Missile Defense Advocacy Alliance Congressional Roundtable Discussion on Missile Defense Sensors
with
RADM (ret) Archer Macy, Former Director of the Joint Integrated Air and Missile Defense Organization;
MG (ret)Francis Mahon, Former Director for Strategy, Policy and Plans at USNORAD/NORTHCOM;
CAPT (ret) William Johnson, Former Deputy Commander of the Joint Functional Component Command for Integrated Missile Defense at USSTRATCOM;
And
Riki Ellison, Chairman, Missile Defense Advocacy Alliance

MR. RIKI ELLISON: Ladies and gentlemen, it's an honor to have you with us today. I'm Riki Ellison. I'm the founder and chairman of the Missile Defense Advocacy Alliance group. We were founded right after the decision was made to withdraw from the ABM Treaty in 2002, and we've been in existence since then.

We today have an opportunity to really delve into our sensors for ballistic missile defense. They don't get a lot of attention. Most of the excitement is about the interceptors. But if you can't see it, you can't hit it. And a very important factor for our organization is the recognition of what their skill bases are.

We've been at SBX, before it was deployed out in Brownsville. We've been at the Beale Air Force Base with the Beale radar, earlier at the range with the joint Canadian Americans operating that early warning radar. We've been up to Clear with that radar. We've been to the TPY-2s that are forward-based in Turkey, as well as the groups in Israel. On that aspect of it, we've been on, I think, about 58 Aegis SPY-1 ships in our nation.

And we recognize, every year we have an opportunity to recognize our airmen -- mostly airmen and mostly sailors -- we recognize our best crews. At our national event we do a NORAD-NORTHCOM recognition of the sensor group. So it's with great appreciation that we can bring some experts to this field for you today to engage and discuss and open up your questions on this subject.

When I look at sensors, I look at a baseball analogy, where we know -- we hear a hit but we have to be able to watch that ball all the way into the fielder's hands. And we've got some pretty good fielders out there today. We've got mits on them. We've got great shortstops and first basemen to pick up the pop flies.

But the ball that's hit in today's world has a lot of things. Inside that ball there's a lot of targets and debris in that moving wave. And our fielders right now sometimes have to shut their eyes for a little bit of that trajectory and reopen them up. So for us to really get confidence, 100 percent confidence, we need to make sure our fielders can see the ball all the way through from hit to where they catch the ball.

So I think with that, we've brought in our experts from STRATCOM, NORTHCOM and so forth to speak to that. So I'm going to open it up with our first speaker today, and that is Arch Macy. Arch is the former Director of the Joint Integrated Air and Missile Defense Organization on the Joint Chiefs of Staff, previously Commander of the Naval Surface Warfare Center and Deputy Commander for Combat Systems Engineering, Navy Sea Systems Command, experienced in naval BMD operations globally.

Arch?

MR. ARCH MACY: Good afternoon. As he said, I'm Arch Macy, retired Navy, background in surface officer and weapons engineering. I retired in June of 2011. As mentioned, my last job was Joint Staff. If you don't like the Ballistic Missile Defense Review, you can tell me all about how you don't like it, I will listen. I wrote it, part of it.

I want to talk about two things today. We sort of talked about how to cover this, to talk about sensors, and I'm going to start off with taking us through the engagement sequence. And a lot of people say yeah, I know that. Please bear with me and think about the role of sensors in each of these steps. As Riki said, the question is, do you know where the ball is at any given moment and do you know where it's going to be at the next moment? Because unfortunately, you have to make decisions while it's still on the way and in many cases before you have necessarily seen it with the thing that's being shot at it.

So we're going to talk through that and then make some comments about discrimination. And then I'll have a few remarks about sea-based sensors, since I'm the Navy guy, on the technical side. We've got another one up here who was on the command side, which may factor into some things that you think about in the future. So let's talk through an engagement.

A threat missile is launched. Usually you don't have prior warning about that. If you do, that's great, but it ain't going to happen in real life.

So the launch occurs and the first opportunity we get to know that it's occurring is when the flames come out of the back end of the missile on the launch pad. That's the first time we can see it, and we see it from space, a sensor, an electro optic sensor in space. So it has to figure out that the launch has occurred, which way this thing is going, roughly, tell the rest of us that it has occurred, and start to feed information back to the rest of the system. And you're going to keep hearing me talk about the system today to figure out where this thing is coming.

So that occurs. It passes the word through the system, from the satellite, that this launch has occurred and roughly which direction it is headed. That gets passed through the system which then tells the radars, any that are within view of this, where to start looking.

I tell people, anytime you talk about ballistic missile defense you have to have a map in front of you, because the ranges are so long and the fact that the earth is round, often means that sensors which are going to be critical to the engagement don't see the launch and may not see the missile for some time afterwards. So the system has to then detect the launch and figure out where this thing is going.

The missile quits boosting. We need to know that because we assume that the missile is on a ballistic trajectory. That means it's not getting power anymore. It has been given a certain amount of energy. It's headed up into space, and once the boosting stops, based on physics, you can calculate where it's going to go and where it's going to come down.

This is all unclassified, by the way. You can pick up textbooks which do this in great detail. Boosting runs anywhere from 24 to 400 seconds, depending on range, so that burns up that much time in the engagement.

Once the missile quits boosting, it starts coming apart, pretty much all but the (short-range?) ones. They stage. Bolts and nuts and fairings come off. Things are discarded and fall off. They all keep going. And they'll keep going basically on the same path that everything else is going on. Again, it's physics. Once you give it the energy it's going to keep going, at least until it comes back into the atmosphere on the other side.

So then we start tracking with radar. We've got to have radars which can track it. We like birth to death radars. General Mahon is going to talk more about characteristics of the radars for different things, so I'm going to skip the technical part. Just keep in mind, you detect a launch. Once booster burnout ends, then you start to calculate your trajectory. You need to have radars tracking this thing as you do that.

You start predicting where all that stuff is going to be. We call it the threat cluster or the object cluster. It's the warhead plus any other stuff that's still traveling along with it headed your way.

The more sensors we can get on there the better we can get the quality of track. That's number one, really refine the path that it's on. The other thing is to start to figure out where's the bad thing in that pile of flying stuff.

All these radars feed data back to the ballistic missile defense system, which calculates this information and then sends it back out to the people who are going to shoot and to the other sensors which are tracking to tell them where to look, to get onto the target, to figure out what they're looking for. At some point in there we say okay, we know where it's going and now we have to decide when to launch the interceptor. We can't wait until the interceptor goes by. We've got to launch it to get to a point in space where we know that the threat is going to arrive at a certain time to do the kill. You can't do tail chases. Again, the physics gets to you.

You can't launch too early, because you've got to have a pretty good idea where the thing is going to fly. So again, it's all about sensors and calculating the flight path and then telling the interceptor when and where to go.

We launch that interceptor. We aim it for the desired aim point, where we think the intercept is going to occur. We continue to update the information on that track and feed it to the ballistic missile defense system so that given opportunities it can tell -- it can update the interceptor on where to be looking when it gets there. Again, the criticality of sensors, the different characteristics of sensors to where is it, what's the track state and where's the bad things inside that flying junk pile?

The interceptor gets up near the interceptor point and it releases its kill vehicles. These are all hit-to-kill weapons, so there's no explosives going off here. It's a chunk of metal hitting another chunk of metal. They are infrared electro-optic guided, the kill vehicles are, a different sensor set because of the accuracy needed to hit something which is about five feet long and usually cone shaped, not a big piece of stuff flying through the sky at multiple kilometers per second.

The better we can tell that kill vehicle where to be looking, the better the odds are that it will find what you want it to hit. And within that cluster of objects, the flying junk pile, somewhere in there is what is referred to as a lethal object. In the vernacular, it's the warhead. So it's identifying what, among that pile of flying junk, is the thing you need to kill.

The rest of it you don't need to kill. It will burn up when it comes back into the atmosphere. And even if something gets to the ground it's going to be small chunks. It's not a warhead. That's the whole point here.

So the key here is to get the information from the missile defense system, provided by the sensors, to the kill vehicle to tell it where to look and within that pile what it should be looking for. And then, the engagement occurs. If there's time, then you would like to have sensors which can figure, was I successful? Did I hit something, and if so, did I hit the right thing, so you can make a decision whether or not you might need to shoot again?

Again, the point is that the sensors are a key part of what happens here. They have to do the launch detection and the threat assessment. That's done by the satellites.

You want to make sure that it's a ballistic missile before you start trying to intercept a space launch. You can do that based on the physics of what you see. You have to track it and figure out where the flying clump is and which direction it's headed, quite accurately, and figure out where within that clump is the thing that you want to hit. That's discrimination.

So as we talk this afternoon about what you could do or where things are, keep in your mind how this sequence goes. You can't use one sensor to do everything. One, because they have different characteristics, as General Mahon is going to talk about. And two, because the Earth is round you've got to have different sensors in different places, because the Earth gets in the way. For anything longer than about a 1,500 - 2,000 kilometer shot the Earth gets in the way.

You need to continue to improve discrimination. That's why you're going to hear about, and you know about, the Long Range Discriminating Radar that MDA proposes to put into Alaska. It's to solve that problem of where is the lethal object in the cluster. And then MDA is continuing to look at how you can combine all of these different pieces of information from different sensors more and more effectively to figure out quality of track and discrimination. Particularly if you have more than one sensor looking at things at the same time you can take advantages of their difference.

So that's where I just wanted to set the stage with that. I think I kept within my time limit. We wanted to set the stage with that so when we get into to talking about sensors -- and that's really what we want to discuss today -- we'll presume for today's purposes, I suggest, that if the interceptor is reliable, we know that we're working on that, and is put in space at the right place looking at the right direction for the right thing, it will kill. But the interceptor guys worry about the reliability part, the sensor guys have to do everything else.

Where does it need to be? What time does it need to be there? Which way does it have to look, and what does it have to go after?

One other thing, and then I will pass it onto Fran, is just talk a little bit about sea-based versus land-based. They're very distinct. They do a lot of the same things. They're distinctly different.

The big thing about sea-based -- and he's going to talk about land-based as well as sea- is he has the ability to put it places that you can't otherwise get to, either because it's somebody else's territory where you would like to put that radar, and they might object; or, where you want to put it because of the curve of the Earth, the shape of the Earth, there's no land there. Look at the Pacific. The Pacific is an awful lot of water. And any sailor in the room knows when you sail from San Diego to Yakutsk, you're spending a whole bunch of days looking at a lot of water.

So it enables you to place things where you need them for physics and for engagement capability. The downside is, you've got to put them there and they're expensive to operate. But just from a sea-based perspective, because that keeps coming up about Aegis and SBX -- why do you do it with boats? Because they can go where other things can't.

So with that, I think I should just pass it onto General Fran Mahon who will go on with the sensors.

MR. FRANCIS MAHON: Thanks, Arch, and thank you all for the opportunity to be here today. Just a little background, I retired from the Army in 2013 from a career air and missile defense officer. My last job was at the Strategy, Policy and Plans Officer at North American Aerospace and Defense Command and U.S. Northern Command. I also commanded the 32nd Army Air and Missile Defense Command, my last true command in the Army.

What Arch has defined for us is really the engagement cycle or sequence. And from a sensor perspective you get an alert, you then survey, you then acquire, you establish the track. You try and classify what that object is. And then you get into the discrimination and identification of the object, and then you make your engagement decision that hopefully leads to an intercept.

And we have a group of sensors today that address most of those skill sets. The discrimination aspect of it, unless SBX is out there, isn't being done. And I'd like to put a little operational discussion on the table today.

You know the steps through classify are generally well performed by the sensors that we've got in the field today. And those sensors were designed to do those functions and bring those capabilities. The early warning radars are surveillance and tracking radars and they do that fairly well.

They are not well suited, though, for discrimination. They weren't designed for that when they were originally built, and their modifications today can only take them so far towards that capability. The task of discrimination is a far more challenging. It required greater fidelity, more bandwidth and more processing power.

To take Riki's analogy of baseball, the crack of the bat is the alert, and then all the players look to the heavens to see where that ball is going. And that ball is coming and we'll be able to determine, is it going to center field? Is it going to right field? Is it going to left field?

Now imagine that ball starts to come apart as it's sailing through the air. What part do you get? Do you catch the shell? Do you catch the innards?

And that's kind of what happens as these multi-stage missiles come towards us. They come apart. And now we're into -- I know where it's going, roughly. I know what it is. And now I've got to determine amongst that cluster of stuff coming towards me, what is the object of interest for the warhead?

The TPY-2 radars today that are in the architecture are marvelous radars, probably the cutting edge of technology that's in the field. Given where they are in the actual geography of the GMD architecture, they only contribute to the early phases of flight of a missile coming out of North Korea today. And at some point, that missile is beyond their field of regard so they can't contribute any more to the calculations for the fire sequence.

Aegis can contribute to an extent to the discrimination radar, but it's got to be on-station and it's got to be in position. And Aegis, as you know, is a low-density, high-demand asset, a multi-mission platform. So it's not on-station all the time and in position to support GMD. It lacks that quality of persistence, which is what the war fighter needs.

The sea-based X-band radar is a good discrimination radar. But here again, it's not on-station 24 hours a day, seven days a week. We only sortie it when we really know something is going to happen, and that's becoming more and more difficult for us to know.

Back to the baseball analogy, everybody knows something may happen when they see the pitcher wind up. What if you can't see the pitcher wind up? So now you're just standing out there -- what's your stance waiting to hear the crack of a bat? That's the dynamic we're into in the absence of persistence in the current architecture.

The GMD system operating environment by far and wide is the most challenging that all the missile defense systems have to deal with. When you stop and you think about the expanse of their battle space, their operating space, it's not large in my mind, it's massive. When you think about the complexity of the systems that it's integrating, it's a challenge.

And our ability to position components, as Arch said, it has been strained. There ain't a whole lot of land in the Pacific that you can occupy. And using aerial sensors, they can help mitigate that challenge and they are flexible and they are movable. Their limited in numbers and costly to operate over a long period of time, and they don't provide the war fighter with persistence today, as I talked to.

When you think of Aegis and you think of THAAD and you think of the JLENS radar and you think of the Patriot radar, all those radars in support of a specific weapons system perform the discrimination function for that system. Collectively, when you net them together through a network, they can assist other weapons in determining their engagement solution, but they can't control it. It comes back to an Aegis ship and its radar controls the Aegis engagement.

A Patriot radar controls a Patriot engagement. In GMD it's no different. The mission geometry mandates the C2 BMC will control the engagement, and it needs a discriminating radar to help it refine its engagement solution.

Aegis is an S-band radar. THAAD is an X-band radar. JLENS is an X-band for its fire control, which probably really does its discrimination, and an S-band for its surveillance. Patriot is a C-band.

All different, all optimized for different characteristics based on the battle space that they operate in. Collectively, though, they can all contribute to a solution, but they can't control the final engagement for another weapons system.

So how important is discrimination? I've going to give a little historical vignette here. There are some in the audience who can add to it or tell you I'm embellishing too much.

But one night during Desert Storm in 1991 the Iraqis fired a volley of al-Hussein Scuds towards Riyadh. And the al-Hussein was a missile that the Iraqis had taken -- it was a Scud -- and modified it to get greater range out of it.

The al-Hussein came up. The architecture gave the alert to the Patriot units. The Patriot units brought their radars up. They acquired. They tracked the al-Husseins, and they began to figure their engagement solutions.

And then the al-Husseins broke apart. So what was one threat missile is now maybe two or three or four pieces of missiles coming towards the Patriots. And what might have been three threat missiles launched is probably now seen as eight, 12, 16 pieces coming towards the Patriot batteries that were around Riyadh.

What did Patriot do? It couldn't pick out of that mess of metal coming towards them, warheads versus debris and strafe. It just starts to engage and it shot at every large piece coming towards it. And in the end, okay, that cluster of missiles that became a barrage, there was no damage on the ground. The radar and the Patriot system took out the dangerous pieces of that staff and the warheads.

But fiscally, it was an expensive night. The batteries were almost what we would call fired out. All 32 missiles were shot.

And what if there had been a second volley of al-Husseins coming in behind the first volley? Well you would have probably had some units that would have been out of action relatively quickly. I mean they couldn't have re-loaded in that short a time. And the whole operational outcome might have been different.

So what became known as the QRP upgrade fixed that problem inside of Patriot, and that was the first generation of missile defense capability any nation ever really fielded. And we learned from that and Patriot radar discrimination qualities have come a long way since 1991. I would venture to say every Patriot radar upgrade that has been applied has always focused on improving classification and discrimination as a quality in the radar because it's that critical to the fire control solution.

I can't stress enough having high quality discrimination is critical, especially for a hit-to-kill interceptor. There is no such thing as a near miss or a tactical kill with a hit-to-kill interceptor. The interceptor is hit-to-kill. You've got to hit the object you're trying to knock out of the sky.

With high quality discrimination data you can tighten the kill vehicle shot group, as I say, narrow its search effort, reduce its search effort, potentially allow for an earlier intercept, and reduce interceptor expenditure. I think the Long-Range Discriminating Radars are an important enhancement to the BMD system. It's fulfilling a key function for the engagement sequence. It's being designed to provide for that persistence in the architecture.

You will still want Aegis. You will still want SBX, if you have the time to get them into position, to contribute to the overall architecture. And it will leverage the most recent technological advances that I think we've got in the sensor field today.

Draw from the TPY-2. Draw from the LRDR. It's the capability the war fighter needs. And I think it's the capability we need to outpace the threat. And that's one of the major concerns, the threat is getting more challenging and more dynamic.

So thanks for the time and I look forward to your questions.

MR. WILLIAM JOHNSON: Thank you. Good afternoon, I'm Will Johnson, recently retired Navy captain. Formerly, my last active duty job was the Deputy Commander for United States Strategic Command's missile defense branch out there in Colorado. And prior to that I was the commanding officer of the Lake Erie, which one of its many functions, one of its 23 missions, was to serve as the test ship for the Missile Defense Agency.

So kind of in summary of what Colonel Macy and General Mahon have described here is a system of systems. You have three basic systems that make up the missile defense system for homeland defense or for any area. You have a sensor system. You have a command and control system. And you've got an interceptor system, kind of the business end of the unit.

You have to have all three. None of these systems works -- you won't get an interceptor to the target unless you have the sensor and you have the command and control. So it's important to know if we have an event, if we have a launch, we know what that launch is going to be or where it's going. We have a successful intercept capability and we can get that interceptor up and get it to the target in time.

An important part of that future sensor system is the LRDR or Long-Range Discriminating Radar capability. It's significant for three primary reasons. One is persistence. It's going to be up 24/7/365. It's going to be available to the operators whenever they need it to be up and operating.

The sustainment costs are going to be a lot lower than a ship at sea. The SBX is a great platform, a wonderful capability. The problem is, they cost a lot to operate.

The LRDR capability doesn't necessarily require a cue. It can search for itself. If it does have a cue it will acquire the target quicker and give you more battle space, but it doesn't have to have that cue.

And finally, it provides that specific targeting information that we've been talking about here this afternoon. It's like sighting a rifle. You want to know where that bullet is going to go. You want to help it to get there, and by the way you can adjust it a little bit on the way.

So here's your picture. Here's what you see. Shoot the bullet. The bullet gets up in outer space.

It opens up its eye. You've already told it what to look for and where to look for it, so it's going to go right to there. It's going to look exactly for that thing, whatever that thing is. We hope it's the lethal warhead.

And if it doesn't see it, it's going to open up a little bit wider and say okay, it wasn't in the first frame, is it in the second frame? Okay, there it is, I'm going after it. And those things are voracious. They will hit what they're sent up there to find.

So we've talked a little bit about sorting through that debris cloud. What is in that cluster? How do you figure out what's there? Is it a fairing? Is it basically a wire harness? Is it a warhead? You've got to be able to tell that interceptor what it's going to go up and get.

So kind of the sequence of events here, and we've talked about it a little bit already, is you have your persistent overhead capability looking down from outer space. It sees that huge IR plume from that rocket motor going off. It says, we've got something here and sends out the alert.

The system now all comes up and says okay, we're going to start looking. Where is it going? Well, you've got to get an idea from what it sees from outer space.

Once that IR plume, once that rocket motor shuts down, you don't have any more IR. You don't have any more infra-red signature. So now you've got to get those land-based and sea-based radars on that target to figure out where it's going and what it's actually doing.

You can get the cue from the TPY-2. You can get the cue from Aegis. They'll give you the idea of where it's going. But then eventually you're going to run out of space and they won't be able to see forever, so you're going to lose it.

What the LRDR does is it really patches up that area. Aegis has lost it. TPY-2 has lost it. Okay, wait, wait, wait, LRDR has got it. And now it's looking inside that volume, picking out that target, passing that information via that very important C2 system back to the ground-based fire control system to tell it what to shoot, where to go and how to go get it.

So those are the kinds of things that make up the system. Those are some of the parts that make it important, that LRDR capability issue of what's seen and what's inside that scene. Now, we can't forget here, this is rocket science. This stuff is very, very complex. You're talking about transporting massive amounts of data in seconds, being able to sort through that data, do the computations and get that interceptor up and out there.

And the closure rates are spectacular. Your closure rates are in excess of Mach 20, 20 times the speed of sound. You are literally hitting a bullet with a bullet. That's the best way to describe it.

So one of the problems that we have with missile defense is, it's a bit expensive. Okay, it's really expensive. So you have to be able to balance out, am I buying enough capability? Am I testing enough? Do I have enough interceptors for the threat, whether it's a regional threat or a homeland threat?

Do we have enough missiles? Are we testing them right? Are we buying enough homeland defense versus regional defense? Again, there's a balance there as we spread the resources around.

It's one of those questions that we have to keep asking ourselves as we go through this thing because the threats evolving. It's not staying static. It's changing as we go.

A few final points before we start the question and answers. The specific sensor information that we need for the engagement, we've got to move that information to the ground so we can generate that fire control solution. The C2 system, the command and control system here is vital. You're talking volumes and volumes and volumes of data that are coming over in split seconds.

How do we deal with that amount of data? How do we sort through it? How do we make the decisions? How do we inform the commanders so they can do the right thing, and get it to display properly?

That stuff is important. It's not all about the bright shiny object and the big interceptor in the ground. Unless you can feed it the right information and then tell it where to go, you've just got a big rock in the ground. So it's important that we upgrade all the systems and we do it together.

LRDR is a very good capability. It's phenomenal what this will be able to do and it's going to really add a lot to the GMD system. But we've got to get the engineering and physics right, and in order to figure that out we've got to test it.

It's amazing what we discovered in materials science as we've gone along here. It didn't always operate the way we predicted it would. So that stuff is important.

And finally, you can't do any of it without those soldiers, sailors, airmen, marines, government and contractors that are out there putting this whole thing together to make it work, that are supporting each other. The team here is extremely important because it's a team fight.

And finally, I'd like to thank Mr. Riki Ellison for bringing us together this afternoon. The Missile Defense Advocacy Alliance has been phenomenal around the world supporting our war fighters that are out there doing this stuff. It's a complex mission and without that support it wouldn't work very well. So Riki, I want to say thank you.

And with that, why don't we go to questions?

MR. ELLISON: Thanks, Bill. Thanks, Fran. Thanks, Arch.

We really took the time to get these experts that are objective in their opinion fresh from the war fighter field all the way from the Joint Chief of Staff to the combatant commanders, so we'd like to really have you probe them. They've given you the foundation. And anything is open on this table for discussion because there are a lot of misperceptions out there on sensors and we know how important it is to get the LRDR in place starting this year as we go forward.

So I'd like to open up the room for discussions and questions to our experts here on the panel.

MR. KYLE ANFELDT: I'll be the first to ask a question. Kyle Anfeldt from Congressman Cochran's office. Can you describe a little more the communication of the sensors into this system of systems? And specifically, if you were to try to engage a target in the terminal phase is it informed by every sensor along the way from space-based launch to Aegis, every piece that's coming in, or are there holes in that system that it's not receiving all of the information?

MR. MACY: There's two parts to that answer. You posited particularly a terminal engagement, which means that the previous ones have not succeeded. It's either a very short-range shot so you don't have time for that, or the other ones have already missed. All the information that's available gets fed into the system. And then, that is passed to whomever is going to try to take the terminal engagement.

In a terminal engagement, the time sequence is so short, it's right on top of you and you have direct view of what's coming at you. That is pretty much a look-shoot because it's just -- so you get as much information as possible that's provided as it comes towards you, but then the system that's doing it will use its own sensors to consummate the final engagement. This is happening within a couple of hundred kilometers. It's not tens of thousands of kilometers.

The other part of your question on understanding what it's doing, whether it's a terminal or any other engagement, is ideally you would like to have what we call birth-to-death track. From the moment this thing lifts off get track on it and continue that track all the way until it ceases to exist because we've engaged it. There are holes in that, depending on where you are in the world and the circumstances.

It's what Fran alluded to with SBX. If it's not out there, then it's not available to feed the system. Right now, there are gaps between radars.

Again, using the North Korea scenario, there are TPY-2s in Japan. There may be Aegis ships in the Sea of Japan or East of Japan. You have Cobra Dane. Hopefully we will have LRDR. The more we get to make sure that we have someone looking at it the whole way through, ideally more than one someone, increases the probability of the engagement being successful, and hopefully prevents us from having to deal with a terminal engagement.

The terminal engagement itself is such a short event that the other information is provided but it's almost going to be too late to be of any effect. Those things happen in a few tens of seconds.

MR. ANFELDT: I specifically asked that just because I wanted to know, at the very last stage -- at every phase is the kill vehicle, is the command and control system, informed by any information in the previous stage so it's all working seamlessly? And it sounds as if -- I understand there's holes if SBX is not deployed. If you don't have any on-site you're not going to get it. But I was curious whether if they were on site, if they were gathering, are they feeding it to all of the systems down the road that are going to potentially intercept it, or are there holes in that communications (system ?). And it sounds to me in the terminal phase it's not going to be able to absorb everything?

MR.: It's system dependent.

MR.: Yeah, it's system dependent. It's certainly complex. You have many sensors feeding the net. The net leads to a command and control processor. That processor takes the information and that processor is talking to the interceptor.

At some point you have, I'll call it "no more good ideas." You've established a track on that object that you think you want to shoot. And that processor will decide, TPY-2 your data is no longer relevant and I'm not going to use it.

As I said, if you go back to Aegis or Patriot or THAAD at some point their sensors are focused on the object and they're hearing the other guy talking to them. The other sensors are talking to C2BMC and that is talking to the command and control system in Aegis. But Aegis says, I've got the best track quality on it now because I've got -- you know, if you ever crewed a tank the tank commander lays the gun.

He'll give the firing command. "Tank Sabo" and he'll lay the gun. He'll bring the turret to the general direction of the object he wants shot. He's announced it's a tank.

The gunner is going to be focused looking for a tank. As soon as that lay stops and he has the tank, he'll announce target. That means, get your hand off control there

T.C., I've got it.

He's going to shoot whatever he's got in the breach. And the loader is going to load -- the next round will be Sabo, because that's what the commander called for. So that's kind of what's happening here.

The sensor architecture is helping to lay the GBI on the object. The GBI is going to launch and up to a point the will take data from the network that the sensors are seeing. But at some point he'll announce, target. I've got it. I don't need any more help.

What we don't have there in that architecture right now is that discriminating radar that can really help him lay the tube on the target. Right now he's getting a big picture, so he's doing a lot of searching. If the tank commander only announced, tank on the right side, that ain't a whole lot of help to that gunner. If the tank commander sees the tank and then lays the turret for him by grabbing the (Cadillac?), he's locking the gunner in the direction of where now he's got to do the search.

MR. ANFELDT: Thank you.

MR. TOM KARAKO: We've heard a lot about the reason we need the LRDR is needed for discrimination. You mentioned geographical limitations whether it's Aegis, TPY-2s, and LRDR supports that, improves that. I guess I want to ask about just how much of the solution -- in other words, what does the LRDR not do? It's pointed in one direction, so it's tailored to a particular threat zone. It's not going to be pointed in the other direction -- (off mic) -- North Korea. I guess it's not going to help in the Southern Hemisphere or the other side of the globe.

I'd be curious to have somebody talk to why you went in the direction of X-band, especially considering all the stuff we've heard about the X-band limitations. Why is LRDR going with X-band? And then also -- (off mic)? So a handful of things trying to get at.

MR. : It's pointed in a direction -- and it may have one or two faces which will give it a wider look angle -- based on the North Korean threat. It will not stop a threat that is shot from say Chile towards New York. It will never see it. To be honest, we don't expect that.

If in fact that level of threat would arise, then you would do that. That's the reason why the EPAA came into play for Europe, was realizing we've got a problem with the Iranians. And what we have looking at North Korea is not looking in the right direction. It's not going to do anything for Europe and not going to do very much if anything at all for the United States. So it is a pointing direction.

Could you launch a missile out of North Korea and bring it all the way around? Yes, you could. But that's incredibly expensive to do in terms of energy usage. And without getting into orbital dynamics, it's just -- no one believe that would be a practical approach for anyone to use.

So if another threat arises somewhere else, then the nation is going to have to make a decision about where else we put a radar. That leads to the question about, would you want an East Coast discriminating radar? My own personal opinion is, yes. A number of people pretty educated about it agree with that. The question is, at what point do you need to spend the money?

These are rather pricey pieces of the kit, to put one, and then where would you put it? And you hear everything from Cape Cod to Halifax, Nova Scotia to pick your favorite hunk of rock that you could put one of these things on. But yes, pointing matters.

That is why the TPY-2 that is in Turkey is pointed in the direction it is pointed in, and not at the Russians, because we don't feel the threat from the Russians. We do feel the threat from the south. So it won't see anything coming from a different direction.

X- verses S-band, everything is a compromise. The best tracking radars for long-range track are L-band. They're lower frequency. They go farther. They get more energy farther downrange due to the physics of how you propagate RF energy. X-band have the shortest wavelength so they're best for discriminating the shapes of objects different from each other to figure out which is that conically shaped warhead versus that hunk of wire harness that came off when you staged from the second to the third stage.

The problem there is because it's a very short wavelength it has a very narrow look angle, a very narrow aperture. The sea-based X-band is like looking through a soda straw. It can do great discrimination, but you've got to tell it right where to look, to look for the pile.

L-band will look over a giant quadrant for the same amount of energy, multiple orders of magnitude more area than an X-band for the same amount of energy, but very poor discrimination, and track quality in the middle. If you want to track it to within a certain amount of error, it's the size of my hand. If you want to get it better, then you go to the best -- as you go to X-band -- it's about the size of my fingernail, relatively speaking.

S-band, which is what's on Aegis and what's on LRDR, is a common compromise between track quality and discrimination and how much power you can get out in what's called the power aperture. So if we're given a number of kilowatts, and oh by the way the expense of the radar, but for a given number of kilowatts you can get this much energy and you can put it in a very wide area or a very narrow area, driven to some degree by wavelength. So the reason, as I understand it and which to me makes perfect sense, the LRDR was chosen as S-band for that compromise. It's the same reason that AMDR is an S-band radar. It's the compromise between track and fine-track, discrimination.

As far as the hyper-sonics go, yes if it's a moving piece of metal the radar will get it. Now it's got to be within where LRDR or SBX or Aegis is looking, absolutely. But the velocity is not an issue, assuming -- let me step back.

Velocity is not an issue from a physics point of view. You may put settings in your radar system so it ignores things you don't think about. So you'll put settings in LRDR so it's not going to try and track an airliner that's coming across the pole, which is by the way how they get there from Moscow or from Japan going to New York. You don't want everybody trying to sort those out so you just say ignore everything that's doing less than one kilometer a second.

So you'd have to choose what's called your track gauge, appropriately. Does that cover the ground for you?

MR. : Yes.

MR. : Okay.

MR. JOHNSON: I want to go back to a previous question for just a second on kind of the end-game because you have more and more advantage in the end-game, not that you really want to go there because you really don't want there to be an end-game. But at one point friction helps you. It helps take away all the stuff that's around that lethal object. All the lightweight stuff is just going to peel away because the beginnings of the atmosphere is just going to cause that stuff to retard and now you've got nothing left but the target. So that's going to help you a little bit.

The other thing to remember is, particularly when we're talking about the sea-based X-band radar, the SBX, it only goes at seven knots, maybe eight, downhill with a tailwind. It takes a while to get it where you want it to be and sometimes you don't have that luxury of forewarning, which is why this persistent radar, wherever the war fighter ends up deciding it needs to go, is so important for the architecture.

MR. : If we do more missile defense radars at sea other than our warships, they need to be on faster ships. Seven knots doesn't hack it.

MR. ELLISON: Can you just talk a little bit, because I know there was a proposal out for a radar in Hawaii. Why do we need a radar in Hawaii if we've got an LRDR in Alaska?

MR. : Okay, this gets back to the geometry of the Earth. If you have a radar in Alaska, it can only see so far down on the horizon. Hawaii is pretty far down on the horizon. In fact, you can't see it -- direct line of sight -- in any way, shape or form.

So there's another proposal working right now to put a second LRDR-like, or MRDR, type of radar in Hawaii. Why, because now it's in the right location looking out to make ensure that coverage that the LRDR or the other radar from the north can't get to.

So you can see much farther down and therefore you add a degree of protection for Hawaii that you wouldn't get otherwise.

MR. ELLISON: And Bill, if the LRDR was in say Shemya, then it would protect Hawaii. So what's the case for that not being the best scenario, from your perspective?

MR. JOHNSON: You would have some protection for Hawaii if you put the radar on Shemya. But as many of you know, operating a radar way out on the tip of the Aleutians Islands is extraordinarily expensive. It's almost better to have a ship at sea -- maybe not by much.

MR. : It's close.

MR. JOHNSON: Having been up there, I can tell you, not a lot. But, you still won't have everything. Remember I talked about resource balance here. There's a balance. Okay, where's the best place to put it?

Well, it might be Shemya. Okay, that'd be great. But then, you have the expense. How much money do I have to operate it? Well, I don't have that much money. Okay, so that may not be a viable option.

So there may be other options available and the war fighter is going to decide this as the capability comes out in the next number of months on where's the best place? How much money do we have to spend? How many resources do we have? Where can I operate it at? What's the best place to operate it at?

Can I put it out in a very remote place and operate it remotely? That might be an option or, is that not an option. So it depends on those resources that are involved.

And then, do you still need something in Hawaii? My answer there is, probably yes. Does it mean the requirements are extensive? Maybe, maybe not. It remains to be seen.

MR. : Sir?

MR. : One of the things I thought it would be worthwhile maybe for you to discuss is, we talked a lot about sensors as it relates to ballistic missile defense. But generally and most always we field sensors that are multifunctional. Maybe it might be worthwhile to talk through that a bit and how these sensors can be multifunctional, because at the end of the day we're going to be waiting a long time -- and as Arch pointed out -- we're likely to be surprised. We don't know the time and place when a launch could be, therefore these sensors can be used for other things. Would you care to comment on that?

MR. : Certainly LRDR, Shemya or Clear, a radar in Hawaii, can all contribute to things like space awareness, what's up there, tracking it when something new has been launched. They can be used for tracking other things, providing alertment. This goes back to, what settings do you want to put into it?

A radar will transmit RF energy and receive the reflection, and you can decide to process it or not. So you can use a radar for doing airline tracking or cruise missile tracking. Again, the trick there, particularly when it comes to things like cruise missiles, is the Earth gets in the way and they tend to be really low, so they're a lot harder to see. Things like JLENS is ideally suited to that. That's what it was designed to do, is to get up and look down at things that are close to the ground.

Now, can you use JLENS for missile? Absolutely. Which way do you point the beam and what do you process? So yes, they can be used for many things.

The problem, Keith, is where do you put them? What else is happening around Alaska that you care about except ballistic missiles, space launch and space track? So helping air traffic control, not much.

And MRDR, sort of the term that's floating around, Mid-Range Discriminating Radar -- sort of like LRDR but perhaps not need as much power or expense in Hawaii, could certainly contribute to air space track around Hawaii. It's there if you want to run it. Again, it's how you set it. You have to figure out how many tracks are coming in so that you don't overload the processing.

Bill talked about how you're processing a whole bunch of stuff, so you don't want to overload your processors. You don't want false alertness. But if you want to program it that way, radar don't care. It's RF out and RF in.

MR. : You get into a tradeoff at some point between designing this device to do mission A, it'd be nice if you could do mission B, C, D and E. How much of A's quality will we trade off to get to mission D? There'll have to be a discussion of that as MDA thinks their way through this new system or whatever new component they develop.

MR. : Fran, talking to that question, can the LRDR do a kill assessment so we know we actually hit it so we can do a look-shoot-look. Does that increase our capability to do a look-shoot-look, establish the fact that we actually hit the object, correct object?

MR. MAHON: I think it will contribute to what I would call battle damage assessment, the engagement assessment. That's an important variable to have. Not only did I fire at the right object, but is that object now gone?

MR. : Combined with where did you intercept it, so do you have time to make the decision to launch another one?

MR. MAHON: Right.

MR. : There's two parts. The timing piece will be, I may not have time to go through to get a second interceptor out.

MR. : So you have to launch two up front.

MR. : And the battle space that you create with the movement of whether it's in Shemya or Clear, does that give you more look-shoot-look capability, or is that even a factor?

MR. : I would say it's not significant. It's not significant.

MR. : There's a great debate on how much battle space (between Hawaii and back ?).

MR. : You know, we often would have discussion in the Patriot realm of, as you analyze what has happened in combat, as you analyze what has happened in tests, our firing doctrine is shoot two. But most of the time we're killing with that first one. Should I change my firing doctrine?

MR. ELLISON: What do you see the vision for the SBX, which is $1.2 billion to create sort of the exact same price as the LRDR? What's the future if we have the LRDR up and running for that platform that costs $25 million a month to operate?

MR. : The SBX becomes number one. It's critical for tests, to continuing to test the system. It becomes a backup sensor that augments the network. If a crisis to the east really becomes a reality, well then maybe you look at -- you do the tradeoff analysis of can I reposition that sensor to the east in its current configuration or in a different configuration to get a capability rapidly to the east? You turn it into a reef somewhere, now you're taking a capability out of your toolkit.

MR. ELLISON: Bill, does placement of the TPY-2 forward-based radars in Japan or other assets, do they relieve our ship capabilities, or is that not -- for our extended ships that have to be out there?

MR. JOHNSON: What the additional TPY-2 that we just brought up and is operational on Kyogamisaki, Japan allows us to do is it gives us a little bit different look angle. You can see longer that missile flying out of North Korea. You can see it longer, that missile, hopefully through your burnout stage. So then you can predict where it's going to go.

I would call it more complementary of the ships that are at sea than a potential relief. Now, potentially you've got some redundancy there so do you need as many ships? Maybe not. That's not a call any of us are going to make in here. That's a call that the PACOM commander is going to make, along with a number of other folks, when they decide how much is enough.

What other things are going on? What are the other things that those ships are going to do? If you've got the spare capability, sure you might want to have two ships out there and both TPY-2. In that way, if somebody hits the wrong switch or whatever you've still got redundancy out there. That's great.

If you can't afford to do that, then having Kyogamisaki up is a great kind of hip pocket capability. Now you can see better. You can see further. You can not only discriminate, but depict, where that track is going so you can get your defenses up. So it's a good insurance policy to have. The new trajectories that are covered by this radar allow the PACOM commander more flexibility, and I think that was the whole point.

MR. ELLISON: Is that a problem with that new mobile missile, the KN-08, or is our radar going to be able to pick it up and handle that situation?

MR. : The LRDR capability will handle any missile launched from North Korea. The trajectories of where it's going to go, if you're aiming at the United States, are relatively the same. It doesn't matter that it's mobile, North Korea is only so big. So the trajectory is going to be relatively the same and LRDR should be able to pick it up. The same thing with --

MR. ELLISON: But we won't get that burnout where we don't know --

MR. : You probably still will.

MR. ELLISON: -- with Aegis?

MR. : You probably still will.

MR. : And there is a big difference. LRDR will be in position, multi-faced, so it almost has a fix while you fight quality engineered into it, and it will be on-station. Aegis is not on-station. SBX is not on-station to contribute to the mission every day. We move to station when we have an indication and warning. With the KN-08, we're probably not going to have the indications of warning we've historically had in the past, because they're no longer fixed sites. And keeping track of mobile launchers is very, very difficult because most don't understand but no we don't always have an eye in the sky everywhere 24 hours a day, seven days a week.

MR. : When you talked about persistence and talked about how important that track is, but we haven't talked about space-based sensors.

MR. : Space-based sensors are great to have, no question about it. The problem with space-based sensors is if you've only got five dollars, where are you going to spend your five dollars? They're extraordinarily expensive.

MR. : What does five dollars buy you?

MR. : Nothing.

MR. : Here again, you're back into the business case analysis, is the technology there to give you the fidelity in the near-term with a space-based asset? I'm not certain how deep and dark into the netherworld we have to go to get that answer, but I'll tell you we could probably field multiple Long-Range Discriminating Radars before I could get that capability robustly from space.

MR. : The other thing about this is it's not just one. You'd have to put a number of space-based assets to have that persistent capability.

MR. : Constellation concept.

MR. : Constellation concept, and now it gets even more expensive.

MR. ELLISON: How about our allies? Can we fuse into their sensors? Are we -- the Japanese ships -- why aren't they buying early warning discriminating radars that we could fuse? Or is that part of capacity building on that?

MR. : They are buying radars. They are buying additional capability. The problem is how do you fuse it in and what are they buying them for? If the Japanese are buying them for their own homeland defense, it makes perfect sense to them and it's great. The problem is, it doesn't help us out very much back at the homeland. So we'd love to have that capability to go further, but why should the Japanese pay a whole lot of money more to defend us? It gets back to resources again.

MR. : Riki, earlier asked a question about interceptor firing doctrine and how does LRDR help with that. You asked about shoot-look-shoot. You mentioned that maybe that does come into play given the geography. But if you have the LRDR with this discrimination capability, how does that help you with firing doctrine in terms of knowing what the threat is from the non-threat, the lethal part from the anomaly (cluster ?), the general's analogy of the Patriot circa 1991?

MR. : If it improves your confidence that you are going to have a successful engagement, then that allows you to consider changing your firing doctrine. The brutal fact is that none of these systems operate to 1.0 perfection. So there are going to be days where the statistics will get you and you will miss. And they will keep coming, and you hope to get a second shot, and it may still keep coming. And unfortunately, that will now be a civil defense problem. That's just the brutal reality of life.

But the closer you can get to understanding system performance, improving the performance to say it does work at .95 or .99, and then believing that it does, allows you to change your doctrine. And to say, I have as much confidence as I'm practically going to get shooting two as I would shooting four, just because I get to that band of statistics, of probabilities where you're not going to know any better until the real thing happens, after it's over with, that's what allows you to do it. That's why there's been this gigantic push not only from everybody involved but particularly from the war fighter, from

General Jacobi, on the reliability of the GBIs, so that he knows that they're going to work.

If he knew that they were going to work to -- pick a number, .8 -- then he could plan for what he's got to shoot to have the best possible, practical estimation that he will successfully defend. Until he knows that -- no Admiral Gortney, you've got to keep shooting until he either hits it or runs out of stuff because he doesn't know every time he pushes the button whether it's going to come out of the silo or it's going to function all the way. So as we were talking earlier, if it works as intended, put in the right place looking in the right direction looking for the right object, it's a voracious killer, and we've demonstrated that.

The question, Tom, really is giving the commander a sense of confidence. When I order a gun engagement I order 10 rounds on target, because I believe that in 10 rounds, as long as I'm inside a certain number of yards, I'm going to get sufficient damage to the target, the enemy ship or whatever it is I'm going after. I can then stop and assess the situation, rather than just empty the magazine.

I can expend 100 rounds on this target. I've got a 500 round magazine. If I've got five more targets I'm all of a sudden in very deep trouble.

MR. : Isn't the argument really, going back to 1990 analogy how LRDR with its discrimination capability will it allow us to not shoot on non-lethal objects?

MR. : Yes.

MR. : Oh yeah.

MR. : You will never have perfect knowledge of the lethal object. You know that as the commander. So what you're betting is -- the engineer is saying, sir I can 99 percent of the time tell you that's the lethal object. That's the best I'm going to do. And the missile guy says, 99 percent of the time it's going to work and that's the best I'm going to do. Okay.

You put it together. The probability is something over 90 percent that you'll have a successful defense. And then you shoot two and you get up to 97 percent. And then, again, the laws of reality get to you. It doesn't matter how much more you shoot.

But you've got to have confidence in that number that you really believe it's going to work that way. So yes, it's all about the '91. It's about how well do you know it and do you think you can really get the lethal object?

MR. : This gets back to why the test campaign is so important, that we continue to test these things --

MR. : Yeah.

MR. : -- so we can maintain that confidence level and make sure the material, the engineering, the physics, all still work together.

MR. MACY (?): And unfortunately it's very expensive because if you want to test the ballistic missile defense system you have to have ballistic missiles to shoot at, which means you've got to pay for a ballistic missile. And those are rather expensive pieces of kit to do everything you want them to do. And, you've got to have places to shoot them from, as General Mahon pointed out, and other minor little details like that. But the LRDR advances us in our ability to have confidence in being able to consummate successful defense engagements and to do it within an affordable shot doctrine. Again, going back to General Mahon's point, it's a good thing that he was not faced with another salvo of al-Husseins because he would have been looking at a whole bunch of empty launcher holes.

MR. : The last thing on the LRDR, its projected capabilities take care of future threats. It's not only threats for today, its threats into the future. It's bringing today's technology now that we can advance forward and we're not relying on 1970s early 1980s technology anymore. We're now relying on today's technology and we can move that stuff forward.

MR. ELLISON: Alright, well thank you for coming today. We hope you use this information and influence as you can to get our country to have the LRDR and certainly more sensors around the world. We're going to be in Europe for the NATO Missile Defender of the Year on April 16, and then we'll be in Alaska for the Alaskan Missile Defender of the Year on May 16th. And I think we're going to hold another one of these sessions for the Aegis battle group and the Aegis missile defense, as well as our future systems.

You're welcome to stick around and talk to our guys here. Thank you very much Bill, Fran, and Arch for the conversation today. Thank you.

(Applause).