May 3, 2017

Department of Defense Laboratories and Their Contributions to Military Operations and Readiness

Subcommittee on Emerging Threats and Capabilities, Committee on Armed Services, United States Senate, One Hundred Fifteenth Congress, First Session

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Stenographic Transcript
Before the

Subcommittee on Emerging Threats and Capabilities

COMMITTEE ON
ARMED SERVICES

UNITED STATES SENATE

DEPARTMENT OF DEFENSE LABORATORIES AND THEIR CONTRIBUTIONS TO MILITARY OPERATIONS AND READINESS

Wednesday, May 3, 2017

Washington, D.C.

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Wednesday, May 3, 2017

U.S. Senate
Subcommittee on Emerging
Threats and Capabilities
Committee on Armed Services
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:32 a.m. in Room SR-222, Russell Senate Office Building, Hon. Joni Ernst, chairman of the subcommittee, presiding.

Present: Senators Ernst [presiding], Wicker, Fischer, Heinrich, Shaheen, and Peters.

Also Present: Senator Warren.

OPENING STATEMENT OF HON. JONI ERNST, U.S. SENATOR FROM IOWA

Senator Ernst: Good morning, everyone. It is just a smidge after 10, so we will go ahead and call this meeting of the Emerging Threats and Capabilities Subcommittee to order.

Today, we will receive testimony on the Department of Defense laboratories and their contribution to military operations and readiness. I am pleased we have Dr. Melissa Flagg, Dr. Jeffrey Holland, Dr. John Montgomery, and Mr. Ricky Peters with us here today. Thank you very much for being on our panel.

I look forward to their testimony, and I hope they are not only able to talk about the importance of laboratories but also the unique role our universities and the private sector play in advancing research and development for our Department of Defense.

From personal protective equipment and lighter radio batteries for our infantry to directed energy, the technology researched and developed today will ensure we continue to outmatch our adversaries tomorrow.

So we appreciate you being here today, and I would like to open it up to my ranking member for his comments.

STATEMENT OF HON. MARTIN HEINRICH, U.S. SENATOR FROM NEW MEXICO

Senator Heinrich: Thank you, Chairman.

Let me start by just thanking Senator Ernst for holding this hearing on our Nation's defense laboratories and technological innovation. I know we both understand the significance of their impact on national security and the economy.

Today's hearing will help us better understand the Department of Defense laboratory enterprise and how this committee can work together to help it flourish. The DOD lab enterprise is a network of roughly 60 individual laboratories across the country, including two in my home State of New Mexico, which is proud to host the Air Force Research Laboratory at Kirtland Air Force Base, where I actually started my career, and the Army Research Laboratory at White Sands Missile Range.

The thousands of men and women at the laboratories, both public servants and contractors, play several critical roles for the DOD, including rapidly deploying new equipment to the battlefield -- for example, the labs did the engineering work necessary to get the Mine-Resistant Ambush Protected vehicles, or MRAPs as we know them, to theater as a rapid response to an operational need; supporting acquisition programs to make sure that DOD is a smart and

technically informed buyer of advanced technologies, and helping control costs of major weapons systems; and performing cutting-edge, next-generation science and engineering research at a network of labs, as well as managing research and development programs in industry and universities, which have led to equipment and weapons systems that our warfighters depend on, like advanced radar and satellite systems and munitions.

A recent Defense Science Board study of the labs stated that the labs are the core muscle the department has to create, transition, and deploy technology to the warfighter, but we need to do more to make sure that those muscles are strong and healthy, and that is the focus of the hearing we are having today.

I know that all organizations suffer from constraints on their budget, and the labs are no different. I hope our witnesses can highlight the biggest budgetary challenges facing the labs, so that we can consider how we can address them as we work on this year's defense authorization act.

I am also interested in understanding how reductions to funding for civilian science agencies, agencies like NASA and NSF, will affect science and technology that is important to defense missions, and whether the labs could, with more resources, help address shortfalls in the Nation's scientific enterprise that may be coming due to those budget

cuts, for example, in areas like STEM education or even university research.

I also would like the witnesses to help the subcommittee understand how we can support the labs by streamlining laws and regulations and bureaucratic processes. On the Armed Services Committee, we have done a lot in the past to make the hiring process easier at the labs so that our labs can better compete with private sector enterprises to get the best talent.

I also know there are major challenges in funding lab facilities and equipment, and in untangling the labs from government red tape. I would like to hear the witnesses' ideas on what red tape they have encountered personally in many years of service at the labs, and how we can best address some of those challenges.

Finally, I know that DOD leadership and this committee want to make sure that our warfighters benefit from the great spirit of American innovation, including private-public partnerships with Silicon Valley. I know that DOD has efforts like DARPA and DIUx that try to leverage commercial innovation for the benefit of DOD, and I think the labs can and should play a bigger role in those efforts. I would love to hear from our witnesses their views on how we can best make that happen.

So I look forward to all of your testimony here today

and will turn it back over to the chair.

Senator Ernst: Thank you, Senator Heinrich.

We will start with our panelists this morning.

Dr. Flagg, we will start with your testimony.

STATEMENT OF MELISSA L. FLAGG, PH.D., FORMER DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH, OFFICE OF THE SECRETARY OF DEFENSE

Dr. Flagg: First, I just want to say thank you so much for having me. It is actually an incredible opportunity to participate in my democracy, in our democracy. I really enjoy it.

And my mother in Missouri, originally when I said I was going to be a witness, thought I had seen a crime, so she is very excited to know that I am actually here.

[Laughter.]

Dr. Flagg: I want to just start by saying I worked for the Department of State and the Department of the Navy and DOD for about 12 years, and then I left government, and I went out to Chicago to work for a philanthropy there. And I spent 2.5 years looking at creative scientists all over the country with no constraints, no bureaucracy, giving away free money, did not ask anybody to write any reports, gave them the money and walked away, because it was not taxpayer money, and accountability and transparency was not sort of the primary goal.

When I came back, I had a lot of negativity of people saying, why are you going back to the bureaucracy? You are going to lose all of your optimism.

And I want to say that after 15 months of spending more

time in the DOD laboratories than probably anyone in OSD, I left the Department of Defense more deeply optimistic about the future of this country than at any point in my life and so deeply recommitted to spending the next 30 years focusing on how I can help have people understand the capabilities that we have, while also respecting the humility and the secrecy that is required in some of these efforts in order to ensure that we have sustained advantage.

So I am an incredible advocate. I am extremely committed. I do not believe they are perfect. I also do not believe I have met an organization made up of humans that is. And I also believe that we need to find ways to celebrate the laboratories without having it show up necessarily in the New York Times.

Thank you.

[The prepared statement of Dr. Flagg follows:]

[SUBCOMMITTEE INSERT]

Senator Ernst: Dr. Holland?

STATEMENT OF JEFFERY P. HOLLAND, PH.D., FORMER DIRECTOR, ENGINEER RESEARCH AND DEVELOPMENT CENTER, UNITED STATES ARMY CORPS OF ENGINEERS

Dr. Holland: Chairman Ernst, Senator Heinrich, and distinguished members of the subcommittee, I really want to thank you for the opportunity to discuss both the current roles and the future of the science and technology laboratories within the Department of Defense. I greatly appreciate the support that this committee, in particular, has shown to S&T over the last several years. I spent 37 years at the Engineering, Research and Development Center in Vicksburg, Mississippi. I actually want to work there just after Grant came through --

[Laughter.]

Dr. Holland: -- and was there right after he left, in fact.

ERDC is the S&T arm of the U.S. Army Corps of Engineers, and it conducts research and development for the warfighter, for military installations, and for the Corps' Civil Works' mission. I was fortunate enough to be the director of that organization for many years, as well as many other functions in the organization.

In fiscal year 2016, ERDC executed a budget of $1 billion of S&T for a variety of activities, and for many different organizations within the Department of Defense,

including $500 million of what could easily be thought of as other people's money within the Department of Defense.

These activities were involved in solving people's problems, which is a primary function of the Department of Defense laboratories.

Today, I would like to address three elements of everything that is critical to what ERDC and, in fact, what each of the S&T laboratories do. That is people, programs, and facilities, and I think we will hear those three concepts all along the way as we move through.

Innovation requires a talented work force. I am proud to have represented 2,300 scientists and engineers, technicians, and administrative personnel as the director of ERDC for the many years that I was the director. ERDC has as its 5-year goal to hire 800 additional scientists and engineers, which would be a net of 300 of growth for the organization over the next several years.

The authorities that have been given to ERDC and to the S&T laboratories under the S&T Reinvention Laboratory Demonstration Projects are the very things that make it possible for organizations like ERDC to be able to compete in the marketplace for the types of talent that the Department of Defense laboratories need.

In every case where these authorities have been fully implemented to the laboratories, I have found that the

laboratories have done a tremendous job of implementing those capabilities. Conversely, where those capabilities have not been fully implemented in the labs, we have found that those opportunities have gone wanting.

Differing NDAAs have provided numerous enhancements to ERDC's hiring authorities and those of the other labs, for example. NDAA 2015 provided direct hiring authority for students. But, as an example, that authority has not yet been fully delegated to the laboratories.

Because ERDC has great people and because the other laboratories, for that matter, have great people, it can execute impactful programs. DOD labs play a key role in national security, and ERDC has a long history among the other laboratories of providing innovative solutions to keep our warfighters and civilians safe.

ERDC force protection technologies are installed in theater to protect base camps from rocket and mortar attacks. The State Department is using them for technology to protect certain critical facilities and personnel, and many of the buildings in the National Capital region, such as the one in which we sit, as well as the Pentagon and others, are safe because of ERDC protection technologies.

ERDC's airborne counter-IED systems are currently providing CENTCOM with unique capabilities, and there actually is a whole story, and perhaps an undercurrent for

another time to discuss, of the enormous integration activities that the laboratories performed in bringing basic science to bear during the height of the IED fight, both in Iraq and Afghanistan, where we were able to field solutions in a manner that went from 18 months or less to just a very few months in bringing solutions to the field.

ERDC tunnel technologies have been provided and applied in Iraq and along the Egypt to Gaza border, U.S. and Mexico, in support of DOD and DHS, for that matter.

Finally, I would like to mention the idea of facilities and the 219 program. ERDC, like all of the DOD S&T laboratories, needs to modernize and recapitalize its facilities to ensure continued world-class support for the warfighter and the Nation.

Its 219 authority allows ERDC to fund facility improvements, and it has had great success in using this authority. This is particularly important, given that ERDC finds great difficulties in obtaining major milcon funding.

It was rewarding to see that fiscal year 2017 NDAA, signed into law in December 2016, extended the program to fiscal year 2025 and increased the threshold for this capability to $6 million. Thank you to the committee for supporting this type of capability.

Unfortunately, ERDC has not yet been able to take advantage of the authority provided in the 2014 NDAA that

allows the lab directors to approve funds over multiple years for larger infrastructure needs. While ERDC is working to make this possible, the labyrinth of implementation issues associated with that provides difficulty after difficulty in making that possible.

In conclusion, I took great pride in being the director of ERDC, as I am sure you will hear from each of the witnesses today in their respective organizations, and I would like to mention to you that, in no small part, the ability to provide this world-class capability that we do very much have is the result of the capabilities that you have helped us to achieve.

Thank you for this opportunity to give this statement.

[The prepared statement of Dr. Holland follows:]

Senator Ernst: Thank you very much, Dr. Holland.

Dr. Montgomery?

STATEMENT OF JOHN A. MONTGOMERY, PH.D., FORMER DIRECTOR OF RESEARCH, NAVAL RESEARCH LABORATORY, UNITED STATES NAVY

Dr. Montgomery: Thank you very much. I have to tell you how I ended up at the Naval Research Laboratory.

Like many things in life, and often in science, it was an accident. It turns out that I was in graduate school, that it was time for me to come out. I had a pregnant wife. I had no way to pay for the baby. I heard through the grapevine that NRL was hiring, and I signed up sight unknown what I was going to end up with.

I ended up in the Electronic Warfare Division of the Naval Research Laboratory in the fall of 1968. I served in that division for 34 years, and 17 years as its director. Then in 2002, I ended up as the director of research of the Naval Research Laboratory.

You know, I thought my first 34 years were fun. The second 14 that I served as director was not only great fun, it was very rewarding. But it was very challenging. And, in many ways, we had a lot of help from the folks on the Hill at managing some of our challenging problems.

I retired from Federal service on the 3rd of August 2016.

So I am really grateful to have an opportunity to talk to you about my experiences there at the lab. I am

currently, as far as DOD is concerned, a private citizen. And I will express a point of view which is mine, but that is founded in almost 50 years both as a practicer and a participant in the larger DOD lab community. And I have witnessed firsthand the great value that it has had to the Department of Defense and in many ways unrecognized, unseen, and unappreciated.

So one of the greatest EW solutions is an active electronic decoy, which is towed by aircraft. Its success rate is really high. I am proud of having been involved in that. But it does not say NRL inside. And it does not recognize the fact that the magnet technology that made the power source a traveling wave tube small was invented by NRL, or that the cathode and the beam control and the aerodynamics and the control systems all came out of the DOD laboratories, and we worked at the Navy and Air Force until it was completed and fielded. And at the time, it was a revolutionary solution, which serves us well today.

So there are many things that I mentioned that we had received as new authorities -- Section 342 that gave us the STRLs; Section 219, the direct hire authority -- all of those have been very important to us, and we have been able to use them effectively.

The direct hire authority, there are several hundred people at the laboratory that we hired using direct hire

authority. The creation of the Karles fellowship program named after Jerome and Isabella Karle, he a Nobel Laureate in physics, she equally honored. He was a chemist, and she was also a chemist. We named it after her. We have almost 200 of those, the best and the brightest this Nation has to offer from all over.

There are authorities that await implementation, such as 1107(h), the NDAA of 2014, which would further strengthen the laboratory.

So I am going to tell you a little bit about the lab. It was created in 1923 by an act of Congress. Its role is to do basic science, fundamental technology, and see that it influences and gets embedded in naval systems. That is both the air part of the Navy, surface submarines, the space part of the Navy, as well as in the Marine Corps, and to take that science and technology understanding and harness it to the solution of problems emerging operationally in the Navy and the Marine Corps, and bringing that knowledge to bear to solve those problems.

An example of that, of course, is the work that has been done over the last number of years in dealing with improvised explosive devices, and others which may yet arise in the radiological and biological and nuclear area.

So NRL has had a long history of putting things out there that changed the military forces and changed the

world, in fact. Many of them with civilian impact -- sonar, radar, nuclear submarines, global positioning system, spy satellites. NRL built and fielded 100 satellites with Federal employees out of NRL. And electronic warfare, which was founded out of the lab, which has come to be of greater importance recently. All of these are continuing today.

Some of the things that we are working on are just now revealing what their potential may be -- the electromagnetic railgun that allows you to fire projectiles at Mach 7 or Mach 8, reaching out 100 miles or more. Or in short-range engagements, they have the potential of engaging hypersonic cruise missiles that otherwise we might not have the ability to engage at all due to the deficiency and relative velocities that we would otherwise have.

Spintronics, a new form of electronics which will fundamentally revolutionize how we do electronics -- higher speed, lower power, greater bandwidth. And it uses rather than the motion of electrons through media -- sort of like running through a crowd at the mall at Christmastime. You waste all your energy bouncing off all those other people. Spintronics do not do that at all. They just flip the electron spin. You can actually make electron currents.

A crude analogy of that, and we have all seen this, these domino constructs where you push and flop the first domino, and you see this wave of dominoes falling over, the

dominoes do not actually move longitudinally. They just change from vertical to flat. That is exactly what happens with these electrons as they flip.

That can carry information for ultrafast processing, high-bandwidth communication. The laboratory is working with the semiconductor industry to transfer that in. It will be a fundamental revolution.

Other things, quantum systems, a big effort on that for encryption, for processing, for sensing.

Bio-printing, very interesting, because what is emerging now among these technologies is the ability to take a skin cell from your hand, induce it to be fluripotent, specialize it to a heart muscle cell, and using 3D printing to build you a brand-new heart from your own cells and then replace it.

Given my age, I doubt it will be in widespread use in time to help me, but I will take great satisfaction in seeing its development along the way.

Synthetic biology for fuels, for creation of drugs that we cannot create today, and the larger field of genetic engineering as we start to understand what all we can do in synthetic biology with the revolutions in CRISPR/Cas9, where we can develop things which are organisms that live and produce products we can use that never existed before in nature.

Other things are still amongst the yet unrecognized products of the basic sciences that we are doing at the lab and across the larger enterprise. They may become every bit as important as the things that I mentioned earlier in terms of shaping the world. It may take decades to do that, but they may, in fact, change the world.

So this is done by Federal scientists with deep understanding of the Department of the Navy in a Navy-owned facility, and its results are owned by the Navy. The laboratory and its mission has been of vital import in the past, but it may be even more critical in the future as the technological and scientific centroid of worldwide activity inexorably moves eastward, and we are no longer the sole dominant player in the world of science and technology. I hope we will have an opportunity to amplify that further on.

So what are the three things that are the most important to me from my experience at the laboratory?

Allowing the director control over the tools of the laboratory. That includes the scientists, the equipment, the funding, the pay scales and compensation, and recognition and rewarding. Section 1107(h) of the NDAA of 2014 would be of great assistance in that area.

Regenerating our facilities, the average age of the facilities at NRL this decade -- our decadal replacement rate is 636 years. When that dropped from 1,101 to 636, I

was really excited because at least there was a biblical precedent of somebody lasting long enough to see one of those cycles through, facilities.

And an acquisition system, a means to buy things that is tailored to the requirements of buying something in partnership with industry and universities that never existed before in the history of humanity, and where the outcomes are truly unknown because you are probing the boundaries of knowledge and understanding, and it was never explored before and it is hard to put down on paper the outcome of that science. And that is not how our current acquisition system is designed.

So thank you for your patience. Thank you for listening to me.

[The prepared statement of Dr. Montgomery follows:]

[SUBCOMMITTEE INSERT]

Senator Ernst: Wonderful. Thank you, Dr. Montgomery.

Mr. Peters?

STATEMENT OF RICKY L. PETERS, FORMER EXECUTIVE DIRECTOR, AIR FORCE RESEARCH LABORATORY, UNITED STATES AIR FORCE

Mr. Peters: Thank you very much, Chairman Ernst and Ranking Member Heinrich. It is a real privilege to be here today, and I appreciate the opportunity. I am also honored to be here with my colleagues to share the Air Force Research Laboratory successes, in particular supporting military operations and readiness.

I was privileged to spend 35 years as a civil servant in the Air Force. What an awesome, awesome time that was. Ten of those years, sort of toward the end, were in the test world, which included an assignment at the Pentagon as the director for Air Force Test and Evaluation. I did spend 25 of those years in the Air Force Research Laboratory.

I retired in September 2015. And so perhaps some of the things I will say today are dated, but it is nice to not have anybody script anything for you, to come in and get an opportunity to answer your questions, and I am truly looking forward to that.

I can tell you, though, in every assignment I had, I was amazed by the talented scientists and engineers and everybody else who supported them. That was the one thing that I learned in the laboratory and across the Air Force. The contracting specialists, the financial experts, the

personnelists were just world-class. As a result of that teaming that we had, that is what enabled our Air Force to be second to none, just an amazing group of people.

So today, I went from an organization of 10,000 people to one of 10, so I am now a small-business person on the outside.

A lot of what we did in the Air Force Research Lab is extended into that piece now. I am working for a small company that actually is formed by the Greater Dayton Hospital Association. The reason I mention that it is 29 regional hospitals that grouped together. It includes the VA Center and the Wright-Patt Med Center, so there are the military aspects of that as well, a group that comes together to help solve medical challenges in the region and also looks at things they can do together, to work closer together.

It was an awesome opportunity. Three of those organizations in the GDHA actually came together and invested in us, Kettering Health Network, Premier Health Partners, and Dayton Children's Hospital. They teamed with a small innovation and design firm out of Cincinnati called Kaleidoscope.

So with that group, we actually take unmet needs out of the hospitals, and that includes things that perhaps would come out of the military side, and look at commercializing

those. So unmet needs are ideas that we want to take on. This small team does that from idea all the way through development, and commercializing out the backend and spinning out small companies. So it is a great small microcosm of what you would find in the AFRL, from very basic research all the way through development. But now we add the commercial side into that.

So a great extension of what I did there. I absolutely loved the time that I was there. I will not spend any more time talking about that now. I am anxious to hear your questions and respond to those. But thank you again for the opportunity today.

[The prepared statement of Mr. Peters follows:]

[SUBCOMMITTEE INSERT]

Senator Ernst: We appreciate it.

Thank you all very much. I wish we had a lot of our younger generation here. They would be so excited to hear about how you utilize science and technology at your various laboratories, and the level of enthusiasm is just incredible. So thank you very much for that.

We will start with 7-minute rounds of questions. As we happen to be joined by other members, as they come in, we will include them in the round of questioning as well.

My first question to you all today is about soldiers' protective equipment. I am concerned that the Department of Defense is not devoting enough attention to advancing individual soldier's protective equipment, like body armor and helmets.

I am even more concerned that body armor currently produced by a private company in Iowa and not being used by the DOD appears to be better than what our servicemembers are actually wearing when they are out on the battlefield. As we devote billions of dollars to advanced aircraft and space capabilities, there simply is no excuse for sending an infantryman into a fight without the best possible protective gear.

So my question to the panelists, if the best body armor is being made in the private sector, how do we go about getting it to our servicemembers? We have talked about

different acquisition issues, but then also, how can the laboratories work even further on that personal protective gear?

Any of you, if you would like to answer? Thank you.

Dr. Montgomery: There is a bit of a challenge in that the services have very large quantities of these equipments to buy. One of the fundamental challenges is understanding, when a new idea comes about, how to validate and come to understand the advantages it represents as compared to that which we have. So testing processes are important.

For example, in working with the Army and new materials as developed by industry, NRL is looking at improved ways to provide body armor out of new material such as ultrahigh-density polyethylene fibers to replace Kevlar, working with the Army and with industry on fabrication of these vests.

That does not really address your issue of how you get them through the acquisition process, which hopefully we will touch on a little further, but it does point out the fact that having clear, demonstrable, greater military value than that which is already there, which is provable, is really important.

There are other aspects of the protection as well that you can see the very large, cumbersome chem-bio suits that our soldiers wear in the field. It is pretty topical these days, given what has gone on in Syria. But work in the

laboratory and in partnership with industry is the coding of every individual fiber within the uniform with enzymes that, on contact with chemical or biological agents, break them down to harmless compounds.

Those could provide a much more comfortable environment in which soldiers, airmen, marines, and sailors can operate in those environments, and yet still provide them protection that they need.

So channels that allow those new ideas, better approaches to, as an institutional method, move into the mainstream and produce and distribute it is something that we need. Rapid prototyping and experimentation are going to be critical to that, and perhaps we will touch more on that later.

Senator Ernst: Absolutely.

Anyone else?

Yes, Dr. Flagg.

Dr. Flagg: I think one of the things that I found as I traveled around the country and I talked with folks is that it is very hard for people who believe they have a great solution to understand the context within which that solution would be employed, and then to really draw the apples-to-apples comparison.

I think that some of the examples of ways that we can go about making this a more effective process are things

like examples where I know the Army has done these sort of roundups, where they allow people to bring their solutions in and have them tested out against common goals.

We sometimes resist using research dollars, that are precious and are small and that we fight to protect, to apply them to clearly testing and sort of acquisition-related processes. But I am a big believer in bringing people at the local, state, regional levels into the process.

I think if you begin to understand that it is not just it stops a bullet better, it is that it is light enough, it integrates with all of the other equipment, it gives them the mobility to run, to move, to shoot, to launch UAVs, to do whatever else they need to do, it is a very dynamic environment, and it is very different than someone who is in a vehicle, getting out, making one shot, which tends to be a more domestic context that many of these things locally are developed against, sort of those goals.

So I think if we can develop places, times, moments, where folks in the region can bring their ideas together and show them, test them out, that actually we would all learn something from that. The laboratories could see that there might be parts of that they could integrate or that they have tech transfer or goals that they could provide to small business to make it more likely that those ideas could be

developed into robust, applicable solutions.

I also think that it would make regular people feel more engaged in their government.

Senator Ernst: Absolutely.

Dr. Flagg: To understand what the real need is is very hard when you are far away.

Senator Ernst: Very good.

Anyone else?

With that, I will yield back my remaining time. We will have time for additional questions in a moment.

But, Ranking Member Heinrich?

Senator Heinrich: Thank you, Madam Chair.

I want to start by asking you all, and I know, Dr. Holland, you addressed this a fair bit in your testimony, about some of the hiring flexibility that has been provided. It seems like that has not been universally applied across the lab enterprises.

How can we do a better job of making sure that that is actually utilized? Where are the challenges to making that happen? And really, from any of your perspectives, how can we make sure that those hiring authorities are actually making it through to where we are able to hire more effectively, more quickly, and get the talent that we need for these enterprises?

Dr. Flagg?

Dr. Flagg: I am going to start, because they are all going to say it is our fault, or it was. I am not constrained by the OSC lawyers anymore, so I can say what I want.

Senator Heinrich: That is exactly why we invited you.

[Laughter.]

Dr. Flagg: Everybody is nervous behind me now.

The first thing I would do is call the lawyers from every service in here and ask them how they are going to find a way to yes, not how they are going to do the easy thing and say, "No, I have never done it before." Because the lawyers are running that organization right now, not the mission specialists, first.

The second thing I would do is call the personnel and readiness people in, and the military folks in each of the services who oversee the civilian hiring and personnel authorities at each of these laboratories, and ask them why they are so obsessed with everything being the same rather than every part of the system being optimized to fulfill the mission.

The mission is: Send those men and women out into the field to do a dangerous, ugly job, and give them the highest likelihood to succeed at the mission and come home alive. That is the mission.

The mission is not: How do I make everybody feel like

they are getting a fair sort of environment where nobody is getting special treatment in personnel hiring authorities or how we do our budgets?

And right now, there is more of a focus on controlling your little pooka and making sure that nobody gets special treatment and everyone is equal and that the lawyers never tell you you are going to go to jail than there is on getting the mission done. And it is a problem.

I will say that, at the end of 15 months, I had spent 15 months banging my head against a wall and being a part of the problem. When I walked out, it was with a realization that, if I ever go back, I would rather risk going to jail than tolerating that kind of ignoring of the mission that I see happening right now -- not because any one individual is trying to do the wrong thing, but because everybody is trying to do the safe thing.

Senator Heinrich: Mr. Peters?

Mr. Peters: Just a couple things that I would add. I would say that everything that happened with the laboratory demonstration projects and Section 340 2 years ago was amazing. What I think built just a powerful system there was that we took scientists and engineers and said, what would you like the system to be?

We had just a phenomenal mentor in Dr. George Abrahamson from SRI. He helped us build that system, and it

was a system that we wanted and we knew it would help us promote people, to retain people, to hire people. It was the right system for us.

We had one personnelist, incidentally, that was on that team. There was a core team of five and about 50 total. The personnelist was brilliant because she would say, here is what we need to do to get a waiver, and here is who has that authority all the way through OPM.

So you gave us that, and we went forward with it, and we built the right kind of system. And everything that has come since then, I believe, has taken forever to implement.

So all the new flexibilities that you have given us --

Senator Heinrich: Why is that, Mr. Peters?

Mr. Peters: You know, 2015, the authorities that the Air Force was given, and the services, in 2015 in the personnel area, the policies still are not in place. We do not know. We just do not have them implemented yet.

Even something like manage-to-budget, we are still being monitored in AFRL by the number of slots we have and the limitation on over-hiring. Instead of saying manage-to-budget -- we had a goal in the lab of no more than 25 percent of our total income that we got would be spent toward salary, so we had something. What are we willing to bet, and what are we willing to put it risk, knowing that we still had facilities to take care of and we still had

contracting on the outside to support us?

So truly give us that manage-to-budget authority and stop measuring in terms of the number of people, and I believe that would really help out in the Air Force.

In terms of the time, though, that it takes to hire people, I cannot answer that. There has been a lot of centralization that happened.

I know, sir, in Albuquerque, we have had some trouble hiring in Directed Energy and Space Vehicles. I cannot give you an answer for it.

But we keep trying to look at the process. We keep trying to fix it. And I think Dr. Flagg had it correct, that we just need to get the people out of the way and have something specific for science and technology. It was working when we first stood up the lab demo projects, I can tell you that.

Senator Heinrich: Dr. Holland?

Dr. Holland: Once we get OSD lawyers all in a room and bind them, however you would like to infer that, then the services then put their own spins on the implementation. So the guidance that comes out of OSD, out of DOD, will have to be clear and relatively unassailable, to the services.

The reason that the original things that happened with the laboratory demonstration projects worked so well is because there was a clear champion at the beginning. I

would suggest to you that the new Under for research and engineering --

Senator Heinrich: Who was leadership-based.

Dr. Holland: -- would have to be viewed as your champion at a very high level, someone who owns all of the purview that is necessary to make these things happen, and someone who you can hold accountable for that matter, because, at the present time, you lack that scenario.

Otherwise, you will get the OSD spin, the service spins, legal and the human resources spins. And then by the time you get done with those, you have a 2- to 4-year implementation planning process going on.

And some of us have actually gone out and implemented, quite candidly, on our own at times, the ones of us who are crankier, who did not pay attention to whether we were retired or not. That was only way to go ahead and get things going, because we felt that you had given us the responsibility and law to do that to begin with. That was fraught with difficulties all on its own.

Dr. Montgomery: Let me comment, if I may?

The direct hire authorities for advanced degrees, bachelor degrees, veterans, technicians have been of tremendous value to us. We can get a person a firm, formal offer in about 2 weeks. Within the Navy, the Navy has allowed this authority for doing this to vest in the

laboratories within the Navy. That was a challenge that OCHR undertook years ago.

But we have a fundamental problem. Our pipeline is founded largely on students. It may be a faculty member collaborating with one of my scientists to say this is the best graduate student I ever had. You ought to hire them.

And so what we would like to be able to do is go out and use the direct hire authority that you have authorized and be able to say, yes, I am going to bring that person aboard and make him an offer. We used to be able to do that. We can no longer do that.

My summer student program has gone from about 500 a year down to a low of 45 a year, creeping back up to about half what it used to be. And we cannot penetrate the system to get the use of the direct hire authority for students.

If you can help get that through the system, that would be of tremendous -- I have some hope. Some of the authorities for personnel within the demos on 4 April moved to OSD, and we hope that maybe there will be a new view in hand after you get the lawyers together.

Senator Heinrich: [Presiding.] I want to thank you all for your candor.

Senator Wicker?

Senator Wicker: Thank you very much.

We have a vote, so it may be that members will be

coming and going.

But let me direct my first question to Dr. Holland. I want to thank you for your work at ERDC. I understand we have some scientists from the lab at Mississippi with us today. Would you like to introduce the scientists?

Dr. Holland: They are from all over the ERDC.

Senator Wicker: Thank you very much. And, Mr. Ranking Member, thanks for indulging me on that.

Let's connect the dots between the lab to the warfighter, if you will, Dr. Holland. How does our supercomputing capability eventually help us win the fight?

Dr. Holland: Senator, the department as a whole has become, I would say, close to 50 percent computational in its scientific experimentation, if you will. So the supercomputing work that we do is fundamental to all of the services and to the work that the OSD organizations do.

A good example would be the work that we did on the MRAP, on the underbelly blast. There were multiple Army organizations that were involved in that. ERDC was one of those. The Army Research Laboratory, the Tank and Automotive Command folks were involved in that.

Endless numbers of calculations were done, literally tens of millions of computing hours were used to do blast calculations. Those were then compared against very specific field studies at multiple scales to make sure that

the calculations were validated. Then those were extended far beyond the range of what we would have ever been able to afford in terms of doing real field studies of full-scale calculations.

From that, we made decisions on what the underbelly needed to look like for the MRAP. That went to full production, and those solutions went to theater.

From that point forward, we have had, as a military, very few, if any, difficulties with IED issues with the MRAP from that point forward.

For the calculations that we believe in, that we validated, we have the capability to make those types of decisions now through the use of supercomputing.

Senator Wicker: So that is just one example of a real success story there.

Dr. Holland: Yes, sir.

Senator Wicker: Let me then transition to some of your partnerships with academia. Particularly, I would like for the members of this subcommittee to understand your cooperation with historically black institutions like Jackson State University. How has this worked with Jackson State on cyber defense and big data analytics? And can you comment on the larger partnership with the historically black colleges and universities?

Dr. Holland: Yes, Senator.

ERDC, in particular, has educational partnership agreements with 13 historically black colleges and universities and minority-serving institutions across the Nation. One of those, and one of the longest standing ones, is with Jackson State University in Jackson, Mississippi.

JSU has been, at various times, either first or second among the research universities in HBCU/MIs in the country. ERDC's relationship with them touches cyber, touches computational chemistry areas. And those things touch several of the military applications that ERDC is involved in. Those relationships go back probably 25 years, to my memory.

Senator Wicker: What would those applications be, an example of that?

Dr. Holland: Those range from environmental quality issues related to cleanup of military ranges to keep those ranges open, all the way up to specific applications on the classified side, to cybersecurity issues, Senator. Those are very strong partnerships. There are even extensions of those that go into homeland security that involve Jackson State University.

So we have been able to meld those relationships. For example, ERDC, actually, openly provides the library to the Jackson State Engineering School that allowed it to be accredited under ABET accreditation, so there is a strong

integration that exists with Jackson State and has been for many years.

Senator Wicker: Well, thank you very much. Let me see if I can squeeze in another question in a minute.

Dr. Montgomery, the Naval Research Lab at Stennis Space Center has worked closely with Naval Oceanography to develop cutting-edge unmanned underwater vehicle, or UUV, systems.

Talk about that, and do you believe the Navy and NRL will increasingly emphasize UUV research and development?

Dr. Montgomery: Absolutely. The depths of the ocean are profound. Their reach is a vast. In order to be able to access areas which are otherwise denied, we need to be able to have vehicles that can span large spaces, that can operate underwater for very long periods of time, that have the intelligence to be able to deal with the unforeseen, the mountain, like the San Francisco that did not appear on the charts that they were using to detect it.

So the NRL is working with the Office of Naval Research on large-diameter UUVs, which are using hydrogen power, and a GE fuel cell based engine of 95 kilowatts, which uniquely we have been provided by General Motors to do this, which can provide payload-carrying capabilities large distances and large payloads.

Other approaches in the research area are taken where air vehicles are designed to penetrate with GPS precision

into denied areas at bird-like speeds so they do not show up on radar, and then insert themselves into the ocean and become a UUV already where you want to do your sensing with the ability to bring things back out, the information that you gain.

This is critically important. It is going to proliferate widely worldwide, not just what we will do in the U.S., but potential adversaries will be doing that as well for undersea mapping, for sensors and detection of hostile forces underwater, and to penetrate into denied areas.

It is a real cool area.

Senator Ernst: [Presiding.] Thank you very much.

Senator Shaheen?

Senator Shaheen: Thank you, Madam Chair.

And thank you all for being here today. I apologize because I had another event. I missed the testimony, so if you have already been asked this question, I will just ask you to repeat it.

But are the labs currently covered by the hiring freeze?

Mr. Peters: Yes, they are. I know AFRL is, ma'am. So that has been a real challenge. This is the prime time for hiring right now. Typically, we do not have trouble recruiting and retaining really top-notch people, but there

is a blanket waiver for some of the PALACE Acquires and some of the things like that, but it is impacting AFRL, I can tell you that. There are vacancies right now that need to be filled.

Senator Shaheen: And so to what extent has the budget uncertainty over the last, as long as I have been here almost, affected recruitment and hiring? Has that also been an issue?

Mr. Peters: Historically, that has not been an issue.

Senator Shaheen: Good.

Mr. Peters: It is more about not being able to manage-to-budget, and actually having to keep within the slots that we have, the over-hires and the ratio that we have there.

I believe the flexibility has been given. Personally, I do not believe we need more authorities in the personnel area. We just need to be able to use the ones that we have.

Senator Shaheen: Great. So that is really dependent upon the leadership within the department?

Is that the challenge, Dr. Flagg?

Dr. Flagg: I think the biggest challenge here is that every single lawyer between you and a lab director gets to say no.

Senator Shaheen: I understand that, but let's be clear. The reason the lawyers can say that is because the leadership has not said to the lawyers get out of the

debate.

Dr. Flagg: I agree. I am not going to argue that. I did kind of have a soapbox earlier that you missed on this issue.

Senator Shaheen: No, I heard it.

Dr. Flagg: Okay. But I do believe that, as Dr. Holland mentioned, there needs to be a strong, unyielding demand signal sent to the new Under Secretary for Research and Engineering that they are not there just to do cool, sexy things that get into the New York Times. They are there to make sure that the future of defense, which is in our laboratories, is secure. And that means doing some of the unsexy stuff like telling the lawyer get to yes.

Senator Shaheen: I doubt that you would get any objection from the members of the committee, but ending the hiring freeze will also be important.

Dr. Flagg: Absolutely. And I would actually say that the budget uncertainty, in my opinion, does, in fact, affect our partnerships externally, and it does, in fact, affect retention.

The moral issue that I see when I would visit the labs is that not the budget uncertainty hurts in hiring, but it makes people feel very uncertain about whether their projects will continue or whether they will get to take on new and challenging questions. And frankly, they have other

opportunities.

So for me, the budget uncertainty is, in fact, a deep challenge, but it is not necessarily the hiring.

Senator Shaheen: Thank you.

The Defense Science Board Task Force on Defense Research Enterprise -- that is a mouthful -- indicated that our Nation's laboratory infrastructure is becoming outdated and that it lacks the benefits of modern efficiencies and technology. In New Hampshire, we have the Cold Regions Research Lab, which has been very important to us.

So when I see that kind of conclusion, understandably, I question what we ought to be doing to make the changes to make sure that our labs can continue to operate efficiently.

So do you all agree with that conclusion? And what should we be doing to change that infrastructure so that it works better?

Dr. Montgomery: May I comment on that?

Senator Shaheen: Dr. Montgomery?

Dr. Montgomery: There are a number of areas of concern.

One is how the milcon process functions. We can make it better. I will mention that a little more. We can make it better or we can find an alternative mechanism.

The sustainment models that are used within the Department of Defense are inadequate. They have been scored

badly by GAO. They have a sustainment, renovation, and modernization model which determines how much one should spend per square foot to maintain a facility on the average over the first 50 years of its life. That model provides 40 percent less for a research and development establishment in DOD than it does to maintain a public restroom.

So the office building called the Pentagon gets about $8 a square foot per year. The Naval Research Laboratory, the corporate laboratory of the Department of the Navy, received in this model at most $2.60 a square foot. Now due to the pressures on the budget, the challenge is for it to actually be given the amount of money that the model actually calls for. Usually, fiscal constraints result in substantially less modernization.

So what do you end up with? What you end up with at NRL, you end up with state-of-the-art scientific equipment and some of the best and brightest people in physical structures that were antiquated.

Here is my story. We had a building that had $15 million worth of scientific equipment in an area that needed a roof. So we got the guys to come put a roof on it after years and years. The guy putting the roof on set the roof on fire, so we were losing the roof. But the good news is the sprinklers actually came on. The bad news is they rained down on $50 million worth of equipment. The good

news is, because the roof had been leaking for so many years, all the vital equipment was under plastic tents.

So what happened is we really did not lose that. The good news is that the contractor was insured. The bad news is, we never saw a penny of it. We had to pay for it out of hide in funds that would have been used for something else.

So the modernization of the facilities is of critical importance.

How can you do it? You can have a set-aside for laboratory milcon and fight the battle of the milcon. You can do what I suggested that in some quarters was thought outrageous, is you change a few words in the law for Section 219, where it says minor military construction, change it to construction. When it says $4 million, you take out the $4 million, and let us take the 3 percent from Section 219, put that aside for several years, and every 3 years, I could have $40 million to $60 million a year, which would build me a building which was about 60,000 square feet, which is big enough to be efficient. If I have $5 million, $4 million, I am going to get about 8,000 square feet and stacking those up, as a fundamental solution, it is not. It is just a Band-Aid.

Senator Shaheen: Thank you very much. I have to go vote, but I appreciate the conversation.

Dr. Montgomery: Well, good. Maybe you can vote for

what I just suggested.

[Laughter.]

Senator Shaheen: Well, we will take a look that, won't we, Madam Chair?

Senator Ernst: Absolutely correct. Absolutely correct.

We will start our second round of questioning. Again, as people arrive, we will take those questions.

So as you all know, when the military wants to research and then field a new product, they have to actually build the product many times for testing. In Iowa, one of our universities has been working with DOD to conduct that testing on human-based avatars. It is cutting down the number of times we have to make products for testing, and it is saving taxpayer dollars, time, and human resources.

So, Dr. Flagg, can you describe some of the benefits of computer-based avatar testing and any thoughts on that program and how we might be able to expand that through our laboratories?

Dr. Flagg: Sure. I think that it is an incredibly interesting area. I know a little bit about it mostly because we are often asked about why we do animal testing. So we have to think a lot about when you can use virtual testing and new ways of thinking about how we do testing and when you actually have to put it onto a living organism to

really understand it.

I think the combination is incredibly powerful. We do not actually have a model of the full human system. We are actually very complex. While we kind of know how things work, we are not actually able to model the things that are going on inside of our bodies effectively yet. Most people think we must have that, but in science, we just do not have that yet.

But what we do have is sort of the macro understanding of how we interact with the environment. This is where I think these virtual training systems that allow you to put the person into an environment that was not necessarily created specifically with the user in mind -- because most engineers, God bless them, think more about the machine than they do the person until we have to shove one of them in there.

I think it is an incredible opportunity to be much more thoughtful about that very early on in the engineering. And I think these types of technologies in Iowa and many other places, and I think were some of our laboratories are sort of playing around with some of this as well, allows you to work on something in Iowa where a lab in Massachusetts, at Natick or something is working on something similar, to be able to compare, where you were doing that similar test in your own environments on your own activities, but to be able

to share those results.

So I think it increases our ability to integrate across the private sector, academia, and our laboratories. It allows us to much more affordably test very early in the system, where we would not necessarily stick an actual human in. It also allows us to test in environments that are incredibly dangerous and incredibly hostile. So I do not want to put necessarily a person into every explosion. So there are great ways of using the virtual testing before you actually get to something like WIAMan or some of the other activities that we have in the Army that are very expensive.

So I think it has an incredibly relevant place in the system as long as we remember that it is one part of a series of things that need to be done to keep the human in mind very early on and to make sure that we minimize cost, but also that, at some point, we really know what is going to happen when we put an actual person in.

Senator Ernst: Very good. I appreciate it.

Any other input from our panelists? Dr. Holland?

Dr. Holland: Yes. It is really important that the environment that we are describing be one that can be validated in some sense. I think that is what Dr. Flagg was speaking to.

From that perspective then, as best these environments can be built from an understood physics perspective, the

more we can believe in them. The more that they are constructed from pure empiricism, for example, the more we are extrapolating on things that we get to the point of guesswork. And then when we add very sophisticated graphics on top of those, then we are drawing beautiful pictures of things that can be pure baloney.

Senator Ernst: That is a good point.

Dr. Holland: In the case of what we are doing for a living, that becomes extraordinarily dangerous, because we are involving someone's life in the process.

So we have been trying within the department to begin the process of just putting together the key environments that we own within the department to be able to put the best physics-based models together, for example, to see what parts of the flight of an airplane, the design of a ground vehicle, the design of the ship, et cetera, can be done computationally and how many of those trade spaces can we look at long beforehand, again, from the idea of being able to play a lot of these what-if games to gain insight long before we bend metal.

Those are where we find our best use of the computational work, because it generates insight for us. It still leaves the human in the loop. But you must be able to validate them in order to believe them.

Senator Ernst: Absolutely, a multilayered approach.

Absolutely.

Dr. Montgomery?

Dr. Montgomery: Models are great. They embody knowledge. They capture what you learn and allow you to be able to apply it. Developing them to be validatable and accurate, of course, is a challenge.

So sort of extending from the avatar approach, for example, you can make physical models of human structures. The skull is a mechanical structure. The brain is elastic material with certain mechanical properties. So by testing those surrogates, you can get to understand what are the kind of effects that are going to have consequences for the person.

So if you have a person who suffers a blast, then there is the initial blast, but there is also the shock that reverberates internal to the brain on several iterations as the shockwave penetrates under the helmet and around the head. Certain frequencies of that appear to be more damaging to the brain structures, producing traumatic brain injury, than others.

So by being able to get a physical sense of that, then one can then feed that into the model that an avatar carries in a larger simulation model, which will then allow you to predict, if I do this to protect them, here is what the efficacy is going to be.

It is critically important. It takes powerful computers.

Senator Ernst: Very good. I appreciate that.

Thank you very much. We will move on. If we can get Senator Warren, and we can come back to you, Senator Heinrich.

Senator Warren, go ahead.

Senator Warren: Thank you very much, Madam Chair. I will get my notes out here. Thank you so much for being with us.

And I appreciate you allowing me to attend this hearing. I am not a member of this subcommittee, and I really do appreciate it.

I asked to be here not only because we have world-class defense laboratories in my home State of Massachusetts, like the Natick Soldier Research Center, and also the MIT Lincoln Lab, but also because I believe that the labs and the research that they do make up the backbone of our future military strength. I just think this is the heart of it.

Last year, DOD reported that China is investing heavily in R&D, including in, and I will read, "applied physics, material science, high-performance computing, innovative electronics and software development, electro-optics, aerospace technology, automation, robotics, high-energy physics, and nanoscience, just to name a few." So that kind

of covers it.

So I would like to start by asking Dr. Flagg, would we improve our chances of maintaining future superiority over China if we increase our R&D investments in similar advanced technologies?

Dr. Flagg: Thank you, Senator. This is a question that has come near and dear to my heart.

Long ago, I ran the Technical Intelligence office, so I spent a lot of time focusing on international S&T, and I was overseas with the Navy as well.

One of the things that I think is really interesting about this question is that it is not just a dollar question. It is also increasing and modernizing our structures and processes and approaches to how we do research. We came out of a period post-World War II where the leaders had been decimated. We rose in a vacuum, and we came to preeminence in S&T.

We have been really challenged over the last 20 years in a rising era of parity. And so that same list is being supported here, and we need to stay in the race. It is like a marathon of two very well-matched competitors.

But what you want to make sure is that you do not have to run so long in that evenly matched race that you get tired first. And so I believe that you have to stay in the race. We have to stay competitive and continue investments

across those areas or we will erode and tunnel under the foundation of our national security, period.

And that is not just DOD funding. My Ph.D. was funded by the National Institutes of Health Fogarty Center. Many people here can tell you that their Ph.D.'s were not funded by the Department of Defense. They were funded by a broader S&T investment in the U.S. Government.

But I think the second piece of this is to really think about new strategies for winning in an era of parity, what success looks like in era of parity.

I think what this means is that we have to send some of our investment back to the first principles. We have to get people to come back from purpose-driven vision but not telling them the specific question they will answer but having the theorists and experimentalists work together to go back to the beginning and say, if I am not trying to be more or better or faster or more trustworthy or more resilient in cyber, if I go back to the first exit and I use all the information we have learned over the last 20 years and I created a fundamentally new network that would be secure, what would that look like?

So while we are running the marathon, somebody needs to invent the train that takes me to the goal so that I do not have to keep running.

So I think it is both the investment in that list, but

it is also a new investment in processes that let us think bigger.

Senator Warren: I totally agree, and I think the point is well-argued. Thank you very much. This is sort of the 6.1, 6.2 investments that we have let fall behind and that are absolutely critical, if we are going to have real security in the future.

Let me get to a couple other questions, because I think this is really important. I want to ask about a recent Defense Science Board report, which highlighted the age and condition of our laboratory infrastructure. I saw you grimace on this.

According to the report, the average Army lab is 50 years old. The Air Force and Navy labs average 45 and 46 years, respectively. The science board says that, "Most lab directors feel they are unable to maintain their facilities and infrastructure to a reasonable standard. They report witnessing leaky roofs, imperiling millions of dollars' worth of specialized and sensitive equipment," as you noted, Dr. Montgomery, earlier.

So I just want to ask the lab directors, just kind of a yes and no. Let me start, does that basically fit with your experience?

Dr. Holland: Yes.

[Laughter.]

Senator Warren: Yes.

Mr. Peters?

Mr. Peters: It does, yes. I would say, though, that the Air Force has done a pretty good job in terms of supporting the lab in the locations that we are in. We do have probably some newer facilities. There are some that are very old.

Senator Warren: But there are some that are very old.

Mr. Peters: Correct.

Senator Warren: So let me turn on this, because I have to say, this is what I have seen firsthand when I have been to Natick, when I have been to Lincoln Labs. We have these world-class scientists doing cutting-edge research in buildings that were constructed in the 1940s and 1950s.

Can I ask each of you just to say a word about the implications of these old buildings, what it means that you are trying to do lab work in buildings with infrastructure that is so far rooted in the past?

Whoever would like to start. Dr. Montgomery? Dr. Holland?

Dr. Montgomery: It is an interesting experience that I had when Reggie Brothers was in OSD. He was visiting my microelectronics laboratory where we developed spintronics and nanoscience devices, the world's highest powered 220 GHz amplifiers that are made by our scientists in our lab, world

leading.

We were walking down the hallway, and there is a thunderstorm that occurs. All of a sudden, groundwater comes gushing out of the water fountain as we are going by because the drainage system of this ancient building had ruptured.

So what do the scientists do? They patch it up, and they get back to work. But when they bring somebody in they want to recruit, and they have maybe been to Google or they have been to some other facility --

Senator Warren: Do you mean Google has better facilities than that? That problem does not happen at Google?

Dr. Montgomery: I am sure they do.

Senator Warren: Yes.

Dr. Montgomery: So this can be both demoralizing for the scientists in the laboratory and discouraging to the individual who is coming to interview for a job, that the science may be very attractive, the equipment to do the science is outstanding, the peers with whom they work will be extraordinary, but they keep looking at these dingy, dreadful surroundings that they are in.

And, yes, it is counterproductive. You can still do world-class science in that, but sooner or later -- NRL's average is 60 years. I had 1.8 million square feet of space

that was almost 70.

So, yes, those are challenges, both from that point of view -- you can still do the science, but it is challenging to moral and people's desire to stay.

Senator Warren: And the ability to recruit. It is a really powerful point.

I am out of time, so I am going to yield to my colleagues on this. But I take it this is a widely shared view by those who are trying to do the work.

Dr. Holland: Senator, just quickly, if you just get beyond the idea of the embarrassment factor in recruitment and retention, just think about the inefficiency.

You are handing over a facility to people who are world-class people who invariably are going to be fixing something that should be helping them do what they are supposed to be doing.

Senator Warren: It is a powerful point, Dr. Holland. I want to say, I appreciate all that you do under very challenging circumstances, but we need to be better partners on this, and we need to invest so that you have the kind of world-class facilities that match the world-class talent that you have.

So thank you all very much.

Thank you, Madam Chair, for allowing me to come in like this.

Senator Ernst: Thank you for joining us. I appreciate it.

Senator Heinrich?

Senator Heinrich: I want to thank Senator Warren for bringing up this issue, because it is endemic across the enterprise.

I also want to thank our guests for their candid remarks on hiring authority, and we are going to try to capture some of that in a letter to Secretary Mattis that I will be sharing with a number of my colleagues.

I wanted to bring up another issue that involves timeliness or sometimes the lack thereof that I hear a lot about from small businesses in New Mexico that deal with our labs.

I have regularly heard about contract delays that sometimes are on the order of not months but years. What are some of the fundamental issues there that we need to address that cause it to take so long to issue a contract from the time that the lab decides that they want to enter into that contract to actually getting ink on paper?

Mr. Peters: So just a little bit ago, sir, I talked about the success of the personnel demonstration project. I just recently looked at Section 233 and the language that is in that, and if I could be so bold to say that I do not think that is bold enough.

So the personnel system that was built was world-class and built by scientists and engineers for scientists and engineers. I think you need to have the same kind of contracting demonstration project that is put in place. Don't just beat around the bush about trying to make everybody feel good and look for efficiencies and we need to try to find ways. I think you need to direct that there is a contracting demonstration project built by scientists and engineers and program managers in the laboratory and in the laboratories across the services, and bring forward the waivers that need to be brought forward to get relief from the FAR.

You are absolutely right that it is the impact to small businesses. I heard it when I was in there. I am experiencing it on the outside with other companies today who are doing the small business piece of this. It is absolutely critical.

But let the folks that have to live with this day-to-day bring forward their recommendations and have a contracting person involved with that can say here are the changes and who has the authority to make those changes, rather than just say let's take a look at trying to make business processes better.

Senator Heinrich: Dr. Flagg?

Dr. Flagg: I just wanted to say that, I mean, I think

this is so dead on, and I also think empowering those contracting officers to be embedded in that team, to have their performance appraisal written by the mission, the folks who are leading the mission, not by someone back in the Pentagon where I was sitting who is in a contracting shop who wants you to do it the same way everyone else is doing it, and also giving them a little top cover.

I was horrified when I sat down with Claire Grady at DPAP and learned about the personal criminalization of taking risk in contracting, how they are publicly shamed for taking risk. I think you are never going to encourage someone to take risk if you tell them: But if you do and somebody sues you, you may wind up on a Web site by name, or you might wind up going to jail.

We have to be very thoughtful about the incentives that we bake into the system and have the incentives tied to the outcome of the mission, not tied to some statistic PowerPoint chart back at the Pentagon.

Not that I don't like the Pentagon. I love the Pentagon.

[Laughter.]

Mr. Peters: Just to give you an example. In the Air Force Research Lab, when I was there, there are 11,000 contracting actions a year. So they are doing everything that they are supposed to do, and they are living by the

intent of the law. And we have OTAs, but we cannot live just by other transactional authorities. We need a whole new contracting system and authorities in the research lab.

Senator Heinrich: Any additions, Dr. Montgomery?

Dr. Montgomery: Let me comment on that as well.

When you are buying a piece of equipment that is made by a small business outfit, and there are two such suppliers in the whole world, and one of them has never provided a functioning piece of equipment yet, then it should not take 2 years to buy the one. The scientists who realize that should not be accused of inappropriateness for going to that particular activity.

So if you are going to do something the like of which was never done before in the history of humanity, if you do not know what the outcome is going to be when you start, it is hard to specify deliverables. If you want to do prototyping, where you reach out to small business, you reach out to somebody, some activity that has an idea that may or may not pan out, and you want to give them an opportunity to display what they can do and integrate it in some larger system, which may or may not succeed, and do it timely and efficiently, you cannot do it under the existing acquisition system, which applies basically ACAT I rules to 6.1 type of research.

And you are not going to get across the Valley of Death

until you can take and bring these things together and demonstrate their military value in prototypes in an operational-like environment so the payoff of this particular new approach -- it maybe revolutionary and never existed before -- can be demonstrably clear and unassailable. That takes rapid prototyping.

It takes a new acquisition system tailored for this, and it takes the ability to have the fiscal resources to take the risk on prototyping to succeed.

Absent that, we are at a glacial process where things that we need to get done today take decades to achieve.

Senator Heinrich: [Presiding.] Exactly. And we end up losing capacity in the meantime, because these contractors are taking real monetary risk in entering into these arrangements as well.

I want to thank all of you for coming today. I want to thank you for your candor. I think it is very helpful for all of us. I am going to gavel us out here, but I hope that this is just the start of the conversation, because I think we have a lot to chew on here that we can get to work on, and we very much appreciate the input from all of you.

Dr. Montgomery?

Dr. Montgomery: Is it possible I could offer one more comment?

Senator Heinrich: You bet.

Dr. Montgomery: The rest of the world is advancing. China is already virtually up here in the scientific world with basically 1 percent less of the publications that we have. So not only do we have to do our own science, but we have to harness the rest of the world's science.

If we are going to do that, we need to have peer-to-peer collaboration across the world to do that. Nobody will collaborate with me. I have been off the bench for 30 years. But on the other hand, somebody who is a new scientist with new ideas collaborating through conferences, through international travel -- NRL does about 1,200 such collaborations during the course of a year, and a couple hundred of them overseas.

Then we ought to also consider, can we take foreign national scientists who came out of one of our great research institutions that is of an allied power that was friendly to the U.S., have them renounce their former citizenship, become a U.S. citizen and be granted clearance to work in our labs? Because they are culturally attuned to their originating country, that would be a powerful tool for building world-to-world collaborations.

Since 2003 to 2013, the percentage of collaborations internationally amongst scientists has gone from 19 percent to about 30 percent worldwide. It is critically important for our future. Thank you for your patience.

Senator Heinrich: Thank you, Dr. Montgomery.

And thanks to all of you for joining us today.

[Whereupon, at 11:27 a.m., the hearing was adjourned.]

RECORD VERSION

STATEMENT BY

DR. JEFFERY P. HOLLAND
PAST DIRECTOR, U.S. ARMY ENGINEER
RESEARCH AND DEVELOPMENT CENTER (ERDC)

BEFORE THE

SENATE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

FIRST SESSION, 115TH CONGRESS

ON THE U.S. ARMY CORPS OF ENGINEERS
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STATEMENT BY

DR. JEFFERY P. HOLLAND
PAST DIRECTOR, U.S. ARMY ENGINEER
RESEARCH & DEVELOPMENT CENTER (ERDC)

Chairman Ernst, Senator Heinrich, and distinguished members of the Subcommittee, thank you for the opportunity to discuss the U.S. Army Engineer Research and Development Center's (ERDC) role and mission as a major Department of Defense (DOD) Science and Technology (S&T) laboratory. I greatly appreciate the support this committee has shown to S&T, and the opportunities this support has provided ERDC over the years to enhance its ability to carry out its mission.

ERDC is the science and technology arm of the U.S. Army Corps of Engineers (USACE), conducting research and development (R&D) in the areas of Military Engineering, Geospatial Research and Engineering, Environmental Quality and Installations, and Civil Works. Army's S&T investments develop technology options to ensure the Army is ready today and remains robust tomorrow. ERDC, and other Army laboratories, create new understandings that translate research into militarily-useful technologies through innovative solutions to satisfy capability gaps across the entire force.

ERDC's seven laboratories are located in four states: the Construction Engineering Research Laboratory in Champaign, Illinois; the Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire; the Geospatial Research Laboratory in Alexandria, Virginia; and the Coastal and Hydraulics, Geotechnical and Structures, Environmental, and Information Technology Laboratories in Vicksburg, Mississippi. In addition to its laboratories, ERDC has field sites conducting specialized research: a 1,800-foot coastal research pier in Duck, North Carolina; an Aquatic Ecosystem Research Facility in Lewisville, Texas; the Permafrost Research Tunnel in Fairbanks, Alaska; and its International Research Office in London, which exists to promote cooperation with the international research community as a means to advance science and engineering knowledge and technical capabilities in areas relevant to the U.S. Army, DOD and our international military partners. ERDC has a workforce of more than 2,300 engineers, scientists and support personnel within its seven laboratories and field sites.

In Fiscal Year 2016, ERDC executed $425 million in research, development, test, and evaluation (RDT&E), highlighted by work in support of the nine Army S&T Objectives (STO) programs, the Army's top S&T efforts warranting Army senior leadership oversight. ERDC also executed just over $70 million in Civil Works direct funding on

R&D to address navigation, flood control and risk management, and ecosystem management and restoration. This body of R&D promotes safe and resilient communities and infrastructure; helps facilitate commercial navigation in an environmentally sustainable fashion; restores degraded aquatic ecosystems and prevents future environmental losses; and implements effective, reliable and adaptive life-cycle performance management of infrastructure. In addition to these major programs, ERDC executed more than $500 million in reimbursable programs for every Service within DOD and other federal agencies, such as the State Department, the Defense Threat Reduction Agency, the Department of Interior, the U.S. Bureau of Reclamation, the Department of Homeland Security, the National Geospatial-Intelligence Agency, and the National Science Foundation.

ERDC builds its program ($1 billion in FY16) by its stakeholder base (i.e., Military Engineering, Geospatial Research and Engineering, Environmental Quality/Installations, and Civil Works). This approach forces ERDC to view problems from stakeholder perspectives, rather than from a technical interest perspective, and necessitates that it solve problems that span technical areas by employing multi-disciplinary teams. As part of its annual program development process, ERDC meets with a wide variety of stakeholders to better understand their problems. At any given time, ERDC has as many as 50 employees embedded in stakeholder organizations to ensure complete understanding of stakeholder requirements and to effectively transfer technology to these stakeholders.

To meet stakeholder objectives, ERDC creates tailored scopes of work and develops solutions to fit their business processes and decision making. It transitions its technology to the Warfighter, to Civil Works, to the acquisition community, and to other government agencies, academia, and industry. It also provides the Warfighter and deployed civilian personnel around the globe with 24/7 access to subject matter experts through the USACE Reachback Operations Center. ERDC responds to thousands of reachback requests each year from around the world. In addition, ERDC provides subject matter experts through deployment to both Contingency and Humanitarian Assistance/Disaster Relief (HA/DR) operations. Since 2003, ERDC has deployed 335 team members, some with multiple deployments, to support Contingency Operations; and more than 435 team members to support HA/DR operations both CONUS and OCONUS.

Today, I would like to discuss three components resident in everything ERDC does as it carries out its diverse mission – People, Programs and Facilities. These three components are essential, not only to ERDC's success, but also to the success of each and every Defense laboratory.

Cutting-edge solutions to challenges of national importance, a satisfied stakeholder base that returns time and again for the services ERDC provides, and world-class facilities in which to conduct that research -- none of these can be successful without our people. They are ERDC's most critical resource and the resource I am most passionate about.

Innovation requires a talented workforce, and I am proud to have represented, as ERDC's past Director, the more than 2,300 engineers, scientists and support personnel of the ERDC. These men and women are committed to solving national security challenges and developing technology solutions to ensure the readiness of our Warfighters and the installations that support them, as well as their responsibility to enhance and protect our nation's water resources and the economic security they provide. These team members are agile, stakeholder-focused, passionate about their work, leaders in their technical fields, and committed to the delivery of exceptional products and services.

ERDC partners with academia, industry and the other Services to provide solutions to military and national security challenges, but it is its in-house capability to assemble multi-disciplinary teams across its seven laboratories, in concert with key external partners, of which we are most proud. It brings the best minds to the challenge, and provides its stakeholders with the technology, products and services they need to fit their requirements and meet mission goals.

If we are to continue providing reliable and sustainable S&T solutions to our Nation and Allies, it is vital that we hire and retain the best and brightest engineers and scientists our country has to offer.

ERDC has embarked on a human capital initiative to hire 800 engineers and scientists during FY16-20 in order to maintain and enhance in-house capacity to meet its mission. In its first year, ERDC exceeded its annual goal by hiring more than 160 new researchers. ERDC was able to meet this important goal in large part because of its Direct Hiring Authorities, which save time, effort and costs, and allow the organization to more effectively hire the best and brightest minds available.

These authorities are possible only because ERDC is one of 18 Science and Technology Reinvention Laboratories (STRLs) with Laboratory Personnel Management Demonstration (Lab Demo) Projects authorized by the National Defense Authorization Act (NDAA) for FY1995, PL 103-337, Section 342. Thank you for your support of Lab Demo.

ERDC's Lab Demo Program was implemented in 1998. Its program includes Performance Management (Pay for Performance); Position Classification (Pay Banding); Hiring flexibilities (Distinguished Scholastic Appointments); Employee Development flexibilities (Degree Training, Sabbaticals), and Reduction in Force flexibilities to assure the best employees are retained.

Over the years, Congress has recognized and addressed the unique human resources needs of the STRLs by including additional authorities and provisions in several NDAAs. These include:

- Exclusion of the STRLs from the National Security Personnel System;
- Direct Hire for Advanced and Bachelor's Degrees, STEM Technicians, and Senior Science and Technical Managers (SSTM) (and expansion of these authorities);
- Direct Hire for Students (authorized in December 2014, but not yet delegated);
- Ability to adopt a flexibility available in another STRL;
- Non-competitive conversion of students to permanent employees;
- Utilization of Retired Annuitants; and
- Retirement incentives payment.

The foregoing provisions address the uniqueness of STRLs like ERDC, first and foremost, by placing the responsibility for Human Resources and the accompanying authorities at the Laboratory Director level.

ERDC's list of success stories is endless, but a few stand out. In an age where we are competing with the salaries and benefits offered by private industry, the Lab Demo Program has increased ERDC's ability to compete for the best and brightest students. Pay for Performance has allowed ERDC to achieve a higher retention rate for high performers, with an increase in turnover for low performers. ERDC has achieved increases in minority and female engineers and scientists, as well as an increase in PhDs. It has successfully utilized Voluntary Emeritus positions, whose experience and technical skills enhance ERDC's reputation and expand knowledge of its programs at universities and organizations around the country.

Implementation and increased authorization for SSTM positions within ERDC (23 positions in FY16) allows ERDC to recognize positions responsible for directing many of its highly visible and technical programs. These SSTM positions are especially valuable to recognize the performance of higher-level duties when Senior Executive Service (SES) and Senior Scientists (ST) spaces are less appropriate.

While these authorities have greatly enhanced ERDC's ability to hire and retain world-class scientists and engineers, it still faces challenges. When Congress includes new

hiring authorities granted to Laboratory Directors in the annual NDAAs, ERDC is currently required to implement them by publication of a Federal Register Notice. For example, in NDAA 2015, Congress delegated Laboratory Directors direct hire authorities for students. The NDAA was signed in December 2014. These authorities have not been delegated, nor has a Federal Register Notice been published authorizing their use. As a result, the STRLs are continuing the untimely process of advertising student positions through USA Jobs and losing valuable students to the private sector. Additionally, NDAA 2016 authorized the noncompetitive conversion of students to permanent appointments, increased authorizations for direct-hire appoints and authorities regarding the utilization of reemployed annuitants and the payment of retirement incentives. These authorities have not yet been delegated.

I want to thank Congress for its continued support to the STRLs by including language in the 2017 NDAA that will greatly benefit the STRLs.

DOD's challenges in recruiting and maintaining a high-quality workforce also include competition for these individuals, a limited supply of top-quality STEM students and careerists, and the ability to make job offers in a timely manner. ERDC's ability to offer competitive salaries and benefits, coupled with other provisions in the Direct Hiring Authorities, allows ERDC to compete in this hiring pool. Additionally, ERDC uses every student program available to increase its pool of future recruits. During this past year alone, ERDC employed more than 230 student interns from 65 colleges and universities. With authority to directly hire students, that number would increase.

Because ERDC has great people, it is able to execute meaningful and impactful programs. DOD Service Labs play a key role in National Security, and ERDC has a long history of providing innovative solutions to keep our Warfighters and Civilians safe at home and abroad. On September 11, 2001, the plane that was flown into the Pentagon struck a section that had just been retrofitted with ERDC-developed blast protection technology. This protection kept the section from collapsing long enough to get personnel to safety, significantly reducing the death toll at the Pentagon.

ERDC has since developed and deployed several pioneering force- and terrorist-threat protection technologies. More than $1 billion in protection technology has been installed in theater to protect base camp structures from rocket and mortar attacks. Research into weapons effects on structures and affordable mitigation techniques informed the composite and construction industry without revealing theater vulnerabilities. ERDC, working with industry partners, identified solutions that were technically feasible and readily available for immediate fielding. ERDC's Overhead Cover Protection system development was fast-tracked, in part, by $250 million in supplemental funding from Congress. This multi-layer protection system was designed and constructed over existing critical facilities at U.S. base camps in Iraq – living quarters, dining halls and

other high-occupancy facilities – to protect the force from insurgent rocket and mortar attacks by preventing them from penetrating overhead cover barriers and hitting facilities. This technology reduced a high casualty rate pre-emplacement down to zero. The State Department later invested in this technology to protect its critical facilities and personnel around the world. The very building we are sitting in today is safer because of ERDC protection technologies in collaboration with the Architect of the Capitol.

Another technology breakthrough is ERDC's Deployable Force Protection (DFP) program. Products include the advanced, lightweight Modular Protection System (MPS), based on an innovative, patented material of high-strength, flexible concrete with ballistic performance – comparable to ceramic armor – at a fraction of the cost and weight. Four trained Soldiers can assemble an 8-by 12-foot MPS module in 15 minutes without equipment or special tools. The Army's Rapid Equipping Force (REF) quickly introduced the MPS into Iraq and Afghanistan, and in 2010, a modified version was developed for the Navy. DFP now includes MPS Mortar Pits, Guard Towers and other quickly-deployable protection systems that are easily constructed and reusable, keeping our Warfighters safe. Prototype protective structures developed in the DFP program were recently needed to protect critical assets in numerous deployed locations. The lab's inventory of prototype structures was rapidly made available to satisfy urgent theater needs, while the Army REF procured additional quantities from vendors holding licenses for the government-patented technology. Anticipating future orders, researchers are working with the Defense Logistics Agency Warstopper Program and Rock Island Arsenal's Joint Manufacturing and Technology Center to prepare both government and industry manufacturing groups to meet future surge requirements.

ERDC-developed technologies to deny, deter and defeat IEDs are being used in Afghanistan, where insurgents employ IEDs powerful enough to throw 14-ton MRAP vehicles into the air. In a five-month period at the beginning of this emerging threat, more than 100 Soldiers had suffered crushed or damaged spinal columns from being thrown around in MRAPs. One ERDC advance, called HARD IMPACT, defends U.S. and Coalition forces against IEDs placed in thousands of road culverts throughout the country by retrofitting existing culverts with protection designs and incorporating those designs into new roadway systems. ERDC was approached by the U.S. Intelligence community to develop forensics capabilities after blast events. Two programs, CALDERA and FERRET, developed procedures, tools and training to effectively collect, measure and document post-blast forensic signatures of underbelly IED attacks. These technologies and products have been transitioned to Intel analysts and Warfighters.

In the interval between 2006 and 2014, in support of numerous U.S. Central Command (CENTCOM) Joint Urgent Operation Needs Statements, ERDC engineers and research

teams led whole-of-government and industry teams in developing more than six major quick reaction capability (QRC) programs that were formerly recognized by the Joint Improvised Explosive Device Defeat Organization (JIEDDO) and CENTCOM as effective counter-IED (C-IED) systems. The total ERDC QRC resource execution in this period exceeded $2 billion. Airborne systems included Saturn Arch, Desert Owl, Copperhead and Radiant Falcon, all of which were transitioned to Army Aviation by the close of 2014. At present, Saturn Arch and Copperhead continue to provide CENTCOM with unique C-IED operational capabilities. On the ground, ERDC led the successful development and deployment of the Sand Dog C-IED system, which was deployed on Talon robots for both Explosive Ordnance Disposal and Engineer Route Clearance teams.

Tunnel Detection technologies developed by ERDC have been applied along the Mexico border, in Iraq, and along the Egypt/Gaza border. ERDC is the technology lead for the U.S. Government's Interagency Tunnel Deterrence Committee – 11 law enforcement and intelligence agencies – which has been involved in hundreds of tunnel detection efforts along the border of Mexico since 9/11. ERDC developed and has remotely operated detection systems in Iraqi prisons; at the request of the State Department and DOD, ERDC installed a tunnel detection system along the Egypt/Gaza border and trained Egyptian military engineers to operate the system. ERDC has worked with additional Allies to provide tunnel detection technologies and training to help ensure regional stability.

ERDC is collaborating with the U.S. Air Force, Army, Marine Corps and others to identify significant challenges for planners, analysts and operators that impede the ability to accomplish operations in an Anti-Access/Area Denial (A2/AD) environment and the capabilities needed to address the challenges. ERDC's role in force projection in A2/AD environments is focused on developing and demonstrating technologies for planning and conducting entry operations with non-existent, damaged or destroyed infrastructure. ERDC technologies include rapid airfield repair kits for early-entry airborne engineer units; terrain surfacing kits for Unmanned Aircraft Systems (UAS) landing strips, helicopter landing zones, and logistics over-the-shore operations; remote monitoring of critical infrastructure using infrasound; battlefield sensors for operational engineer reconnaissance, assessment and planning; and decision support tools to capture Subject Matter Expert (SME) processes for remote infrastructure assessment. Coastal modeling technology developed in ERDC's Civil Works mission area is also being applied to the A2/AD environment, a great example of dual-use technology that crosses mission area lines. Also, as part of the Long Range Research and Development Planning Program-Ground Combat (LRRDPP-GC), ERDC and its fellow S&T laboratories are currently working to help shape policy for the Third Offset

Strategy. This strategy's goal is to identify high-payoff, enabling technology investments to provide U.S. forces with a decisive advantage in land-associated operations in the 2030 timeframe.

ERDC's Map Based Planning Services (MBPS) program provides DOD with a unique, web-based capability for military planners to collaboratively develop strategic plans. MBPS employs the concept of a digital plan with automated tools to reduce the burden of manual work, the risk of human errors, and the resources expended on updates and corrections. With military planners deployed across the U.S. and all over the world, substantial time and cost savings also result from reduced travel to various planning team meetings. By increasing efficiency in the planning process, MBPS allows planners to provide senior decision makers with more options within months rather than years, and thereby meet the challenges of a rapidly evolving world.

National- and theater-level assets provide a synoptic view of the operational environment; there is a growing need and a growing number of requests for ERDC's Tactical Mapping (T-UAS) program on demand – high-resolution tactical mapping capabilities at the lowest levels to support mission planning and enhanced situational awareness. The T-UAS program uses a variety of UAS full-motion video and electro-optical image data to rapidly produce 2D and 3D geospatial products and provide enhanced local situational awareness to users at the lower echelons of the Armed Forces. This technology builds on previous ERDC R&D to fill in gaps for mast-mounted Light Detection and Ranging (LIDAR) efforts and has gone from a concept and capabilities demonstration in late 2015 to funding by REF to field mapping platforms and FMV kits for Warfighters in Iraq in June 2016 with the first map products created in July.

Future readiness includes not only providing our Soldiers with the equipment and technology advances they need to win the fight, but also delivering environmentally sustainable solutions for energy, water, and waste (EW2) on installations at home and abroad. ERDC R&D also supports installation training needs while protecting the environment.

ERDC has developed a holistic approach for EW2 environmental sustainability at military installations around the world and in contingency environments. The ERDC-developed Net Zero Planner (NZP) is a web-based tool for installation-wide EW2 planning. The tool is designed to perform complex engineering calculations with relative simplicity and provide an engineering-based solution for planning EW2 investments at installations. NZP has been demonstrated at multiple DOD installations and is currently being used by the USACE Fort Worth District to develop sustainability component plans as part of the master planning process. ERDC is working closely with Headquarters,

USACE to develop a transition plan for NZP and incorporate it into the planning process across the Corps.

ERDC is the Army leader in Operational Energy R&D and is developing scalable solutions for small, semi-permanent contingency bases (300 to 1,999 personnel). Operational energy R&D focuses on the primary areas of planning and analysis; resilient distribution; metering and monitoring; demand reduction; and supply efficiency. These focus areas are inter-related and are designed to address all stages of the base camp lifecycle. Planning tools such as the Virtual Forward Operating Base assist in base camp planning and operation to reduce supply and logistics burdens on camp operators. ERDC's Deployable Metering and Monitoring System gives operators knowledge of where their resources are being used.

ERDC, together with the National Aeronautics and Space Administration (NASA) Marshal Space Flight Center and Kennedy Space Center, and Caterpillar, Inc., is developing an additive 3D printing technology capable of printing custom-designed expeditionary structures on demand, in the field, using concrete sourced from locally available materials. The three-year Automated Construction of Expeditionary Structures (ACES) program brings together expertise from within ERDC, NASA, Caterpillar, and Contour Crafting Corporation to conduct highly-focused research designed to prototype an automated construction system that can fabricate a 500 ft^2 structure in less than 24 hours. In late 2016, when the Secretary of the Army asked for examples of Army innovation, the Honorable Katherine Hammack, then-Assistant Secretary of the Army for Installations, Energy and Environment, briefed him on the ACES program. Presented with more than 35 examples of Army innovation, the Secretary chose ACES as one of three to present to the Secretary of Defense to show the most promising innovation activities going on in the Army.

ERDC R&D is also providing integrated maneuver land sustainment technologies to support installation training land management through the use of vehicle-based impact models; application of training exercise impact assessment and monitoring technologies; range design guidance; impact mitigation and resolution technologies; and installation encroachment assessment software. One success story is ERDC's work to assess training lands at Fort Hood, Texas, the largest active duty armored post in the U.S. Every acre counts, to both the Army and to two endangered species of birds that call the installation home. In 1993, 36 percent of Fort Hood training land was under seasonal training restrictions for habitat protection. ERDC worked with Fort Hood biologists for years to assess habitats, sources of negative impacts, and potential stress from military training on both species. This collaboration has proven that military impacts on the species are nominal and that current management strategies have positive impacts on both endangered birds. By 2000, the percentage of restricted

training lands had dropped to 24 percent; by 2010, it was 4.6 percent; and by 2015, it was 0 percent. The U.S. Fish and Wildlife Service rendered a Biological Opinion in 2015 that allows the Army to manage all training lands at Fort Hood without seasonal restriction, but within agreed-upon impacts to the bird species.

In the area of information technology, ERDC manages and executes the DOD High Performance Computing Modernization Program (HPCMP), a comprehensive, highly-integrated, high-performance computing *ecosystem* that includes supercomputers and related expertise, a nationwide DOD research network, and system and application software to the Services and Defense agencies. The HPCMP is characterized by three core elements: DOD Supercomputing Resource Centers, information-assured networking (the Defense Research and Engineering Network and associated cybersecurity posture), and software applications expertise that addresses the unique computational requirements of the DOD. These three elements form a complete *ecosystem* that supports the DOD research, development, test, and evaluation (RDT&E) and acquisition engineering communities.

The HPCMP supports approximately 2,000 active users from Army, Navy, Air Force, Marine Corps, and other DOD agencies within the Science and Technology (S&T), acquisition engineering and Test and Evaluation (T&E) communities. HPCMP users address challenges such as the discovery of new materials to address unique DOD requirements, numerical modeling of hypersonic flight, modeling and prediction of weather to support DOD, analysis of space systems, and evaluation of options for future DOD systems, including the design of next generation aircraft carriers, submarines, air vehicles and ground vehicles.

DOD Supercomputing Resource Centers (DSRCs) provide advanced computational resources and specialized expertise to enable DOD to take advantage of supercomputing. DSRCs are located in:

- AFRL DSRC at Wright Patterson Air Force Base in Dayton, Ohio;
- Air Force Maui High Performance Computing Center (MHPCC) DSRC at the Air Force Optical & Supercomputing Observatory site in Kihei, Hawaii;
- Army Research Laboratory (ARL) DSRC in Aberdeen, Maryland;
- Army ERDC DSRC in Vicksburg, Mississippi; and
- Navy DSRC at the Naval Meteorology & Oceanography Command, Stennis Space Center, Mississippi.

The Defense Research and Engineering Network (DREN) provides a robust cybersecurity posture for the HPCMP. DREN provides a very high bandwidth, low latency, low jitter network specially designed to serve the needs of the science/engineering and test/evaluation communities. The DREN supports

Unclassified, Secret, and above Secret communications and delivers service to 53 of the DOD's 62 laboratories and 20 of the DOD's 22 major range and test centers. In the S&T environment, the DREN is a critical enabling technology for the collaborative science and engineering workflow; in the T&E environment, the DREN is a unique resource enabling a diverse range of critical activities that cannot be provided by traditional networks. For example, the DREN supported 26 T&E events in FY16, including:

- F-35 Joint Strike Fighter (JSF) Record and Playback Event 3
- Small Diameter Bombs (SDB) II Live Fly Testing (On Going)
- TRITON Flight Testing (On Going)
- Aegis Integrated Air and Missile Defense (IAMD) Base Line (B/L) 9C1D BLD 18.1.2
- Joint Distributed Infrared Countermeasures (IRCM) Ground-test System (JDIGS)

The HPCMP is also charged with the creation, improvement and optimization of software applications that use the network and supercomputers efficiently to develop effective solutions to the DOD's challenges. This includes training for engineers and scientists on effective use of HPCMP resources; R&D to pull emerging technologies from industry and academic centers into routine use by HPC users; and efforts to increase effectiveness of existing applications to new DOD challenges or develop new DOD-unique applications.

The largest strategic software investment for DOD resides in the Computational Research and Engineering Acquisition Tools and Environments (CREATE) initiative, which provides government-owned high-fidelity, multi-physics software for ships, air vehicles, radio frequency, and ground vehicles essential to supporting the acquisition engineering community. While HPCMP-developed software applications are service/mission specific, they are designed to provide cross-service/OSD agency capabilities. As such, these investments provide the Department with significant synergies in terms of software sustainability and applicability within the services. One example of leveraging HPC resources to address high-impact DOD challenges is the ERDC-led Engineered Resilient Systems (ERS) program. DOD is leveraging years of S&T investment to transform acquisition processes through ERS. By enabling more detailed engineering analyses, ERS significantly increases the number of materiel alternatives examined early in the acquisition process, in equal or less time than traditional methods. The program and its associated DOD Community of Interest are developing concepts, techniques and tools that significantly sharpen requirements prior to major acquisition milestones and support prototyping and experimentation.

In addition to its world-class research to support the Warfighter, ERDC is also the world leader in Water Resources Infrastructure and Management, Navigation, Operations and Maintenance, and Environmental Resources R&D in support of the USACE Civil Works mission. This R&D is critical to national security by enabling a vital lifeblood link to our nation's commerce and economy, and supports the movement of supplies and materiel vital to our national defense. The Civil Works capabilities ERDC develops and provides not only support national security interests within our borders, but also enable this Nation to support water resources maintenance, repair and rehabilitation operations in war zones, like Mosul Dam in Iraq, and Kajaki and Dahla Dams in Afghanistan. ERDC Civil Works expertise, combined with its military technology and environmental security R&D, is truly unique. ERDC's ability to leverage these otherwise disparate capabilities within the bounds of one organization creates powerful dual-use opportunities. ERDC's Critical Infrastructure Protection Program is a perfect example of how it leverages its military expertise to protect Civil Works infrastructure. Technologies developed to protect personnel and facilities in contingency environments have been transitioned to protect critical infrastructure in the U.S., from buildings in our capitol and major cities, to locks and dams and other navigation infrastructure; and from bridges like the Golden Gate, to other transportation infrastructure such as subway and railway systems.

Finally, I welcome the opportunity to discuss the importance of facilities, infrastructure and the 219 Program to the overall DOD S&T posture.

The ERDC employs a world-class team and conducts world-class research, but it has a need to modernize and recapitalize its experimental facilities to ensure it can continue to support the Warfighter and the Nation in a world-class manner. While ERDC has some new and state-of-the-art facilities, the average age of ERDC facilities is 41 years, and its recapitalization rate extends into the next century. Technology advances are moving at a rapid pace and U.S. adversaries are taking full advantage of these advancements. Research facilities must be built to be adaptable and resilient or they will become outdated and obsolete. Just as importantly, the Nation must ensure our research facilities have sufficient sustainment dollars in order to minimize the amount of research dollars we must divert to support operations and maintenance. Finally, our research facilities must be of a quality to aid in recruitment and retention of the best and brightest research staff in the world.

In FY14 and FY15, ERDC was successful in obtaining funding for two Unspecified Minor Military Construction (UMMC) projects using the Laboratory Revitalization Program authority provided by this Committee. With that funding, ERDC constructed a new $2.5 million Fragmentation Research Facility and will soon begin construction of a $3.8 million facility to construct large concrete targets to support blast, penetration and fragmentation research. For FY17, ERDC submitted a list of requirements for

consideration in the UMMC program, its number one priority being a Transformer Yard ($1.9 million) at its Cold Regions Research and Engineering Laboratory in New Hampshire that will improve efficiency, safety and operations. ERDC also included a project to expand its capacity to improve Projectile Penetration Research ($3.8 million) at its Vicksburg, Mississippi, campus to meet current and future requirements. Both projects were selected for funding in FY17. The expanded authority for labs provided in the Laboratory Revitalization Program, particularly the $4 million UMMC threshold, has been extremely valuable to the ERDC. It was rewarding to see that the FY17 NDAA signed into law in December 2016 extended the program to FY25 and increased the threshold to $6 million. ERDC hopes to take advantage of the new threshold right away, and is optimistic that, over the next few years, Congress will see fit to make this program permanent, allowing Laboratory Directors to plan and execute infrastructure improvements well into the future.

While ERDC has had some success with minor construction, it has yet to break into the Major Military Construction future years' defense plan. ERDC has not had a project funded with MILCON in recent memory, nor does it have one in the current POM. In light of significant reduction in funds available for military construction and the requirement for Army leadership to support Soldier readiness initiatives, ERDC has deferred asking for support in MILCON for the past few years. ERDC leadership has begun identifying requirements where MILCON would be an appropriate funding source in order to try again in future. With limited funds available and considering Army needs, it is understood that there will be many more projects deferred than will be programmed for funding. This reality is likely to remain the situation for years to come, making the Laboratory Revitalization and 219 authorities even more critical to ensuring laboratory directors can respond quickly and adapt to emerging threats.

ERDC's 219 Authority gives it a mechanism to provide funds for innovative research, technology transfer, workforce development, and to improve facilities and infrastructure. ERDC has had great success in using this authority over the years and greatly appreciates the Committee's willingness to extend the authority each time it was close to expiration, to expand the authority, and to provide clarification of the Congress' intent in order to improve the program's effectiveness. I always appreciated that your staff took the time to meet with me here in Washington, D.C. and travel to ERDC facilities and see firsthand how we were implementing this program. The cooperation across the Committee staff and with their colleagues in the House has resulted in a great program, and I am pleased to see that the FY17 National Defense Authorization Act made this authority permanent and increased the amount that can be collected from 3 to 4 percent.

The 219 Program has allowed Directors to allocate funds toward research efforts to address needs and requirements that arise faster than the normal budget planning cycle. This was recently highlighted by an ERDC investment to develop an Advanced Blast Load Simulator prototype. This research led to a working 4-ft by 4-ft prototype and a comprehensive and affordable plan to build the capacity to conduct controlled blast experiments on target surface areas of 12-ft by 12-ft. Previous attempts to build this scale were technically challenging and cost-prohibitive. Conducting blast experiments of this size in a controlled laboratory environment will allow ERDC to perform multiple experiments in a shorter period of time at significantly reduced cost and with improved accuracy. Full-scale field tests are expensive, time-consuming, and require valuable range time. While field tests will always be necessary, the simulator will ensure those tests are optimal and shorten the time required to provide solutions to save Soldiers' lives. This would not be possible without Section 219 authority.

In FY15 and FY16, the 219 Program allowed me, as then-Director of ERDC, to spend approximately $5 million a year to upgrade facilities infrastructure at the four main ERDC sites and at our research facilities in Alaska. Improvements include airfield and pavement testing areas; backup generators and chemistry labs for projects that ensure ERDC was able to properly maintain housing of animals and live organisms for experimentation; and to upgrade and maintain dominance in extreme cold environments. Each of these projects is relatively small compared to some of the multi-million dollar military construction projects you may see, but they have a huge impact on the quality of research and capability of ERDC engineers and scientists. I appreciate the flexibility this mechanism provides. Unfortunately, the labs have not yet been able to take advantage of the authority you provided in the FY14 NDAA that allows directors to accrue funds over multiple fiscal years to support larger infrastructure needs. Laboratories continue to work toward a way to implement processes that will allow them to do this in an accountable, auditable and sustainable fashion. Your staff are aware of this and are committed to working with the laboratories to address these challenges.

In conclusion, Army Chief of Staff General Mark Milley has stated that "we will do what it takes to build an agile, adaptive Army of the future. We will listen and learn … from the Army itself, from other Services, from our interagency partners, but also from the private sector … we will change and adapt." I always took pride in the relationships ERDC built within the Army, with its Service partners and other federal agencies, and with academia and industry. These were "my" stakeholders, as were Congress and the American public. It is for you I worked, and I did not take lightly the trust that was placed in me to solve problems critical to our Nation's security and the well-being of our Armed Forces and citizens.

The engineers and scientists, support personnel, and leadership of the U.S. Army Engineer Research and Development Center take extreme pride in what they do. On behalf of its new leadership, I invite you all to visit at any time to see this firsthand as you talk to the ERDC team. ERDC team members come to work every day, knowing that what they do makes a difference – they are saving lives; helping safeguard our citizens at home and around the world; and protecting and enhancing the environment around us.

Thank you for your time.

Madam Chairman, this concludes my statement. I would be happy to answer any questions you or other Members may have.