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DWG: Welcome to the Defense Writers Group, and thank you very much, Dr. Walker, for being our honored guest today. And Peter Highnam, the Deputy Director is also with him and may also speak to us perhaps. I'm sorry I missed you last year, but I'm really excited to be here this time. There's quite a good turnout, a lot of interest in DARPA.

I'm not expert enough to ask detailed questions, but I am the moderator and I do get to ask the first question. Why don't I just ask you, your agency's known for working on projects that sometimes lead to pretty major breakthroughs that change the way we live or change the way we defend ourselves or whatever. Perhaps tell us about one or two things that are happening now that you think might be important if they work out.

Dr. Walker: When I took over as Director, it's been about two and a half years ago, I set out sort of four strategic imperatives for the agency, and first was defend the homeland against existential threats. The second was to deter and prevail against high-end adversaries. The third was more effectively execute what I called at the time stabilization efforts, but what I really meant was counterinsurgency, counterterrorism. Get better at that. The fourth was really to win the tech race into the 21st century and do what DARPA has always done well I think, which is follow where technology is headed, understand what the big national security problems are that the country faces, and then bring those together to solve those problems.

I'll just give you two that we're focused on now in that last

category, tech advancement. Two are, I would say artificial intelligence, and Peter can talk more about this once we get into any other questions on AI, but DARPA's been funding AI research for over 50 years now and we're pretty excited about not only the latest developments in applying machine learning which we sort of put in the second wave category, but really excited about moving into third wave which is, when we say third wave we're really referring to how humans and machines become partners. Humans don't just use machines as tools but actually as partners. So this is still very foundational work, but I think if you can actually build that relationship between the human and machine in a partnership type role, you can think about all sorts of things that warfighters can do more effectively in a time of war.

The second area I would just mention is biotech. I mentioned this before. A very fast-paced field. Five years ago DARPA stood up the Biological Technologies Office because we could see the advancement in those technologies coming down the pike. We're very excited about some of the work we have ongoing in Eurotech but also the gene editing space. Trying to understand that, number one. Get ahead of it. Last year it was reported that DARPA was stood up to prevent technological surprise from happening to the country, and one of the things we're trying to do in the gene editing area is not be surprised. So trying to understand how that works, or how it doesn't work, frankly. And if we can understand how it works and use it to our advantage to understand how to give our warfighters an advantage in how they do their jobs, that's something we want to look at.

So those are two areas I'm pretty excited about in the context of the imperatives I've laid out for the agency.

Those of you who know DARPA well know DARPA's a bottom-up place. We hire the best people we can find to be program managers, and we sort of say here are the areas we're kind of interested in from the standpoint of where the problems are, and they go find the ideas in their research communities and other places and then come and talk to Peter and I about why we should fund them.

DWG: Space satellite robot repairs. Can you tell us how that's going to work? How are you going at being able to do that? For example, will this technology if you were able to develop it, be able to fix satellites that are already up there? Or will it be designed to fit only satellites that will be made so that they can be worked on by these new pieces of technology?

Dr. Walker: I think it's a little bit of both. I think our Program Robotic Servicing at GEO was started several years ago because we could see the advantage of having a robot that could go up and service existing GEO stationary satellites. These things are big, expensive. But sometimes they go up and they don't quite work the way folks intended. So a panel might not extend like it should, et cetera. So we've been working with the Naval Research Lab on a pair of robotic arms that will last several years and a company called SSL who is our private sector partner to build the GEO bus that would take the arms up and be able to do things like extend an antenna or a solar panel with these arms that maybe had gotten stuck.

The refueling piece, you can think about, we heard back from the commercial sector that one of the things we're interested in is they typically have to save fuel on board these satellites for about a year to actually put them in a graveyard orbit at the end of their life. If they could use that fuel and not have to save it to do the graveyard orbit thing at the end of life, we could take our robotic servicer and push the GEO satellite up into the graveyard orbit, so they could have like a year's worth of fuel left on board to use, keep that satellite in orbit a year longer. That would be a big deal for them. So we can do that with existing satellites that are already up there with these robotic arms. I think if you want to refuel it you have to design that refueling mechanism to be on the new satellites that go up. That's why I said it's both.

Those of you that follow this program, know that the private company has pulled out of the agreement, SSL, and they did that for their own financial reasons. So what we've done is we've released an announcement recently where we're going to have an

industry day, I think it's May 22nd at NRL. Bring in capital firms, bring in DoD firms, bring in other private commercial firms. Show them the arms, show them the capability that's there and say do you folks want to team with each other to come on board and help us get this thing into orbit. That's where we are on that program.

DWG: Ellen?

DWG: I was going to ask you about the April 23rd award to Raytheon to provide surveillance technology for [inaudible] and because it is part of the friend or foe initiative. But I'm also interested in what you just mentioned about the [inaudible] test that's underway.

Dr. Walker: Neurotech. Okay.

I would say over the last couple of years, I'd say ten years ago DARPA started focusing on revolutionizing prosthetics. These programs were about giving our wounded warriors coming back missing arms something better than a hook which had been the traditional thing you could do for them. And we had programs, in fact one that went all the way through FDA approval and is now for sale through the Veterans Administration which is a high degree of freedom arm that can be controlled by a veteran's feet, with [inaudible] motors that can control his arm to do things like pick up this cup and do a lot more than they could ever do with a hook.

That was disconnected from the brain work that we've been doing. We took that type of technology and went further, and said how do you tie that into someone's motor cortex and have them just think about picking up the cup and have the arm do that. We've been successful at showing that in several patients.

I would say in the last two years what we've been able to do is actually put sensing into the prosthetic. Again, this is an application of AI, first wave AI, where you can use AI means to actually use that prosthetic, think about picking up the cup, and

the veteran will actually feel the cup, and that really helps with that action, right? If you can actually feel what you're trying to grasp, that helps you do it even better than you could without that feeling.

So we've proven that in several patients now and we're actually giving patients the ability to take these, I think we have four patients that are going to be taking these arms home with them, doing a year-long trial to actually use the arm in their home environment. This is an arm that is tied in to their nervous system and their arm, the stump that's left, and allow them to touch and feel. And where we're headed with this if those trials go well, is to kind of make it a completely wireless thing. Right now there's wires sticking out of the arm and the prosthetic, but if we could make it wireless -- if you think about a mechanical hand or arm being attached to a person and having them use it as a real arm. It's pretty interesting, the technology and the pace of change there.

That's what I'm most excited about when I see the neurotech stuff.

Of course we have other programs, looking at, tying into the motor cortex has required major brain surgery. How would you do this without invasive surgery? We have a program looking at trying to do that with non-invasive means. And then you can start to think about if you could do similar things without surgery, that opens up a lot of opportunity for working machine interface in the future with our warfighters and pilots in cockpits, et cetera.

DWG: John?

DWG: A year ago we had a vigorous discussion on hypersonics. You were very bullish. Dr. Griffin was getting ready to build a plan, how to orchestrate all the various efforts. And you also said we'd probably see something flying in 2019. Tell us, DARPA's efforts, the things that you're partnered with on the other services and your part of that master planning.

Dr. Walker: That's one of the areas I pay a lot of attention to. Number one, my boss, Mike Griffin, pays a lot of attention to it. So I do. But it's an area that I believe the U.S. really needs to make progress in and be a leader in. I think from a technology standpoint, as Mike has said, we have led the way in hypersonics. I think some of our peer competitors, though, have taken that technology and turned it into capability faster than we have.

So what we did at DARPA, starting in 2012, is we started two programs with the Air Force building on what we had done in a previous decade in looking at boost glide systems. These two efforts were the Tactical Boost Glide Program and the Hypersonic Everything Weapon Concept. These were focused on more tactical theater level operations. But basically TBG was looking at taking a boost glide, so a glider on top of n rocket and having it go a certain range. And then the HAWC Concept was taking advantage of what we had done in scram jet technology, and having a system that could be self-powered. Two very different concepts, but when you're talking hypersonic it's good to have what I consider intended redundancy because it's a hard technology. Making materials and propulsion systems that last in 3000 degree Fahrenheit temperatures is not easy.

So these programs were on track for both to have flights before '19, before the calendar year ends. That's going to be sporty because those of you who have built hardware and demonstrated things know when you actually get into the building of these things and qualifying the hardware, things tend to slip. But I'm hopeful we can fly both of those by the end of '19. It may slip into the early '20 time frame. These will be important tests for DARPA and for the Air Force.

I think I mentioned last year that we worked hard with OSD and the Air Force to put some prototyping activities together so that the service, the Air Force could accept these concepts if they were successful in flight. So the Arrow Program in the Air Force is about taking that TBG concept and flying it several more times

at a prototyping level, building some number for the Air Force. So that was a very important thing that we were able to do last year in the budget. Mike Griffin, of course, has gone on and been able to get a lot more money put into the service budgets for hypersonics moving forward in '20. You've seen some of that. Those are sort of outside the DARPA program window, but you will see in the next couple of years the U.S. very aggressively pursuing these technologies. And not just pursuing the technologies, but really thinking about how to turn it into capability.

DWG: Are you working with any of the other services?

Dr. Walker: We are. We have a joint program with the Army, basically taking advantage of what we're doing with the Air Force on Tactical Boost Glide. And building a system with the Army, so a 50/50 cost share, [inaudible] buyers, looking at giving them a ground-launched capability with a TBG front end. So that's ongoing. We're very excited about that.

DWG: How would that get up to altitude? What do you put that on?

Dr. Walker: We're developing a booster to do that.

DWG: So not a derivative of ATACMS or something else?

Dr. Walker: It's a brand new booster. We have three companies involved in the phase one looking at a booster that gives some controllability to where that front end can be put. The entry conditions for a glider are very important in how far it can go and what the environment it sees is, so this new booster would allow a lot more controllability, mobility for the Army and an ability to really use the system in the most effective way versus any other existing booster that's out there. So we have some small companies working on this for us.

DWG: Ashley, Jane's Defence.

DWG: I wanted to ask you about directed energy. [Inaudible] briefly touched on it. I wanted to get an update on [inaudible] programs [inaudible] working with the services [inaudible].

Dr. Walker: DARPA, we did the HELLADS program. That was really the first foray into solid state laser technology and proved that yeah, you could do a solid state laser that was in that case a slab laser. Still pretty big, pretty powerful. We were able to get some good tests done and that is out with AFRL at White Sands to experiment with.

After that, I'd say the last five to seven, eight years, DARPA really focused on fiber laser technology and the advantage there is you can integrate these lasers in much smaller packages. We have been successful with Lincoln Lab in developing a pretty small-scale fiber laser that has some pretty significant power levels and that should be fully demonstrated I think by the end of this fiscal year. Also working with some companies on programs to actually not just build the laser piece but also tie in all the beam control, the sensing capability that you would need to actually have it be used for missile defense applications. We've had some successful tests lately out at White Sands in that area.

So we've been working with the services on this technology for a while. We think fiber lasers offer a lot of opportunity for, again, size, weight and power integration into real systems. But we had a Directed Energy Day at DARPA I would say almost a year ago where we invited all the contractors in and service reps, and there's actually quite a bit going on in all the services right now to try and take this technology and turn it into real systems. They should speak on behalf of what they're doing, but there's a lot of activity to actually go from the bench to a real world system in a lot of different spaces.

DWG: On the Lincoln Lab one, could you sort of talk about what's the weight of the system and what power levels you --

Dr. Walker: I can't really talk about the power levels in this

forum, but you can think of it being the size of that little section of the table right there, everything included. Power generation, thermal management, et cetera. So it's not a large system. I can't really go into the power level.

DWG: What type of platform would it be? Looking at [inaudible]?

Dr. Walker: When it comes to lasers certainly the first applications are ships and ground vehicles, right? Weight is not as big an issue. I think we're still a ways away from putting these things on airplanes I would say. Those would be the first application areas.

DWG: Yasmin, National Defense.

DWG: Last summer you guys announced [AI Next] and put $2 billion towards a multi-year program. I was wondering if you might be able to give us an update on where things stand right now.

Dr. Walker: I'll let Peter do this one.

Dr. Highnam: AI, artificial intelligence investments in general. Sometimes it feels as after 50-plus years of investment it was a success overnight when you read stories and so on. DARPA's been investing for a long time.

If you look at the investments, we split them into three waves. The first wave was broadly characterized as [described], and there's a [rule]-based system, [expert] systems. Those of you who were around at the time, it was a big deal. If you use TurboTax today, there's an [expert] system inside there. If you have a router in your home internet system, that's a [rule]-based system.

After that came Recognize which is a machine learning or machine [training] system that we have today. Those were enabled by [inaudible], but the theory was done back in the '70s.

Now moving into this third wave, we're describing that as

Explain. So Describe, Recognize and Explain. Don't just give me an answer, system, give me an answer in context that's relevant to what I want to do now and help me establish trust in the system.

Stepping back a little bit, the term AI is, the I is unfortunate because it comes with so much cultural baggage that we bring to it. If you give it as a computer system, we're after a vision that was proposed by JCR Licklider in DARPA back in 1960 which was turning, at the time a room-full of computers with valves and teletypes and such, and doing trajectory calculations. His view was taking the computer as a tool, the computer as a partner. And partnership means trust, being able to explain -- all the things that come around trust. Trust is a multi-faceted object. Just as when you get in your car, you turn it on, you expect and you trust the brakes will work, you trust that you're going to [inaudible] and so on.

So we're now into that phase. We haven't completed the second wave of technology. The Recognize. There's a lot more to do, but it explains where we're going now.

What we said when the Director announced the AI Next investment, the $2 billion over five years in September at the DARPA 60th anniversary, was that we're going to invest broadly in three areas. The first, the second wave technologies, we don't have robust underpinnings to that yet. We have a lot of really good examples of successes, but the notion of being able to use a second wave technology in a safety critical situation on its own isn't there yet. So we have a lot of robustness work to do, a lot of basic theory, a lot of AI system engineering to be developed. Engineering [inaudible] DARPA's role, but we are exploring with a number of programs things like introspection against culturally loaded terms, but can a system monitor itself just as any control system would. Here we're talking about AI technologies. And say I'm going to maintain, I system have been trained with these data sets and these internal models so I can operate this well in this context. But if you try and put the system with its sensors in a different context, then all bets are

off or expect degradation.

That's an awareness, in loaded terms, of the ability is the type of thing we're after, as well as worrying about adversarial attacks on AI technology enabled systems and so on. So robustness of current technologies.

We're also doing [requested] applications of second wave technologies, putting them into a lot of interesting places. Steve mentioned for example the neuro technology area. So when you do the mapping from the [spike trains] to the arm control, and arm sensors back to [spike trains] to go back to the brain, those are machine-learned interfaces and they have to be recalibrated continuously. But that's one way of doing it. That's an example of applications. And we have many others.

We have about one-third of DARPA's 250 running programs, about one-third either building new AI technologies or making them more robust or are aggressive applications of AI technology. So it's not a casual thing for us, really, across the board.

So three thrusts. One, robust; second, aggressive applications; and third is doing the other things, what the third wave is going to look like. An example of programs there, machine common sense, explainable AI. These are all unclassified, fully documented on the web site. A lot of publications from great research teams.

DWG: You already have given some awards then to companies?

Dr. Highnam: Oh, yes.

Dr. Walker: Talk about AIE a little bit.

Dr. Highnam: We did a [broad] agency announcement where we go out and solicit major research proposals [inaudible], and yes, we've done ten of those, ten AI-related programs since the announcement.

But alongside that we're watching a community that's on fire. A lot of smart people working AI technologies or data science. These things are almost interchangeable in many places. And they want to be able to work on things now. We don't know what the third wave is going to look like yet, so at that intersection, we have something called AI duration awards. For these, we post a topic of interest and we award in other transactions within 90 days of posting the topic. If you deal with government acquisition you know this is fast. But it's being done very intentionally. These are awards up to a million dollars apiece. They last 18 months to two years. Those are parameters that enable us to do this. We've given awards now getting up to about $50 million since September.

We have huge interest in the research community. If you're a graduate student you can think about entering a master's program and being involved in a proposal, getting the funds to proceed, equipment and so on within three months of starting which you get to do within the life of your one or two-year degree. Some fascinating ideas in terms of research. The topics are posted. You can see them on the AI Next web page, on the front page of DARPA's web site. It's been broad. Everything from putting physics into AI systems, to back to neuro, how do you self-calibrate or monitor the environment around electrodes, close to nerves, the body scars and adjust to them. How do you self-adapt. And some also in the social sciences in there too.

So this is actually exploring where the big programs are going to, research programs are going to be for third wave AI.

DWG: Fantastic. That's at least two questions. [Laughter].

Center for Public Integrity?

DWG: Actually also on AI. When you're working on the trust elements, you mentioned in the [add] programs there's a technical difficulty in trying to come up with an ability to understand what a neuro [nap] in particular is doing, right? But the secondary part of that technology part is the ability to do test

and evaluation. The ability to have an expectation of the ethical standards that an AI system can apply. What work are you doing to work on this sort of policy problem in addition to the technical explainability issue for AI?

Dr. Highnam: A number of tacks. Setting policy, what can be used to support policy, yes. So two examples. One Steve mentioned, assured autonomy. They apply control systems and it can be quite rigid, purely physics based. We found that adding some second wave AI technologies to those systems going from a pure tactical control system to something that's more of a hybrid, we can get a system that is able to adapt to a wider range of conditions and behave appropriately. Assured autonomy brings to that guarantees of performance inside in an operating envelope. Bigger than the original control system but not fully broad. So that's putting, think about putting monitors into the system, baked in. That are appropriate for those types of systems and it's flight, it's all kinds of systems. But assured autonomy is a really good program to watch. There are a lot of publications coming from the research teams.

I want to draw analogy to the work we do in the biological office, [BTO] where in addition to having the normal protections for human subjects research and so on, we also have a separate ethics, legal and scientific integrity panel and that's standard for all of our programs. So we're trying to figure out how to place, what the equivalent should be for AI technologies. For me the term AI, the I has too much cultural baggage and I'm much more comfortable thinking about it as computing systems or, that's why I say AI technologies in the same phrase. I don't break it out. That's why assured autonomy is a pretty good model, because people can use cars in an inappropriate way just as they can use guns. So it's, to narrow it down to something specific just on one type of technology is a little awkward.

DWG: Can you tell us anything about that panel structure? You said it [inaudible], I'm trying to figure out what it would look like for AI. Is there a place to put similar sort of ethics panels for future AI work? Is there something already in place?

Dr. Highnam: It's not in place yet, but there's a lot of discussion both in the department, I mean the department around us, because we have the Joint AI Center under the CIO. So AI technologies are being applied really across the services. So there's a bigger discussion going on.

We're concerned on the R&D phase to put whatever protections are necessary, again, my analogy to human subjects research activity. So research based.

Dr. Walker: We're starting to dip our toe in that water because we had a recent event called the AI Colloquium where we invited all of our researchers in to talk about their programs, and a significant two hour portion of that we spent on ethics of AI led by Richard Danzig. Paul Sherry was on that panel who writes a lot about it for one of the think tanks in town, and two other folks. A very interesting discussion. It was one of the hits of the Colloquium, so it's definitely an area we want to do more in.

Dr. Highnam: If you go to the web site, we have, we posted the video of all, including that panel section, on the AI Next web page.

DWG: Saundra, Space News?

DWG: I wanted to ask you about Blackjack. There's a little bit of a turf battle between the Secretary of the Air Force said just recently that she thought that intelligence Air Force [inaudible]. She said we're doing the real [inaudible] the Air Force. However, I understand that it's technically a DARPA program. So if you can help us clarify what is going on and when would it transition and what are sort of the terms of the transition?

Dr. Walker: Blackjack was started at DARPA in [TGO] I don't know, a year ago. And we've gotten through the source selections now for the -- what Blackjack is, to be very clear, it's a demonstration of a large constellation of small low earth orbit

satellites. It's going to be a 20-satellite demonstration of this idea of getting away from big GEO satellites to do everything and augmenting those with a cheaper, in some ways more resilient architecture at LEO that would take advantage and leverage what the commercial sector's doing, putting up the [inaudible] satellites to do other things.

So the DARPA idea was to leverage that and build this 20-satellite demo to start looking at how do these constellations help with doing certain types of sensing that we would need to do. How do they provide a com layer at LEO to do global coverage, et cetera. We partnered with the Air Force on that. So it's a DARPA-Air Force program, Blackjack. We're going to put up the first two satellites and then the Air Force is going to come up with 18 more. I believe the first two satellite demo might be '21 with the 20 satellite constellation in '22. Then Blackjack, we're going to demonstrate that capability, probably pick one or two payloads to demonstrate. We have gotten through source selection on the payload side, on the bus side, and now we have a BAA out on the street to do what we call the pit boss, which is how to use a form of AI to do the sensing and real-time configuration of the constellation.

So it's accurate to say it's a DARPA-Air Force program at this point.

As you know, the SDA has stood up, and Fred Kennedy would like very much to build on Blackjack and to, my understanding, what SDA is going to do is try and develop an architecture for a proliferated LEO constellation of some type, and certainly his vision should take what Blackjack does and multiply it into a bigger architecture for operational use. So I'm guessing he's going to be working with the Air Force on that.

DWG: Isn't there a request to reprogram money from the Air Force to SDA which I guess Congress has to approve that, but that would indicate to me that the program will transition. And then also for the missile warning on some of these hypersonic missile warning layer of the [inaudible] that's also going to be done by

SDA. So what is the time line for that?

Dr. Walker: That I can't answer. It's not really a DARPA thing. It's probably, I don't know if that's an Air Force reprogramming action or what that is, but it's accurate to say right now Blackjack is a DARPA-Air Force program.

DWG: So you have not changed as far as when you put out [DCAAs] the requests have not changed the initial plan that you had for [inaudible]?

Dr. Walker: It hasn't changed at all.

DWG: Otto?

DWG: I'm representing the Navy here. You talked about hypersonic, you mentioned coordination with the Army, but the Navy has also been [in there]. Anything particular you're working with the Navy on on hypersonics? They're looking at both offensive and defensive systems from their ships.

Dr. Walker: Yes, we have been doing a study with the Navy looking at whether HAWC, Hypersonic Area Weapon Concept I mentioned would be a good solution for the Navy. That study, I believe, is still underway and they have not committed to moving forward with that system. I do know the Navy is working on the larger OSD program but that's really not a DARPA thing.

The most exciting thing I'm really happy about with the Navy right now is what they're doing with Sea Hunter which is the autonomous 132 foot surface ship that DARPA demonstrated a couple of years ago now. The Navy has taken that and is really using it and experimenting with it. They talked about recent excursions on that vehicle from San Diego to Hawaii and back, which I think demonstrates the autonomous capability we put into that vehicle. They're really interested in how that helps them with their distributed lethality concept moving forward, and they're talking about using that as a basis for medium sized and large sized unmanned surface vessels. So I'm really excited about where

they're taking that.

DWG: The crucial issue when you get into autonomous systems is identified as sensors, [inaudible] relays. But when you start weaponizing it gets into the question of where is the man in the loop? Where is DARPA on that? Your ethical studies on all your AI programs, where is the man in the loop when you start weaponizing your autonomous systems?

Dr. Walker: I still think it's important to have that lethal decision reside with the human being. Whether that human is on the platform I think is still an open question. But I still think the lethal decision is important for a human to make.

Sea Hunter has potentially a lot of uses that don't involve weaponizing it. Mine/countermine. As you say, sensing opportunities. And there are others.

Part of this autonomy world, especially autonomy in motion is getting out and experimenting and seeing how these things work. Peter mentioned the assured autonomy program. It's really important, because how do you really even do the test and evaluation for these systems? If you really want to do it the way we do it for [hood] things, you have to run the thing through many, many, many different test points, almost an infinite number. So how do we get our head around, how do you even test and evaluate these autonomous systems for all different possibilities is really what that program is about.

Dr. Highnam: Post-deployment, the notion of system engineering. Anything that has a machine learning or machine training aspect to it, because if the data that was used for training is no longer representative of the conditions in which the system is deployed, when do you recognize that and where and how do you retrain?

So we have several programs going against that. It takes a lot of data to train anything in second wave machine learning systems. One example program there is learning with [inaudible],

just trying to reduce the amount of data by, the target in the program I think is [inaudible] of magnitude for initial training and reducing the retraining data requirement down to a small number of hundreds of examples, all carefully chosen, carefully prepared. That's when you do the retraining or do the training. But in a system that's embedded in [inaudible] component, there may be several in a larger enterprise, how do you know, how do you monitor and track when this piece's performance starts to degrade given it wasn't engineered to a specific thing, specific input, but it was engineered and tested in development time and approval to use with certain parameters. Now it's being used in a slightly different way. Like a drug being awarded by the FDA for condition X, is being used off-label. The whole system engineering tail is yet to be figured out. Big companies like Google, Microsoft and so on, whose world is all about data, I think have a pretty good handle on some of these issues, but there isn't a practice of AI system engineering yet in the way there is say software engineering.

DWG: Justin?

DWG: A follow-up on the AI issue. I think a lot of the investment there is also coming out of the private sector in addition to what you guys are working on, and you obviously have [inaudible] to take advantage of things that are commercial [inaudible]. But for what you're working on, and maybe what Google [inaudible], Microsoft Research Lab, are they working with you guys on those leap-ahead projects? Are you making [inaudible] into the commercial sector there?

Dr. Highnam: Across the board, the bulk of DARPA's research funds go to companies, and that's continued to be true in AI investments as well. The leading edge, the newest ideas always come from the [school] so there's a lot of fundamental research that still goes on. We don't fund -- we do fund places, IBM Research has awards. I don't know if there's any in AI. We can find out. We're certainly working with the big shots who need external money. Google doesn't seem to need that. From us. We're talking research dollars, not acquisition dollars. But

they have huge experience to bring to the story, and we certainly talk to them about that and other topics.

DWG: So you're talking. Are you working together on some of these issues at this point?

Dr. Highnam: One of the most interesting conversations with them is around one of our programs called MEDIFOR which is all about the detection of fraud or forgeries in imagery, speech and video. It's a huge interest to them. They have the data. They have experience. And we have access to the research program through DARPA's normal processes to a lot of very [inaudible] teams in universities really across the board. A completely open program. A lot of publications coming from it. A lot of knowledge coming from that?

DWG: What's it called?

Dr. Highnam: MEDIFOR.

Dr. Walker: Media Forensics.

As an example of what you're talking about, we had a session where we went out to Google, took the whole leadership team last January. We shared what we were doing in the space and they shared what they were doing. It benefits all of us if those companies have these capabilities.

DWG: Dimitry of TASS.

DWG: Dr. Walker, you told us a year ago that DARPA started several projects with Ukraine. Mostly in the information space, as you put it back then. So I wanted to ask if those are still being carried out or if they're done, if you started anything new there. Any update?

Dr. Walker: No update really. It was mostly technical discussions that we had with folks there. Those have all been completed.

DWG: Completed. And nothing new. Thanks.

DWG: Jack?

DWG: I just wanted to turn to electronic warfare really quickly. I know it's an area you guys have looked at a little bit, and specifically with the Syria case study, it seems like U.S. commanders, the Pentagon is particularly worried that that was a particularly aggressive EW requirement, disabling planes, drones, communication links. I'm curious what you see that revealing in American posture as it relates to Russian EW broadly, and how that's changed the way of investing and thinking about this problem.

Dr. Walker: Certainly the EW environment is getting more complex. It used to be more of a tit for tat, you know, prepare for the next threat, have a counter to that threat, and go back and forth. It was more linear, I guess I would say. Now with the ability to operate across the spectrum in a much more real time way, our adversaries have more capabilities in that space, we have more capabilities. So we spend a lot of time looking at how to, we call it control the EM spectrum. How to operate in the EM spectrum in a real-time flexible way and not go in there with pre-programmed counters to their counter, but have the ability to move across that spectrum at the speed of electrons and be able to do what we need to do in that spectrum.

Lots of programs in that space. As you might imagine, it's powerful electronics, it's radar arrays that have that kind of flexibility and ability to program those radar arrays in real time. So lots of underpinning technology to allow you to do that. Programs in all those spaces.

One of the reasons why we stood up the Electronics Resurgence Initiative two years ago was to make sure that DoD continues to get the best electronics our commercial sector has to offer and build teams between the intel and the cadences and the QualComs work with the Northrop Grumman, the Lockheeds, the Boeings and

make sure we're getting the latest and greatest electronics that our private sector can develop into our DoD systems and EW is the reason why, frankly.

DWG: When you talk about sort of underpinning technology, do you see that as more true on the offensive side of EW or the defensive side? And as you break that out specifically, what services and what [inaudible]?

Dr. Walker: All the services, and we have great relationships with all the services. Certainly in that area it's mostly Air Force and Navy. But we are working with ground forces also on EW. And in our program we have Squad X which is developing some pretty unique capability there, and capability is actually being used.

DWG: Wes Moran, Politico.

DWG: I was wondering if you could talk a little bit about Assault Breaker [inaudible] that DARPA is working with. Can you talk about what the service's roles are and what sort of the common threads are [inaudible]?

Dr. Walker: Sure. This is something I'm very excited about and actually the building has gotten pretty excited about. Assault Breaker One, it wasn't called one, just the Assault Breaker, back in the late '70s started as a DARPA-led program with the Air Force and Army to look at how to stop a Soviet advance in Europe without nuclear weapons. So what we wanted to be able to do was only use conventional means to stop a Soviet invasion coming West in Europe. That was the goal. Out of that Assault Breaker program, came things like JSTARS, ATACMS boosters and a lot of precision-guided munitions we saw used in Desert Storm. But it was more about how do you build an architecture, conventional architecture to stop that from happening and out of that came some specific programs that led certainly the advantages in all domains, other domains.

What Assault Breaker 2 is about is focusing initially on the

Indo-PACOM theater but then also probably in EUCOM as well, focused on how to think about new, I call them warfighting constructs. If you want to call them architectures or concepts, but how to think about, all the services have been talking about multi-domain operations. That's great and it's a great concept and great vision, but what is the technical underpinning to allow that to really work? How do we communicate across all domains in real time? How do we have persistent multi-mode sensing across all domains at all times? How do we have the battle management command and control across all domains, across all services in real time? So those things actually are hard to do today. They don't really exist. How do we build those technologies to enable these new warfighting constructs to again deter but then prevail against a peer adversary if we're required to do so? So what we're doing is we brought all the services on board. DARPA's leading the program. All the services are involved. They're in our building. We're developing these new concepts. We are building a modeling sim infrastructure, government owned, to actually do the analysis. Then we're going to go do experiments to show that it's actually possible. We've gotten some good traction in the building with this concept. People are paying attention to it. I really believe it's going to build the technical baseline for actually how we do [inaudible].

DWG: Jillian Rich, Investors Business Daily.

DWG: I have a follow-up question about the hypersonics test. Which one do you expect to fly first, and what may be the biggest hurdle or something that could cause the schedule to slip the most?

Dr. Walker: There's all sorts of hurdles.

It's really a race between HAWC and TBG to see which one goes first. Actually they're both scheduled about the same time now. I can't really see right now which one's going to win out. But the hurdles are certainly when you start, when you go into an AI&T phase which is assembly, integration and test, you have to qualify all the hardware components. Sometimes you run into

issues with qual tests. You've got to requalify things. Put that all together and you test the whole system. You hope it all works and has been done correctly, but we're still very much in the early states of that AI&T for both programs.

We've got to get through safety boards on the government side at the ranges to ensure that we're doing everything safely and by the book. Then we've got to meet our range window when we're scheduled to test. If we don't meet exactly that range window we've got to wait potentially for another range window. So all sorts of things once you get into testing real hardware that you have to face down every day and beat back.

So I'm hopeful, end of calendar year '19, but it could slip into early '20, but bottom line is it's going to happen within a year from now. I'm keeping my fingers crossed we'll have some good success stories come out of it.

DWG: So when you say fly, how far are we talking?

Dr. Walker: I can't go into the ranges here, but significant distances. And the advantage of hypersonics is not only time of flight, but you also get range out of a high speed vehicle just from the physics. So you get long ranges, you get quick tome of flight, and you also get a lot of potential maneuverability that we don't have today. So a combination of all those factors make it an attractive technology, which is why our adversaries are working on it.

DWG: And you're testing off a B-52 or --

Dr. Walker: I believe that's correct.

DWG: May I ask, when you said you thought that one of the U.S. competitors actually succeeded in weaponizing that thing, you meant Russia or China?

Dr. Walker: I don't think I said weaponizing. I think I said turning the technology into capability quicker. I think both

countries are developing that technology and capability.

DWG: On the engineering side of hypersonics, you mentioned the one problem, material that will withstand the intense temperatures. But the propulsion systems, we're into several different ideas of how you can maintain hypersonic propulsion. Which are the biggest challenges? And where are we on the propulsion?

Dr. Walker: DARP again, last decade, started working on what I call sort of second gen scram jet technology which is trying to develop scram jets that are much more efficient, easier to cool, better mixing technologies, and as opposed to what we did under the National Aerospace Plane days which I kind of characterize as first gen. We had several successes with sort of the basic propulsion system. Things like 40 percent less cooling required, some pretty interesting ways to get the fuel and air to mix with some new technologies, proprietary technologies to some of the companies. And so I feel really good about where we are with that basic technology on the propulsion side. And now we've got to see how well it works compared to the first gen.

Cooling is a big deal in hypersonics, but also getting that with super -- scram jet stands for Supersonic Combustion Ram jet. Getting fuel and air to mix at supersonic speeds in the engine is no small feat. So that is an area we've got to work on.

DWG: Thank you very much for coming.

Dr. Walker: Thank you all.

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