GETTING INNOVATION RIGHT IN THE STRATEGY FOR LONG-TERM COMPETITION

Workshop Summary

April 16-17, 2019

Center for Global Security Research
LAWRENCE LIVERMORE NATIONAL LABORATORY

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Background:

On April 16 and 17, the Center for Global Security Research (CGSR) at Lawrence Livermore National Laboratory (LLNL) hosted a workshop to better understand the relationship between defense strategy and emerging innovation. A primary objective of the workshop was to uncover which processes foster innovation that can help the United States outcompete adversaries and bolster national security. The workshop brought together 63 participants from across the policy, military, and technical communities. Panelists addressed U.S. innovation strategy and inter-departmental initiatives, adversaries and innovation, drivers of technology strategy, private-public collaboration, and ally innovation. The conversation shifted to identify obstacles standing in the way of effective innovative policy, and how any long-term strategy must adjust accordingly to ensure innovative might.

The following key questions guided the discussion:

1. What is required to "out-innovate" major power adversaries?
2. What goals and metrics should guide innovation strategies?
3. Does the strategy for S&T innovation address adequately all of the military domains where the major powers compete?
4. Does the defense strategy ensure the needed innovation in strategic and operational concepts, organizations, and processes?
5. Are there useful lessons for innovation from past defense reform efforts?

Key Insights:

1. Long-term competition with other major powers is inherently multidimensional. Competition is not limited to the military dimension of relationships, but also encompasses economic, scientific, political, even ideological aspects. The National Security Strategy takes this broader view, whereas the National Defense Strategy focuses primarily on the military dimension.

2. Innovation means something different in each of these dimensions. Different communities of interest use a common vocabulary to mean different things, and thus sometimes miscommunicate. The goals of innovation vary across this multidimensional landscape, as do the obstacles to success and the metrics for judging effectiveness.

3. The aspiration to "out-compete adversaries" implies a net assessment approach with Russia and China—whose strengths and weaknesses as competitors are often misunderstood in the U.S. Both are formidable competitors, though each has different strengths and weaknesses as innovators. Both have innovated at the strategic level of war and have achieved major reforms in defense and military strategy, in planning for all-domain regional war, and in exercising for such a war. Russia's innovative strength is its deep scientific culture. China's is its ability to generate and direct huge amounts of capital, including human capital. It's no longer just a "fast follower;" it is moving into a leadership role on many fronts.

4. In the U.S. strategy for long-term competition, innovation can play an important role in shifting the military net assessment in Blue's favor. But it cannot do so without a sound understanding of the problems that the military needs to solve. As the National Defense Strategy Commission concluded, that understanding is missing today. There is insufficient understanding of the operational challenges facing U.S. and allied forces in a major regional war against Russia or China, or of the ways in which existing or conceivable technologies might be utilized to address those challenges. More attention is needed to assess the operational challenges that the U.S. and its allies can or might be able to present to our adversaries or of the ways in which existing or conceivable technologies might be utilized to address those challenges. U.S. military planning and thus U.S. capability development plans are informed by a number of dangerously optimistic assumptions: (1) that the U.S. will face a single military foe at a time, (2) that the U.S. homeland will be a sanctuary, (3) that the U.S. will have assured access to critical overseas facilities, (4) that war with a major power adversary will be localized to its region, (5) that the U.S. and its allies will have air superiority, sanctuary in space, and information security, and (6) that the U.S. and its allies will be able to re-supply their forces at war. Innovation at the conceptual level, at the operational level, and in capability development are essential to dealing with the reality of these flawed assumptions.

5. Successful strategies for innovation generally require:

    - A high degree of motivation (in the military realm, a strong dose of fear or failure)
    - Clear goals aligned with the right kinds of questions
    - Sustained leadership focus
    - A healthy irreverence for precedent
    - The freedom to experiment and the time and resources to get it right while learning through failures
    - Organizational structures that are mission-focused and flexible.

6. Some organizations are capable of meeting these requirements for the long term, others succeed only for a single major cycle of war, and still others prove incapable of innovation. A critical discriminator of success is institutional culture: many organizations are averse to both risk and to the changes necessary to become more open in identifying new opportunities and challenges

7. Successful innovation often involves partnerships outside the USG. Overseas allies can play numerous useful roles. They may have unique scientific or engineering expertise. They may be effective in coming to quick but durable decisions. They may be able to test in a more permissive environment than the U.S. Private sector partners also play numerous useful roles. The successful mobilization of private venture capital to enable start-ups and experiments has helped re-focus DoD priorities. Innovative funding mechanisms (DARPA, In Q Tel, DIU, SOFWERX) are making progress. Some bigger tech firms are stepping up, while others shun close association with the USG. Further progress in developing public-private partnerships requires more than ad hoc collaboration. Long term partnerships depend on developing a cadre of people who build bridges between the USG and the private sector. Temporary exchange assignments between government and industry are key to building such bridges.

8. The national laboratories are also focal points of technology innovation, but often must respond to USG sponsor interest in applied science at the expense of basic research. Innovation is needed to empower the national labs to explore new technologies. However, funding and management practices developed during the Cold War are no longer as effective at spurring innovation. Allowing greater flexibility to explore innovative ideas will help to energize the contributions made by the national labs.

9. Cold War successes in innovation cast a long shadow of expectation over the present period. Among Americans there is a widespread optimism that America and Americans excel at innovation and can readily engage military competition to U.S. advantage. This may not be particularly well-founded. There are many sources of innovation in the U.S. economy but their application to military operational problems has been difficult to mobilize. Foreign competitors appear to be highly motivated to compete with the U.S. in military technology, including large expenditures for technologies with direct military applications. It is not a foregone conclusion that the U.S. will prevail with superior technologies and military strategies.

Panel 1: Innovation and U.S. Defense Strategy

- How does the National Defense Strategy (NDS) define the role and contribution of innovation, Science & Technology (S&T) and otherwise?
- How did the "3rd offset" strategy of the preceding administration define them?
- What did the NDS Commission conclude and recommend?
- Has thinking converged or diverged?

After a quarter century perceived respite, the United States now faces intensified competition with Russia and China. The National Defense Strategy (NDS) has diagnosed this challenge and the operational circumstances accompanying it, but the issues remain. It identified a need to innovate but was limited by what could be released publicly.

In response to the NDS and its stated need for a clear strategy, the NDS Commission produced an unclassified list of challenges. This list resembles those threats and limitations identified in the 2001 Quadrennial Defense Review released 18 years ago. These include:

- Protecting critical bases of operation
- Rapidly reinforcing and sustaining forces abroad
- Projecting and sustaining U.S. forces
- Defeating area denial threats
- Deterring and defeating the use of nuclear weapons
- Enhancing the capability and survivability of space
- Leveraging innovative concepts to develop interoperable C4ISR capability

Regarding technical innovation, the challenge is how to foster or "nudge" novel technology that will advance U.S. national security interests. One solution is to increase government partnerships with the private sector and allies abroad. Since the end of the Cold War, U.S. Research & Development (R&D) investment in technology as a percentage of Gross Domestic Product (GDP) has declined, however overall dollar amounts have remained linear because the private sector has made up the difference. Japan, Germany, Korea and Israel are in the top five spenders on R&D in the world, following the U.S. and China. Leveraging the expertise of allies will be a crucial to U.S. innovation strategy going forward. Discussants asserted that when attempting to outcompete adversaries, partnering with allies and private entities can help elevate strategic positioning within contemporary great power competition.

While the U.S. is still the top spender in R&D in terms of absolute dollars, China is quickly catching up. In terms of Chinese expenditures in R&D relative to the U.S. as a share of GDP, China spending was at 80% relative to the U.S. in 2007. Now in 2019, that percentage is closer to 120%. Similarly, China is spending more than the U.S. as a whole on Artificial Intelligence (AI) R&D at the moment. If these trends continue, China will eventually surpass the U.S. in absolute R&D spending. Russia is not investing at a similar pace in R&D but place heavier emphasis on nuclear weapons and deterrence as a priority for their innovation policy. Partnering with the private sector as well as allies can offset these growing challenges to U.S. technology

advantages. Attendees noted that defense spending can indicate doctrinal focuses and that this trend may indicate shifting postures within great power competition in defensive strategy.

The decline in federal R&D and the rise of private sector investment has had a noticeable impact on U.S. federal strategy. Silicon Valley does not necessarily see strategic competition the same way the USG and the traditional defense sector do. Few leading tech companies prioritize defense related technology innovation or government partnerships, while some corporations are interested in helping but don't know how to do so. Others avoid collaborating with the USG for fear of alienating foreign customers. From an industry perspective, one particular roadblock to effective collaboration is the absence of clear policy objectives with compelling incentives to guide public-private partnerships.

Clear, coherent leadership and direction within government tech bureaucracy is a major challenge for U.S. innovation. Participants agreed that many organizations with Science & Technology missions in the government currently compete with each other, muddling which agency holds jurisdiction on initiatives. Additionally, inability to prioritize and request needed technology from the private sector further impedes crucial collaboration on matters.

Communication is essential for the U.S. to fortify cooperation with allies on defense related strategy. Thus, providing clarity surrounding national security priorities may answer some of the toughest questions facing effective innovation for the United States. Though the NDS starts this process, clearer delineation of goals outside of classified realms is necessary to override imbalances in public-private security agendas.

Panel 2: Adversaries and Innovation

- What are the strategies of Russia and China for defense innovation?
- What are the strengths and weaknesses of those strategies?
- Are there useful lessons for the United States and its allies

After analyzing strategies employed by U.S. near peer adversaries in the innovation space, considering renewed strategic competition, any useful assessment must focus on insights from Russian and Chinese efforts and the ways in which they pose threats to U.S. interests.
One explanation for Russia's innovation push is its belief that NATO overmatches its own native capabilities and thus it must generate superior technology through domestic innovation. China has taken the last few decades to learn from U.S. successes and failures by taking an "economy first, defense second" approach to modernization of its military capabilities. China has directed significant economic resources toward critical S&T sectors for the purpose of advancing economic and military objectives.

Looking at Russia's advantages and disadvantages in innovation, Russia's bright minds and Cold War success stand out as leverageable traits, but their limited S&T private sector is an obvious Achilles' heel. Russia seeks genuine innovation in the military space based on its own experiences and strong scientific heritage. This task remains challenging, as genuine innovation

requires investment and infrastructure, which are in short supply. Nonetheless, Russia's primary advantage in innovation is a history of cooperation between the government and private sector.

Leveraging this cooperation, the Ministry of Defense initiated projects such as the Technopark-ERA, which brings together military and civilian experts to develop next generation technologies; the National Technology Initiative, which identifies new key technologies and focus areas for innovation; and the Advanced Research Foundation, which fosters closer ties between government and technical universities stressing AI and robotics specifically. These initiatives attempt to bolster domestic innovative spaces, but few significant breakthroughs have yet to be cited.

The Syrian conflict has proved the ultimate testing ground for Russian innovative technologies, skills, and warfighting tactics. However, even though Syria has been opportune to test Russian defense modernization, attendees concluded that Russia will still have to overcome its lack of infrastructure supporting internal innovation. Crucial infrastructure includes supporting a start-up culture, increasing venture capital and investment, and necessary protection for intellectual property. The absence of reliable legal structures inhibits innovative business models. This lack of infrastructure and the "brain drain" of capable personnel to the West, has resulted in a generally low level of Russian national innovation despite newly invigorated government efforts, especially in the Russian Silicon Valley, Skolkovo.

China presents a mounting threat for United States supremacy in S&T. China's focus on building a stronger economy to ensure consequent innovation is succeeding. China has shown its ability to not only copy technology but has also demonstrated that they can genuinely innovate, especially in the areas of AI, biotech, space, and quantum computing. Thus, the playing field between China and the U.S. is more level than ever, with much of this being attributed to China's ability to learn from the successes of the U.S.

China's advantages also stem from its significant investment in the education and cultivation of future talent, its ability to influence technology companies, and its focused initiatives such as those championed by the Chinese Academy of Military Science. China employs a more focused strategy than Russia, guided by ambitious plans and timelines supported by human and institutional resources. Rather than trying to catch up in all areas, China seeks to outpace peers in specific fields such as in AI and quantum computing where it is fast becoming a global leader.

However, China also faces difficulties. "Private" Chinese tech giants are both dependent on and subject to the Chinese Communist Party (CCP). Some think the commitment to state ideology could also spell problems for China as it balances control with spurring innovation. As these companies seek to distance themselves from government control, China has had to reexamine their perception of private companies, which may become a double-edged sword. Previously seen exclusively as national assets, the CCP has begun to understand that corporate independence may become a threat to their control. The PLA also lacks field experience and seeks to learn from Russian and U.S. military experiences to bolster operational readiness.

Discussion concluded that the most effective strategies employed by Russia and China include monitoring the opposition's war fighting tactics, testing innovation in current conflicts, and the mimicking of initiatives like grant programs and monetary resource allocation to desired areas of growth.

Panel 3: Comparing the Approaches of the Departments of Defense and Energy

- How does DOE approach the requirement for S&T innovation?
- Is it well aligned with the DoD approach?
- Should coordination be improved? Can it be? If so, how?

The Department of Energy (DOE) was born out of the consolidation of multiple governmental missions, including the core mission of supporting the military and peaceful uses of nuclear energy. These missions depend on innovation, which has traditionally come from the National Laboratories. Building on the nuclear missions, DOE and the labs have used resident expertise to bring innovative solutions to a wide range of U.S. national security issues, many of which are shared with and sponsored by DoD. However, there are important differences between the basic scientific research conducted by the labs and some of the applied science that is directly funded by DoD. The latter projects are conducted and funded according to optimal timelines and restricted budgets that often leave little room for true innovation. By contrast, basic scientific research funded by DOE provides the basis for specific applications, but may not comply with programmatic metrics due to the nature of scientific discovery.

Basic scientific experimentation can span decades, with breakthroughs emerging that can change the way the entire world understands nature. These breakthroughs then can be transformed, or "spun off," into applications for national security, although that may take time. Innovation in this context comes in the form of experiments with unknown results. Efforts like Laboratory Directed Research and Development (LDRD) and various initiatives by Defense Advanced Research Projects Agency (DARPA) have been critical force multipliers for exploiting such scientific breakthroughs.

Nevertheless, both DOE and DoD face challenges with innovation. For example, as DoD focuses much attention on the procurement of large weapon systems, it devotes fewer resources to pure research and development. Moreover, by the time a large weapon system such as a ship, airplane, or satellite is delivered, its technology is obsolete. In this case, innovation is needed in the processes for procurement. Additionally, contrary to innovation coming from the government for the majority of the 20th century, most technology now comes from the private sector, leading the DoD to increasingly rely on the private sector and "commercial off-the-shelf" supply chains. This begs the question: how does the government innovate in light of such dependence on existing government and commercial arrangements?

The rapid pace of technology development poses a major challenge for DoD innovation. Artificial intelligence offers a useful illustration of a technology that is advancing faster than the ability of government bureaucracies to integrate into their plans and operations. The Third Offset started a process of preparing bureaucracy to adapt to the timelines of Silicon Valley and their fast pace

creation processes. Working with the private sector on cutting edge technologies also has implications for export controls and proliferation of emerging technologies, as these companies depend on global markets and reject restrictions based on national security. Defense officials are aware of the need to bridge the gap between private and public interests to prevent sensitive technological developments from becoming global assets, while at the same time respecting the bottom line of tech companies.

DOE and DoD have significant experience working together to foster innovations across the spectrum of weapons, command and control, delivery platforms, and strategies to guide the use of these capabilities. Both departments facilitate long term commitments to build these multi-billion-dollar systems. However, panelists noted deep differences in organizational, cultural, legal/operating procedures, and development timelines that accentuate the differences between the two organizations. These departmental characteristics apply to the operation and management of their respective laboratories as well.

Throughout each institution's evolution, coordination between DoD and DOE has remained consistent regarding the nuclear stockpile. NNSA labs have largely facilitated these linkages between the design and production of nuclear weapons and their deployment by the armed services. DoD and DOE have no choice but to view each other as continuous partners in deterrence, and to serve STRATCOM and other DoD customers accordingly, which may require collaboration in emerging fields beyond their historical nuclear cooperation.

Panel 4: Balancing the Drivers of Change

- What happens when technology drives strategy?
- What happens when strategy drives technology?
- How can the necessary balance be achieved?
- What lessons follow from past experience?

When analyzing the drivers of innovation strategy and distinguishing between when technology drives strategy and vice versa, participants focused on three major drivers of innovation: environment, need, and opportunity. Considering past environments surrounding ages of innovation, panelists reflected on historic successes and failures and the threat perceptions that inspired innovation.

Attendees generally agreed that today's environment appears to be one in which technology is driving strategy. Cyber and space are good examples. Changes in technology occur at tremendous speeds, which in turn has led to an even wider gap between policy and technology. This environment has granted nations, organizations and individuals unprecedented access to technology at a higher volume than ever before. One result of this fast pace accessibility is the recognition of new security issues that naturally come along with new opportunities for human benefit. Balancing the threats with the opportunities is the domain of strategy, especially within the context of Red and Blue strategic competition.

The threats and opportunities resulting from global innovation require new strategies to cope with great power competition, terrorism, regional conflict, and the full span of hybrid warfare including information warfare, cyberwarfare, and multi-domain competition. Grand strategy must address complex deterrence, taking into account the many permutations of offense and defense in multiple domains. Innovation is bringing rapid change to the technological means of conflict but seems to be lagging in strategy and policy.

Ensuring that innovation from government sponsored projects addresses strategic goals requires communication between inventors and operators, creative conceptualization of defensive capabilities, and resourceful integration of existing technology. Discussion posited that the U.S. doesn't necessarily need innovative responses to every possible threat; the essence of strategy is to prioritize the uses of resources. Participants noted the lack of innovation devoted to many mundane yet fixable problems long recognized by DoD, such as the Defense Travel System (DTS), inadequate cyber defenses, and the national system for passing security clearances. Instead of fixing these legacy systems and reaping tremendous benefits from improved security and efficiency, innovation efforts focus on the latest "shiny widgets."

Finally, the best way to ensure that threats can be recognized and mitigated is to maintain a deep S&T bench of experts who are capable of rapid innovation when needs arise. This means not only maintaining a cadre of scientists, but also developing "bridgers" who easily move back and forth between government, researchers and the private sector to connect and translate the needs of military and intelligence operators with R&D tech innovators. The national labs are particularly well suited to play this role.

Panel 5: Partnering with the Private Sector

- Over the last few years, how did such partnerships form or evolve?
- Have those partnerships met, exceeded, or fallen short of expectations of both public and private sector actors? Why?
    - Are there particular challenges of partnering with the "discovery sector?"
- Looking to the future, what does "out-partnering" with the private sector require (of both the public and private sectors)?
- Accelerating innovation for the intelligence community

The group reviewed lessons learned from previous efforts to develop public-private partnerships. Panelists discussed the achievements of In-Q-Tel and Defense Innovation Unit (DIU) as examples of successful partnerships. In-Q-Tel leverages venture capital partners to invest in dual use technologies to address intelligence community needs. DIU provides limited funding to emerging tech companies to meet specific defense requirements. In both cases, the companies are not solely dependent on the government for commercial success.

Participants agreed that the government must do a better job of clarifying its specific requirements to its private sector partners. Many companies expect greater transparency about the applications for which its technology is being sought. Furthermore, the government needs to

be more willing to explore innovative/non-traditional options for collaboration. Security requirements and working conditions sometimes dampen enthusiasm for working with DOD, the IC, or DOE.

Another problem is longevity and consistency. Companies are more interested in long-term, mutually beneficial partnerships and less willing to jump into one-time contract jobs. For example, when software is a primary product, updating hardware and software becomes a major concern, especially when program managers and designers have moved on. In order to ensure operational users' access to that technology down the line, long-term collaboration is key. Participants gave examples of well-known but solvable problems that plague DoD that are ripe for solutions rather than trying to generate new technologies. Even for tractable problems in which the government and the private sector successfully collaborate, sustaining such collaboration is often difficult. After the initial success, a budget and management handoff are essential to move from developmental to institutionalized status.

Another roadblock for successful private-public collaboration is a perception that there is a lack of willingness, or even patriotism, for tech companies to work with the often-cumbersome national security bureaucracy. Participants noted examples such as Google employees opposed to supporting DOD projects, but complacent about helping the government of China with tools that are used to suppress freedom. Discussants asserted that this is not necessarily the case, and that despite such opinions stemming mostly from a vocal minority which are not reflective of industry as a whole, bureaucratic red tape along with under-compensation (for both contracts and individuals) are unattractive for private industry. Innovation throughout the acquisition process will be necessary for ensuring public-private cooperation and for sustaining the U.S. cutting edge in defense.

The U.S. is in many ways already "out-partnering" U.S. adversaries, due to the leading position of many of its companies and research centers but should make improvements to enable the government and the private sector to expand collaboration to solve mutual problems.

Panel 6: Partnering with Allies

- Is defense innovation, in all its dimensions, something that can be pursued collaboratively with allies? If so, how?
- What are the lessons of recent experience in trying to build such partnerships?

This session compared the defense innovation experiences of two U.S. allies, France and Japan, and assessed options for advancing allied collaboration.

France has historically built its defense innovation system around its goal to sustain high levels of self-reliance and independence. After the Second World War, the responsibility of developing, testing, and assessing emerging equipment and technology for the French military was entirely in the hands of the French Defense Agency (Direction Générale de l'Armement – DGA). Generous budgets and, to a lesser extent, the DGA's ability to co-specify and influence technical

solutions for the French military, contributed to such a system being sustainable and successful during the Cold War.

However, owing to budget reductions following the end of the Cold War, France needed to build novel partnerships between the DGA, its military services, and the private sector if it were to avoid dependence on foreign innovation. By doing so, it recognized that while public procurement agencies were capable of managing long-term problems, the private sector exceled at answering immediate needs in a speedier manner. As a result, France remained a highly independent and explorative innovator, nurturing an entire spectrum of technology over multiple domains, including space, cyber, and artificial intelligence.

In contrast, Japan's defensive strategy has been primarily adaptive rather than forwardly innovative. But recent events like the devastating earthquake followed by tsunami in 2011 served as a lesson for Japan that it needed to make a shift from adapting to innovating. To address this issue, the Japanese government undertook a series of activities, focusing their effort on policy innovation. With its desire to lessen the burden of protection placed upon the U.S., Japan adopted legislation that opened up new frontiers of cooperation with the United States. Thus, Japan's Ministry of Defense decided to replace almost half of its older fighter jets with new F-35A and F-35B aircraft. Japan has also ramped up efforts supporting its conventional missile capabilities in response to hostile actions from North Korea and increased cooperation with the U.S. on missile defense. For Japan, these moves represent a form of innovation in partnering and strategy.

When looking at both cases, participants observed that partnering with allies is a defining issue. While the positive effects of innovation from collaboration were undeniable, the risks could not be ignored.

On the one hand, there is a possibility of overdependence, which is why the French Ministry of Defense generally dissuades collaboration with the United States, even though there is an ongoing active interaction between the French and their U.S. counterparts. Overreliance on ally acquisition can have stagnating effects on domestic capabilities. Further, too much sharing of technological development can result in the loss of control over valuable domestic assets. In other words, sharing has its limits. For U.S. allies, limited military budgets prohibit large scale purchases or running operations at scale with the U.S. As a result, some European/NATO countries are tempted by cheaper alternative supplies from China and elsewhere, which can cause problems for interoperability and joint operations with allies.

Secrecy and confidentiality are a constant concern, be it for national security or commercial reasons. Cooperation on common projects is only possible when all parties agree to share sensitive information. Variation in export controls and sharing policies sometime impede common goals. Innovation among allies should be understood in a broader context that goes beyond tactical and operational cooperation to include high level competitive strategy.

Panel 7: Overcoming Obstacles to Success

- What is success? Are there metrics?
- What are the barriers to more effective innovation?
- What can be done to address the barriers?

During the Second World War, science and technology were seen as a strategic advantage by all countries involved in the conflict, and the United States, perhaps more than any other, has been relying on innovation ever since to harness that advantage. In the Cold War era, the military component of economic competition gave the U.S. a definite edge over the USSR. While useful to spur innovation then, today economic competition might not guarantee the U.S. its leading position against different opponents today. Special effort must be given to foster R&D in topics that are vital to military competition. Given China's ambitious goal to shift the center of global power from the Euro-Atlantic to the East, how can the U.S. direct innovation to maintain its competitive advantages?

The group noted that innovation remains largely undefined, especially on a national scale. Successful R&D requires working on the right questions, whether directed by the federal government or the market itself. For basic science, the search for knowledge essentially guarantees innovation, but does not ensure military applications. For applied science, a good understanding of the problems to be solved is essential. Moreover, innovation involves trial and error, meaning that engagement needs to be timely and resourceful enough to allow for mistakes to be made and course corrections to be asserted. Long-term perspectives on innovation provide room for failure and create an environment of learning, allowing enough latitude to step back and look for alternative ways of thinking. The alternative is to stick with proven, low risk solutions.

Regarding metrics, translating the potential value of ideas into quantitative measures is challenging. Beyond the standard measuring tools, such as money spent, return on investment, number of patents, and awards received, equally important is the record of failures. Within the private sector, where failures are expected and embraced, they are used to gauge whether there is sufficient innovation to break new ground. The absence of failures indicates conservative thinking. Metrics should be geared to assess the exploratory learning process alongside programmatic successes. The U.S. government is notoriously intolerant of R&D failures, which are viewed as a waste of taxpayer dollars. Too often, guaranteed success also means reliance on old approaches.

The fact that most of present-day U.S. defense capabilities stem from earlier innovation illustrates the problem of inadequately harvesting innovation outside its expected area of application. Bureaucratic stovepipes, cost and time restraints, and regulations can prevent innovative ideas from being shared across government agencies. One result is redundant efforts in which government agencies attempt to reinvent solutions that already exist.

As major sources of technology innovation, U.S. government labs are particularly well-suited to the scientific research and longer time scales often required for complex national security problems. However, onerous reporting requirements and operational mandates imposed on the labs can undermine efforts to innovate. Aggressive timelines, uncertain budgets, low risk tolerance and voluminous bureaucratic red tape minimize the room available for innovation. These conditions also create obstacles for recruiting talented people who choose to engage with the free-spirited and high paying private sector instead of government-sponsored research facilities.

The group expressed optimism that these obstacles to innovation can be surmounted, but a compelling case must be made to persuade leaders of the relevant institutions that greater transparency with partners, higher tolerance for risk and failure, and flexibility with longstanding practices will pay off in the long run.

Panel 8: Acting Now While Looking to the Long Term

- How should we answer the workshops key questions?
- What can and should be done now by DoD and DOE?

The final panel focused on how innovation can be applied to achieve U.S. national security objectives, such as those expressed in the National Security Strategy. For innovation to improve competitiveness, it is crucial to identify and prioritize key objectives as part of a "competitive strategy". Having identified our strategy goals, how do we use innovation to achieve them?

The group expressed a sense of urgency to spur innovation in R&D as well as in strategy and policy. An integrated approach is required for innovation in DoD acquisition. Bureaucratic practices must be updated to accommodate modern processes of S&T discovery and application at the national labs and with respect to public-private partnerships. Small steps and pilot projects are valuable, as some contributors argued, but a systematic overhaul in the S&T acquisition process may be necessary in the long run.

Identifying and establishing metrics is important to ensure that the money, time, and personnel invested in government R&D are garnering desired results. However, established government metrics are not appropriate for new processes needed to spur innovation. New metrics that align with broad goals can help demonstrate progress within innovative programs and processes. However, the bureaucratic differences in operational, legal, and cultural practices within the DoD and DOE makes metrics difficult to compare across projects and agencies adhering to different expectations. This is true for DoD and DOE labs as well as universities and companies. Discussants agreed that while metrics are important, they are not universal. New metrics should accommodate different organizational cultures and reflect differences in risk tolerance, flexibility, and transparency needed to exploit innovative ideas.

Regarding innovation to address pressing national security needs, the group identified several issues that appear well suited for innovative initiatives but are not current priorities. Areas where innovation on a national scale might succeed include energy, climate, and transportation.

Fortunately, deterrence has reemerged as a priority worthy of innovation. Some in the group questioned the ultimate goal of competing with Russia and China, beyond seeking military advantage, recalling the ideological component of the Cold War and the fight between democratic freedom and communist repression. For the government, (in contrast to the private sector) innovation requires motivation beyond improving efficiency and material advantage. Solving big problems on behalf of one's nation - and perhaps for the good of humanity – is a key motivation. Thus, the articulation of shared goals that require innovative solutions, such as John F. Kennedy's challenge to put a man on the moon, are an essential driver behind bureaucratic action. If "necessity is the mother of invention," the need for competitive advantage must be couched in broader terms.

The workshop represented a first step toward applying lessons learned from various agencies, companies, and countries regarding about what has been tried, what worked, and what failed in the attempt to innovate in national security technology and strategy. These lessons will be valuable as future leaders advance and improve the deliberate use of innovation and apply it to national priorities.

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