Mitchell Institute for Airpower Studies

Presentation: "The Radar Game"
Air Force Association Headquarters, Arlington, Va.
September 30, 2010

Dr. Rebecca Grant, Director, Mitchell Institute
Col. Michael A. Fantini, Division Chief, Combat Force Application, Hq. USAF
Col. Leonard D'Amico, Assistant Division Chief, Combat Force Application, Hq. USAF

Mitchell Study: The Radar Game

Dr. Grant: [In progress] — stealth and survivability and why that's so important for airpower today and in the future.

I think it's a great time here in the fall of 2010 to put up a picture like this. Someone asked earlier, what are those? Broadcast towers? I have to say they're pretty much close to that's what they were, but this in fact is a picture of some of the Chain Home radar installation system that was put in place on the coast of England during the Battle of Britain. This, of course, is the 70th Anniversary year for what I think was pretty much unquestionably the most decisive air battle ever and one of the very most decisive battles in Western military history. The ability of the British to use radar really started, in my opinion, the radar game.

Radar, of course, was a known phenomena. It had been used in detection of ships in a small way by several different countries as early as 1900. There were fits and starts in development both in the UK, here, and some other places. But there's no question that it was the RAF that really put it together in the operational sense the first time.

The Battle of Britain, I've often asked what's the real date of the climax of the Battle of Britain? And I'll give you a suggestion on that later on. But as we know, it came after the fall of France, the pulling back of the RAF forces who had been helping to defend France in order to defend the island itself.

The RAF forces were really outnumbered and the Germans were able to move fairly significant wings, as we would call them today, into bases close to England and France.

The key, and what the Luftwaffe was looking to do was to gain enough air superiority to make possible an invasion. In order to do this they had to get air superiority over this particular coastal area. You see the line here that divides the approximately reach of the ME-1 and 9 escort range. They had to try to win this battle in this key corner of Britain

in order to gain control of the air. They certainly had the manpower, the pilots, the aircraft and the resources to do it, and one of the big reasons they didn't turns on the use of radar.

The Chain Home radar system, to simplify it greatly, was a naval, the detection of incoming attacks, and this enabled the RAF to organize their defense. So instead of trying to defend in a line, they were able to vector aircraft to where they were most needed. That's in a way how they made their inferior numbers cope with a larger number of German aircraft.

Had they not been able to do this, had they tried to simply do point defenses of key airfields or plants or cities, it's very difficult to say if the RAF would have survived the difficult exchange ratios that prevailed through July, August and September. The exchange ratio was in the favor of the RAF, about 2.5 to 1, but it wasn't enough to compensate for the superior numbers and all the difficulties this entailed. But with the success of radar they were able to create this operational advantage.

The result we know was from the Luftwaffe's point of view, in those days, a failure to control the air. And because of this, the invasion was first postponed on this very decisive day of 17 September, was postponed until October, then in October it was postponed indefinitely.

It's interesting to me that the chart at the bottom shows German sortie totals for a seven month period here, and they continued to fly and continued to try to attack, and of course the attacks went on and on. A lot of this was a blunder of a strategic diversion to attacks on London itself, but it wasn't as though the RAF had completely decimated the Luftwaffe. What they did was to use radar and smart tactics in order to prevail and to continue to deny them control of the air over the south of England.

We saw the next phase in the radar game begin with ways to defeat radar, and the most famous of those coming out of World War II was the use of electronic countermeasures, the first one being chaff. The picture on the right shows a German Wurzburg radar scope. It's important to understand that not only did the RAF and England have radar set up on their side of the channel, the Germans had a very highly integrated radar air defense network during the war as well. So much so that although the RAF had this invention of chaff and used strings and small strips of metal to defeat radar, they waited a full year before using it, not wanting to have a countermeasure come up or to unveil their secret. So [World War II German Gen.] Adolf Galland talks about the impact of this first use of electronic countermeasures and obscuring of radar and simply says, the whole quote is interesting to read, but "Not one instrument of our radar defense had worked."

So there you see it from the Battle of Britain through the use of chaff, the radar game, which was such a central part of the operational strategy for air power in World War II.

The duel changed enormously, of course, in the 1950s and '60s with the development and the employment of surface-to-air missiles. So now instead of carrying chaff or trying to have speed and altitude, in other words to outrun it, you really had to look for a different way to cope with the surface-to-air missile as part of the integrated missile threat.

I think it's interesting to look, the few years that it lasts from the famous shoot-down of the U-2 through a period where the North Vietnamese really began to stock a significant number of missile batteries, and that becomes a major source of losses in the Vietnam War and a major part of the strategy from then on for dealing with how to gain air superiority for dealing with control of the air. Another phase in the radar game.

But at this point as the missiles come in, you run out of other things to do. You cannot make an airplane that flies high enough or fast enough with the possible exception of the SR-71 to defeat these missiles. In the end, the advantage will go to missiles. What to do?

What you want to do of course, looking at this modern day thing, is to take, as the cartoon on the left shows, conventional strike where you have overlapping, integrated air defenses and you've created a zone of danger in that whole shaded area. You want to change it so that in another setting you have a stealth strike that can still have aircraft that penetrate and can reach and attack their targets.

Stealth can reduce the effectiveness of that integrated radar coverage, and one of the key insights to this came from the [inaudible] of missile [inaudible], the tests by the U.S. of early missiles. It showed that you could get amazingly small radar cross-sections if your shape was smooth enough and conformed to certain requirements.

How did this happen? Well this is largely the subject of most of the rest of the radar game, and I'm going to run through just a few of the ways this argument is laid out.

This is, of course, a primer on why stealth is important. It's far from the last word. It was actually cleared and released by the Air Force quite some time ago, but the principles remain valid today. I've been struck as an observer of air power and the application of it, to the extent that we don't always understand in our public discussions what stuff is really designed to do.

To break it down, you have diffraction from aircraft. You take principles like this. What are the areas of diffraction? What is the specular reflection? How do waves travel? What are those principles of diffraction? What are the many different ways that radar can form over and around a shape and create a return back to the receiver?

The breakthrough, of course, is being able to take all of these numerous variables and put them in some way into a radar range equation so that you can begin to understand what type of radar reflector you've created and how then to use stealth in order to shape,

control, and reduce that return. Shaping and controlling it being at least as important as the aspect of reducing it.

That's why you see the earliest designed as well, and of course we have 117, based on facets where the geometry made the prediction and calculation of the radar waves relatively easy to control. I say relatively easy because it was in itself a tremendous breakthrough.

The second phase came with the second generation, think of the U-2. It's curved surfaces and the ability to take a curved shape and understand how the waves would react around that.

All of this, of course, was tremendously assisted by heavy investment by the U.S. aerospace industry in the process of computer aided design which enabled us to go from a set of principles or something that would be mock-up in a workshop and then tested on a radar range into something that could really be manufactured, understood, improved and refined.

Of course in dealing with stealth the proof of concept always came either from a pole model that would be taken out and tested at night, or from tests on the range as well.

So in the end you could take all the principles and all the calculations and all the things that the engineers said should work, but you'd have to go and test that aircraft and see what its signature is like on the range to understand if it's achieved the benchmarks that had been set for it, whether it's maintaining that signature, and how it will work in combat.

As we know and as we read a lot about now in the last years, really two decades that we've been discussing stealth and how it works, there's also an issue of maintaining it and of how the materials involved in the structure and the design of the aircraft relate to its combat effectiveness. These two little cartoons show you partly why this is important. These are elements that go both into design and into maintenance.

The first one on the left here looks at the impact of a gap or a crack on a surface. Imagine a perfectly smooth shape that's controlled the way you want it to be that has a crack or a rupture. What is the radar return from that? How do you anticipate it? Maybe it's something that's developed through wear and tear. Maybe it's something that's there in order to have a door or an antenna in the earlier designs.

Equally was the issue of radar wave absorption. That was the first way that stealth was really reduced was by using materials that could absorb and thereby control, lessen the reflection back from radar. As we came to find out, while this is a very useful technique and it applies successfully on many types of aircraft, it's really the shaping itself that gives some of the primary return and benefit. But all these complex tradeoffs go into the creation of a stealth aircraft.

Then of course the design evolution with which we're so familiar. If you take an aircraft such as the venerable A-10, tremendous, proved in combat many many times over, in use today probably as we speak, and yet how it differs from an aircraft like the 117, now retired. Where you see a deliberate effort made to capitalize on the techniques of stealth. A decision so important that it was seen to be the way forward.

What does that do? In the most simplified and roughest sense, you can take a very large return and control it into something smaller. Maybe it's a small shape, maybe it has different pieces that go around it. But you create something that is not what the receiving radar and the integrated air defense system is expecting. It is not something that's optimized to handle, and that's how you get stealth.

The evolution of stealth I think is very clear to see in some of the design changes. You see here an F-15E from [RAF] Lakenheath [UK] on an OIF mission carrying a lot of [inaudible] important stuff. Again, especially [inaudible] taken today over Afghanistan. You see on the right, F-22 in tests where much of this has been tucked inside. Why? You want to minimize the return, or eliminate it if you can from all that stuff that is hanging underneath the aircraft. And while there are various things you can do, just a simple glance back at the physics tells you why the conformal stealth design such as F-22, F-35 are so unique and why they represent such a leap in the capability for the radar game.

It all comes together in the operational piece. I think as this quick discussion of stealth shows you, this is not about a sure thing. This is not about guaranteeing that you're going to have always a certain level of reduction. It's about taking the techniques and doing your best to outwit and to deny the optimal functioning of that adversary radar system. And it varies in so many different ways. One of the key ones, of course, being frequency. A larger, longer radar wave will literally paint or react over the surface of an aircraft very differently from a smaller, shorter wave length, higher frequency radar such as [inaudible] fire control. And there are tradeoffs. You may have a wonderful long, long, long, low frequency radar wave, but it's periodicity is not what you need for fire control. So it's all these many variables that are taken into account.

What they do together though is they really do screw up the ideal function of an integrated air defense system. And these notional cartoons which were run from a series of an old [inaudible] called [inaudible] that looked at different radar shapes, to begin to show you how this works.

Ideally, aircraft, medium altitude, enters the [zone]. Think of the system in the middle. All of it is a kill zone. That's what it's designed to do. You get this close and we can get a valid shot, the right number of valid shots. Stealth immediately begins to break that up. These simulations are discussed in more detail in the paper, looked at different shapes, different notional shapes and how they acted. The ideal, of course, is to reduce signature all around, 360 degrees, all aspects. Make it like a fuzz ball, a perfect shape, a perfect stealth shape. In this case it would show that the areas of red are greatly

diminished and the prospect of valid shots becomes very very low for a shape of this type.

Take another shape like a bowtie where you have reduction in front and reduction in back. That notional shape is going to give you a different impact on the integrated air defense system. And other shapes as well, such as a front aspect [inaudible] reduction. These are all discussed in the report.

But put them together and what they show you is the importance of stealth and of shaping but overall of the use of this technique in the radar game, whether it was going back through the earliest use of chaff up through electronic countermeasures, there was always a duel between attackers and defenders. Stealth was the way to make a great advance, a great asymmetric capability against that integrated air defense.

The value of stealth was such that after the Gulf War where it was proven in combat for the first time on a large scale, the Air Force decided that it simply did not intend to buy any more non-stealth fighters. It would have been easy for the U.S. Air Force to look at the superb performance of F-16, F-15s, A-10s, and on and on and come back and simply manufacture many many more of those. The decision was really quite the reverse, and that was to put into development the programs that became F-22, F-35, and to pursue them.

We know that that program is now defunct in a way. The aircraft are there, but our new strategy within the Air Force is to have a combination of stealth and legacy forces.

This is my final slide. As we get to this we see, however, again, why the advantages of stealth, the radar signature reduction, are so profound in air combat. That is why we have been holding I think as a nation and with our allies so hard to the F-35 program, because of its uniqueness in giving that ability to do really significant radar cross-section reduction.

That's not all there is to stealth. The next two gentlemen will talk a bit more about all the dimensions of stealth. Electronic countermeasures have been and remain very important in aircraft survivability, but there is something truly unique about the value of stealth in [inaudible].

Now I'll turn it over to Mike Fantini. Go ahead.

Colonel Fantini: Thanks, Rebecca. For those of you that don't know me, as Rebecca indicated, I'm Mike Fantini. I've been the Division Chief of the Combat Force Application Division in the requirements area for General [Maj. Gen. David A.] Scott at Headquarters Air Force. So in that portfolio I have legacy airplanes, I've got legacy munitions, I've got new munitions, F-22, B-2, B-1, B-52, all those kind of touch-points back.

My background, I've been a fighter pilot for my 24 years or so, most recently came out of Balad [AB, Iraq], where I got to work with General [Maj. Gen. Douglas L.] Raaberg [retired Jan. 1, 2010]. I was troop commander out in Balad in Iraq in 2008-2009.

I think what I'd like to touch on is to talk stealth reference radar, but I think stealth is an enabler. Stealth is what makes the joint force capable of ranging the battlespace. So as we get to more and more advanced threats, stealth is going to help us open that battlespace up if the national command authorities say they want to do that.

So what is stealth? Does stealth apply to a soldier who's camouflaged? I submit yes. Does stealth apply to a submarine? I would submit yes. Does stealth apply to radar? Absolutely. Does stealth apply to noise and acoustics? Absolutely.

So in my mind when you come at it from an operational perspective, stealth is the ability to deny the enemy their ability to complete a kill chain and it allows friendly forces to complete this kill chain. So I see it as a joint enabler.

If we could have an entire stealth force, I think people would say yeah, great, but I don't think that's an affordable and prudent use of resources. As Ms. Grant alluded to at the end of her discussion, what we see in the Air Force force structure is a combination of stealth capability and legacy capability, if you will. The key then is going to be to integrate that. Just like the Brits had to do in 1940. They had to integrate Hawker Hurricanes, Spitfires, and radar, rudimentary radio communication systems. But their ability to think on their feet, because it didn't quite work the way they thought it would work maybe right off the bat, along with this piece of kind of, I approach problems from a combined arms approach. I need to have a spectrum of capability. I can't put my eggs all in one basket. So to tack back to the British example, a smaller force, that had concept of operations that were flexible and they had tactics, techniques and procedures that enabled them, they were able to defeat a superior numbered force over a certain length of time."

I just read the book *First Light*. I would recommend you read the book *First Light* — the author's name escapes me [Geoffrey Wellum]. But a 19-year-old British gentleman who fought in the Battle of Britain and it kind of talked about all these things and what they had to deal with back then.

So number one, I see it as a joint capability that is necessary to enable joint operations in a battlespace in a range of spectrum — not just the EW spectrum, but others.

Number two, this enabling concept of stealth for legacy forces, but as threats become more advanced I need capability that goes along with the pure radar equation. I need electronic warfare, I need electron protection, I need electronic attack capabilities. I would like to have ISR associated with that for information, surveillance and reconnaissance. And again I need to integrate that together.

How do you plug a B-2, an F-22, an F-35, Hornets, F-15s, F-16s, B-1s — how do you net those things together? Planning and integration is key to again successfully being able to range into a highly contested battlespace. So this planning and integration effort needs to be key. I kind of dial back to concept of operations and TTPs as well.

Many times in Washington, D.C. we have a tendency to neck down to a particular widget where these widgets are fantastic. We again have to make sure we integrate those correctly. With any stealth capability comes this integration so you have to be able to sit down and think. That's where I want to dial back to smart captains and smart majors and even lieutenants and sergeants, on how do you do that? So the tactics, techniques, training and procedures and how do we do it better is a piece that I think is huge.

Then I guess it comes down to this kill chain aspect. Lenny D'Amico and I have talked about this a bit back in the office. It enables us to complete a kill chain. Otherwise, why would I do something? And the kill chain is to accomplish the objectives of the joint force commander. If that's a JASSM, it needs to hit a target. How are we going to do that? If that's an F-22 that's going to ingress into a highly contested area, how are we going to do that? Because we need to be successful, otherwise it's not going to really improve investment. So enabling and ensuring that kill chain is a key player there.

I'll kind of throw that out on the table, and I probably took all the good points away from Lenny. I'd like to just hand off to Colonel D'Amico for kind of quick opening comments and then we'll kind of take it from there.

Colonel D'Amico: I'm Lenny D'Amico. My background is, I started off as a bomber guy [inaudible], RC-135s, and [inaudible] programs. I did a stint here at the Pentagon '02 to '05 [inaudible]. That's a little bit about my background.

But Fan Man touched on it really well. Mission planning and ISR are really the more important elements to stealth. If you don't know where the enemy is it's really hard to disrupt his kill chain. So the big players, being a B-2 guy was know where the enemy was and being able to mission plan appropriately to [inaudible] over target.

Fan Man really touched on everything that's really good about stealth. [Inaudible].

Colonel Fantini: You have two non-deep thinkers up here. [Laughter]. That's why we have Rebecca.

One of the other things I will touch on quickly for our industry partners is the fact that as we're developing new capabilities, retrofitting into current capabilities, industry partnership is key on this, and the affordability associated with that industry partnership. That is a fact of life that we have to ensure that our requirements are balanced against realistic resource capabilities. That's where we in the Air Force want to team to ensure we're making that type of thing happen.

Again, we're all taxpayers for the most part in the room here. I'm a taxpayer. I want to make sure that it's a reasonable prudent investment. But again, if I don't meet the joint force commander's objectives, whether it's killing or destroying a target or an airborne platform from a threat, then we've kind of missed the mark. So it's obviously quite complicated.

The other thing I would allude to is in this enabling concept I talked about electronic warfare, ISR. But again, from a combined arms approach I'm not just going to put a lot of money necessary into materials in the form, fit, function aspects of it. I talked about ConOps and TTPs, but the other enabling capabilities for a fifth generation aircraft, I would like to be fast, I would like to have fused avionics because that's an advantage that builds situational awareness. This fused avionics concept allows me to integrate with other platforms. And I need to be maneuverable. All those things also enable this stealth platform that began with, I guess you would say with the radar game as Rebecca has discussed.

We in the Air Force think we're moving down that road, frankly. With the B-2, F-22, and with the Joint Strike Fighter coming on line, those are obviously major emphasis areas, but along with those emphasis areas are weapons integration, weapons development to ensure we're killing the target. And understanding what capacity and capability is going to be needed in a legacy type force that's going to fly along with these stealth capabilities. So all that's in the mix.

I don't stay awake at night. I think it's all very reasonable, informed, executable plan, and your United States Air Force is advocating for the proper capabilities as we kind of meet these threats in the future.

Dr. Grant: Thank you very much.

I'm going to take the privilege of asking the first question if that's all right, and then I'll open it up to questions from all of you.

Would you tell us a little bit more about how this is working out in the field to integrate 5th Gen aircraft and legacy and how you see that unfolding? Are you guys starting to exercise that stuff? How is that working so far?

Colonel Fantini: I'm just a requirements guy. I sit in the bowels of the Pentagon and push electrons around. But we work very closely with Air Combat Command and Global Strike Command. That's really their bailiwick. I'm going to hand off the block here in a second. But I think there are a couple of things.

One, the integration of F-22, F-15s, B-2s that is ongoing at Red Flag is all very positive. We're learning a lot of lessons on how that goes. And we will continue to.

Those types of lessons that are coming out of the Air Warfare Center now are feeding back into the requirements process to say how are we going to continue to integrate?

How are we going to network together? Because networking, as we see at home when you dial up whatever web site you're dialing up, it's amazing the amount of information you can get and I can more quickly react to my kids' soccer game, right? Well, if you take that silly analogy, I template into just the netting that we have today, I can more quickly react to things and build my situation awareness among the platforms.

I'm going to ask Lenny to talk more directly on what did you see in the B-2?

Colonel D'Amico: You kind of alluded to it already with the Red Flag and the exercises we do. B-2 and [inaudible] are kind of working hand in hand for the last [inaudible] on trying to develop packets to maximize the capabilities of the platforms. And then incorporating that into the legacy fleet as well. You can think of it as a football team. You can't have all running backs on your football team. You've got to have your guards and your tackles, running backs, receivers. So being from Nebraska, that's how I allude it to. [Laughter].

The bottom line is our tactics are evolving daily when it comes to [inaudible] the entire force. And not just the joint force, but our allies as well.

Dr. Grant: Do we have questions from the floor?

Question: Bill Sweetman, Defense Technology International Magazine.

One thing, [inaudible] comprehensive, but policy can only go so far. One thing that I see having changed in the defense environment is that it's become much more realistic [than magic]. You'd start by [inaudible] top down. Now if you — Once you've got a lot of sensors working in different spectra, working in different ways. You've got over the horizon, AESAs, things like this. Once you've got all those networked and cueing one another, doesn't the sort of — And once you have double digit SAMs which do what the heavy SAMs used to do but do it while being able to be relocated, doesn't that put your bow tie signature type aircraft at some degree of risk that wasn't there before? Assuming there's still a very similar, as I understand it, fairly similar signature levels to the F-117, but up against a very different, more flexible and more diverse threat. Do we need, can we raise our game in terms of [inaudible] in order to make stealth truly effective in that kind of highly networked battle [group]?

Colonel Fantini: That's a tough question to answer but let me see if I can take a hack at it.

I'm going to kind of fall back to, as the threat has matured so has stealth and the capability to enable that. When you start talking signatures and that level of detail, that's an area that I can't trespass into and I won't. But that's where you kind of have to have this combined arms approach. And like Colonel D'Amico just indicated, you can't have all running backs. There's going to have to be a balance on how to complete the proverbial kill chain in that higher threat environment.

If a Klingon cloaking device was available and affordable, that's what everybody would like to have, but it's not realistic.

But I think in terms of technology development, the concept of operations and TTPs in a combined arms engagement, we're going to have success in that high threat environment.

Again, I go back to it's a joint force problem. Platforms, weapons, joint integration, all those kind of things. You meld it into the kill chain solution.

Colonel D'Amico: Also [inaudible] radars and all those other threats that may try to devalue stealth in terms of the kill chain, those are all targets as well. I'm sure it's going to be number one on the force commander's list to destroy, is to be able to knock those out and then bring those threat circles, if you will, back to a smaller size. We just can't assume that we're not going to be able to [inaudible].

Dr. Grant: Those are great responses. Let me just add from a historical perspective that with the first stealth aircraft they weren't going to have all this help. They were going to go in, 117, in a very bad place, fairly deep, and go in and put a bomb on and it was so important that with the 117 they gave up everything else. Emissions, everything was done for that. So I think the way that those people like you and I who have followed this for so long, you think of it as well, we've just got to get smaller and smaller and smaller to make it work. But in fact you now have a larger force. You have more stealth aircraft, you have all the other things that these gentlemen talked about. So it's not like saying the B-2 mission which was planned to go in and cope with a lot of Soviet aircraft by letting them not get a hit before they run out of gas or get vectored away, all the things they had to do that's so dependent on minimizing signature, was all you could do. There were some other things, but that was so, so, so essential for these kind of single shot, deep start targets. You're now looking at an integrated campaign that has a lot more to depend on, I think a lot more in the way of ISR resources. So the goodness of getting teenier and teenier and teenier on the signature, yeah, I think that's still important but it is quantitatively different two decades on from what that meant in the Cold War scenarios.

Question: Can we just pick up on that? We know where we were at, one airplane all by itself, in and out. That's a problem. Now we've fast forwarded [inaudible]. What's the next [inaudible] you said which is this is a, stealth is not a [inaudible]. It's a concept. What's the next conceptual move to [inaudible]?

Colonel Fantini: I think it's to continue to work the integration aspects. To improve the current integration that we have, move into advanced data links. And that's why, the football team analogy, after I came out of Marine Corps Command and Staff College I came out with this combined arms mindset of it's going to take multiple efforts to enable one particular thing, so I Think that's what you're going to see where we're going, with better electronic warfare, improved ISR, where we're going with future platforms. That's what we're going to see, sir.

Question: At the [widget] level, how do you see the unmanned capabilities being enablers for signature reduction [inaudible] in terms of getting the human out of the pocket and all the things you can do with that [inaudible] and also the fact that it increases the maneuverability of the aircraft? What is your assessment to that? Is it an order of magnitude difference? Or is it just an incremental change in what you can do with the platform?

Colonel Fantini: Because it would be unmanned in general, if you will?

Question: You don't have a [inaudible], so you don't have to worry about the transparencies and all the things that come with a human being on board. Does that make a difference, or the fact that now you're not limited by your maneuverability [inaudible] have more maneuverable platforms?

Colonel Fantini: I would say that in particular, that specific fact of whether something is manned or unmanned is not going to be directly tied to whether I am more stealthy or not. In the big picture, whether I'm manned or unmanned is almost interesting but immaterial. If we are able to develop the technologies to be able to do these things, an unmanned platform may be the way to go. Having a manned platform, I don't see that as a driving difference for stealth in general.

In terms of what's in the realm of the future? That technology needs to be developed. If we go down that road within the Air Force — pardon me. It's not if. We're flying plenty of remotely piloted aircraft right now. That is again, a force structure enabler to the rest of what the Air Force does. And it's space, ISR, multi-mission platforms—all melded together.

I also need to kind of dial back. I'm not the engineer. So I'm not the person that's putting seats in cockpits or displacing cockpits or not. I can't kind of sign up to being an expert on that. But I personally don't see it as a driver of whether I can be more or less stealthy.

Colonel D'Amico: Or cheaper. We're still trying to figure out what manned or unmanned aircraft, the kinds of costs associated with that. Just because there's not a man in the cockpit doesn't mean there isn't a fleet of people keeping that plane in the air. So from an affordability standpoint, that's [inaudible].

Question: Talk about ConOps and TTPs. Stealth, the idea is to get in without, delay the detection. EW, active EW, you're letting them know you're coming, but handicapping their detection capabilities. It becomes a question of what comes first, or how do you mix those two? Do you let the stealth go in and then jam for the legacy force? Do you have to do, with the advanced capabilities of the SAMs, do you have to jam even with the stealth?

Colonel Fantini: At weapons school I learned how to answer questions like that with three answers. I can't give you the first one or the third one, but it depends. [Laughter].

I really think it depends on what is that target really going to be? How heavily defended is it, and advanced? And that's going to dictate how we would complete our proverbial kill chain.

But you identify it very correctly. If the threat is trying to — they're trying to complete their kill chain and we're trying to complete ours. We think the fact that again, because of the spectrum of capability that we're going to be able to reduce — He won't be able to complete his, and we'll be able to complete ours. So whether ours is via reducing threat envelope size or denying him situational awareness. It depends on, I couldn't give you one specific answer.

Question: [Inaudible], Air Attaché, Australian Embassy.

Gentlemen, we've fought a particular way for a while. The 16 ship [inaudible] Eagles, the four-ship [inaudible]. We [inaudible] our techniques and applied them. Is there sufficient long range — is there enough capacity in the dinosaurs, in the colonels, the one stars, the two stars, to allow those captains and majors you mentioned earlier to really expand on the potential of stealth? And are we really opening that up at Red Flags and in exercises and on paper, [inaudible] letting the boys and girls who have the smarts really use them?

Colonel Fantini: I think that's one of the strengths of Western military employment, and in the Air Force in particular of the decentralized controls. General [Charles A.] Horner [USAF, Ret.]—and I wasn't there—but I'm told night one in Desert Storm he kind of leaned back and said it's up to the captains. I think that's pretty close to what was probably the mindset. I think we need to do that.

It's interesting, I just had a conversation with a great American who I would consider a mentor a couple of weeks ago talking directly about I'm concerned that there's maybe too much reaching into the proverbial cockpit. Whether it's from the Pentagon and a 5,000 mile screw driver or not. I think some of that has to do directly with the pace of operations. But I was educated, benevolently on hey, you need to understand what's going on in the units because I'm well outside the tactical level right now. The concepts of how stealth platforms are employed — Lenny talked about we're still developing that, just like we developed the Eagle and Viper tactics and Hornet tactics in the late '70s and '80s, we're still developing that stuff right now where I think you're not going to see 16 airplanes two miles apart. Because it's not beneficial. And the guys that are coming up with that are captains and majors that are out at Air Warfare Center at Nellis developing that.

I sleep well at night kind of saying the captains are able to expand that envelope and inform how to do it better with TTPs. Because like I said earlier, relying exclusively on a widget. Just like we have operators in the room. If something doesn't work in my

airplane do I go home or do I press? If I'm going to press forward into that engagement, that's because I have confidence that I can accomplish and be part of the mission. We're going to see that with F-22, F-35, and those types of platforms.

Does that answer your question, sir?

Question: Can I ask kind of a follow-up to that? I understand and agree exactly with what you're saying, that it's a system that has to be optimized. But we still buy widgets. So in your position, are you seeing more difficulty or less difficulty in trying to really drill down and figure out how do we want to invest our money. Are we able to take those larger view points and drill down to how we buy the weapon systems?

Colonel Fantini: You're trying to get me in trouble with my boss. [Laughter].

I joke about that, but that is an important question. It's an important reality of this, the fact that requirements that we have need to be balanced against the return. And it's extremely frustrating to see things that are over-promised and under-delivered. I would rather see things under-promised and over-delivered.

Now I try and drive that home with my folks in the shop. Okay, that's the answer, now start scratching below the veneer and find out if that's really tangible and true. I think we pay due diligence to that, but that is in close coordination with the Air Force's Air Combat Command, Global Strike Command. I don't have space requirements, but those types need to be pushed hard because we're going to have to balance that type of thing out.

Am I frustrated by it? It probably puts a couple of extra hours on my day, but it's just a fact of life. I think that's due diligence for the Defense Department. To trust that the services—the Air Force in particular—that we're paying due diligence to that to push hard and go is this really the answer?

Question: From the tactical to a more strategic perspective, [inaudible]. It seems the Navy's developing [inaudible] electronic attack capability. The Air Force and coalition partners [inaudible]. The Navy and Marine Corps [inaudible] stealth capability [inaudible] platform. [Inaudible]. In terms of collaborating or shaping that integration, how well do you feel that's coming along? For example, [inaudible]. For example the Air Force and the Navy signing an MOA to really go beyond and really work closely together in terms of [inaudible]. How well do you [inaudible]? Electronic attack [inaudible]?

Colonel Fantini: I'd say it's very positive. In terms of warfighter talks between the Chiefs of Staff of the respective services are providing a very high level of okay, these are the areas we want you to go work on. We're seeing in those warfighter talks with the Navy and the Air Force go-do's out of how to make sure that we're integrated better. Whether it's an air-sea battle concept, or whether it's ensuring that Joint Strike Fighters

are netted together properly. All that is kind of in the churn. And electronic warfare is a large piece of that.

Question: [Inaudible], Australia.

You mentioned stealth in terms of the ability to [inaudible] the kill chain a number of times. I wondered if you could comment on the weapons that we [inaudible] from these platforms that [inaudible] is a requirement or the feasibility of extending the stealth concept to weapons that we've employed.

Colonel Fantini: I'm going to hand that one to Colonel D'Amico because he's global precision attack. After one of my comments, because I'm in transmit mode, he goes don't forget the weapons. So over to you.

Colonel D'Amico: Weapons are a concern. As a weapon comes out of a stealth platform it can be detected. So as we're going on, if we're going into the future, stealth aspects for weapons is also on our radar scope.

Without trying to go any deeper than that for reasons, we are trying to encapsulate stealth technologies into our weapons after delivery. Whether it be gravity weapons or cruise missiles or whatever.

Colonel Fantini: There's a bit of an [inaudible]. Is it a standoff thing or are we planning to penetrate? If I can reduce the threat to kill chain to the point where they can't react, then obviously that aspect of the weapon stealthiness is different. If it's going to be something that's going to be with a long time of flight, that's obviously different. Then you can think about the traditional mass and multi-pronged attacks, those types of things. But it's certainly a valid and prudent consideration as we're developing advanced weapons.

Dr. Grant: Any other questions for these two gentlemen?

Thank you.

# # # #