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PARTICIPANTS:

Featured Speaker:

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P R O C E E D I N G S

MR. O'HANLON: Good morning, everyone. Welcome to Brookings, and thank you for coming out in this weather. I'm Mike O'Hanlon of the Brookings Foreign Policy program, and we are all honored today to have General Paul Selva, vice chairman of the Joint Chiefs of Staff, the 10th person to hold that position, here with us this morning to talk about defense technology and innovation in the Department of Defense.

General Selva, I thank you and will welcome you in just a moment, but first let me give a brief introduction about his career, very accomplished, obviously. He began in the Air Force Academy, was a 1980 graduate there, has received several degrees since that time, but also was the combatant commander for U.S. Transportation Command, which as you know is one of the top commands in the U.S. military.

He spent a lot of time in Illinois in various jobs at Scott Air Force Base, also probably more time than you enjoyed or relished at the Pentagon, and a lot of time in various kinds of missions and operations supporting forces in the field, in Afghanistan, Iraq, and elsewhere. His expertise and background, as you know, has been in transportation, transport aircraft, refueling aircraft, and a number of other types of equipment.

If you could all, please, join me today in welcoming General Paul Selva. (Applause)

GENERAL SELVA: Thank you.

MR. O'HANLON: I'm going to begin with one question. The format will be I will just have a little conversation, and have the pleasure of asking him a few questions, and then we will go to you, in the 60 minutes that we have.

I'm going to begin with a fun question, which is I've been reviewing your CV and looking at all the different aircraft that you've flown. What is your favorite?

GENERAL SELVA: I don't have a favorite. (Laughter) I get asked that question a lot. I will say the airplanes that I've flown have spanned technology from the 1950s to modern day technology. There is an astronomical difference between what you can do with an airplane that was built in the 1950s and what you can do with an airplane today, because of the way we've incorporated humans into the airplane and presented information to them.

The ones that are the most fun to fly are the ones that were built in the 1950s, because you can feel the airplane. The ones that are the most interesting to fly are the ones where all the information is optimized to be presented to the person flying the airplane.

So, I don't have a favorite, but those are certainly the bookends.

MR. O'HANLON: In the same vein, I hope I can a question here that is slightly more original. Looking back on these airplanes, like the B-52, that were built in many cases even before you and I were born, certainly when we were kids, when you look back, have we kept them too long? Obviously, we don't want to depend only on old airplanes. I think that's implied in what you just said, and in Air Force modernization strategy.

By the way, I recognize you are responsible now for the entire Department of Defense, so we'll get to that in a moment.

Looking at the B-52, have we kept that plane too long or has it wound up being a remarkable sort of success story, how we managed to innovate and keep doing new things with an old airframe?

GENERAL SELVA: I think it's actually an interesting story of innovation, in how you can take an old technology and add to it new capabilities over the course of its lifetime. It's not lost on me, shouldn't be lost on you that the engineers that designed

the B-52 did it with a thing we call a slide rule, which most people in this room don't know how to use.

They applied a safety factor of 2.0, which means the airplane is vastly over engineered, so any equation that they built, they factored in the possibility that they might be off by a factor of two.

What we have is a really robust platform into which we can add new capabilities. If you were to look at a B-52 circa 1973, and walk into a B-52 today, and see how the information is presented to the flight crew, it's a vastly different process. We have computerized an analog airplane and we have made it more effective. It won't last forever, but it will last probably into its 80th year.

MR. O'HANLON: Not bad. There are a number of technologies we can all cover today, and I'm sure you will have some that you will raise in the discussion period. I want to begin with a couple up here. Obviously, we will be talking about broad issues in defense innovation, but also a couple of specifics.

If I could begin with the nuclear enterprise, and I know it's been area of considerable concern and focus for the Department of Defense in general, certainly for the Navy, certainly for the Air Force. Could you just maybe bring us up to speed on how you see that general effort unfolding right now?

GENERAL SELVA: Michael, there are probably three major lines of effort in the management and sustainment of nuclear enterprise. The first is actually the safety, security and reliability of the weapons themselves. Since we are in an atmosphere where we have signed up to not testing, we have a very scientific and deliberate method of assessing the security, safety, and reliability of the weapons themselves.

The second major line of effort is the delivery platforms, the missile

systems, the submarines, and the airplanes that would actually deliver the nuclear weapons if we ever had to use them. Those also require sequential modernization.

All of those systems are reaching the point in their lifetime where they will have to be replaced, whether we're talking about the B-52, the Minuteman III platform, or the Ohio Class Submarine. We're going through a process of prioritizing how we go about the modernization of the delivery platforms themselves.

The third piece is the command and control network that allows us to assert positive control over the weapons and assert to the President that he or she is in fact the only person that has the authority for the release of those weapons. That involves indications of warning systems, as well as the communication networks that allow the President to communicate with his or her decision through the Secretary of Defense to all of our field and forces.

All of those pieces of the network, of the nuclear enterprise, require our attention, and will have to be modernized over the next decade and a half.

MR. O'HANLON: Let me ask one follow up, if I could. This is mean to be a slightly sort of contrary and/or skeptical question, but not in broad terms, just on a specific. I'm instructed that the Navy, in particular, has said that the nuclear modernization mission is its top priority. I think you have helped explain why it has to be a high priority, reliability, the age of the submarine fleet, et cetera.

To my ear, it has always been a little bit disconsonant why it has to be seen as the "the top priority," when to me, at least, it's the type of weapon we are at least likely to actually ever use, recognizing we need a robust and safe deterrent.

I wonder if the Navy hasn't slightly overstated the priority, and maybe it should be seen as a top priority, but in a world where China's Navy is rising and doing a lot of things in the Western Pacific that we have to watch with our submarine fleet and our

EP-8 fleet, and all sorts of other platforms, and many other things are going on in maritime domains, have we slightly exaggerated the relative importance of the nuclear mission?

GENERAL SELVA: I don't think you can exaggerate the importance of the nuclear enterprise in any measure, I'll borrow your words. I think you said reliable and credible deterrent.

In an atmosphere where the creditability of a deterrent actually lives within the domain through which you execute the deterrent, you have to keep the delivery platforms up to the potential threats. If the maritime domain is becoming less opaque and more transparent, we have to address the things like the stuffiness of the submarine, the quietness of the submarine, the reliability of its nuclear power plant, and its ability to actually operate in the undersea domain in a way that allows us to assert the reliability and creditability of that leg of the triad.

I think for the Navy, or in the case of the Air Force for the bomber and missile leg, to say those are their top priorities, it puts them in exactly the right place. There is not only a nuclear deterrent capacity that comes with our nuclear enterprise but it also underpins some of our conventional deterrent capability.

MR. O'HANLON: Let me follow up on a couple of areas of technology that you have already alluded to. You talked about command and control. I'd like to ask about the robustness of our command and control network, and also I'd like to talk a little bit more about robotics, if I could. Maybe at that point, we will see if it's a good moment to pivot to the audience.

One of the things that I'm sure you thought a lot about in your career, a lot of us think about in this think tank world, is the notion that we have gotten used to having a very robust, reliable C4ISR network, because we have been fighting the Taliban

and al-Qaeda and other insurgents who are tenacious on the ground, if you're near them, but don't have the ability to really get inside of our information systems.
Of course, that could change in a future conflict against a different adversary.

I'm especially concerned about cyber, like many people are, but also about satellite systems. Do you feel we have appropriately prioritized the resiliency and redundancy of satellite systems, and if not, is that an area we should be thinking more about for the future?

GENERAL SELVA: I would take it from the satellite conversation, the robust command and control network conversation. Satellites are a pathway, the radiofrequency pathway is a pathway through which we do command and control. It is not the only pathway.

What we need to be able to do is have a resilient enough satellite architecture that can act as a redundant pathway to atmospheric communications through the RF domain as well as digital communications through the fiber domain. Fiber as a domain, not to be argumentative, but the amount of bandwidth that you can push through a piece of wi-fiber is actually exponentially larger than the amount of bandwidth you can push through most of our satellite systems.

If you use that entire set of criteria for how one executes command and control, then you have a variety of pathways through which you can do that. The second thing that it does is it helps you have variation in how you protect your cyber network because you control the pathways through which information comes and goes.

I think you have to do both. You have to address the hole of the dam that they are going to use and space, and you have to address the pathways through which information comes and goes from your systems.

MR. O'HANLON: One follow-up on that before I go to robotics, if I could.

I'm just wondering if in this period of fairly robust defense resources and yet considerable downsizing from where we had been, if this general mission of protecting reliable command and control has been somewhat under prioritized, not in your tenure, but since the Cold War ended.

Because clearly that was sort of the defining moment when we didn't worry as much about an all out nuclear war against a peer adversary, and I think from what we can tell in the unclassified world -- I realize you can't give us a lot of details here -- but there has been a lesser emphasis on things like hardening against EMP, other kinds of nuclear effects, and obviously our dependence on cyber has grown dramatically since the end of the Cold War, so is this an area where those who would think about the future of the U.S. defense budget should be thinking about some unmet needs that we really need to find more resources for than we have been able to so far?

GENERAL SELVA: I'm not sure it's entirely a resource question. I think there are two things that have to happen. One is to build in the resiliency in the networks that allows them to react to external actors. You notice I didn't say allows us to react, but allows the networks to react. That may get us to your robotics question and some of the artificial intelligence that will be required to accomplish that task.

The second is to build in the physical resilience into the network, whether it is fiber, atmospheric RF, or the satellite constellation, to build in adequate resiliency to deal with a nuclear threat.

I think the word "adequate" is appropriate to this conversation because you don’t have to harden every part of the network, but we have to harden the parts of the network that matter to the nuclear mission. I think that is the middle ground that we are going to have to strike as we address the resource question.

MR. O'HANLON: It's not an area of gaping, huge unmet budgetary

resource requirements necessarily, but it's an area that requires a lot of creative and careful thought.

Let me talk a little bit with you about unmanned systems, robotics, if I could, and then I may ask a question about missile offense before going to all of you.

If I could ask about unmanned systems, let me put it this way. Obviously, please frame for us the problem as you see it however you wish, but let me give you a specific additional question.

It looks to me like we have made just huge headway in aerial robotics, in drones, unmanned aerial systems, call it what you will. Obviously, you have to think a lot about whether we have enough and we are all focused, and the Chief of Staff of the Air Force and other Services focused on that question intently right now.

I want to ask a little broader question about where we are and sort of the march of technology and innovation. It looks to me like again, especially since the turn of the century, we have made huge headway in the use of aerial unmanned systems.

My suspicion is that we haven't prioritized as much or maybe weren't at a cusp of innovation where we could, where we prioritized quite as much unmanned undersea systems and unmanned vehicles.

I wonder if in the next 10 to 15 years both of those things can and should change quite a bit. For example, just to make it very specific, and then let you react as you wish, if we have a future counter insurgency, and let's hope we don't for a while, but a future mission like the ones in Iraq and Afghanistan, having a lot of the convoys be by unmanned vehicles would seem to me a natural way to reduce our exposure to casualties. Secondly, in this world, we're still talking a lot about is our Navy fleet going to be 280 ships or 300, and Secretary Carter is finally trying to remind us not just to think about the size of the fleet or what it contains.

Is this a period where we really need to broaden our understanding of what's in the Navy, to start thinking about the undersea unmanned platforms that perhaps come back to a mother ship but become part of a constellation.

Are we at the point where that conversation really needs to become the norm in how we think about Navy modernization?

GENERAL SELVA: You made two points. One is about what I'll call "unmanned" at the moment, ground vehicles, the second, undersea vehicles. In most of the incarnations, these vehicles are not really unmanned. We use the words now "remotely piloted vehicles." For the aviation enterprise, most of those aviation assets are actually managed and/or actively flown by an aviator who is not physically in the platform.

You and I are on the cusp of being able to own cars that will drive themselves. The technology exists today. It's been proven. Some of us in this room own cars that park themselves and they do a substantially better job than we do.

We have proven that we can build and field unmanned underwater vehicles, unmanned surface vehicles, unmanned wheeled vehicles, and remotely piloted air vehicles. We can actually build autonomous vehicles in every one of those categories.

This gets us to the cusp of a question about whether or not we are willing to have unmanned autonomous systems that can launch on an enemy. I think that is a huge technology question that we will all have to wrestle with.

There are ethical implications; there are implications for the laws of war. There are implications that I call the "terminator conundrum." What happens when that thing can inflict mortal harm and is empowered by artificial intelligence. How are we going to deal with that? How are we going to know what's in the vehicle's mind, presuming for the moment we are capable of creating a vehicle with a mind.

It's not just a programmed thing that drives a course or stays on the road or keeps you between the white lines and the yellow lines, doesn't let you cross into oncoming traffic, but can actually inflict lethal damage to an enemy and has an intelligence of its own. How do we document that? How do we understand it? How do we know with certainty what it's going to do?

Those are the problem sets that I think we are going to have to deal with in the technology sector that making building the platform actually a relatively simple problem.

MR. O'HANLON: Fascinating. When you put it that way, let me try a little further. When you put it that way, it sounds like you're trying to encourage maybe a national debate as opposed to just an internal DOD debate, that you feel that the rest of the country and the Congress need to be involved in helping make these decisions.

Because otherwise, what is going to happen is you all will do your best and probably at first it will be a classified program and then it will leak out that we have this sort of thing, and people will wonder if the Pentagon has gone crazy, and in fact, this actually is a big broader philosophical/ethical issue that the whole country needs to be involved in.

Is that you're saying? In other words, most DOD decision making hasn't actually wrestled with this in a programmatic sense yet, but we're getting close to when we have to?

GENERAL SELVA: We haven't gotten to the point where we have built artificial intelligence that will make the decision to inflict harm. At the very extreme of the conversation we're having, that's a debate we need to have, I would argue nationally and internationally, and answer whether as humans we want to cross that line.

I think artificial intelligence can help us with a lot of things that make war

fighting faster, that make war fighting more predictable, that will allow us to mine all of the data that we have about an opponent to make better operational decisions. I'm leaving none of those decisions at this instant to the machine.

MR. O'HANLON: Just to think this through, one could argue that a smart mind at sea is already sort of a very early incarnation of that, right, because you're basically saying when you hear a certain acoustics signal, detonate, or some of the sub-munitions that have been proposed, I think Rand has written about these for 20 years now, that could loiter above a potential area of an access of approach by an enemy tank army, they would be empowered to attack when they saw a certain visual or acoustic signature, and they are already deployable in theory, right?

GENERAL SELVA: They are robotic, but not intelligent. There is a significant difference. When you create a weapon that answers a signature, a specific program, it is code that we write, and we tell the weapon when you hear this signature, detonate, or when you see this signature, prosecute the target. The signatures are known, thus, consequences are known, and all of the rule sets that go into the weapon are hard coded.

At the very extreme of that technology is artificial intelligence. Where I might say to a weapon go learn the signature, once you have learned the signature, identify the target. That's about how far as I'm willing to go at this point. Once you have identified the target, a human has the responsibility to make the decision to prosecute the target.

That's a very different world than the one you just described, which is a hard coded weapon where I wrote the code or an engineer wrote the code, and we have tested it to a level of comfort that we know precisely what that weapon is going to do.

MR. O'HANLON: In fact, this makes me think, at Brookings, we can't

even quite get the thermostats to work. (Laughter) If anybody could turn it down from the 90 where I think it is now to 70, that would be much appreciated.

I think you are really raising a great set of issues because as much as we see things go forward and go in incredible directions in the technology sphere, we also know there are always things that go wrong. We have to think about that early and as an inherent part of the process.

One last question for me on missile defense. The Director of the Missile Defense Agency was just at CSIS this week and gave a very nice overview of a lot of the systems there, and that is of course, a big ongoing area of innovation, but I don't want to ask about the whole missile defense mission.

I want to ask about directed energy. I think we all know that as long as the defense needs to build an elaborate interceptor to shoot down an incoming missile, the defense is going to be challenged. Maybe that is going to be okay if you're dealing with North Korean IBCMs, they can't build very many, they can't even prove the technology yet, and even once they do in the future, if that happens, it will be hard for them to build a lot.

We know for protecting air fields in Okinawa or some place, it's going to be pretty hard to do that against a peer adversary unless we have some kind of a game changer technology.

How would you describe progress in directed energy, and what's your sense of where it may go in the next 5 to 10 years, especially for the missile defense mission?

GENERAL SELVA: In the directed energy space, directed energy is not the only solution. I would suggest in this missile defense space, we actually have gone for the solution we could build, which is essentially the most elegant interceptors that

exist to go after individual warheads. That is the absolute wrong end of the cost and position curve. We are doing a $10 solution for the 10 cent problem. We need a 10 cent solution for the $10 problem.

When you think about directed energy weapons, potentially powdered cannons with hypervelocity rounds, and a variety of others, where you can mass a defense against an incoming threat, whether it is cruise missile or ballistic missile, you get on the opposite side of the cost and position curve, so your opponent is actually having to build more and more elegant weapons to try to defeat a relatively inexpensive and relatively certain defense.

It's still an end game defense. I think we need to get into that space. Certainly, directed energy weapons have potential in that space, but they're not the only potential solution.

MR. O'HANLON: This is a great start for the conversation. I want to share the fun with the others who may have questions for the Vice Chairman as well. We will go here in the sixth row. Please wait for the microphone and identify yourself, if you could.

QUESTIONER: Thank you, General. John Harper with National Defense Magazine. Can you talk a little bit about how deep learning will play into the advancement of autonomous systems, just kind of give a quick overview of that concept and kind of where you're going with that? Thank you.

GENERAL SELVA: Great question. I know about as much about deep learning as you could put in a thimble, so I will share that part of what I know.

The whole concept of deep learning fits nicely into the space of analyzing big data. We have both, a requirement for deep learning systems and a requirement to be able to sort some of the largest databases on the planet.

If you just think about our intelligence databases and all the digitized information that exists about the planet, and how one might direct an analyst to look at particular parts of that data and make human decisions.

If we can build a set of algorithms that allows a machine to learn what's normal in that space, then highlight for analysts what's different, it could change the way we predict the weather. It could change the way we plant crops. It could most certainly change the way we do -- change detection in a lethal battle space.

What has changed, what is different, what do you want to address that matters in that difference, and building the algorithms and the learning algorithms that can do that makes a difference. I think that's the place where we are going to have to go. The data sets that we deal with have gotten so large and so complex that if we don't have something to help us sort them, we're just going to be buried in the data.

I think the deep learning concept of teaching coherent machines, not using artificial intelligence, teaching coherent machines to advise humans and making them our partners has huge consequence.

I'm going to give you an example, by the way. Almost all of you do this every day and you don't know it. When you log into your bank, almost all of our banks use a rudimentary piece of artificial intelligence to determine who we are. I happen to log in almost every morning at a particular time on a particular device. My bank knows that.

If you happen to the be the person that logs in from the wireless at the Starbucks down here on the corner at 8:30 in the morning, the bank knows that. If that's your routine, they let you right into your account. By the way, if I log in at 3:00 in the afternoon from a different device, my bank asks me for an authentication and so does yours.

The program that allows your bank to do that is a deep learning

algorithm that actually tracks all of the millions of subscribers to that network. It knows every device that's on the network. It introduces new devices, and it tracks your behavior. I'm going that's really cool.

If a bank can teach a piece of software to learn about us, that is early proof that this deep learning set of algorithms can actually learn about change, if we can teach algorithms to help us understand change, we could be better at this task of using the information we have to make good, reliable, and coherent decisions in a very complicated battle space.

MR. O'HANLON: It might have helped with the roads last night.

GENERAL SELVA: It might have. (Laughter)

MR. O'HANLON: Let's stay in that same area, the young woman across from the gentleman who posed the last question.

QUESTIONER: Hi, I'm Amy Kruse. I'm a Chief Technology Officer at Cubic Global Defense. I've been on a couple of defense studies on autonomous systems, so this is near and dear to my heart.

One of the things that I think is really interesting in that space and wanted to get your thoughts on was the test and evaluation of autonomous systems. We're very comfortable testing and evaluating humans, right. We're very comfortable testing and evaluating deterministic systems. Now, we're into a space where we can't even conceive of potentially had to test and evaluate autonomous systems or maybe combinations of humans and autonomous or learning systems.

What are your thoughts about that?

GENERAL SELVA: That's a great question. I'll go back to the bank discussion. Banks deployed that piece of software when they were confident it would do what they thought it would do. They didn’t know it was going to work. They were

confident that piece of software would do what they had designed it to do.

We actually have to get to a different place, because what we are talking about are humans and machines that are teaming together to accomplish a task which has lethal consequences.

In our operational testing and evaluation world, we test everything to failure, but how do you test something that you taught to a high level of confidence.

We are actually going to have to invent the deep learning software that will actually tell us -- that is how we test humans, right. I still fly. I take a flight evaluation every year. The instructor pilot sits next to me as the flight examiner and asks me 101 questions about the airplane, and then he tries to get me or she tries to get me to break one of the rules I just told him about.

We do that in a simulator, and they test me until I'm tired, and they finally realize I know what I'm doing.

By the way, how do you know your 5 year old actually learned what you wanted them to learn? Because they tell you. They demonstrate that they know what you taught them, but they can also interact with you.

We haven't built that piece of software yet that I know of. I say "we," the entire enterprise of software engineers who are trying to build this artificial intelligence deep learning space have not built the piece of software that can actually tell you what it has learned.

I think that is one of the milestones we are going to have to cross before we can actually get into a high confidence area where we can say the technology is actually going to do what we want it to do, because not only can we physically test it, we can intellectually test it. It's not a game. It's not a stimulus and response situation. It's actually cognitive testing of the software, and it's going to tell you what it learned. That's

really hard.

I think that is the frontier that we are going to have to cross. Otherwise, what we're doing is we are just building a little more elegant programming into machines that we can truncate. They are never going to learn. They are just going to do what we tell them. That's robotics. They are going to anticipate what we need. They're going to feed us information. They're going to help us make decisions. Now, we're starting to cross that frontier.

I take your point. In the Department, we build machines and we test them until they break. You can't do that with an artificial intelligence deep learning piece of software. We're going to have to figure out how to get the software to tell us what it has learned.

There's a second piece to this. Algorithms that learn actually write their own code. My elementary school way of describing smart software. They write code that's irrelevant because they're learning, just like a child learns, there are things that a child does in a learning experience that are totally irrelevant to what you want them to learn. It doesn't mean they didn't learn them.

We need to figure out how to have that feedback loop in the software where we can un-teach it or expunge irrelevant code, because it occupies space, and when you occupy space, you're taking away from its capacity to learn.

There is a lot embedded in your question, and I would love to interact on that a lot more as we begin to invent these systems.

QUESTIONER: Thank you.

QUESTIONER: Hi, General. Tony Bertuca, InsideDefense. I wanted to introduce the topic of budget into the discussion. The third offset that's going to be funded in fiscal year 2017 is the Pentagon's first sort of organized budgetary swing at all

of this.

Mr. Work has said it's about 12 to $15 billion over the POM for this. This is Congress' first chance to really look at what type of investments the Pentagon will make.

Is there concern that Congress might see this effort as diverting funds from readiness that's existing, F-35 LCS programs, to a bunch of small, little bets that may or not pay off? My question is how do you sell Congress on doing all this, this first time around, to launch the effort basically, and what can we expect in fiscal year 2017 that would get a few eyebrows raised?

GENERAL SELVA: I don't have a lot to tell you to expect in 2017 that will cause people to raise eyebrows. Your characterization of what we are trying to do is exactly right. This is a learning space. Some of the investments we make won't pay off. We are going to place multiple small bets on places where we think we can make a difference, where we think the leverage of the technology exists to actually move the enterprise forward, and look at the potential for a third offset. Notice I didn't say "implement" a third offset.

Look for the potential.

Most of you know the history, but those of you that don't, the term "third offset" comes from the fact that over the last 60 years, we have gone through two major changes in the way we, the United States, think about warfare.

The first one happened in the late 1950s. We looked at Europe. We realized we were vastly outnumbered in Europe. We introduced the concept of battlefield tactical nuclear weapons into our formations. We had organizations that were built around those nuclear weapons. We had concepts and doctrine that were built around that capability.

That persisted in our Services through the early 1970s. Then we struck upon this idea that if we could combine stealth with precision, we could provide conventional weapons with nearly the same effects as battlefield nuclear weapons.

The first offset was tactical nukes. Second offset was precision combined with stealth to give us similar effects on the battlefield, so we could still fight vastly outnumbered.

The question we're trying to pose now is do the technologies that are being developed in the commercial sector principally provide the kind of force multiplier that we had when we combined tactical nuclear weapons with fielded formations or precision and stealth with fielded formations.

If the answer is yes, then we can change the way we right in this battle space. By the way, if the answer is no, then the third offset will never come to past. We are going to have to figure out how to do what we're doing just a little bit better.

History tells us there is the potential that by changing the way we organize around the technologies that are available, we might be able to change the pace and scope of the fight on the battle space. That's where we are headed.

MR. O'HANLON: Right here in the fourth row, please.

QUESTIONER: Colin Clark, Breaking Defense. Good morning, General. There is a fair amount of work by DARPA on prosthetics, boosted armor, all that. There is a lot of work on microelectronics. DARPA doesn't like to talk about this in these terms, but it seems as if in the next 7 to 20 years, we're going to end up with something like boosted humans on the battlefield, when you combine the microelectronics with those.

That is sort of the other side of the artificial intelligence issue. How do you see this playing out, and how important are biologics to the third offset?

GENERAL SELVA: There are three huge questions in that question. One is how far will we go with biologic augmentation. I would argue that's a legal and ethical question that we're going to have to -- this is another one of those do we want a national debate or do we want an international debate.

What might our adversaries do with that technology is something that we need to be able to understand. It's not just do we want to do it, but if somebody else does it, how do we or can we counter it.

The second piece of your question, which I think is incredibly fascinating, is the potential to embed or add mechanical capability to humans that makes them more effective or more efficient. I would argue the same. It's in the same space as biologics. When do we want to cross that line as humans, not as Americans? Who crosses it first? What inventions need to be added to that discussion that says we either will or won't do it and in what space we will do it.

Those are really hard ethical questions. The third part of your question, which I think is most fascinating, and has the nearest term potential for doing good things for humanity, is the combination of microelectronics, artificial intelligence with connectivity to the human cortex, and additive manufacturing. I throw the third one in on purpose.

If we can do all three of those well, you could build actual prosthesis that react to human inputs, not from muscle tissue or nerve tissue, but from your brain.

That has huge implications for people that are injured in accidents, people that lose limbs, soldier, sailor, Marines, Coast Guard, or anybody else that's injured in the work they do could be restored to their previous self with an artificial limb.

I've actually seen early prototypes of some of those capabilities, and they are astounding. What we're learning about the human brain in an attempt to get artificial limbs to react to human input will help inform that debate.

I think we are a long way from actually being in the middle of that debate, but I think we're going to have to have conventions around it.

MR. O'HANLON: By having just reviewed your resume, I'm stunned at where you found the time to be so good on some of these issues, very impressive. That's a great conversation. Let's do one more up here and then I'll work back.

QUESTIONER: Byron Callan, Capital Alfa Partners. I want to take the discussion back to budget and resources. We couldn't match Soviet conventional strength in Europe, thus, all the fiscal parameters. When you think about the third asset strategy on some of the technologies out there, Michael mentioned directed energy as one that fundamentally changes the cost equations in these systems.

Are there other things you look at from the broad pallet of technologies that are available that might enable the same thing, to match these threats or over match them, without busting the bank?

GENERAL SELVA: There is a whole menu of technologies that exist. I'll put them into three sort of large bins, if that's helpful. One is energy production and storage. If you're going to have all of this machinery that's going to do work for either augmenting human intelligence or assisting human intelligence, how are you going to power it, source of power, source of power storage, and cooling? By the way, none of those are easy.

The second sort of broad set of technologies that I would talk about are the lethal end-game technologies. Again, whether it's a directed energy weapon or a physical kinetic weapon that gets its energy from either powder or electric rail gun or that kind of technology, you're still going to have to direct that weapon at your end game.

What are the terminal guidance pieces going to look like? They will become increasingly complex. The time lines will get shorter. The risk we take in fielding

those systems will go up.

Essentially, you're getting more shots as whatever the bad thing is that's coming at you gets closer, and we're going to have to figure out how much risk tolerance we're going to have in that space.

The third big broad basket of technologies are the underlying software and guidance and control pieces. I put those together because they are all about feedback loops. How do you get the things you built to do the things you want them to do.

If I take those three big broad baskets, energy production and storage is actually moving faster in the commercial sector than it is in the military space. Like Tesla, not just an electric car, but now a battery storage process by which you can store power that you generate in your home. That technology has a long way to go. They have moved it a fair distance.

If you look at the middle bin of technologies, those are almost entirely military. How do you get at that kinetic or directed energy solution to solve the problem?

In the third bin, innovation moves faster in the commercial sector than it does in the defense sector by a large margin. If you look at the net -- we were having this discussion in my office before we left -- if you look at the net area under the curve of change in the civilian world and change in the military world, it's probably pretty close to the same.

The difference is we look for step function changes. We want to completely change the way we prosecute warfare. If you look in the civilian sector, innovation is the summation of 1,000 little changes that are happening all the time.

There is much more innovation going on at a much faster pace in the software and artificial intelligence sector of the civilian world than in the military world.

We're going to have to take advantage of all three.

Just broadly, I would put them in those bins for now.

MR. O'HANLON: Before I go to you all again, I'm going to ask one more question that raises in my mind, which has to do with acquisition reform. I know this is largely an issue for the Office of the Secretary of Defense and Mr. Kendall, but nonetheless, given your role leading the Joint Resources Oversight Council and just your thoughtfulness on technology issues, and the fact that now the Services have been given more responsibility by last year's National Defense Act, I wanted to ask you what your thoughts were on acquisition policy.

I'm enjoying the fact that most of this conversation is not about acquisition policy.

GENERAL SELVA: As am I. (Laughter)

MR. O'HANLON: If we look back at what happened last year, we had a lot of attention to the issue, Congressman Thornberry, Senator McCain, and many others. They wound up, I think, doing some good work, and they wound up trying to steer the influence and the role of the Services to be a little higher in visibility and priority than it had been.

Otherwise, I don't know that there were a lot of major breakthroughs on things like getting Silicon Valley more involved, and Ash Carter has his outreach campaign, and that's smart, and I think you have been involved in that, too, but beyond trying to break down psychological and political barriers, is there any kind of new legal or regulatory reform or use of authorities that we need to get better at within the Department of Defense?

GENERAL SELVA: There are a couple of things. One is in a joint requirements process, we have broadened our scope a bit in how we look at what

constitutes a requirement.

We have had a history in the Department over the last several years of defining requirements by desired capabilities, and that's interesting, but it leaves out a huge part of the process, which is the potential adversary to which those capabilities will be applied.

It's possible in that world where you talk about capabilities to have an adversary that doesn't care what our capabilities are. They're going to build to what they want the world to look like. If we don't react to that threat and adapt the way we think about the capabilities we wish we had, we could actually go down a fairly low pay-off path.

We have built back into the requirements process a fair assessment of what we believe the potential threats to be from those nations that are competing with us in the international space. It doesn't mean we will ever enter open conflict with them. It means we have to pay attention to what they're doing. That's one piece that we have taken a look at.

The second part that you raised is a very interesting one, and I have spent a little bit of time trying to figure out how we can interact better with those parts of the commercial sector that are doing the kinds of innovation that we're interested in.

We have a small fund, and I'm not going to put a dollar amount on it, so nobody try to get me to do that. We have a small fund in the Department that we're using to go out and interact with companies that are operating in those spaces, and they have been very open to looking at the kinds of innovation we want to involve ourselves in.

That goes a little bit to the artificial intellgence, it goes a little bit to the deep learning. It goes to the exploitation of big data, to answer very specific Defense Department related questions.

To a software engineer that is enticed by big data, what better place to put them than in some of the largest databases the world has to offer, and let them swim around in the data and help us understand how to exploit it.

We have entered into some of those arrangements. They live on the fringes of the acquisition reform initiatives that were put into place last year, but they are very, very useful.

The final point I want to make is having the Services involved in acquisition is exactly the way the system is designed. The requirements' oversight process allows us to determine whether those requirements that the Services are bringing into the acquisition arena actually meet the fundamental requirements of being able to interoperate and operate jointly with the other Services.

It solves a problem that has existed in the Department for decades. That is really the heart of what joint requirements does. Are you meeting a need that is not just unique to your Service but transcends all the Services, and once you build it, will it actually interoperate with the joint force in the battle space.

We have a classic example of when this didn't happen, and most of you don't know this story because you weren't paying attention in the 1970s or early 1980s.

We had a young captain in Grenada have to use an AT&T credit card to call back to his headquarters at Ft. Bragg to direct an airplane to bring a support strike onto the location he was supposed to be prosecuting, because his radio was built by his Service and it wasn't able to communicate with the radios on the airplane that was providing his air support, because we did not design the system that way.

We have to have that oversight and integration process that allows us not to make that mistake again, and empower the Services to bring to us the best capabilities they can possibly build.

MR. O'HANLON: Here in the fifth row.

QUESTIONER: Hi, I'm Jen DiMascio with Aviation Week. Congressman Thornberry and I think an official from the GAO who handles S&T accounts have recently talked about the need for greater risk tolerance in pursuing technology.

I wondered what your comfort level is with that, particularly as you look ahead at programs like designing a sixth generation fighter.

GENERAL SELVA: It's a great question. It goes back to that small pot of money that I'm not going to define for you. I actually help manage most of that with a small staff. My tolerance for risk is pretty high. Not in the end game, but in the journey.

This is something we have to be very, very careful of. Once you start bending that or working the actual composites to build the machine, this tolerance has to go down. In the journey to actually figure what the technologies are you are going to embed in that machine or how you are going to use that machine in the battle space, I think our early risk tolerance needs to be a little bit higher. I, personally and professionally, am fairly tolerant of failure, because I don't ask easy questions.

When I go out, and I have done this in Silicon Valley, when I go out to Silicon Valley and ask a software engineer to think about a learning software that's going to answer one of my problems, it's a really hard question.

It’s not about improving my profitability by one or two percent or three or four percent, or understanding my customer base, and I use these words very, very with intent, with some of these people, I say I have to be certain -- it gets to your testing and evaluation question earlier -- once I say I'm going to commit to the piece of technology you're going to give me, I have to be certain that it's going to deliver the outcome that I need.

There are very few engineers in the software space or the hardware

space that deal with the word "certainty." That is my opening proposition. If they say I'm willing to try, I say I'm willing to help you try. You have to be willing to tell me if you're failing.

That is really tough for most military people to take on. Civilian technologists deal with this all the time. Venture capitalists deal with this all the time. They will place 300 bets in a year and expect one of them to pay off. We place a handful of bets every year and we want all of them to pay off.

In this cycle of rapid innovation, in civilian and military technology, we have to be able to accept failure, not in the battle space, in the development phase.

MR. O'HANLON: We have time for about two more questions.

QUESTIONER: I have a question for the current situation. I would like to know what is the unmanned system specifically for the maritime in case the battlefield has happened in the Asian Pacific, and also is there any system to tackle -- the prevention system?

GENERAL SELVA: Right now, we have very few unmanned systems that are deployed in the Pacific. The one that I'm aware is actually a reconnaissance platform, and it's an airplane that's flown by humans, the humans are not on the airplane. The fail/safe system, the guarantee that the system won't fail, is the human that interacts with the system.

At this instance, I am not aware of any other completely unmanned autonomous systems that we are operating in the region. I'm not sure that gets to your question.

QUESTIONER: Yes, thank you.

MR. O'HANLON: Let's take two to wrap up together, and then we will just make that the final grand finale, like the fireworks on the 4th of July.

QUESTIONER: Hi, General. James Drew from FlightGlobal. Going back to the B-52, does North Korea shrug when you fly a 50 year old B-52 into South Korea, and in looking at your next generation bomber and your next generation cruise missile, what do they need to do to be worth the billions?

GENERAL SELVA: That is two great questions. Without revealing anything classified, the intelligence reports that I get on the North Korean reaction to the B-52 flying a low approach at Seoul, say no, they do not shrug. They actually pay attention.

We have maintained a bomber presence in the Pacific since the early part of the last decade and intend to continue to do so. The North Koreans are very aware of the presence of the aircraft and the capability that they represent.

So far, that's about what I can say on that issue. On the long range strike bomber and the long range strike system of systems, the missiles and weapons it will carry and the platform itself, they're going to have to be capable of going into some of the most complex surface-to-air missile defense systems that humans have built. That's the requirement.

I can stipulate how many decibels of noise reduction and radar reduction that's going to require, but the fact of the matter is all of the people that want to compete with us, any country that wants to compete with the United States, has watched the last two decades pass. They have gone to school on the way that we use air power as part of our joint force, to empower our joint force, and they have built incredibly elegant and integrated surface-to-air missile defense systems to try and keep us out.

Part of the process of undoing that advantage is to actually build a platform that has the range, the payload, and the stealthiness to actually get inside of that network and accomplish the operational and strategic objectives that we need done.

That's the combination of a long range strike platform and the weapons that it carries. That is why the requirements are written the way they are for that platform and the family of weapons that it will deliver.

A second part of that requirement, as many of you know, was a fixed price tag beyond which we would not let the designers go. It was not an open-ended process where every engineer could come to the table and say if I built this next cool thing onto that airplane, it will be this much better. We stipulated a requirement. We stipulated a cost cap, and we demanded that the contractor that did the contract stay under that cap.

In the development, to the earlier question, tolerated some early failures to get to a reasonable success under a fixed price cap.

MR. O'HANLON: The very last question.

QUESTIONER: Tom Olson. This is about our adversaries. Are any of our adversaries anywhere near where we are in the innovations you're talking about, and if they either reach some success or they steal what we have, do we have a way to counter them?

GENERAL SELVA: Three really good questions again embedded in one. The terms "near-peer competitors" is often used to refer to Russia and China, and I am loath to use countries but I'm going to. Russia and China both have extremely robust technology sectors. That doesn't mean they are at par with us, but they could very quickly be at par with us.

We have to pay attention to the kinds of things they are developing. They have chosen a divergent path from the path we chose. They have chosen what we have colloquially phrased the "anti-access area denial path." We're going to try to keep you out, and we have gone down a very different path, which is we are going to try

desperately not to fight on our shores. We're going to try to project power abroad.

We have to watch the branches and sequels of the path they have taken, because as they get increasingly sophisticated about the process of trying to keep us out, we have to become increasingly sophisticated about the process of breaking the door down.

That competition is happening right now. We still have, in my estimation, a slight upper hand. We have an upper hand in the technology sector. We have an upper hand in the innovation sector. We have an upper hand in the range of payload sector, and all those matter in that competition.

That is not guaranteed. We are going to have to pay really close attention to the paths our competitors take, and everything that both of those countries build, they are willing to sell. The extent to which they sell it to other potential competitors or other countries with which we have political or international friction, it multiplies our problem. We have to be very careful about that.

I hope that gets to your question.

MR. O'HANLON: Everyone, please join me in thanking the General for his great remarks. (Applause)

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