AA173\_U2\_Reaper

**John "Slick" Baum:** [00:00:00] Welcome to the Aerospace Advantage Podcast. I'm your host, John Slick Baum here on the Aerospace Advantage. We speak with leaders in the DOD industry and other subject matter experts who explore the intersection of strategy, operational concepts, technology and policy when it comes to aerospace power.

So if you like learning about aerospace power, you are in the right place. To our regular listeners, welcome back and if it's your first time here, thank you so much for joining us. As a reminder, if you like what you're hearing today, do us a favor and follow our show. Please give us a like and leave a comment so that we can keep charting the trajectories that matter to you most.

Intelligence, Surveillance, and Reconnaissance. ISR. It's one of the most critical missions when it comes to any military operation. It all comes down to understanding the context in which you're operating and securing a decision advantage over your adversary. You need timely information to maximize opportunities while minimizing points of vulnerability.

Aircraft have long been [00:01:00] associated with this mission and that's what we're here to discuss today. How the mission has evolved, what stayed the same, and where we think things are going in the future. And I get it, there's a ton of focus with ISR increasingly going to space, but it's important to recognize that we are the strongest when we can present a multi domain set of capabilities.

We don't want single points of failure, and there are strengths and weaknesses with each solution path, so at Mitchell, we are huge advocates of ISR through an aerospace lens. We are going to explore the air side of the ISR equation by focusing on two of the most iconic aircraft to ever execute the mission, the U-2 Dragon Lady and the MQ-9 Reaper.

The U-2 Dragon Lady, designed by the famed Lockheed Skunk Works, is one of the most notable and historic aircraft ever designed, and given so many decades of service, it's hard to believe the aircraft's operational life is in its sunset phase. That said, it's still hugely capable, [00:02:00] in high demand, and we can learn a lot by studying it.

The aircraft came into being thanks to the pressures of the Cold War. The Soviet Union posed a major threat, and we wanted to avoid operational surprise. They had significant aerial defenses, so leaders wanted to fly above them, hence the incredible altitude performance of the jet. The shootdown of Francis Gary Powers on May 1st, 1960 changed the types of flight profiles we executed, but the aircraft have always been super active since they first entered the inventory.

And it has continually evolved to ensure its relevance for today's combat demands. To help us understand this mission, we have the distinct honor to discuss the Dragon Lady with Major General H. D. Jake Palumbo, the highest ranking officer to fly the U-2 in combat. Jake's experience goes well beyond the Cold War history of the U-2 and highlights what airmen do best.

Innovate under pressure to provide mission impact in the air and on the [00:03:00] battlefield. The other part of the equation, and a more recent development, is the MQ-9 Reaper, an uncrewed, remotely piloted aircraft that is both a sensor and a shooter. The aircraft evolved from the MQ-1 Predator and was an absolute rock star over the past two decades.

People associate it most with Afghanistan and Iraq, but trust me, it serves all over the globe and that type of broad employment is going to continue. The flexibility to execute long dwell missions, not put a human at risk, gather tremendous amount of real time information and have the ability to execute kinetic strikes is absolutely incredible.

Other sorts of mission pods can also be loaded to the Reaper, making it super flexible as a multi role asset. I am really excited to have Lieutenant Colonel Johnny Duray back on the podcast to discuss how the MQ-9 has evolved, understand where it's going, and key considerations we should think about as we look to meet a broad range of mission demands.

Johnny was one of the [00:04:00] first to talk about Reaper on Season 1 of this podcast, and if you missed it, please listen to Fear the Reaper, Episode 15 of the Aerospace Advantage. Bottom line, these aircraft and their crews are second to none. They've revolutionized what it means to secure the decision advantage in modern combat operations.

And that's what we're discussing today on the Aerospace Advantage. Well, General Palumbo, sir, welcome to the podcast. It is great to have you here today.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Hey Slick, it's great to see you and hear you again and very nice to meet Johnny. Johnny, good to meet you as well.

**John "Slick" Baum:** Well, awesome. And Jake, sir, thanks so much for helping me introduce Lieutenant Colonel Duray.

We've had Johnny Duray on the Aerospace Advantage. He really helped us out getting kicked off with a great episode in season one. And I can't believe Johnny, we're in season four now. So thanks so much for helping us get kicked off and thanks for being back.

**Lt Col Johnny Duray:** Yeah, thanks so much, Slick. I greatly appreciate it, I didn't realize it's been that long time flies and we're having a good time and sir It's been a pleasure to meet you as well this morning.

**John "Slick" Baum:** Well [00:05:00] guys, we're just gonna jump right into it because we've got a lot that we want to cover and Jake, sir, I want to get started with you. You know, you are a U.S.

Air Force Academy graduate. You've flown every block and tape of the F-16. You're a fighter weapons school graduate and commander at the squadron, wing, numbered air force, you name it, command. How did you end up as a U-2 pilot, as a general officer?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah, slick. It's a question I've asked myself many times and I appreciate the chance to go through it.

I think that really it had to do with the fact that before I went to Beale Air Force Base, I was a colonel in the Pentagon in the Joint Staff and the J3. And one of my duties was to shepherd a sensitive, reconnaissance operations book through the Joint Staff and up to the SECDEF and then ultimately I think it made its way across the river to the President and back. And we'd get a okays or [00:06:00] you know caveats to what we were trying to do around the world. So since I knew so much about the SRO book and what was going on in the intelligence surveillance reconnaissance world.

I think they said, "what the heck he's been flying Vipers forever. Why don't we send him to Beale and see if he can handle the Dragon Lady." So, I think that's how it happened, Slick.

**John "Slick" Baum:** Well, absolutely incredible, sir. I just find it fascinating because, you know, if most folks were asked, "would you want to fly the U-2?" You would hear the resounding, "yes" echo in the room.

You know, there aren't a lot of folks that you meet every day. It's not like you're going to stand in the checkout line or at the line of the grocery store and, and probably bump into a U-2 pilot. So your experience is absolutely just incredible. So can you give us some insight though. I mean, you were selected as a general officer based on all of your accolades before.

What is it like to get selected? You know, I assume there's physical requirements, you know, above and beyond the normal class one flight physical that, that most people are probably familiar with.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah. It's, it's interesting [00:07:00] because as the 9th Reconnaissance Wing Commander, as "RECCE One," as I was called at Beale. I was the last line of review for new U-2 pilots, and so as we got them in, I would get them in my office after they had gone through their first three rides to make sure they had the ability to fly the airplane.

And then one of the, one of the main questions I'd ask them, Slick, was, "Hey, what the heck? Where did you hear about us? Why do you want to fly this jet? And, and what is it that really has got you sitting in my office today?" And, and the stories were wide and diverse. And listen, I mean, we got Navy guys in there.

We got Marine Corps pilots in there and gals that wanted to fly the Deuce. And I think what it is, is the adventure, Slick. You are a mission commander, you are on your own, you are alone, wherever you're going in the world, around the world, you can self deploy, [00:08:00] and if you were like me, which most of them weren't, but if you were like me, you were scared as hell.

I mean, I was alone and afraid a lot of the times, especially if I flew at night in Afghanistan. So, it's a tough airplane to fly. And incidentally, a number of the young O3s that I interviewed while I was the wing commander. Now, they're very senior U-2 pilots in the program. In fact, the current Vice Commander of Beale, Bog Bartran, James Bartran, wonderful guy, but I interviewed him as a young captain and said, "Hey Bog, what in the world are you doing in my office wanting to fly the U-2?" And here he is now one of the most senior U-2 pilots in the Air Force.

**John "Slick" Baum:** Yeah, it's just, again, just fascinating. And that the adventure part that you bring to the table on this discussion, of course, is just, I think it's every young person's dream to live a life of adventure. And you certainly do that in, and I love when you call it the "Deuce," in the U-2. And sir, you know, I tried to lay it out in the [00:09:00] opening, but can you walk us through the U-2 history from an ISR mission perspective?

I mean, when it began in the 1950s, it was really focused on the national intelligence mission. You know, pictures that were processed and given to the most senior decision makers. And today the jet is engaged in a broader set of... to a broader set of customers, right? From the strategic to operational and even tactical.

So can you talk to us about how this evolution played out?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah, it's a great story and it's going to be told a few more times in detail because of the pending retirement of the airplane. But, to put it into perspective, you know, my U-2 number is 826. We're probably sitting at around 1100 pilots that have flown the U-2 in its 60 plus year history.

But when you think about, what Kelly Johnson was asked to do when he was was told, "we need you to get an airplane that can do this, this, [00:10:00] and this, and we need it quickly because we've got to know what's going on in the Soviet Union." What he did was put an airplane that could fly really darn high.

He skipped things like fuel gauges and different things because every pound was like an extra foot of altitude that he could get or a hundred foot of altitude, maybe that he could get out of the airplane so they could fly over these SA-2s-and-3s. But all they were really doing Slick, was taking pictures.

All they were really doing was looking at the bad guy and figuring out, you know, where he was, where he's putting his missiles. To where we are today you know, fast-forward to 2024, the airplane (U-2) is an incredibly capable platform and it can do any kind of radar missions any kind of electro-optical and very, very sensitive missions with SIRES 2C or the different noses you can put on there.

It still can do Optical Bar Cam, but in some ways [00:11:00] that's really not that necessary anymore with the great things we have from space and from what Johnny's going to talk about different things. But, the other thing is it can listen. So we've evolved an airplane that can look at a lot of things. To an airplane and a platform, a sensor platform, that can look and listen at the same time. Then that "canoe" on the spine, that communications tether pod, can move terabytes of information, real time anywhere in the world as long as you've got the comms capability on the airplane. You've got a platform that can stare at the bad guy, stare at the enemy, stare at the adversary, and really give the combatant commanders what they need today to have their phase zero prep done, but also any of the lead up to combat conflict.

You can get real, real good ISR out of this platform. A lot of things have evolved and, and Kelly Johnson was amazing in [00:12:00] what he envisioned. He might, he might still not recognize it though today since we've modified it so much.

**John "Slick" Baum:** Yeah, it really is incredible. And it's funny that you just said the "Bar Camera" term, because I think I've talked about it, but not really in depth being an enlisted sensors guy when I was 17 and I got, you know, selected to go to this school and I got to work on all the various, you know, EO, IR, radar sensors on aircraft. But the U-2 was part of the program and, getting to work on that camera that obviously we weren't using anymore, but I still had to learn the information. You know, it was just absolutely incredible what the airplane could do back then, what it was still being asked to do in the 90s.

And now what it's doing today. So I've got to ask you, why do you think the U-2 is so adaptable? Because, you know, it's just incredible that it was, you know, think about this. This airplane was invented before color television. You know, when a telephone was a thing that was still bolted to the wall and the internet was decades away, and now it's a networked asset that is feeding information [00:13:00] age requirements across the battle space.

So why could this machine evolve so well in your opinion?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Well, "generator." It's got a big darn generator and this is one of the things that I think we'll find out, as we put some of these sensors on unmanned platforms, and we've already found out that you've got to have electricity to really power these huge sensors.

And so, because the core engine of the Deuce, Slick, is a Viper engine. It's a GE motor and it's just like you and I flew for a long time. You can really run a lot of gadgets that require electricity. So, that's one. Second thing is we've modified it to be able to really handle some very, very unique communications that permit probably 15 to 20 people to be on mission at any one time.

So, you know, I was alone and afraid in Afghanistan at [00:14:00] night in the middle of the winter, but I had 15 to 20 people that were working with me on mission. Just like we do today with other platforms that Johnny will talk about and that ability to communicate with the big "IC," if you will, the intelligence community widely around the world, then puts a combatant commander into a position where he or she can ask for specific things. It can get sorted out real time, passed back and forth, and those kinds of things become incredibly capable. And we can talk a little bit about it.

But, we're still doing it today. General Mobile Holmes, COMAC at the time. Mobile decided he would open a federal lab at Beale to try and take advantage of what the U-2 can do at altitude in a high altitude to really test new capabilities. And so this Fed lab is using open architecture, software integration techniques to really see what [00:15:00] else can be done when we get to high altitude, close to the enemy, over the enemy, over the adversary.

So, those are the things I think that make it really an incredible platform, Slick.

**John "Slick" Baum:** Yeah, I could not agree more. You know, I've had my, time trying to upgrade airplanes with smaller generators and it just doesn't work. I also want to ask you this, cause this is such a unique thing based on your broad experience, sir.

That you are the highest ranking officer to fly the U-2 in combat. And I know they say that rank has its privileges, but you know, you are flying this airplane with a different perspective than, you know, the average O3 or O4 in the Air Force. And at the time you were a commander in Afghanistan. And two things I want to ask you, first, how did you get to be a GO flying in combat when you were in Afghanistan?

And then, you know, with that mindset, I know we've talked about your ability to bring some new, you know, TTPs to the warfighter, which was really a game changer that really you only could have done the fact that [00:16:00] you had the strategic mindset as a general officer and you had, frankly, the rank to make some of these decisions. That you were able to bring so much capabilities to the warfighters on the ground.

Can you share that with us?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah, I mean there's a lot in that but first and foremost, you know, I grew up as a Viper driver, an F-16 pilot, and you said all blocks and models and engines, almost, almost. I never flew the block one. I flew the block one simulator for the F-16. I never, I have not flown the block 70 and I'm really upset about that.

And I'm still trying to get the Air Force to let me go back and get a block 70 sortie. But everything in between all engines, tapes, et cetera. And I went to weapon school and taught there. And so teaching at the weapon school really gets you, you know, an awareness of what other platforms and what the other services can do when we really get ready to go downtown.

So I'm flying the U-2, at Beale and I'm qualified. I'm high altitude qualified, and I'm [00:17:00] low altitude qualified. And I get a call from General Gary (aka. Norto). Norto says, "Jake, I want you to go be the Expeditionary Wing, 380th AW Commander at Al Dhafra. I need you to get over there pretty quickly. Tell Sandra, you know, we'll take care of her, but you're gone." And I said, "Okay, sir." And he goes, "What do you want to fly?" And I said, "Well, I want to fly F-16s."

And he goes, "That ain't gonna happen." And I said, "Well then, I'm going to fly the Deuce. And he goes, "That ain't going to happen." He goes, "You're going to fly the KC-10."

And I said, "That ain't going to happen." He said, "Okay, all right, we'll let you fly the U-2 since you're already qualified." And then I did another month's worth of training to get really mission ready in the airplane, which is wholly different than flying it. But here I am now, a weapons school instructor in the fighter world, and I'm going to fly the U-2 in OEF and OIF.

I never got down to the Horn of Africa. The captain schedulers would never let me do that. It was too far away and they thought I'd get [00:18:00] lost. But here I am. And what did we do? We really instituted a lot of tactics and reviews and different things. We didn't have a weapons and tactics officer in the wing when I was there at Beale.

So I instituted that, and then when we got over into the Middle East and into the OEF, OIF scenario, I really made sure the Deuce was tactically relevant to the warfighters on the ground. It ruffled a lot of feathers. We came off the black line more than we were supposed to, but I figured, "What are they going to do, fire me?"

So I ended up really, really making sure that people, warfighters knew that we were overhead the fight. If they needed us, we could put some tactically inserted ISR into the equation and some SIGINT, COMINT, ELINT, different things that maybe they never thought was available until we got over there. So that was my year of flying it in combat in both Iraq and Afghanistan.

And I said, [00:19:00] I was proficient. But I wasn't the best weapons and tactics officer in the U-2 at the time, Slick. There were a bunch of good guys and gals flying it.

**John "Slick" Baum:** Well, I'm sure. And again, that leadership challenge that, that you had, and it is pure leadership to where you're willing to hang it out on the line so you can bring capability to the folks at the bottom of the stack that need it.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah and General North, Norto, told me after I finished my year in the Middle East, he said, "You know what, Jake?" He goes, "I never slept while you were flying because I knew if you'd ended up in the wrong country on a divert with a crashed landing..." he goes, "both of us would have been relieved of command." And I laughed and said, "All right, boss, never let you down, did I?"

But Norto, was a, as good of a CFAC you'll ever work for, for sure.

**John "Slick" Baum:** Oh, for sure. I mean, and I've been lucky to work with him as well. Obviously, massively, separated in rank and responsibility, but yeah, another leader in the Air Force. That was absolutely great to work for. You [00:20:00] know, sir, you mentioned Kelly Johnson.

He's an absolute aviation legend. He designed the U-2 in the 50s. If he were able to see the jet today, what do you think would surprise him the most?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Well, I think he would probably be surprised at how survivable it is now. Remember, Gary Powers got shot down because he was predictable. And once he was predictable, and once they found him, they were able to really, you know, point those, that SA-2 right at the point of intended intercept and shoot that missile way up there.

And it happened. You know, the shoot down happened. Today, it's really not that possible because of the defensive systems the Deuce now has on it, because of the awareness the pilot has with so many linguists, so many people working and being on the mission, he would be surprised, I think, by the [00:21:00] survivability of the airplane.

So again, the biggest problem with the Deuce compared to the other high altitude unmanned systems we have right now is the pilot. It just gets really, you know, beyond the point of being able to fly any longer than eight, nine, 10 hours. And again, coming home from Afghanistan, it was a three hour commute to get home, Slick.

I'd been on mission in, in the country. You know, for five, six hours, and now I had a three hour commute. And it was tough to get home and land that airplane. So, you know, what Johnny does is really provide that very long range persistent stare that we need of the adversary. And that's probably still the limb fact in the airplane.

**John "Slick" Baum:** Well, thanks for that, sir. And what a great segue to bring in Lieutenant Colonel Johnny Duray into this. into this discussion. And, and I know there, there's a lot we can cover, you know, since Shakey also has experience in the RQ-4A Global Hawk. And we're going to talk about that in [00:22:00] a little bit. But, I know all of the UAV guys have the secret handshake and you can't share that with us.

And we obviously don't want you guys to dive into anything that could potentially be beyond the unclass level. But Johnny, you know, I just want to get some comparisons with, you know, high altitude ISR from the U-2 and how you gather and integrate information in theater with your MQ-9 and vice versa.

And, you know, what makes the RPA unique and distinct when you compare it to a man asset like the U-2.

**Lt Col Johnny Duray:** Yeah, that's a great question. I actually started my career by flying U-28s for my first six years. So, so a manned ISR platform, obviously, you know, different mission set, different attributes than what the U-2 does, but I had a chance to see that world before transitioning over to the RPA world so that allowed me to see both sides of it at this point too, which has been really advantageous.

So we'll start with some what I think are some obvious ones that are kind of like right off the bat when you'd be like, "I understand that would make sense from an RPA perspective" and then we'll dive into maybe some not so obvious ones to the average listener. [00:23:00] But I would say, you know, first and foremost, we've already hit on it.

The first thing to focus on as far as advantages of MQ-9s. You're really limited in your sortie length more by the air common in any way, shape or form to have two to three to four crews flying a single sortie, in the MQ-9 realm. And they'll cycle through it, you know, throughout that duration. And so, what that allows you to do is you're not limited necessarily by crew duty day or some of the other things that we have, where you are in the "man world."

That's just not applicable to the MQ-9. You're really limited eventually just by fuel and how long the aircraft can stay in the air. And even then, sometimes you actually, we struggled initially with the program where we were limited more by the fact that when you started going over 24 hours, it started getting really complex from a paperwork/admin perspective, as far as launch times and everything else like that.

And so we ended up keeping it below that in some ways when we first started out, just because it made a lot more sense from a paperwork perspective and whatnot. So [00:24:00] 19 to 21 hour sorties are fairly common in the platform. And so that's far and away, I think the first obvious one you think of. The second obvious one is your ALR, your "acceptable level risk," is just inherently higher with RPAs.

You can take a little bit more risk. It allows COCOMs to push boundaries that they might not necessarily be able to with manned aircraft. Now, obviously, you know, we still want to bring the birds back every single day. We still have technology and things on there that we need to keep protected from our adversaries.

But, when you take the actual human out of the loop in that regard, you're able to push the boundaries a little bit more with unmanned than you can with a man platform. So I think those are, you know, some of the obvious ones you think about right away. Some of the not so obvious ones that are advantageous to RPAs are, they fly really, really slow.

Which is disadvantageous when you're trying to transit large distances and you know, those three hour transit times, you know, I've sat through many of those plus. However, where it's really advantageous from a tactical execution standpoint is you can [00:25:00] essentially "park," I use park in quotations, overhead.

And so what that allows you to do, you know, from an ISR perspective is, I can see down what I'll call "Indiana Jones" type canyons or tight alleyways. Because you can just kind of sit there and use the wind in your favor. And you're not moving fast enough for some of these viewpoints that are tough to get to just fly right by.

Also, if you're looking for intel more along the realm of, you know, "Hey, how high is this door in this alleyway," versus, you know, "how many aircraft are sitting on the ramp right now?" You're able to do that because of how you can maneuver the aircraft just a little bit easier because of how slow it is.

It also allows for pattern of life type intel. We can kind of park it and sit overhead and do that "steady stare" for hours, days, weeks, and months on end to build a pattern of life collection that you can't do if you're just kind of coming by taking pictures and then trying to compare pictures later. It gives you that just real time feed of what's going on. You also have a lot of flexibility between theaters with RPA. So what I [00:26:00] mean by that is, let's say you have, you know, location "A" and location "B." And you're flying about evenly between the two and they're, you know, split by a great geographical distance.

And then all of a sudden, one day, you know, location "A," the weather just goes to complete, you know, "dog garbage" and it's overcast and you're not going to see anything no matter what platform you're in for three or four days. What you can do is if you have enough aircraft at location "B" (you generally do). You can take that crew that's been flying at location "A," because they're just sitting in the same area and now you can double your intel collected location "B" and you can say, "Hey, instead of giving you four lines a day... why don't we give you eight for the next two or three days because these guys aren't going to be able to fly in this original location."

And so you can just on demand double that intel collection. And so there's a flexibility with that, that you just don't have with manned aircraft, cause you're not going to pick up those pilots, sit in at location "A" and fly them across the world to location "B" for a day or two, and then fly them back. It's just not going to happen.

So you have a lot of inherent flexibility with RPAs when it comes to that. And I think last thing, that I'll mention is you just have those real time intel conversations, because [00:27:00] you're sitting in the cockpit on the ground, and you have you know, 85 different means of communication around you. One of which is just simply a telephone and it's as clear as day as talking to you and I, and so you have the ability to talk directly to folks that are, you know running the mission to have a conversation of, "Hey, as we're following this, if "this" happens, do you want us to do "A" or "B"?" And so you can just import and have direct conversations with the folks that are helping to run the missions. To just have those clear as day conversations real time like, "If this happens, what would you like us to do? What's the intent?" All those sorts of things that sometimes just the fog and friction of war comes into play when you're overhead the actual target area in a manned aircraft, you just can you can eliminate some of those with unmanned. So, those are kind of the big ones that jump out at me that the RPAs specifically bring to the fight that are just a little bit different

**John "Slick" Baum:** Yeah, that, that is a great rundown.

And just to make a quick comment, that you and Jake also share another secret handshake with the U-28 connection. Cause I know Jake, has a year of flying that [00:28:00] airplane as well. So I know we were going to dive into more ISR, STACK, and that type of discussion, which you guys can really fill in a lot of that.

But, I do want to ask you this, the fact that RPAs are relatively new from a capability standpoint. You've experienced a lot of that history across your career. So, you know, why do you think the COCOM demands for RPAs like, the MQ-9, were so high and remain still so super strong?

**Lt Col Johnny Duray:** Yeah, I think, you know, first and foremost, there's just some attributes there, some of which we've already talked about that just make the platform pretty desirable. And one of the things we didn't talk about is the camera on the MQ-9, is just absolutely fantastic. We talked a little bit already about kind of that, you know, swap those size, weight and power considerations.

They're not as much of a factor in an unmanned aircraft. You can load the aircraft down a little bit more than you can a manned aircraft because you're carrying a ton of fuel. And so that camera and that feed is just absolutely fantastic. One of the other things too is that the platform [00:29:00] launches at an incredibly high rate. I don't know what current numbers are, but you know back a few years ago, we were still sitting above a 99 percent maintenance launch rate. And that's obviously relatively speaking, fairly incredible compared to some of the other aircraft that are out there. And so, I think it just it gives the COCOM just such a high end capacity. Because what we're doing is getting that 24/7 news channel.

And just to be frank, I think you can get kind of addicted to just always knowing what's going on, at all times, and in all critical areas of your theater with a platform that's, you know, low risk, high reliability, and has maximum flexibility. Especially in mission sets that require the unblinking eye that you just cannot afford to lose or you end up going back to zero.

And so I think that's just a large part of why we've stayed in command just constantly over the past couple of decades now.

**John "Slick" Baum:** Yeah, great points. And you know, we are in love with information. So the more information we can give our leaders, I'm sure they just, they want to have that at their fingertips, like you said. And Jake, I want to bring in on [00:30:00] this, you know, for any thoughts, cause you've, you've seen this in a Global Hawk as well.

You know, are there things an uncrewed asset can uniquely execute that deliver a nuanced value to the COCOM from your perspective?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Oh, definitely Silck. We've talked, or you mentioned the STACK. And the STACK for the United States of America, goes from a Cobra or an Apache or a platform that's very low altitude all the way up through the MQ-9. All the way up through Global Hawk and other high altitude platforms.

I remember being in Afghanistan in the, at the top of the STACK, and I would watch so much going on below me. Including the Global Hawk, about every 12 minutes I would intersect with it because we knew where the point of interest was that we were working on. And then I also flew the Liberty. I flew the MC-12 for a year while I was the AATF Commander in Afghanistan.

And the Liberty program, [00:31:00] again, was very, very capable, but it was only in a permissive environment. So here's my point. And, and Johnny knows this, somebody who understands truly what sensors are at play for the COCOM during that point in time in that day can really start to drill down in what the adversary is doing or intends to do or can do.

That pattern of life, can be anything from what is the current president of an adversary country doing to what is the current field commander in an adversary's army doing. And that persistent look gives the ability, it gives the decision makers in the U. S., an advantage that they truly need to make the right call when we have somebody or we're holding somebody at risk.

So think about it. Even in the Pacific, we're going to have a STACK. Even in that very diverse AOR, we're going to have an ISR STACK, and somebody like Johnny, somebody [00:32:00] who understands really what's going on with exquisite, elegant comms, is going to be able to say, "Mr. COCOM, Madam COCOM, you can do this if you need to right now, we have the targeting coordinates." That's important for warfighters on the ground.

**John "Slick" Baum:** Well, I want to dig in a little bit more and again, just an emphasis that, you know, we make sure that we, we stay in the unclass realm here. But, when a COCOM asks for ISR support in the 90S versus today, how would you compare the requests and what they would expect?

Because I think this hits exactly what we're trying to get at, you know, the fact that we live in a radically different world when it comes to ISR and it's really a credit to the aircraft and the crews that they can keep evolving.

**Lt Col Johnny Duray:** Well, I think General Polumbo is infinitely more qualified to answer this question than I am.

So I'll, I'll probably pass this over to him fairly quickly, and we can take this out, not that I wasn't around in the 90s, but I wasn't flying aircraft at all in the 90s to know how they did it back then. I will say that [00:33:00] from my experience, even from the early days until now, you know, we have just delivered, a product that has just gotten so much better over the years.

From a timeliness perspective from a just detailed perspective and what it's allowed them to do is go from asking just very basic questions expecting basic answers and results to getting really nitty gritty detailed on some of the finer aspects of not just ISR, but that intel collection that goes right along with it.

And so, and not just asking, you know, very basic questions of, Hey, what does this look like? What are we seeing right now? But what are we also gathering simultaneously at the same time? With that intelligence. And how can we pair those two things together to paint the best picture possible on what the enemy might be doing and might be thinking about as we move forward. That instant integration, I think is something that has changed over the past, even five or 10 years that I've [00:34:00] seen that back, you know, a couple of decades ago, just wasn't possible at the time.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Slick, I think what you understand as well as anybody is the nature of the next battle, the nature of the next war is going to be different than the last one. And therefore, what a combatant commander and his field commanders are asking for is in phase zero, not to be surprised. Don't let me get surprised.

Make sure I understand where the real risk to mission is, the real risk to force, and risk to our soldiers and our airmen and our sailors and Marines and our allies. Where's the risk? And do I understand it and can I handle it if I choose to do something that goes into a shooting type war? So, it's evolved.

What we did in Iraq and Afghanistan really kind of skewed our way of thinking. We believed then that we could always figure out what the bad guy [00:35:00] was about to do and whenever we needed to take him out, we could. And we did. It's not that way anymore. And so a COCOM is going to ask for information, is going to ask for enemy order of battle information and analysis.

And we need to be able to get it for the prep, the phase zero. It's when the shooting starts where it really gets difficult. And that's where you've got to have somebody who truly understands what our sensor capabilities are. And that's why I say it's going to be a mixed of crewed and uncrewed. If you want to do what the Secretary asks us to do, we'll use that term.

It's going to be a man on the loop or a man in the loop or a woman in the loop or a woman on the loop. However you look at it, ISR has got to be worked in a very integrated way so that we have low risk to force and manageable risk to mission if the President tells us to go do something. It's fun to think about ISR, because unlike kinetically targeting weapons, ISR [00:36:00] kind of depends.

What are you trying to do? What do you have in theater? What do you have that could get there within 12 hours? How do I put it together and get me some daggum answers? It's really challenging, Slick.

**John "Slick" Baum:** Yeah and you really hit the nail on the head, Jake, from the perspective of ISR used to be just Let me know what I'm getting myself into.

And then once the shooting starts, we're kind of on our own and we'll play it real time from there. And yeah, to be able to just continually have a "global SA", if you will, is pretty incredible. Johnny, I do want to bring you back in and ask you a little bit of the MQ-9's evolution because you've seen it and you've been operating it for a while and Jake laid it out, you know, how the U-2 has had an incredible past.

So, how has the MQ nine continued to meet new requirements?

**Lt Col Johnny Duray:** Yeah, that's, I mean, it's absolutely incredible. If you look at how the platform has evolved over the past two decades here. Just in the Global War on Terror alone, but you know, we first started out and you know as an [00:37:00] MQ-1 and then obviously transitioning to the MQ-9 just single ship, you know, intel collection, ISR was what the platform was mainly asked to do. And then we slowly transitioned into you know, more of the strike role and that strike role was a fairly simple role initially, where, hey, we're taking very simple shots.

Very, if you want to call them kind of easy, open shots, nothing integrated, nothing complex. And let's see what the platform can succeed from there. And then we start moving into more dynamic shots, more moving targets, things of that nature, which are significantly more challenging at times in your static type targets.

We start transitioning to there. Then we start a little bit of an integration phase. We start integrating with other ISR assets. So, you know, looking at U-28s and some other aircraft overhead in that STACK, you have an MQ-9 that's not just out there on its own as the weird robot in the STACK, but is no kidding, actually talking and integrating with all the other platforms as well.

And then we started transitioning into working with fighter aircraft on strikes. And that was a game changer for not just our community, but for the fighter [00:38:00] community as well, because we could start that real time integration with, you know, that sensor shooter connection with staring at targets, bringing fighter guys in and instantly passing off targets to them real time for them to strike and just working with a lot of, you know, lazing and buddy lazing techniques and things like that with those guys.

And then we started developing more as a community and getting into more formation stuff. And that's where we really started pushing the ball forward a little bit, where we would have multiple MQ-9s working, not just disparately, you know, across the platform where you just bring them together and hope for the best. But no kidding, working on real time target sets, pre planning them, going up together, using, leaning on each other overhead, coming up with these integrated strike type scenarios where we are going after advanced targeting solutions, simultaneous strikes, large scale attacks with a formation of MQ-9s that are working together, pre planned from the start and advancing the platform that way.

Simultaneously, while all these TTPs are being developed, we're also seeing [00:39:00] tremendous advances in the weaponry. Particularly on the Hellfire realm from what we had initially to, you know, what we, what we use and have now. Same thing on the GBU realm from what we had initially to what we have now.

The camera software is rapidly, rapidly different now from what it was back when we first started out, and that has enabled a lot of these advanced target sets we've been able to go after. And then the SIGNIT collection has advanced along with that. So all these hardware advancements and software advancements are happening simultaneously.

With some of those TTPs and what you have right now with an MQ-9 is just vastly, vastly different than what you can ask an MQ-9 or a formation of MQ-9s to go do than you could back in, you know, the early 2000S.

**John "Slick" Baum:** Well, Johnny, yeah, it's incredible when you talk to, obviously the airplane and weaponry evolving, but it was the crews that really came up with those TTPs and going from, you know, what was intended to be just a single ship ISR collection platform to now flying formation and buddy lazing and all of those kinds of things.

I mean, it's just absolutely [00:40:00] incredible. What the crews have brought to the table here. Now I do want to ask you this because, you know, Jake had mentioned it a little earlier. You know, as we look at the great power competition, there's a lot that's going to change for ISR. You know, there's obviously the threat environment, the Pacific AOR is physically just immense and there's a lot more things to track.

So how do you see that mission evolving? I mean, for the U-2, it's kind of like back to the future and for the Reaper, it's a whole new world. So Jake, let's get started with you.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Well, I think it's going to be one of two things in the ISR, air breathing ISR world, Slick. And again, our space capabilities are incredible and you need to get experts on your show to really understand exactly what they can do.

But for what Johnny and folks who are like me and younger in the U-2 can do, is one of two things. Either be somewhere where the enemy [00:41:00] doesn't know they're there or be somewhere where they know what the enemy's about to do and be able to defend themselves and not lose themselves in combat. So how we think about how our ISR is able to do its job, some of it's going to be where hopefully we're going to be somewhere where they don't know where we are and we're going

collect what we need to know and we're going to do it in a way that really gets out what the essential elements of information are that the warfighter needs. But the other way is to be survivable and that survivability whether it's a unmanned or uncrewed platform or whether it's a manned platform.

It doesn't matter. We've got to have people understanding the threat and that's where I really, really believe that our secretary, our chief, our warfighters need to really get a full view and understanding of what the threat is, how we're going to handle [00:42:00] it, and how we're going to handle the tough missions to go up against it if the President tells us to do it.

So, ISR, how do you collect, how do you surveil, how do you do reconnaissance in a very contested, congested area of operation? We've got to have people that know how to do that. So I know we focus on platforms in the U. S. Air Force, but for me as an old guy, I focus on people. We need really, really good weapons and tactics officers.

They need to have practiced in a tough setting, in a tough scenario. Whether it's up in Jay Park or at Knitter or wherever. And we need to really be honest with ourselves on whether we're survivable or not and whether we can do it or not. So think about those two ways. Either the enemy doesn't know we're there and we get it done, or the enemy knows we're there but he can't hit me.

And that's ISR in the future in a congested, contested AOR like INDOPACOM. [00:43:00]

**Lt Col Johnny Duray:** Yeah, no, I'm not going to answer it any better than that. So I'm going to, I'm going to do the tactical thing and jump into a platform for a second or two. But General Polumbo hit it right on the head when he talked about being somewhere the enemy doesn't know you are.

So one of the big initiatives that the MQ-9 has undertaken over the past couple of years is something called SATCOM Launch and Recovery. And essentially what that's enabled us to do, and I'll put it in the context of great power competition in the Pacific here shortly, but previously, just very simply how the aircraft would operate is you'd have a crew on the ground locally, launch it and then hand it off to a crew that would then grab it via satellites and execute the mission, then bring it back and give it to those guys to land.

And the reason we did that very simply was that the delay and flying it with satellites just wouldn't allow you to land the aircraft. We have overcome that since then. And we are now transitioning to a point where we do have the ability with our automatic takeoff and land capability to have a single crew.

From start to finish, take the aircraft off and everything else like that. Execute the mission and come back. Why that [00:44:00] matters is this gives us a ton of flexibility and it really allows us to do things frankly like island hop in the Pacific, which we previously wouldn't be able to do. We would set up shop somewhere as an MQ-9 platform. And that was it. That was where we were launching out of because the infrastructure needed to set that place up was massive. And there was no ability to flex anywhere else besides that airfield.

We have overcome that and that is a game changer for us when it comes to great power competition. The pacific and some other theaters where we can now jump around like manned aircraft and as long as we have runway length and we you know, have a couple other things in place, we can take this aircraft anywhere we want to go which opens up a whole new world from us from that specific platform's perspective. The other thing that the general Polumbo mentioned was survivability.

So, that is another thing that the MQ-9 specifically has really taken seriously over the past couple of years is hardening up those links that he's talking about. You know, operating for the past two decades in the Global War on Terror, there was no real threat to that. And so it really wasn't anyone's fault, but our links weren't survivable.

Um, and you couldn't really [00:45:00] blame anyone for that because to be honest, just to use an analogy, if you're flying in nothing but clear weather VFR all the time, you're not really thinking about needing an ice boots. And all of a sudden, like one day when you hit a little bit of weather, you're like, "Well, man, we should probably operate the ice boots."

The problem is we even have ice boots to continue the analogy, let alone know how to operate them. And so, you know, we've now taken that problem very seriously because we've recognized how vulnerable some of those links were that we've had, and we have taken tremendous steps forward to harden them and develop TTPs to overcome that.

So the aircraft becomes more survivable in that type of an environment from there. Then the other big thing that we're really focused on as a community too, is, you know, a lot of our maritime type training. This is just not something we've looked at before previously. And this is something that's become a great area of focus for us. Starting at the very basic, you know, MQ-9 initial qualification course, all the way through mission qualification training (MQT), and into some of the exercises we're getting after now is just focused on that maritime environment, because that's just not an area we've had to play in previously.

So all of that in our great transition towards [00:46:00] looking for, "Hey, how do we take this platform and make it relevant to the great power competition that we know is coming?"

**John "Slick" Baum:** Yeah. Great, great, solid points. And I often do this to my guests. So I apologize, but I do want to hear you have a little bit of future foresight here and I want to get, just based from your experience, where do you think we'll see ISR capabilities in five to 10 years? And, you know, I'm really guessing we're going to need the STACK to expand obviously beyond air into space, which I know that we're doing some of that now. And costs will be very important. And also capacity.

So, you know, not everything will need to survive the highest threats, but some will. So, perhaps a tiered level of capabilities and instead of sensor shooters who might be, you know, something more like a sensor effector given the role of non-kinetics. So, any thoughts that you have on there, Jake?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Yeah, I do Slick and I'll kind of go back to where I started. The United States has got a [00:47:00] ton of capabilities. It's kind of a platitude, isn't it? But somebody's got to understand how it all interleaves and works together and we do that as a nation in this book called, Sensitive Reconnaissance Operations. And I'm telling you when the COCOMS put it forward and the Joint Staff looks at it, it better be complex.

It better be interleaved. It better be a STACK that makes sense, not what used to work, but what will work. It better include cyber. It better include every element of space that we can move and manipulate and change and adjust such that the warfighter gets what he or she needs. So I really believe that it's going to be, it's going to evolve out of the J2s and the J3s in the COCOMs with their ability to really say, "Well, sir, ma'am if you need to know about that here's how we should figure that out." And it's going to [00:48:00] take in open source. It's going to take in very deeply sensitive aspects of looking at the internet and studying the enemy. But it's going to include crewed and uncrewed, manned and unmanned platforms and it darn sure better be able to handle all the data that we get off of things like F-35s, sensors off of B-2 sensors, off of B-21, when it finally gets flying. We better put all that together. We better ask the President for permission to do the smartest thing. In the shortest period of time and it's all going to come out as a "yay" or "nay" in that SRO book, Slick. So we need to do that right.

**Lt Col Johnny Duray:** Yeah, absolutely. I agree 100 percent with all that. And, you know, Slick, I mean, you hit it on the head and you talked about capacity. I mean, in five or 10 years, we're barely looking past the palms cycle at this point. And so, a lot of what we're bringing, we're bringing what we have right now to the fight.

And so [00:49:00] when you're talking about anything that involves great power competition, you know God forbid, but you're looking at an attrition rate, like things we haven't seen in a very long time. So you have to have capacity. And one of the other things I think that gets overlooked a little bit and we talked about this previously was that tiered approach is going to be so essential, right?

We like to focus a lot of the high end stuff and we absolutely need to have that. But I mean if you take a look at you know, Russia and Ukraine right now, man if you don't think fourth gen fighters and RPAs are going to have some kind of a role, I just don't think you're paying attention to that one. I mean who in a million years thought we'd be seeing you know, a slugged out artillery ground war in 2024 between two fairly large powers. So, I think you have to have that day zero ISR. But you also have to have that day 100 ISR.

And those are different platforms with different capabilities. And at this point we just, you never know what that next war is going to bring. So I think it is essential to be just tiered and balanced across the spectrum so that you have capacity across each one of those different tiers, because you just don't know how that's going to unfold in the future.

No matter how [00:50:00] much we think we do, we just aren't very good at predicting that. Then to go back to your sensor and effectors, absolutely. I think that is 100 percent what we're going to see, taking over from sensor shooters. And I will say that from an MQ-9 perspective, we're already there in a lot of capacities.

The MQ-9 has a ton of great plug and play capabilities, and there's just a lot of things that can be brought to the fight in that realm that we're playing with right now and seeing where we end up with.

**John "Slick" Baum:** Yeah, I'm in violent agreement with a lot of what you just said, Johnny. So thanks for that.

You mentioned links before and, you know, I've got to ask you what is Joint All Domain Command and Control (JADC2) impact with, you know, things with this notion that there's going to be a lot more real time teaming going on, information gathering, processing, you know, and this exchange is going to be crucial.

So how does that factor into the mission evolution from both, you know Jake and Johnny's perspective?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Johnny you go first.

**Lt Col Johnny Duray:** I'll go. Yeah, I'll grab it real quick. I [00:51:00] think that, you know, we have to speak the same language and this is something that I've just seen unfold a little bit in my time is that we just have a lot of proprietary everything and this isn't pointing fingers at anyone. This is just identifying a problem as I see it and trying to work towards solutions, but we just, we can't have proprietary everything.

You know, industry needs to get pretty serious about that. And if we don't, we're gonna end up with team America that speaks 65 different languages over the battlefield. And then we're not going to team anything at that point. And so that's one aspect of this. I think another one that we've alluded to already, is, we haven't talked yet about it, but AI and that processing equation.

I mean, I think it was General Slife just a couple of days ago, talked about some of the issues that we see with the F-35 and the amount of terabytes that it can produce on a single sortie that we ended up just dumping into the data swamp because there's just no way to process and exploit that much information that's coming in.

And that's from a single fifth gen fighter. When we start talking about having a STACK with [00:52:00] multiple fighters overhead like that, and RPAs and everything else, the amount of data that's going to be coming in, it's just going to be absolutely massive, like nothing we've ever seen. And so we need to get our minds and our efforts.

And I know we're doing it. It's just, it's a hard problem to solve, but we need to get towards that idea of, "Hey, how do we take supercomputing... how do we take AI..." how do we take some of these, these buzzwords that we talk about, but no kidding, find a way to utilize them to. Not just process, but exploit the amount of data that's going to come in a next generation type fight, where you just have so many sensors out there collecting all at one time.

And how do we take that information and figure out how to actually use it to produce actionable data and intelligence to a COCOM commander. And it doesn't just all end up in a data swamp from there. So that's where I know, JADC2 is a hard problem. I am very thankful that I'm not working here right now. And I'm just sitting in the tactical realm at this point. We have a lot of smart people working it and that gives me confidence, but it is not an easy problem to solve at this point, but I think that's where it's going to come in.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** I believe that it's our operators and our intel analysts and it's the weapons [00:53:00] officers that are going to be JADC2.

I know everybody wants to get a computer hooked up and connect all these data analytical devices. I think it's people that are going to say, "I need a little bit of this, a lot faster than that" and "get me something that'll do this." But when I go in to brief the CFAC on our options, I'm going to put my thought on it and I'm probably going to be right because I've really thought my way through it.

The human brain is pretty powerful, Slick..

**John "Slick" Baum:** Well, as always, we're in this incredible conversation. We're getting a little bit tight on time. So I really want to wrap up. this up with some flying swords. I can't let either of you go without hearing about your time in the air, especially in the U-2 and the MQ-9.

So Jake, I'd like to get started with you. If you can let us know what it was like to fly that incredible machine.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** I will Slick, but I'm going to say one thing, if you permit me, that the ISR piece of this war fighting edge the United States should [00:54:00] have. It's not going anywhere. It's not going away and we've got to keep taking it into account. Especially as we think about how to program new platforms new capabilities into the future budget. So it's not going away ISR is a really important piece of winning wars But you asked about four stories man, you know, I feel like a lieutenant in the 36th Fighter Squadron, the fiends and the mayors going, "Hey Lieutenant Polumbo, entertain us."

**John "Slick" Baum:** Harumph for those that harumph right?

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Harumph for those that know about that.

But listen, I only have three stories But I only have three minutes, so I'm gonna tell them very quickly. The first one is General Kevin Chilton (Chili), Chili told me one day before I went over to the Middle East to fly the noose in combat. He said, "Jake, do good, don't screw it up, and don't fly at night." And I said, "yes, sir. That's clear." Eight months later, I'm flying a night mission in [00:55:00] Afghanistan. The airplane is mock surfing. It's to the point where it won't stay on autopilot. We're at 71, 000 feet. I'm at 71, 000 feet, pitch black Afghanistan, scared to death, and it comes off autopilot. And I went, "Chili, you're right, sir."

But that's one. Two was I was flying a Christmas mission, OIF, and I always flew on Christmas when I was deployed as a senior guy so that the captains could talk to their kids. And I was over Baghdad, and I was getting a little bored, and I decided to call the DCFAC, Lance Undhjem, who was on duty because the CFAC was taking the day off and I talked to General Undjem, the DCFAC in the CAOC there at Qatar.

And we talked for about an hour and a half and it got me through a very long mission. But that wasn't really the war story I wanted to tell you because the real one was, I was sitting in my conference room one day at Al Dhafra and the maintenance group [00:56:00] commander said, "Sir, we got a jet at..."

I'll say it, I think it's okay now, Akrotiri.

"And we gotta get it over here in theater because it's repaired and ready to go." And he goes, "We need to find a pilot that can go get it." And I said, "I volunteer." So I got on an airplane, flew to the base in the Mediterranean, suited up, and took off. And the only two people I talked to.

Slick, were the tower at the base where I was leaving and my tower at Al Dhafra when I came there and I flew through Jordan through Iraq, right next to Kuwait, right near Saudi Arabia, all the way down into the Gulf north of the UAE. And I came back and roller of the landing. Got out, unsuited, went to work and went to the staff meeting and said "Hey, we've got our new jet everybody. Be happy that we've got pilots know how to fly that airplane."

**Lt Col Johnny Duray:** Yeah, I spent a lot of time thinking about this and I'll be honest with you, every single [00:57:00] story that I could come up with to tell you was either going to get me fired immediately from my current job or get me thrown in jail, potentially shortly thereafter.

So, I'm going to avoid right now telling any kind of war stories. If that's okay with you, it is. I'm going to transition to taking this opportunity you've given me to recognize two things. First and foremost, I'll tell you the quality of folks that I have seen come into this community over the past five years has been absolutely mind blowing.

And we have a whole new generation coming to fly the MQ-9 and it's a generation that, you know, they will, let me put this differently.

We have an entirely new generation of folks coming in to fly the MQ-9, and they're coming in with just a background and a knowledge and a skill set that I never had coming into the community.

And they are pushing us forward faster than anything I could have ever imagined. And I'm an old guy at this point. I grew up just prior to the internet and obviously the folks [00:58:00] coming in now have not and it sounds crazy but, I'm telling you what they have experienced growing up and what they have seen a from a technological standpoint and just the things that they've experienced Have brought just a fresh blood to this platform and a set of ideas that we just have not had previously and i'm super excited about the future of it. Simply from what they're bringing to the table. And the last thing i'm going to do is I got to give a shout out to my current squadron.

Great Flying Nights of the 9th Attack Squadron out here at Holloman Air Force Base. They told me when I was doing this, if I did not shout them out in some way, shape or form, they were literally going to just cold stone not talk to me for the rest of my time. And I have never seen a squadron as talented as one of them now and I'm being dead serious about that. They have made my time in command about 100 times easier than I ever expected it to be. So I'll use my final seconds here to say that I want to thank them and just give them a special shout out for being just a tremendous group of aviators and professionals throughout my time here at the night.

So shout out to those guys and [00:59:00] gals.

**John "Slick" Baum:** Awesome. Yeah. And I could not agree with him more. I had some time recently out at Holloman and that squadron just absolutely kicks butt and you do have great folks there. So Johnny, thanks again for being on the Aerospace Advantage. Really appreciate your time and really, really love the work that you guys are doing.

The innovation is just incredible. So keep it up.

**Lt Col Johnny Duray:** Yeah. Thanks a lot, Slick. I really appreciate it.

**John "Slick" Baum:** Jake. Thanks for being here, sir. Really appreciate it.

**Maj Gen H.D. “Jake” Polumbo, USAF (Ret.):** Thanks for having me on the show. Slick.

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 our listeners for your continued support and for tuning in to today's show. If you like what you've heard today, don't forget to hit that like button and follow or subscribe to the Aerospace Advantage.

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Thanks again for joining us. And we'll see you next time. Stay safe and check six.