

Statement of Dr. Eric Schmidt
House Armed Services Committee
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Mr. Chairman, Ranking Member, and distinguished members of this committee, thank you for the opportunity to appear before you today to testify on the state of innovation in the Department of Defense (DoD). Today, I am testifying in my personal capacity as an interested citizen, not as the Defense Innovation Board (DIB) Chairman, nor as a board member of Alphabet, Inc. My remarks also do not necessarily reflect the views of the Department.

Since joining the DIB in 2016, my fellow board members and I have traveled around the world, visiting dozens of military facilities and installations, and engaging with hundreds of service members – from senior commanders to our men and women in the trenches. Coupled with our collective expertise and experience, these engagements inform the Board’s official recommendations aimed at providing the Department with tangible proposals to tackle diverse challenges. They also inform my testimony today.

I consistently meet brilliant, creative, entrepreneurial people in DoD with novel and implementable ideas, but they are fighting against entrenched processes and regulations that – in some cases – haven’t been modified in decades. Incentives are often misplaced. Decision-making seems surprisingly diffuse for an organization known for its hierarchical structure and decisive leaders. Some of these *intrapreneurs* find workarounds to inflexible systems or receive temporary shelter under a like-minded commander; far more do not. Even the most senior leaders described responsibilities being so intricately nested across the organization that a sense of true ownership proved elusive to them. Early on, I reached a fundamental conclusion that has been borne out over time: DoD does not have an innovation problem; it has an innovation *adoption* problem.

In a sense, this is understandable. The growth in size and complexity of the Department’s mission and systems has contributed both to the increased friction and latency in its decision-making processes and has driven a demand for additional layers of coordination mechanisms. And over time, every lapse in judgment or performance accretes further rules, regulations, or procedures aimed at preventing errors. Yet, the cumulative effect appears to be disempowering for many, even for those engaged on the frontlines of conflict. It is troubling to consider that good ideas were not implemented because of prevailing norms that reward perfunctory compliance or reticence of supervisors to consider new approaches. It is even more frustrating to see passionate service members choosing to leave the military after being continually stymied by these structures.

It is not will, but inertia, that hinders innovation. Most people who protect the *status quo* are motivated by a sincere desire to protect vital institutions that they hold dear. **In my view, the Department tends to overestimate the benefits of consensus, stability, and transparency at the expense of speed and agility. This has produced a culture that prioritizes compliance over results and favors consistency over ingenuity.** When there is relatively little benefit for entrepreneurial results, but grave potential consequence for entrepreneurial risk, there is little

incentive to serve as a change agent. As one of my Board colleagues often says, “process does not trump competence,” and DoD must make that axiom true in our self-assessments and personnel practices.

The Need for Speed

If there were one variable to solve for it would be speed. For decades, DoD has sought to field the “perfect” system to put into the hands of service members, hewing to the notion that superior quality would deliver enduring strategic advantage. Today, that goal largely remains, with some exceptions. I’ve found the Department to rely on the requirements process as a key driver of technological progress, and as a way to manage increasing complexity and ensure incremental gains across multiple systems. That requirements process is now the single greatest barrier to rapid technological advancement.

DoD built a system that assumed it was the prime mover in defense-relevant sectors, and that the world would wait for a perfect answer from the requirements process. This logic held for nuclear weapons, stealth, and precision weapons. But the world waits no longer, and organizations that take years to develop a capability incur the risk of failure. Some argue the Department is risk-averse - I see it differently. DoD assumes a massive amount of risk, but pushes this risk out of the headquarters and onto the battlefield, where service members must wait years before accessing current technology. While change has inherent risk, I believe there is more at stake by maintaining the *status quo* in the face of quickly-evolving security threats and adversaries that are accelerating their technological advancement.

Today, the private sector, not government, is developing the most critical technologies from which modern weapons systems are deriving the most significant advantage. Software and processing speed drive the leading edge of complex weapons systems today, including electronic warfare, cyber, space-based systems, algorithms and machine learning for sensor fusion, the proliferation of unmanned systems and autonomy, and so forth.

With this in mind, everyone in the world - including U.S. competitors - has equal access to this technology. But a slow-moving requirements process intended to maximize consensus among users and drive precision into the defense industrial base does more to hinder rapid adoption of commercial technologies than it does to facilitate it. Improved software engineering and a focus on artificial intelligence (AI) will accelerate DoD’s speed, but only if the Department invests enterprise-wide resources towards this effort.

While many senior leaders I have spoken to recognize this truth and have begun to integrate these ideas into their messages to the force, it is a massive undertaking to overturn decades of deep-rooted processes that impede a shift toward becoming the “fastest follower.” A number of organizations in DoD are adopting proven approaches seen in industry and academia and deserve mention here because they are the most promising examples of defiance to the prevailing systems.

Innovation Success Stories

Part of the Board's mission is to identify promising examples of innovative behaviors and activities to better understand how to spread these practices by both studying and celebrating them. I have encountered a few dozen excellent examples of DoD teams and leaders that are trying – and succeeding – to adopt new approaches and change the culture in their respective organizations. Below is a sampling of just a few of these examples:

The Defense Innovation Unit Experimental (DIUx) opening of offices in key innovation ecosystems around the country two years ago is the main reason why the Department is again considered a viable customer to the commercial innovation ecosystem today. DIUx accomplished this in three ways: first, by rebuilding and fostering relationships with venture capitalists and commercial technology companies; second, offering the Department compelling examples of accessing technology by articulating capability needs rather than more traditional requirements-driven acquisition processes; and third, and most importantly, developing the Commercial Solutions Opening award mechanism, a streamlined procurement process that allows the Department to work at the speed of business.

Moving in days and weeks rather than months and years is a necessity for the kind of start-up companies and small businesses that are at the frontiers of digital technologies that dominate the world I come from. DIUx has demonstrated a keen understanding of how to navigate that ecosystem. I attribute DIUx's success in these three areas at least as much if not more to their organizational design, culture, and the degree of autonomy afforded their project leaders than to their use of Other Transaction Authorities (OTAs) or waivers. DIUx plays a key part in many of the efforts that the DIB is championing, from the agile software development in the Coalition Air Operations Center (CAOC) to upgrades in major weapons systems such as the F-22 and F-35. The CAOC efforts alone have saved hundreds of millions of dollars in fuel and maintenance costs that can be reprioritized to other key projects.

"Kessel Run" is a project run out of the Air Force Life Cycle Management Center to modernize the Air Operations Center, with DIUx's support, whereby over 70 airmen have recently undergone training through a partnership with a company, Pivotal Labs, to learn software and app development in a genuine agile software development environment. It is DoD's version of a Software Factory. These airmen regularly ship new features every week in an iterative process seen in successful software companies. Kessel Run has already saved vast sums of money that would otherwise have been spent through the traditional acquisition process. Cycle times that may have extended years are accomplished in weeks.

One of the DIB's fundamental observations is that DoD has shockingly few "software people," underscoring the DIB's October 2016 recommendation to make computer science a core competency. The benefits of applying modern software development techniques are dramatic and efforts such as Kessel Run demonstrate the need for a more software-centric approach to DoD systems. One of the officers leading this effort said, "Our mission here is to turn the Air Force into a software company that provides airpower." I could not agree more.

Other groundbreaking efforts include *Project Maven*, which is the most successful DoD effort to deliver AI to date; the *Joint Improvised-Threat Defeat Organization (JIDO)*, which enabled the rapid collection, fusion, and dissemination of operational data by building a classified DevOps-enabled cloud computing environment; the *Defense Digital Service (DDS)*, which brings in the nation's top technical talent to work on problems of significant impact where technology fails the mission of national defense.

I am also pleased to see each Service has undertaken promising efforts which, while still nascent, suggest that senior leaders have a deepening appreciation of the innovation challenges each is facing and are taking steps to introduce and apply new approaches. For the Air Force, I applaud the establishment of *AFWERX*, the launch of *Squadron Innovation Funds*, the appointment of a *Chief Data Officer*, and an emergent focus on talent management and unleashing a culture of innovation among airmen; for the Navy, the establishment of the *Digital Warfare Office* and the application of entrepreneurial principles in the form of ICORPS – imported from the National Science Foundation and the Lean Startup movement -- by the *Office of Naval Research*; for the Marine Corps, the establishment of an *Deputy Commandant for Information* to align and focus information management and digital initiatives, as well as superb work on automating logistics in a program called *NexLog*; and for the Army, the launch of *Futures Command*, which while in its early stages reveals a sense of urgency to consolidate decision-making into a more coherent and compact team.

Barriers to Scaling Innovation Efforts

DoD needs to recognize and reward innovation to ensure that the Department has the right tools, capabilities, and approaches. Yet, the innovations I mentioned above were largely developed outside of the mainstream DoD processes for developing and fielding capabilities. Today, innovators in DoD understand this strategic imperative, which explains their use of alternative pathways and acceptance of calculated risks. **Owning this risk requires a level of collective understanding, and even courage, that seems to elude larger Industrial-Age, process-centric approaches.** DoD needs to change processes to make these sorts of results the norm, rather than the exception.

There is no single approach to reform – the Department must manage a spectrum of capabilities from Industrial-era aircraft carriers to Internet-era software platforms – but DoD's new normal should include improved approaches to risk, accelerated timelines, and openness to venture innovations. There are a number of structural barriers impeding such a transition:

Software vs. hardware acquisition

The DIB is supporting the Secretary on the study of streamlining the Department's software development and acquisition regulations, as directed in the fiscal year 2018 National Defense Authorization Act (NDAA), to include procurement of software for weapons and business systems, and organizational, behavioral, and cultural barriers to the use of modern software practices. The final report is due next year, and I know the DIB looks forward to sharing its findings with the Department and Congress.

For decades, U.S. military hardware has been the envy of militaries everywhere, and in many cases, still is. However, as we move further into the Information Age, hardware will become commodified, as it has in the computer industry. Competitive advantage is increasingly derived from the power of software and data.

These algorithms, built by AI and machine learning from massive datasets, should be developed through agile software development methods, which must become the norm in DoD. The hardware is simply the delivery system for the software, but it is the software that matters. Yet DoD's current acquisition posture is designed for hardware, as is the budget processes that support it. Failing to address the underlying reasons why so many DoD technology programs run years behind schedule and hundreds of millions of dollars over budget will allow our strategic competitors to catch up in areas where the U.S. is still dominant, and surpass us in emerging areas where the U.S. do not have the same head start. As long as the Department remains organized for hardware acquisition and relegates software to an afterthought, DoD is bleeding out its own advantage.

Based on my personal observations, I see ten core principles that should inform how DoD leaders think about what constitutes effective, modern software development:

1. DoD personnel -- and especially developers -- need access to abundant computing, storage, and bandwidth
2. All software projects should start small, be iterative, and build on success or be canceled
3. Software is never done; budgets should be constructed to support the full life-cycle cost of the software, anticipating that it must be continually upgraded
4. Adopt a DevOps culture for software systems where actual users are placed at the heart of the process and the measure of success is "customer adoption"
5. Automate testing, validation, and certification of software to accelerate critical updates; testing should be concurrent with development, not in long sequential stages
6. Every purpose-built DoD software system should include source code as a deliverable
7. Software is local; every DoD system that includes software should have a local team of DoD software experts who are capable of modifying or extending the software through source code or API access
8. Only run operating systems that are receiving (and utilizing) regular security updates for newly discovered security vulnerabilities
9. Secure data at rest and in transit; data should always be encrypted unless it is part of an active computation

10. All data generated by DoD systems - in development and deployment - should be stored, mined, and made available for machine learning

I've found genuine software engineering a rare occurrence in the Department – with some exceptions such as DDS, Kessel Run, and JIDO, as described above – because DoD has not fully grasped that software decays in place. Unlike hardware, which can be maintained and does not require constant upgrades, software must be upgraded constantly and is usually outdated within two years. This explains the failure of many DoD software programs – costs spiral due to the need for legacy system support, while the software is rife with cyber vulnerabilities. When software fails, the cost to fix it can run in the tens or hundreds of millions, and even then it may ship with reduced capability.

Initiatives like Kessel Run are not only enabling DoD personnel to write an application via agile software development -- as opposed to the more rigid waterfall development that most of DoD employs -- but the Air Force is also training its airmen to do software engineering. In this case, the Air Force has access to its own code, does not have to rely on third party programmers, and can rely on an organic force to tackle challenges the way DDS software engineers do.

Color of money

The current budget and appropriations process was built to address Industrial Age challenges. Software cannot be effectively acquired and employed in such a linear fashion. Poorly-designed major software systems that unnecessarily run millions of dollars over budget point to a need for strong congressional oversight of DoD, but the Congress should also acknowledge that the current inflexible “color of money” system compounds DoD’s software challenges.

To capitalize on the potential of software, the Department needs to move quickly when fielding the latest upgrades as well as when testing and operationalizing emerging software solutions. This requires deftly shifting from one color of money to another (and potentially back again) in a matter of weeks or months, not over multiple fiscal years. This could be done in such a way to ensure transparency and accountability, but new paradigms are needed.

Beyond colors of money, OTAs and similar flexibilities can help DoD pursue these kinds of initiatives; however, I have found that too many people in the Department are unaware of these authorities, do not prioritize them, or fail to incentivize program managers and others to use them. As one way to remedy this, DoD should track and encourage the use of such waiver authority.

Cloud

Any military that fails to pursue enterprise-wide cloud computing isn't serious about winning future conflicts. AI is not achievable without modern commercial cloud computing that can store and secure the data DoD regularly collects. This volume of data will only increase in the years to come as the use of sensors proliferates and DoD's ability to collect data expands – while its ability to process it deteriorates due to a reliance on outdated data centers with

limited data storage and transport capacity. This urgent need to address DoD's lack of compute and storage was the focus of one of the Board's official recommendations announced in October 2016.

Fortunately, in recent years, a number of DoD organizations have shifted or begun to shift to the cloud, culminating most recently with the Department's decision to adopt the cloud across the Department. While the Services and other DoD organizations pursuing cloud solutions should be commended, the enterprise-level decision is an important step for the entire Department. Moving to cloud services at an enterprise level will ensure that AI efforts have a common foundation as opposed to operating in silos, which is the DoD norm. A common infrastructure allows many AI projects to grow relatively quickly in an iterative learning environment and for less cost than currently constructed.

Artificial Intelligence

The significance of AI is akin to the first and second offsets that took advantage of nuclear weapons and precision munitions and stealth technology, respectively, to ensure American military supremacy. AI has the power to affect every corner of DoD, from personnel and logistics to acquisition and multi-domain operations; and to create and sustain the asymmetric advantage required to outpace our adversaries. In the long run, AI will profoundly affect military strategy in the 21st century.

DoD has yet to embrace the transformational capabilities of AI. In this space, the Department is neither keeping pace with private industry or academia, nor effectively incorporating or guiding breakthroughs for defense. Deeper focus, closer collaboration, more resources, and a sense of urgency are needed to solve problems of significance to the U.S. and our allies.

Apart from a few excellent examples, most of the Department's work in AI is in basic research, which has been foundational to the development of the technology but is typically not immediately delivered to the warfighter because of the infamous "Valley of Death" in the DoD acquisition environment. From an acquisition perspective, there are no shortcuts to AI. The Department collects large quantities of data, but takes few steps to label, structure, and process them. Though labeled data is the fuel for AI, DoD has yet to fully leverage the value of both unclassified and classified datasets. Data must be collected and then stored and secured in the cloud, at which point the Department can use agile development techniques to train AI systems. Data, therefore, must be viewed as a strategic asset.

The world's most prominent AI companies focus on gathering the data on which to train AI and the human capital to support and execute AI operations. If DoD is to become "AI-ready," it must continue down the pathway that Project Maven paved and create a foundation for similar projects to flourish, in addition to its basic research efforts.

Because this is more of an organizational than a technical problem, 18 months ago the Board proposed establishing a DoD AI Center that would centralize AI coordination and provide enterprise expertise and enablers to Services and the Office of the Secretary of Defense (OSD).

Simultaneously, this center would encourage decentralized execution of AI projects, led by the Services, and the insertion of AI capabilities into existing programs of record. This could be done without disrupting the excellent work of the Service labs, DARPA, and other DoD research organizations upstream by focusing on solving operational problems with existing commercially available technology that requires modest adaptation to military use cases. Without some type of unified, broad adoption of an AI foundation for the entire Department, DoD will soon reach a tipping point after which it will be unable to catch up to its competitors.

I cannot emphasize enough how competitive this field is today, internationally and economically, or how consequential. It is imperative the Department focus energy and attention on taking action now to ensure these technologies are developed by the U.S. military in an appropriate, ethical, and responsible framework.

People and talent

The U.S. military is home to some of the most intelligent, resourceful, creative people I have ever met. Unfortunately, service members have to innovate to work around the barriers that the DoD bureaucracy or poorly designed systems impose on them. I have heard too many stories of entrepreneurial soldiers, sailors, airmen, and Marines who have left the military because their good ideas are regularly ignored or stifled, particularly because these ideas deviate from the norm. This environment generates little motivation to change behavior and undermines the culture of innovation that I believe is widespread in DoD. Unfortunately, this culture is usually thwarted by labyrinthine and unnecessary red tape.

I know that DoD leaders are aware of these challenges. They too are struggling to make sense of a bureaucracy that does not always respond to good ideas unless one is able to survive a gauntlet of complex decision-making processes. And even then, change is not guaranteed.

As one example, I'd like to go back to Kessel Run. This is one of the most promising initiatives in the Department. But the vast majority of participating airmen are using temporary duty assignments to undergo software engineering training. These airmen apply it to real and urgent Air Force challenges and are having a tangible impact in terms of time and money saved. Kessel Run is itself a workaround to a culture and personnel system that does not produce indigenous software engineers. For instance, the initiative lacks permanent billets. Air Force leadership understands this problem well and is seeking a way forward. The alternatives they devise should be closely examined and supported by the Department. This anecdote is but a microcosm of the Department's broader challenge of conducting effective talent management in the digital age.

DoD is fortunate that innovative ideas are breaking through the bureaucracy, but they do so in spite of DoD, not because of it. Along the way, many of these ideas were nearly terminated at multiple stages. It should not be this hard to do the right thing. A fundamental change in recruiting, education, operations, and culture is necessary for the Department to maintain superiority in a technology-driven world. This includes, but is certainly not limited to, an understanding throughout the ranks of how to solve problems using AI, a culture of moving

faster and experimenting with data and software, and the will and imagination to see beyond current workflows and discover future concepts of operation that create advantage over adversaries. It also may require moving the software side of DoD from a hierarchical structure to a meritocracy, arming the Department with ways to match a service member's capability and talent with the requisite authority, responsibility and compensation.

Based on my experience and the hundreds of meetings and site visits with the DIB, government salaries are less a barrier to recruiting and retaining talented service members than is the Department's lack of digital infrastructure these people are used to working with. A lack of comprehensive data access capability, commercial cloud computing, agile software development environment, and a common machine learning platform is holding the Department back technologically. More importantly, it is keeping away top talent that would otherwise be interested in working on DoD's unique problem sets. I have no doubt that top software engineers and data scientists will take a year or two out of their careers to work in DoD. They may not spend more time than that, but DDS's model is viable proof of concept. It is exciting to imagine a future state where DoD's digital infrastructure attracts DDS-level talent across the entire defense enterprise.

Rapid organizations

DoD has attempted to address its structural innovation flaws by establishing organizations that are meant to move fast. Some follow the model of the Air Force's Rapid Capabilities Office, the first Service to establish such a group. They all now have an RCO or equivalent office, which complement the activities of DIUx. For example, the Strategic Capabilities Office takes existing platforms and capabilities in DoD and repurposes them for different but critical missions, such as the Navy's Standard Missile-6, which was refashioned from a solely defensive weapon into an offensive asset designed to attack enemy ships. Conversely, as you well know, DARPA finds new technologies for the future fight via longer timelines and research that examines the viability of certain technologies. Each of the rapid organizations has a distinct yet complementary responsibility in making the U.S. the predominant technological force - today and in the future.

At their onset, these rapid organizations were placed outside the usual hierarchy, to establish autonomy and facilitate results, but the ultimate goal must be to incorporate their practices into the broader acquisition system. The Department is not at that point yet, but the mindset of adopting innovative best practices as the norm rather than the exception is the correct one.

In an organization as large as DoD, good ideas that cannot scale would seem to have limited utility. Scaling innovation is crucial, but it is also important to create pathways for new ideas and environments that can nurture different approaches and contrary views. You need both – they are optimized for different variables. Organizations optimized for consistency, reliability, and stability produce value, but not ingenuity or innovation. That requires a different culture, rules, and organizational design, and often different people. This is the reason why innovative organizations often must be started separately, managed differently, and protected from bureaucracy. This is true in industry as well as government. When considering the mechanisms

for scaling innovation, DoD leaders – and their congressional overseers – should be mindful of balancing these competing priorities.

Conclusion

In my opinion, the Board’s efforts and recommendations to date dovetail with the recently-published National Defense Strategy, which correctly captures the dynamics of technological competition (“Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting”) and introduces new operational concepts that could widen the competitive space (“foster a culture of experimentation and calculated risk-taking”). DoD leaders understand the need to adapt to new security realities, and countering institutional inertia will be challenging, but after nearly three-quarters of a century of U.S. strategic and technological dominance, the status quo will only guarantee a loss of superiority on the future battlefield. Change is more important than ever before.

I believe Congress can play an important role in influencing the Department’s culture of innovation. Alongside other Board members, I have heard many times from leaders and personnel at all levels whose fear of congressional censure was a major contributing factor to their slavish adherence to process and reluctance to try new approaches or take calculated risks. At the same time, in interactions with Congress, I am heartened to hear many of the same frustrations and criticisms of the Department that DoD leaders make themselves. There is common ground here. This committee has helped enact significant acquisition and personnel reforms over the past few years and I invite the committee members here today to devote some time to this question of how to further partner with DoD to balance the need for oversight, transparency, and accountability for taxpayer resources with the reality that DoD must adopt a more entrepreneurial mindset, or risk a potentially devastating loss of competitive advantage over time.

I hope I’ve shed light on the path forward, what this change might look like, and how to get there. There are no shortcuts on this path. The Department must overcome significant obstacles in its culture, talent management, and processes, to name a few. I am not alone in these assessments and hope this hearing serves as a call to action for everyone concerned. Thank you and I look forward to your questions.