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REPLICATOR AND BEYOND: THE FUTURE OF DRONE WARFARE

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DISCUSSION

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O'HANLON: Good morning, everyone. Welcome to Brookings. I'm Michael O'Hanlon with the Strobe Talbot Center. And we're here today to discuss "Replicator and Beyond: The future of drone warfare," a topic that all of us are thinking about if we study defense or just follow the war in Ukraine. And we know that there's a lot more to happen in this realm. It also brings in technologies, including, of course, artificial intelligence. But a lot's happening even in real time, day by day, month by month.

Just a quick word of background on Replicator, then I'll introduce the panel. We'll talk up here for a while and then get your questions towards the end of the hour. But I think many of you know that then-Deputy Secretary of Defense Kath Hicks announced two years ago, with the support, obviously, of Secretary Austin and President Biden, that she would encourage a new office within the Pentagon, part of the Defense Innovation Unit, to field systems within two years, meaning by this month, August 2025, that would be numerous, attritable – meaning you didn't have to worry too much about having everyone come back home, you could afford to lose them in the course of operations – and autonomous, and across potentially all domains of warfare, air, land, water, underwater, and also operating as swarms potentially, but also operating individually. The chalkboard was erased, the sky was blue, the ideas were encouraged across the board. And we've seen a lot happen in those two years, including things we'll talk about today, of course, and Replicator being just one element of a change agent within the Department of Defense that's trying to accelerate progress. I think it was a very good idea of the Biden and Austin Pentagon to undertake this initiative. It's been a very idea of the Trump and Hegseth Pentagon to keep pushing on similar technologies. And the Army, of course, has done big things this year in terms of moving with some new initiatives in this direction. But all the services have, and we'll hear about that today.

So let me now introduce very briefly our panelists and what we're going to do. I'm going to start with General Berger. And let me just say, as many of you know, he was the 38th commandant of the U.S. Marine Corps, an amazing 42-year career, retired two years ago. Hails from the great state of Maryland, went to Tulane University as an ROTC officer and has operated and commanded at all levels in the Marine Corps and in most of the places you would have expected a Marine of his generation to wind up serving, including the Balkans and the Middle East and Afghanistan. He also is known for what was then called Force Design 2030, the big initiative in the U.S. Marine Corps during his tenure as commandant. That was controversial, because it pushed hard on innovation, including with robotics, but not exclusively, and with a focus on the new national defense strategy, as had been outlined at that point by Secretary of Defense Mattis, and told the services to please focus more attention on China in particular, but on the Indo-Pacific more generally. And so there were a lot of innovations and changes associated with that, and so I'm going to begin in a minute by asking General Berger to take us back to that moment and explain where robotics fit in in his broader vision. Now, after that got going, and as I mentioned, in 2023 we saw the stand-up of the Replicator initiative and Aditi Kumar then became a crucial strategist and spokeswoman for this effort operating out of DIUX. Her background is remarkable. She hails from the great country of India and the great state of Missouri and also had a number of stints at Harvard University, getting masters in both business and public policy. Returned later there to the Belfer Center, which as you know is known for technology as well as strategy. So she's always had an interest in technology and as I say has been with or had been with DIUX en route to being one of the key authors of this replicator concept starting in 2023 and she served through the early weeks of this year. T.S. Allen hails from Florida, joined the U.S. Army, went to West Point, spent a good chunk of his still young life in the U S Army. I believe he's in the process of retiring. So he was actually an officer serving within the Replicator office, again, a joint civil military venture, if you will, and left just a couple of months ago. So in many ways, he has the most recent vantage point on what's going on within that office and where we are today.

So thanks for putting up with me. That's by far the longest I'm going to speak, but I wanted to give you some context and then tee up the initial round of conversation as we first get through understanding where Replicator is today, and then ask about the future. So General Berger, if I could, again thank you for being here. Thank you for your service to the country and to all three of you, but could I ask you when you started with the idea of Force Design 2030, how did robotics fit into that?

BERGER: The notion of Force Design 2030, and robotics and autonomy began before I became commandant because I had the privilege of, like some of you all know, serving in Hawaii as the commander of the Pacific and then the combat development for the Marine Corps. So you could see, it gave me an opportunity to see already where things were going. And my interest in China began across the street at SAIS at Johns Hopkins. So the two of them for me merged in 2017, 2018.

To make a couple things clear that came out in the planning guidance and the direction we were going with Force Design, I think first of all that the technological advantage that the United States had owned for decades was rapidly diminishing in some areas, where we would have parity, and in fact maybe some cases in some area we would be behind our competitors. Second, that we could not out-build our chief competitor, which the, both of the national defense strategies clearly outlined, you know one, one competitor as an existential potential threat. So okay that's the bar that you got a measure up against, and they could out-produce us. And I was pretty clear, you know, six, seven, eight years ago, one because of mass, but two because of course, no surprise to everybody in here, you know they have a, they have a different model than we do. And we have a market-driven defense industrial base, and they have a Xi-driven market defense industrial base. They can focus and scale with speed that's hard to match, so they were gonna out-produce us. Technology wasn't gonna give us a great advantage, so autonomy and autonomous systems and robotics became a way to make yourself bigger than you are and be in more places than you are. Not to replace human beings, but to spread out the battlefield and to actually enable service members or war fighters to do more over a larger area. Weren't sure exactly how in 2019 that was gonna happen.

But the last part I'll just mention before we move on was I think with a realistic point of view, you have to work with the tools that you have. So, we started writing and talking in 2019 and 2020 about using what you have now for robotics. And it began with a discussion of things like amphibious ships and aircraft that could become somehow enablers for, or motherships for, or the centerpiece for sort of a quarterback kind of an idea. Because you can't wait for something custom-built for, you have to use what you have right now. So for us, it was, but what if you had amphibious ships that could use either Marines and manned vehicles or unmanned, and it'd be very difficult to tell what's in the well deck kind of thing. That's really hard for the opposition to kind of discern. So, all that wrapped together was, we need to go faster. We need to experiment and make mistakes and learn at a much more rapid pace than we were going. And lastly, the learning was going to take place out on the edge. So give them the tools, which was what Replicator did. Give them the tools out in the field quickly, as fast as you can. Give them a 60% solution, they'll figure it out. They'll tell us what works and what's not.

O'HANLON: Before we move on, could I ask one follow-up? Thank you very much for that framing. Was there any one, you mentioned a number of technology areas where we were losing our lead or maybe China was out-producing us in quantity, et cetera. Was there any one or maybe one or two drivers that had you most anxious at night? In other words, command and control and the survivability of satellite communications or survivability of big weapons platforms. Was there anything that really drove you to think we've got to move faster in this direction more than other things?

BERGER: We knew, and we won't talk about it in here, but we knew the few areas where we clearly had an edge and we needed to sustain that, and probably pretty commonly known. But in other areas like the air domain where we could establish at least local superiority for a pretty good defined period of time, that was vanishing pretty quickly. And even when you look at just the fourth, fifth-gen aircraft a decade ago, the F-35, when the opposition can take the intellectual property and they can produce a lot faster than, we were not gonna stay with a wide margin of advantage like we could before. So I would say on the water, on the surface, clearly we were starting to get worried about that. In the air, how do you get inside an air defense system that's integrated and in, in much higher level of tech in numbers than we had seen before. How're you going to penetrate that? Have you got a defense against drones? You, because even, even in 2019 it was become evident If the other side has it and has it in numbers, how are we going to protect our own forces?

O'HANLON: Fantastic, thank you. Aditi, if I could go to you and maybe bring us back a little bit to those early months of Replicator in 2023, what were you most excited about, what were most worried about, and also tell us a little about the internal politics of this, what was the hardest to, you had to break through a lot of red tape, whether it was resistance within traditional acquisition portfolios of the services, because not everybody thought about things the way General Berger does, or maybe just breaking through regulation, because you were trying to encourage. New kinds of companies to get involved and go faster. What was that period like?

KUMAR: Sure. It was very dynamic. So I think that the definitive account of the concept of Replicator will come from Deputy Secretary Hicks, because she really was the driving force behind this. My sense is that she recognized that the department had this perennial innovation problem, that it was much more rooted in culture than in authority or budgetary constraints. And that the way to break through that would be to focus all of the senior leaders on one particular capability area and work with them to concretely deliver that and demonstrate that we could do this, draw lessons from that, and basically create this playbook by which we could replicate this for lots of different capability areas.

So in executing that vision, I think there were, with a little bit of distance as I reflect on what ended up being really important, the first was this idea of creating a distributed leadership team for Replicator in which every organization in the building did exactly what it always does for acquisition and fielding processes, they just did it faster and more collaboratively. And the alternative version of that would be DIU trying to do a lot of things ourselves, But that is not sustainable, it's not replicable, it doesn't drive culture change. And so having the services lead acquisition. And in some cases, DIU partnered with them, as it always does in cases of bringing in commercial technology. But the services were at the helm of the acquisition processes. The combatant commanders were at the helm of developing the concept of operations. Research and engineering was at the helm of testing and experimentation strategies and so on. And that was a lot harder to corral all of those stakeholders and not everything went well and there was some tension. But I think, in the end, that created a distributed ownership of Replicator that wouldn't have happened in that alternative scenario. The second thing was the idea that we would invest in systems that were already in the pipeline that could be scaled quickly, but then we would also take bets on systems that were novel, and we didn't know if they were going to pan out. And there was some risk to this, obviously, when the deputy has gone out and said multiple thousands of systems fielded in two years, taking some big bets that may not pay off would take up resources within the initiative. But again, part of this was also diversifying the industrial base and you can't do that unless you give new firms a shot and they're ramping up their manufacturing capacity and they may not get to hundreds or thousands in your time frame, but it's building that capacity that will pay off in the long

term. And there were solutions that we took bets on that I think will be game changing in the long term that maybe just in this two year time period did not achieve everything that they needed to.

And then the last thing I would highlight is the decision to invest in software. And this is where I would actually give DIU a lot of credit and experts like TS and our autonomy team that recognize that delivering thousands of pieces of hardware was A, not that helpful. To a commander that is trying to orchestrate all of this. And B, it didn't really help us push the frontiers of autonomy. And so we spent a lot of our resources building data libraries, soliciting command and control solutions on autonomy solutions, creating an entire campaign to integrate these and test these in successively more complex forms. And that's happening now, the department is doing it now, they're learning a lot, they're blowing up some boats. But that's what testing is, and that is what pushing the frontiers looks like, that's risk taking looks like.

O'HANLON: Speaking of resources before I go on to TS, Replicator's been funded at roughly a half billion dollars a year. Right? And is that money allocated by DIUS or is it just a sort of a different way of cataloging what's happening anyway? In other words that you have independent authorities to decide what the money was spent on

KUMAR: So the initial iteration of Replicator was a reprogramming request to Congress. So as I said, we did not think this was a budgetary constraint. We did not think we needed more top line. The thesis was, we have resources, some of them are under-executed and we can take those from existing programs where we're not going to execute in the fiscal year, reprogram them and put them towards this effort. And so that was the initial set. A lot of that came from services budget. Some of it came from DIU. And in this augmented budget situation where DIU got a billion dollars last year and now is slated to get even more, we certainly channeled some of that to autonomous systems. Some of them were officially part of that Replicator umbrella, some of them are outside of that. But it has been a, as I said about the team structure, the resources also reflect that it has a been a cross-department effort with services and OSD pooling their resources for this.

O'HANLON: And just one small, final follow-up. Just to get a specific system on the table and in the discussion, Switchblade is one of the systems. And I'm thinking back, correct me if I'm wrong, but wasn't it an earlier incarnation of Switchblade, well before Replicator, that was involved in the killing of Qasem Soleimani? And that's a loitering munition that we're now building. We had it five years ago, but now we're building in much greater numbers. Is that a fair example of what you've been trying to do?

KUMAR: That was an example of something that was already in the pipeline that was ready to scale. So I would put that in that first category. We were using it in Ukraine. I think, if I remember correctly, they were still being produced in the single digits. And so the idea that we could take something like that, while we were still getting the battlefield feedback. So to the general's point, we're learning as we're going. And so scale that quickly. Take the lessons. Adapt it as we need to as things are coming off the production line. And deliver that to the field.

O'HANLON: Thank you. TS, you've been with Replicator up until just this summer, and I wonder if you could pick up where we are in the conversation. Just tell us how you think it's been going, what you're most excited about in terms of what's been accomplished and just where things stand at this juncture.

ALLEN: Of course, and thanks for having me, Dr. O'Hanlon. So I joined the Replicator team in late 2023, and I'd been working on Ukrainian issues for a year and a half as part of Project Maven and then elsewhere in the Office of the Secretary of Defense. And I think, like most American soldiers and sailors and airmen that have been working, and Marines that have working

with the Ukrainians over the course of the war, the fact that the Ukrainian battlefield was saturated with drones, and our motor pools were not saturated with drones in the United States, and the fact the Ukrainians were taking a very flexible approach to software, where they were pushing software updates in days or weeks, which typically take the Defense Department months or years, was very frustrating. And when I first interviewed with Aditi for the job, she emphasized that it was very outcomes-focused. Our goal was to address a lot of those issues. We were serious through Replicator about delivering thousands of drones and getting the software right. And I found the pitch very compelling and joined the team.

And over the next couple of years, until I left the team a couple of months ago, we were able to deliver, at least initially, as of the time that I left, hundreds of drones to war fighters, not just getting them to some exercise in Indiana, but actually getting them out to the Joint Force, which was really exciting. We put thousands more on contract, and when I left they were still rolling off the assembly line, so I count that as a win and sort of mission accomplished. We also made tremendous progress on the software for these systems through the integrated enablers effort, made huge changes in how the department manages data for autonomous systems, which I think will yield dividends for years to come. And in general, I was pretty happy when I walked out of the Pentagon on the last day about what we were able to do.

I think when the full sort of unclassified history of Replicator is written, which will be many years from now, since there are still aspects of the system that the department has decided not to reveal, the most important impact of the initiative will be what we did in the maritime domain. Replicator partnered really strongly with the Navy in order to help the Navy build an uncrewed fleet. The Navy had kind of wanted to do that before Replicator, but Replicator gave them a mandate to alter the acquisition system in order to do it better. And our key tool to do that, by the way, was those commercial solutions openings that Aditi mentioned. We did those for uncrewed surface vessels for the fleet, as well as for the software to enable them to swarm and communicate. And that allowed the Navy to work with new and more innovative partners, which was great. And the Navy's on track by the late 2020s to have probably the largest uncrewed surface vessel fleet in the world, which is really exciting. We also accelerated a bunch of other programs. We work with the Air Force on a program called the Enterprise Test Vehicle, which is going to decrease the cost of our long-range strike options. That's sort of a little bit more of a developmental effort. Obviously about Altius-600 loitering munitions for the Marine Corps, which was huge. And a lot of systems for the Army, which I spent a lot of time thinking about.

And I will say for me, the kind of best day on Replicator came in about May of 2025. So this was after the transition, you know, under the new administration and an Army brigade commander came to visit the Replicator office. And he had actually just been showing a bunch of our drones to the secretary of defense. This is Secretary Hegseth, mind you, out in Poland, which was kind of neat. We'd seen a bunch of pictures of Secretary Hegseth looking at Replicator stuff, which was cool. And the brigade commander, when he had assumed command of his brigade a year before, had not had any modern drones in his formation. They just had not been there. The Army had a couple of sort of ancient ISR platforms, and that was it. And through Replicator, we were able to get him a bunch of Switchblade 600 loitering munitions and a bunch of Anduril Ghost-X and PDWC-100 ISR platform in order to support what he was doing. And in recent exercises, this brigade commander had found that these systems were some of his most lethal weapon systems and so they'd really improved the lethality of his brigade. And then he handed it over to his staff, who spent about an hour giving us a laundry list of things we still needed to fix in order to maximize the value of these things for the department. And I know that the great teams at the Army and the Defense Innovation Unit are still working on that laundry list because it's pretty long. But I think that really brought home to me that even if we probably didn't select the perfect systems, and even if there's a strong case to be made, that especially in the land domain, we probably need to do about 10x what

Replicator delivered in order meet the of the modern battlefield. Replicator had kind of gone from zero to one for the drone fleet and a lot of our formations, and that was ultimately the goal, so we'd accomplished that.

O'HANLON: That's excellent. Before I get to my second big question, which is the future and where you see autonomous vehicles and warfare going, could I ask each of you to comment briefly on a philosophical question? We've mentioned Ukraine several times, and a lot of people wonder why we even keep half the stuff we've got in today's military, because the Ukraine war suggests that fighting has become much, much different. That's probably an oversimplification, which I'm going to ask each of you to comment on. To what extent does the American military's broad set of requirements resemble or differ from Ukraine's right now? The other thing I'd say by way of provocation, we had Admiral Paparo here last fall; at that point, he had gained a little notoriety, among other things, for his use of the term hellscape, for what he wanted to be able to turn the Taiwan Strait into if the Chinese ever tried to invade, largely using autonomous loitering munitions of one type or another, I think. But he went out of his way in that public presentation next door to say that he did not think that we should get too caught up in short-range drone transformation as the be-all end-all, because he had an 8,000-mile-by-8,000 mile theater where he had to do a lot of different things, not just tactical killing of Chinese ships trying to cross the strait. So I'm sorry for the long preamble, but maybe, General Berger, if I could start with you. I guess the more specific way to put this question, are we, do we need to really fundamentally turn upside down our allocations of resources and put a lot more into drones, or is this a different problem than the Ukrainians have when you're looking at future warfare from an American point of view?

BERGER: Fair question. This is an oversimplification, but they're in an existential situation where they have one scenario, one situation they have to survive in. That's a subset of what the U.S. military has. So no, I don't think you throw out everything over the transom and go over here. But you definitely take lessons from there and know that it's more than likely you're to face that at some point in the future. You don't ditch all the capabilities and capacity you have today. But if you ignore that and you face that, you're going to do it at your own demise. So absolutely, you watch the lessons learned. For most of us, not so much the things, but the speed of adaptation. If you can't match that, in other words, if you were Ukrainian, you couldn't make that transition, that adaptation fast enough, you wouldn't survive. We would have a lot of casualties if we can't adapt at that speed. So I think you observe it, we move in that direction, knowing that that's probably gonna be an operating environment we're going to face. But you don't, that doesn't mean you ditch all of our capabilities and throw in there. It's a subset for us, but it's everything for them.

O'HANLON: Thank you. Aditi, I don't know if you'd like to comment as well, and then if you want a more specific question, it's how much bigger should the pool of money be to help us move at the pace we should be moving?

KUMAR: My sense from being educated by people a lot more qualified than I am is we need the right set of weapons for the right situation. So there are instances where we need multi-million dollar munitions, and there are instances where a \$50,000 drone will do, and if it will do then we should use that and have it in our inventory. So I think it's about finding a balance. And I'm not advocating for a huge defense budget by saying that. I think we can do a lot more with the budget that we have. I think there are lots of efficiencies to be found with these traditional exquisite systems. I think that we can push the boundaries on emerging tech at the same time and integrate the two. And I think sometimes the department gets caught up in this distinction where you have these sort of, you have this acquisition enterprise and you have the innovators over here and each side demonizes the other thinking that they're advocating for like a all-or-nothing approach and like nobody is saying that. Nobody is saying that. I think the, the idea for at least for the Defense Innovation Unit and AFWerks and Naval X and some of these organizations is to say,

okay, where are there instances where commercial technology emerging technology can be brought in and there're actual use cases where it will be deployable and helpful to the force? So I would advocate for balance. I do think that we're just scratching the surface of the amount of investment that does need to go into atomic systems. I mean, it was near zero before Dr. Hicks jump started this. It was, as you said, about a half a billion the last couple of years. I think it should be magnitudes of that. I think we should be producing them, testing with them, attriting them as part of our testing and training so that we can learn more and really integrate them into the way that the force fights.

O'HANLON: T.S., your thoughts on that same issue.

ALLEN: Yeah, the way that I think about this is that no one in the Joint Force is really excited about denial yet. Ultimately, what the Ukrainians have demonstrated is that large numbers of drones are very good at denying access to parts of the air, land, and sea to your adversary. But there's really no one, in the Joint Force, with some rare exceptions, that sees their primary job as denial. They all think their primary is superiority. And so as a result, we acknowledge the possibility of doing this, but we don't think that it's our core mission. And we say, yes, we could buy those systems, we can build a hellscape, and we also need all these other things. And so what we have a lot of experimentation left to do as the joint force is to figure out where these newer, alternative autonomous systems fit into our current force structure, probably as part of a high-low mix, and where they can help us achieve those superiority missions that we ultimately think are critical in order to deliver what our political master is one of us. There's of course also the possibility that we're over-indexed on superiority, and 10 years from now we'll realize that strategy to denial are more important, but I don't think we're there yet, and I don't think that's a proved case yet either.

O'HANLON: That's a great question -- great answer to a simple question that I took a long time to pose, but you all answer really succinctly and very clearly. Let me now talk about future visions of warfare more generally. And it's a big topic. And so I'm going to invite each of you to just say what you like but also take a specific angle if you would prefer. And so there are a couple of questions that are on my mind about the future of Replicator and everything else with autonomous warfare. One of them is, okay we've done interesting things with Switchblade and with task force 59 and with the Navy, so what's the next specific concrete thing that's really, that you're watching over the next one or two years? But also I'm intrigued by this question, and you mentioned, TS, denial versus offense, how soon do we need to think about swarms of drones going on the offense on their own? And is that something we should wanna do? Or is that something that's inevitable, whether we like it or not, as scary as it may be with scenes of Terminators taking over part of territory somewhere? Or is it really more realistic to think, more like the next generation aircraft with a collaborative combat aircraft on its side, we still have humans in the lead with any tactical operation, but the swarms of fighters, robotic fighters are jargon to be helping the people rather than going on the offense themselves? These are some of the questions on my mind. I'm sorry to throw so much at y'all at once but what I really want you to do is grab whatever part of the question interests you the most: near-term modernization future offensive swarms, anything else in between. And general, I could start with you again please.

BERGER: OK, we've clearly gone to where we can at least conceptually think about swarming in a domain among the same similar types of vehicles in the air. Less so, I agree, on the surface, subsurface, other domains, areas where we've spent most of our brain cells thinking about and I think first expand that into the other domains. How do you swarm in other domains to do different things? Second, how do you get different domains' worth of autonomous robotic vehicles to work together? We're not there yet either. In other words, between surface and air, between air and subsurface, where those membranes go away completely and the communication is not something that you think about. Because it will definitely be challenged to communicate back and

forth. But we've got to get out of the same type of environment between robotic systems and autonomous systems and move to multi, different domains talking to each other. I think we've got to get past the -- we we're to the point I think, conceptually, of thinking manned-unmanned teaming, okay that's great. But this is another, that's, that's a step towards something else. And that, I think, is teaming, teaming between systems. There, we have to figure out where the -- that's the great, you know, comment about where's the man fit in? And it's great when you can see the wingman and it's a drone. But what if it's a different construct where there's bodies of robotic systems that are operating out there, and there's not a wingman, per se, it's just a step or two beyond that. How do we think beyond that? We're way behind in logistics, in using robotics and autonomy in logistics. Because if you can't communicate and you can't support yourself, you can have the best systems and the best trained force in the world, you're not gonna last very long. So we're, logistics is a much more difficult thing to think about. It's not as fun to think about as killing stuff, but frankly if you run out of stuff it doesn't matter how good your munitions are. So we have to think, I think, hard about logistics and in a contested environment.

O'HANLON: That's one of the things you wanted to do with the Littoral Combat Regiment, right, and make them more self-sustainable beyond the issue of autonomy. How is that going from what you're seeing?

BERGER: I think great, not because I had a great vision, but because the commanders at lower levels are turned loose in the Philippines and Europe and other places to try different approaches with the tools that they have. And like always happens, the service members at the lowest levels have ideas that generals and admirals will never think up, and they send back, just like T.S.'s point, like okay, here's the 17 things that you've got to do better. And these four things you thought it would do great, they don't do so great, so stop working on that. So the faster you can get to that point where engineers can get direct feedback without six layers in between, you will start to move pretty quickly.

O'HANLON: Thank you. Aditi, same question about the future and what's most intriguing to you, whether medium term or longer term.

KUMAR: Yeah, three things that I'm looking for. One, as the general said, pushing the boundaries of both the homogeneous, same-system autonomy and then the heterogeneous varied-systems autonomy. We're not there yet. I think there's a threshold in terms of operating sub-30 systems versus more than 30 systems. There's a step change in the complexity of the technology there that I think we need to work through. And that's why this testing is so important. Secondly, I think the cost point, you know, we're still at a point in this country where we're not producing enough to mirror what some of our adversaries can do for tens of thousands of dollars. We're still, you, know, multiples of that. So I mean, this administration recently declassified one program, which is the low-cost UAS, which is reverse engineering a Shahed, which we started to work on, and I think that's great because now you're aiming for cost points more in the 10 to \$50,000 range for a UAS as opposed to like \$150 to \$200,000. So I think driving to that is going to be really important. And then lastly, I think with the quantities targeted by Replicator while they were ambitious, they didn't really stress test I think the supply chains in the way that if we actually were to go for hundreds of thousands of these systems that we would, you know, discover. So I think. Building out that industrial capacity and the supply chains and figuring out, you know, the batteries and all the critical components that will need to be produced at scale to enable this kind of capability, I think is something on the medium to long-term horizon as well.

O'HANLON: That's great, thank you. T.S., same question to you.

ALLEN: Yeah, so what I'm most excited about is how commercial developments and what they're now calling embodied artificial intelligence might generate technologies that we can then apply to make our weapons systems more lethal. To give one really specific example of this, you know, first-person view drones are ubiquitous on the battlefield in Ukraine. They cost about a thousand bucks. And right now most of them are like wire-guided, weirdly. I would not have predicted that a year and a half ago. And you have these extremely elite pilots figuring out how to use an FPV drone to, for example, strike a weak point on a tank, right? In the future, and so right now, it's very hard to put artificial intelligence on one of these drones because an advanced AI chip that you could put on that drone that could very easily sort of pick out a feature on that tank and help you, for example always hit the track of a tank and thus take out the tank at a weak point would cost another thousand bucks, right, so it would double the cost of the drone. At this point, it's like almost a law of computing that the price of that chip is going to get cheaper very quickly, and so two years from now, we're almost certainly going to have AI-enabled FPV drones that can almost always hit the track of a tank, right? I just think, you know, that is coming. And you're going to see a series of other things where the sort of routine tasks that are part of war, the subtasks, the targeting tasks, you know, hit the the track of a tank rather than its very powerful armor, are increasingly automated and increasingly handled by machines. That being said, DoD policy will still be that commanders will exercise appropriate human judgment over the use of force, so I'm not particularly worried about Terminators. And the reality is that almost all contemporary AI approaches perform very poorly in unpredictable situations that are outside of our training set, and war is characterized by uncertainty. So I do think human judgment will, if anything, become more important in how you employ these systems. The decision to send something off to kill a tank will become more important even as the process of actually killing the tank is increasingly handled by machines.

O'HANLON: Nice. OK, well, there's a lot of firepower in the room, I can see, and so let me share the pleasure here of asking questions to this great panel with you. So we've got folks with microphones. Please wait until I call on you and identify yourself before asking a question. We can go to the audience now. I've got a couple more questions up my sleeve just in case, but I'm guessing I won't need to go to those. Anybody want to start? Up here in the front, please.

AUDIENCE QUESTION: Lonnie Wilson, I'm one of the federal executive fellows from the Marine Corps, so, commandant, good to see you again, sir. My simple tactical question on logistics, you just, you know, you gave a nice description of where AI is going and how it will develop. Could you describe energy and what Replicator looks at for energy and looks at these systems, and how we can and how we're moving towards producing more energy, storing more energy and making all these systems last longer on a battlefield that isn't defined with shore power, with energy readily available? Thank you.

ALLEN: Yeah, so we spent a tremendous amount of time thinking about the battery for these systems. And in some cases, the battery is just the key thing that's going to determine its battlefield lethality because it decides how long it can loiter, how long you can keep it charged prior to launch. That matters for a tremendous number of use cases. So the operational energy concerns are real. And I will say the U.S. has a lot of work to do on its battery supply chains. The simple reality is that many of our tier two and tier three suppliers are getting the critical minerals that are inputs to those systems from foreign countries. Almost the only processing for most critical minerals is occurring in China and Malaysia. That's just a global reality. And so I think we have a lot of work to do in order to reinforce those supply chains.

O'HANLON: By the way, it's interesting. I'll just comment that I was recently reviewing the national defense industrial base strategy. And it does single out batteries as one of our greatest areas of concern and weakness and dependency, along with, I think, castings and forgings,

explosives and kinetic materials, and just one or two others. So it's on the short list, as you say. Thank you for the question. Let's go to someone else. Go to the second row here, please, and the woman in blue.

AUDIENCE QUESTION: Hi, Theresa Marr, Inside Defense. I was wondering, Ms. Kumar, you talked about how you feel like the Replicator 1, the quantities targeted, didn't stress test the supply chain enough. Are there any other kind of lessons learned that going into Replicator 1 you didn't expect would be an issue and became something that you had to target? That makes sense.

KUMAR: Oh, there are so many lessons that we learned. I mean... I'll start with the organizational, so just within the department, right? As I said, a lot of this was service led, the acquisitions were service led. But a lot these capabilities on the software side, they're joint solutions. And so how do you think about housing those types of missions in the department over the long term? Who owns that? Who's going to maintain the C2? Who's gonna maintain the software layer? I think that's something that Replicator 1 surfaced that the department will need to work through. Similarly, the idea that we could do all of these things towards fielding in parallel versus in sequence ended up needing to create a lot more handoffs between teams that didn't necessarily exist before because they just never saw each other in that sequence. And so how do you kind of work in that way? On the technology front, you know, one of my lessons was actually, there was a lot of promising technology in different pockets within the department. We had the CBER program, we had the AppFit program, DIU is constantly soliciting. And when we actually looked at these programs, we were able to pull things in to Replicator that otherwise I think would have just gone in their own pipelines and their own silos. And so really connecting those dots and nailing those transitions between the innovation pipelines to the acquisition pipeline. I think was a really important lesson learned. The software and data piece, we didn't, I mean, when I started, I wish I had thought about it earlier, honestly, but in August of 2023, when the deputy went out and she said multiple thousands, we all went to hardware, I think Doug Beck, my boss, had more foresight than I did, but I certainly was like, how do I get more systems out there? And really the problem to solve the real challenge ended up being on the software side, and that's where I think we'll have a lot of longevity for Replicator as well. Maybe T.S. and General Berger, you have more to add to that. Those were top of my mind.

ALLEN: Yeah, I think to dig into the software side a little bit, you know, DoD has a tremendous amount of data that you can use to develop autonomous systems. However, DoD has a federated approach to everything, including data management. And so kind of step one for Replicator software was, we actually spent about six months doing this data sprint where we just brought everything that mattered together, all the sort of test data, all the data from the operational force that could inform our understanding the performance of these systems, all of the theoretical data about what we thought what happened in future wars and put it in a couple of unified places where we could actually use it to develop these systems. And that was sort of antecedent to the autonomy development that's still ongoing, and it took a really, really long time. So to me, that was one of the most surprising parts of Replicator was everyone says DoD has a lot of data, and we do. We have more data than anyone else in the world by a million miles, but it's not in one place. And so there's a lot work that you have to do in order to unlock it and make useful.

BERGER: Maybe just two quick points, great question. One, we have to, at the same time we're thinking of what we're gonna field forward, we have think of what were gonna field to the training establishment and the services. Because you don't want the service members to see it for the first time. So if you need seven of them, you also have to count what you need at Fort Irwin and everywhere else, right? So don't overlook what you need in training and sometimes you're gonna field the training probably first. I know it doesn't sound quite right, but sometimes for some system, some capabilities, you wanna field it to the training establishment actually before you put it out

forward. Second, I think different than our current model where you define the requirements and you know all this whole 17 step kind of thing. If you don't know exactly what's going to work and you're asking 10 companies to give it a try, you need the flexibility like Dr. Hicks had to grab from eight and give to two if they're pulling ahead in that race, quickly. Within a budget year, not next year, now. Because you have to feed the winners, if you follow what I'm saying. But that's not how our current system normally operates, we want to buy a hundred of those and seven of those. But I think wherever the money lies, if it's the deputy secretary of defense, they need the flexibility to reprogram within a budget year to move quickly from that, which isn't proven out to be so good and added in there, infuse those funds quickly.

O'HANLON: So how do you do that? Do you need permission from Congress? Is this new? I mean, a lot of people criticize the Trump administration for putting a hundred plus billion dollars into a quote unquote mandatory account, but it does seem to have the advantage of this flexibility. Is there a better mechanism than that?

BERGER: There is, there already are statutory regulations regarding reprogramming, but it goes up to a threshold and it's very specific for good reasons. What I'm suggesting is in certain areas that the administration, the executive branch and Congress work together and say we need more flexibility for this defined problem set and here's how we're going to, here's we're gonna describe it. And maybe that isn't the same for ships and F-35s and everything else, but for this area, we're going to allow much more latitude in terms of reprogramming. There'll be oversight from Congress, but it's probably a little bit different model than the norm.

KUMAR: And we did have a lot of success with that. I will give Congress a lot of credit here. Not only did we get broader chunks of money that had more flexibility just by being in a wider sort of line, but colorless money. So this ability to go from RDT&E to production without having to reprogram across colors was super helpful.

O'HANLON: The gentleman in the white shirt in the second row here as well.

AUDIENCE QUESTION: Thank you so much, Ferdinand Rother, American Gas Association. I just wanted to go back to energy again, and I was wondering if you saw any alternative fuels to fuel drones other than batteries as a lot of critical minerals are now in places that the US does not have a lot control over.

ALLEN: Yeah, I guess I'll take that one. And I really wish there are so many people on the team that were way smarter on operational energy than me. And I wish I could phone a friend here. But they're in the Pentagon doing their good work. Obviously, some of the systems are still going to be powered by fossil fuels. In particular, you know, uncrewed surface vessels and most things that are going to deliver that kind of range are going to be reliant on sort of gas or diesel depending on how the fleet wants to use them for the short to medium term. So, yeah, definitely a critical role there. I don't think we looked at any systems that weren't electric battery powered, gas or diesel though, at least not that I can remember.

BERGER: There are a couple things happening in which you asked the question, so I'm guessing you're aware of. One is within the government right now, there's discussion about rare earth minerals in the United States, which right now we don't mine, and what might we do? And the second is just the evolution of batteries, period, beyond lithium base, which is happening pretty rapidly also. Both are happening at the same time, and there's no telling where that will lead, but your point. I don't know if that gets at your point, because it is a lever right now. Is that what you're asking? That's the shortfall. Do you have any suggestions? I mean, have you heard of any, in other

words, alternatives to what the batteries that we're using now are, the next-gen batteries? Have you heard any?

AUDIENCE QUESTION: Well, I've heard that hydrogen could play a-

BERGER: OK, yeah.

O'HANLON: Great. Next question please. We'll go to the fourth row. Maybe we'll take both those gentlemen in this round before we come back to the panel.

AUDIENCE QUESTION: Hi, [inaudible] German Navy midshipman and working for the German Embassy right now. I have a question regarding the difference between Replicator 1 and 2. Like how did the work change? What is like more the focus? Are they working parallel? It just in generally how things are changing right now?

O'HANLON: Thank you, and then please hand the microphone to your neighbor.

AUDIENCE QUESTION: Yeah, John Pryor. I'm a data science consultant. My question actually somewhat builds on his question, is if Congress said, hey, we need 50 Replicator projects to run in parallel today, how much faster could you get to where you are today given the lessons you've learned so far and the, let's say, internal changes you have made to all the management culture, appropriations and what other procedures you have?

O'HANLON: You want to try it first?

KUMAR: I'll start. So Replicator 1 was low-cost unmanned systems. Replicator 2, which the department announced in the fall of '24, the winter of '24 was counter-UAS. As I said, the idea of Replicator was to create something that we could apply to different capability areas. And so I think that Replicator 2 will look similar in the sense that, I hope that the leadership team now will take into consideration that that distributed leadership team structure really worked. And the way those teams are set up, they actually can apply pretty perfectly to future iterations of Replicator. I think this idea of bringing in existing solutions and taking bets on novel solutions is also true in the counter-UAS space. I think this idea of data and software and how do you take all of these systems, make sense of what you're seeing and give the commanders the ability to decide and act. I think those are all things that will carry forward. In terms of how many replicators can we run, there were lessons that we learned that we tried to make systematic changes on. So, for example. One very small thing that came up was we were working with a bunch of small vendors, they didn't have a cybersecurity framework in place. And so how do we bring together the CIO and everybody else to create a cybersecurity framework where these firms are ramping up? How do we get them the resources that exist in different pockets in the department to implement that? So now we have a process for that, and that's great, and we can apply that to Replicator 2. Similarly, I think T.S. spearheaded this effort on developing an information strategy. It blew the department's mind to create a classification strategy for something that was still in development, and to start thinking about what our message was going to be. But T.S. insisted that they do this in parallel, not in sequence, and so we did it, and now we have this framework for creating classification strategies that can apply. So I think there are lots of things that we can do faster. I don't think that this happens, though, without leadership attention. You need somebody either at the deputy secretary level, certainly the service chiefs, certainly the combatant commands to be pushing this and making sure that we're maintaining speed, that all the handoffs are happening. And so I think the constraint is still human leadership.

O'HANLON: Anybody else care to comment?

ALLEN: Yeah if you want to do fifty Replicators, I think that two fundamental constraints would be first leadership attention. The deputy secretary of defense doesn't necessarily have time to personally provide leadership direction on fifty programs. And second, you know, the actual sort of program manager talent that we had on Replicator was really unique. I don't know where we found the, like, Green Beret McKinsey consultants that were running Replicator, but they were pretty awesome people. And there are just only so many of those in the department willing to build new processes. But I do think one of the things that Replicator did for the unmanned systems community across DoD is it showed them a better way to build these systems and it did it all in partnership with them. You know, the overall majority of Replicator's acquisitions were actually done by the services with DIU involved as opposed to by DIU for the services, although DIU did path find in a couple of cases. And so I think to a certain extent we're already on track to do maybe not 50 Replicators but sort of like five or six Replicator as the department takes the money from reconciliation and applies it to unmanned systems programs that are now sort of comfortable doing commercial solutions openings, comfortable going outside of their traditional vendor base, actually excited to work with these kind of venture-backed autonomy firms that are revolutionizing the way that embodied AI works. And kind of just does replicate or in a service without leadership focus or that unique DIU talent.

BERGER: Just a couple quick thoughts. First, I would say, and you heard the kind of common variables here, which are different than normal traditional thought: speed, scale, and affordability. Those are not kind of the three that you would have thought 10 years ago for a system, right? Now they are. Second, I would say, anchoring on what they said, the traditional defense industrial base, you gotta blow that out of the water, because the things that made Replicator work are not in the traditional seven big -- they're the lower tier companies, you have to enable them to play the game. And that's not bending the rules, but it's not, if you just go after the defense industrial base to make any one of those 10 programs work, it ain't gonna work. The non-traditional lower tier of companies, you have enable them get in the game.

O'HANLON: Go over here, please, second row.

AUDIENCE QUESTION: General Berger, good morning, George Nicholson, Global Special Operations Forces Foundation. I don't know how many of you all have read this report -- General Berger's smiling. He did a detailed report that was, I guess, funded by Bloomberg, and it was briefed, we had a large briefing over the business executives for national security. It's a blueprint for breakthrough and defense innovation, and he goes through a large number of recommendations. It's 50-page report, but it's one of the finest reports I've read. I sent a copy after my friend, Admiral Bill McRaven, and he's very impressed with it. A question for you, general. Looking at the recommendations you made, how well do you think those are on track right now? And then the other two members of the panel. Have you all read his report?

O'HANLON: I've got it printed out too.

BERGER: First, they aren't all my ideas. There was a group of people that Mike Bloomberg enabled me to get together, so I will not take credit for everything in that report by a long shot. There are smarter people than I, which is the way to work, right? You surround yourself by people that are smarter. Second, I couldn't give you a grade on how this administration or this Congress is doing, I think too early to tell. But I don't, I haven't thought about how do you grade it. I don't know, that's a question, I think I would have to be in government right now to know the answer to that. That, I don't.

O'HANLON: I'll add a couple of points myself about where I'm encouraged by certain things in the Trump administration, or at least hopeful. And this is not to defend everything that's happened in the five-sided building or in the Department of Defense, but Secretary Hegseth's idea to tell the services, tell me how you'd reallocate 8% of your budget to get on board with new priorities. Not everybody agreed with those priorities, but the basic intellectual exercise of thinking where you can save eight percent and maybe redirect, I think, is a healthy way to plan. And so on that one, I'm fairly encouraged. Also, he doesn't get a lot of press, but Deputy Secretary Feinberg is a very capable guy, not just because he's my classmate from college, but that's a strike against him, but more seriously because his background involves a lot of defense with his private sector and private equity work. So I think he understands how to drive change, as does Bridge Colby, the undersecretary for policy. So there's some real talent there. What I don't know yet is just how well things are gonna be handed off. But the broader point here, I guess as I give my little sermonette, I'm really impressed by the amount of collegiality and cooperation across lines where we usually don't think of Washington working very well these days. Whether it's Trump to Biden to Trump, the easiest political transitions at the top, whether it's Congress and the Department of Defense collaborating and freeing up funds to be reallocated more quickly, and whether it is the different parts of DOD and the Office of the Secretary of Defense collaborating well with the services and the combatant commands. The stories I'm hearing today and that I've seen play out are really impressive stories about how to make defense reform work. And it's happened in a 10-year period where the high-level politics have not been pretty. So anyway, it's just a little sermonette on one little hopeful thing I'm drawing out of this whole experience. Does anybody want a final question or two?

KUMAR: Add one thing to that, which is one thing, you know, there are lots of these reports and the department has undertaken a lot of reform efforts in various areas. And in fact, even in the Biden administration, we have this large sort of mapping of all the pain points in the innovation ecosystem, and you have to fix authority to operate processes and cybersecurity. And my experience is that it's really hard to do all of that in the general sense. What I really appreciate, Replicator, is it just focused us on, hey, just delivered this thing. And solve all of the challenges that you have to solve to get there. For me personally, in my development as a leader and manager within the Department of Defense, that really helped me ground the goals of what I was trying to accomplish. Instead of boiling the ocean and oh my god, how are we gonna do innovation reform? It was like all I have to do is deliver thousands or multiple thousands of attributable systems and in so doing, I will solve all these challenges. And I think that is a really helpful framing. And that idea of do something concrete, then take lessons and apply to the next thing, I personally found very rewarding.

O'HANLON: Last question from online, I'm guessing, Alejandra.

AUDIENCE QUESTION: Yes, this is a question from Allison Park at National Defense Magazine. General Berger mentioned the need for using robotics and autonomy for logistics. Can you expand on that? What are some specific ways, sorry, what are some specifically ways autonomy can help war fighters in a contested logistics environment?

BERGER: This question from Allison, just make sure I understand, is she talking about robotics or autonomy and artificial intelligence or all of that?

AUDIENCE QUESTION: I think it's broader, she says the need for using robotics and autonomy for logistics.

BERGER: Everything from predictive logistics, which we're, we're thinking about now, we're not quite there yet, in terms of anticipating what needs to happen where, through the use of

artificial intelligence, much better than any human could do it, because that allows you to plan. That's the lead time that you need in logistics. To the basic blocking and tacking of moving supplies, where, do I need a human to drive that truck or fly that aircraft or what, or can we actually do it better, faster, 24-7 with systems rather than a human-operated machine? The answer is yeah, we absolutely could. And if you're working in a world where there's not, ubiquitous is a big word, but if there's a lot of sensors in your operating environment, then you may actually have to generate stuff to throw off the adversary. And that means you're gonna need a lot them. So, in other words, rather than the one car driving the actor from Hollywood to the restaurant, and everybody knows where you're going, 17 cars to leave at the same time. We may need to do some basics of decoys and deception, and you need numbers to do that. Shoot, I mean, that's where robotics can come in, right? So all of the basic functions of logistics, I think, are right for taking advantage of. The autonomy part, in terms primarily of planning, but also in stride, where a set of whatever is coming your way, but then it needs to be diverted over here. We don't need a human to do. If the system is talking the way that they describe, it can divert itself. To where the higher priority is for fuel, for munitions, for water, for whatever. We have a long way to go.

O'HANLON: I have a lightning round question to end for each of the panelists, and I want to sketch out very briefly maybe about four or five capabilities that I could imagine, at least in science fiction terms, being available in five or ten years. I'd like to hear if you think any of these are achievable within the next half decade to 10 years or so. Some kind of a mesh of unmanned systems that could be deployed over Seoul in Korea to shoot down incoming North Korean artillery in war. That's hypothetical capability number one. Hypothetical capability number two, a much less densely manned US-ROK defensive line in Korea because we can do, we can prevent a North Korean attack, an incursion with drones building on the Ukraine model and then use our forces to go on offense perhaps. That's capability number two. Capability number three, let's say our satellites have been compromised in a future conflict with China and we need to build an air-breathing command and control and communications link, dependent on drones to maintain the connections over periods, over distances of miles, tens of miles, hundreds of miles, you know, and then pass off to the next. For Golden Dome and defending the United States whether it's against air threats, missile threats or drones, to what extent can robotics play a big role in that? And then finally, on the more, maybe, scary side, how soon until we have to worry that an adversary could put robotic systems near our submarine ports and try to destroy our submarines as they go in and out of port, because we always think of our nuclear submarines as invulnerable, but that assumes they're in the open ocean. So out of those five, let me start with you, TS, and work back towards me. Any of them strike you as achievable over a five-to-ten-year period?

ALLEN: I think all are potentially achievable, certainly over a five-to-ten-year period. I'll just comment, you know, there's been a lot of discussion about the potential threat posed by small drones to strategic assets like our nuclear submarine, so your scenario number five, since the Ukrainian operation Spiderweb earlier this year. And I think the one thing that everyone should keep in mind when they think about those types of operations is that the bottleneck on them isn't the drones. If you have the advantage of sort of tactical surprise, your drones are probably always going to get through. The bottleneck on operations like that is going to be the clandestine logistics and the ability of our adversaries' intelligence services to operate covertly inside our country or ours to operate in theirs. And so I think we will certainly see more Spiderwebs, but it is very hard to predict when they will be successful because it's really about an intelligence competition more than a military competition.

O'HANLON: Thank you. General Berger, over to you please.

BERGER: I'm not sure about the sustainability of the airborne mesh. It's probably feasible, but 10 years from now I'm not sure there will be artillery on the other side, probably something

else, but just the sustainability. How do you maintain the airborne presence that you need 24-7 and the density that you needed? The rest I think are all doable. I think the air-breathing C2 mesh, which is something we worked on in the Marine Corps conceptually, because we assumed that satellite communication would be degraded. You have to go there. We have to get there fast. If you look, because if you're dependent on, you know, if that's your Achilles heel, it's not. But if you are very reliant on it, okay, you better have another mesh in mind. And it has to be one you generate.

O'HANLON: Thank you. Aditi.

KUMAR: I think from a technology perspective, all are feasible. I don't know what Golden Dome actually is, but all are technically feasible in a 10-year time frame. I think the constraints are going to be more on the organizational and human side. Like are we doing what we need to do to prototype, test, field, like all of the things that we've been talking about over the past hour in a very rapid way so that we can get comfort with these systems, we understand how they work, We work through the autonomy policy directive, we figure out how the human needs to team, where is there appropriate human judgment, all of that. I think figuring that out is probably the longest pole in the tent, if I were to choose.

O'HANLON: Well, thank you to all of you for being here, and please join me in thanking this great panel.