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WEBINAR

THE FUTURE OF AMERICA'S DEFENSE INDUSTRIAL BASE: A CONVERSATION WITH KATHY WARDEN, CEO OF NORTHROP GRUMMAN

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P R O C E E D I N G S

MR. O'HANLON: Good afternoon from the great Commonwealth of Virginia on this gorgeous fall day. I'm Michael O'Hanlon with the Brookings Institution. I have the real honor today of speaking with Kathy Warden, the CEO and president and chairman of the board of Northrop Grumman Corporation, one of the Nation's most important and largest defense contractors and innovators in the space of commercial as well as military technology.

We're going to have a conversation that will benefit from some of your questions that have already been received, but we're going to have a little bit of a flow that also follows a fairly natural structure for what I myself am most curious to hear Ms. Warden discuss, beginning with how her company has handled the great challenges of these last two years. Obviously, the international challenges have pre-dated Covid, but keeping a workforce going, keeping supply chains going, a particular challenge. But also, now we want to link that to how is the U.S. defense industrial base doing more broadly defined, where do we stand in terms of, you know, 25 years after the post-Cold War consolidations and well into this period of great power competition. How are companies like Northrop Grumman responding and what new steps may be needed after a period of considerable congressional activity in recent years as well to try to spur new kinds of innovation, new entrants into the defense modernization space, and so forth.

And along the way we'll talk a little bit about the international environment, not only threats, but partners, allies, and those with which Northrop Grumman works so frequently.

So that's the basic flow of events and conversation.

Let me just say a quick word on Kathy Warden. She is a product we're proud to say –- I'm a resident of Maryland, proud to know that she comes from the great Terrapin State and is a product of the DIV in general because she went to James Madison University out in the Shenandoah Valley and then did foray inside the beltway briefly for her master's degree in business administration at George Washington University. She spent a career –- or I should say a half career –- still a very young and rising star even though she's at the pinnacle of Northrop, but spent the last 20-some years in various sectors of

American corporate and technology space, including with other companies like General Dynamics, but also now she has been with Northrop for a number of years and held positions at the vice president or COO level, including for different parts of the company, and since 2019 the entire Northrop Grumman Corporation.

So, Kathy, if I may, thank you for the privilege to speak with you today. It's really nice to have this opportunity.

MS. WARDEN: Well, Mike, thank you for inviting me to talk with you.

MR. O'HANLON: And I should also say, we're very grateful at Brookings that Northrop Grumman is a generous donor, one of a number of donors that we have. And, of course, we're all each speaking for ourselves here independently, as we always do.

And so, I'd like to begin if I could by just asking how's the company been doing, how has your workforce been doing, your family, over these last two years as you've had to cope with Covid and all the other things that have gone along with that challenge?

MS. WARDEN: Well, thank you about asking about the workforce first because they have been the heroes of this pandemic from my perspective in the defense industry. They have been incredibly resilient, showing up for work every day. The majority of our workforce needs to be in our facilities, either because they're hands on building product or they're working in secure facilities and Northrop Grumman provides them a place to do that work.

So, we right out of the bat had to get people back to the office safely and we're really proud of how the workforce responded and stepped up. And not just the Northrop Grumman workforce, but the entire supply chain has worked diligently to make sure that we have the support we need to deliver the weapons systems that we deliver to the Pentagon.

MR. O'HANLON: Do you feel like you've been in sort of a stable place? The first few months must have been an enormous headache and a great challenge and a lot of anxiety, but do you feel like for maybe 12 months or, so you've been in a relatively new normal that's been somewhat stable? Or are there new challenges that present themselves all the time, from the delta variant and other things?

MS. WARDEN: I would not use the word stable. It has been a weary dynamic environment. We have found that we will operate to a certain standard and then feel that we can relax some of those standards because the community spread has reduced, only to find ourselves back with –- delta variant is a good example –- to needing to re-institute some of the safety practices that we had early on in the pandemic. And what I will say is the workforce has diligently changed alongside of us so that we can protect each other. And that's what we've asked of them.

MR. O'HANLON: Have you had particular challenges? Have there been outbreaks, have there been –- or supply chain interruptions, other thing that stick in your mind as the most notable along this 20-month saga that we're into so far?

MS. WARDEN: We've just more recently seen supply chain challenges. Certainly, early on we had a few businesses, particularly smaller businesses, that shut down for a period of time while they reconstituted their spaces of figured out how they would work safely. But what we found is we had a solid year, from last summer to this summer, of really strong productivity despite some of the challenges with worker absenteeism as people battled with their own instances of Covid-19, or their family.

But what we have seen in the third quarter of this year is another resurgence due to the delta variant. That is starting to subside. We're seeing case rates across the company and across the country come down again and we're pleased to see that, but we're ever vigilant in watching that data so that we can ensure we continue to operate safely.

MR. O'HANLON: And one last question, if I could, on Covid before moving on. Is there any particular effect on your output? Have you had deliverables measurably reduced or scaled back at certain periods? And is there any way to quantify –- I mean some of that may be proprietary or sensitive or classified, but can you give us a rough sense about just how much you might have had your own production somehow compromised by Covid?

MS. WARDEN: So, we haven't quantified it, but we have talked about certain supply chain challenges, including in the third quarter we saw a higher level of absenteeism, not just within Northrop Grumman, but our suppliers. And that did slow some deliveries. We also have talked about the

elongated lead times on certain supplies, areas like chips that we use for field programmable gate-arrays. Those products are ones that we have had to lengthen our lead time. We've also seen some inflationary pressures in those areas. And, of course, the entire country is dealing with logistics challenges, being able to ship our products, even domestically, and get supplies in domestically.

So those are some of the challenges that we are working our way through.

MR. O'HANLON: I guess one more question, although its tarts to get into one of our other main topics. Do you have any effects that you have noticed that have compromised your ability to do research and development on some of the new programs that of course are at the center of the National Defense Strategy and Great Power Competition, the desire to innovate, whether it's the B-21 bomber, whether it's certain satellite systems. Have you been more or less able to keep doing R&D even if you've had challenges on production?

MS. WARDEN: We have. R&D has been a real strength in the company even before the pandemic, certainly continued through the pandemic. And we've found that there's quite a bit of capital going into the areas of R&D that we're most interested in. So, the new starts of new businesses, as well as the funding sources for businesses in the commercial space that we partner with to bring technologies into defense have all been very robust, even through the pandemic.

MR. O'HANLON: That's good to hear.

That leads me to want to ask you about the international environment. And I don't want to spend too much time on this because there's so much to discuss with innovation and the defense industrial base and other topics, but I think it's interesting to hear from a CEO of a major defense company how you see the environment, not only in terms of threats, but opportunities, partners. You spend a lot of time working with other countries. Some of the questions we've received concerned people's interest in knowing how those relationships are going. So, I just wondered, when you take a snapshot of the world today, in late 2021, how do you see it? And, again, you've been around this business long enough to have seen a couple of different phases. You're a post-Cold War defense, you know, person and manager and technician and leader, but still, you're very familiar with these different

periods of crisis and challenge and opportunity. How do you see today's world compared to other parts of your career?

MS. WARDEN: When I first came into the industry there was a lot of discussion about the "Vs", velocity of threats, the volume of threats, and the variety of threats. And I see that more pronounced today even than when I came into this industry 20 years ago. And what I mean by that is we see a wide variety of nations that are nuclear capable today, but we also see countries that are aspiring to be nuclear capable and countries where counterterrorism and counter insurgency are the biggest threats.

So, when you look at the breadth of challenges that the U.S. and our allies need to deal with, I can't remember a time when it's been a broad as it is today. Layer on top of that the fact that technology is changing more rapidly than it ever has before. You know, I got my degree in computer programming, and I think about the skills that I had when I graduated and sadly none of them would be relevant today. That some of the thinking that goes into being a good programmer, but all of the languages have changed, all of the architectures for computing systems have changed. And so, the half-life today of those skills is about two and a half years. Just staggering to think of that. And then layer on top of that the complexity of the threat environment today from under sea to outer space and everything in between, including cyberspace.

So, we really are seeing a threat complexity that is more significant than anything I remember.

MR. O'HANLON: I like your choice of the term "complexity" because I think it really gets at what I see as well and also conveys a certain, you know, soberness about the reality of today's world without bridging into fear mongering. You're not saying it's necessarily the most dangerous time or that we're on the cusp of great power war. Obviously, we have to worry about those possibilities. But I assume the word "complexity" was one you chose carefully. And if you were to try to sort of measure your anxiety level, looking at the risks from China, Russia, North Korea, Iran, elsewhere, and you were to compare that to different parts of your career, so getting beyond the complexity to the actual, you know, potential imminence of conflict, how do you rate today's world? If I could ask that before moving on.

MS. WARDEN: Mm-hmm, right. I joined the industry immediately following 9/11. And so just to put into context, there has not been a time in my life where I have felt less secure in my own home living outside of Washington, DC than I felt in that period of time. It was an awakening for me as a citizen, because I had not worked in the industry up until that point, and as a mother and thinking about the world that my children would grow up in. So, I don't feel that same sense of imminent danger as I sit here today.

But what I will say is I look 10 years into the future and the pace at which other nations are building up their arsenals, including nuclear weapons, it worries me that we are on the verge of finding ourselves in a very complicated, if not dangerous, world.

MR. O'HANLON: So, let me ask about allies and partners a little bit more.

You spend and your companies a fair amount of time working with others around the world and obviously this is one of the great strengths of the United States in strategic terms, that we have so many. Of course, a lot of our debate is also about why they can't do more and burden sharing. And President Trump wasn't the first one to raise those concerns, even if he did it with his own style. But you also see, I'm sure allies and partners as collaborators, as customers, as partners in the systems you're building and fielding. Have you noticed any trend lines that strike you looking over a 20-year career in the sector? And where do you see us going now? Are our allies and partners working with us more seamlessly, more begrudgingly, are some of the Europe-first efforts across the Atlantic, in your mind, causing some concern about the strength of the Transatlantic Alliance? Do you see Asia as more important than Europe for American industry? Any broad observations on how to work with allies and partners?

MS. WARDEN: Well, allies are incredibly important, and I say that from the U.S. vantage point, but I would say that from all of our allies' vantage point as well. Their willingness and desire to work with the U.S. and our other partners is also strong. So that foundation is there for us to work together.

There are some challenges in working together seamlessly. First and foremost, every nation is worried about providing jobs in this economy for their people. And so, as we think about the

work that we would do for allies, it can't be fully exported from the U.S. Some of those jobs need to be the benefit of the nations that we are supporting, the allies that we're working with.

The other thing that I see is the ability to trade information, share information openly. We all know that's the way of the future. And the co-development would be ideal, that we would be able to work with our allies and partners in a very seamless way. And we don't have the export regime to do that in this nation. And so, there are reforms under way that are I think really important as we think about how we will work with our allies in the future and how we will enable their needs to have sovereign capability and to interoperate with the U.S.

So, these are not insurmountable challenges, but they are ones that require us to think of it differently and to make some changes in the processes that we have around export

MR. O'HANLON: I know you work with allies around the world and partners around the world, do you — I mean do you think of them in terms of several different major categories, like European allies, East Asian allies, Middle East allies, and each one sort of has a regional flavor to it? Or don't you break things down quite that way?

MS. WARDEN: We operate regionally but we very much think of each nation separately. Just because a country is in a certain region doesn't mean that its interests are specific to the other countries in that region, nor are their operating norms all the same. And so, we very much think of — in the Asia region, for instance, Japan independently is — we would think about South Korea and partners in that region want to be viewed as individual partners with relations with U.S. companies and that also take into consideration the partners within that nation that they rely on to do business. And so, we have different partners in each of those nations as well.

MR. O'HANLON: Do you have any concerns that Europe is trying to become more autonomous? Of course, there's been a lot of this debate and some of it was stronger during the Trump years when he made it clear he wasn't all that happy about their level of relative contribution and President Macron of France talked about NATO being brain dead and then there were pushes for more European independent procurement authority. Has this made a measurable negative difference in how

you do business in Europe, or do you not see big effects? At least so far.

MS. WARDEN: We haven't seen big effects so far. And the announcement of Aukus I think is a step in the right direction, which says that Australia, the UK, and the U.S. will work together in an area that traditionally we would not have been as open sharing technology. In that case, nuclear submarines. What I see is a real willingness to work through the challenges of each nation doing their part, the desire to have local and sovereign content in weapons systems that are shared in their both development and production. And just a sense of knowledge that we need to work together, and that interoperability is the end objective.

Just some disagreements along the way and with different political parties as to how we get there. And I don't mean just the U.S. political parties, I mean other countries as well. And they're responding to their citizens and what they're demanding of the country at the time.

MR. O'HANLON: By the way, you mentioned jobs. And it makes me want to go back briefly to the question of the workforce at Northrop Grumman and think about the future workforce. And I just wondered, you know, there may be some students listening to this conversation, people thinking about what careers to choose. I wondered if there are any particular words of encouragement or advice you would give to those who are trying to figure out where modern high-tech America needs their skills. For example, engineers, scientists, but also welders, also, you know, experts on industrial production lines. Are there any areas where you see either gaps in how you're able to recruit today or the likelihood of needs in the future that we haven't yet quite grappled with in the United States and we're going to have to emphasize more? Any kind of broad views about where we need to shape the future American workforce?

MS. WARDEN: Certainly, I am a big advocate of STEM fields, science, technology, engineering, and math, because I see the demand for those skills growing in our country and in our company specifically. As I think about what disciplines, it's across the board. All forms of engineering, computer science, physics, math. So, it's really a broad spectrum of STEM fields that we see continuing to have application as we move forward.

I also will point out that the trades are incredibly important in the production of the systems that we build. And schools have moved away from having the trades as part of an option path in high schools. And so, we're big advocates of bringing that back to high schools and even partnering with community colleges to help students get trade skills and then pipeline directly into employment in our industry, and really, any manufacturing field.

But one of the beautiful things about the defense industry is that we hire American. So, these are great U.S. jobs that put people on a pathway to sustain a family. And we believe that that's a really important part of our economic engine, not just a desire to get people educated, but to give them a pathway and a career.

MR. O'HANLON: Yeah, just a quick editorial comment of my own, if you don't mind too much, which is that in our debate about whether to make community college free or not, which is a worthy debate, but I sometimes have been frustrated based on what I've learned from people like you about how we maybe should focus more on the content and quality of what's taught at community colleges, at least as much as on the price tag. Obviously, it needs to be affordable for people to go.

But these partnerships have been fascinating to see where they arise in certain places. And sometimes it is local governments plus local corporate interests working together to recognize that certain skills are needed and then sort of helping the curriculum improve in that community college.

So, thank you for making that point.

If I could turn to the overall state of defense industry today in the United States, I would just love to begin with a big picture question to you on its overall health as you see it today. I mean, you know, there are sort of forces pulling in different directions, as you know better than I. One the one hand the defense budget is relatively robust and higher than Cold War averages after adjusting for inflation. On the other hand, costs are greater, weapons are more sophisticated, the military is smaller. So, we're not building as many. Don't get economies of scale quite as easily. And obviously Congress tends to be quite late in passing budgets, which makes it harder to do longer-term planning.

So, with all that, and other factors as well that you may want to enumerate, how do you

see the overall health of the defense industrial base in the United States today?

MS. WARDEN: I still see the U.S. defense industrial base as the strongest in the world. But to the point you were just articulating, we can't assume that that will be the case going into the future. There are a few dynamics that are at play. One, China has increased their budget, basically doubling their budget on national security in the last 10 years, and it's growing on average 7 percent a year. So, to your point, we're not keeping up with inflation with U.S. defense budgets.

We also have an industry that does have to rely on annual appropriations process. Most of the time not done on time, and that introduces uncertainty that doesn't allow us to invest in the ways that we would like over long periods of time.

And certainly, workforce shortages in this country are ones that we have to address, as we were just talking about. Having the STEM but also the technicians that we need to be able to continue to innovate and stay ahead of the technology curve.

So, all of these are issues that are not foreign to the defense industry and me and my peers, but these are things that we have to work to address to just remain at parity with other nations, let alone to be able to work at speeds that are faster than and deliver capabilities that are greater than what other nations are able to produce for their governments.

MR. O'HANLON: So, I wanted to ask a little bit about — we've already touched on procurement, as well as research and development, sort of building the systems of today and tomorrow, but then also planning for the next generation. I wanted to ask a little bit about each of those separately if I could.

And on research and development, how do you feel about the way in which we now fund it in the Department of Defense? Because of course we've seen over the years that trends have gone in various directions, but you may not always find it as easy financially as the company to invest in next generation systems that may or may not pan out. But that kind of innovation, that kind of, you know, effort to experiment is crucial to the invention process.

Do you feel like the finances are reasonable for how you're able to do that? Because on

the one hand, you can't go off and make the kind of profit that iPhone does selling its products multiple times above actual costs. You're constrained by working largely for the government. On the other hand, you need some of that same ability to do research and development, unless we're going to assume the government is going to handle all that by itself.

So how is the state of financing for research and development in the United States today for future defense systems?

MS. WARDEN: So, the financing is in great shape, but no doubt that the amount the government is spending on R&D compared to what commercial industry is spending has decreased over time. And we are at a point where I believe it's dangerously low. If we want to be able to develop capabilities that are truly innovative, meaning they're not available on the commercial marketplace, that give our military intelligence and policy makers options that other nations don't have, or even individuals operating at adversarial means don't have, then we have to have something above commercial grade. And that's what our government has funded in the past and has enjoyed the benefits of.

So, we need to have a healthy R&D budget.

And then to your point, it has to be provided in a way that balances the risk and reward that comes with serving that very small customer base of the U.S. Government and our allies, because we can't spread those development costs over a much bigger market. We are reserving them for our customers' use. And what I have seen is as we shift too much risk onto industry, industry actually pulls back on R&D spending because the costs are too high for any one project. If we want the breadth of innovation and we want to be able to move forward and take risks — and as you said, that includes failure — it means that we have to count on some of those ideas that we are investing in will not generate results. Then, again, you need the financials on the ones that do to make sense for our investor community.

So, what I see is it's about the risk-reward balance. And moving too rapidly toward putting all that risk on the industrial base is not healthy for the industrial base and it doesn't deliver the capabilities that our customers desire.

MR. O'HANLON: So, is there any particular fix that you would recommend? I mean one of the things we have seen in the last few years, the late Senator McCain and former Chairman Thornberry and others worked hard on defense acquisition reform. And one of the things they did of course was to break up the Office of the Under Secretary of Acquisition Technology and Logistics and now we have an Under Secretary for Research and Engineering. Is that going to help? Or do you need different kinds of "colors of money" within the Pentagon budget that allow you to do more things as a company that are really just blue skying on innovation, or is it the amount of money?

I mean where does the fix need to happen if there is a problem today?

MS. WARDEN: I do believe in the value of having an Army organization that is focused on longer-term technology and ensuring that appropriate investment goes into those technologies. And so that's good progress.

The use of firm fixed price development contracts I think is very detrimental. It shifts too much risk too early in the life cycle and it discourages leaning far forward and taking the risk that you may fail and need to reset and move forward in a different direction. Plus, the government loses control over those decisions because they all get shifted to the industrial partner.

The other thing that I believe is really important in looking at reforms for our processes is how do we get longer-term commitment on certain technology vectors, meaning ensure that the research and development work that we're doing, if successful, does bridge into programs of record and operations. And so that's where the separation of R&E and acquisition and sustainment is going to mean they work very closely together so that we don't have things die on the vine in the research phase, even if they've proven their effectiveness.

MR. O'HANLON: Now, you've also worked in other corporate settings, for example, General Electric, I think, where you — and within Northrop itself you've also built commercial systems, not just defense systems. And so, I should probably ask a question that probably is on the mind of some people watching, because some people are more skeptics of the broader Department of Defense and the defense industrial base, and they remember $600 hammers from the Reagan build up and things like

that. How do you assess the state of inefficiency, and even waste, within the defense sector today? And are there efforts that you make to try to further reduce that, even if you think there has been progress? I'm not suggesting it was every horrible, but clearly, we've had waste and clearly in periods of increased defense budgets in the past at least, there have been times where there were things that went awry.

How do you, from a corporate perspective, manage that problem or speak to that problem?

MS. WARDEN: We drive efficiency into everything that we do inside the company. And so, what that helps to do is create a culture that is consistent with the objectives of the taxpayer. And ultimately the government buys, but on the behalf of the taxpayer. And we inside this organization remind our employees that that's who we're working for at the end of the day, and we need to be diligent with those resources.

I think if you set the tone in terms of what you value within the organization — and it's not just financial, its values, like we do the right thing, we commit to the collective success. Those are two Northrop Grumman values. They seem really simple. And we only have four by the way. But they guide our people to think about how is it that we ultimately want to be viewed. What is the core of our reputation in the long run? And then what decisions do we need to make today.

So, we wouldn't develop a $600 hammer. And the reason for that is we care about the use of government funds in a way that's responsible and we want to make sure that we do it as efficiently as possible.

Now, you ask what is it that keeps us from doing that as efficiently as we would like, and sometimes it's the layering of government bureaucracy on top of the process. People checking other people's work. And we guard against that too much inside the company. There's a healthy amount of that that ensure product quality, safety, reliability. It's essential. We have to do that. But then there's a level of it that's checking the checkers and becomes a compliance driven set of objectives. We try to drive that out, right. We want to look at what's adding value in the process but eliminate the steps that aren't adding value and could be substituted with trust. Contractual relationships, other ways to ensure

that we don't have the bad behavior that you discussed.

MR. O'HANLON: I want to ask you if I could two questions. One about the large prime contractors, Northrop being obviously one of the great jewels of the country, but then also new entrants into the defense industrial space and what we should be doing about that, if anything.

So, in terms of the big players and consolidation, do you feel like defense industry in the United States today is sort of about the right size in terms of the number of major players? Or do you think there's further room for consolidation. You were instrumental in the acquisition of orbital ATK, for example, by Northrop. And I think in most technology areas we still probably have two producers, but not all. For example, you folks are dominating the bomber space. And so, there are times where we may already have gotten too small, one could argue from the point of view of competition. I wonder how you see today the state of the defense sector and whether consolidation has gone far enough, whether we should be trying to break up firms, whether we should be looking for new opportunities to further consolidate, or are we about at the right point, in broad terms?

MS. WARDEN: What I think is far less important that what the U.S. Government thinks. And what I see is a belief that in many areas we are either at the right number of industrial base participants or even a little light. So I don't see a lot more consolidation, particularly not at the top tier or even at what I would call the middle tier of companies. There will always be some level of consolidation of smaller companies. That's healthy. It helps those organizations to be well capitalized and being able to take their ideas and scale to the next level.

And so, I believe that will continue to happen. As long as that happens at a pace similar to new companies coming into the industry, that's good in my view and that's what I see today.

So, we're probably at a healthy place as we sit here today.

MR. O'HANLON: So how do you feel about getting more new entrants in? And, you know, I've been to a million conferences, and I'm sure you have too, where it's — you know, we say we've got this great Silicon Valley, you know, on the commercial side and if we could only harness some of their genius and bring them into the defense world. Of course, to some extent, you obviously do.

You're using a lot of electronics and software in all of your systems. But people are sometimes suggesting well, if we could have, you know, communication devices that were less focused on stringent regulation and all that goes along with government contracting and could be flexible — like Steve Jobs used to make phones at Apple — we'd be better off.

Is there anything to that debate or have we really — is it sort of a false premise that we can somehow bring Silicon Valley more into the defense world? I mean some of our systems have to be more resilient and different, right? They have to be able to survive battlefield effects, maybe even nuclear effects.

So, I just wondered how you thought about this whole debate about trying to encourage more non-defense companies that are cutting edge in their own sectors into the defense space.

MS. WARDEN: Look, I think it's healthy to create a path for commercial companies to do business with the U.S. government. I also believe that often times that path is through a partner that understands mission and understands the broad set of requirements that that technology might fit nicely into but wouldn't be economical for that business to build in those additional requirements, like security or hardening against nuclear effects. Those kinds of these are expertise that is built in the industry and probably not worth replicating because there's no commercial application for them.

But at the same time, what I would say is that this has been a question for many decades. This is not a new question. Commercial aircraft and is there an application of them for defense. Yes. Commercial satellite broadband, is there an application and can the U.S. government use it for certain things? Yes. Computing. You know, I came out of the commercial industry and worked in commercial computing. Is there an application? Yes. But does that mean that the defense industrial base no longer has a role in taking those technologies, building them into weapons systems that are superior to operate in a complex threat environment that only the U.S. government and our allies would need to operate in? Probably not. The economics aren't there for those commercial companies to want to replicate that expertise.

So, I don't see it as an either/or, but I know that many times over the past 100 years it's

been talked about as an either/or. And I think it's healthiest when we talk about it as an and. How do we complement the commercial investment with the defense expertise, and vice versa?

MR. O'HANLON: So that leads me to a question about cyber because this has always struck me as an area where people will say, of course we want to harness what Bill Gates does or what Steve Jobs does. On the other hand, those companies have been successful by building systems that sometimes have a lot of software flaws and vulnerabilities. And doing it quickly enough that they're always sort of fixing and then preparing the next iteration fast enough to make themselves a lot of money by delivering more capability, but also along the way you've still got these bugs and these problems in your software.

There was a Defense Science Board study — you probably know it too — that came out a few years ago. It was on cybersecurity in the defense sector. And it basically said, if anything, we've gone too far in putting windows into all of our systems in the military because now they have the same vulnerabilities that the rest of us do on our home computers. And the study concluded, I know somewhat controversially, by suggesting that there was no American defense system that we could fully vouch for in terms of its cyber resilience.

So, I don't necessarily need to ask you to comment on that study unless you want to, but I would be curious for your sense of our cyber resilience across the Department of Defense, and whether we have in fact built in too many Achilles Heels, partly by trying too hard to use commercial software.

MS. WARDEN: Well, we certainly have seized an opportunity, used commercial software, and expect that the security be built in. But at the end of the day, there is risk in that approach, as you pointed out. And I think there always will be because the tolerance, the risk threshold for a customer like me to operate through those security vulnerabilities is different than for the U.S. government. And unless we change that desire to have systems that are going to have higher reliability, that are going to have higher security then we would not get to a point where you'd want everything to be running on commercial technology over commercial broadband. It's just not the way the U.S. Government can think about operating in a contested environment. It might be fine for peacetime, but if

you get into conflict and those systems have those vulnerabilities and you are no longer able to rely on them, it's the time you need them the most.

And so those are things that need to be considered in a resilient architecture. And it doesn't mean there's no place for commercial technology, but it does likely mean that there is absolutely capability that is not reliant on that commercial technology.

MR. O'HANLON: When you look across the different domains of warfare and, you know, we've heard a number of the latest Pentagon buzzwords and initiatives on this front, so there's multi-domain operations and now there's joint all domain command and control. And Secretary Austin is thinking about integrated deterrence across many domains, some military, some not. Do you feel that there are other areas besides cyber we need to be especially concerned about in terms of our current vulnerabilities?

I mean my former colleague at Brookings, now in the Administration, Frank Rose, talked about undersea cables a lot. Obviously, space architecture. And with space — I know it's a leading question, but you've got a lot of thoughts. Let me just conclude therefor by saying, on space specifically, do you feel better that as we've gone to more constellations of smaller satellites in the commercial and defense sectors that we're now becoming a little more resilient, not depending quite as much on the big, you know, billion dollar sitting ducks? Or do you think that undersea cable or space or some other part of our defense posture is particularly vulnerable today and in need of redress?

MS. WARDEN: Well, space was certainly the first that came to mind and only because the systems that have been built over the last couple of decades were never built to be resilient. They just based on where they were, and their methods of operating were viewed to already be safe. And so, we have to go through a re-architecting of space in order to build resiliency in. That makes sense because many of the missions we're now able to do from space we can do much more capably based on today's technology than we could when those systems were fielded in the past. So, it's not like we're re-architecting simply for resiliency. There also is a tremendous amount of more capability that we're adding as we recapitalize.

But at the end of the day, I think space will continue to evolve. So, what works for resiliency is going to be dependent upon what the threat environment is, what other nations are capable of doing in space, what we desire to have in peacetime and in periods of conflict. And that gets to architecture that makes sense. I don't think everything will be proliferated LEO for instance, where you only have satellites in low earth orbit, because at the end of the day those are inherently less resilient just based on the distance and the number of adversaries who might be able to remove those satellites from operation. No matter how m any you have, if you have an adversary capable of taking them out, they're no longer there.

And so, my view is the architecture should follow both the threat environment first and foremost, but also the capabilities that one sees as necessary in their concept of operations in a high-end conflict. And that will lead us to the right architecture. My belief is it's going to be a combination of highly valued assets and proliferated LEO as well.

MR. O'HANLON: By the way, this is such a fascinating topic because — especially those of us who live mostly in the unclassified world and sort of seeing it evolving on the inside in snippets, something changed pretty big in the last 10 years, didn't it? I mean because certainly when I entered the field, and even when you did, we were assuming that space was largely a sanctuary. And I don't think people think that way anymore.

MS. WARDEN: Not at all.

MR. O'HANLON: Yeah. And that probably is a development that more or less coincides with the return to great power competition in the last decade.

MS. WARDEN: That's right. That's right. And countries defining that intent to be able to operate in space, but also demonstrating their ability to do so.

MR. O'HANLON: Is it primarily just the big two, or are there are number of players, would you say?

MS. WARDEN: It's primarily the big two, but when you think about who would have been on that list 10, 15 years ago, right, not even the two. So, if we keep seeing nations investing and building

intent to be able to operate in all domains, I am quite confident that we're going to be talking about even more nations with that capability a decade from now, which is why we have to think toward that potential future, not just operate with requirements in mind of who is able to do it today.

MR. O'HANLON: So, I have a little bit of a delicate question because I don't want to ask you to speak critically of your main customer, but I am interested, as all of us in the defense space, about the way in which the military services — and the congress — but prioritize certain kinds of systems. And there tends to be, to use a relatively kind word, inertia, in breaking out of the mold of what we prioritized historically. And we know that there are cultures within each military service that prioritize fighter jets or aircraft carriers, or tanks or what have you.

And sort of make the question practical and not just ask you to answer the unanswerable, is there — do you sense enough churn in our debate that maybe goes back to the end of the Obama Administration, the third offset concept, and then through the Mattis period and Mark Esper, and now in the Austin period where we're at least getting a little bit less wedded to our old ways of thinking because we sense the need to do so and we see the challenge and complexity of the environment? Or do you still feel like there's just a little bit too much tradition and, you know, commitment to the same old, same old within the five-sided building today?

MS. WARDEN: Well, there certainly is inertia and commitment to programs that have in some ways run their useful course. But I do see more willingness by the services today to recognize those and go forward with a plan to phase them out over time. And I mean even more quickly than what we would have seen in the past. So that's definitely a step in the right direction because we've got to free up those dollars for modernization.

If we don't have capability, you can have quantity that is still not very useful. And we need to in my view stop measuring force structure just on the number of certain assets but look at what are those assets then capable of doing. And if they aren't going to be capable and relevant in a high-end conflict, and we think that's where we might be over the next couple of decades, then we need to make decisions based on that.

I will say that the Congress has this year through a very bipartisan approach looked at plus ups, but also supporting service reductions in ways that I have not seen in the past. I believe we've got a lot more work to do to get aligned between the services and Congress to make these important decisions and to affect them in a timely manner, but there does appear to be less inertia in the system than there has been in the past.

MR. O'HANLON: So, let me, at further risk of asking a slightly, you know, delicate question, ask about a couple of specific systems. And I have had the pleasure of interviewing the always entertaining Chairman Smith a couple of times, who of course can be very colorful in his depictions of the F-35 program. And you folks are a major player in that program, even if Lockheed is sort of the lead player. And I wonder how you feel about the F-35 these days. I mean the trend lines on costs are certainly in a very encouraging direction. But when you look at the whole system, and you wonder about the numbers of whether we should be buying 2450 or so for the U.S. military, is there a debate that maybe we should buy fewer D-35s and maybe more B-21s or maybe fewer surface ships and more unmanned underwater vessels that have various kinds of deployable sensors? Is there anything that you would want to say about any of these specific programs either in terms of how they're going or where they may still be either over valued or undervalued?

So, I threw a lot in there so you could pick and choose what you most want to touch on.

MS. WARDEN: Yeah. Well, you asked specifically about the F-35. We're a proud partner. It is a fabulous fighter. The user feedback has been extraordinary about what the aircraft is capable of doing and it clearly fits a need.

To your question about should we buy more of this and less of that or more of that and less of this, it really comes down to what do we need to be able to accomplish in the future. And one of the reasons the B-21 is an important platform, and the Air Force is talking about even buying more of them is because it is a penetrating aircraft. And so that's a very different mission set than when we talk about other aircraft. And it's built for that purpose. We are certainly focused on delivering that program on cost and on schedule. And we're really proud actually. Chairman Smith has said some nice things

about that program and so I'd rather focus on that --

MR. O'HANLON: Yes, he has.

MS. WARDEN: -- and what he has said. But, you know, he says we're doing that program in intelligent ways. And to me that's a compliment not just on what we're building, but the process of us working with the government to stay on cost and schedule. Really important because if you can't do that, it crowds out how many of anything you can buy. So, I think the entire industry needs to be focused on delivering on our commitments. It not only improves the credibility of the industry that has Congress more confidence to give us the taxpayer dollars on their behalf, but it also means that we're able to reliably predict what we will be able to do on programs and when we can deliver on those quantities for the same amount of money that we said we would every program gets to thrive. But if we have programs with major cost overruns that are taking money away from others, then important decisions have to be made, but nobody gets what they actually deserve. The Congress, the taxpayer, the government, and certainly not the industry.

MR. O'HANLON: I wanted to, as we start to get near the end of this conversation — it has touched on so much and thank you for all of your insights — I wanted to ask about any observations you would have on the state of our military planning today and the so called 4+1, 2+3 frameworks. I think most of our viewers today are probably defense specialists, but just for those who may not know these buzzwords as much, let me just remind folks that, as we well know, after the Cold War, the United States settled on sort of this two regional war construct as the main way to generate some answers about how much was enough for force structure. And of course, Operation Desert Storm happened at about that same moment, so that created a little bit of a model and we wound up fighting protracted, if somewhat different kinds of conflicts, in Iraq and Afghanistan for 20 years.

But about 10 years ago we started realizing we weren't paying enough attention to China and Russia and so General Dunford, when he was chairman, talked about the so called 4+1. And instead of just thinking about Iraq, North Korea, countries like that, that we should think about Russia and China, North Korea, and Iran, and then terrorism, transnational extremism. And then the Mattis National

Defense Strategy took that and modified it somewhat and sort of talked about a 2+3 and they talked about great power competition, Russia, and China. But they took the same five threats and just sort of slightly re-prioritized and turned the pyramid upside down. And that's where we stand today with the Trump National Security Strategy under General McMaster talking about this great power competition.

Now, the Biden team is trying to modify, tweak some of that, perhaps maybe change it fundamentally. Any advice you would offer to them from a defense industry point of view as to how those previous constructs have helped you or impeded you or catalyzed you to do things you might not have. And any new ideas that you think should be part of the mix today.

MS. WARDEN: It certainly helps industry to have a clear national defense strategy that lays out priorities, ones that we can align behind and think about how to best address. And so, I just support fully the reassessment of the threat environment as the starting point for then a review of the National Defense Strategy and the elements underneath of it. What I do see is that China continues to build up their capabilities across a very wide spectrum and we have to be mindful of that while at the same time recognizing, as the DNI recently said, that Russia will remain in the near-term the pacing threat, having the greatest capability in weapons of mass destruction. And so that argues for the two as a focus point.

And then I think how we prioritize resources beyond those two pacing threats is the question for this Administration, recognizing that we can't be all things to all people across the globe and we need some level of prioritization. I think what defense industry can do is ensure that we're building systems that are adaptable, so as the threat evolves, we don't have to throw out a current system and build a whole new one, but that we can make them more adaptable and that we are leveraging technology in connectivity, computing, command, and control. So, it's not all about new platforms, it's also about how those platforms work together interoperate, share information for greater effect.

And I know that the defense industry is moving in the direction to provide those options so that we cannot just think about traditional ways of building force structure and projecting power, which ultimately is the end goal to keep peace, but that we can also give them some new options in order to

meet those goals with less resources.

MR. O'HANLON: And do you feel that —– and this comes back a little bit full circle to where we began, talking about the international environment and your choice of the term "complexity" to describe it, and obviously potentially dangerous as well —– but if I could just sort of start to wrap this up on almost a more philosophical note, do you feel that if we do these things well, that this can still be a very positive promising period for the United States and for its allies in the sense that we still have a lot of strengths. I think I've heard you enumerate a lot of them. And we talk a lot about our failings and our problems as a country. We're obviously struggling to come up with compromise in Washington and many other parts of the country, but I think I hear a somewhat hopeful message from you as well.

And I just wondered, even though I realize your main job is to build good technology and let the Department of Defense operate it and build it into foreign policy for the United States, do you sort of have a gut sense that if we do what we're capable of doing that we can probably manage China's rise and deter China and Russia along the way and keep the peace or, you know, again, at the risk of repeating, do you sort of feel more of an anxiety of that? That somehow war is likely, and the question is how do we mitigate the damage from what some people think is more likely than not. You see what I'm getting at?

MS. WARDEN: I do. I am an optimist. I believe in this country and the capability of its people even more so than what technology can offer, what policies will define. I have seen the resiliency of the American people and I do believe that we will rise to the occasion, whatever is required. And at the same time, I do believe in the strengths of this country, its diversity, its entrepreneurship, it's desire to defend freedom. And it's really important that we remember that's the purpose of this nation. It was built because people wanted to come to a country where their freedoms would be preserved. And as long as that's at our core, the mission that we as a nation are defining these capabilities around, preserving the peace, deterring conflict, and protecting people's human rights, I think that it rallies human nature to say we will be successful because we must be successful.

And so, I truly do believe in the power of the people in our country. And the ones who

work in our industry are a phenomenal example of being committed not only to that mission of national security and preserving freedom, but also doing the right thing.

MR. O'HANLON: You know, that's a fantastic answer. And even though we have five minutes to go I'm tempted to stop there because I'm not sure I can ask a question that gets a better answer than that. That was quite inspiring.

But let me just, in the interest of getting you to speak on one last subject if I could, some of the new technologies. And I'm just going to sort of trot out the usual, you know, Washington list of the hot new technologies and see if you want to comment on any one of them where you see particular opportunity, or maybe you want to tell us to just take the enthusiasm down a half notch. Because we hear a lot about artificial intelligence, almost as if advanced algorithms are just now becoming available. And you're a computer scientist from, you know, a couple of decades ago and remember this has been a pretty exciting field throughout your and my career. We hear sometimes about quantum computing, which to me still feels pretty far away, but I'd be curious for your thoughts if you want to touch on that.

Another issue is directed energy missile defense and whether that's ever going to really become a meaningful way to protect bases or our country at a time when the threat is becoming so much more potent and accurate. And I'm a skeptic that directed energy missile defense is going to make a major difference in the offense-defense balance, let's say in the next one or two decades. But maybe you feel differently.

So, with those and any other areas that are especially exciting to you, maybe I'll make that my last question to ask you to talk a little bit about technology opportunity and where you see the most exciting possibility or perhaps a debate that's gotten a little ahead of where the technology really can deliver anytime soon.

MS. WARDEN: Well, all three of the areas you mentioned, artificial intelligence, quantum computing, and directed energy, are ones we're investing in. So clearly, I see potential.

Now, to your point, are we going to identify applications that are game changing tomorrow? No. Are we going to though miss a real opportunity if we ignore any one of those technology

vectors? Yes. And so that's why we need to be looking at all of them.

You know, artificial intelligence, to your point, we have been using machine learning and artificial intelligence for decades. This is not new technology. I think the view is that it will be in ways game changing now that it couldn't be before largely because of the compute packaging. The fact that you can do more computing in smaller size weight and power packaging than you could in the past, and so you can bring that artificial intelligence to the end where it's most needed in the Department of Defense to make real time or rapid decisions that before were not possible.

So that has absolute potential in how we apply the technology, but it's not so much that the technology has advanced to a new state, it's our ability to use it.

I would say with quantum, yes, it's a little further out, but we're doing investment there with partners. We are on Wednesday going to be announcing our investment alongside Virginia Tech's innovation campus in a quantum computing lab. And this really is about the fact that that technology, while it may be a way out, will completely change the way we do everything, the radars we build, the processing back ends, the way we think about aircraft vehicle management, all can change with the more enhanced computing power of a quantum computer versus more traditional CMOS based computing.

So, these are important technologies for us to be working in. One thing that Northrop Grumman has always prided ourselves in is that we do look to the next generation of technology. We stay on that leading edge. It's why so much of our work is classified. We view that as the crown jewels that the U.S. Government wants to protect and keep for itself. And so, we have to stay on that front end and will continue to invest in all of those technologies as well as a few others.

MR. O'HANLON: And with hypersonic missiles and missile defense efforts, do you tend to agree with me that it's going to be — we can mitigate the threat of offensive missiles, but the offense is probably going to have the edge for quite some time to come?

MS. WARDEN: Yes, we certainly need to be investing in the defensive applications to be able to track those weapons and be able to intercept them. But we also need to invest in the capability for ourselves because you can't have an effective deterrent if you're only defending.

MR. O'HANLON: Kathy Warden, it's been a great privilege. Thank you so much for what you do here and your whole company and the opportunity to talk today.

MS. WARDEN: Thank you, Mike. Appreciate it.

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