The Testimony of
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BEFORE THE HOUSE ARMED SERVICE COMMITTEE, SUBCOMMITTEE ON TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES, ON HARNESSING TECHNOLOGICAL INNOVATION: CHALLENGES AND OPPORTUNITIES

Mr. Chairman, Honorable Members, thank you for the opportunity to appear before your Committee. My name is David Lehman and I am a Senior Vice President at the MITRE Corporation. I am also the General Manager of MITRE's Command and Control Center, which is part of the Defense Department's (DoD's) Command, Control, Communications, and Intelligence (C3I) Federally Funded Research and Development Center (FFRDC). Also pertinent to this discussion, I was MITRE's Chief Technology Officer for nine years, managing our internal research program. I would ask that my prepared statement be included in the record.

Steve Jobs of Apple said, "An innovation is an idea that ships." The idea may start as a technical curiosity, a result of scientific research. If someone can connect that curiosity to a solution to a real-world problem, an invention is created. If people or organizations adopt that invention, an innovation is created. Too often the research community lacks an understanding of real-world problems and the potential users do not know that the enabling technology exists. The result is too few inventions and even less innovation. To combat this, we must create an environment and processes that carry research results through invention to widespread adoption and, thus, innovation.

In my testimony today I will present four recommendations to improve both the processes and the environment in order to increase the yield of innovation from our science and technology (S&T) community. I will focus less on research—the creation of technical ideas, which might come from government laboratories, academia, industry, or amateur scientists—than on the management processes necessary to increase invention and innovation. These recommendations are:
1) Improve the alignment of S&T investment with warrior needs;
2) Improve the funding mechanisms to carry research results and inventions through to innovations;
3) Adopt open systems architectures for programs of record so that these programs can more easily accept and adapt to innovations; and
4) Change the business model used in programs of record to increase incentives for contractors both to meet requirements and to apply creativity in doing so.

The key to a good research program is to align investments with the goals of the organization or the needs of the end user. When an organization fails to achieve such alignment, the researchers tell the developers, "You don't use anything we invent" and the developers retort, "You don't produce anything we can use." This stand-off occurs because the two departments have not worked closely together to understand:

- The needs of the customer or the organization,
- The research problems,
- The research risks, and
- The funding profile that links the research schedule and budget to the production schedule and budget.

When an organization can solve these problems, it can put a plan in place that includes continuous dialogue around the inherent uncertainties in the plan, and adjust the plan as necessary over time. Optimally, this process enables the organization to bridge the chasm between research and production.[1] I should caution that if the linkage among the customer, the researcher, and the developer is too tight, the organization might fail to discover new approaches because the incremental improvements desired by the customer blind the developer to new, disruptive technologies[2] that offer vastly more efficient ways of solving problems;[3] consider the old observation that Henry Ford would have made faster horses if he had listened to his customers.

Government organizations have proven that they can achieve optimal alignment between research and development. The National Reconnaissance Office (NRO) of the 1970s and early 1980s offers an excellent example. The organization tightly linked its research investments in increased sensor sensitivity and satellite technology to production projects, resulting in continuous improvement in intelligence collection capability. The NRO could achieve this alignment of budgets and schedules partly because of its organizational structure, in which the users, the programs of record, and the research organization all reported to the same manager, creating unanimity of purpose and control. The NRO also had exceptionally strong and technically competent program offices—essentially technical peers of their contractors.

Beyond lack of better organizational structure and technically strong program offices, there are four additional reasons why most organizations do not achieve this alignment:

First, neither the research community nor the acquisition community fully understands the needs of the end user (in the case of the DoD, the warrior). A well-intentioned but overly bureaucratic documentation and review process hinders efficiency in requirements generation by unintentionally isolating the warriors from those who will design and build the system. The acquisition process believes that the specification is in essence flawless when the program begins and limits the interaction between researchers and warriors that would lead to acceptable—and feasible—tradeoffs in system design and functionality.

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[1] For a good discussion of this topic, see Philip A. Roussel, Kamal N. Saad, and Tamara J. Erickson, *Third Generation R&D: Managing the Link to Corporate Strategy* (Boston, MA: Harvard Business School Press, 1991).
[2] See Clayton M. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Businesses to Fail* (Boston, MA: Harvard Business School Press, 1997).
[3] William L. Miller and Langdon Morris, *Fourth Generation R&D: Managing Knowledge, Technology, and Innovation* (New York: John Wiley & Sons, 1999).

The formal research and acquisition process as practiced offers far too few opportunities for rich dialogue between the engineers, who know what technology can do but do not understand the real-world problems, and the warriors, who have the real-world experience but not the technological insight. 3M Corporation attributes its early success as a company on its strategy of placing its researchers in automotive production plants to understand the automobile industry's particular requirements for abrasives.[4] It is this dialogue, where the technical curiosity or idea becomes linked to the real-world problem in a give-and-take discussion, that leads to problem discovery, invention, and innovation. Today in Iraq we see rapid innovation with systems such as Command Post of the Future, FusionNet, and Cursor on Target because the technologists are in the field with the users, listening to their needs and rapidly adapting the systems.

To achieve this kind of interaction in the research and development cycle we need to create a development environment in which the warriors and the technologists interact continuously, experimenting with new inventions and applications, and rapidly incorporating those that prove themselves into the programs of record. As noted, some of this is happening in Iraq today, but many of the improvements will be lost because training and sustainment—which the acquisition process properly enforces for programs of record, though at the cost of acquisition speed—are often overlooked when quick-reaction capabilities are developed in the field. Particularly for programs that have a large information technology component, we must create a development environment in which the S&T community and contractors constantly test possible improvements by installing innovations and allowing cadres of warriors to interact with the innovative systems, understand the systems' utility, and provide feedback so that the developers can incorporate improvements into the systems. This represents a feasible but radically different development environment than the one that exists today.[5]

Second, the S&T community's research portfolio is not as well aligned as it needs to be to both the needs of the warriors and the programs of record that exist to satisfy those needs. Tighter alignment must come from joint management of the investments through continuous dialogue among warriors, researchers, and developers; otherwise, we will continue the pattern of research results that are never used and programs that are less technically advanced than they could be. Please note: only *part* of the S&T budget should be tied to user needs and existing programs of record. The S&T budget represents a portfolio of programs, some of which should support basic research, risky investments, and searches for disruptive advances to give our warriors a technological edge for which no program of record exists. Such disruptive technologies can have the highest impact, but they too will become innovations only if the system developers who understand the technology engage in a rich dialogue with the warriors to understand their problems.

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[4] Jim Collins and Jerry I. Porras, *Built to Last: Successful Habits of Visionary Companies* (New York: Harper Business Essentials, 1997).

[5] For a more complete discussion of this idea see Victor A. DeMarines, with David Lehman and John Quilty, "Exploiting the Internet Revolution," in Ashton Carter and John P. White, eds., *Keeping the Edge, Managing Defense for the Future* (Cambridge, MA: Harvard University, The Preventive Defense Project, 2000), http://bcsia.ksg.harvard.edu/publication.cfm?program=CORE&ctype=book&item_id=143

Third, research schedules are not aligned with acquisition schedules. Achieving such alignment is understandably difficult, because research does not follow a timetable. Scientists cannot invent on the government's schedule. Government programs must learn to manage the inevitable uncertainty. Service laboratories regularly present inventions to acquisition programs, but the acquisition program usually has little latitude to make changes: the program has a contract and a contractor, a budget, a schedule, and a system design. Inserting the invention, while it might benefit the warrior, would represent an unplanned expense and a schedule slip. Acquisition programs must plan better so that they have the flexibility to accept promising inventions. This can occur only if the acquisition process accommodates advanced collaborative planning by the program and research communities and features constant communication throughout the research and development cycle to manage the uncertainty.

The fourth failure in alignment relates to funding. The research and acquisition communities must plan for success from the moment they embark on a research project. The funding profile in the Program Objective Memorandum (POM) must bridge from research funding through acquisition funding. Too often research programs, Advanced Concept Technology Demonstrations, Joint Expeditionary Force Experiments, and the like validate operational needs, but the budget lacks funding for follow-on development, acquisition, and fielding. It is also axiomatic in all research that some programs and experiments will fail to achieve their intended results, which creates uncertainty in the budget.

To deal with this uncertainty the acquisition community needs to have a set of funds available that allow it to harvest the best ideas that have achieved practicable results. In economics, this approach is called "real options." Having many investments in a portfolio creates options for the investor. Some of them do not succeed, but others do, and the investor can choose to adjust the budget and allocate more funding to those that have proven their worth. Having a line in the POM that gives program managers the flexibility to apply funds to research investments as they mature and carry them into programs of record will increase the innovation yield from the S&T community. This line item should be large enough to harvest some, but not all, successes, forcing the services and programs to prioritize user needs and control budgets.

As a corollary to this observation, we must improve our ability to manage failure. If we recognize and deal with failure early, we can afford more new starts.

The same funding gap characterizes other innovation programs run by the DoD. The Small Business Innovation Research (SBIR) program offers an effective mechanism for funding small innovative companies, but many promising ideas are never harvested for lack of the funding needed to bring the ideas to development and lack of connections among the company, the programs (and their prime contractors), and the warriors who could use the invention. The following quotation comes from Helen Greiner, co-founder and chairman of iRobot, a company that develops robots for the DoD and commercial markets:

> Risk and Reward – There were numerous times when we "bet the company." Like most innovative companies, we shouldered high risk ventures. We were rewarded for our successes; but, there is a problem with how the government deals with new technologies. The government doesn't balance higher risk with higher reward; and, in fact, seems to negotiate lower profit with small companies. Perhaps this is because of the lack of understanding small companies possess regarding how to "play the game" vis-à-vis larger defense companies. The transition from prototype to production is a critical step for innovative companies. The government's support for developing technology (e.g., SBIRs) is not in harmony with the lack of support to transition that technology into production. I'm left to wonder how many great ideas die on the vine...

Once programs have achieved alignment in the four areas I have mentioned, they must ensure that the systems they field are designed with open architectures that have defined interfaces and use well-known and accessible commercial standards. A good architecture allows a system to be modified easily, and thus to accept with relative ease some—though not all—future innovations and improvements. Google, eBay, and Amazon do this very well. They have invested in an infrastructure that features well-defined interfaces and enables their own employees and their business partners to experiment and add innovations with great success.

The DoD acquisition community is striving to build systems with open architectures, but to meet this goal the DoD must find a new business model for its contractors. Under the standard model, the DoD lets a contract for an entire system, usually for its entire lifecycle, which gives the contractor little incentive to design an open system. On the contrary: such a model motivates contractors to design proprietary systems, tying future profits to their exclusive knowledge of the system. To avoid this outcome, the DoD should let a contract for a base infrastructure with as open a design as possible. It should then let separate, smaller contracts for the applications that will ride on the infrastructure and bar the infrastructure contractor from bidding on these applications. Many smaller contracts versus a few larger contracts present a radically different model for the contractor community and the DoD must construct the model so that contractors can profit from it—and will therefore dedicate their best efforts to achieving program objectives. The contracting community will undoubtedly find it difficult to adapt to this change. However, such a structure will allow the DoD to become a faster adopter—and beneficiary—of innovations.

In summary, to increase the yield from our S&T investments I recommend that the DoD strongly encourage the S&T community, the acquisition community, and the warriors to manage the acquisition process *as a team*. Technologists and program offices should together engage in dialogue with the warriors about needs and technical solutions. They should agree on investments in promising technologies. The services should craft the POM for success in the resulting investments using a funding line that allows them to harvest successes. Together they should continually review progress and adjust schedules to align maturing solutions with the POM money and programs of record. To the extent possible, programs of record should feature architectures that allow easy adaptation to new innovations. Finally, acquisition strategies should incorporate incentives for open architectures, competition, and innovation. I wish to point out that the DoD already possesses the authority to act upon all of these recommendations with the exception for some of the flexibility in the POM line.

Finally, I would like to mention the possible contributions of FFRDCs in the context of these recommendations. FFRDCs could play key roles because of their combination of technical expertise and their inherent, government-mandated impartiality. This impartiality is especially important, because commercial organizations can freely share their latest findings with FFRDC staff and because FFRDCs have no commitment to a particular vendor or system.

The strong technical talent of the FFRDCs can augment the expertise of government program offices, enabling them to interact with their contractors from a position of peer-level understanding of technology. This would allow the program managers to use technical, measurable criteria to determine which innovations actually perform best.

To assist in increasing the yield of innovations from the wealth of technology available, FFRDCs could work with the S&T and acquisition programs to accelerate technology transitions from the government S&T community, industry, and academia. Their access to both government information and commercial proprietary information would permit FFRDCs to conduct impartial evaluations of inventions stemming from a broad range of the research community and to select those most relevant to identified needs and most likely to succeed in fielded programs.

I believe that implementing the recommendations outlined above will keep the United States at the forefront of applied technological innovation, and contribute to the success, and the safety, of our warriors.

Thank you, Mr. Chairman. I would be happy to answer questions.