

## **Aerospace Nation – Episode 211: Building the Precision Strike Arsenal We Need: The Mass Challenge – Transcript**

[00:00:00] **Heather "Lucky" Penney:** Welcome to the Aerospace Advantage podcast brought to you by PenFed. I'm your host, Heather "Lucky" Penney. Here on the Aerospace Advantage, we speak with leaders in the DOD, industry, and other subject matter experts to explore the intersection of strategy, operational concepts, technology, and policy when it comes to air and space power.

So aircraft like the B-2, the B-21, F-35, and F-22 and eventually, uncrewed collaborative combat aircraft. They're super cool. We love watching them fly. They even look incredible just sitting on the ramp, right? You know, trust me, nothing is better than strapping into your jet and taking to the sky. But that said, it's important to understand that these jets, these aircraft, are just a means of delivering an effect.

What really achieves mission objectives is the missile, the bomb, the bullet, or the nonkinetic effect that is typically tied to electromagnetic spectrum operations like electronic warfare or cyber-enabled warfare. And it's easy to take these things for granted. We just expect that we'll have them when we need them, and the supply will always be available.

And, I mean, think about World War II. We dropped what seemed like a countless supply of bombs, and more just kept coming out of the factories. But today, things are a lot more complex in the real world. First and foremost, technology has moved a long way from the dumb bombs that B-17s and B-24s dropped 80 years ago.

And munitions are so much more capable. But it also means they're more difficult to produce, and they have higher unit costs. Plus, we live in a world where defense budgets are really tight, and they have been since the end of the Cold War, especially given the scale and the scope of operational demands that we've been placing on our forces.

That means the Department of Defense has been buying way too few munitions for far too long. The munitions accounts have been the billpayers for everything else. But we've been burning through these munitions at a really fast rate, given the number of operations we've executed over the past 30 years.

So, we really need to pay attention to what's happening in Ukraine. That's a great example of the risk and the cautionary tale. Those forces are running out of key munitions as they fight the Russian occupiers. And that could be us if we're not more careful and take the steps needed today to reset our munitions stockpiles with the right mix of capability and capacity.

So that's what we're here to talk about today. We've got to build the right munitions arsenal for the U. S. and our allies to address current and future challenges. And we're going to focus today specifically on the Air Force because while all services are part of this ecosystem, the Air Force is charged with delivering the preponderance of firepower behind enemy lines.

The Mitchell Institute, my colleague Mark Gunzinger in particular, have done a lot of work in this area. Gonzo pioneered a concept he calls affordable mass, and it's really important because it speaks to the right level of capabilities for sustainable price points. And let's face it; we're not going to build ourselves out of this capacity deficit with munitions that cost as much as an F-35 per shot.

And yes, those types of expensive, long-range missiles exist. We really need to focus on the affordable mass, the affordable munitions that can give us the capacity to meet the target set and target numbers demanded. Now, Gonzo has pioneered this concept, but we're bringing a new voice into this conversation.

My colleague, JV Venable. JV, thank you so much for joining us today.

[00:03:17] **John "JV" Venable:** It's a pleasure to be a stand-in for Gonzo, I'll tell you, and that's a big shoes to fill. Great to be with you.

[00:03:23] **Heather "Lucky" Penney:** Well, I'll tell you, you are a good-looking stunt double.

[00:03:25] **John "JV" Venable:** Go on.

[00:03:27] **Heather "Lucky" Penney:** And it's also fabulous. We've got Jeff Peters, the Deputy Vice President and General Manager of Precision Strike and Sensing Solutions at BAE.

Jeff, thank you for joining us.

[00:03:37] **Jeff Peters:** Yeah, thanks for having us today, Lucky. Looking forward to the discussion.

[00:03:40] **Heather "Lucky" Penney:** And also Dr. Kathy Bahari, Technical Director for Precision Guidance and Sensing Solutions at BAE. The challenge we're talking about here today is one that ties to innovation production, and so this industry expertise is crucial.

Kathy, thanks for joining us.

[00:03:53] **Dr. Kathy Bihari:** Thank you for the invitation, Lucky. It's a pleasure to join you today.

[00:03:58] **Heather "Lucky" Penney:** Okay. So, JV, we're going to start with you. I want you to give us a thumbnail sketch of the challenge that's facing us right now. Gonzo has been saying this for years, but it's certainly an issue that you have addressed a lot in your own research and so you're also very familiar with the challenge of the target sets and the munitions required to be able to execute operations. So, could you walk us through an explanation of how we should think about the DOD's current munitions arsenal? Especially the Air Force's air-to-ground weapons.

[00:04:24] **John "JV" Venable:** Yeah, it's a great and very large can of worms you just opened up. So, there's a couple of thoughts, but they're binned into three or four different areas. Capacity, the number of munitions that we have, the capability, both with precision and with the range that they have. The cost of those munitions and then the rate of production that we can spit them out in a time of crisis.

Um, during Desert Storm, if you go back to that period talking about capacity, we, over the course of 4 months, expended roughly 225,000 munitions. And that comes out to about 5,000 munitions a day. Every day of the conflict.

[00:05:04] **Heather "Lucky" Penney:** Wow.

[00:05:04] **John "JV" Venable:** And you start metering things. You start judging things in terms of that regional conflict.

A war with China would be much broader. Many more DMPIs, designated mean points of impact. Targets.. And target sets would be large and then the environment, begins to change it both with regard to the expanse, the large volume of water and coastline that we would have to approach. and the, convolution of that environment, um, the fog of war gets much bigger than the ones we faced in the recent past. So that's how I would bin it and we can go into specifics on down the road.

[00:05:39] **Heather "Lucky" Penney:** So I think it's really important you bring up the fog and friction of war and what we would face in the future being very different than what we've experienced for the past 30 years was a very permissive air environment.

Right? And so there was nobody who is trying to shoot down our munitions to counter our munitions. And so it's not just a one-for-one that we need to plan for within our stockpile. We need to have more than a one to one of weapon and target available for the future. Because although we would, we want to ensure that we've got the right type of munition that can be survivable for the target set, we also need to make sure we've got a backup inventory just in case.

[00:06:14] **John "JV" Venable:** No, you're exactly right. So just take, Ukraine, for example, the number of GPS munitions that we've provided them. And then the counter GPS jammers that the Russians have put out that have been very effective against those munitions, causing big miss distances and us to go back and reassess and the Ukrainians to reassess about how we go about attacking them. So something with just a GPS guidance kit or an INS and GPS guidance kit may fall into some type of, subterfuge, if you will, something that can move the aim point that missile is aiming for just enough to cause a missed distance, and it's no longer precise at that point. That's one.

The second is their counter missile capabilities with regard to kinetics and potentially lasers. We will, as you mentioned, very likely have to expend not just one for one munition to target as we have for the last 20 years, but maybe six or eight or 10 to one, and that becomes very expensive. Just to go down the rabbit hole of what the expectations of the military has been over the 20 years.

I had a composite group in the Gulf of 2004, 2005. If you missed your target with one bomb and one target, if you missed your target, you generally had to report to the two star as to why you missed that target. the expectation was that

high. Now we're going into an environment where you fire one and you can almost certainly expect that it's not going to get to its target unless it has a great deal of assistance and by and large, that means buddy missiles that are coming in that cause them a targeting problem.

[00:07:53] **Heather "Lucky" Penney:** So can you describe how the munitions inventory evolved in these recent years? We just talked about what things have been like with the one for one expectations, a super precision, as you mentioned, if you didn't, if you missed your target, you had to report. And we've also seen a trend line where we've really miniaturize the explosive power and capability of our munitions, not only for size and range, right?

Because the smaller the munitions package, the longer it can go because it doesn't weigh nearly as much, um, and, but we've also wanted to reduce collateral damage. And so I think things have changed, right? I mean, in Desert Storm, the paradigm you described looked very different. Um, but we had a number of super sophisticated laser guided bombs for really important targets. And you also mentioned GPS. So, should we think about how weapons have evolved.

[00:08:39] **John "JV" Venable:** Yeah. So let's go back and revisit Desert Storm just for a second. Coming off the end of the cold war we had a massive weapon stockpile, global weapon stockpile. Our allies in europe had weapon stockpiles that were supposed to last 30 days, right for the cold war, right?

[00:08:55] **Heather "Lucky" Penney:** The Fulda Gap gap scenario, World War III

[00:08:57] **John "JV" Venable:** And so you're going from 1989, 1990, end of the cold war 1991 and we go right into Desert Storm. So we have those munitions in reserve. Going down the PGM rabbit hole just for a second, we had the expectation that our precision guided munitions were going to be great, and they would also be one for one.

Generally speaking, those were laser guided munitions, some EO munitions going in. But even there in that relatively medium threat environment over Iraq in the early 1990s, the total success rate when you drop a string of iron bombs, that was about 45%, meaning every time you dropped one, you generally had to drop two strings to be effective.

The total mission effectiveness rate of the Precision Guided Munitions was only 54%. And so here you go from the fog and friction of war, of a clear, training

environment, into, hey, weather really becomes a factor. Oh, uh, sandstorms in the desert affects things, and then people are shooting at you.

And so that, that takes the calculus and changes it. So it's really important to remember that no matter how sophisticated we get in our guidance systems, no matter how sophisticated we get in range and precision, there's always going to be that other side that enters this factor. So 225,000 munitions were expended in the Desert Storm.

I was in Korea. I watched them gut our bomb dump in Korea to feed the fight in Desert Storm. And that was really important to remember when we talk about global sourcing of munitions in a fight with China, we'll have to do that. Now, going back into some simple math into mass right now.

So, we built up a stockpile of JDAMS over the course of the post Desert Storm era, we started getting into producible mass. That's expensive compared to an iron bomb, but it's in the \$45,000, \$55,000 a kit that range. And we built, and we actually acquired something on the order of 350,000 of those between us and the Navy.

Today, that stockpile has dwindled and not been actually replenished. And it's around 180, let's call it 200,000. So coming back to mass, you have this JDAM kits that are \$45,000 a piece that we built up into the 350,000. We expended a lot of those during the Global War on Terror. And now we're right around 200,000. We've got another, 55, 56,000 of the small diameter bombs in our inventory, those are very high-end weapons, but we have even better ones, the LRASM and then the JASM. Um, those two missiles are longer range, and they are also precision guided, but we have very few of those. So if you looked at this as kind of a pyramid at the top, for a war with China, we're gonna try to stiff arm the threat as much as we can.

We'll throw these long range systems out 250 to 500 miles, but each one of those systems costs over a million dollars. The LRASM, you're talking about over 3 million. And so it becomes very hard to think about how few of those missiles we have and how broad the target set is.

[00:12:23] **Heather "Lucky" Penney:** Because it's a lot of targets, right? It's like 140,000, DMPI's.

[00:12:27] **John "JV" Venable:** Yeah. So we were looking at about 40,000 in Desert Storm. We're looking at least three times that amount up in the 140,000 range for a war with China. You're exactly right.

[00:12:36] **Heather "Lucky" Penney:** Wow. Now I actually dropped precision guided munitions myself in anger, and I will say that the precision element is actually really important because not only does it decrease the amount of revisit rates you need to have, But when the stakes are really matter, you want to make sure that you hit the target.

And so having that element of precision is important and whether or not it's perfect. there's, I'm not sure. I really want to go too far down that rabbit hole of being perfect. But,

[00:13:02] **John "JV" Venable:** but you're exactly right though. When the expectation was, it was one for one, no one was shooting at us. By and large, the environment you and I flew in, it was above the threat. We will be in the threat in the next war.

[00:13:15] **Heather "Lucky" Penney:** That's true. So Jeff, I want to bring you into this conversation. From an industrial based perspective, how has this journey, um, been like for you? Have you seen DOD and the Air Force munitions requirements evolve? I mean, we've, we came from dumb bombs of Vietnam and we've been strapping on those, uh, the JDAM kits and the laser guided kits and so forth.

And now we're, moving even more towards precision. And in some ways, very long range precision, think that there's a, there's sort of a sweet spot, but I'd like to hear your perspective on this journey.

[00:13:48] **Jeff Peters:** Yeah, thanks Lucky. I, uh, so I think JV is hitting it on the head. We've seen this migration over time from low cost, high volume munitions to exquisite, very high end of the system spectrum, and especially over the last five years, if you look at a lot of the systems that are actually being fielded, they tend to skew towards that very high end of the spectrum. So there's a couple of major impacts to the defense industrial base. First, if I go back to those mid 1990s, one of the things that you'll see is that there's been a significant amount of industry consolidation since then.

So we have less sources of supply for these precision munitions. And in a lot of cases, those sources of supply tend to be very vertically integrated. So now when you need to go surge production, you're naturally going to run into bottlenecks in industry, right?

[00:14:35] **Heather "Lucky" Penney:** Interesting. Okay.

[00:14:36] **Jeff Peters:** And that's. And that's especially true for exquisite precision munitions, where, you know, as you had, as you had mentioned before, annual production rates on a lot of these very high-end solutions right now, they're in the hundreds and that's nowhere near what's likely going to be needed going forward into the future.

One other impact that I'd highlight is when you look at the production of these more complex precision weapons, you see significantly longer lead times, both in top level integration and through the supply base. And that's both from a development life cycle and from a production life cycle. So a lot of these exquisite solutions are taken at least a decade, if not more to get out to the field.

So it seems like we've got to do something different to be able to field capability sooner and get it out in the numbers that we're going to need.

[00:15:23] **Heather "Lucky" Penney:** Yeah, no kidding. I mean, the decade or longer to be able to get these munitions to the field and, and numbers that matters, frankly, shocking to me because I would have expected and I would demand my munitions portfolio to be more rapid than, for example, my aircraft portfolio.

We know it already takes too long to be able to develop and field a new airplane like this. Whether or not that's a fighter, a bomber or some other type. And so when we look at adaptability across our capabilities within the Air Force, I would be looking at munitions to be able to provide that, uh, that agility.

So Kathy, I'd love to hear your thoughts on all of this.

[00:16:00] **Dr. Kathy Bihari:** Well, Lucky, I think Jeff highlighted a lot of challenges, but fortunately for us, each of those come with an opportunity for innovation and for new solutions. And I think there's a lot of ways that BAE systems and the entire industrial base can really address these challenges.

Modular and scalable systems are going to be critical because they'll allow us to deliver the right size capability to the warfighter. We need to develop multiple sources of supply in order to address a lot of the supply chain issues that we're seeing. And if we have open and well defined interfaces, we can interchange components and subsystems, leveraging that increased supply base, and that will allow us to meet those mission demands and keep the solutions affordable.

[00:16:44] **Heather "Lucky" Penney:** So I really like what you say regarding multiple sources of supply, modular and scalable, amen to that, open mission

systems, absolutely. But I want to kind of go back to a little bit of regarding the supply piece. Because Jeff had mentioned that there's vertical integration, but I think there could also be some fragility regarding how deep or how broad our supply base is, because if you even have a supply base that is relatively thin and feeding, different primes, if we don't have enough of them, we still won't be able to scale, even though it's not vertically integrated.

[00:17:17] **Jeff Peters:** Yeah, so this is a really tough problem, right? Industrial capacity isn't something that can be solved overnight, and it's not something that can be solved by just giving bigger contracts to the same players. So when you step back, there's a few actions that we see that would be able to help meet the demand that JV described.

And first off, DoD needs more sources of supply. You need more players on the field. So to hit those 200,000 aim points that we were talking about earlier, if you want to go hit those by 2027, and you start in 2024, then that means you need to be building at least 50,000 weapons a year. And if you spread that out across two companies, that's 25,000 a year that they both need to build.

And then for the kind of weapons that we're talking about, nobody is building at those rates, right? But if you take that burden and you spread that out across five companies, say, then the math turns into 10,000 units a year. Right. Better yet, if you go to the 10 to 12 companies that JV was talking about, now you're down to 5,000 units a year, and that's much more manageable. So there's no way to hit all of these aimpoints unless you broaden the industrial base so it broadens and matches the need from a quantity perspective.

[00:18:32] **Heather "Lucky" Penney:** Yeah, and it's not just simply the primes, but you need to also then broaden the sub-tier suppliers as well, because we can't have the bottlenecks in the sub-tier suppliers, because if all 10 or 12 of those production facilities are relying on the same two suppliers that still remains a bottleneck.

[00:18:48] **Jeff Peters:** Lucky that's an outstanding point. And when you're looking at bidding and executing contracts, that's one of the first and foremost things that we're looking at is how do we build robustness within our supply base and come up with multiple sources of supply for critical subcomponents. So if one particular source of supply has a setback, we can go throttle and other sources supply up. Or if we have a significant increase in demand, we're able to go throttle up that entire infrastructure at all levels of the supply base.

[00:19:19] **Heather "Lucky" Penney:** That's good news to hear that that that is clearly a focus that you have. JV, there's another variable in here, and that's long range standoff munitions. Now, we know bombs and missiles have less standoff, and then there's the very short range direct attack munitions, but how does that apply to current requirements, especially as we look at peer competition?

[00:19:38] **John "JV" Venable:** That's a great question. So there's a big, uh, debate, battle, if you will, on how we're going to fight the next war. Where, will we be based? So the first island chain is well within the missile range of the Chinese. The second, island chain, well within the missile is also and then the third you're talking about Hawaii, Alaska way out.

And so the further you get out, the, the more you constrict your resources, like our fighters can't fly that far and back, the bombers can, but we have a very limited number of bombers. And so you have to kind of integrate the whole thing together. Uh, if you're going to use long range systems and, and, and you actually have non stealth, um, bombers and fighters to use those, that might be the best of all worlds there because they can stay away from the threat and still go and strike the target.

Whereas your stealth, um, B-21, B-2, and the, uh, stealth fighters that will be available to us, they can go in and they can drop the very less expensive, munitions like JDAM, small, diameter bomb and the likes. And so that's how the next war is going to be fought, and we're going to have to meter that out.

But still, when you're talking about numbers as small as we've got at the top of that pyramid, you're looking at a total of what? 6400 total munitions that we will have that are JASM or LRASM. And that's a really constricted area. And when, Kathy and Jeff were talking about this modular, uh, capability in the next missile system, I'm a knuckle draggin fighter pilot.

I look at that as the Lego missile, right? You can take this Lego piece and you can put it on the, on the, as the seeker of the missile body, that's another Lego piece, and that allows us to actually broaden our supply chain and our, the number of folks who can build it. And so if we can expand that out to something on the order of 10 or 12, primes, if you will, that can actually do that workforce, both here in the States and with our allies.

And the allies are a huge question mark with this, their capabilities, their magazine depth. If we can do that, then we're going to help everybody out. The one fundamental driver in all that is going to be demand and the services have

to actually give the demand signal that's consistent with these folks that allows us to expand it out.

Right now, the total number of missiles that we're building a year at LRASM, um, a total of 200. Um, JASM, a total of 600, you're talking about a total of 800 missiles a year. And that's hard. It's hard enough to keep two, primes in the fight with that much less broadened out to 12.

[00:22:18] **Heather "Lucky" Penney:** Yeah. It's time for us to stop raiding the munitions accounts and start building up our stockpile and the M series weapons that you just described, these, this Lego of, of weapons capabilities, whether or not that's a seeker, the bomb body, uh, et cetera.

That gives us. Not only the range of characteristics and attributes of the weapon, but also allows us to Lego it together in the ways that we need, Jeff, I see you nodding over there. What did you want to add?

[00:22:44] **Jeff Peters:** You know, I totally agree from an industry perspective. When you look at how do you go face into the, you know, how do you meet this demand?

This is not a problem that can be solved overnight. Industrial capacity isn't something that you could just flip on, uh, and it's definitely can't be solved by just giving bigger contracts to the same players. So I totally agree with JV sentiment from a source of supply. We got to go and diversify the primes, and, you know, to go hit those 200,000 aim points or more, you got to go diversify that out to be 10 12 more companies, but really, really enjoyed the, what was it?

I think the Lego bricks discussion because when I look at how do you, build out that industrial capability? Another way that you can do that is you invest in technologies that can be used across multiple platforms, right? Not one off solutions. And an example that I use is if you look at our navigation and sensor solutions business, yeah.

That business provides GPS solutions for most of the U. S. Weapons platforms. And we have this great GPS module called a Sabre. And today it's used on JDAMS. Right now, that same exact Sabre GPS module is also used on a number of the exquisite class weapons, same hardware built on the same production line.

So when it comes time to go ramp those weapons and ramp them to the thousands, It's easy for that team because they're already running down a

common production line that's already scaled to tens of thousands of units. We can do that exact same thing with other subsystems, whether that's seekers or other electronics that you have as a payload.

[00:24:18] **Heather "Lucky" Penney:** Yeah, when you, have that sort of Lego type of approach, and you've got a number of different companies that are producing this, then it just simply becomes a matter of how can you scale and increase the rate of production per year annually, um, and then you are able to gain the economies of mass, right?

So that brings each unit price down. And so there's goodness to be had around all of that. I, Jeff, I'd like you to dig even further into what meeting that level of demand means from an industrial based perspective, because we also know that again, like you said, you can't just flip on a switch and suddenly do a step function change in terms of your production rate.

I mean, you need to be able to have some level of predictability to make the investments, to enhance not only the size, the scale of the production facility, but also invest in the workers that you need and the training that they require to be able to produce the quality articles that were coming off the back end of the line, as well as invest in the raw materials.

So, as I explained to the opener, we, we face a major munitions deficit. Um, could we build our way out of this given the levers we have available today?

[00:25:23] **Jeff Peters:** So I think some of that discussion goes to you have to change your approach on how you're going about it, right? We, we talked about the need to have more players on the field, and that's both at the prime level and at the sub tier level, we talked about design for modularity.

And then I think a little bit earlier, the discussion came up of clear demand signals from DoD. You know, if you look over time, go back to those 1990s to where we are now. Industry has optimized their cost basis at a level lower than what's going to be needed to hit all of those aim points that JV described.

And same as the, the previous discussion, that's not just within the four walls of the top level integrators, that's through multiple levels of the supply chain. So as we go and look at our contracts that we have today, where we're making investments and where we're focusing with our customers, is to go diversify our supply chain and make that investment now to bring on multiple sources of supply for those critical subcomponents.

Because if you don't start doing that work today, you're going to see disruption down the road and you mentioned workforce. That's absolutely true along the way. Right? You can't go and train a new production line overnight. You need to organically develop that capability and that takes investment and foresight up front.

[00:26:42] **Heather "Lucky" Penney:** Yeah, and I mean, once you've trained those workers, I mean, that's an investment that you've made. And frankly, as far as I'm concerned, that's a national asset. So Kathy, what about the capability part of the equation? History's made it clear that we want as much precision strike as possible. Not only because that makes our operations more effective, but that also increases flexibility across the broader campaign because then we can use the munitions we have against other targets. And Ukraine, if anything, has taught us that the legacy ways that we've secured that, especially on the affordable end of things, may no longer be a secure bet. So how do we take the notion of affordable mass with tech that will still work when facing a peer adversary?

[00:27:23] **Dr. Kathy Bihari:** Lucky as you and JV know, facing peer and near peer adversaries are particularly challenging. And as JV described, the U. S. has some of the most sophisticated weapons in the world. However, they come with a pretty hefty price tag. And as we face increasingly sophisticated adversaries, we need to think of ways to augment those exquisite weapons with a complement of affordable solutions, which is exactly what we've been talking about.

There is no one size fits all weapon. And so we need to develop a layered engagement strategy where we can use a suite of these weapons. We want to augment our existing inventory with new low-cost technology. This is JV's Lego model. I like to think of it as Mr. Potato Head, where I can put on a different hat.

And I think a really good example of this is the APKWS laser guided kit. So we took an existing Hydra unguided rocket and we put a guidance kit on it to make it more accurate. But not only did we do that, we made it modular. You could put on a different warhead, you could put on a different rocket motor, you could put on a different fuse, and that allows you to be very flexible to meet the mission needs. And we're all doing this at a very low cost.

[00:28:35] **Heather "Lucky" Penney:** That's phenomenal. I mean, I just imagine what, you know, a planner and the NPC is looking at when they've been given new assignments from the ATO and they go, okay, what do we got

in the bomb dump and allows them to be a lot more flexible. And so those units that are forward in the battle space have a lot more utility.

They're not limited by the types of weapons that they have. You know, JV, I want to kind of go back a little bit because first of all, we need to foot stomp. We have to have more weapons than DMPI. We cannot assume that it's going to be a one for one. And those weapons have to be affordable so we can meet the stockpile required.

We talked about the ranges imposed by First Island, Second Island, you know, or are we operating out of Hawaii or even the west coast of the U.S.? Those long range, really long range weapons, are crazy expensive. And once you use them, you lose them. Like, that's the nature of munitions, right? You don't get to They don't come back, land, and you reload them, and they go again.

I mean, that's, that's what the aircraft are for. So there's actually a sweet spot. Gonzo did a great study on this with his affordable mass paper regarding what the sweet spot was of, of range. And payload for the weapons, right? So we're actually talking about like, what's the actual range of the weapon in terms of cost?

Because he was, he was looking at cost and how that affected your inventory, how many weapons you could then have in the inventory. As you mentioned, it's kind of like 200 mile range is kind of the sweet spot. So we still need to be able to get inside bad guy land in order to be able to get close enough to the targets and release the weapons from there.

I'd like to pivot though and have you dive deeper into Mr. Potato Head or the Lego series M series initiative. And what those objectives are meant to address. So the goal here is i'd like to give the Air Force credit for recognizing the problem and going after it in a very productive way

[00:30:19] **John "JV" Venable:** So just gonna say right up front Kathy's right. I overstated my intellect. I never really qualified for the for the legos I was always a Mr. Potato head person as well. So well done. So this idea that you can actually build a munition that meets your needs, for long range or shorter range, for a larger explosive or a smaller explosive for a more precise or a less precise target.

You can also take that same bomb body and, and figure out, do you need stealth? Or do you not need stealth? Yeah. So, the 158 series, if you get wrapped up in the paperwork of JASM versus LRASM, it's, they're both 158

series munitions. They look a lot alike. One is stealth and one is more lower end on the radar detection capability.

So you actually have the ability to pick and choose all of these. The, the, the biggest thing with regard to the battle of goods though, when you talk about a heavy, explosive capability. So, a large fragmentation capability. A lot of weight is going to go a lesser amount of range, right? Whereas a smaller munition, uh, uh,

[00:31:30] **Heather "Lucky" Penney:** Weighs less and is going to be able to go further.

[00:31:33] **John "JV" Venable:** Exactly.

[00:31:33] **Heather "Lucky" Penney:** But not as much boom, not as much kinetic effect.

[00:31:35] **John "JV" Venable:** So when we start thinking about this, and in a very, um, foggy war, Your precision of a very small explosive device may be actually countered by the jamming that's hitting that munition. And so you're hit as opposed to a 10 feet circular error probable.

[00:31:56] **Heather "Lucky" Penney:** There are times when close enough is not good enough.

[00:31:58] **John "JV" Venable:** Exactly right. So the. The fundamental caveman, I need big boom, right? I need big boom. Sometimes you have to sacrifice that distance. Drive in a little bit further with a heavier warhead. And, and make that get close to the target and then have the same effect. So it's a trade off. It's a battle of goods. And with this modular concept, with the Lego of Mr. Potato Head concept, we have that capability.

[00:32:25] **Heather "Lucky" Penney:** I just want to make sure that the Air Force planners know that we're, we've now reduced the M series weapons to Mr. Potato Head.

[00:32:30] **John "JV" Venable:** It. Oh, it's not the M series. It's the MP series, Mr. Potato Head.

[00:32:35] **Heather "Lucky" Penney:** There you go. There you go. so Jeff, we're going to move on to a different acronym, regarding open mission systems.

So I think folks in business call it the weapon open systems architecture or WOSA for short. So how is this shaping things?

[00:32:49] **Jeff Peters:** Yeah. So, I mean, WOSA is really just a continuation of a lot of this modularity discussion that we've been having. I think the important part of WOSA It reduces the barrier of entry, to some other, you know, potential partners on a particular platform. But the one thing that I would highlight also from a WOSA modular architecture is if you look at Ukraine and what we've learned over the last year, two years in Ukraine, it's that what is working today.

Might be totally irrelevant six months from now. Right. And by having an open architecture of these modular solutions, it's going to allow technology and then industry to be able to keep pace with the rate of change that we're actually seeing on the battlefield today. So being able to go and develop different solutions based on the actual real world challenges and scale them rapidly and drop them into existing architectures. That's what's going to enable the agility to both get technology to field at the quantity that you need.

[00:33:49] **Heather "Lucky" Penney:** That's awesome. And that really gets back to munitions being probably the most agile capability that we have on in the battle space to be able to respond to changing and dynamic threat environments.

So before we move off of WOSA, I do want to clarify, is WOSA about integrating in a modular way, the components of the weapon itself or integrating an M series weapon onto any aircraft?

[00:34:13] **Dr. Kathy Bihari:** That's a great clarifying question. WOSA is a standardized architecture of a weapon, which includes its interfaces and its messages. And this flexible or modular approach allows for parts to be connected or combined in a lot of different ways. And with this modular approach, it allows you to plug and play different manufacturers components, for example, secret components, which leads to reduced weapon system costs and enhanced performance.

[00:34:38] **Heather "Lucky" Penney:** Okay. No, thank you very much because it's not very clear from the WOSA, um, acronym, whether or not, as long as it's Seek Eagle, the body is seagulled onto an aircraft that you're good to go, whether or not that was the interface or whether or not it was the actual, weapon interface internal to the weapon, if that makes sense.

[00:34:56] **Dr. Kathy Bihari:** It does. And I think that what makes this so attractive is that it allows you to apply these interfaces to a class of weapons so that you're not tied to one specific design, one specific, weapon. It allows you to be a lot more flexible in that integration,

[00:35:12] **Heather "Lucky" Penney:** Which again, gets back to agility. So Can you provide us some concrete examples of. weapons that you're developing or munitions that you're currently working on to really kind of prove out the theory of the WOSA case?

[00:35:25] **Dr. Kathy Bihari:** Absolutely. And I think the beauty of the approach is that it's not about a specific example. It's really about being able to apply this idea to an entire class of weapons.

So if you think of a class of weapons, for example, let's say a JDAM small diameter bomb type class of weapons, I can leverage the definitions of WOSA in order to develop a platform agnostic seeker. Now, each weapon might need a slightly different mounting mechanical interface for that seeker. Think something like mounting brackets that are a little bit different.

But the seeker itself will have WOSA compliant interfaces. And what that means is I don't need a bespoke platform specific design. My cost of integration is going to be vastly reduced because of that. And I can build the exact same system for multiple platforms, and I'm going to reduce my cost by volume through that approach.

And further, we talked about modularity, and I can develop a modular seeker so that I can put the components I need into a seeker to meet a given mission. So I'm not putting oversized capability on a weapon when I don't need it. And it's also not just about hardware. It's also about software.

Because I have standard interfaces, I could load different software depending on my mission, today is an air mission, I'm going to make sure my weapon has the air to air mission software. Tomorrow it's air to ground, I'll put the air to ground software in there. So it's all about flexibility and, as you said, agility.

[00:36:45] **Heather "Lucky" Penney:**

And just to be clarified for our audience, when you're talking about platform, you're not talking about airplane, you're talking about weapon body.

[00:36:53] **Dr. Kathy Bihari:** I am talking about weapon body, correct, when I talk about platform.

[00:36:57] **Heather "Lucky" Penney:** You know, one of my pet peeves, I want us to stop talking, in the Air Force circles, stop talking about aircraft as, platforms. No, they're airplanes. and also just start calling weapons, weapons, and so forth pet rock right there. Okay. so Kathy, what about our allies? I mean, everyone knows that they're going to be a hugely important part of the capacity equation. And they also need these capabilities.

So how do we ensure that they get these weapons and all of the associated elements that we've just been talking about in their hands? How does that factor into your efforts?

[00:37:34] **Dr. Kathy Bihari:** Yeah, so absolutely. We want to consider our allies and our partners as we're developing products and solutions. We're certainly thinking of the needs of our U.S. forces, but we're also thinking about how we can meet the needs of those critical allies. As we go through designs, we consider design for affordability wherever we can. And a really good example of that is our GPS systems, where we are able to share those with authorized allies and partners in dozens of countries.

[00:38:02] **Heather "Lucky" Penney:** And I imagine the fact that it's modular allows you to create more options for allies and partners and, you know, scalable because you just, because you can break those down in smaller components and the pieces that aren't exportable don't prohibit you from exporting other elements that are.

[00:38:17] **Dr. Kathy Bihari:** Exactly, and you can assemble those modular components in ways that are meaningful and appropriate, given the situation that you're in.

[00:38:24] **Heather "Lucky" Penney:** Perfect.

[00:38:25] **John "JV" Venable:** Yeah, look, if I could jump in, I love Kathy's words. This idea that our allies and partners have to be in the process of building and developing and maybe not developing, but certainly. in, uh, producing these munitions is very important. Go back to a little history, when we took on Libya as a joint, allied campaign, we dropped a total of about 7,000 munitions in that, four-month war.

The allies in Europe were out of munitions at the six week point. So they went back and they decided to pool their resources and buy into a JDAM, stockpile. And if you go and do the math and use Desert Storm numbers of 5,000 munitions a day, they have three and a half days worth of munitions in that stockpile.

You go to our allies and partners, right now in the Pacific and Grace Kelly talked about how big of a player Japan and Australia are going to be, but our, total, foreign military sales in that ballpark. have not equated to one week's worth of munitions. It's markedly less than that. And so when, the balloon goes up, We're not just going to be providing U.S. assets these munitions, we're going to be relied on by our allies and partners to give them these munitions unless we've actually modularized this to the point where they're producing them in their countries and they can take care of their own needs. This is a big deal and it's one of those things we've got to figure out now.

[00:39:50] **Heather "Lucky" Penney:** Yeah, being able to license and then export that technology so they can be part of the production. Uh, piece because, you know, we might be living in an information age, but war is still fundamentally industrial. We still have to make sure we've got the industrial capacity to produce at volume and at scale. So, you know, we take the number of dippies that we talked about, add a little bit for mom and pop. And then you also have to add a little bit, actually a lot, for our partners and our allies.

[00:40:16] **John "JV" Venable:** Absolutely.

[00:40:17] **Heather "Lucky" Penney:** So, given this imperative for affordable mass, because we're talking about numbers, what implications does that have for the way that we approach force design, especially from the Air Force perspective?

[00:40:26] **John "JV" Venable:** Numbers matter. It turns out and, we have been decreasing capacity in, uh, I'll move away from the term platforms because I never liked it either, in aircraft that can deliver these munitions, bombers and fighters that can do it. And we've been decreasing that markedly to the point right now where we would have a very big challenge in manifesting the same force that we projected into Desert Storm against a China.

And, and now we're talking about big differences, both in our, the number of munitions that we have, the duration of that conflict and how many, aircraft fighters and bombers that we have to deliver them. We have to turn that equation around.

[00:41:03] **Heather "Lucky" Penney:** Well, and I would also argue it means that the Air Force needs to remain an inside force. We have to be able to operate from inside the first island chain, be based in the first island chain. Okay. And be able to operate and penetrate bad guy land.

[00:41:13] **John "JV" Venable:** So the paradigm shifts here are ginormous, right? You're not just talking about one for one munition. You're talking about the willingness to put aircraft and human beings at risk, knowing that you're going to have losses in that. And that is a completely different mindset. If you go back to, I think it was Mattis who may have said this, "what are you looking for in your next admiral?" He said, "I'm looking for an admiral who can take the loss of a carrier and continue to fight." And that's the mindset that we have to adopt going forward. We need a lot of everything because, just because we have 12 missiles on an aircraft, it doesn't mean that that aircraft is going to survive long enough to launch them. We have to get back into that mindset.

[00:41:58] **Heather "Lucky" Penney:** Yeah. And if you're talking about long, those super long range munitions, you know, we need to understand that that's going to have, attrition losses as well.

Absolutely. So just because we're firing it from the third island chain or even the West coast doesn't mean that that particular missile is going to necessarily make it to its target. Right. Certainly isn't going to be able to service the number of DMPI, be able to hit as many targets as an aircraft that's actually penetrating.

So I'm glad you mentioned Madison, the Admiral, right? That example, because we're going to sort of shift from just looking at this from an Air Force lens. To Jeff, how are these things that stacking up for the other services? How do you see their munitions requirements and how you're working to meet them?

[00:42:36] **Jeff Peters:** Yeah, we're so we're working across the services. I think one common challenge that we're seeing and we're working with every service is counter UAS and actually. Another way to look at solving the math of affordable mass is, can you go repurpose existing inventories to new missions? Right? So I think BAE has a really good legacy of doing this.

Kathy mentioned earlier, our APKWS guidance solution. Uh, so that's a legacy system. Take a Hydra-70 unguided rocket and go turn it into a precision munition really at a very low cost. That's a great history there of APK being used in air to ground applications.

Fast forward to today one of the biggest cost per effect challenges we have across all of the services right now is how do you go shoot down a group two or a group three drone? And how do you do it from the land? And how do you do it from the air? And how do you go do that without spending hundreds of thousands of dollars, if not millions of dollars per intercept shooting down what's really a \$50,000 drone.

Right. So working across DoD we've been able to go deploy a PKWS to theater for counter UAS and shoot down those drones for a fraction of the cost of any other interceptor and our factories producing over a thousand of those a month. Right, 1000 a month. So we're working across the services there.

And then the other thing I'd point out is working in particular with the Army in long range projectiles. And a lot of that discussion today is centered around that same thought of how do you know that your solution today is going to be relevant 6 months or a year from now and going back to another spin on that discussion of affordable mass.

Another way to solve that equation, especially when you're talking about projectiles is your P hit. And if you can increase your P hit, you can drastically reduce the number of the base projectiles that you have to build to be able to cause the effect that you're looking to achieve. It's a really complex trade space. And I think the services are all looking at it within their own lens.

[00:44:33] **Heather "Lucky" Penney:** Yeah, no, I P hit is basically it's, it's the probability of kill. And that's just another way of looking at precision. Do you, are you able to get that bullet kinetically on target. And that's something I really like because it's about physics, right?

You know, but, but clearly it's, it's a lot more, complex because you're having to deal with the aiming solution and the guidance solution and so forth. And what you're doing, um, to be able to target those drones and to change the cost equation is really important. It's going to be crucial to ensuring, base survivability.

Those are not necessarily threats that we're thinking of in terms of the long ranges for the Air Force when it comes to be able to protect our base and continue to operate outside of our bases, that's going to be crucial from the Air Force perspective, but you're clearly aggressive, aggressively attacking some of the problems we're seeing in the Middle East with the Houthis and Yemen, so forth. So thank you again for what your team is doing. You're clearly on the side of the warfighter.

[00:45:24] **Jeff Peters:** Yeah. Very much appreciated. Thank you.

[00:45:27] **Heather "Lucky" Penney:** So, Kathy, what relationships do you have with the service labs that are helpful as you look at this process, both this near term adaptation that you've just described, and we've heard Jeff described as well, as well as evolving towards the future. Is there anything effort you'd like to highlight in particular?

[00:45:42] **Dr. Kathy Bihari:** Absolutely. That's a, that's a really important collaboration that we have with the service labs. They're helping us develop technology that we can move, use to move the capabilities of the warfighter to the next level. A really important example of that is QUICKSINK, which is an effort that's now in phase two with the Air Force Research Laboratory.

So, as you and most of your listeners know, QUICKSINK is a concept in naval warfare that's using a cost effective precision guided munition kit. Now, why is this important? Well, it's important because the detection, identification, and engagement of maritime targets over wide areas is a significant challenge.

We've been talking over the past few minutes about the number of targets that we're going to engage over those wide areas as well. So QUICKSINK was a proof of concept demonstration under the Maritime Weapon Improvement Program Joint Capability Technology Demonstration, or MWEPJCTD for those of us that prefer shorter acronyms.

[00:46:37] **Heather "Lucky" Penney:** We got a lot of acronyms going on here.

[00:46:39] **John "JV" Venable:** I just about lost consciousness there. That was a big one.

[00:46:43] **Dr. Kathy Bihari:** Well, QUICKSINK uses a WOSA compliant all weather open system architecture, and the significance of this is huge. As we have discussed, WOSA compliance means we can take this seeker that targets maritime threats and adapt it for other missions while maintaining those affordable mask goals.

In fact, Secretary of the Air Force Frank Kendall has spoken publicly about what a deterrence QUICKSINK is based on the recent results of maritime exercises in the Pacific. And I think this is exactly what we need. We need increased deterrence. Then it's also cost effective.

[00:47:15] **Heather "Lucky" Penney:** So I have to say, I like, I like the term QUICKSINK because it articulates, look, we're going to be able to go sink your boats really fast in any weather, any time.

So that sort of brings up another piece is the multi domain, right? I'm moving from counter maritime and looking at this multi domain piece. Because we now live in a world where we need to be able to effectively and collaboratively operate in multiple domains to ensure that a weapon achieves the desired effect.

So, for example, a missile carried aboard an aircraft may use a space based data link to receive target updates that might come from a range of air, sea, or surface data. So that also touches on cyberspace and communication. Jeff and Kathy, what does that mean for you from an innovation perspective? How are you looking at knitting this together? Because that involves a lot of different talent pools and technical expertise that might not have really talked a lot in the past. How are you and your folks working that demand signal across BAE?

[00:48:12] **Dr. Kathy Bihari:** Absolutely, that's a critical problem. And breaking down those stovepipes is going to be important for us to find success.

I think we have an opportunity to develop innovative solutions, leveraging technology and concepts from multiple domains in new and novel ways. I really like to be able to take something that's old in one domain and apply it to a new domain where it's a new and exciting solution. And we're always looking for opportunities where we can leverage existing technologies as well as develop new technologies in order to get those capabilities out to the warfighter.

At BAE Systems, we have an R&D organization, FAST labs, staffed with researchers working on cutting edge technology, and we collaborate closely with them so that we can increase the technology readiness level of those technologies and work to get them out into the field to the warfighter as quickly as possible.

We also use operational analysis and digital engineering and modeling to evaluate our solutions. And what this means is we take performance models of individual systems and we combine them into integrated engagement scenarios and we can look at the performance of different combinations of sensors, aircraft and weapons against representative threat lay downs.

And using those high fidelity solutions, we can look at how those solutions help us close the kill chain. We can compare the performance of these exquisite, expensive weapons with affordable mass solutions, and we can also look at how

combinations of them might work well together. And we can evaluate all sorts of metrics, including things like cost per engagement.

Through digital engineering, we can consider a lot of these solutions, and we can also incorporate some of the technology that's being incorporated by FAST labs. And we can use this operational analysis to then inform requirements and build capability into these multi domain solutions so that they can address multiple missions, further increasing the flexibility of engagement options for the warfighter.

[00:50:05] **Heather "Lucky" Penney:** Okay, Kathy, you're totally getting my inner geek like super excited because you're talking about being able to, to model and evaluate, not just the design of the weapon versus the target. So the Joint Munitions Effectiveness Manual, how likely is it going to be to kill the target?

But also its survivability, is it going to be able to get to the target? So we're then layering its effectiveness against the target set, against the survivability of the threat lay down. And then how can we maybe use different types of munitions to achieve a synergy? To increase our probability of a kill and do that in a cost effective manner. Like that's crazy exciting. Like I said, I just touches my inner geek.

[00:50:48] **Dr. Kathy Bihari:** Well, you're welcome. And I think it's exciting because, because we're doing this digitally, we're not building a lot of hardware. We're not doing a lot of flight testing. We can answer a whole lot of what if questions and then focus our energies in really exciting ways.

[00:51:03] **Heather "Lucky" Penney:** Well, yeah, because then you can evaluate what your high probability is and then take that to live testing. And that's, I mean, that's really a huge value of the digital engineering environment is we still have to move into the physical real world. And validate because there are some cases, especially on the edge of those engineering models where we, don't necessarily know all the answers, but it gives you the lines of inquiry where you can go test that in the physical real world.

So JV, we've talked about booms. let's talk about booms again. When I'm saying booms, I'm not talking about aerial tanking. I'm talking about blowing stuff up because that's exciting and really important when it comes to delivering the effects, whether or not it's kinetic or non kinetic against adversary threats and targets.

So no matter how much innovation we, have in the mix or the multi domain capabilities, you know, space, air, ground, sea, we still need the warheads of sufficient size and power to net the desired effects, especially when so many targets in a peer conflict will likely be armored, deeply buried, hardened, or mobile.

I mean, that's a key reason why the aircraft that deliver these munitions are so important because there is that trade off of distance and range and explosive power and cost effectiveness. So I'd love to hear your thoughts on where the sweet spot is there.

[00:52:18] **John "JV" Venable:** Yeah. So it's all of the above, except there's one more factor, and that's the air crews.

So we've talked about the aircraft, we've talked about the munitions, we've talked about the threat even, but we haven't talked about the threat, the, uh, the competency, the currency and the capabilities of our air crews. The worst kind of evaluation you can get is the one that comes in combat. Only your grade sheets are handed back to you in combat losses.

And what we want is to win. We want to win the war, not by a little bit, but by a lot. We want to dominate this fight, not make it an even play. And so we need to bring our air crews up to the readiness levels that we knew during the Cold War. And that can be done. We need to bring our aircraft capacity up to a level that we had during the Cold War.

And that can be done. And then we need these weapons to come in sufficient numbers. And with the variety that we're talking about, be it, uh, Mr. Potato Head munitions or other, we need to have each one of those capabilities in hand or else we may find ourselves on the bad side of the grade sheets and we can't afford that.

[00:53:28] **Heather "Lucky" Penney:** It is our moral obligation to ensure that we provide the equipment, the tools, to our warfighters so they go into bad guy land, execute their mission successfully, and come home safely.

[00:53:36] **John "JV" Venable:** Absolutely.

[00:53:38] **Heather "Lucky" Penney:** So Jeff and Kathy, what does getting on the right track look like so that we have both the necessary munitions capabilities and capacity? How should we grade DoD and the Air Force's homework five and ten years from now?

[00:53:50] **Dr. Kathy Bihari:** Well, Lucky, I think getting on track means doing all of the things that we've been talking about today. We need to embrace affordable mass and the technology solutions we've discussed in order to adequately supply our warfighter to engage with peer adversaries.

We have to continually adapt existing inventories and develop an industry base with platform agnostic solutions. If we do all of those things, I think the DoD and the Air Force gets a good grade on their homework.

[00:54:16] **Heather "Lucky" Penney:** They get a good grade sheet. But again, it always comes back down to what happens in combat.

[00:54:21] **Jeff Peters:** Yeah, you know, at the end of the day, I, I think it comes down to, for me, uh, we need to get more players on the field building these, these munitions. Uh, we need to build lower cost precision munitions and we need to do it with modular architectures and at the end of the day, you know, the scorecard is going to read by are we getting enough rounds into inventory? Are we projecting to hit those slide slopes that we need? Because at the very end of the day, the most important thing is we got to get our warfighters the tools that they need and they have to be the right tools and they have to be in the right quantity.

[00:54:52] **Heather "Lucky" Penney:** Amen. Well, thank you all for joining us today to talk about this. It's been a really great conversation and I look forward to having you all back again.

[00:55:00] **John "JV" Venable:** Yeah, it's been a wonderful getting to know you, Kathy and Jeff. I agree with everything you said. I do have to question your wall hangings, Jeff, because you've got a picture of the second best jet demonstration team on the wall there.

And I think if you're going to do that, you ought to have a picture of the first best jet demonstration team.

[00:55:18] **Heather "Lucky" Penney:** If y'all aren't following. JV was a Thunderbird, and unfortunately, we're seeing the Blue Angels in the back of Jeff's wall.

[00:55:30] **Jeff Peters:** I'll try harder next time, but thank you for having us today. It was, it was really a great discussion.

[00:55:36] **Dr. Kathy Bihari:** Yeah, it's been a wonderful opportunity to talk with you today. Thank you so much.

[00:55:41] **Heather "Lucky" Penney:** With that, I'd like to extend a big thank you to our guests for joining in today's discussion. I'd also like to extend a big thank you to you, our listeners, for your continued support and for tuning into today's show.

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