



NATIONAL MUSEUM
OF THE UNITED STATES AIR FORCE
Wings & Things Guest Lecture Series

NEXT GENERATION UAS

Sean "Skipper" Moulton delves into unmanned aerial vehicles (UAVs) from a warfighter's perspective.

All right, well, good evening, thanks for everybody coming out, especially in the very cold weather here. I have to start off a little humble; that's the first time I've ever been introduced, for any talks in my whole career. So that's a good start. Well, I'm glad to be here. First I want to say, in case I forget to say thanks at the end of the night, thank you to General Metcalf and the whole aviation museum staff here. They were wonderful setting this up and making me feel relaxed and getting ready for it. So, thank you very much, sir, and to the whole staff for helping me along.

I'd better talk a little bit about how I got into UAVs, what a little bit I did, and what some of the challenges are for the future. I wish I had time to talk about the whole history of UAVs, but we'd have to go back to the Civil War and all the way to this point. So I'm going to concentrate pretty much the mid-nineties, where I picked up, and some of the challenges in the future, but there's a ton of history here at the museum, where you have some of the first ever UAVs and they've even got one of the latest, the AV-3, the last Global Hawk. It's an actual combat-tested bird, a test bird out there that I got to fly, and I'll we'll get into a little bit more of.

So when did I first get my introduction to UAVs? It started in the mid-90s. I was in C-130s at Pope Air Force Base, and the first UAV assignment came down for a pilot. Now you would think that people would want to go and do something new and exciting. These first assignments were the dread disease of pilots; nobody wanted them, people were forced upon them, and you felt really bad for the first pilots who got them because it was like leprosy. It was like nobody wanted to talk to them because they were being traded to a non-flying team, and they disappeared very quickly. So my first introduction was [in a whisper] "That's an assignment you don't want to go to." So guys disappeared, we didn't hear from them, but then later on I had the opportunity to go through the C-130 Weapons Officer School and at the end of it all the different weapons officers from every weapons system from B-52s to B-1s to Strike Eagles, you'd get together for a massive exercise at the end of Weapons Officer School. On the first day of Weapons Officer School during the massive employment was actually a noncombatant evacuation operation mission. The idea was, you'd have Country A and Country B going at each other, and the first day was to go in and get the ambassador for your country out of the other country. So for C-130s, we had – the first two days were all about us – we had to go in and get the ambassador and his family and all of his staff, so everybody got to support us for a day. Well, one of the first reports on that was that a Predator was going to watch the operations during the first day, so we had to sit down with the Predator guys and talk about, "Well, what does that mean?" and what we found out was going to happen was we flew into Country B – we were A and they were B – we flew into Country B and we had to land in a field out in the middle of the desert and we had to simulate picking them up, but the Predator was going to be flying above us

the whole time. What the operation was, is that the commanders on our side would be able to get a full-motion video live feed of the ambassador being picked up. Well, this kinda caught my interest quite a bit because there's some powerfulness in full-motion video that your commanders, up to the president in an ambassador situation, would get a live feed of what was going on. Of course, we were a little bit bothered because that meant the president could see our landing and if we messed that up or not. So there's another side to "you'd better get it right because if you go around the White House could call and want to know why you messed it up." So after I graduated from the Weapons School, I started, was very interested in Predators after that, and my brother, who happens to have been also a pilot in the Air Force (he was a commander at the same base at Little Rock where I got to be stationed) – his ops officer, when he was a squadron commander, a gentleman, Duke Bender, was actually one of the first 15 Predator pilots who got to go to Nellis and fly the Predator. So I started thinking about my next career move, and I sat down with Duke and I sat down with my brother and I started thinking maybe I could make a move to UAVs, maybe there's a future in UAVs. Some people think these are maybe a good system to go to, so I spent actually a year and a half doing research on the Predator and other UAVs and what would be the possibilities of going to maybe Predator and doing that.

Things lined up and had a chance to volunteer for a UAV assignment, so I put in my paperwork. I had a very good commander able to support me and try to get me to go to the assignment. Now, I picked up the assignment and I was going on my way to Nellis, pretty much, and then the week before we closed out and got my orders an advertisement came up on the Air Force system. There was a new weapon system called Global Hawk out at a Beale Air Force Base. Now, I didn't know where Beale was and I didn't know what a Global Hawk was, but I thought, well, I'm going to something new, let me go to something new-new and try Global Hawk. So, lo and behold, they were still taking first cadre folks out there and so I got an assignment and in December of 2002 I got an opportunity to show up at Beale. I showed up at Beale, dragging my family out there, like many officers do; we drag our families from base to base. Showed up at Beale, thought that we were going to have a very slow ramp up, bringing the Global Hawk into the base, and this is probably where things rapidly turned. There was no slow ramp up. Within 90 days of starting work in January, we got notice that the first OIF was going to happen and we knew about it before and we started preparing for it, deployed the Global Hawk and I found myself doing a very short-notice combat qual in the Global Hawk, on the fly. I was very lucky to have Northrop-Grumman instructors actually teach me while we were on the way to combat how to fly the Global Hawk, while we're going over to the Middle East. It's a whole different perspective to fly with first generation instructors in aircraft. I was at Edwards AFB, we didn't even, we couldn't even bring airplanes up to Beale; we were flying them directly from Edwards to combat. So, I'm actually at Edwards. This is the level of guys I got to train with; I'm up in the nosewheel with my instructor, Brad Norman, a great Northrop-Grumman pilot. He looks up at the nosewheel and says "What's special about this nosewheel well?" I'm thinking, OK, what did I miss in academics, I forget? I said, "Brad, I forget what's important about it." He goes "I designed it, this is my nosewheel well!" So, he had actually been an engineer and got picked up as a ... he was a private pilot ... he actually designed the wheel well, so I had the opportunity to be with guys who literally were with the plane for years and years before it got to fly. So I got the opportunity to do a combat upgrade – now that sounds really cool until you're flying the plane solo over Baghdad and it's not so cool. You're actually praying that nothing flashes or

"zaps" in front of you that you can't handle. You're just hoping that nothing happens, like losing the engine, which is the biggest concern and you wouldn't know what to do with it. So, I got the opportunity from there. Now after that it was kind of a marathon run and nothing ever really stopped.

These are the big three we talked about – the Predator, which I got to know a lot about, the Reaper below it, and also my baby, the Global Hawk, right there.

Now, some of the neat things I got to do. I got to help after the first year, that first success. I got to help write the first tactics training manual for the Global Hawk, which was very interesting because we got to mix with all the other weapons systems. I got to be in the test unit at Beale and be involved in that and get to do some of the first testing ever for the Global Hawk, which also was the U-2 test unit, which was very interesting to be with one of the oldest weapon systems in the Air Force, the U-2, and also be with one of the newest weapon systems and to see how some things change and some things don't change over that time. Now, when we start to look at UAVs, some of the successes that we've had may sound kind of academic, but they really come out. The first thing that we noticed with UAVs when we started to look at it is their endurance. All three of these planes have one thing in common: they fly for a long time and they fly longer than you'd ever think. On a typical Global Hawk mission, you can do the takeoff, hang around for three hours, go home or go back to your hooch, in the desert is what you'd call it, get 12 hours of crew rest, come back in and the plane's still flying and it's not even close to landing yet! So, to put that in perspective, we could launch the plane tonight, you could come back and hear another guest lecturer tomorrow and the plane would still be flying that entire time with no tanker responsibility and considering that's where you go in the future and now, especially when you start looking at armament and how much it takes for F-16s and F-15s to refuel, that's an incredible force multiplier to have that. The flexibility you have with them is very tremendous because you don't have the limitations of the human person and I'll talk a little bit more about that later. That provides a great capability to put them where and when you want. Optic capability on these planes is also phenomenal. If you look at the full-motion video capability of the Predator, it's utterly phenomenal that at 10,000 feet, you can spot a person doing what they're doing. I got to see a lot of interesting ops in the Air Operations Center. One op I saw, which is good for the good guys and bad for the bad guys – they were tracking some bad guys over there and one of the ways they found them was a group of them would get together and do barbecues on the deck of their house. It's very interesting to watch a full-motion video and see how bright a barbecue fire is on an infrared camera. It makes for a very good target for the good guys and a very bad target for the bad guys. They don't have a porch anymore; they took care of that when they lased it and brought in a Strike Eagle and took care of a bad cell over there. But, what was interesting about the Predator on that was it monitored the house for like two days straight. They rotated out two Predators and were able to hang over there, so it wasn't like you had to go over there in one second. You could stay over there and keep looking. Keep a perspective. Think about someone watching you for the next two days all the way through the weekend and every time you step outside, they can track you, where you're going.

Now the other interesting thing about the Predator in particular was the weaponization of the Predator was not some grand master plan; it was done on the fly, so to speak. It was done very quickly. I talked to a couple of the engineers who did the first weaponization. There were a lot of

jokes that the first time it fired off the rail, a lot of people weren't sure whether the wing was going to rip off with it or whether the weapon would even separate but it was very successful and it grew into the MQ-9, which now they're now building lots of MQ-9s. Other countries want to be able to fly it, and it can carry a tremendous amount of armament. You put up two or three Reapers you have more capability than a lot of F-16s and Strike Eagles and they can stay for a long, long time. When they integrate together, they make for a very deadly force that a lot of people know of overseas. Two stories on the Global Hawk I'm going to mention. I'm going to throw out the cool stats that we got. I'm going to tell a little bit about what the human side of the story is.

One of the first stats for the Global Hawk was we had the opportunity to be involved in 55 percent of the Integrated Air Defense targets that came up as time-critical targets. That meant the target was found short notice and it was an IADS target and had to be taken out. What was interesting was, and those numbers have been published, publicly, that was a big deal, that over half the targets and the reason why that happened was the Global Hawk was airborne so long. When in doubt, the Global Hawk was airborne, go take a photo of it, let's get the coordinates and pass it on to bombers and fighters and go take out those targets. What was interesting was one of the main things that precipitated that was one of a good friend of mine, now a Lt. Col., then a Maj. Mark Williamson, was actually in the laundry room, doing laundry, over in the Air Operations Center and a colonel came in, and he was doing laundry and they got into their discussion with each other, (hoping the laundry room was classified) but they started talking about the fact that the colonel was actually one of the chiefs of the time-critical target cells in the Air Operations Center, and he was very unhappy because they had a lot of bombs on bombers they weren't dropping on anybody and Mark was equally unhappy because they were taking a lots of images from Global Hawk and no one was blowing them up. So the chocolate and peanut butter story sticks pretty well. They agreed – this is the rest of story – they agreed to get together on the Air Operations floor the next day and got together and started sharing information and they were able to set up some data links between systems, and that's where that success today comes from, two guys talking in a laundry room talking about you have images, and I have bombs, let's try to get together, and it became a very successful, important part. I was practically tackled by an F-16 pilot six months later at a tactics conference when I introduced myself as a Global Hawk guy. You think you're going to stay in the back very quietly and he about tackled me. He says "I want to know why I was able to get targets every time you were flying." He'd actually been involved in the first briefing with some F-16s were briefed that they were going to guard the Global Hawk, when it was flying. This did not go over well with the fighter pilot! Now it didn't go over at first, but a lot of the fighter pilots, and I've talked to a lot of them over the years, when they found out that we could generate a lot of targets for them, they were very happy. Some F-15 pilots I know, when we were developing support tactics, they enjoyed it, because we were bait to them. They liked it because we would be a high-value target and people would want to come after us and that was targets for them. I don't how I felt about being bait for them. Now we joke in the Global Hawk that if I get shot down, the only thing that gets hurt is my feelings, so it's not like I'm in personal danger, but we still took a little pride that we didn't was to get shot down that much. So that was interesting; that was the first one that happened.

The other was we were involved in some SCAR missions with the F-15 Strike Eagles. Those were strike armored reconnaissance missions. The Strike Eagles would go into these SCAR

boxes, and they were basically cleared to lase and look for anything that they needed to look at. Well, Mark Williamson and another group over there said why don't we have Global Hawk go in and image the area and we'll pass any data on to the Strike Eagles and see what success we have. Interestingly, they took this to the Intel cell side and the first response from the Intel side was "You can't do that." "Why can't we do that?" "You have to have a second source of information to be able to pass to a Strike target or it's illegal and an act of war." Well, here's the scoop. The Strike Eagles are going in anyway, so it doesn't matter whether we get imagery or not. They talked to the Intel officer who first said you couldn't do it. Then he came back and said, "Not only can you do that, I've changed my mind. I can help set up a data link, direct line to be able to help them." So he turned round, it was about two days later and they did the first direct support SCAR support mission. The first day, when the Iraqi Republican Guard was doing its counterattack from Baghdad, the formal statistics in a public release form was 70 tanks and 300 vehicles were killed the first day. That was the success. Now part of that success was that Global Hawk was able to be flexible. They would take targets, and I got to fly some of those missions. Our targets were not passed on 24 hours later. We looked back at the Cold War, Vietnam and Korean Wars where we would take a picture and 24 hours later we would go in. We would take an image and Strike Eagles would be there in less than an hour. Now unless they're moving that fast, they're not that far, so we actually were able to do a timely strike integration with the strike forces and have tremendous success and that was one of the successes we grew off of. The interesting point about that – it was pushing a new paradigm against older paradigms, and we were very successful, and that is still part of the tactics today, if we ever have to do another force on force.

Now planes look really fancy, but that's not where I live. This is where I live, in the ground station. If you want to find pictures of the ground station it took me a couple of days to find these four photos because there's lots of pictures of the plane, they look very cool. Ground stations don't look very cool. Ground stations look like a big computer rack. I was a little bit dismayed when I went into my first ground station, I was thinking Buck Rogers and all kinds of fancy screens. I went in and had very disjointed screen that did not look very good together. The bottom left hand corner actually was my home. This is actually the ground station that flew AV-3, which is here, and you can kinda see the clip-ons and the older screens, and he is flying with a mouse. The Predator in the upper right hand corner -- that's got a joystick, which makes you feel a little bit like a pilot. The Global Hawk used a mouse, so we called it mouse-time when we flew, and we would make jokes about my mouse, your mouse. You have to check your ego. When I became a UAV pilot, any ego I had as a pilot went out the door. I finally just decided to learn all the UAV jokes so other people can tell them, and I would challenge pilots "C'mon, what's the difference between a duck and a UAV pilot? The duck actually gets off the ground." Yeah, I get it. You hear them all the time. Now in the upper left hand corner this is actually what's called the Mission Control Element for the first Global Hawk. There's a lot of comm equipment around it. People are not going to put this on a nice poster board, it's not attractive. The plane is very attractive but a computer rack inside is not. Now this screen is the first major step for the Block – this is what's called the Block 10 setup, which is actually ACTD (Advanced Concept Technology Demonstrator), and this is the first production one which are now flying. That's one of the few release photos I was able to find to show what it looks like inside – a lot of computers. And this is a generic screen capture because now you're flying the plane from a screen capture. I do have to kid. I did have to call my mom after I first started flying and explain that when she told me

that playing all those video games wasn't going to do much for me in life that perhaps she was a little bit wrong, perhaps the video games were helping a little bit. Now my kids are in the audience and this is not permission to play extra Xbox 360; you still have to do your homework before you do that, but we are allowed to play a little bit at our house.

Now a couple of interesting things about operating from a computer system is that one of the things is that I went in to fly an actual mission one day and I logged into the computer and it didn't come up. It said "Wrong Password." Checked the caps lock, you know, standard stuff. We found out that while we were trying to get the plane airborne, the password had changed. We were in a unique situation. I was in that chair, and we didn't have the password, so we actually went through a 30-minute gyration to find someone who had the password. Then when we got the password, my first instructions were "Well, we need to write that down" because we can't have this happen, because it was actually a weird combination stroke that actually would lock the screen, and it was actually an emergency procedure almost to learn how to unlock screens. That was actually important to not have your screen lockup when you were flying it, not that the airplane going to turn upside down automatically, but you're still good if you can see the plane, and ironically, I had a conversation in the shelter when the comm guy turned to me and he said "Well, you're not allowed to write down passwords," and I was like "Dude, you're going to have to write this password down." And the funny thing is not only do you have a password for these screens, but a separate password for this screen and that screen, so we actually were able to convince them that this is a cockpit and not someone's office and we needed to write things down. Now that's kinda humorous but it's an interesting difference when you get into that world. Most of our maintenance folks who actually took care of us were not your mechanics turning wrenches; most of your folks were comm folks, communications folks who came in and lived in a very different world, so it was really interesting and fun to work with them because they were now in an ops environment that a lot of them had never been in before, but it was a lot of fun doing it. If you get really tired you can order pizza, which you can't do in a normal plane [laughter]. Hey, you use what you can get, use what you have, I mean if you can order it. Of course, there was always a question if you have to go out to the gate, who's going to fly the plane while you're getting the pizza, so that was always a challenge.

Now I want to talk a little bit about some of the things you trade off. One of the first things you trade off when you get a cockpit on the ground is that your human limitations are going to change greatly. No longer are you limited to 9 Gs, like the 16, which limits you to a certain amount of Gs. One of the philosophies, and I know there are a lot of ex-aviators in here, is that you can build a SAM (surface-to-air missile) and it can pull 50 Gs and you can only pull 9. Well, now you can build planes to pull any amount of Gs because you're on the ground, and unless you trip over something, you're going to be fine where you are. You don't have to have that limitation, which is greatly different.

You also are not limited by crew duty days, because you can change out people in the ground station. We actually started doing some scheduling at Beale and what we found out was, instead of the traditional pilot schedule that we would schedule on, we found it was almost more effective to look at a doctor or a fireman-type scheduling augmented crew because that made more sense than a typical pilot crew because pilot crews are built for one crew to get in the plane, do a mission, come down and land. Well, now we can rotate and go through the mission, and so

that was very different.

Another area it'll be interesting to see how we change is what are the actual requirements for a pilot to fly a ground station? I mean, I was pilot-qualified when I showed up, but truthfully, if someone doesn't have a leg, they could still do exactly what I did. So it'll be interesting to see where we go with pilot qualification. The Air Force is starting a new track; they got their first instructions to have their first UAS operators to start UAS training and they'll be going directly to Predators within the year. Part of that is because the orbits are growing so much in the Air Force, they can't produce enough pilots. They're going to have to have another source. Also, the Air Force is finally, is formalizing, very smartly. They realize you can't have a guy go do one UAS tour and then leave. You have to have UAS operators to go from lieutenants all the way to commanders. So we're going to see our first generation of lieutenants and captains that 20 years from now will be your squadron commanders and group commanders, and 25 years from now will be your colonels and generals as UAS operators. So just like the Air Force constantly changes, it will continue to change in that area, too.

The other area you see a big change in is size. We've spent a hundred years with cockpits, making them smaller and more efficient. HUDs got better, CRTs got better, flight management systems get better. Everything is arranged around cockpits. If you want to see a nice cockpit, look at a 787; it's magnificent how everything surrounds you. Well, we can actually now change some things. Now maybe I can put a big screen in front of me, and I'm a computer geek, so maybe I want a 24 inch, maybe I want a 50 inch, maybe a cockpit is now me sitting back at a console and looking at a wide wrap-around screen around me. A hundred years of getting smaller and more efficient, we can now go a complete opposite direction in how we build a cockpit. No longer is size a limitation. Now you have limitations of field of view and how you want to move things around.

Now, those are two good things you gain, but there are also things that become challenges. Comms. I'm not going to talk much about comms because that's a limitation on the plane, but the same problem you have with anything where you have communications, you're going to have bandwidth limitations, you're going to have limitations with everybody sharing those frequencies. It's going to be very important how you develop comms because that's how you talk to the plane. That's life/death to the plane. Some of my most harrowing moments were when you'd lose contact with the plane and you would sure hope the plane was doing the right thing that it was supposed to do. I know we lost link with the plane one time. It was very interesting to call up international air traffic controllers and ask if they had a Global Hawk on their radar screen or not. [laughter] Once they say yes, you quickly hang up. I don't know what was worse, the fact that I hung up or the fact that they would talk to me. You hope the bad guys don't think, hey we can call up and do that, too. Comms will be a challenge because you have to be able to talk to us.

Situational awareness . We've found out, I know in the Air Force especially, and I've talked to a lot of my Army friends who I work with now – eyeballs are very hard to replace. We do not have an optic yet that can replace the eyeball to look around. Also I lose tactile feel with the plane, I lose the smell, I lose the roll. There have been cases of disorientation. Now it's not the leans where you think you're turning left when you're turning right. The disorientation comes from the

fact the plane is not flying where it's supposed to on your screen. I've had that happen before where I thought the plane was turning one way and it was turning the other. One time I did mess it up. I was on the border of a country that you wouldn't want to go into. I started to turn the plane and I got distracted, and I started chatting in a chat room, and thank goodness there was a brand new airman, brand new sensor operator, sitting next to me. I'm a lieutenant colonel, instructor-evaluator commander. He's a brand new airman and thankfully that airman tapped me in the shoulder and said "Sir, do we really want to go left into country X?" I turned around to avoid the international incident, which I didn't know about yet and sure enough we were turning the wrong way into a country we probably didn't want to fly into. I told the airman, "You're right, we don't want to go in there." We quickly did as many mouse clicks as you could in a heartbeat, made sure the airplane was turning. The Global Hawk doesn't turn that fast, only 15 degrees of bank at a high altitude, so I was able to turn the plane, but that's this kind of situational awareness. When you're in an actual plane you kinda see where the plane's going because you see in front of you. So it will be a challenge how we build that situational awareness for the next generation because you have to have that feel, and it will be a different feel and different responses that we have to go through.

Autonomous logic. I spent countless hours between the engineers who wanted to design a 100 percent autonomous airplane where we don't need a pilot because our computer will do everything to sitting with people who wanted a design with a human in the loop and autonomy is not good for anything, and we'd constantly go back and forth between them. What we will have to design is an autonomous logic that pilots understand and can control with a mix between the two. Both paradigms have problems that you need a mix to balance between the two. An interesting thing about autonomous logic is that we are getting into an almost an artificial intelligence level of decision making. One of the jokes when I went through training – it wasn't so funny when I was in training – one of my main instructors would kid me that in an emergency one of the first things you do was take your hand off the mouse and let the plane do what it was supposed to do. That is very hard because what we do we teach pilots from day one of pilot training: Fly the plane! Whatever you do, keep flying the plane! Well, now we teach guys: Get your hand off the mouse; don't override it! Almost every situation I saw in the Global Hawk that got pilots in trouble, they were pilots on override that made mistakes. I never saw once in five years (if anyone's out there from Northrop Grumman you can give me a little tip later on, help me out here), I never saw the Global Hawk make a mistake. It always flew exactly where it was supposed to go; it was pilot override that got us in trouble, because you get into trouble with autonomous logic. First generation autonomous logic, it's interesting the development going on with the second and third generation.

Termination logic is the other thing that will always be a challenge in UAVs. A UAV is going to have to land, somewhere, at the end of the day. Interestingly enough, one of the ways the Global Hawk is designed is that as the plane sends itself around, it has certain parameters to land. It'll send itself around if it doesn't see those certain parameters. Well, on one of the first missions when they were testing Global Hawk it would go around – it was supposed to go around and land, and at a certain point it was not paying attention to the fact that it didn't meet those parameters or it would keep sending itself around and then it'll land wherever it runs out of gas. So they were testing at Florida and actually the plane sent itself around, because what was interesting was the two radar altimeters in the Global Hawk that help it land, to help it come

down, and it senses its sink rate. Well, right off the runway at Eglin there's a big ditch before the runway, so what the plane sees when it's coming down, it sees a sudden change in vertical velocity. So what does the plane do? Well, that's not good, something's crazy. We need to go around. So they sent it around and the pilots would put it back on its normal logic. Well, on the normal logic, it senses the problem. They sent the plane around three times, talking to the pilots who did the mission before they finally had to leave it on what's called the C-4 logic and see if the plane would actually disregard those parameters. So that's interesting. Those are not the kind of parameters you'd flight test, so they got to do a couple of test points and actually leave it on the logic and be able to land. You're always a little more motivated when you're in the plane to land it. It'll be very interesting to see how we handle termination logic when you're not in the plane. We used to joke there were two options: 1) you land it or 2) you give it to someone else and they can land it if your shift is over. I wouldn't really do that! [laughter] We did make jokes that if you ever were in a crash, could you hand it off in time? [laughter]

What I'd like to go through now some of the big challenges ... One of the first major challenges is going to be sense and avoid. I get to work on a project – integration of the national airspace and that's very important, but even more than integration of the national airspace is our airspace where our combat forces will be when they deploy is getting busier and busier. If you look in the paper, and I follow a lot of the UAS news, everybody – the Army's buying them, the Marines are buying them, everybody's buying a lot of unmanned aircraft systems and we're not going to need just a single sensor, but as we integrate UAVs across the board, it's going to be a busier and busier airspace. Now, ideally, the sense and avoid logic and procedures and parameters that will have to be developed for UAVs will have a dual purpose to be able to integrate into the national airspace and be able to integrate into combat ops. Now I do mention that integration into the national airspace isn't what a lot of people think. The Global Hawk doesn't need to go into Chicago next week and land and pick somebody up. So it's not like we have those kinds of problems, but there are a lot of training areas, and when you start getting into a lot of other missions like border patrol and other areas, it will be important to integrate, and the same procedures will be there for combat, more importantly.

Weaponization. We've seen the Predator be the first to have weapons put on it, but if you start looking around, there's many other weapons they're starting to design on UAVs and a lot of countries are looking for more lethal UAVs to put different weapons on different weapon systems. One of the challenges that will present itself is at what point are you going to trust how, if you're an old Odyssey fan, are you going to trust a computer to drop it without a man in the loop? We get into constant discussions about how far are you going to let a UAV do an autonomous mission before you let it drop a weapon? There's a lot of discussion you'll see in the papers about does this next bomber for the Air Force need to be manned or unmanned? The discussion is not technology, the technology to make the next bomber unmanned with current information. If you talk to B-2 and F-117 pilots, the computers do most of that mission. They're hands-off during the drop. The question will be – it's almost as much a political argument and a confidence argument. At what point do you still want a person in a bomber mentality where we go in the next few years?

Multi-aircraft control. One of the other main challenges, and you see this over and over again will be – we are starting to fly so many UAVs, you are not going to be able to have just UAVs,

with one guy flying one plane. There are going to be multiple missions with two or three planes are flying one mission and I know the Air Force itself cannot produce enough pilots, even with the new UAS operator track, you won't be able to keep up with the growing demand. There's going to have to be a push for one person to be able to fly multiple planes. Now this is very interesting because never in aviation history have we ever tasked anybody – you go the opposite direction – you need two people to fly one airplane, and so now we go in the opposite direction. How can one person monitor two? Now some of that gets into two arguments. Are you flying two UAVs on two separate missions, or do you give one command to your formation of UAVs and they accomplish the mission together? This will be interesting to see where it goes, but it will also be a challenge.

Civilization. I think we're going to start seeing UAVs used for civilian operations and I think we'll start seeing them as they become, they're becoming very cost affordable, cost-effective for civilian organizations. We'll start with police 'copters. Instead of the police 'copter being an expensive helicopter with people in it, now you can have a UAV go up and stay for 24 hours to monitor. I think the future of, you know, chasing Broncos down the road, you know, on television, it's going to switch over to UAVs to be able to do that. Now again, that's gets into that integration of the national airspace will have to happen as a precursor but the cost affordability of that is going to push it to be able to do that. You're going to get into rescue. You start looking at when they chase people around the mountains that escape, they're going to want to be able to go after them more and more. You start looking at weather cameras and TV news cameras, I think you're going to see that integration go on for the next many years. Now a lot of people ask me, "Sean, when do you think they're going to un-man a Delta jet or an American jet, I don't think they're going to do that for a long time. I think airlines are going to be flying with two pilots for a long time, but what I think you will see is you're going to see half-manned cockpits. FedEx and UPS and cargo carriers – right now the technology exists if you want to finish it. You could have a half-manned cockpit. You could have one pilot with the plane. He could do the takeoff with someone in a remote area and then he could actually – the person on the ground could fly that FedEx jet or that international cargo plane. It could be done very well right now. Where you get you savings on that, from a cost perspective, is that if you fly 10 747s, you have to have 20 pilots, but if I half-cockpit and if I half-unman those, now I have 10 pilots instead of 20 pilots. If I only require three guys on the ground to support those operations, I've gone from 20 personnel to 13 personnel. If you ever talk to CEOs in those kinds of companies about cost savings, if you could save them one pilot, that's a tremendous savings. You're talking immediately 25 to 30 percent savings on some of those. So it will interesting to see where we get a push, not so much from the technical, but from a monetary side, you'll be able to start seeing that technology. Most airline pilots, and I have a lot of friends, they talk about the fact that flying airlines now, once they takeoff, they're hands-off and they're plugging in information. You look at the latest Airbus plane that came out, what's in front of the pilot, there's actually a keyboard that comes out – the sticks are on the side – and he spends as much time on the keyboard as he does flying the airplane. So they're not that different even if they'd like to think so.

Anti-UAS development. The reason I wrote anti-UAS is because there's a lot of different countries developing UAVs out there, and we've had the advantage with our first UAVs operating in friendly environments. But, two things; number one, we may not be in friendly environments in the future, and there's so many other countries with lethalties that we're going

to have to look at how you also go against UAVs that are coming against us. What will be interesting is, if anyone knows a little bit about the Warsaw Pact NATO days, they overpowered us with numbers, so it will be interesting to see when countries that can develop UAVs at a much different, lower cost than higher-end fighters than we tend to have sometimes, is that, what happens if they have 10 UAVs that are coming against us and we have fighters that go after them, we will rapidly, just like the Warsaw Pact ratio where we would run out of weapons possibly before we run out of targets. It'll be interesting to see how we look at anti-UAS and how we're going to look at the challenge of taking on other countries. There's a lot of discussion about, you know, getting more UAVs, more UAVs. But as much as it's positive for us, we have to, number one, figure out how better to protect our UAVs with protection. Now it's interesting when I mention protection for UAVs, I'd mentioned when I was in Global Hawk, we'd get into discussions about maybe Global Hawk should have a defensive system. The question comes up, why would you want to defend a Global Hawk, there's not a man in there? What you're defending is the capability that the plane brings. It's a very expensive sensor, and I think you want to be able to protect that, especially at the cost. So there's defensive capabilities coming on, but we're also going to have to have an offensive capability that is able to project against other countries. Other countries are going to have UAS technology that is going to be offensive against us and our allies in the future, and that'll be very interesting to see how we do it.

As an example, what's next? Just one of the few examples – this is the X-45, which was a Boeing bird at Edwards. This was the drop of the first munition drop from a UAV that was done out there in tests. This is a view of what would be the X-47 coming off a carrier, the Northrop Grumman against the Warthog, very capable systems that have shown us a lot in the UAV world. Interesting, this is an AeroVironment, a hydro-powered plane. AeroVironment actually developed from an energy company, and they actually have a non-oil-based engine, hydrogen-based engine that runs. What's interesting about this guy – the prototype I got to work with a little bit and talk with these guys – it's a 500- to 1,000-pound payload, but it can stay airborne for seven days. Now, I thought the Global Hawk was Mr. Bad being up for 24; this can be up for seven days. This is in research and development right now, but what's interesting is every time you see UAV records being set, it's no longer hours, now it's days. Quintitech, I believe, out of Europe, has done some development, and they're actually talking about solar-powered flights that are going on right now, and they're talking up commissions up to a month long. If you're flying for a month, you're no longer an aircraft; you're a satellite, and that's how it needs to be treated. Now, we actually got more out of talking to space guys about controls for the Global Hawk than we did out of cockpit folks we talked to because it actually is much more in line. The other one I put up because it's very interesting to see – I first saw this and I thought what is that? This actually is the latest BAE aircraft called the Mantis that Britain came out at Farnborough this year and produced. You can kind of see the size of a person back here and the size of a person up here. This is what you kinda get as a competitor, or a compadre because we hope they're our friends still, with the Brits. This is kind of an MQ-9 level being able to carry multi-missions. This is already what's being introduced. They have their first flight test, from what I understand, this spring, and they're going to be going beyond that. So this is just a little bit of what's next.

What I find out most interestingly is that, of all the development, the biggest breakthroughs I got to see with UAVs were human ideas of how to push the technology. The success of the Global

Hawk that I got to be blessed with for almost five years before I got out was there were a lot of ideas to do something different that had never been done before, never been done with a Global Hawk. I'm excited to still get to be with UAVS. A lot of my friends who first thought that I was going to lose my career and never get to fly again – they were right, I never got to fly again after that, but it's been extremely fun getting to know a whole new world. We're going to see probably some of the biggest differences, I think, in flying in the next 10 years that have ever happened in aviation, with unmanned aircraft systems, and I'm hopefully going to get to be a part of that.