Aerospace Advantage – Ep. 192 – Want to Win? You'll Need Digital Engineering – July 13, 2024

Heather "Lucky" Penney: [00:00:00] Welcome to the Aerospace Advantage Podcast, brought to you by PenFed. I'm your host, Heather "Lucky" Penney. Here on the Aerospace Advantage, we speak with leaders in the DOD, industry, and other subject matter experts to explore the intersection of strategy, operational concepts, technology, and policy when it comes to air and space power.

So, if you like learning about aerospace power, you're in the right place. To our regular listeners, welcome back. And if it's your first time here, thank you so much for joining us. As a reminder, if you like what you're hearing today, do us a favor and follow our show. Please give us a "like" and leave a comment so that we can keep charting the trajectories that matter the most to you.

Today, the speed and complexity of modern warfare is increasing at an unprecedented pace. To maintain our competitive edge, the Department of Defense must be able to rapidly develop, field, and sustain advanced capabilities. However, traditional engineering practices and acquisition processes are struggling to keep up with this pace of change.

We know what [00:01:00] kind of capabilities we need, but we just can't seem to get them to the warfighter in a timely fashion. Consider that, in the 1950s, the Air Force could field, on average, a new aircraft from a contract signature to initial operation in five to seven years. Today, that timeframe can easily extend to 15.

Yes, major weapon systems are far more complicated today than they were in the 1950s, but the need for speed and development and fielding remains even more urgent. Especially today, when the Air Force is the oldest and the smallest that it has ever been. Getting our warfighter the capabilities they need and the quantities they need is a moral imperative.

That's where digital engineering comes in. Digital engineering represents a paradigm shift in how we approach the entire life cycle of defense systems. Engineers have been using computer aided design and modeling programs, what you may have heard as CAD CAM, since the 1990s. But today's IT infrastructure and processing is completely changing not just how we engineer weapon systems, but how we manage [00:02:00] that engineering.

Here's what changed. In the 1990s, an engineer could work on a design using CAD CAM, but this data was only available on his or her hard drive, or maybe a building's local area network. This drove time into collaboration and review, and could result in problems with integration and version control. But today those models can be stored in the cloud and they're available to everyone by high speed, secure, high bandwidth networks.

This has the potential to streamline, de-risk and accelerate very nearly everything about the design process. And it can have a big payoff throughout the life cycle of a system from production to sustainment and to training. But what exactly is digital engineering? How has it evolved from traditional engineering practices? What are the key technologies enabling this transformation? And what challenges must be overcome to fully realize its potential.

To help us answer these questions, we have two very accomplished guests joining us today. First, we have Brian Morra. Brian's 40 year career has included time both [00:03:00] inside the government, and military, and working in industry. He spent a combined 15 years in active and reserve duty in the US Air Force as an intelligence officer, with assignments at the Pentagon, and he's held senior executive roles at major defense contractors like Northrop Grumman and General Dynamics.

Brian partnered with me on a recently released paper here at the Mitchell Institute, where we found the digital engineering has the potential to accelerate the design, development, and delivery of capabilities to the warfighter. Without the need for acquisition reform. And we'll make sure that the link is in the show notes.

We're also pleased to have Dr. Amanda Bullock from the Air Force Research Laboratory. Dr. Bullock is the AI lead at the Air Force Research Lab, and a lot of her work is focused on how to leverage the power of artificial intelligence and machine learning to even further improve digital engineering processes.

From modeling and simulation, to knowledge management, and intelligent automation of design tasks. Brian, Dr. Bullock, thank you so much for making time for this conversation.

Brian Morra: Thank you for inviting me. Happy to be [00:04:00] here.

Dr. Amanda Bullock: Yeah, I'm really honored to be here. I look forward to this conversation.

Heather "Lucky" Penney: Me too. So Brian, let's start from the beginning because your experience with digital engineering goes far back. So you have a lot of knowledge and expertise and some history that can help describe for our listeners what the traditional engineering processes looked like for complex defense systems before the creation of these digital tools.

So would you walk us through those key stages of the life-cycle, from requirements creation to operation?

Brian Morra: Well, I think the major distinction between the traditional way of doing things and digital engineering is, can be summarized in one word, paper.

Heather "Lucky" Penney: There you go.

Brian Morra: Lots of paper. Paper in requirements, documentation, paper in early design ideas, paper throughout the process, including all the way to the way that we logistically support weapon systems and so on and so forth. So paper, paper, [00:05:00] paper. A lot of also physical prototypes. Prototypes that were developed, some of our listeners may remember words like "brass board" and things like that, that were, initial ideas about how a system, whether it's a subsystem or a full up system, might be realized in the physical domain.

So, another watchword would be "physical." Lots of physical models, lots of stuff that you could put your hands on. And that was replete throughout the entire life-cycle as well. So, a major distinction with digital, as the name implies, is that much of what was physical, either in paper or in brass board models, is now instantiated into the digital domain. Digital records, digital models, many of you've probably heard the term "digital twins," for example. So lots of paper, lots of physical. Lots [00:06:00] of stuff that you could put your hands on was the traditional way of doing business.

Heather "Lucky" Penney: So, let's talk a little bit about why the physical and the paperwork, created friction in the design and the development process.

I mean, that could cause teams to to desynchronize their efforts. It could cause a lot of rework. So, could you explain a little bit why that was such a barrier to speed and quality?

Brian Morra: Yes. Very difficult to share, information in the physical domain. Very difficult to share models in the physical domain.

People had to travel. They had to go see things. They had to actually be in a laboratory, seeing how a prototype was being developed and so forth. Not that there's anything wrong with that, but it does slow things down. And things were very compartmentalized and an example, one of the reasons I should say that the internet came about, the original [00:07:00] version of that was the ARPANET, that was built at DARPA. For the purpose of really linking together national laboratories, research and design elements, throughout, not only the Department of Defense, but DOE and, other agencies.

And what that did for the first time was enable people to operate in a virtual environment, even if it was just via email and other tools like that, at least they could share information, through the internet rather than in a physical way.

Dr. Amanda Bullock: I would be remiss if I didn't point out also that AFRL, Air Force Research Laboratory, Rome Labs, had a hand in creating the ARPANET too.

Heather "Lucky" Penney: Okay. Yay, Rome.

Brian Morra: Yeah, that's true.

Heather "Lucky" Penney: You guys get the great shout out there. And we can also think of ARPANET and the ability to share information at that stage is really kind of being digitized, because in many ways it was just a digital representation of the paper artifact. So, there was still a lack [00:08:00] of interchange and interoperability and the ability of different teams to be able to manipulate the artifact itself.

So, you had configuration control issues. And when we think about the physical elements of that, we also had a lot of discovery that was going on because we didn't have the ability to model or anticipate. So, you could even have, as a result of the paper friction and the physical artifact, you could have parts and pieces like a main fuel pump that had been redesigned, but because it was redesigned, if the configuration wasn't appropriate or they had different paperwork, it might not fit onto the engine.

Dr. Amanda Bullock: Yeah, that's absolutely right. We went through a phase where we had a lot of physical stuff and then we moved to paper digital as I would say. It's not actually interactive type of digital thing. So, now we're starting to move towards that really three dimensional CAD CAM, MBSE, Model Based [00:09:00] Systems Engineering, methods and approaches. And that's really helping our digital engineering processes and approaches in the Air Force.

Heather "Lucky" Penney: Now, CAD CAM was originally developed by Northrop. And Brian, you were there at the leading edges when a lot of these digital tools that moved us away from a digitized paper version, like a PDF, into actual software model based systems engineering.

Can you explain some of that?

Brian Morra: Yeah, that's exactly right, Heather. And I think the B 2 program is really a great example of an early adopter for CAD CAM techniques and tools. B 2 was designed using a variety of proprietary CAD CAM tools that were developed just for the program. The program itself, as you can imagine, was highly secure.

It was a compartmentalized program itself, special access program, and so it was very difficult to share. [00:10:00] Even though we were creating these digital models, it was very difficult to share them even within the program. Because of compartmentation and because of different folks in the supply chain were developing their own CAD CAM models and they couldn't share them because of security concerns and because there wasn't the kind of backbone, that would enable secure transfer of these tools.

So, in many ways it's a great example of an early program adopting this, these techniques, but it also did point up some of the limitations, that were due to the infrastructure at the time. The infrastructure at the time was not really suitable to sharing and allowing people to collaborate.

Heather "Lucky" Penney: So, even though an engineer might have an advanced tool, a CAD CAM, computer aided design, computer aided modeling, on his desktop, because that's what we had back then, not laptops. It might be connected via a local area network, a LAN throughout that one [00:11:00] building, but he didn't have the ability to share that maybe across the country or even globally, because that sort of infrastructure simply wasn't there. And certainly not the secure elements of that infrastructure.

Brian Morra: Yeah, that's exactly right. In fact, they had a hard time sharing them even within the building, because of compartmentation, because there were so many Individual SAP programs within the overall program. It was tough to share across any kind of a local area net. Not impossible in some cases, but it was tough. But yeah, you're right, and sharing beyond the local geography was virtually impossible. People just had to go travel to the other distant location and work within the SCIF that was located there.

Heather "Lucky" Penney: Hardcore sneaker net. They certainly didn't have the bandwidth either. Amanda?

Dr. Amanda Bullock: Yeah. Even as, little as I think three or four years ago in AFRL, we really struggled with that with our data. We collaborate a lot with external [00:12:00] people, academia, industry, even sometimes foreign governments. And the only way that we could do that was through snail mailing hard drives or even worse, having someone travel to the site with the hard drive.

And so we had like a really ingenious solution from one of our engineers. And he decided he was sick of that and so he contacted Google and set up a Google pilot and we were the first one in the DOD to really set up a Google workspace. So, that we can collaborate with our external users in a seamless fashion and still be secure in an IO 5 CUI environment.

Heather "Lucky" Penney: That's amazing. But we didn't have that back then in the 90s, in the early 2000s. So, Brian how did we advance past this stage?

Brian Morra: Well, as the Internet began to mature, as you say, in the 90s and in the first decade of this century, the infrastructure began to be there to enable greater collaboration, but it was still very, [00:13:00] very difficult.

I think that one of the key evolutionary steps and it's already been mentioned is model based system engineering. Which really began to take root, I think, in the early 2000s and it, you can think of that as, it's a natural evolution, an important major step, but a natural evolution from CAD CAM, that we were using in back in the eighties. So, the whole philosophy really, not just the tool set, but the philosophy around model based system engineering, began to take root in the early 2000s and began in industry and in government to become kind of a standard and table stakes really for being selected for major program development. As I think people both in government and industry became more comfortable with it, it was the next big evolutionary step leading toward what we now think of digital engineering and digital ecosystem.

Heather "Lucky" Penney: [00:14:00] So Brian, what is model based systems engineering for folks that aren't engineers, how do they differentiate from what it was prior to MBSE?

Brian Morra: Well, MBSE, one of the key attributes of it is tools. Is tools to enable one to really build what we call digital twins today. They weren't called that then, but in effect, a model of a component, model of a subsystem, model of a system, et cetera, et cetera. And to be able to visualize the entire system. Which is really getting at the system engineering piece of it. So, highly visual, it kind of went hand in hand with some of the modern software development tools that were being adopted in the early 2000s as well, which were object oriented. They weren't FORTRAN, they weren't these old languages.

So, the combination, I think, of object oriented software development coupled with the development of [00:15:00] models really created an environment for model based system engineering that was a big leap forward from what had been done before and an important precursor again to digital engineering.

Heather "Lucky" Penney: So did model based systems engineering, did that change the processes of engineering or was it simply just the tools?

Brian Morra: Yeah, that's a really good question. It was primarily tools, but I think that of necessity, it did begin to change processes. I think it began to change the way people thought about system architecture and the way that you would develop subsystems within an architecture. In a more coherent way.

And it also, we talked about collaboration earlier and model based system engineering also, lent itself to greater collaboration. And as I said at the outset of the program, paper, paper, [00:16:00] paper, you're out of a paper kind of environment. And it's much easier to share and collaborate when people have the same model based system engineering environment and the same toolkit that they're operating in.

It certainly made, from a process standpoint, if you include object oriented software development, it's certainly made software development much easier and much faster and a much more collaborative kind of practice. So I think that, yeah, it did have reverberations throughout the way we did business.

Heather "Lucky" Penney: So, you mentioned sharing, and I'd like to dig on that a little bit more because I think it's a really important piece to understand how model based systems engineering began to enable better sharing and integration, but you had to have tools that were interoperable, that, that could interface.

So, were these software tools that engineers and teams were using, were they largely proprietary for the companies? How did they integrate and how did that flow down through their sub tier suppliers?

Brian Morra: Yeah, it was a [00:17:00] combination, I'd say, of proprietary tools and commercial COTS tools. And there were, in the 2000s especially, COTS tools for model based system engineering became reasonably ubiquitous, I would say, and they really enabled you to have, throughout the supply chain, people with similar tools. Now, it is true that some suppliers, some of the smaller companies, might not be able to afford the tools and that could be an issue, but it certainly did lend itself to greater collaboration.

Dr. Amanda Bullock: Yeah, I think even in the last decade, we are seeing a really big shift from 10 years ago to now with companies who want to work with the government. We've made it very clear to them that we will not have siloed platforms. There's kind of the big three that work in the cloud space. And all of them understand that we don't want our data in one [00:18:00] space. We want to be able to move it seamlessly without paying for it again. It's our data. We don't want to pay to move it. So, we're really seeing that. And we're also seeing small businesses willing to collaborate with other ones, large businesses willing to collaborate with small businesses. And I think that's really part of the MBSE movement has really helped with that.

Heather "Lucky" Penney: Data is going to be a huge piece of our conversation, not just today, but for anybody going forward in the future. But Amanda, I'm really glad you mentioned the cloud, because I think that's one of the things that has enabled us to transform from MBSE, model based systems engineering into a fully fledged digital engineering. Brian, would you like to speak a little bit more about the enablers that have really expanded this kind of growth?

Brian Morra: Yes. And you're spot on there. It really, the infrastructure is key. We talked earlier, in an earlier era where the burgeoning in internet and intranets enabled people to collaborate even if it was not very sophisticated [00:19:00] collaboration. It was still better than what had been there before. Digital engineering environments though are characterized by a number of features that were not available even 10 years ago. And I think you made a great point about how things have really improved significantly in 10 years. So, what are some of the key elements of that infrastructure?

Well, one is high performance computing and high performance computing is now much more widely available than it was here before many of us, me included, remember the days when there might be one crate computer somewhere, and it was really difficult to program and so on and so forth. And people had limited access to it. Now we have a really incredible compute power. That is relatively ubiquitous, so that's one key element.

Another has been mentioned already, which is cloud. [00:20:00] Cloud for data storage and data transfer, enormously important. Another is data analytics, and the fact that there are now data analytical tools, most of which, are commercial and can be utilized in these environments. And then, Another key element is the internet of things. The ability to have systems throughout, an ecosystem, communicate with each other over the internet and provide data content back to a centralized repository or to the cloud more appropriately, in most cases is a big step forward.

So, those are some of the key elements of the infrastructure that enables a digital ecosystem.

Heather "Lucky" Penney: I'm really glad that you mentioned sort of the Internet of things because it's easy to focus on the initial stages of design and development and how you refine that design and then test that design through the model, through the digital artifacts, through the cloud using those data [00:21:00] analytics because you're connected over the high speed, high bandwidth, secure internet.

And you've got all that big processing. But core to this is that digital engineering is not simply located in that first part of the life-cycle. It expands throughout the entire life cycle and Brian, I'm really glad you mentioned that because tracking the data and the performance and the feedback of the system as it's in the field, as it's operating, as it's going out on the mission and coming back, is core to some of the value propositions of digital engineering.

So Brian, you at a very executive level at a prime defense company and you saw this transformation firsthand. What were some of the challenges that you experienced implementing digital engineering across the company as well as some of the unexpected benefits?

Brian Morra: The challenges are largely but not exclusively cultural, but culture change, as we all know, is difficult, and this [00:22:00] is a new way of doing business. Knowledge is power within organizations. And so for some people, the notion of putting their knowledge into a central area where everybody can have access to it is not a very comfortable thing to do. So, and then there, there are other things too that relate and one is, cost. Which is another obstacle and that you hear time and time again. In fact, I got a call from a senior executive who's in charge of digital engineering for one of the big aerospace companies just last week. And he wanted to talk about obstacles to implementation and one of those is cost and where individual programs typically are going to have to absorb the cost of implementing digital engineering environments. And that can be very costly. One of the things I discussed with him was at the corporate level, particularly in [00:23:00] these larger companies, I would urge companies to seriously think about having a digital engineering store in effect. Where common tools, common environments, common visualization and user interface, user interaction kind of technologies and products that are largely commercially available, could be purchased at the corporate level and then made available broadly throughout the organization. So, that each individual program did not have to invest in those tools.

Dr. Amanda Bullock: Yeah, it's funny. So, you're echoing exactly kind of the problems that we see in the Air Force. I'm sure both of you are aware from your time. And culture number one, hands down and I think cost additionally too, because we see that especially with continuing resolutions and people will have budgets being cut.

So, they're going to [00:24:00] cut something that's innovative and new and that they're not sure about. They're going to go with the tried and true, which oftentimes is not in the digital space. The other thing that we're really seeing and we're really trying to lean into is kind of upskilling who we have.

It's getting harder and harder to recruit people to work, both in uniform and out of it, because they can go to Silicon Valley and make a lot more money and it's flashier and it's more exciting. So, how can we train the people that we have to use the tools that we have, right? So, we're really focusing on education part and one of the ways the Air Force is doing that is through the DICE Center at the Air Force Institute of Technology.

Heather "Lucky" Penney: I'm glad you brought that up, Amanda, because the cultural challenges and the resistance and the training are something that we see not just in the engineering field, but I think importantly in the acquisition and program management field. Those individuals also need to be trained. They also need to be incentivized and there needs to be a culture from the bottom up and from the top down, that really holds people to a new digital [00:25:00] engineering process. Especially when it comes to acquisitions, because these people can go to jail if they don't get the process right. So they're very wedded to what is known and stepping into the digital arena can be very, feel very risky.

But I think it's the only way that we're going to begin, that we will begin to be able to go fast.

So Brian, you've been very connected with companies across the defense industry and you remain so today, as well as folks in senior leadership positions in both the department of the air force and within OSD. So, what's your perception of where the defense industry is? And where the Department is in adopting and implementing digital engineering across their workforce?

Brian Morra: Well, I think the good news that I can report is, I think both in government and in industry at senior levels, at C suite levels, there is an understanding of the potential value of digital engineering. And there's a commitment to rolling it out [00:26:00] across the organization. Where you tend to have a gap is as you go down into the organization and part of that's culture, part of it's cost, part of it's training, all the things we've talked about are certainly elements of that. But, I think good news is that there seems to be a commitment and an understanding that this is an important way of doing business and we need to get on with it. Despite the obstacles that may exist.

Heather "Lucky" Penney: To go back to a suggestion that you had regarding having a digital store, a digital library, not just within a company, but perhaps across the government or the DOD. Is that something that could lower the barriers of digital engineering for non traditional suppliers, sub tier suppliers, mom and pop shops, as well as improve the integration across defense primes?

Dr. Amanda Bullock: Yeah, I think absolutely. We're really seeing that in the new organization that I'm in that was stood up around a year ago, the Digital Capabilities Directorate and AFRL. And they're [00:27:00] really trying to lean into making all these things accessible. We really want to encourage those small businesses, but yeah, the barrier to entry for them can be just massive.

So, by having a central place and location that they can go to, whether that's Tradewinds AI, which is from the OSD CDA office or a marketplace, like we're standing up in AFRL for digital tools. We need to have those spaces available for them so that they know and also I think another thing that we could do is looking to open source software.

We historically in the Air Force have not really embraced open source software, but I'm happy to say that in the last couple years we've really been leaning into packages and tools like Python and R in our environments.

Heather "Lucky" Penney: Fantastic. Now, Brian, what would you say are the top three things that you'd recommend to really unlock the power of where we are with digital engineering today? And having a digital library, digital store can't be part of it because we already talked about it.

Brian Morra: Oh, come on. Well, we touched on one key element already, which is [00:28:00] training. I think training coupled with incentives is important and train on the government side, train and incentivize the acquisition workforce to where appropriate, and I think it's appropriate in most cases to demand digital approaches in procurement and program management. So, that's kind of on the acquisition side. I think that's one of my go dos.

I think a second is to incentivize industry to implement digital engineering across their internal enterprise and within industrial teams and into their supply chain. We've already talked about, and Amanda talked about some of the things that AFRL is doing and taking a leadership role in and helping with, especially these smaller firms. And that's, that's critically important.

The third thing is something, again, you've touched on, Amanda, which is to encourage the government to create widely available non proprietary software and digital [00:29:00] twin libraries. I think also standards. Government can help with standards for IT infrastructure to support digital ecosystems and a general sense in the acquisition world that this is the way we're going to do business from now on. I think having that bully pulpit and AFRL certainly has one to really encourage the adoption of these ecosystems is critically important.

Heather "Lucky" Penney: Yeah. Well, you mentioned having that secure infrastructure is, I think, a key component that's foundational to everything because it is going to be digital, we have to be concerned about securing the data and ensuring that's not something that adversaries can have access to that they can hack into, steal, learn from, exploit, or even corrupt.

But one of the things I thought was brilliant about what you said, Brian, was ensuring that this is really spread across all of program management and acquisition, because what I see in digital engineering is the ability to accelerate [00:30:00] the design, development, fielding, and operations of new weapon systems without the need for acquisition reform. We all know that we have to be able to deliver at the speed of relevance. We've got to outpace China. But the only way that we're going to be able to do that, I think, is probably digital engineering, because as much as everyone has worked on acquisition reform, we have not seen the receipts. We have not seen the evidence of really being able to speed that, except in isolated cases. And I would argue that in some cases, digital engineering contributes to that, to those program speeds.

Brian Morra: Yeah, digital engineering is a surrogate in effect for acquisition reform. I think that's what you're saying, right?

Heather "Lucky" Penney: Exactly, and so we can do that without having the laws changed.

So Amanda, you are leading a lot of this digital transformation at the Air Force Research Labratory, and you've got a lot of experience in artificial intelligence, and I'd like to bring that expertise, more into the conversation because Brian's done a phenomenal job at [00:31:00] contextualizing where we've been and how we've got here today. Could you explain what the imperative, the digital engineering imperative, why we need it at the Department of the Air Force?

Dr. Amanda Bullock: So, the only thing that we have the same amount of as the adversary is time. In order to create more time or cheat that time, we have to embrace these digital tools. We have to embrace digital engineering and digital processes. And that's the way that we're going to really accelerate our change in the Air Force. As a General Brown said, accelerate, change or lose. And he said it, that's the perfect quote to really frame this up.

Heather "Lucky" Penney: And losing is unacceptable. So, we do have to be able to accelerate this development and delivery of capability. And your specialty is artificial intelligence, which you've been working at how to apply that AI to digital engineering. So, let's start to look towards the future of where we're going to go and how we integrate AI into dital engineering and what that means.

Dr. Amanda Bullock: Absolutely. [00:32:00] So, I'm really excited that you guys were touching on the acquisitions and the program management because we've got some really exciting things underway at AFRL.

One of the things that we're looking at is platform or an app called Ackbot. And that is with, it started with the OSD CDA office and it is a way to generate the research and the background for currently, it's OTAs, other transactional authorities. AFRL is going to be working the currently working on small business phase three, and we're seeing that as a way for our engineers who do not want to be program managers, but have to at AFRL, because that's what we tend to get put into to be able to create this. And we're, I think we're seeing a reduction in about from something that would take months to send back and forth between contracting and the engineers is now taking days. So, that's one of the ways that we're really embracing it.

We're embracing it in a lot of different ways. In our research as well, I'm sure you guys are aware that AFRL has been doing AI for the last 60 years. But we're also embracing it in the [00:33:00] generative sense. So, we're really looking at how can we use generative AI to accelerate our mission to increase our efficiency and achieve time.

Heather "Lucky" Penney: So could you explain what you mean by generative AI?

Dr. Amanda Bullock: Sure, absolutely. So generative AI uses large language models. It's really just a fancy way of saying you're using probability and math to predict what's going to happen next. That's kind of what it boils down to. And we're exploring several different pilots and projects on how we can use that, including in our program management reviews.

So, we've got a project right now that's going to look at taking those files, those PowerPoints, all of that stuff, and putting it into a generative AI tool and asking those questions and getting on demand answers. I'm not going to have to spend weeks anymore preparing for a PMR, which takes me away from doing my research, which takes me away from accelerating things in the Air Force. I'm not going to be able to within an hour or two create that PMR. Just using, using these tools and then also embracing things like Microsoft Co Pilot and [00:34:00] Google Gemini for our PowerPoint creation. I'm sure everyone on here loves creating PowerPoints, right? It's their favorite thing to do is create those PowerPoints.

And also to watch a PowerPoint that's a death by PowerPoint.

Heather "Lucky" Penney: So you got that PowerPoint ranger tab, right?

Dr. Amanda Bullock: Oh man. Yeah. So, with these tools they can create those awesome graphics. It's going to be visually engaging and they can also pull that data for us.

Heather "Lucky" Penney: So, it's interesting that you've got these generative AI tools that are building up these presentations. Is that sent the same as having, for example, a program management review or executive? Being plugged in and watching and in real time and tracking the program's progress real time? Or is this just replicating, but faster, existing program management reviews?

Dr. Amanda Bullock: So I think both. It's really a pilot project right now. We're seeing what can we do with this. So everything that we're using is kind of like, how can we make things faster? So, that's definitely a number one. Number [00:35:00] two is we think of it as a very eager intern, right? So, how can we use that eager intern to create this? How can I, I know people who have their executive assistant put all the stuff that they have to in PowerPoint for program management reviews.

We don't have to use an assistant to do that now, we can have them do it, and then we spend the time reviewing the material. Always review the material, just like we've seen plenty of cases, about people not reviewing material that's produced by generative AI. And so that's, something we really want to drive home to people is that it helps reduce your time to create it, but you're still responsible for the content.

Heather "Lucky" Penney: Yeah. You still have to check the homework because generative AI is fast and it aggregates, and it creates, but it's not always a hundred percent accurate or true or gets the answer correct.

Dr. Amanda Bullock: Exactly.

Heather "Lucky" Penney: So, this is exciting because you're powering engineers to actually be engineers, right? And as the complexity of major weapon systems has grown, I mean, it's just exploded. That has to have had an exponential impact on the complexity for engineers. So, how can AI [00:36:00] assist those engineers and acquisition professionals in their tasks? You already spoken a little bit about that, but are there other things that you're looking forward toward or developing?

Dr. Amanda Bullock: Yeah, absolutely. Things like, tagging data automatically, processing analytics, and rapid speed. Being able to perform detailed simulations and providing design optimization recommendations. These are things that AI is really going to help us and lean into. We can take AI driven simulation tools and they can model various operational scenarios and stress conditions that will allow engineers to identify potential issues early and optimize their designs before the physical prototypes are created and that's going to cut down on our rework.

Heather "Lucky" Penney: Yeah and rework, I think, is something that a lot of folks don't appreciate is, is how much effort goes into either the design or the prototype, and then you put it together, you go, "Oh, that didn't work." And then everyone has to go back and start over and this introduces a tremendous amount of cost and it extends the schedule because of just the rework that has to [00:37:00] be done.

So, being able to reduce rework not only produces a better design, but it's a much more efficient process for everyone. But of course, engineering doesn't stop with design, it's fundamentally creating a capability for the warfighter to use and ideally at scale. So, this is also test, it's production, it's operations, it's sustainment. So you know, Amanda and Brian, I would love to hear your thoughts on this as well because you've remained connected with the major defense primes and through the sub tier suppliers and defense leadership. How are you seeing digital engineering and these advanced manufacturing practices coming together to do the production piece, to do the test piece, and to do the sustainment piece. I mean, how are we addressing the rest of the life cycle?

Dr. Amanda Bullock: I think a really good example of how additive, how manufacturing and digital engineering coming together is the AI Forge project out of Robbins Air Force Base. And they're using 3D printing to create parts. So, they're [00:38:00] taking those CAD CAM models and they're creating it. We're also looking at investigating using subtractive manufacturing. So, take CAD cams and put them into a CNC machine. So you can think, you guys can think of the impact this will have if we're in theater somewhere, right? If a part breaks on a aircraft, we don't have to wait weeks and weeks and weeks for it to come. We could potentially create that park either using subtractive or additive manufacturing.

Heather "Lucky" Penney: That's phenomenal, and certainly would reduce the logistical burden in a theater that we already know is going to be stretched to the max.

Brian Morra: Yeah, absolutely. I mean, that's a great example, Amanda. That's terrific. I, one of the things I want us to guard against, in industry in particular is stove piping, additive manufacturing in one bucket, and AI in another bucket, and digital engineering in, the third bucket, because Amanda said it, exactly right. It's really, there's enormous value to be unleashed by [00:39:00] interlinking these kinds of techniques into an ecosystem, into a single ecosystem. And it's, I know in talking to some people in industry, they're like, "Oh my God, you're making my head hurt because I'm just trying to do one of them. And you want me to integrate all three?"

Well, but that should be the vision. And, and that's where enormous payoff can come across the whole life cycle.

Dr. Amanda Bullock: Yeah, we don't want to think of it, as you said, as stovepipes, right? Just think of it as an entire digital life cycle. That's really, I think, why AFRL stood up our Digital Capabilities Directorate. To really enable all of that, to just, it to be a mindset rather than just, you know, three different things, "oh, we have to do this again." I think that's a really good point.

Heather "Lucky" Penney: And Brian, I love how you refer to it as a digital engineering ecosystem, because I think that really gets at how all of these things are integrated, how they play together, and how they collaborate across that entire life-cycle. So, we've been talking mostly about digital and models of idealized [00:40:00] systems, but real world systems are never totally identical. Right? Every aircraft will be built a little bit differently. It'll have a different operational repair history. Individualized and updated models of systems, are what we call digital twins. And so I think this is, we hear it, we hear those two terms a so much, I think it's an important thing to just make a distinction for our audience that the digital model is the idealized version that can aggregate the data from all of the individual twins, where the twin is actually the avatar of the actual aircraft sitting on the ramp that has done everything that actual aircraft is done.

And that's why a lot of that internet of things, that data sharing of the individual experience of that weapon system is crucial to inform not just the twin, but the model as well. But could you lay out to us the value of those twins and how different types of systems are, like a B 52 or a satellite, might want to have digital twins that are updated at different levels of detail or speed?

Dr. Amanda Bullock: Yeah, I think I'm going to go one extra too on [00:41:00] there and talk about something that they're doing in the human performance wing at AFRL. Which is a human digital twin. That's not really something that you hear a lot of. It sounds a little scary, but it's a really great, unique concept. Taking those same MBSE tools and looking at wearable technology that we have, looking at genetics, looking at diet, looking at all these things that go into the human warfighter, and how do we optimize them? How do we create people who are going to recover quicker from whatever they're experiencing? How do we see, okay, this person's more susceptible to this?

And so looking at that and in a scenario like that, you're going to want to make sure that the data that you're receiving is very accurate. This is still a very like, a research experimental concept, but I think it has tremendous potential.

Heather "Lucky" Penney: So for all of our folks out there that are really interested in the health and the biohacking, they're like, they're getting all excited about this, right?

Dr. Amanda Bullock: Yeah, it's really neat. They just do some really cool research there. And I think this is one of those things. But to get back to your original question. So, whether it's a B52 [00:42:00] or a satellite, we really have to weigh out cost and importance, right? All of these things are important, but how much is it going to cost us and how often do we really need the data?

If it's a communication satellite, we probably need to have data every day, as close to real time as we can have. If it's a weather satellite, maybe, weekly might acceptable for that. If it's a B 52, we face things like, we still are not at a point in the Department of Defense, and I don't know if industry is, because I'm not as plugged into that, but with edge computing. In order to really have these digital twins of our aircraft in real time, we're going to have to bring edge computing more to the forefront in the Air Force.

Heather "Lucky" Penney: So, I have a question about that edge computing and how we deal with this for legacy systems, right? So we take the B 52 example, they're not digital twins of B 52s, right? We don't have a twin for every single tail of the B 52. So, when it gets back [00:43:00] to that kind of decision making regarding the benefit versus the cost, how do we evaluate that? How do we assess that?

Dr. Amanda Bullock: Yeah, we're not going to be able to have digital twins of everything that we have. It's just going to be completely impossible.

And so a lot of times what happens is that we take these blueprints and we scan them and now, "Ooh, it's digital paper, right?" Kind of like what Brian mentioned. And so really we have to weigh out how long are we going to keep these? I mean, we know that B52 has been, the life cycle of it has been extended, and extended, and extended.

And is it worth going back and creating all that digital? Or do we look to the future and to say, okay, now when we create these, work with industry now, when we create these, we need to have digital prints of this, we need to have digital schematics, we need to have all this stuff, so that when we need to make decisions, we have all that data. If Tesla can do it, I think the Air Force can do it.

Heather "Lucky" Penney: The Air Force is now looking at creating a digital model of a V1, but they assess it's going to take about six years to do. So, it's not an unsubstantial effort in terms [00:44:00] of cost and time to be able to do. So, maybe for these legacy systems or even hybrid systems where there was a level of CAD CAM, it makes more sense to scope the effort of digital engineering that we do with it with the modernization.

So, we're really getting that right knee in the curve regarding cost, effort, and benefit. So, for the B 52, I would suggest, you know, focusing on the reengineering effort. We don't need to necessarily create a twin at all, and maybe just a model might be good enough.

Dr. Amanda Bullock: Just enough.

Brian Morra: Yeah. And I think it's a great, great point. And you made it really well. And industry is looking for guidance also because of the trying to hit that knee in the curve, Heather, that you talked about. And where do they invest in developing digital twins and where do they not do so? And it's one of the questions I get repeatedly from industry is, what is the type of program I should initiate, not just digital twinning necessarily, but digital engineering [00:45:00] concepts on? What's the type of program? What's the complexity of the program? What's the size of the program? I mean, some folks have asked me, what do I do with an R&D program? Let's say I'm executing something for AFRL and it's a $1 million project. Do I, do I do digital engineering on that or do I reserve it for the B 21? So, you have this spectrum, right, from a small research and development project on the one hand that may be a million bucks or less, all the way up to the B 21.

So, give us some guidance. I think the industry's aching for, you know, how do we do this in a smart way? How do we hit that knee in the curve and know which programs really will benefit the most from digital engineering techniques?

Dr. Amanda Bullock: You know, that's a great point, and I think we're seeing a shift, and I would encourage any industry, whether it's small or large [00:46:00] business, to really work with your customer.

This cannot be throw it over the fence and get what you get. We really need to adopt, continue adopting agile principles. Where we have our end users, where we have our customer, all together to develop these requirements. Because as you said, we're the ones who know what we need and we need to be better at relating that and letting industry know how they can help us.

Because we can't, we can't do everything. We can't expect a company to do everything. We've, you know, we've had small businesses that we work with that have expressed, "I can't meet this part because it's going to cost me too much." Then you have to weigh, as the customer of the government, is that worth it? And if it is, to see this cool technology that has potential to change things. Then that's something that you have to take to your leadership and really be vocal about.

Heather "Lucky" Penney: And I think this gets back to having digital libraries and digital stores that the government ensures are available not only across the defense industrial base, but deep down into sub tier suppliers and also facilitating that [00:47:00] secure infrastructure.

I think what's interesting, Brian, about what you brought up is also that the defense industry, they have the actuals. They know what the cost is. They know the hours that their engineers spend on certain activities. And so they have the ability to really do the analysis to facilitate and help inform the government on where and when they should be implementing digital engineering, what the scope of that effort might potentially be.

And I think that that's a really important piece, because they've got the ground truth. And in order to be able to make good policy, the government will need to be able to have that. And Amanda, some of your folks have that as well, especially with all the data that you're collecting.

Dr. Amanda Bullock: Yeah, absolutely.

So we are definitely, collecting that data and what we're finding out now is that we don't necessarily have the infrastructure to do it. And so we are really leaning into a hybrid multi cloud approach to do that, which means that we have a lot of data. We have the high performance computing at [00:48:00] AFRL. We are the home for the Department of Defense's high performance computing. So how can we use those places? How do we store what we need and how do we use AI to get what we don't have, right? So, we don't need to store every single piece of data for everything anymore. It's really about right size at the right time.

So we want to take our AI tools and we want to have them, really enable us to find this data better. And one of the ways that we're doing that is we purchased a tool that we're doing a project with, that will use semantic searching and knowledge graphs instead of just your basic keyword searching.

So, what I mean by that is when anyone goes into SharePoint and you type in, Program Management Review, you have to have somewhere in what you're finding Program Management or Review. You can put boolean statements in there to get all three of those. That never works. I don't know if it works in industry, but in AFRL, I can never find what I'm looking for.

And then, so you have people that save something is 2024, five, you know, and left the date and then like a [00:49:00] long title that is just awful and it spins more space. And so we're looking at these tools that can use kind of AI models and knowledge graphs to go in there and say, Oh, program manager review that's related to cost, schedule, and performance. Here's something in that has cost schedules performance. It's only one degree away from program management review. Maybe this is what you're looking for and provide that and provide links to that exact stuff.

Heather "Lucky" Penney: Wow. Yeah. I mean, if you don't have the ability to discover your data, then it doesn't matter how much data you've logged.

And so finding those, having it discoverable and then being able to analyze the patterns is huge.

Dr. Amanda Bullock: Yes.

Heather "Lucky" Penney: So, digital engineering has a lot of advantages, but one clear one is that its greatest value is when it's used as an enterprise solution. We've alluded to this throughout the conversation. The Department of Defense and even a single major acquisition program, they're massive enterprises. So, what challenges have you seen when it comes to adopting digital engineering? I mean, you've got a lot of this forefront.

Dr. Amanda Bullock: Yeah. You know, I think Brian really touched on it [00:50:00] earlier, and I mean, I just can't, number one, number one is culture. We have people who are just very risk averse a lot of times, and even though our senior leaders are telling us to go faster and do more and take more risk they still will not. We're seeing that with AI, generative AI especially. We have a model that was just announced yesterday that is approved for CUI data, that was developed by the Air Force Research Laboratory, called Nipper GPT. And this is an experiment that we're using to enable our people to feel more comfortable with the commercial tools that might exist out there.

We know that this is probably not going to be the solution that we go with, but we want an environment that people feel comfortable in playing around and trying, and that AFRL developed one which sits on a high performance computing servers, is giving people more of a comfortable space to create and play around because they know that a company is not seeing their data and taking their data.

Heather "Lucky" Penney: Excellent. So, one thing I think that's important when we have these [00:51:00] conversations about advanced technologies or the future, or is also sort of scoping expectations, right? I mean, there's a level of being genuinely optimistic about the potential for a particular capability. Or just being unicorn optimistic about the potential for a capability.

What's true. What's what we have here. What's now. And frankly, also what's a little bit of snake oil. So, how would you frame digital engineering, many of the AI tools that you're building, how would you manage those expectations for smart adoption and how senior leaders should understand where we're at? Because if they run too fast, people will be disappointed and they'll throw the whole thing away. How do we build on this gracefully?

Dr. Amanda Bullock: So, I would say the number one thing is to understand that AI is not a solution to everything, right? People say, "Oh, well AI can do this. You can do that." We found several use cases where you know what? The technology is just not there yet. What you want to do, we don't have the capability of doing. [00:52:00] And it may not be there for a couple more years. So, can we get a small part of that for you? Can we help with that process? Can we reduce that toil for you by just a little bit? And that makes people, okay. It's really, again, it goes back to the agile principles.

Let's, do incremental small things instead of trying to wait to show a really big thing that it may or may not work. And then people are like, "Oh, I give up then. I don't want to try any of these tools. None of it works." It's really showing that there's certain things that it can do and there's certain things that it can't do and being open and upfront about that.

Heather "Lucky" Penney: Brian, you've had decades of experience and expertise within the defense industry. And so from your wisdom, what would you share with senior leaders regarding how to scope their expectations and how to build smart policy for the adoption of digital engineering?

Brian Morra: Well, I think Amanda said it well in terms of tempering expectations. You want to get people enthused and excited, but you don't want to declare [00:53:00] that this is a panacea that's going to solve all of our problems because no such thing does exist, but digital engineering, digital ecosystem combined with AI, combined with additive manufacturing, these are things that are going to help us with the tyranny of time. You said it earlier, Amanda, very well, the one thing we and our adversary both have in common is time, and we've got to make better use of ours.

I would also stress, I think, to senior leaders, the need to rethink collaboration, not just within programs, although that's incredibly important, but collaboration between industry and the government. That the kind of environments, the kind of ecosystem that we're, we've been talking about here today offers opportunities for much greater collaboration.

And that also will require a culture change and a [00:54:00] reversal in some cases of an adversarial relationship between government and industry, which isn't everywhere, but it does exist in some places. So I think those are some of the key things I would stress.

Dr. Amanda Bullock: Brian, I mean, you really could not be more on target with that. We really, we're seeing a shift from some of our senior leaders on that. I really applaud the Department of the Air Force's CDAO, who's acting Ms. Donaldson. She really, along with Ms. Goodwine, who's the CIO for the Air Force, set off a series of roundtables where they brought in small businesses, large businesses, and academia to ask them, like, what are you doing and what can you do? You know, really trying to embrace that. Let's not be scared of each other. Let's all work together.

Heather "Lucky" Penney: Brian, Amanda, thank you both so much for being here today, Brian. It was a pleasure to work with you on this report and thank you for your insights and your thought leadership. Dr. Bullock, thank you so much for taking the time to talk with us and walk us through all the benefits and challenges, and those insights regarding not just digital engineering, but [00:55:00] with artificial intelligence and how we'll bring those together for the future.

It's been awesome.

Brian Morra: Thank you very much. It's been a real pleasure to be here with you.

Dr. Amanda Bullock: Yeah, I want to thank you for the opportunity. I really enjoyed it. Thank you.

Heather "Lucky" Penney: With that, I'd like to extend a big thank you to our guests for joining in today's discussion. I'd also like to extend a big thank you to you, our listeners for your continued support and for tuning into today's show.

If you like what you heard today, don't forget to hit that like button and follow or subscribe to the aerospace advantage. You can also leave a comment to let us know what you think about our show or areas you would like us to explore further. As always, you can join in on the conversation by following the Mitchell Institute on Twitter Instagram, Facebook, or LinkedIn, and you can always find us at mitchellaerospacepower.org. Thanks again for joining us and have a great aerospace power kind of day.

See you next time.