Department of Defense Laboratories

Recalibrating the Culture

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In his welcome message as the new Secretary of the Air Force, Frank Kendall noted that today, as it was during the Cold War, we are facing peer competitors that demand our attention to strategic and technical superiority.[1] Over the last three decades, the US military's focus on terrorism and low-intensity conflict pressured US science and technology (S&T) infrastructure and culture to concentrate on more mature technologies that could be rapidly transitioned to war fighters. For example, American scientists and engineers refocused on countering improvised explosive devices and other cheap, exploitable weapons of war.[2] The time has now come to recalibrate the Department of Defense (DOD) science and engineering workforce and investments back to strategic, complex, and sophisticated technology that will support twenty-first-century warfare.

Military innovation emerges from a combination of strategy and the means to execute that strategy.[3] Strategic and tactical advantages can be gained by a combination of terrain, location, speed, and the element of surprise supported by offensive and defensive weapons. These innovative advantages have been exploited for centuries, from ancient armies taking the high ground to the use of stealth aircraft by today's militaries.[4]

After World War II, the Department of Defense transformed the US military-industrial complex into a formidable force for military innovation focused on and supported by technology. Complimenting the military-industrial complex, the DOD laboratories evolved to concentrate on almost everything—from basic re-

search to advanced prototyping—with one goal: to achieve and maintain technical superiority.[5] This synergy gave the United States leadership in the defense research and development field for the next half-century.

During the decades following World War II, DOD laboratories coalesced around a Cold War mindset, trying to stay ahead of the Soviets by engaging in high-risk, high-reward, leap-ahead technology discovery and development.[6] After 1989, however, the emphasis shifted to the Middle East and terrorism.[7] While the enemy was innovative in its simplicity, the imperatives of the DOD laboratories changed to the rapid deployment of individual and small-unit technologies designed to counter terrorist threats such as handheld improvised explosive device detectors. The resources (funding and people) followed this shift as did the culture of technological risk-taking.[8]

As China emerges as a near-peer competitor and Russia continues its saber-rattling with technological advances in missile and space technologies, DOD labs should recalibrate from a near-term, terrorist mindset focused on rapid transition back to a more deliberate, threat-informed technology development process that supports great power competition with China and Russia. This recalibration will require more than just changing policies, redirecting priorities, and reallocating resources. An Edisonian mindset of risk and failure that leads to leap-ahead science and technology requires a fundamental shift in culture.[9] While funding is easier to reallocate, changing the culture is slow. Guiding that change will require thoughtful, deliberate actions by leaders in the DOD labs.

Changing Culture

Edgar Schein, a thought leader on organizational culture, noted culture is stable but not very malleable. Leaders create culture when they establish groups and organizations. After cultures exist, they determine criteria for leadership and thus determine who will or will not be a leader. But if elements of a culture become dysfunctional, it is the unique function of leadership to perceive the functional and dysfunctional elements of the existing culture. Leaders must manage cultural evolution and change in such a way that the group can survive in a changing environment.[10]

In June 2000, Navy research, development, test, and evaluation was beginning to see many of its labors finally come to transition with the introduction of the DD-21 Zumwalt-class Land Attack Destroyer.[11] Many S&T programs funded by the Office of Naval Research for decades were coming to life as advanced computing, multifunction radar, integrated propulsion systems, and new gun systems. But on September 11, 2001, everything changed. The S&T community ar-

rived back at work on the morning of September 12, 2001, focused on developing technologies rapidly to fight the new global war on terrorism.

From 2004 to 2016, supporting the war on terrorism subsumed nearly the entire focus of administration direction, congressional attention, and the priorities set for the DOD labs.[12] This "rapid acquisition-tech transition" mindset and the resource allocation decisions made by its leaders influenced the DOD lab workforce. Many scientists and engineers hired during this time never had the experience of the Cold War technoscientific arms race.[13]

Based on over 20 years in policy and program development in the DOD lab community and feedback from hundreds of scientists and engineers in the DOD lab enterprise, this article presents themes for leaders to consider if they want to change the culture in their organizations. These themes are focused on shifting cultures in the DOD labs from evolutionary-focused innovation with low-to-medium risk, to the pursuit of more revolutionary research and development (R&D), with medium-to-high risk. Such a shift produces leap-ahead innovation but can be useful for any leader interested in developing a healthy innovation culture in their organization.

Following Schein's model of culture (fig. 1), the article presents recommendations under themes offered in order of most to least malleable and shorter- to longer-term periods of change.

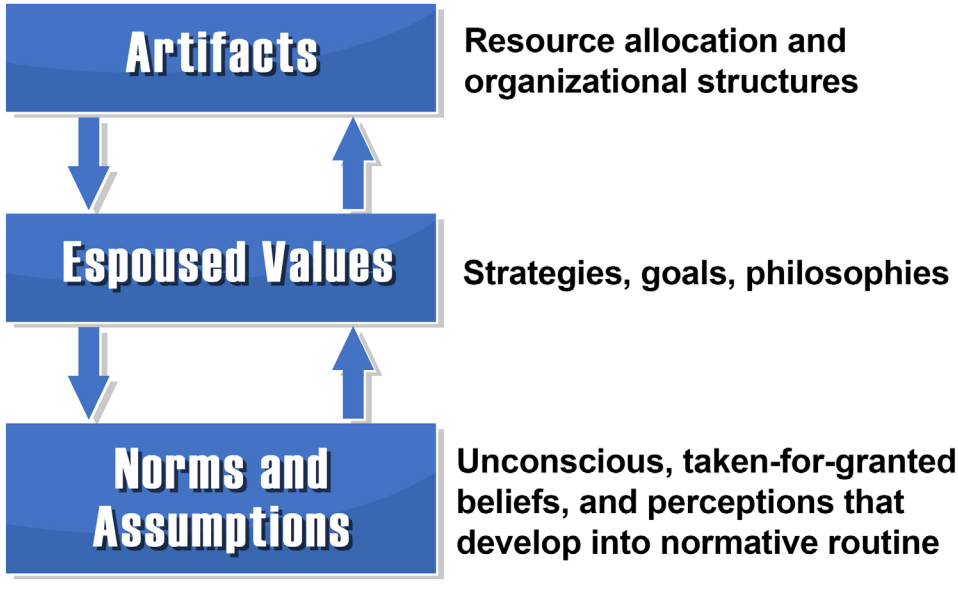

Figure 1. Adapted from Schein's body of work on culture

Resource Allocation and Organizational Structures

Organizational theorist Mary Jo Hatch extended Schein's theory by drawing on symbolic-interpretive perspectives around the leader's role in culture creation and change. In her view of cultural dynamics, strategy formulation is the manifestation of assumptions that underlie values and how those values point back to the assumptions. Championing the vision, goals, and objectives of an organization can be an effective communication tool for expressing underlying assumptions in the form of desired values.[14] Leaders show what they value by how they allocate their resources. Similarly, how they design their organizational structures shows their preferences for access, resource flow, and ultimately trust.

Under the theme of resource allocation and organizational structures, this article offers three recommendations. (1) Strategically allocate resources by connecting with the larger ecosystem to potentially leverage others' investments, thereby freeing more resources for higher-priority goals. (2) Fund more projects that seek the unknown, higher risk for higher-reward breakthroughs. (3) Allow multidisciplinary teams to form spontaneously—agile teaming—to inspire a spirit of collaboration.

Engage the Ecosystem

Historically, the United States dominated the R&D landscape, "funding as much as 69 percent of annual global R&D in the period following World War II."[15] While such funding in the United States has remained strong, the source of expenditures has shifted dramatically. Two sectors—business and the federal government—have together accounted for more than 90 percent of US R&D funding since 1953, though their combined share has fallen from a high of 98 percent in 1956 to 92 percent in 2016.

Federal R&D expenditures as a share of total US R&D expenditures peaked in 1964 at 66.8 percent, the same year that business R&D expenditures reached a nadir of 30.8 percent. Between 1964 and 2000, the federal government's share of expenditures fell and business's share rose: by 2000, research and development expenditures of business and the federal government, as percentages of total US R&D expenditures, accounted for 69.4 percent and 25.1 percent, respectively.

This shift in the composition of R&D funding resulted from faster growth in business R&D expenditures rather than a reduction in federal government R&D expenditures. From 2000 to 2010, business's share declined from 69.4 to 61.0 percent and has risen each year since, reaching an all-time high of 69.7 percent in 2018; from 2010 to 2018, the federal share declined from 31.1 to 21.9 percent.[16]

This data reveals federally-funded R&D is a smaller share of the total US research and development enterprise. This shift makes it imperative that DOD labs

reevaluate the apportionment of their limited R&D dollars and partner with business/industry counterparts and academic researchers, where appropriate, to synergize their investments by leveraging other R&D spending.

Before deciding with whom to connect, leaders should decide on their goals for connecting. The *US Air Force 2030 Science and Technology Strategy* directs the use of lead, leverage, and watch to support necessary organization and resourcing.[17] After determining the vision, mission, and goals, leaders in government R&D organizations typically align resources and organizational structures to mission-related scientific, research, or engineering topical areas. For basic and applied research, this is the point where lead, leverage, and watch principles should be incorporated.

A distinct advantage from the Cold War is the easy availability of advanced artificial intelligence tools and data analytics that can support leaders' decisions about where they should invest limited science and technology resources.[18] While many government S&T organizations use the lead, leverage, and watch paradigm for resource allocation, more can be done.

With the democratization of S&T in the past two decades, it is easier than ever before to watch and leverage research and technology globally. Once those decisions are made, leaders should ensure the free flow of that information to researchers by supporting information sharing in virtual and in-person environments. What remains is where the organization wants to lead. Leading in an area of S&T requires the right people, the best lab facilities, and a high risk tolerance.

Seek the Unknown

Government research and development organizations are constrained by planning and financial systems that impose structures to account for the expenditure of taxpayer dollars. Having determined S&T areas in which an organization wants to lead, leaders can shift resources accordingly. Creating resource flexibility to support S&T that seeks the unknown is difficult. Leaders must take deliberate and thoughtful actions to liberate resources (people and funding) in support of leading-edge science and technology. In a government lab, the best way to accomplish this is to create and fund program categories that are more general and wider in scope. Once those resources are made available, leaders should be careful not to add their own structural and process impediments to pursuing the unknown.

Encourage Spontaneous Teams

After leadership has determined their lead, leverage, and watch construct and created flexible funding structures to allow for the pursuit of leading-edge research, researchers will have the mandate and the resources needed to pursue their agen-

das. The final enabler of pursuing a breakthrough research agenda is collaboration across vertical, horizontal, stakeholder, demographic, and geographic boundaries.[19]

Some experts have noted that capability development starts with the convergence of multidisciplinary knowledge and teaming. "Combining new knowledge in materials science, nanotechnology, cognitive science, and human-machine interface technologies gave us the cell phone platform," a good example of convergence that "captures the synergism between multidisciplinary domains" and integrates them to support a new technology.[20]

Enabling the convergence of multidisciplinary knowledge can be accomplished either deliberately through matrixed organizational structures or less directly by opening avenues and encouraging collaboration and sharing of ideas and interests across organizational elements. Either way, collaboration of cross-disciplinary teams is a proven technique for enabling the pursuit of high-risk, high-reward science and technology.[21]

After considering these more malleable artifacts of culture, including resource allocation, organizational structures, and communication systems, leaders can turn to a level deeper in the culture—espoused values—to promote change. Values are difficult to change, but not impossible. Going back to Hatch, assumptions are manifested when the artifacts of culture are established, and the choices made point to the leaders' values.[22] The values behind the choices selected should be confirmed and reinforced with consistent messaging of decisions made and actions taken.

Walk the Talk

Modern leadership theories, including transformational leadership, authentic leadership, and servant leadership, hold that being transparent and consistent are positive traits.[23] Say what you will do, and do what you say. When promoting a culture change, message transparency and consistency acquire even more importance as conscious decisions can be undermined by seemingly unrelated actions that send a different message.

David Nadler and Michael Tushman developed a congruence model that illustrates how elements of organizations are connected. This model can be used to diagnose potential disconnects that might adversely affect transformational change efforts.[24] During the transformation process that occurs between inputs (environment, resources, history) and outputs (effects on individuals, groups, and organization), the model offers culture, organizational structure, work processes, and people's behaviors as checkpoints for incongruencies. Their findings indicate a successful transformation of the culture requires consistent policies and messages about work and mission, organizational structure, and opportunities for

people. The following three recommendations discuss ways to ensure innovation messaging and actions are consistent.

Allow Time for Innovation

One of the resources often taken for granted is people's time. Organizations and their leaders often talk about innovation and might also challenge people to be more innovative while at the same time burdening them with a seemingly unending list of administrative and programmatic duties and actions.[25] Allotting a specific time or amount of time per week for innovation can affirm a leader's commitment to their innovation rhetoric. Combined with collaborative tools, carving out time specifically for innovation can spark the multidisciplinary cross-pollination that allows a diversity of ideas and new ways of thinking.

Embrace Failure and Risk Taking

Thomas Edison is credited with the quote, "I have not failed 10,000 times. I have not failed once. I have succeeded in proving that those 10,000 ways will not work."[26] He understood that innovating is a series of creating, testing, and revising until the desired result is achieved. Throughout the process, learning takes place. Making pronouncements about greater risk-taking is not enough to change espoused values. A change in this level of culture requires a pattern of embracing and celebrating high-risk, high-reward innovation.

One way to celebrate failure and risk-taking is to plan an event or series of events where experienced researchers discuss their "Edison experiences"—when they engaged in the pursuit of a result that eluded them. Other stories from basic researchers might involve failures that turned into valuable knowledge leading to other breakthroughs, like the popularized 3M Post-It note example.[27] Many less popular examples involve pharmaceuticals. One such case is Iproniazid, which was being developed as a treatment for tuberculosis. While it failed as an effective treatment of tuberculosis, Iproniazid became the first marketed treatment for depression.[28] These types of events can also lead to cross-disciplinary collaboration and mentoring opportunities.

Risk-Taking and Innovation as Measures of Effectiveness

The DOD labs experience innovation dissonance in two areas: resource incongruence and performance evaluation. Both challenges create opportunities for leaders to show they value greater risk-taking by making the right resources available and rewarding high-risk, high-reward innovation.

Corporate R&D can take two forms—the evolutionary improvement of products or more revolutionary innovation that takes the product in a different direction or to a higher level of functionality. In the case of revolutionary innovations, risk is managed by calculating the return on investment. Will the customer be willing to pay $X more for Y improvement? A good example of this is adaptive headlights. The precursor to adaptive headlights was the idea of swiveling headlights on the 1948 Tucker sedan.[29] In the late 1990s, what we now know as adaptive headlight technology was developed, but a decade passed before automobile manufacturers achieved an acceptable return on investment for introducing this technology into their production vehicles.[30]

While government research and development does not have the same return-on-investment restrictions as corporate R&D, it faces the formidable challenge of transition. With the focus in recent decades on combatting terrorism, the science and technology community has been pressured to find transition mechanisms earlier in the technology development process. This "transition creep" has affected resource allocation by encouraging activities funded as applied research with higher risk to focus more on advanced technology development where risk is reduced.[31] Consequently, researchers are pressed to achieve higher levels of technology readiness toward transition with resources that should be used to pursue projects with more risk.

A second area incorporating risk into measures of effectiveness is personnel evaluations. Regardless of the profession, personnel evaluations focus primarily on success. In the laboratory culture, success might mean a transition of technology, publishing of successful experiments, or awards won for successful projects. Celebrating failure and risk-taking are not themes ordinarily seen in military or civilian personnel evaluations in DOD labs. Aligning leaders' desires for high-risk, high-reward innovation with advancement-worthy personnel evaluations will take time and effort. Military and civilian research community standards must be addressed and adjusted to ensure that engaging in higher-risk innovation is rewarded.

Provide Escape Routes

The final area of culture to be addressed is normative orientation, the least malleable and slowest to change. Norms are unconscious beliefs, perceptions, and attitudes that develop into patterns of behavior. Changing norms requires a long-term commitment and constant communication to manage the often uncomfortable shift in the way people think and behave in reaction to these changes.

The concept of structuration describes the process wherein norms are developed and communicated to the members of organizations. It is a reciprocal process of meaning-making at the organizational level.[32] Structuration is further

defined as "explicit actions (e.g., setting boundaries, physical interaction, organization of work, social status, rules, leadership) and implicit guiding social patterns (e.g., norms, values, traditions, culture)." These actions and patterns allow individuals to make meaning of their experience; instill integrity through normative orientation, including sanctions for violating norms; and bring order through power and control.[33] Said much more simply, norms are the invisible boundaries that cause people to act in certain ways.

Noted social and organizational science pioneer Kurt Lewin believed changing culture entailed a three-stage process—unfreeze, change, and refreeze.[34] Unfreezing cultural norms is easier said than done. A new organization chart can be drawn, new seating arrangements can be made, and even new policies and procedures can be issued, but changing norms or behavioral patterns, requires deviation. Said another way, if norms are the invisible wall, leaders must provide escape routes over, under, or through cracks in the wall.[35]

The following recommendations are exit routes leaders can provide or allow so people can begin to change behavioral patterns and ultimately their beliefs about the organization's commitment to innovation and greater tolerance for risk.

Encourage Personnel Exchanges

A long-standing practice that ebbs and flows in application is personnel exchanges between government, industry, and academia. The benefits of these exchanges are numerous, but the one most pertinent to this discussion is cultural transfer. Anthropological studies show that when a person goes from one culture to another, they bring along certain artifacts, habits, and routines.[36] Inevitably when they return, the process is repeated. For this reason, sending a government civilian to a business perceived to be more innovative has become increasingly popular.

With this in mind, an opportunity exists in the DOD labs that has not been fully explored. Personnel exchanges within the DOD lab, between DOD labs, with other federal agencies (e.g., National Aeronautics and Space Administration and Department of Energy labs), and with others in the ecosystem (e.g., federally funded research and development centers and university-affiliated research centers) provide other opportunities to cross-pollinate cultures.

Flip the Script

Another escape route that can unfreeze and change behavioral patterns is to change perspectives. Tangibly, this might mean empowering bench scientists to perform a task usually reserved for leadership. In a current example, a senior leader

elected to give a group of bench scientists the task of developing the basic research agenda for the organization, a task normally reserved for senior leaders.

Several benefits will likely arise from this action. First, perspectives of the bench scientists will change as they realize how difficult and daunting the task is of betting on the future with the nearly unknown portfolio of science. Second, the inexperienced individuals will learn valuable lessons working together as a group. Action learning in this instance provides participants an opportunity to use self-reflection and learn from each other while engaging in problem-solving and decision-making processes.[37] Finally, changing perspectives will be an opportunity for coaching and mentorship, including reciprocal communication between leaders and bench scientists.

Sink or Swim

The final recommendation for kickstarting a change in norms toward a more innovative culture is a combination of almost everything discussed to this point. In the same way that a bird pushes its offspring out of the nest, giving a bench scientist full autonomy to run a research project is perhaps the truest sign of walking the innovation talk. Allocating enough resources and allowing a bench scientist to choose the location, facilities, and their research team sound like an extravagance, but DOD labs give millions of dollars each year to external research organizations with the same autonomy. Breaking that norm by giving internal scientists and engineers the same autonomy imparts the trust that is the bedrock of any healthy culture, and more importantly, a vibrant innovation culture.

Conclusion

The United States has always maintained an edge in creativity. Turning that creativity into innovation has been the hallmark of US domination in commercial and military innovation. The current and future complexity of the national security environment is defined by the increasing pace and globalization of technology development, fragile system-of-system dependencies that are vulnerable to attack, and new domains of military conflict such as space and cyberspace that require new S&T investment under constrained budgets.

This complexity and the increasing technological threats from China and Russia demand a recalibration of how the DOD labs think about innovation and risk as they engage in the exploration of science and development of technology. A culture of creativity and scientific adventurism fueled by greater risk tolerance and learning from failure might be the key to attracting and retaining the DOD lab workforce of the future.

This analysis of organizational culture with specific recommendations for refocusing the culture in the DOD labs is formulated for leaders in those labs and other organizations to consider as they continue to carefully navigate the increasingly complex research and development landscape of the twenty-first century. ✪

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Notes

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