NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE

Wings & Things Guest Lecture Series

From Weasels to Raptors: A Test Pilot's Story

Rocketplane Global Vice President and Chief Test Pilot Paul Metz discusses his more than 37 years and 7,000 flying hours in over 70 different types of aircraft.

It's a real pleasure to be here tonight. I wonder if you've ever heard somebody say that and then asked yourself, "I wonder if that guy really is comfortable and wants to be here tonight or is it just a throwaway line." Let me tell you a little story – I was born in Springfield, Ohio, about 20 minutes to the east of here. I loved airplanes from the moment I was born, I believe, and this place has a very special meaning to me.

[Slideshow]

The Air Force Museum – in those days it wasn't this magnificent structure you have around you; it was a series of small World War II huts and most of the airplanes were outside. You could touch and feel them, crawl all over them and it was a very inspiring thing to me and I never could get enough of coming down through Fairborn and looking through the side streets till I saw the Atlas missile and knew that this was where all the airplanes were at. Over the years, the past 50 years, I have come back here many times. I make it a point to stop here in the museum in Fairborn and if it's only 10 minutes I'll whip through one of the exhibits or spend a couple of hours here so it's very much a part of me and I'm sure that it's a very inspirational museum, one of the best in the world. So I was delighted when I got the invitation and I am indeed delighted to be here tonight.

First of all, you notice that the title is different. I figured there were a few more animals that I needed to throw in here to tell the story properly so it's a bit more than just the Weasels and the Raptors, which are the end points of the story. What I want to do is put this all in a context because I had trouble with this thing when they first said they wanted me to talk about these three different airplanes. I said, "Well, gee, they're so different." They're really not tied together in my career, and surely not tied together as subjects. But the more I thought about it I said, "Yes, they're absolutely tied together." So I want to present it this way – if you think about aerial warfare and specifically fighter aircraft, as in all weapons there is an offensive capability and there is a defense against that weapon and so that is true with aircraft. So, for example, offensively it soon became apparent that the machinegun was going to be a primary offensive weapon in the aircraft – offensive against ground troops or you could shoot down an airplane with another airplane equipped with a machinegun. You see that here in the Marine, here, mounted on the galling is a machine gun, one of the first applications, in1915. On the defensive side you're always trying to get rid of this weapon, and so from the ground point of view the simplest solution was you simply take a piece of artillery and you mount it on a chassis so that you can traverse and elevate quickly to point at the airplane trying to shoot you down. And in World War I it became known as 'Archie' or 'Ack Ack'; today it's called AAA. But those are

the two fundamental starting points.

If you look at it as a timeline with 1915 down here and 2015 over here … and I've highlighted the various major conflicts – World War I & II, Korea, Vietnam and Iraq, and Afghanistan down here; what you see is that first thread of a gun on the airplane and the anti aircraft on the ground continues for the past 100 years or will continue into the future and are still integral parts of the airplane design and defensive capability.

But beginning shortly after World War II and certainly, past the Korean War we began to see another type of weapon, and that is the missile, the guided missile. And on top of that we began to see, in Vietnam, the ground-to-air missiles. So now you see two additional weapons introduced. The main thing that is important here is that these original weapons … if you like the GEICO commercial … technical problem here.

Okay. These are ballistic weapons; in other words, you shoot them and then it's up to God and gravity and aerodynamics will determine where that bullet goes; you shoot it and release it. The difference was now you get into what are called 'guided weapons'; weapons with a brain, weapons that can actually chase you down. When you jig-and-jug they move with you and try to get to you. So it adds a whole new flavor to the air warfare.

So what I want to do from this point is take you to Vietnam where we encountered the kinds of guided weapons that were added later on. The real difference in these guided weapons is the weapon, certainly, but the radar – the introduction of radar; tying those two together.

On the left you see the guideline missile; we call this a flying telephone pole. I like this picture because there is a telephone pole right there, about 35 ft long, about 350 lb charge that when it went off it went off like a shotgun throwing ballistic pellets out so all I had to do was get close and it could knock you out of the sky. What was different here was that now they could see you when you couldn't see them. A radar can look through the weather, a radar can work at night, a radar can work and detect you at very long distances where the human eyeball can't see you. So you have a situation for the pilot that is becoming increasingly dangerous because of the ability of the radar coupled with the weapon. I think the best way to see this is to actually see a demonstration of what this looks like.

This is SA-2 sites. In Vietnam a battle was to fire two missiles – the first one and then 6-seconds later, another. The booster goes off and there is a big plum of smoke as you can see and then once the booster drops off this guy is coming at you and you can't see him until he starts coning, in this particular case, and you finally start to pick him up. Watch the motions of this missile; look how agile it is, and you just have a tough time getting away from something that can move in that manner. Now the second missile is already on the way. I'm not sure what this targets is, coming into view, up here near the top, but this is the target and I believe the target is something hanging; probably it's just some parachute, so it's a fairly static thing, but that missile is continually correcting and very agilely, finally hits it. Interestingly enough, the second missile sees a chunk of material coming out right there and is going to go after that little chunk of material. So not too much is left. Boom, they've got it.

Obliviously, the impact in combat was tremendous. This is a very rare picture. An SA-2 SAM missile has come in a beam in the flight path of the aircraft, exploded and it has hit the aircraft and he is on fire and will be probably ejecting very shortly.

When we first saw this it wasn't a surprise because … told us that these sort of missiles where around and can do us damage but people didn't pay as much attention until we started losing airplanes. Initially we tried to counter it by jamming the radar signal on the ground but for fighters that doesn't work very well and we had to come up with other ways of doing it. So we came up with the 'Wild Weasel' concept.

Now this is the 'Wild Weasel' patch. You'll see it out on the museum floor. The air crews that first told about this; they said, "Look, here is our idea – we're going to get this special airplane fitted out. We want you Weasel pilots, we want you to go into the target site before everybody else and we want you to have the missile shoot at you. And then while they're shooting at you we're going to have the other guys come in with bombs; they're going to bomb the target but they'll be so busy shooting at you that the other guys will get their bombs off and can leave but you can't leave until they have left. So we you want the first in, we want you to be shot at and then we want you to wait around and only leave when everybody else is safe." And 'Willy Weasel' was supposedly the look on the face of the pilots when they were being explained that, "This is what you're going to do."

And then down here, if you've got to be … exploitive me. That became the symbol of the Weasel mission.

Now the airplane … this is the second type of airplane; the first airplane they used was the F-100 but they finally started using F-105 and the reason was it was the standard bombing airplane at the time so there were a lot of them. They took a two-seat version and they put on jamming pods which you couldn't use because if you used the jamming pods then the radar couldn't see you but you couldn't see outside the jamming signal, yourself, so you had to basically turn those off all the time. And then we added some missiles, so these are radar seeking missiles that can see the energy coming up from the ground site and home in on it. There was another one called the AGM-78, which is also programmable to go after the missiles but that's how we were supposed to defend ourselves against these guys who were trying to shoot at us.

There were two crew members onboard; of course, the pilot and then this guy back here who was called 'The Bear.' I'm not sure where that comes from; some people used to say, "Like a trained bear, you have them with a big chain around their neck and you yank them around" and so they were affectionately known as 'Bears." You flew as a team; you worked and never split the team up. And the reason why was because to be successful the backseat or 'The Bear' had to interpret the signals from the radar and give you good information on where they were at and together, you both had to be able to try to evade that sinuous snaking missile as it came up towards you. So you actually got to the point where you read each others' minds and you knew exactly what had to be done and that's why you teamed up and flew as a group of two.

I want to give you an example of how we worked, just one example tonight. I wanted to show you what our missions looked like and compare it with something you may be familiar with,

which is World War II. We were stationed at Karat, Thailand and we would go many places including Hanoi, and that distance – 424 miles one way… just to give you a feel for it – from London to Berlin is 492 mile; so kind of, a comparable distance transit to get to the target area. We had two basic missions – we went in with the fighters to support the fighters' strikes but we also supported B-52 strikes. The B-52, most people don't know, was used for eight years in Vietnam. It was there from the start; they had a lot of missions under them. However, they were never sent into high threat areas. Strategic Air Command was afraid of losing their nuclear strike capability and they really weren't supportive of these minor wars, which they considered Vietnam to be, a minor war; so the B-52s were heavily used to bomb The Ho-Chi-Minh Trail, which you see here. The tons and tons of bombs that rained down on this place made it like the surface of the moon; you can just see the amount of jungle salad that was made by the B-52s. That situation continued for most of the eight years and we spoke disparagingly of B-52s because we didn't feel that they hung their necks out and anytime there was a threat they would never go in. But in 1972, President Nixon was determined to end the Vietnam War. We had got the North Vietnamese to the Paris Peace Talks but it was clear they were not serious about it; they wrangled about the size and the shape of the table they were going to sit at and never came to grips with the actual issues of how to end this war. So Nixon decided, in December of 1972, that he was going to send the B-52s into then, the most heavenly defended target area in the world and that was Hanoi; rained with all forms of AAA and the surface-to-air missile, the dreaded SA-2.

Now let me give you a feel of what we're going to see in a few minutes here. The B-52 is equivalent to twelve B-17s in terms of bomb tonnage. So even though the numbers I'm going to show you may seem to be small it's actually representing a huge number of equivalent bombers used in World War II. The standard SAC maneuver was to fly three airplanes together called a cell and they would stack them vertically and space them laterally so that their radar jammers would jam the signal of the SA-2. That was their primary defense against the surface-to-air missile, was jamming. They had to stay in this formation. If they ever deviated from it and lost the protection of the jammers they were a huge radar target and could easily be detected and shot down.

Here is a turnoff target of B-52s; they generally flew at about 35,000 ft. This is called a 'post target turn.' It's an exact 90 degree turn off the target. The reason they turned 90˚ off the target was because that's how the manual said to do it for nuclear weapons to minimize the blast. Unfortunately, we were not using any nuclear weapons in North Vietnam. It turned out that this was going to be a fatal flaw for the B-52s because they're not in that carefully orchestrated three-ship formation and they do not have coverage at all from their radar jammers at this point.

Now I'm going to talk about a very specific time; it was called 'The Eleven Days of Christmas' 1972. It is considered probably the last mass bomber attacks that we'll ever see again. Strategic Air Command directed tactics based on the greatest fear they had, which was that two of these bombers might collide with each other and be destroyed. So what they did is they took the airplanes and they sent them all on the same route, at the same attitude but they split the force up, of 129 airplanes, into three groups; equal groups. The first group would go through with the cells lined up one behind the other; this crew is called 'Ants going to a Thick Neck.' We called it 'ducks in a shooting gallery.' So one third of the force is coming in along this track, lined up one

behind the other, and they would wait then, four hours and one-third of the force would do exactly the same thing four hours later and then they wait four hours and the rest, the last third, would do the same thing once again. Now the Vietnamese were not stupid.

About the first three guys who came over the run in, they saw two things – they saw 1) everybody is at same altitude and they're always going on the same track so let's just aim right towards this area because you know where they're coming from. And also, exactly one minute before they're going to release, they open their weapons bay doors, their bomb bay doors and suddenly, from a radar's perspective, they become huge. So SAC ordered them to open the weapons bay doors one minute. So they gave the North Vietnamese one minute of free time, coming straight and level into the target and when they made the post target turn in 90˚ they lost their radar protection again and so they could shoot them again, and that's exactly what they did. It was carnage on the first night and then SAC went and did it the second night and did it again on the third night and the results were horrific.

That's the graph. Bear with me but I think it's very illustrative. These are the eleven days of Christmas – December 18th to December 29th. Each dot is the day and the blue line is the number of sorties, read over here, that were flown. Okay. So on December 18th 129 sorties were flown up here, and you can see the other days. This blue line right here is the equivalent of a thousand plane raid of World War II in terms of tonnage. So you can see that on the first day and the second day and the sixth day we were actually larger than a thousand plane raid on this place. Red goes with red; this red line is what SAC estimated would be their loss rate, and you can read it over here – it's 3%. The bar represents the actual lost rate. So instead of 3% you can see what happened. The first night it was a little less than 3%, nothing on the second night but the third night it was almost 8& loss rate on the aircraft. And again, you can see here, on the 27th it was a really high loss rate. What happened was this – remember we had the North Vietnamese in Paris, trying to get them to talk peace. They had such a field day here that they became stubborn because they believed they were wining. Strategic Air Command was so perplexed by what was going on here that they pulled the airplanes back in the next three nights here. They moved the aircraft almost 60 miles away from Hanoi at targets that were not defended and only sent in 30 bombers instead of 129. That also caused the North Vietnamese to figure, "We've won, they won't even come near us anymore." So they were not in any mood to bargain. Nixon insisted that SAC go back in but finally they got the message that the tactics were not going to work with 'Ants going to a Picnic' because it was going to be 'Ants going to a Slaughter.' So they changed the tactics, sent in a huge force up here; 116 airplanes and this is what it looked like.

Here in Hanoi, these tracks represent streams of B-52s. You can see these guys are going this direction, the ones in white are going this direction, these guys are going here and so forth, back and forth. All the airplanes were flying at different altitude, obviously different tracks and they all were going simultaneously. Instead of eight hours all the bombs were dropped in 15-minutes. The affect was devastating – the North Vietnamese simply couldn't react; they were overwhelmed. The interesting thing about all this – the 'Ants going to a Picnic' was driven because they were afraid of midair collisions. Their own doctrine for nuclear weapons was this tactical method and they wouldn't use it initially.

So what we learned was this – SAC was a very regimented organization; you'll do it SAC's way or you're out of here. And that was good post World War II and it worked but you can't be inflexible like that in real combat and SAC was in the mission before. They didn't think the Vietnam War was an important war for them and they didn't know how to fight a conventional war nor did they have a doctrine to do it. The combat crews knew what was going on right from the get go but they, out of hand, rejected it, as did the commanders in Thailand and Guam who told them that we have to change tactics; they were rejected by Headquarters-SAC and that reason was just because they have very little combat experience there and people were book driven, rule driven when they should've been using the tactics like the ones you saw on December 26th; they didn't. And then use tactics like the post target period and the 'Ants going a Picnic' when they were unwarranted. And from my point of view this was one of those times when bravery was the common thread for those crews. They pressed on amidst fire from the sands; that was awesome to look at, obviously devastating. 15 airplanes were lost. Our job was to try to intercept the signal and tell the SAM sites. We flew at 17, 000 ft, the B-52s were at 35,000 ft. We tried to fly underneath of them so that the radars would have to look through us and we could detect and kill them but it turned out to be very difficult do. They were a mirage firing hundreds of surface-to-air missiles at the time. The lesson is that when you use aircraft probably it gets the job done and if you don't you squander lives and you squander resources.

Okay, so that's Vietnam. And we're going to segway into the YF-23 and why the linkage is there. We talked about this before; we talked and you've seen the effect of guided weapons, weapons that can see you when you can't see them. It takes away your ability to operate in weather, it makes it difficult at night. And so when they can see you it makes it tough. So rather than develop some new kind of super weapon people started looking at the problem differently. Well what if they can see us; how does that effect combat? And that's why, about the early '70s, studies began and by the time of the ATF it really solved the approach we were going to take. Everybody in this room knows what the approach is; we've noticed since we were kids. And just as you mentioned, somebody would probably pay a pretty penny for this baby and people were willing because it seemed to be the only way out of that conundrum of, "They can see you and kill you." So people have been toying with this idea for a long time; there have been four generations, recognized generations of stealth. This Horton-229 occurred late in a war – December of '44 it was flying as a prototype; high subsonic conditions, very maneuverable. Very maneuverable fighter but it couldn't go very far with the jet engines of the day but has been proven recently. It was virtually invisible to the radars of the today; special materials, special shaping in Generation-0 Stealth.

Generation-1 is the SR-71 Blackbird meant to penetrate the surface-to-air missiles of the Soviet Union. It had some rudimentary shaping that we know today as stealth. It was extremely fast – Mac 3+ but pretty much straight and level. It didn't carry a lot except camera sensors but it could go long ranges supersonic.

We get to the second Generation and you see airplanes that don't look like airplanes anymore; they look like a serious of flat plates welded together which is kind of what it is. The 117 Nighthawk is a high subsonic airplane. It's somewhat maneuverable but it's not a fighter; it can carry a limited payload up inside the weapons base and limited range except all these later airplanes can air refuel so they can go greater distances.

These platforms are uniquely flat plated but they're not very much an aerodynamics extreme so people who're looking for something a little bit more like an airplane… and the third Generation looks more like an airplane although; it's a flying wing it has smooth shapes, it's not made out of flat plates. The B-2, obviously, is a subsonic airplane. Again, straight and level like the SR-71. It carries a huge payload and can go for long ranges. So the question is if you look at all these characteristics which ones are missing in a fighter? And that became the challenge of the advanced tactical fighter, was to put all the pieces that we've seen in several airplanes into one airplane. Specifically, what the Air Force wanted or what the service wanted was it to be 'invisible' and be omissioned. Now what that means is, you know, the highway patrolman hides in the bushes or underneath the underpass with this radar gun; he is invisible to you from the eyeball. You don't see him but with your fuzz buster he gives himself away when he turns on his radar, right. So he becomes visible because of the use of his sensors. What we were asked to do is get something to be invisible, like Wonder Woman, but you've also got to be able to see the other guy and do something about it. So you've got to go with sensors that you can operate and they can't see. It's the ultimate radar gun for the cop, and they don't have it yet but that had to be done. It has to b e highly maneuverable just like the fighters of date or better and had to be able to go at supersonic speeds for long ranges; it's something fighters cannot do because of the use of the afterburner which gobbles fuel. And you had to carry a lot of stuff up inside the airplane. So that's the boundaries for these airplanes.

The ATF program started in the late '70s. There were companies that put forward proposals for these kind of invisible, omissioned maneuverable kind of airplanes and in '86, Halloween of '86, they picked two companies to build and demonstrate these advanced technologies. We're going to talk about the airplane but there were many other things like the avionics that were tested separately and shown to be possible, possible for the future. So that happened in '86 and then in 1990 we flew the prototypes, which we'll take a look at here in a minute. So two engines and two different airplanes – two for Lockheed, two for Northrop, and they were all tested. Interestingly enough, of the seven companies there was a mad scramble for the other five who didn't get the contract to see if they could get a piece of the pie so there was a great amount of teaming that went together, so that Lockheed General Dynamics and Boeing joined up to build the YF-22 and Northrop and McDonnell Douglas joined up to do the YF-23 and then in '91 they selected the winner.

So I'll talk a little bit about the flight test program. There were only five pilots who flew the YF-23; three of them were contracted pilots, one was an Air Force test pilot and one was an Air Force operational pilot. Those were the only people who flew the YF-23. And then there was a separate set of pilots who flew the YF-22. So no pilot has ever got to fly each one of the prototypes by Air Force directive.

And this is what it looks like. You know, it has a very distinctive shape. It was meant to replace the F-15 so you can see they're fairly similar sizes, and just for reference here is the F-16 which is an air-to-ground primary type of a fighter aircraft, but a smaller aircraft.

The airplane has a trapezoidal shape. It has these V-tails. I always found it interesting that to really understand what these V-tails look like if you took them and laid them flat like the wing

they're huge; they're almost as big as the main wing. What's important is that this is an unstable airplane; without computers it would flip out of control but you put a large tail on like that in an unstable airplane and the airplane becomes extremely agile. It can point and maneuver extremely well, and the YF-23 certainly did that.

From the side view the airplane has the sleek lines, kind of, of an SR-71 and you can almost intuitively say, "Boy, it's pretty sleek design" and in fact it had a very low drag so that its speed, without afterburner, was the highest of all the ATFs.

And of course, you can see it here on the plan view and it looks like a totally different airplane; these are called Edge Aligned Plant Forms. If you look at this angle and that angle, and that angle, and that angle they're all parallel and that is important from a radar reflectivity point of view – it cuts down the radar return and it helps you to be invisible. It is invisible because, in fact, these airplanes can be seen but the equivalent is looking at a bumble bee in flight, and that's what you're looking at so they're extremely tiny from a radar cross-section point of view.

We learned several things from the airplane. We had what was called the Picture Window Effect. You can see the big tails here, laying off the side. And in any other airplane, F-18, F-22, with twin tails what you'll see from the cockpit looks something like this – you'll see these two vertical tails sitting up there. So when you're looking through the back or what we call 'Checking 6' these guys are always here and you get used to it but surprisingly, they are blocking your vision and when you do it like that the airplane has this unreal or surrealistic effect of just being an open window behind you. It was something new that none of us had ever seen. And also, if you look at test airplanes you'll see about a 12 ft long boom or tube coming out the front of the nose and that is used to sense air data when you don't know what it really is doing on a first airplane flight. This airplane doesn't have that; all the sensors are mounted on the skin of the airplane and you just simply sense the air around the airplane and by computers, determine air speed and altitude. I was really nervous about that but the engineers comnisciented it and they knew what they were doing and they did it; it worked very well.

This is an old movie; there are surprisingly very little remains of the original materials that were done on the program so it'll be a little blurry but I'll kind of, narrate through it and give you some idea of what the airplane looked like flying.

Anyway, the competition lasted only about 90-days, the flying portion of it lasted about 90-days, and the YF-22 was selected as a winner to be developed into the F-22 which know as the Raptor today. It was a competition for a large contract so we were isolated physically and did not communicate with each other but nonetheless, the Chief Test Pilot for the YF-22, Dave Fergusson was a good friend, a personal friend, and we made a vow before we started the test program that if there was a common problem that could affect both airplanes we'd like the other guy to know so we could take steps on our end to make sure that we didn't put risk on our pilots and we held to that, but the outcome was in favor of Lockheed.

So let's talk about the transaction from a prototype to a natural production airplane. Somebody once told me, "Well it's such that your mother wouldn't be able to tell the difference" but this is the prototype and this is a production airplane – production – prototype, prototypes-production.

And they do look very similar. The realities are they are very, very different.

This is from the YF-23 but it is a similar sort of picture for the YF-22. When you build two airplanes you're not going to build customized everything, you know, you're going to go the cheap route, get what you need to demonstrate. In our case the shape could be – have good aerodynamics; so we're going to demonstrate that. The rest of it you do it on the cheap. And if you look over here to the contributors, we took parts from the space shuttle, helicopters, F-18, F-15, landing gear and so forth and used those to build that airplane, as did Lockheed for theirs, all to keep the prices down. The other thing about a prototype program is it has different objectives. This was to demonstrate to the government that the potential was here for these airplanes. It lasted about three months, as you can see, and we had less than 100-hours on two aircraft. To take that airplane and put it in the hands of an operational pilot you spend quite a bit more time and energy. Eight year, 5,000 hours – there were nine aircraft used in the full production program. So you had an airplane that was physically different. It had all the omission sensors in it which the prototypes had none, and it had to be placed in the hands of the operator knowing that nothing could harm them no matter what they did with the airplane.

We started the program in Marietta, Georgia in 1997 – first flight, and after the first airplane we moved them out to Edwards Air Force Base where the bulk of the test program was done. The airplane proved to be extremely well behaved, flying qualities were excellent. This was one of the tasks where you find that the flying qualities are very demanding from a pilot point of view and if you can't air refuel you're not going to be able to fly a good formation and some of the other things that require great precision, but the F-22 was probably one of the easiest airplanes I've flown. And we tested on both, KC-135 and KC-10 with good results and used air refueling everyday in the test program.

Another aspect of it is angle attack. These airplanes have to be well behaved when you take them to the extremes of their flight envelope; either very fast or in this case, very slow and they can't do anything untoward like loop, go out of control and damage the airplane or the pilot. So we have special programs and we'll send the airplane up into unusual altitudes and do things with it to make sure it can recover. And assuming this guy's going to work, here's a short video clip of it.

The green that you see on there is a view through the pilot's heads up display and it gives him the altitude and air speed; it's not really important here as much as just simply seeing the airplane fly, so please work. There we go.

The airplane is taken to conditions of zero air speed with various kinds of throttle conditions, slamming throttles from idle to max.

Here is one just simply falling backwards through its own smoke, stops, backs down and it will come out flying. It doesn't always do that in the test program and you have to go back and tweak the flight controls but when you're finished… we had an airplane; it was called Carefree Abandon. No matter what the pilot did with the stick or the throttle you couldn't hurt the airplane or the engine. It would simply obey your commands. And when we get to the air show I think you'll see just how much confidence the operators had in the Carefree Abandon airplane.

One of the segments on testing is your weapons separation and what you're interested in here is will the weapon come off the airplane clearly and not fly back up and collide with the airplane? What happens when the rocket exhaust motor kicks off and you swallow it down the engine? A lot of engines don't like that. What happens at various speeds and angles of attack and roll rates? And this next video will give you some idea of what this kind of testing looks like.

The weapons are all carried up inside. Again, that is for stealthy reasons. So the weapons bay door opens and the missile comes out and off it goes. Remember, the buffs, when they open their weapons bay doors one minute before a bomb run, they could be seen by radar and the same applies for an airplane like this. So the weapons bay door is actually opened and closed very quickly.

There's a gun mounted internally, you know, a gun from 1915, updated for… the galling gun; they carry flares, that's what you see going out here. We had to shoot the missiles and drop things while we were in a roll. Here is a roll with … going out. We're players. The airplane, at high angles of attack, will cause a missile to pitch off like here and start to isolate but you have to test all those conditions because the operator will.

I think there is a final sequence coming up here of two missiles. There's one, there's two. It can ripple launch up to six.

And there's just kind of, a neat shot with the tracers coming out of the gun.

A lot of things we can't talk about – stealth technology is obviously highly classified, the omniscient sensors are highly classified. We feel like we've done a pretty good job with the airplane, stealthy-wise.

It's hard to believe that from the time the contract was first let for those prototypes until the first operational pilot took an F-22 up on his own it has been 19-years; these airplanes are computer airplanes. Everything from the brakes to the launching of missiles and flight controls are all done by computers. How much does a computer change in 19 years? So one of the challenges we have today is in these long gestation periods you have this really short timeline in the driving technology, which is computers, and we've got to learn to do it much faster if we want to feel relevant pieces of hardware. But the airplane has turned out great; we hear nothing but plaudits. It was originally designed to be at least twice as effective as the F-15. Early on when we were doing simulations we would come out and scratch our heads at night saying, "You know, this isn't about being twice as effective as the F-15. This is like 20-or-more-times as effective as the F-15." And sure enough, that's the way it had come out. It's a remarkable piece of engineering.

So with that let me give you a little short picture of the air show and, Dan, if you would bring up my audio there and let's take a look at what it looks like today.

[Clip]

Okay. So the interesting thing is that people always ask me, "Well, you know, is this better than the Mig-29 or Mig-36 or whatever?" The problem is that this airplane, to go back to what we originally said, is designed so that they can't see you and so its effectiveness is done stealthily. It just goes out and people fall out of the air and they don't know what hit them. This is an air show, this is impressive to be sure, but this is not how the airplane fights and this is not how the airplane wins. So somebody can dream up some day how to show people all this exotic super secret stealth and avionics at an air show.