Science, Technology, Engineering and Mathematics Workforce Needs for the U.S. Department of Defense and the U.S. Defense Industrial Base

LHS Presentation, Aug. 1, 2011

I want to thank the committee for the opportunity to participate in this very important workshop. Most of the technologies that will be fielded during the next fifteen years have already been identified and are currently moving up the development path. I'm certain that further transformative scientific breakthroughs lie ahead, but I have no special insight about that which is "yet to be discovered". I've chosen instead to discuss known technology issues that will be critical to DOD in the next 15 years, selected because they illustrate issues in STEM workforce development.

Robots, remotely operated by humans, reached ~8000 in number at the maximum intensity of warfare in Iraq/Afghanistan two years ago. In coming conflicts, we are certain to see fully autonomous systems from single isolated robots to self-coordinated swarms. The science fiction of only a few years ago is just around the corner. Flying vehicles are being planned, scaling in size from today's "drones" hovering in swarms high over the battlefield to minute, insect-like spies, designed to fly into enemy dwellings and map the insides before soldier entry. Land-mobile "bots" are envisioned as teaming with soldiers, carrying supplies, seeking out and disarming IED's, some large, some insect-like in size, all independently mobile. Weaponization of some of these systems is certainly a possibility, raising interesting ethical questions. Not only are these developing technologies complex from an engineering perspective, their use will challenge the most fundamental nature of our humanity and how we wage war. In any event, battlefield use of these systems will require an increasingly sophisticated warfighter population stretching the current boundaries of the STEM knowledgeable DOD workforce.

While the autonomous systems will be new, their uniqueness will derive from integrated technical developments on the part of current experts in science, engineering and human effectiveness. Among the multiplex of technologies required for these autonomous systems are new materials and new energy sources, elements of continuing importance for many other DOD needs.

Materials, the stuff that things are made of, will continue to be a critical technology for DOD. From personnel protection to higher operating temperatures in engines, new materials are constantly sought. Improvement of materials intended for systems we already know about will be augmented by new capabilities only possible through completely new materials concepts. Nanotechnology offers a range of new and improved capabilities that will continue to enter DOD systems and expand the design space. Autonomous systems, particularly the very small light weight ones, will benefit from multi-functional materials, those providing both structural integrity and energy storage, for example.

Perhaps the most dramatic change on the materials development scene over the next decade or so will be the implementation of computational tools that are now reaching maturity. Spurred by decades of investments by many agencies throughout the world, computational tools have now reached a sufficiently mature stage, enabling materials by design for specific system needs. DOD laboratories and contractors will need to expand their STEM workforce to ensure full utilization of computation in future materials development efforts. A critical step remains in academia, namely to fully integrate computation into the engineer's toolbox by building the instructional environment in many university departments that will expand the required trained workforce.

Wherever we turn today, the need for more efficient energy sources is an issue, and there is no shortage of investment in various strategies. Yet the equipment load carried by individual soldiers continues to expand, the cost to the DOD for energy continues to expand, and the logistics tail associated with energy sources continues to expand. Enormous investments are being made by DOE and other agencies, but it remains for the DOD to shape the advances being made to address specific warfighter needs. Strong links exist here with the design and fielding of autonomous systems. These systems will be powered either by batteries or small to tiny sized engines. Batteries, as we all know, provide a short usage time and must then be replaced or recharged, creating logistics complexity. Small engines may power some of the larger autonomous systems, but DOD standardization on JP8 fuel brings technical challenges for small engines, especially with regard to ignition. Specific workforce needs in these areas are not unusual, but DOD investments in the specific required technologies will demand a continually renewed workforce in "traditional" science and engineering areas.

Autonomous systems development will demand collaborative, interdisciplinary and system-organized research. We are familiar with systems-organization in the development stage and often depend on industry for this structure. However, many of the novel autonomous systems being considered are clearly at a research stage now and will remain so for several years to come. The breadth and depth of required technical expertise can not likely be fully developed and maintained in DOD labs, nor will it be found in the traditional industrial contractor base. Technical leadership in many of these fields is often located in other government laboratories, but especially in universities including those in other nations. To achieve the required systems systems-organized collaboration, DOD will require new modes of interaction between its labs and these other entities such as the critical technology alliances being utilized by the Army.

I want to turn my attention now to technical issues of a very different kind, those critical to the aging transportation and attack vehicles that constitute the bulk of our warfighter materiel support.

Prospects for dramatic replacement of major weapons systems in the foreseeable future are severely limited compared to those experienced in cold-war years. Consequently, vehicles remain in active use for many years beyond their original design lifetimes. Opportunities for technical upgrades, can be important in this life extension process. For example, the replacement of aircraft engines can not only reduce maintenance costs, but can simultaneously extend vehicle life while reducing fuel costs. These upgrade opportunities will continue to demand engineers familiar with such traditional disciplines as materials, electronics, software, and nondestructive evaluation. Herein one finds the first of the noteworthy STEM workforce issues. Reduced investment in research in some of these traditional areas by

DOD has been one of several factors leading to less academic attention to these topics and danger to the workforce pipeline. A critical example recently addressed dealt with corrosion engineering. Notably one of the major costs to the DOD maintenance budget, corrosion had nearly disappeared as a subject taught in undergraduate engineering education. Intervention by DOD is now beginning to address this critical skill issue. For example, a new program at the U. Akron, sponsored by DOD and organized with the help of the Natl. Assoc. of Corrosion Engineers, will now offer undergraduate degrees in corrosion engineering.

Another key workforce aspect of this ageing systems technology issue is the need for a career trained workforce to populate the repair depots around the country. Increasingly sophisticated systems demand increasingly skilled maintenance crews. Frequently located in somewhat isolated, low income areas, maintenance depots must often depend on locally career-trained labor. Attention to STEM education in local high schools and community colleges by DOD is an important element in supporting this critical technical workforce need.

DOD will continue to have need of STEM capable workforce, both civilian and military, with education and training spanning the broad range from vocational to advanced degree and including the hard and soft sciences and the full scope of engineering research and practice. A broad, coordinated DOD investment will be required to ensure the availability of this critical asset.