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Paul Thies: When it comes to aviation-based supply drops, it's not a simple matter of pushing things out of airplanes and hoping they land where you want them. It's a highly advanced and precise science that demands a number of technical and theoretical proficiencies. Hello, I'm your host, Paul Thies, and on this episode of *If Win*, we discuss the art and science behind aviation airdrops with chief engineer Jeff McCoy, and product manager Jeff Cusato, both of the Jacobs Software Engineering Center.

Jeff and Jeff walk us through the Jacobs airdrop solution, which allows us and Allied Air Forces to execute high-precision airdrop missions that range from troop insertions to advanced forces logistics support to critical humanitarian aid. Through incorporation of custom analytical and automation algorithms, our solution delivers a 98% reduction in drop zone size while simultaneously raising the airdrop release point by 500% with no loss in accuracy, which keeps ground crews safer and our flight crews out of harm's way.

Well, Jeff McCoy and Jeff Cusato, thank you both for joining me today. We're going to talk about aerial drops and data analytics. It's not as easy as pushing something out of an airplane and it landing where you want it there. Apparently, there's a lot of science that goes into something like this, and so I'm really looking forward to unpacking it with both of you, so thanks for joining me today.

Jeff McCoy: Thank you.

Paul: All right. Jeff McCoy, I'd like to start with you. Can you describe some of the challenges involved in aerial drop missions? What are some of the things that must be accounted for in order to have a successful aerial drop?

Jeff McCoy: Yes, so the number one priority is safety. Safety of the crew, the people on the ground, jumpers, the cargo, the airplane itself, so the drops must be accurate. Things are landing on- very heavy things where people are landing on the ground. We want to make sure we don't land on schools and mosques or in areas where people are threatened. We are providing solutions to supporting the Air Force and the army and the capability to plan and execute the drops of both cargo and personnel.

That's what our software does, and we'll get into that in a little bit. It's all types of missions, humanitarian drops, troop resupply, combat operations, personal cargo, weapon systems, all are priceless to some degree or another. Safety is key. I'd say the biggest challenge to that is the weather, predominantly the winds. There's a challenge in understanding. It's not just whether it's sunny or raining at the drop zone, but what's the 3D vertical wind field look like as the aircraft enters that area and prepares to drop. What altitude are they at? What's the local terrain effects? When was the last forecast updated? How good is that forecast?

If we have inaccuracies or timeliness of data, maybe the winds changed since the last time you got your forecast. The time between planning and execution is key, which is what we do. We're trying to work on ways to tighten that and improve that so that they have the best idea of the situation in that drop zone. You have local effects

that sometimes forecasts are regional over a large area. These drop zones are pretty small.

Local effects are is there a mountain pass there that the wind is channeling through? Is there bodies of water? Is there canopy, desert? All those things have to be taken into consideration. Some of it's currently mitigated by releasing a drop-sand, which I think Jeff will talk about a little bit later. Basically, they make a passover and drop a sand, which we talked to as it falls through the vertical channel or vertical cone core of the air. Then they can get the latest winds, which helps. There's challenges to that because if you're in a combat situation, you're exposing the aircraft by that first pass because then you got to come around and do your drop.

There's of course other challenges. The fact that there's different shoot types, there's different aircraft, the different ramps, different parameters on the plane, different drag coefficient, all those things. The type of delivery system matters. The performance parameters. The ability for us to model large data sets and provide accurate assessments how best to load the cargo and the bay of the aircraft, the timing of how it exits, the things that happen when it exits, whether it's a person or a large payload a tank or something.

The mathematics and the algorithms and the software are very complex. We have to ensure that we conform to the right mathematics and algorithms in accordance with Air Force regulations and things that the Department of Defense specifies to us. Not every aircraft is the same. The avionic system is different. Some of what our software creates is solutions that we'll talk about in a minute, but a lot of that data gets loaded onto, or at least considered in the avionics of the aircraft and where the plane goes and when to release the payloads.

That differs by some of the platforms. The attitude of the aircraft, its weight, the speed, the level that it's at the drop path, how it exits the drop zone how it runs in, where the threats are. Is that data accurate? The challenge is basically where-- How do we tell the crew where to put the right- where in space should they release the payload? Then is that the right spot to make sure that it's where we think it's going to be as terms of placement on the ground? There's things we want to avoid on the ground and we also want to make sure that the people that have to go out and get the cargo from the drops aren't under harm's way.

Location is really important in proximity to threats. I'd say the last maybe challenge is really our software itself, not only do we have to keep our math accurate and everything, but the crews use our software to plan obviously and all through the execution. User interface and being intuitive, the right workflow understanding what the users need and not getting in their way. It needs to be concise and easy to use and quick because they've got a mission to fly and they can't get bogged down in our software.

We have to understand the user's mindset and keep designing our software to be right for them because if they have to spend more than a few minutes figuring out what our software is doing. They're just going to go to the jet and do their mission by hand. I'd say those are some of the key challenges.

Paul: Oh no, that's really fascinating. I've seen some of the demonstrations and the accuracy is just mind-boggling. How high-up that the planes can go and how accurate and how small the drop zone is and how the consistency by which they can drop stuff is truly astounding. Now Jeff Cusato, can you tell us a little bit about Jacobs has this product, it's a Aviation Suite airdrop and can you tell us a little bit about how airdrop works and what are some of its benefits?

Jeff Cusato: Yes, sure. I think Jeff McCoy did an excellent job running down all the various facets about an aircrew and what they have to go through for an airdrop, and really that's what we're trying to build ultimately is that piece of software that they can see through all those things that are happening and ultimately divine that one or two pieces of information that's going to help them out. In terms of what we're doing for airdrop, we are trying to calculate a point in space for the aircraft to fly to. At that point, it's called the green light and no getting in the back of the aircraft. There is a big light that turns green and it signals time to release the payloads.

Then a whole bunch of things end up happening. Now there are a couple of ways that payloads can exit the back of an aircraft, get pulled out by another parachute. It could be jumpers that jump out the back, but one of the most common types is called rollout. Speaking of that, this airplane hits this point. Green light goes on, it pitches back, the tie downs are cut for the payloads and the payloads begin to slide right out the back of the aircraft. At that point, when they've left the aircraft, they're traveling at the same velocity of the aircraft and hit air resistance and they start slowing down. Their forward momentum is slowly bringing them to a stop.

They're also falling thanks to gravity and their parachutes inflating. They reach this point we call the stabilization point where there's no more forward momentum from the aircraft. The parachute canopy is fully deployed and now floating, it's at the winds of the wind. It'll follow that wind all the way down and land on the ground. Our goal is to allow them to target where they want it to land and then work backwards to do all that math to say this is that spot you want to hit in the air. It's pretty neat our software, in order to give them that one point, we try to give them as much additional situational awareness data to help fight all those things that Jeff just mentioned.

We'll generate and run hundreds if not thousands of simulations about where these payloads could land and try to give these aircrews a good idea about what is most likely going to happen on the ground so that they can make the tactical decision about how to approach this problem. Put all that together, our software, we allow airdrops from as low as a couple of hundred feet all the way up to 35,000 feet. It's really something and those types of systems can be these dumb ones, call them ballistics that come out and they float. They can be pre-intelligent and have their own guidance units steer their rigging themselves, steer the parachute themselves and that's a whole nother piece of math to make sure we allow aircrews to drop as far away as safely away, but also with enough confidence to actually carry up the mission.

Paul: Wow. That is amazing, and the fact that you can drop something from 35,000 feet it's crazy. Then you think about some of the various situations it could be like a combat zone where you don't want to miss the drop because it's hard for the guys to go and reclaim that, or if it's like Jeff was saying earlier, if like a place where there's

schools or whatnot, you certainly don't want to be dropping a tank on top of a school or something crazy like that.

Jeff Cusato: Exactly. We try to build this software to give them a couple of scenarios so they poke and prod depending upon what's important to them, because like you just said, what could happen? What's the chances of the wind pattern shifting until something is no longer- an unideal situation shows up? Should I change my altitude, drop lower? Can I go higher and stay away from things on the ground?

Can I attack from a different run in a different heading, write a different way into this area? If I have to not drop because something happened, we were just too far shifted, our course was off by a little bit, what's the best way to re-attack? Do I turn left? What are my options in front of me? If we're trying to- given that there's terrain, there's weather, there's ground positions of enemies and friendly. Again, how do we give them tangible data so they can make smart decisions when they are disconnected and decentralized from the larger Air Force?

Paul: Now, Jeff McCoy, how is this solution, this airdrop solution, how is it different from anything that might be offered out up there by the competition?

Jeff McCoy: Well, to date the solution that we have that Jeff just described is customized over many years with the DOD principally the Air Force and the Army. We've worked over the years very closely with the government and the end users, very tight relationships. We have end users that come into our office and they're in their flight suits and they're talking to our developers, and it really customized and tailoring to the mission that the Air Force has with the Army drop getting the stuff out of the people and cargo out onto the ground.

We've really been the go-to people for that in that environment. There are other tools and use in other arenas, but ours is specialized and fairly sophisticated as Jeff pointed out to this particular mission. In our development, I guess our direct competitors are other enterprise contractors in our mission planning arena. There's several, four, or five other developers that work in our environment in terms of developing mission planning tools and they support some of the same aircraft we support, C-17 and C-130Js have airdrop missions. We are doing things for the C-17 and C-130Js and other contractors are as well.

Airdrop data does get loaded to those aircraft and sometimes it's data from our tool that they integrate in other systems. At any time, other people can pick this up and provide solutions, but it really takes a lot of domain knowledge and understanding. It's not something you're going to pick up overnight. It takes a while to develop this stuff and have an understanding of all the parameters that we've been discussing. I'd say one benefit that we have over the competition is that it's not just the software that we've built, but it's maintaining it in the field and supporting the users in their missions. If there's an off-drop issue or, "Hey, we're not hitting our target for some reason, what's going on? Is it the weather? Is it drop zone? Is it software? Is it the aircraft?" All these things?

They'll come back to us and we'll investigate, we'll run data analysis. We'll study the situation. Our team members have gone out there and watched drops. Again, working with the end users, "Hey, this one time this happened to me, why did that

happen?" We have that continuing relationship. It's not just us selling a product or anything here, it's an ongoing relationship, and providing domain expertise is one of our discriminators working with our users.

We continue to be the go-to people there. In fact, other tools out there, we've been approached to, "Hey, can we integrate this into our solutions?" We understand our users' challenges and constraints and we've had a longstanding relationship, but that's not to say that there's no competition. I think our future outlook is that we'll have to really watch things as payload and delivery systems change and modernize over time.

This is an area of a lot of technology improvement, things are getting more precise. You've got Pizza Hut able to deliver things on drones or Amazon or whatever it might be. Now our competition might turn out to be OEM manufacturers who own the hardware and the delivery system and the software and all the other parameters. This is an evolving field. It's modernizing over time and we have to keep our spear sharp here.

Paul: No, that's very interesting. Now Jeff Cusato, you and Jeff McCoy both mentioned some use cases, one of which was for instance humanitarian uses and of course combat drops and things like that, but Jeff Cusato, can you unpack for us what are some of the compelling use cases for the airdrop solution?

Jeff Cusato: I'm just thinking back on it. I've been involved with writing airdrop software since about 2007, and back then there was Operation Enduring Freedom from out in Afghanistan. That started just after 9/11 and went all the way up to about 2014 or so. One of the big things with airdrop, there was a huge increase in its utility because it kept convoys and soldiers off the road. Do you remember that movie, *Hurt Locker* with **[unintelligible 00:15:52]**? That was a big deal because you remember the news back then we were hearing about IEDs and what that did to convoys, and so moving equipment was very dangerous to do it on the ground.

Airdrop really started to enable equipment like blood and in addition to ammo and other things to be directly brought to Ford operating areas without putting ground forces at harm. I was out at Little Rock, Arkansas and I was talking with some users and one guy had just returned back from Afghanistan. This story just sticks with me just because he remembers being in his aircraft trying to recalculate some of his airdrop as he was in flight. He wasn't using our software at the time. They were trying to do some new advanced techniques and he remembers getting some math wrong and went out the back and he has looked down going, "Oh no. Like please make sure it's on that drop zone."

He had actually had a buddy down on the ground, and at the end, everything was probably fine with this drop. It actually landed okay, his buddy was fine, but he just told me for those 15 minutes, flying back to base, his emotion when he told me the story is certainly stuck with me because again, this is pretty, pretty amazing that we're enabling the aircrews to help resupply folks on the ground that otherwise are going to be in dangerous place.

We have air supremacy in Afghanistan, but that obviously could radically change in a future engagement. That's something that always sticks with me. Humanitarian aid,

this is something I like to talk about a lot, about the Air Force National Guard does is my favorite thing. It's called Operation Christmas Drop. There's even a Netflix movie. I don't know if it's well done or poorly done. I haven't watched it.

It happens every year around Christmas to some of the remote islands in Micronesia. The Air Force has been doing it since like 1952 and they do it with a lot of their ally partners as well. It's a pretty cool thing to read about. They're going out there and dropping these big cases of utilities and supplies to these remote islands. That's always a great thing to note that the software's being used for something like that.

Paul: Jeff McCoy, can you tell us a little bit about the team that's involved in the conception design, and construction of airdrop? I imagine there's a variety of disciplines that go into the manufacturer or something like this. Can you tell us a little bit about the types of professionals that have to be involved to pull something like this off?

Jeff McCoy: Definitely multiple disciplines involved in this. Our current airdrop team is around 23 people fairly small, tight-knit group. It's about 15 software developers and software testers operating as development teams. It also includes a support staff that includes subject matter experts. Some are crew members who have been doing drops on those same aircraft that we support and that's how we get some of the smarts and understanding of how some of this works.

Security engineering, of course, systems engineers who are also domain expertise provide domain expertise, DevOps, technical writing for the end users, here's some help information for using the software, those kinds of things. All those different disciplines come together and basically, we're end-to-end product developers. We're involved from if you want to say requirement solicitation, but really understanding more what our customer needs.

Sometimes they don't give us requirements. They come to us and says, "Hey, let's figure this out together," and we do that. All the way from planning through design of what we're going to build over time into implementation, deployment, sustainment, end-user support. We'll go out and show them how to use the software. We go to the government's integration testing and operational testing to make sure that the software works in the user's environment along with all the other mission planning tools they use.

The team has to be knowledgeable of all that, and we try to build the teams in that manner. We make sure that the developers have the right tech stacks in terms of the type of architecture and the code base that we're supporting and moving into in our customers' environment. Need to understand data analysis and the mathematics and the complex algorithms that we've talked about and also the end users' platforms, understanding what kind of computers they use laptops, mobile devices, workstations, whatever it might be to make sure that we're developing the right things for the right time and the right people. Key concept, we've implement the Agile process. We're CMI and Agile. We've been doing it for a few years. The teams that I just mentioned are really small teams, eight people or so, and work gets allocated to those teams. The idea is to keep those teams together as much as possible. They learn how to plan together. They learn how to estimate together and they really learn

how to work together and so your velocity gets established and you start to become a well-oiled machine. Our team, frankly, has learned very well how to behave as an agile team.

They've changed the culture and the workflow from the traditional waterfall process. There's a really awesome trade of innovation that we have. When the customer comes to us, it's not just asking, "What do you guys want us to do?" It's like, "Hey, let's talk about this, and we have some ideas. Here's how we can solve your problem." Maybe something the user or the customer hasn't thought of. It's our value to them that we're providing just making sure that end-user has the right product at the right time.

Really the key of the team, as I mentioned, is domain expertise, like we talked about earlier. It's one thing to understand how to write software. It's one thing to understand the algorithms, but if you don't know how to apply it in your user's domain and understand your user's challenges and needs, it's not going to be as successful. Some of our people on their staff are, like I said, subject matter experts. They're ex-crew members. Some are pilots and they work right alongside our developers, laying out user interface designs and workflows, making sure that terminology on the software pages matches what the user's looking for, so they don't sit there and look at something and not understand what it means.

Those are really key important when you're flying an airplane, you can't have confusion in the cockpit or in the crew area when they're trying to release a payload. There's a lot of subtle acts aspects to that. We make sure our teams have the right mix of the developers and there's end-user domain knowledge. If security and those kinds of things are part of it, DevOps, we have people that support the teams and work with the teams to deploy correctly to the software platforms. Again, understanding the mission of the aircraft is key. That's really who our team is and the disciplines involved.

It's really taken years to get up to plane, if you will, on that and have the right formation of those teams. Sometimes you have to make adjustments and stuff, and people come and go, of course, but it does take a long time to learn this thing. We try to keep those teams together and it's been successful.

Paul: Now Jeff Cusato, looking forward, what do you see as the future state of aerial-based material deployment?

Jeff Cusato: Again, we're really supporting the Air Force and their mission here. We talked about how they did a lot in Afghanistan and turning the airdrop into almost a logistical weapon to keep people supplied and safe. We had air superiority in Afghanistan. As we look out to these future engagements, that might not be the case. There's a couple of countries in the news even recently that also have a pretty impressive military. It's going to be difficult, but we have to find ways to make airdrops successful in those areas. If you don't pay too close attention to even technology, we all know that Teslas can drive themselves nowadays. Amazon makes deliveries with drones to porches.

There's obviously some very interesting applications for aerial delivery when it comes to things like that. We don't have a crystal ball, so we can't predict exactly

which of the new technologies will reach their way to the field, but our job is application developers will be to create those tools for the aircrews to use to make those decisions when perhaps they're isolated and without communication. Every week it's about trying to anticipate what they need and provide that type of insight so again, they can make better decisions.

Paul: Then Jeff McCoy, my last question is for you, is what's next on the horizon for the Aviation Suite team in terms of new technologies and capabilities being explored? What can you share with us that isn't top secret or proprietary?

Jeff McCoy: As Jeff described, things are changing, technology's changing. The way we do airdrop today is going to change in the future. It has to, and when we have to be right there with it, like I mentioned before when the aircraft makes that first path to have to do a drop zone, that exposes the aircraft maybe unnecessarily. How do we enable them to just fly over once and understand the accuracies of the data so that they don't have to release that drops on in advance? How do we make sure that the winds are- that forecast that we have for the winds or the understanding of the wins is accurate, latest, and greatest, and represents accurately the area around the drop zone? Advances in technology is going to open new doors for us along those ways.

We're actively working on some of those things right now. We're going to need to drop to really small exact spots and locations on very small, tiny things, so even smaller than the drop zone rather, which could be the size of a football field or something. We're talking maybe smaller than that. That's where things are headed. In terms of technologies, I guess the other piece of it is more data services and web services. Our customer's moving into a different architecture for mission planning in general, where things are more microservices-based approaches to managing the data and serving the data to multiple platforms and multiple capabilities and tools.

We are working in that arena too, and looking at our code and where can we move some of our capabilities that are in our airdrop tool into these services based applications. Another thing that's happening is mission planning is evolving from the traditional, "Hey, before I walk out to the jet, I'm going to sit at my desk and plan my computer and draw charts and look at data." Mission planning now is moving into the cockpit, that planning doesn't stop when you close your laptop and walk out to the aircraft, things change, the weather's changing, the mission's changing, unexpected things happen. Really you want to be updating your mission plan all along the way through execution to include all of your airdrop parameters that we've been talking about.

We need to be able to provide situational awareness for the crew, enable them to update things, even if they're disconnected from the Wi-Fi that was in their office. All these things is where mission planning is going and what we have to do for our crew members, even handheld devices, is it a laptop? Is it a phone that they're going to use on board? As I mentioned before, user interfaces and workflows are hugely important. No matter what technology we use, we got to make sure that the user can use it correctly, and it's a constantly improving and refining effort on that. There's a lot happening in the Air Force in terms of its priorities and things are changing very much, and technology's changing a lot.

We are actively engaged with our user right now and our customer to move forward in the new arena that seems like it's coming here. The other thing we're doing in other areas is we also, JSEC is involved in not just airdrop, but we support a lot of aircraft platforms for air mobility command in the Air Force, as well as other platforms across the DOD, helicopters, cargo jets, air fuelers, tankers. A lot of what we do is load aeronautical data onto those aircraft platforms. It's not just airdrop data, it's also mission data, routes of flight, which airdrop has to interface with. What's my route of flight approaching that drop zone? How do I exit the drop zone? Where do I refuel before I approach that drop zone? Where am I going from point A to point B in the world?

That's the AMC's mission. We have a lot of, they call it unique planning components, UPCs as well as navigation database loaders that we work with our customers as well, similarly with the airdrop tools to provide capabilities for those platforms. A lot of this needs to be integrated, it needs to be seamless. A lot of our efforts moving forward are going to be having the right technologies and data services to integrate a lot of these capabilities so it's a seamless capability for the user from their office into the jet and back home again. We need to tie it all together for the warfighter.

Paul: Jeff McCoy and Jeff Cusato, thank you both so much for your time today. This is really fascinating and really appreciate you unpacking the science, and the skill, and the art that goes into managing aerial drops, particularly in uncertain situations. Thank you both so much for your time.

Jeff McCoy: Thank you. Thanks for the opportunity.

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