2015 Air and Space Conference

The Imperative For Innovation

14 September 2015

MODERATOR: Ladies and gentleman, thank you on behalf of the Air Force Association, and welcome to our 2015 Air and Space Conference. The title of this forum is The Imperative for Innovation in a Time of Austerity. Our panelists include Dr. Greg Zacharias, Chief Scientist of the United States Air Force, from here in Washington, D.C.; Dr. Mark Lewis, the Director of IDA Science and Technology Policy Institute; Major General David A. Harris, the Commander of the Air Force Test Center, headquartered at Edwards Air Force Base, California; and Major General Tom Masiello, the Commander, Air Force Research Laboratory at Wright Patterson Air Force Base, Ohio. Each of them will be kind enough to make a short presentation, and then after that I will be happy to moderate questions as you might have them.

So, Dr. Zacharias, your presentation please, sir.

DR. ZACHARIAS: So thanks, everybody, for attending our panel discussion. We know we're in a time of austerity, and we'd like to discuss how opportunities arise to be innovative and bring new ideas to the table and keep the Air Force strong and active and effective for decades to come. That's what this panel is about -- to start that conversation.

I don't have to introduce the panelists. I'm delighted that we've got this group together, and I want to just start to kick things off in terms of setting the framework with a discussion of the strategic master plan, kind of a top-down view of things.

We've got five major vectors -- and I'm sure most of you are familiar with that -- deterrence; global ISR (Intelligence, Surveillance and Reconnaissance); a high-end force; multi-domain approach; and airspace cyber. And what excites me the most as a chief scientist is we're looking at a fifth vector here, which really lays out the Air Force's commitment to pursue game-changing technologies, and

you can see them right here that have come up. And I want to say a few things about them and then what the potential is for changing the cost curve -- or bending the cost curve as the phrase is these days -- in these times of budget caps.

So, I bulletized just a few of these areas. I'm sure you're all familiar with them: Hypersonics with a high survivability because of speed and range to get us through A2AD (anti-access area-denial) environments; directed energy, both high- and low-power lasers that have a great cost-exchange ration if we can get the power up enough and get them onboard the vehicles that we need to get them on; high-power microwave, as well, in terms of doing non-kinetic kills of the adversaries' electronics; nanotechnology of incredible broad-based technology that's got lots of applications across a lot of systems; unmanned systems. We've seen what fantastic success they've been over the last decade in a half. They're clearly going to be used in many more roles out there as time goes on. And then, finally, autonomous systems,

another technology that can range across lots of platforms as well as at-rest types of platforms like the AOC and decision aids. These all have the potential for bending the cost curve by really introducing a new calculus of cost exchange ratios.

The big question, though, I think is that with all these game changers, how did we get them out of the decades-long acquisition cycle and get them out there more quickly and more effectively.

So, I want to say a couple of things about the processes involved in getting these out both in terms of strategic planning, in terms of life-cycle management, and in terms of training-- three separate processes that we need to get these things out. And these all could benefit from earlier, more extensive, and more comprehensive use of modeling and simulation, especially if we could make use of common M&S resources across all three processes of planning, development, and training. We break down existing stovepipes; we speed up the process; we field successful systems faster; and we terminate

unsuccessful systems faster. And we detect the technical baseline, because we own the M&S description of these systems.

So, let me talk briefly about each one of these. I won't take too much time on them. But, first, I've drawn the traditional M&S pyramid upside down to emphasize the fact that the engineering physics models are at the bottom. They tend to be a high-fidelity but very narrow scope, and then as you move up the pyramid you get much broader models but often very qualitative and less quantitatively driven.

The models in the middle are the ones that we make our developmental planning decisions on in trying to look at mission effectiveness as a function of cost and time to field these developmental planning things. But if we could link together models at each level -- for instance, across different communities at, say, an engagement level -- we'd have better models there. And if we could also link vertically these models, we'd be able to not only justify the high-level qualitative models from more physics-based

ones but we'd also be able to constrain some of the physics-based models by large issues to do with strategy and policy and so forth.

So, we could make our acquisition choices faster, both top-down constrained and bottom-up rationalized. Multi-level M&S is not a trivial exercise. There are a lot of people working it. But I think there's a great opportunity here to benefit the acquisition process, the strategic planning process.

In terms of acquisition, I put a cartoon-like linear process there we all know doesn't really exist. There are lots of loops and so forth. But the key thing here is that there are lots of different models used along this whole linkage, and they're often at different stages, sometimes at different times; sometimes they're rediscovered by different groups and sometimes inconsistent with one another. The key is to link them to ensure consistency; eliminate redundancy; and minimize development testing and training times. So, again, an M&S background here

would help us accelerate our development process.

So, let me move to the last Venn diagram, talking about training. This I stole from General Masiello, which I think is a great construct showing how live training has become augmented both with virtual training as well as with constructive computer entities to increase the strength in the resolution of the simulations.

But now we're fielding much more advanced systems against potential adversaries that have also made great strides in their weapons systems both in sophistication and in numbers. And so the question is: How do we train for this when our ranges aren't big enough; when we don't want to broadcast to the world what our TTPs are and what our weapons capabilities are. And, frankly, we don't have enough money to be burning circles in the sky for the next engagement opportunity.

So, what we really need to do here is boost our virtual and constructive capabilities to start to emphasize the V and the C portions of training so we

can expand from an unrealistic, low-density engagement, which is shown in the lower corner there -- lower right corner -- to something that's more representative of what's to become very high-density engagements. So, more M&S-driven VCL training, I would claim, is the real way to proficiency for the future.

So, let me close by moving to the last slide, which is the framework I started with, and given our composition of our panel, I'd like to focus down on the acquisition part, with General Masiello talking about some of the S&T; General Harris talking about the back end of T&E, and then Dr. Lewis focusing on a specific game changer, namely, hypersonics.

General Masiello.

GENERAL MASIELLO: Thank you, sir, and good afternoon, and let me just thank the AFA for just putting on a great event. We really appreciate it and all the support to AFRL as well.

Where is the magic clicker? Here we go, okay.

So, I'm going to, in a real quick fashion, lay out five broad areas and themes that we're working within AFRL to achieve what the Secretary this morning talked about -- agility and speed; what the Chief at an AFA event talked about -- we have more mission than money, manpower, or iron; and then General Powlikowski coming in as the Air Force Materiel Command commander laying out one of her most important priorities, and that's agility.

So, I'm going to talk about what we're doing, again, real quickly in terms of how we as AFRL internally are trying to be more agile but, more importantly, how can we support the Air Force -- support the Air Force both in acquisition agility with the readiness issues and even personnel? Our Human Effectiveness Directorate does work to support a lot of personnel initiatives. So, let me talk to the first one. That's Warfighter Focus Innovation.

I mean, we just cannot afford anymore to be working in areas that the warfighter and the acquisition community aren't on the same page. So, we

have codified over the last 10 years or so what we call capability collaboration teams, and they're representative from both the major commands as a core function. There are 12 Air Force core functions. They'll have a core function lead integrator -- for example, air superiority, ACCS. We'll have a capability lead at the SCS level, and then we'll have a commensurate lead from LCMC -- or, if the case is space, it'll be SMC -- working together to document the warfighters gaps and requirements, and then potential S&T solutions -- and it's a dialogue, a three-way dialogue to come up with us with an S&T annex of the Core Function Support Plan.

I think the biggest difference from where we have evolved to is that we are actually documented now into the Core Function Support Plan that rolls up into the Core Function Master Plan. This is a new initiative this year. We have an opportunity to brief the Chief and the Secretary every six months on our S&T way ahead on certain areas, and after one of them the Chief said: You know, Tom, you have in AFRL

uncommon technical knowledge. Your scientists and engineers have uncommon technical knowledge compared to the rest of the Air Force. The rest of the Air Force, especially from the operational standpoint, has uncommon common sense, if you will. So, we need to work to get folks with common sense and knowledge of -- I don't know if that was a slam on our scientists and engineers or not. Maybe it's me for not having a lot of common sense. But I got it. So, let's get essentially the operators, the people in the field, the people who just came from the fight in all three areas -- acquisition, ops, and personnel -- and link them with your researchers, and who knows what can come out of it. So, we partner with General Kwast at AU. I mean, what better place is -- to reach out to AU, you have these high-speed officers at Air Command and Staff College and Air War College taking a year out of the fight, if you will, and then work with our scientists and engineers and looking to create, you know, the next generation Air Force. It's worked out very, very well.

Let me go on to the next one, the Broad Network of Innovators. You know, so we have what's called the Small Business Innovative Research. It's SBIR money. It's about $125 million a year that we execute anywhere from 50,000 to 150,000 chunks at a time. We said, hey, maybe we can do a better job of bundling those funds and target against specific problems within the Air Force. We did a prototype last year with SMC and looked at GPS. It was so successful we're going to expand that.

And then internationally -- you know, the U.S. at one time was the center of the universe 20 years ago maybe for science and technology. We're not anymore. I still think we're the best, but as AFRL our job is not just to do internal research. We do great internal research, but it's more important than that. We do internal research. A big part of why we do it is so we can be smart harvesters of science and technology around the world. Our researchers have the credibility. They have the network. So, we need to leverage that, even more so

than what we have been, to look at other countries, especially of allies -- how we can help with their technological gaps.

Changing the way we do business. The first little sub-bullet up there is Experimentation Campaign. The Air Force senior leaders have supported an experimentation and prototyping campaign. They're looking to the AFRL to help stand that up. It's a significant amount of resources, and that really, I think, links back to when I talked about AU. So, if we're linking -- the operators were linking the technologists, hey, let's go out and test some of these environments. Dr. Zacharias already talked about having a modeling and simulation environment, which we're working to tie together within AFRL and then working the standards so we can tie in other modeling and simulation environments across the Air Force and industry. But, more importantly, let's have some money to bring it beyond a computer and out into the field and go ahead and iterate on some of those things.

And then I really want to highlight our Air Force prize. This is a $2 million prize that's run by Air Force Research Laboratory. It's on a small turbine engine. It's kind of taking a page out of DARPA's playbook where they did their big robotics challenge and that sort of thing, where we have set specifications, spark innovation on a small turbine engine for a medium-size UAV, let's say, where we're going to take the efficiencies of a turboprop engine, combine that with the weight and life-cycle ease of maintenance of a turbine engine, and see if we can spark some sort of innovation with a $2 million prize. We've had several teams already sign up, and we just listed the specs. The first team to meet those specs will win the $2 million prize. Very exciting.

Going on to Demonstrations. Demonstrations of advanced systems are very, very expensive. Dr. Zacharias talked about hypersonics or game-changers, high-energy laser on aircraft, autonomy. We have built programs to demonstrate each of these three game changers as laid out in the Call of the Future.

The first two -- hypersonics and high-energy laser, to the tune of almost a billion dollars each partnering with DARPA to move these game changers along, just to get them out of the lab just as you talked about; and this year, we're putting together an autonomy program where we can do the same thing. Very -- and I'm not talking a small scale; I'm talking large-scale demonstration to help the warfighters understand, as well as the technologists: Okay, what is the power of autonomy and how can we really harvest it for our gaps and requirements.

And then, finally, affordability: banking that end right up front; looking at manufacturing, technology investment so we can get close to right independent production; talking about open architectures; and making it easier and less expensive to go ahead and update weapon systems if they're going to be in the inventory for 50 years.

So, I want to go to the next slide. I've got a quick video, and this is an example of what I'm talking about. This is a total team effort. This is

a partnership between AFRL, the Test Center, the acquisition community, the warfighter on auto ground-collision avoidance.

The system has been in the works since the '80s. But finally we have some enabling technologies -- basically GPS with a digital-trained database, linking those so that you can integrate an effective ground-collision avoidance system. And I will say, it took a lot of work with the operators in this thing, because -- do you want a system -- do they want a system where it's going to take control? Believe me, my wife will a hundred percent attest, pilots like being in control. So, we don't want to design a system where they feel like they're not in control -- so, again, partnering with the Test Center, partnering with ACC to work a system that is actually operational and relevant. It's out in the field in less than two years.

We have two confirmed saves. That letter -- I know you can't read it -- that letter is from a captain, F-16 fighter pilot, from Spangdahlem who is

writing to the Collier Trophy Committee endorsing auto ground-collision avoidance system as it saved his life.

So, let me go ahead and run the video. I apologize for the quality. I know it's *South Park*-like, the quality and, you know, it's not the most illuminating video I'll admit right now, but at least we'll get the point across. So, this is the mission the captain was on. He's in the green airplane. It's two F-16s fighting over the Med in a high-aspect, basic fighter maneuver mission, and you'll see the auto collision avoidance is going to engage here in just a little bit and engages -- and I'll show you the parameters where it engaged. So, the fight started at 20,000 feet. He was at 500 knots, 65 degrees nose-low. So, basically, pointed at the water and almost completely upside down, the system kicked in and saved his life. He had about two and a half seconds before he would have smacked into the water. So, if that isn't a total illustration of why our mission matters, I don't know what does, but thank you.

GENERAL HARRIS: Thanks, good afternoon. It's customary to start these off with a war story, so here's mine. There I was, sitting at the kitchen table helping my daughter with homework. It's math homework, and after a while she just smacks her head and goes: Dad, this is so stupid, we'll never use this again. Well, I'm here to tell you that we'll be here to use it again. All these complicated systems that are being invented by our scientists eventually, at the end of the acquisition chain, get tested and evaluated. They get harder and harder to do that as they become more and more complex.

Let me give you an example. All right, so we do the program called ASTE -- Advanced Strategic and Tactical IR Expendables -- flares. For those of you who are not familiar with flares, they are decoys that decoy infrared-seeking missiles away from the aircraft. That's what we're supposed to do. So, if you go out to your average fighter pilot, he'll go: Well, how hard is that to test? Right? You punch a flare; you see if it decoys; if it did, good; if it

doesn't, send it back to the drawing board.

It's not that easy. Just think about all the different things, the different variables, and they're listed there in the Xs, right? And this is a simplified list: aircraft type, you know; an F-16's different than an F-15 and, you know, whatever -- the MANPAD type, the missile seeker head, right? There are all different kinds. And then there are all different aspect angles of the aircraft -- what's the background -- all those different things.

When you try to put a matrix together like that, it's a seven-dimensional space, and I can think in two dimensions and I can put two dimensions on a PowerPoint chart, but after that my mind starts to get a little bit muddled and you have to be, like, a linear algebra fanatic to sort of even be able to wrap your mind around twelve-dimensional or seven-dimensional space. So, how are you going to do that? Because if you do all those combinations and put it out in a test matrix, it's 10,000-plus test points, and you have to do each one of those 30 or 40 times to

get the confidence level to make it any good, right?, to a decision-maker. You just can't do it.

You model these things in a complex battle space of testing, but after all those combinations sort of get fleshed out, you realize that there isn't enough money in the world, even if you were printing it -- or time, right? -- to actually test it and give the warfighter what he or she needs to know.

So, what are we going to do? Well, you go back to that kitchen table discussion. Math comes to the rescue. We used to do this the old-fashioned grunt way, right? It would take about a million dollars to run a very simple test and you'd get a series of data that looked like this. The black dots are an average of all the 30 or 40 test runs that you ran, and the little red brackets on top and bottom of those black dots are your confidence interval. If you run more runs, you can get those to collapse in toward the middle; fewer runs, it's less helpful to you.

But you can see with even 30 or 40 runs, you're only getting information on a very few areas of

aspect angle, and you only know the answer to within about 25 percent of what you need. It's just not useful. But it's too expensive to do anything more.

What's more, you can't connect these dots, right? You don't know anything about the battle space in between the dots because, remember, testers are making the assertion to a contractor that their thing does not live up to the contract, right? And you'd better darn well be able to prove it scientifically or they're not going to spend their resources to fix it. So, we have to use generalized linear models. And it works for tests where it's a binomial kind of an answer, right? -- hit or miss, pass or fail -- and it works for any kind of a test that has that kind of a result. And you can change data that looks like this into data that looks like that. And you can connect the dots, and you can shrink those error bounds by 25 percent.

That's how, with the same amount of money, you can either make more runs to shrink the confidence interval or you can do fewer runs for the same

confidence interval by yourself that should cost, should schedule -- just remember, at the end of the day it should work, right? If it doesn't work, there's no sense of coming in under cost and under budget, right?

So, I look forward to your questions later.

Dr. Lewis.

DR. LEWIS: Thank you.

Well, I'm going to use my status as the only "former" on the panel to be a bit more philosophical, if I could.

So, Greg had asked me to focus on one particular feature system: hypersonics.

I'm not sure why you picked that one for me, Greg, but I'll move forward on that.

And so I want to draw a couple of statements based on our history in hypersonics research but may be related to the topic at hand, which is Innovation at a Time of Austerity.

So, as was mentioned previously, last year the Chief and the Secretary came out with their 30-

year plan, and one of the great parts about this plan, especially for those of us who love S&T, is that S&T made the plan. And I think that's actually really important, because at a time of austerity when you're worried about where the next dollar is coming from, that's the time when you actually want to be thinking about these capabilities, and that's the time when you want to be investing in a future in S&T.

I circled "hypersonics." It was the top one in the plan. We've been doing hypersonics for quite some time. We first flew hypersonic systems in the late 1940s. But we kind of saw reenergizing of the field in the mid-1980s. We've also learned some lessons that I think apply to this time of austerity.

So, many of us remember the National Aerospace Plane Program -- the X-30 -- began in 1986. It was going to build a hypersonic vehicle, single-staged to orbit, powered by air-breathing engines. It was going to be a 50,000-pound vehicle, and it was going to cost roughly about a billion dollars. By 1993 when the program was canceled it had grown from

50,000 pounds to 450,000 pounds, and the vehicle was going to cost $12 billion. So, lesson number one in time of austerity: Plan well; don't do really dumb things; and do your homework ahead of time.

Unfortunately, we've got a pretty long [inaudible] of other failures. Programs across the board: Air Force; DARPA; Navy. If I could pull out a theme from some of the failures that we've had, I'd argue that the number one reason was lack of investment up front. We didn't do enough basic S&T leading up to the program, and we didn't do enough test and evaluation before flight.

So, how do we solve that? Well, one way is invest in T&E, and I didn't -- this was not preplanned, by the way, ahead of time. But I constantly hear the question: So, can we get rid of our T&E facilities entirely? Let's just go right to flight, build the system and fly it. Yes, if you want it to fail. But if you want it to succeed, then you need to do your homework, and you need to make the investments up front.

At IDA we've been doing a study most recently on the business case for ground test facilities, and you see some of the high-speed ground test facilities that would be used for developing the sorts of systems I just mentioned. And the bottom line is that those ground test facilities must be used in conjunction with flight tests in order to have successful programs.

Several people on this panel have already mentioned doing things a little bit less expensively. One of my favorite examples that it can be done is a program that Tom's folks have been leading called the High Fire Program. It's a joint U.S.-Australian program, and going to that program the manager was a hypersonic series of experiments where flights would be conducted early and often. If things failed, we fly again. We've learned what we could from failures as well as from successes.

Most recently High Fire did its seventh flight, and the flight was successful except they lost all the telemetry in the vehicle. And so what was the

answer? The answer was: Well, we're going to fly it again, only this time we're going to be sure we get the telemetry. And that's the right response if you're going to develop these sorts of programs.

If I may, let me close the slide with what I think are kind of broad themes that apply to hypersonics and maybe apply across the board.

First, good science actually does require consistent investments, and so we get to times of austerity when it's very easy to say let's cut the S&T because that's the future and we can invest in S&T later on. That's definitely when you don't want to cut the S&T. That's exactly when you want to keep those investments going. At the same time, S&T dollars are precious. All of our dollars are precious, but since S&T is such a small piece of the budget, we have to invest wisely. That means investing in things like test and evaluation, investing in the basic science to make sure we get those programs right.

There's a tendency at times like this, when

in austere times we to look to other people to fund our programs, looking to other agencies: Let's have DARPA do the program. That can be a mistake, and I'll warn against that. The Air Force has to own its own innovation future. It's our warfighters who understand how those systems will be used. And I'll point out that innovation is different from invention. Invention is creation; innovation is use. And who better to understand the use of these technologies than the United States Air force? Again, the time to invest in innovation is precisely when acquisition budgets are low, precisely when we're in times of austerity.

And let me, if I may, close with a quote from Mike Wynne, who was Secretary of the Air Force for a lot of the time that I was in the building. Whenever anyone wanted to cut the S&T budget under Secretary Wynne, he would just look at them and say: S&T should not be a bill payer. And I will highlight that message. No matter how austere the times get, we need to make sure that S&T -- and T&E as well --

cannot be a bill payer.

Thank you very much.

MODERATOR: Thank you, gentlemen. Rich comments at least. And while I'm waiting for questions from the audience, let me offer a few, and I'll ask you, Dr. Zacharias, you mentioned game-changing technologies, and I'm curious about what you might regard as a holy grail? You mentioned several developmental areas. Which one do you believe can have the greatest impact on our ability to fly, fight, and win as an Air Force?

DR. ZACHARIAS: This like asking about your favorite child, right?

MODERATOR: Well, that's okay, that's okay.

DR. ZACHARIAS: I think the warfighter would like to be -- if he's in an aircraft would like to be invisible at the highest possible speed he could be and invulnerable. And I think anything that contributes to that, whether it's an autonomous wingman, hypersonics DE, I think those are all contributors. I think we have to look at this

holistically and think about the mission and the engagement.

MODERATOR: General Masiello, you discussed briefly an agility to adapt and respond as a guiding principle. I'm curious what you see as the biggest inhibitor to that agility. Is it something in policy? Is it resources? Is it technology? Is it science? I'd be interested, and I think the audience would be interested, in hearing your views of what inhibits the agility that you think is necessary.

GENERAL MASIELLO: Well, a couple of things I think come to my mind without putting a whole lot of thought to it. First of all, it's a mindset. I mean, we've just got to understand what is the art of the possible when it comes to, say, a big acquisition system or other areas in terms of, again, supporting the personnel realm or supporting in the readiness area. So, it's a mindset to understand that, you know, we can and we must get more agile.

Sure, there's an aspect of policy behind it in law, but I don't think we should hide behind that.

I think we need to understand. I think the environment is definitely right to approach the Hill to see if we can get some relief so that we can become more agile. And then just look at each organization in their own business practices and looking, okay, what is hindering us?, and then work to bulldoze those through.

MODERATOR: Thank you.

General Harris, you discuss briefly in your comments this concept of confidence intervals and the notion of some balance of testing, and Dr. Lewis mentioned it as well, so this is directed to both of you. How do we establish policy to ensure adequate testing without -- as some of us who've lived in the field and the operators not testing and IV & V-ing something to death, how do you establish that balance of both from a warfighter perspective and from a testing perspective? And General Harris, if you'd respond first please.

GENERAL HARRIS: That is the key question. That really is the key question. I read in a

warfighter trade journal quote -- and I've got it on my desk, because I remember it was a warfighter complaining about developmental testers -- and the quote says: "Those guys have an infinite number of test points, and they want to do every one three times." Well, that's completely false, right? We actually have an infinite number of test points, and we want them infinitely repeated. (Laughter) Because we're scientists, right? We want to get the confidence level down.

The balance really comes in the mind of the acquisition professional and, ultimately, the person paying the bill, whether that be the warfighter or Congress who provides the money that buys the program. We, the testers, must be agile enough to meet that warfighter's expectation and to help the PEO find the right balance.

It's true, right? Should cost, should schedule -- but, remember, it should work. We, the testers, are the quality conscience, if you will, of the government. We are going to just make sure that

you understand, if you're the decision-maker, what compromises you have made when you cut runs out of a test program, for instance.

MODERATOR: Dr. Lewis -- oh, I'm sorry. Go ahead, Dr. Lewis. Dr. Lewis, do you care to respond?

DR. LEWIS: Sure, what he said. (Laughter)

So, I agree that part of it is a mindset. I think you can actually make a business case. In fact, we've been trying to do that in this particular study that I mentioned where we look at the cost of flight testing versus, say, ground testing, the cost of a failure in-flight versus the money you would have spent just up front. And needless to say, you always spend less money up front. I've always likened testing to -- it's kind of like car insurance. You hate paying that insurance bill until unfortunately the tragic day when you need it and then you are very thankful that you have it. And then that's what this is all about.

I remember about six months someone in the White House actually asked me: Sir, do we still need

wind tunnels? What do we need those things for? And I said: Well, okay, the reality is I guess I don't need wind tunnels if I'm willing to build any airplane and fly it the first time and hope and pray that it works. I can guarantee it won't work if I don't put it in a wind tunnel first, but I could take that approach.

I've also observed that I think we've gotten ourselves into a little bit of a pickle on that. We have a mindset, not of testing and experimentation but of demonstration, and this is one that I've been in a bit of a tear about because demonstration is fundamentally different testing. In testing, I'm allowed to fail. Any result I get is a good result, because I've learned from it and I move forward. In demonstration, I claim I already know the answer so I'm just flying something or putting something in the tunnel to prove what I already know. And that's a very dangerous mindset, because it's much easier to do it, to spend your money, and then realize you haven't actually accomplished anything in that mindset.

MODERATOR: And we have time for a couple more questions. I have one from the audience, and the neat thing about AFA events is the audience is not shy about controversy. And this question is for General Masiello. The question asker would like your perspective on OSD's push to control and approve IRAD. While they seem to have backed off, what is the current thinking and discussion on this issue? Do you care to respond to that?

DR. ZACHARIAS: Say that again? (Laughter) No, I think it's actually a good news story where we're moving to. So, it's, first of all, very, very important. Like, we've talked in time of austerity, limited budgets. You know, the contractors, they consider their IRAD funding, which is ultimately billed to the government, precious resources as well. So, it only makes sense to increase the dialog between industry and government, especially AFRL, to understand, hey, we have a direct connection to the warfighter, like I already talked about, as well as the acquisition community, so we have technical

roadmaps; we have the S&T annexes already built with warfighter input. So, it only makes sense if industry is going to spend their precious IRAD dollars that, hey, let's interface with the government to make sure those investments are wise. Now, I know initially OSD said, well, maybe we need to have actual approvals -- and it was like that before -- but I do think that's going to be very difficult to implement. And what I understand kind of, OSD is leaning now kind of, to what the Air Force has championed called technical interchange meetings, and that was a partnership with AFRL, LCMC, SMC in terms of let's have a call, and now it's actually been adopted by the OSD communities-of-interest panels where we actually have a call in Fed Bus Ops, this area, let's say space. We want to look at space situation awareness. Bring your IRAD ideas, submit them to White Papers, we'll go ahead and review, and then we'll have a sit-down, and that's where, the way I understand it, OSD is going to -- I think overall maybe it was a little controversial getting here, but I think we've got it about right

now.

MODERATOR: Thank you, sir.

Dr. Lewis, this question's for you, and it involves wind tunnels, and they do cost money, and it's an infrastructure that we sustain. We would be interested in hearing your view on the possibility of using live virtual constructive simulators in place of some of those wind tunnels. Can you discuss that?

DR. LEWIS: Sure, so for the past I think three decades, we've heard calls for replacing real physical facilities with more modeling simulation. The reality is the way we use wind tunnels today is very different than the way we did 10 years or 20 years ago, because we have completely integrated our ground test facilities with modeling and simulation.

That hasn't eliminated the need for the ground test facility. It's changed the way we use it, so instead of doing hundreds of tests, for example, in a wind tunnel, we can do tens of tests and use those data points to anchor our computation results. The

reality though is, as of this date, is we still don't have computational solutions that will completely and totally simulate the physics that we see in-flight. And that's especially true, by the way, in the hypersonic realm. We understand most of the basic physics, but our ability to model it exactly and perfectly really is limited, and so we will, at least for the foreseeable future, need to use those two capabilities in combination.

MODERATOR: Ladies and gentlemen, I'm afraid that's all the time that we have. Before we thank our panel, I'd like to remind you that full coverage of what's going on at this conference is available at *Air Force* magazine's Website, AirForceMag.com. I'd also remind you that there's a wonderful exhibit floor downstairs that you're welcome to visit, and I would encourage you to help us do these kinds of things by visiting the Air Force Association booth and possibly becoming a member of AFA. And we've got a sweet deal for you. It's half price while we're here at this conference.

And with that, we are adjourned. The conference will resume tomorrow morning at 9 o'clock. Please join me in thanking our panel.

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