificial Intelligence Research Resource Task Force (NAIRRTF). 2023. White House Office of Science and Technology Policy, https://www.ai.gov/nairrtf/. Last accessed August 11, 2023.

[12] Defining PPPs. 2022. MITRE, https://ppptoolkit.mitre.org/defining-ppps/. Last accessed August 11, 2023.

[13] The Government Effectiveness Advanced Research (GEAR) Center was a White House concept to create a public-private partnership that would improve mission delivery, citizen services, and stewardship of public resources. For additional information, see: https://trumpadministration.archives.performance.gov/GEARcenter/index.html.

[14] Note that this lever was the primary focus for the previously mentioned GEAR Center project.

[15] The Challenge Model: An "Outside-In" Approach to Tough Problems. 2020. MITRE, https://www.mitre.org/news-insights/impact-story/challenge-model-outside-approach-tough-problems. Last accessed August 21, 2023.

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