# Virtual CRT: Lasers Defeating Cruise Missiles, Thursday July 9

**Riki Ellison:** Good morning, ladies and gentlemen, from a muggy July day here in Washington, D.C., in Alexandria, Virginia, coming off our 250th birthday as a nation. We're excited to be here. I'm Riki Ellison. I'm the Chairman and Founder of the Missile Defense Advocacy Alliance, and our mission is to make the world a safer place, and our nation a safer place, through the development, the deployment, and the evolution of missile defense. I've been doing this for 46 years, and MDAA was founded about 20 years ago. Our job — it's not a job, it's what we love to do — is to illuminate, educate, and advocate for missile defense. And we've done it. And we have been right. We have been right.

**Riki Ellison:** With that evolution of missile defense, and with the cost curve the way it is, directed energy is the future to reduce that cost curve. It is a system that we're very familiar with, and it goes all the way back 40 years. It was put forward by President Reagan. It was put forward by Edward Teller — I had the opportunity to be lectured by him in 1980 — on how this system could defeat any ballistic missile, any ICBM, from space. That was the evolution of the technology 40 years ago. And we had another opportunity 20, maybe 30 years ago, when we broke out of the ABM Treaty and North Korea was creating ICBMs. One of the solutions for that was an airborne laser. It was developed on a 747 — a chemical-based laser — and we shot down missiles off the coast of California in the early 2000s. A phenomenal system. And the plan was to do CAPs around the Korean Peninsula. But due to administrations, due to policy — mostly policy — they took it away.

**Riki Ellison:** As we've evolved, we've spent hundreds of millions of dollars in the labs, across our defense contracting industry, to create directed-energy lasers that have shot down drones and cruise missiles. And two weeks ago, on June 24th, under the Secretary of War, Pete Hegseth, out in New Mexico — where Shotgun's from — they announced they shot down a cruise missile, essentially, with directed energy. This is not the first time. But if we look at what directed energy is, it may be an exotic weapon system, technically, today — and fielding it in space, in near space, in the air, on land, and at sea, in all those domains — still, it will always be a supplementary interceptor compared to our kinetic interceptors. It's not strong enough to do that. And I say that for three distinct reasons.

**Riki Ellison:** The first one is force posture. You have to put this system forward and be able to defend it. We are unable to do that today. We know what happened with Epic

Fury. And even in our safe United States, the threat that we saw in Epic Fury, by Iran, on our bases, is absolutely real for our nation. I've had the opportunity in the last two weeks to be out there — I was in L.A. at Space Systems, I was in Hawaii at INDOPACOM, I was in Guam for Valiant Shield, I was in [South] Korea, and I was back over in Germany with Europe. All of them require a missile defense against cruise missiles. And it's not what our fighter pilots here want to hear — it's not fixed-wing air-to-air capabilities, which we are having to do, and doing very expensively. But you cannot handle the mass. And we've got to talk about the mass — whether lasers can actually handle mass, because they're one-shot systems. Right now, if you're going to put forward a system and you can't force-protect it, that's a huge challenge.

**Riki Ellison:** The second thing is infrastructure, because directed energy requires an immense amount of power, and all the infrastructure has to be built around that to put it in play. And the last thing is the network. You're going to have to be able to put all the data

from all the other sensors and capabilities you've got into the system. So I'm saying right now, we don't have those three things. We may have the technology, but we don't have those three big babies that need to be developed and moved. And that is where Golden Dome is primarily in play. And I would even venture — because I know we're not going there yet — that our space-based interceptors should also be looking at laser capability, like we did in the 1970s, to be able to move on that.

**Riki Ellison:** But Golden Dome is working toward creating limited-area defense systems — underlying infrastructures around our nation that could provide the power and the capabilities to enable that system and force-protect that system. But most important is the network. It is the C2 that Golden Dome is supposed to be doing, and they are doing it successfully, because they did that test two weeks ago. And I think the biggest success, which nobody talks about, is how they were able to bring in six different data streams in the C2 to cue that laser to intercept successfully. So it's exciting. It is real, but it's still very premature in its ability to deploy fast and quick. Hopefully we may have this capability in the United States under Golden Dome by '28. But more importantly, we're not going to wait until '28 to defend our forward operating bases. We cannot wait until '28. So there needs to be more aggressive risk-taking — which we don't see in the Pentagon, as we know, and these gentlemen have lived that — to take risk and put this out there as a supplement to what we have.

**Riki Ellison:** The world is in a very challenging place right now, with Russia and China challenging our world order. And they've been pretty good at doing that. Things are happening — they're thinking about bigger conflicts or bigger ways to move that influence. So this is certainly an offset, but we have to be much more aggressive than we are today in getting it in play. I just wanted to put that out there. We have two great experts who are familiar with lasers, obviously. I'm going to have each of them speak, and then we'll follow up with questions and have a good discussion. And you can ask questions through our website.

**Riki Ellison:** So, I am excited about Randall Parker — his nickname is Fu — and Thomas Browning — his nickname is Shotgun. We do have some specialists here. Fu has been involved with R&D for 20, 25 years — a former F-15 pilot, very familiar. I think that plane did use some laser targeting, and I think the laser targeting that came out of ABL is phenomenal — that's one good thing that came out of there. And we have Shotgun. He is a gem. He is on our board — former DARPA, former R&D on special projects. So, this is an enlightenment for us, to have a great discussion and push forward as hard as we can to get this capability to our warfighters. Okay. Shotgun, welcome, and thank you for bringing your thoughts with you.

**Thomas "Shotgun" Browning:** Thank you. Hey, Riki, thanks. And as always, thanks immensely for your leadership and what MDAA is accomplishing. And thank you for letting me be a part of the family. You touched on a lot of the opening remarks that I want to make, and I'm excited to hear what Fu says in questions and answers after that. But as you indicated, back in the '80s and '90s, DARPA started a laser program for the purpose we are talking about right now, which resulted in both the MIRACL and the COIL lasers. That COIL laser is what transitioned into the Airborne Laser program about 30 years ago. The first firing took 10 years. The first shoot-down took another five years. And then, two years after that, they canceled the program. Successful, but they canceled it, as you said — based on administration, based on budget, based on challenges.

**Thomas "Shotgun" Browning:** Fast-forward 20 years ago: DARPA started the HELLAD's program — there's a lot of great DARPA energy starting each of these things — which was

an effort to get away from the chemical lasers and go to liquid-cooled. That was also a successful program. It occurred just up the street here at White Sands, New Mexico. I think Fu was actually even with me, but I got to go out there about 10 years ago and watch a live firing. And, you know, it reminded me almost of Star Wars with the Death Star, where they had separate keys on separate sides of the room. And they said, "Are you ready?" "Yes, I'm ready." "Am I ready? Yes, I'm ready." Turn the keys, push the button, beep. Okay, hey, we fired a laser. Completely non-combat-relevant, yet the system worked and the DARPA program completed. And there have been service-related demonstrators based upon that. In fact, the Air Force started a program called SHiELD, which was a concept for putting a laser on an airplane about 10 years ago — and I'll talk a little bit more about that. And that ended — terminated again — because of budget, because of competition, without ever doing an airborne demonstration.

**Thomas "Shotgun" Browning:** So, we've got a track record of 40 or 50 years of successfully showing demonstrations. Congratulations to the Department of War for yet another live demo. We've done an abysmal job of going from live demo to actually putting capability in the hands of the warfighter — of walking away from scientists in a room saying, "I'm ready on the left, I'm ready on the right, turn your key," and working toward giving actual capability to the warfighter. And those who've heard me talk a lot know one of my favorite quotes is: the first one sucks. And it always does. Every time we try to field something that's cutting-edge, that's new and different, the warfighter tells the RDT&E community that we're idiots because we gave them something crappy. But that's an emotionally important step in actually giving them something not crappy.

**Thomas "Shotgun" Browning:** Where I think we're stuck — and I'm all for Golden Dome getting us out of that cycle — is we see the problem, we see the technological opportunity, we go out there, we do a kick-ass demo, we pat ourselves on the back, and then we go back to old business. Someone realizes we don't have to field it, and so we start another program and go through this vicious RDT&E cycle. So, number one: we've got to get the product in the hands of the warfighter for real. They've got to use it. They've got to yell at the tech community that "this isn't what I need." And then you evolve from there. You know, electric cars were not going to be viable until we put them in the hands of the user. The user said, "I need more range." The user said, "It needs to be lighter." And we're in an era now — because we got it in the hands of the user — where electric cars are becoming viable and, in many ways, becoming the better alternative.

**Thomas "Shotgun" Browning:** I did mention the flying part of it. For point defense, lasers — directed energy — really are an economical way, once you get them out there, of dealing with the threat. But it has extraordinarily limited range. It has a limited horizon. So, it's really important if you know exactly where the bad guy wants to hurt you, right? And I think, you know, if we had lasers around our radars in the Middle East, Iran would have been a whole lot less successful in going against them. But this challenge, as you brought up, Riki, is we aren't talking about a single cruise missile going against a single highly defended asset that we are waiting for — that we scheduled range time for — to be able to shoot the laser at the right time to hurt the thing. And so, there's a broader architecture here that I think is important.

**Thomas "Shotgun" Browning:** So, just touching on two quick things. Dr. Jim Galambos came up with a concept that we call the rubric, which is that every kill web has a foundation — and Riki, you touched on this — of battle management, command and control, communications, and position, navigation, and timing. And then, to complete each kill chain, I need sensors, platforms, and weapons. What we've seen in the Middle East, and what we've

seen in Eastern Europe, is they don't send a single cruise missile, let you know it's coming, and then make sure that you're at the right place to intercept it. So there's the need to have an integrated command and control architecture that is linking those Patriots to those airplanes that I wish I didn't need, to those ground-based lasers — making intelligent, real-time tactical targeting decisions, deconflicting who is shooting what, and leveraging the most optimal capabilities of each of those components. So having the command and control that would allow you to integrate phenomenologies, having the communications that would allow you to talk to each other throughout that, and having a common position, navigation, and timing architecture is important.

**Thomas "Shotgun" Browning:** I did bring up airborne twice — and whether it's because I'm an ex-fighter pilot or not, I don't care. I will tell you that even the article you guys shared about Golden Dome talked to the difficulty of boring a hole through the nose of a cruise missile. And if you are at the target, and you have limited time and limited line of sight, that is kind of scary, because the nose of the thing is what's coming at you. If, alternatively, I have a laser on a manned or unmanned aircraft — realizing that these drones are flying sometimes for hours, these cruise missiles are flying sometimes for hours, not minutes, but hours — if I have the sensing to know that that [threat] is coming my direction, and I can put the laser out there where that cruise missile happens to be, and I can pick my geometry on that cruise missile, and I can fly at the same speed as the cruise missile, your tactical problem becomes a heck of a lot easier. I've obviously got to get the laser to that location, but the ability to pick a target point on the cruise missile or drone, the ability to pick your intercept geometry, the ability to attack them well before they get to the target we're trying to defend — all of those, I think, lend themselves to airborne lasers being a pretty important part of that architecture.

**Thomas "Shotgun" Browning:** So, yeah — I think we need to get out of the lab and into the field. Enough said there. I think airborne is actually an important and critical component of this laser architecture. And none of this matters — none of the effectors matter, whether it's a Patriot or a laser — unless I have that integrated architecture to tie it all together. So I'll stop there from the opening perspective. Excited to see where we go with this.

**Riki Ellison:** I've got a couple of questions for you.

**Thomas "Shotgun" Browning:** Sure.

**Riki Ellison:** I want you to go a little bit into the different domains. I want you to talk a little bit about whether it's possible for a space-based interceptor to use directed energy to shoot down a missile in boost phase. Is that something that's real? Because we pushed that back in the '80s. I'd also like to talk to you about near space — putting a balloon or some object high up, where there are no atmospheric effects on your laser, to be able to do what you're talking about. I also see the limiting factor of your planes carrying lasers, just like they do with the AMRAAMs right now. You don't have enough. You're not going to have enough planes and lasers to stop this. You're not. We know that. And you're going to have leakage, which is what happened. So all of these are not the end-all, be-all. I also want you to talk about the Navy and how they've done well with it, even with the sea atmospherics, because I think we've had a couple of lasers there, and we've done some small lasers, I believe, on some of our force defense. But I want you to carry that a little bit further, Shotgun, and give us some insight on those four domains that we discussed just now. And hang on, one more: you've got base defense. If you're going to do that, how are you going to stop a thousand drones with lasers? You can't do it alone — but how many can you do? You know? So go ahead.

**Thomas "Shotgun" Browning:** No, so, yeah, a couple of things. All of the above are possible. And when I was bringing up airborne, I was not bringing it up as an alternative — I was bringing it up additively. Meaning, you're right: what I want is all of them. Again, if I know I am at the place the bad guy wants to hurt, then terrestrial systems are your best answer. From a naval perspective, I am where the guy wants to hurt — and so lasers on ships for self-defense are fantastic, because I am where that bad guy's missile wants to go, right? But all in all — and again, you're getting the well-informed fighter pilot answer here — from a laser perspective, my power is going to affect range. My power is going to affect how long I need to be on the target. Atmosphere is going to negatively impact that. And more power equals more weight equals more expense. So I've got this — just like a missile on an airplane, to be honest. If I make a very exquisite laser, it can probably go really far and probably doesn't need a lot of dwell time, but it is really expensive, very fragile, and very heavy.

**Thomas "Shotgun" Browning:** That's one of the reasons I brought up the airborne part: if I can get closer to the threat — back to your point about boost phase — if I'm doing boost phase from a thousand miles away, a laser is probably not the right answer. If I'm doing boost phase from an airborne platform, from an ABL, then it absolutely can make sense. And elevating yourself, both from an atmospheric perspective and from a line-of-sight perspective, is a really, really, really good thing. So, bottom line: there's always going to be — and that's why I brought up that electric car analogy — there's always going to be a weight and power challenge. What you require for your tactical environment, with respect to range, with respect to responsiveness and dwell time, is going to drive how heavy it is, it's going to drive how expensive it is, and it's going to drive how fragile it is.

**Thomas "Shotgun" Browning:** And that walks into your raid point. If I have a very flexible, mobile, low-powered laser, I'm not going to be able to deal with a whole lot of inbound threats simultaneously. If I've got a whole lot of energy and I've got a really big laser — and I've got the appropriate targeting and cueing and the appropriate beam directors — there's every chance I can actually respond to a lot of incoming threats. So it's all this balance: whether I want to be light, lean, and agile — but then I've got to get close, and it takes me a while to kill it — or I can afford to be hooked into a nuclear power plant, and then I can be very aggressive, but I'm not very mobile. Does that help?

**Riki Ellison:** That helps. But at this stage, right, we have to hit the side of the missile, because it's got the most surface area. It's very difficult for us right now to hit the point coming at us. So that means, like you said, you have to be positioned to hit the side of the cruise missile. And I don't know how point defenses can do that — you'd have to have multiple, because they will just come in right at you. So just answer that one. And then I've got to keep pushing you on the boost-phase space-based interceptor — not at 100 miles, on a big ICBM rocket coming up. That seems very doable. Is that doable, or is that limited by the amount of power we can put in a low-Earth-orbit satellite or system? I also think there is huge potential for Golden Dome to develop that.

**Thomas "Shotgun" Browning:** Yeah. So, again, speaking to whether it's doable — of course. Whether it is possible or not: SpaceX, the U.S. military, lots of people are already using lasers to communicate between satellites, and lasers to communicate from satellites down to the dirt. So, the ability to aim a laser really, really, really far away and put energy there is proven technology. You get back to what I said earlier, though, which is: do I have enough energy to drive a powerful enough laser for the target on the other end to be injured, versus just communications? And there's nothing technically that makes that impossible. It

just, depending on what you want to do, becomes cumbersome and expensive. And so, you get back to your prioritization, right?

**Riki Ellison:** So, Shotgun, from your perspective, what is the biggest challenge that we can break — the biggest obstacle that needs to be broken — to make lasers real?

**Thomas "Shotgun" Browning:** No, I got you. Like I said —

**Riki Ellison:** What is it?

**Thomas "Shotgun" Browning:** Yep. Zero — zero — negativity toward the services, because they are all trying it in all domains. But we need a Billy Mitchell, Wright Brothers moment. Meaning: I use these when it's still kind of dangerous to use these, and I use these when I'm still trying to figure out how to use these. So, getting them more ubiquitously into the hands of the warfighter, for them to think of new ways to use them that we never would have thought of before. And truly — and you brought this up and I agree — with a lot of inbound threats, deciding who does what, with enough accuracy so that the lasers can be effective, is hard. So, whether you call it intel, whether you call it sensing, whether you call it command and control — all of that, the JADC2-ness of it, needs to be figured out. And in my opinion, it's not going to be figured out unless the lasers are part of the architecture. So: getting many lasers out into the field, getting them into the architecture, figuring out how to integrate them with kinetic weapons, figuring out how to deal with recharge times and everything else. It's just not going to happen when, every 20 years, DARPA comes to the rescue to start a new program, and every 10 years we have a press release that we yet again did a kick-ass demo and then we put it in the boneyard. We've got to get over that.

**Riki Ellison:** Shotgun, what do you think the ratio should be between kinetic and non-kinetic energy? Is there a secret ratio? Kinetic seems to be more expensive.

**Thomas "Shotgun" Browning:** No, you earn it. Lasers are going to be more expensive getting out the door than a pistol — but the bullet is going to be more expensive than the laser shot. So, there's a lifecycle cost. I do not know that we've got that figured out. I'll say again: point defense, I think, is a no-brainer. And I absolutely think — whether it's a balloon in near space or whether it's an unmanned vehicle — because right now, you look at the amazing success in Ukraine: drones are a long game right now, a really, really long game, where you're sending them from good-guy land over a very long period of time to bad-guy land. So, it gives us a whole lot of time. It's kind of back to your boost phase, right? It gives us a lot of time and a lot of opportunity in the middle to do something about it. If all you do is point-defense lasers, you are not going to be able to deal with them from a directed-energy point in the middle. That's where I was going.

**Riki Ellison:** Okay. Thank you, Shotgun. Randall, you've got a lot here to follow up on. So, we are going to pass it over to Randall Parker — Fu.

**Randall Parker:** Yeah. So, again, having worked across all these things for quite a few years, just to amplify some of the things you all were talking about — some of the challenges, and some of the things you can take off the table. First of all, back to the demo that was done: there was a level of autonomy that was prescribed as part of that demo. As you get into the more challenging kill chains — drones and cruise missiles — those you can probably take your time with a little bit more. But when you start getting into the really fast things that happen on the whole ballistic side of the house, it's ripe for autonomy. It's ripe for faster-

than-human decision processes — human-on-the-loop. I know we're working on things like that, so that's something that can be taken off the table.

But, again, with autonomy comes risk. We are very good Americans, and we absolutely want to minimize collateral damage. We want to minimize fratricide, all those things. And until you have exercised that autonomy, you're never going to know all of the problems you're going to have — just like we do with humans in the loop. You're never going to realize all the problems you may have with autonomous systems until you go exercise them and try them out in the real world, in a very congested environment. So that's one of the risks, and one of the technologies, that I think will be both an enabler and something that comes with some risk, along the lines of fratricide and collateral damage.

Most of these high-energy lasers are not eye safe. They're certainly not safe for optics. So, we do a really good job of working through the laser clearinghouses to make sure that, when we're taking shots, we're minimizing the possibility of those kinds of things. But then, in a big shooting war, sometimes that's just going to have to go out the window, because we need to take that shot now and have to hope that the windows we've been given in that clearinghouse are tight enough that we're not actually committing fratricide or causing collateral damage. So, again, that's another area where, if we want to continue to fight the way we fight and minimize the potential risks to civilians and even our own systems, we need to be able to get that tight.

What are the risks to the civilian population? Airliners, pilots out there who happen to be just flying through when you're taking your shot. That laser energy, if it's looking up, may or may not — at least initially — hit the target you're aiming at. It may actually miss the target for a while until you hit the target, and that could potentially cause harm to someone else. Certainly if you're looking down. How do you mitigate that? Again, lots of command and control, lots of sources that come in and say, “Here's where airliner X and Y are” — and things like Thresher, and products like that, can potentially help mitigate those kinds of risks. Looking down from space, there's a lot of ground and sea that could potentially be affected, given the shots you're taking. So, again, not something that can't be overcome — just something that, given the way we fight and the way we try to minimize these things, is an issue.

One of the things that does delimit some of the capability is always magazine depth. We've talked a lot about power generation; one of the things we haven't really mentioned is heat dissemination. These things create a lot of heat. You'd think that in space it's really cold, but actually disseminating heat in space is a challenge. So, you can take shots, but then you have to cool — take shots, cool. Magazine depth is always going to be a problem. Until you get a proliferated system anywhere — on the ground, on the sea, in the air, in space — you're going to have to manage those shots.

**Riki Ellison:** How do you resolve cooling it? Do you just have different lasers?

**Randall Parker:** You would have to. Currently, with the technologies we have, you'd have to have different lasers able to take different shots. At the same time, that derives a different level of command and control and orchestration that, again, has to be tested and tried. I think the good folks at Golden Dome are very aware of these things, and I think they're certainly working across those problems. Again, until you get a proliferated thing — and you're talking a lot about whether we can get these in space — orbitology matters, and command and control matters, and being in the right place at the right time really matters, with the right aspect from the shooter to the target. So, again, that's not a trivial thing; it's not just getting a few lasers in space. It really does matter where we're at there.

The other one — you were mentioning the point-defense stuff. Again, I don't know that we've spent enough time with the air defenders on the ground looking at how you would do a CONOP to address multiple inbound threats, and where you would actually place these point-defense systems. So, I think there's probably a lot of CONOP work that can be done that would, again, help you get that technology into the warfighter's hands and make them start thinking about it, and then make them start asking for it.

Back to your kinetic-versus-non-kinetic ratio — what's the ratio? Well, each has strengths, and each has weaknesses. Each has costs. Each has benefits. So, I don't think that I — I don't know of anybody that's actually done a trade-space analysis on that. Maybe Golden Dome's doing that kind of analysis. But I think that's a —

**Riki Ellison:** Golden Dome's doing an analysis between space-based LM and legacy systems.

**Randall Parker:** Yeah, yeah — kind of that same sort of thing. But, again, they each have strengths and weaknesses, so you can't discount either one. We always said — as part of the things Shotgun and I have talked about — you'd be a fool to rely on space; you'd be a fool not to account for space. So don't be a fool. We need to account for all the domains, like we're talking about, as we go. So I think that's kind of it on the amplifying things — unless I missed something you guys wanted to talk a little more about.

**Riki Ellison:** Let's go into a couple of things. From your perspective, how can we get it into the warfighter's hands, and how soon can we do that? Okay, so that's one. And then, policy. Let's go back in history: we created this great weapon system, the 747, and we killed it. Does something need to be done in policy? It looks like we got the presidential order for Golden Dome to do anything — to go into space and do that. Are there still limiting factors in policy? So those are the two points I'd have for you.

**Randall Parker:** Looking back across history, it's been very administration-dependent how excited we are about building these kinds of things. Certainly, the current administration is very excited about it. Getting that ingrained and entrenched and making it such that we've explored these things and dealt with all the policy issues — you do that through testing, through modeling and simulation, and through warfighter engagement. But it's also more than that; it's an education thing, I think. The people who work on policy need to actually

understand the technology. They need to understand the concepts, the CONOPs, and the things that will take certain risks off their table.

**Riki Ellison: Are** we limited by policy right now, in your view?

**Randall Parker: I** wouldn't say yes; I wouldn't say no. I'm not an expert in policy. What I would say is that the more education we can do to help the people who are developing and proliferating the policies, the better. I think your organization is one of the ones that advocates for these things — and advocating policy, with the people who actually create and develop those policies for the administration to execute, is a critical function.

**Riki Ellison:** And then, how soon can you get into the field?

**Randall Parker:** I mean, that's kind of a funding decision right now. It's also service dependent. You may get things into the field on the ground faster than on a ship, faster than in the air, faster than in space. There are technology challenges across all the services and all domains, and I think those can be mitigated differently in different time frames, depending on the domain. So I couldn't tell you, like, “next March.”

**Riki Ellison:** Okay, let's go back to your goal — that's $200 billion. We've got money to do this. And the warfighter — let's go to the warfighter, and let's go right into your service, the U.S. Air Force, which got hurt bad, with its planes on the base, because of the roles and responsibilities of missile defense. It's so awkward having another service defend that. It is my clear understanding that the U.S. Air Force has now moved to doing base defense for counter-UAS. That was done at Corona, and it's led by the chief of the Air Force. So, this would seem to be a great place to insert it, through the Air Force, because you're more worried about anything shooting your aircraft down, and about being able to integrate and synergize with this ability. And if the Air Force doesn't — I mean, that's what they've got to do. Their mission now is — I don't know if you knew that, Tom, but their mission is counter-UAS for the bases they're going to take on.

**Randall Parker:** So, I'm not privy to any of the Air Force deliberations on any of these things, but it's shocking, and I will attest. Being fighter pilots is great, but you don't get to take off without all the infrastructure there. And it's really hard to take off with smoking holes and no tankers, and your infrastructure disrupted. So, absolutely, protecting indigenously would make some sense to me. But, again, the roles and responsibilities between the services and the area air defense command structure are up to the services to solve.

**Riki Ellison:** So, Shotgun, you got any — ? Yeah, Shotgun, you've got to have something on this. Come on.

**Thomas Browning:** Yeah, well — again, it's why organizations like MDAA are so important. Defense doesn't sell. This administration has taken it on, and I can't thank them enough for

the effort of Golden Dome. But, as I keep saying, lasers are not going to magically be cost-effective and viable, period. You are going to field not-cost-effective, potentially not-viable lasers before you field cost-effective ones. So, on my timeline: the timeline is as fast as Mike Guetlein wants that damn timeline to be, or as fast as the United States Air Force, or as fast as the United States Army. But we make budget priorities based on the budgets we have.

I guess I'll be a little bit more contentious. Every year, and for many, many years, those budget decisions did not warrant accepting risk on a new, unproven technology, and did not, to a very large degree, include adequate base defense. That's why we're having the discussion we're having. So the answer is, when an inspirational leader decides that this is something we're spending enough money on — and understands the limited capabilities... The first heat-seeking missiles were not good. The first jet aircraft were not good. The first radar-guided missiles were not good. But we have amazingly effective weapons today, because we took and fielded those potentially-not-as-capable weapons, as Fu said, got the TTPs, and, frankly, learned some hard lessons on collateral damage and everything else. So there's a level of risk acceptance — both technical risk and operational risk — that needs to occur to usher in new technologies.

The reality is, for a lot of years, we have blown smoke with respect to defense. What Ukraine has shown the world is that you can hit somebody really frigging far away if they are not adequately fielding the capabilities necessary to defend themselves. So I think we have an opportunity right now. I think we've got the money right now. We've got the people right now to aggressively lean into this. They just actually have to.

**Riki Ellison:** So, I want to hear both your thoughts on this. I think there are four organizations that can do this for us. Obviously, Golden Dome — but Golden Dome is doing a hell of a lot more than directed-energy research; their plate is already full. Let's not discount the Missile Defense Agency, because they're the ones that put the ABL up. They've done a tremendous amount of work and research — it goes all the way back to SDIO — and we haven't tapped them enough to go forward. Then we've got the Army, who's been doing this at White Sands. And the new opportunity, which I just mentioned, under Corona, is the Air Force on base defense, being able to incorporate this on their planes as well, and their labs being able to actually get capability into it. I think it's a brilliant opportunity. Am I right with those four entities, or are there any others? I know you love DARPA, but we just didn't include that one.

**Thomas Browning:** My opinion — and this is just one person's opinion — is that services organize, train, and equip. So a service, or multiple services, in my perfect world, should be the entity given the task to organize, train, and equip to do this. We know that base defense has been a fight between services for years, but it hasn't garnered the fiscal resources necessary to do it. So for me, it's really simple: I don't care who it is. The four you brought up — fine. The U.S. Navy would be fantastic, too. The U.S. Space Force, if they've got it.

That's not what's relevant to me. What's relevant to me is that the entity given the task applies the appropriate amount of resources to aggressively acquire the capability.

And we are still exchanging fires in the Middle East today. So this is not a “worry about it in '29 or '30” issue. It is about somebody having the fortitude to take money that absolutely is needed for other things and shift those resources to this underfunded requirement — whether it's lasers or just missile defense in general. It's all about fiscal priority, and it's all about accepting the reality that you are not going to buy something else when you buy this. And then, finally, as you usher in something like directed energy, you are going to accept technical risk early on — we will never get there without you accepting that. So, to me, it's not the “who,” it's the “what.” It's actually prioritizing base defense, ground-based defense, and U.S. population defense against cruise missiles and drones, and acquiring the necessary hardware to do that at scale.

**Riki Ellison:** You're absolutely right. But the motivation for doing this is the 20 bases that got destroyed, and the financial hurt on us, on our force projection — especially the Air Force and especially the Army. And we're not addressing that yet. We're not. Nobody's held accountable. And so that has to happen. I think the ones motivated the most are the ones that lost the most in this, and they're the ones who can make the hard choices of trade space — like you said — from their offensive capability to their defensive capability. They have to do that. And then they have to make that request to Congress and the President, which I think is receptive to this. But until you get accountability on this, it's not going to go fast enough for the warfighter, and for the world to be safer than it is. They're going to keep chipping away. So, I'm passionate about it. Randy, have you got anything to add to that?

**Randall Parker:** I'd say one other aspect of this, too: as we proliferate these things, I think we're going to learn a lot about how we need to protect our own systems from these kinds of threats. The rest of the world isn't stupid — they're working on this stuff, too. So, the more we have out there, the more we'll understand about the vulnerabilities we have, which we can then go address as we move forward.

**Riki Ellison:** Can I ask about power generation really quick? Because we're maxed out already on power generation for our radars and sensors on our bases, at home and away. And then you add a directed-energy weapon that's both in combat — mobile, if we're doing that — and fixed-site. Where is that power coming from? Are we going to have to create new power sources, like small nukes, to be able to do this on land and on sea? I mean, I think they've got some generators. How do we do this, from an infrastructure point of view, on this fancy weapon that's going to require a tremendous amount of power in addition to everything else requiring power?

**Thomas Browning:** Yeah — I'll let Fu pile on. And I know this is an annoying answer, but it gets back to that: if I can get away with a lower-power laser, then I obviously get away with less of a power challenge, and — as Fu hit on — less of a cooling challenge. That lower-

power challenge and lower cooling challenge allow me to shoot faster and give me more bullets in my magazine, for lack of a better term. The demos our industry has done are amazing. Whether it's the primes or others, we have things in the field — not necessarily fielded, but we have vehicles in the field, whether on land, in the air, or on sea, that have power on board for an appropriate magazine level, for appropriate range and power. It exists today. They are not tremendously powerful lasers, so there are range issues you need to plan around. But for moderately powered lasers with moderate capability, that's solved. When you start talking about really long range — like an ABL, or impacting something from space, or impacting things at extremely long range, say from something like Guam — then you're absolutely going to run into power challenges and cooling challenges. Fu, you got anything to pile on?

**Randall Parker:** I think, mostly, we're at the stage where you bring your own power with you. We're plugging into the grid kind of power at this stage, because of those things Shotgun just brought up. Yeah, we are maxed out on our power-generation capabilities for bases to operate. But, in theory, most of these things would not require plugging into that and drawing from it at this point, because, again, they are mainly those shorter-range, less-power-required capabilities — as long as they're optimally placed.

**Riki Ellison:** What's your realistic projection on when we'll have a deployed, operational laser that's able to defeat a threat in combat? What year is that? That demo just proved it's possible — I got that. But when do we get an operationally deployed capability that's defending our warfighters? What's your projection on when that will happen?

**Randall Parker:** So, I go back to a very pointed point that a former colonel brought up all the time: it's not a capability until you can train with it and execute it. So, again, the level of training that is required to operate these things now is probably greater than it should be. And if we go toward more autonomous capabilities and more push-button sorts of things, that will reduce the time. But, again, unless we've got people in the field actually trying these things out... The demonstration may have had operators — actual Army operators — doing it, and that's great. But then, to get it out into the field, with the appropriate training, to the different areas it's going to, it's still not a capability. So I'd say that's probably going to take a series of time to get there. If we do things like we normally do, it'll take years — I think we've seen that in the past. Depending on the level of effort that's put forward, it could be shrunk by however much. I can't make an honest assessment even across all the services, because it will be different for each service and each domain, in my belief. But, again, it depends on the level of commitment and emphasis put on all that.

**Thomas Browning:** Should I go?

**Riki Ellison:** Yeah.

**Thomas Browning:** So, I want to be disastrously wrong — let me say that up front. But I think, 10 years from now, we're going to have a science fair out on White Sands Missile Range, just like Fu and I did 10 years ago, watching a really cool demo. That's what I think the truth is. And what I think is going to change that is when you have a commander who is responsible for a mission and is incapable of doing that mission without the capability. And I actually think we're already there. So the challenge I see is this: I want somebody to break this cycle. I would love it if that's MDA, or Golden Dome, or the United States Air Force, or the Army, or the Navy. But I am pessimistic that, with all the fiscal challenges we have, someone's going to have the fortitude to alter fiscal priorities and push this out front.

They need to understand the con-eps, the con-ops, and those things that will take certain risks off their table.
Riki Ellison: Are we limited by policy right now, your suggestion
I mean, I say, I wouldn't say yes. I wouldn't say no.
And Fu hit on something really important, and I understand that. When I say we could field it tomorrow — and I actually think we should — that is fielding the first one that sucks. That is giving the warfighter the opportunity to tell us in the development world that we are idiots. So, in the best-case scenario, we're likely a couple of years away from being best-in-breed on Earth at this. But that couple of years — you're not going to shorten that much. I think autonomy is a great way to potentially shorten that timeline, but unless you start, you're never going to shorten it. So, yeah, my pessimistic answer is: 10 years from now, we're going to do a really exciting demo, and then people like us are going to be on TV saying someone should buy this. And I really, really, really hope I'm disastrously wrong.

**Riki Ellison:** Well, from my insight, we as a nation are going to create an automated command. And that automated command is in the NDAA today. And that automated command will have a DERPA, like Golden Dome. The automated command is going to have drones off it. Does the laser fit into this new DERPA, for automated command? Or am I pushing the envelope too much? Or does that belong back in Golden Dome, back in the NDAA, and so forth? I'm just throwing that out because we're moving at this pace, and we can't fight a war today at all until we get the automated fight done — and we're not in any shape to do that. We all know that. And that's another incentive: besides the Air Force and their planes, this seems to be a pretty big one. Well, maybe I'm throwing too much at you there, but any comments on having the laser fit in an automated command with a DERPA?

**Thomas Browning:** Yeah, I think, when we are doing this right — whenever that occurs — bullets, missiles, bombs, lasers, cyber, and RF energy are all on the table. They're all a suite of tools, whether that's Army, Navy, Air Force, Marine Corps, or Space Force, and whether that's an autonomy command. I think of directed energy as yet another effector — and I realize we can use it for many other amazing purposes, but we shouldn't think of it otherwise. So yes, an autonomy command should have it. Yes, the United States Army should have it. Yes, Pacific Air Forces should have it. And we should use it in all the areas where it is most tactically and fiscally appropriate. The challenge is, until you get out of the

starting gates, we're never going to know the answer to that question — or we're going to be in that evil cycle.

**Riki Ellison:** So we've got to get out of the starting gates, is what you're saying.

**Thomas Browning:** Yeah, absolutely.

**Riki Ellison:** Any comments?

**Randall Parker:** I agree totally. You've got to get something out there. The first IR missile stunk, right? We didn't get to really good IR missiles until 30 or 40 years into IR-missile development. So until you get it there, it's going to continue to take more and more time. So just getting it out, and letting the 19-year-olds try it out — obviously with supervision, but let them try it out.

**Riki Ellison:** I'm still leaning so far forward on space-based lasers, because that's what we grew up with. I can just say how cool that would be, and what the development would do to really have deterrence and global domination sitting there. And I know it's so sensitive, policy-wise, to do it, but it looks like our president has given us the green light.

Do you have any other questions between all of us before I open it up for questions from the public? Anything else we didn't cover that you think we should have? You good, Phil? Yeah. Okay. So, ladies and gentlemen, we're going to open up for questions. Ron Christman, who works for us, is going to relay the questions to us. So, Ron, do you have any questions for us today?

**Riki Ellison:** So, I can't speak to that. I really don't know. Shotgun may have more insight, but…

**Thomas Browning:** No, again, that's actually singing my theme music. It's cumbersome and not effective, right up until it's not. And it's never going to stop being cumbersome and become effective until you get it out there. So there is trade space. And if I were a soldier and I had a choice of buying a laser that's going to be good in 10 years, or a machine gun that's going to be ready for me right now, I know what I would choose. The reality, though, is that we've got a department that needs to think about both. So, if I were the soldier, given the system I am absolutely promoting, I'm probably going to be dissatisfied. But, ideally, with the right resources, we're going to take the inputs from that soldier, figure out those technical challenges and operational challenges, and address them. So, again, where I'm pushing is absolutely not to put a toy in the field and see what the kids think. It is to put an operational system in the field, understanding that they are going to say it's cumbersome, it didn't cool off, they don't like it. But we can't address those challenges until we get there first.

**Riki Ellison:** Hey, Ron, we've probably only got time for one more — we're pretty close to the end already. So just pick the best one you can of the group.

**Randall Parker:** I think the world has moved into the development of solid-state lasers and has embraced that. Going back to chemical lasers — there are a lot of valid uses for chemical lasers, but a lot of the logistical chain required to execute chemical lasers on a big scale was cumbersome, and that was actually part of what led to the demise of the ABL. Which is why, I think, the world went too heavy into solid-state lasers. So I can't say yes or no, but I'd say that, based on the investments that have been made, and the lessons learned — at least on the defense side of chemical lasers — we've probably moved on from that a little bit.

**Riki Ellison:** Okay. Shotgun?

**Thomas Browning:** No, I actually think Fu nailed it. And I don't know that it goes away, but it includes logistic challenges and operational challenges that make it a lot harder for some troop in the field to use it. So there's a big allure to solid-state, in the sense that now I can ruggedize it — we're good at that. I can ruggedize it, I can throw it into the hands of a soldier, and I don't have to worry about those challenges. So I think all of the technologies are worth considering. But I'll say it this way: if we can achieve the power, the responsiveness, and the magazine that we need, solid-state-wise, that removes a whole lot of operational challenges.

**Riki Ellison:** Okay, all right. So we're going to wrap up now. I'm going to pass around to each of you for a couple of concluding remarks on our discussion today, and whatever you'd like to end with. So I'll go with you first.

**Randall Parker:** Sure. Thank you very much for the time. This is a great discussion, and I think it's very timely. I think we are, with this administration and with the Department of War, very well placed to actually move this along. So, again, we're not going to be out there in 10 years watching the same demo — which I think has just been the way we've done it. So the impetus that the administration and the department are putting on these things is hugely valuable, and I'd love to see the follow-through, and to have that carry on into the future.

**Riki Ellison:** Thank you for participating with us today. Shotgun?

**Thomas Browning:** No, as always, Riki — thanks. It's been fun discussing this. You know, I was a vice commander for air forces in Iraq at the end of Operation New Dawn, and when we were removing a lot of stuff, we found hangars full of good intentions in counter-IED. There were many, many demos that were sent to the field, that we used until they broke, and then we shoved them in a closet — and there wasn't a whole lot of follow-through. So, yeah, getting things into the field is important. But there's got to be the spine to have some follow-through, again, to understand that the benefits you reap from that investment early on are probably not going to show. But the benefits for the United States of America, as we get ahead of the world on both directed energy and — again, I'll tout Fu's point — as you

get better and better at integrating directed energy, you're going to get better and better at understanding how to defend against it. So it takes a lot of guts to start it, but it takes a lot of guts also to get through that initial period and not have a hangar full of misfit toys that we've got to clean up later, and instead have real capability for the warfighter.

**Riki Ellison:** Thank you, Shotgun. Again, we're at a tipping point. We are at a tipping point with this capability. And this is not the be-all, end-all — it's not the be-all, end-all. There's an illusion that lasers are, from watching movies and all that, the be-all, end-all. They're not. It's a supplementary aspect of it. But what it does — and the urgency for it, because I think the cost curve is driving this faster than any other system, to reduce million-dollar interceptors, and 10-million- and 100-million-dollar interceptors, down to this — that's forcing us to go forward with it. And having directed energy now forces everything else around it to be better. It's a prime example. It's done.

And, you know, bringing this up, where we're at, is about putting the money in. And there are some great opportunities for some great organizations to lead on this now. And I think we've got, again, strong leadership to take and lead courageously, accept risk, and get this thing moving for the bigger picture. It's not the be-all, but it's about enhancing everything around it to have missile defense in reality. And that, I believe, has to be done.

And I think — I'm going to be more optimistic than you. I think it'll be done by 2028. We will take the risk, because we're going to keep losing our bases until we take some hard risk at this thing. So, great discussion, guys. Thank you for taking the time and effort to be with us today, and for educating, illuminating, and advocating for that system. So, thank you. Thank you, ladies and gentlemen.