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Paul Thies: From pods mounted on the underside of propeller planes, to orbital sensor systems on the International Space Station, remote sensing technology is providing us with a host of amazing images and data points with applications ranging from precision agriculture efforts to disaster response aid. When it comes to the possibilities that remote sensing provides today's data scientists, cartographers, aid responders, and climatologists, seeing really is believing.

Hello, I'm your host, Paul Tis. On this episode of *If Win*. I sat down with Scott Stetson, division Vice President for Growth and Strategy at Jacobs, and Andy Eichelberger, Remote Sensing Division Director at Jacobs, to discuss remote sensing technology and how it can be applied to address a variety of challenges. Scott and Andy also shared how remote sensing can be used for sustainability endeavors, how it might be combined with other emerging technologies such as artificial intelligence, and how it may evolve in the future.

Scott and Andy, thank you both so much for joining me today to talk about remote sensing. I know Jacobs is doing a lot of great work in this area. I've actually seen the product that has been built to support this technology. I think it's really fascinating and it is really cool what you all are doing. Really looking forward to diving in on this. Scott, to start us off, can you tell us a little bit about what remote sensing is and what are some of the applications that it can be used for?

Scott Stetson: Remote sensing is loosely defined as collecting data from a remote distance, and generally speaking, it's used to describe the activities done from satellites or aircraft and also from drones. Andy's group does a lot of work with aircraft obviously, maybe moving into drones at some point. It's also important though to nod the head to the satellite imagery world as well because they all have very important roles to play. In general, applications-wise, they range from wide area coverage of whole regions to do things like forestry management or crop yield predictions, all the way down to individual parcels with drones where they're doing 3D models of a building or doing inspections of smokestacks and things like that.

Some people could argue that that's not that actually remote and that might not fall into the remote sensing category, but that's more of a nuanced discussion. If you look at really wide area collections, they're used for things, again, like oil and gas exploration. There are public service programs such as the 3D elevation program that the US puts on in order to give basically a public service of provisioning a 3D map for everybody to use. It's a pretty low-grade map, but it's another public service thing that is useful across a lot of industries.

Remote sensing results in things like Google Maps, for example, which combines satellite imagery and aerial imagery to generate the high-rise maps that we all like to use when we navigate through the cities. Then there's a lot of coastline monitoring opportunities and facility planning, a really wide range of applications. In general, you could say if any activity or any site has a geographic location, and most activities do, there may be an application for remote sensing.

Paul: Right now, it's mostly airplane-borne technology, but I guess what drones is it just really a matter of like-- I've seen like for instance, the pods that we use or that

Jacobs uses for remote sensing and, they're fairly stout so I think of a drone, I think as something maybe the size of a shoebox. I don't think it could bear up under that technology. Is it really just a matter of the technology eventually will get smaller and smaller and then a drone can bear it up, or?

Scott: There's a yes and a no to that. There's pure physics, which will really eliminate some possibilities. You're not going to ever get a very large camera system or mapping system on a shoebox-sized drone. Obviously, it's not going to work. Just like you're never going to get a large enough telescope on orbit to compete with what a drone can do from five feet away, for example, from a spatial resolution perspective. Then when we talk about the geo pod that Andy's group uses to go collect, there are certain niche areas where it outperforms both drones and satellites.

When we think about a remote sensing strategy, for Jacobs in particular, it's how do we use all different platforms and their benefits in terms of how much they can carry, how much area they can cover and what geometries they're most suited for. Those are the things that we need to think about as far as remote sensing.

Paul: Very cool. Then, Andy, so what are some of the most pressing challenges you would say that aerial remote sensing can be used to address?

Andy Eichelberger: One of them, given that it's remote, it's generally suited for things that are large in scale, that you can't be immediately adjacent to. When I think of what you want to use remote sensing for, I often gravitate to all our large-scale infrastructure. We've got a ton of infrastructure that is, whether it's a transportation network or a rail network or a city, it's of the scale that makes it very difficult to just keep tabs on. I think what remote sensing, especially the satellite and aerial scale once allow you to do, is to get some level of detail that is consistent and comprehensive of that entire infrastructure.

It can't be all things to all people. There are still going to be people driving trucks with lidars to go fill out the last street view level information, there are still going to be people with cell phones and iPads capturing additional things. What it gives you is that wide-scale that can stitch everything together to give you a cohesive, geospatially oriented index into your infrastructure. That's one.

I think maybe another I'd go to is, I think there's a lot of potential for remote sensing to add speed to our projects. Everyone would like our projects to go more quickly. I think it gives you the opportunity to find out about your site before you even have access to it, to accelerate the permitting and early phase design steps, and then you can refine it as the project goes on. I think it has a lot of potential to speed up the progress towards construction and then the transition from construction to as-builts and an O&M digital twin maintenance.

Paul: Then, Scott, so I'm thinking about remote sensing and how it's deployed and it allows us to look at huge areas of geography and track them and digitize them. Can it be used for things such as sustainability endeavors, I'm thinking like, for instance, going out on a limb here, like coastal squeeze? Maybe it's like you do flyovers of beachfront geographies to see, is it eroding, is the sea encroaching, that kind of thing. You can track that over time. Are there sustainability types of endeavors that you could see remote sensing being used for?

Scott: Absolutely. This is possibly one of the most exciting application spaces for remote sensing. Not just because it's a noble endeavor obviously, but because a lot of what we need to observe about climate change or ecological system change really is at the large scales that Andy described as well. Coastal resiliency, huge, we're developing a Lidar right now. For example, that could detect very slight changes in elevation over time as the coast erodes or as roads subside and maybe dip and crack with changes in the water table below them, things like that. His team right now has just finished up a project actually in the Midwest, which we do every year for precision agriculture.

One of the key objectives out of that work using multi-spectral imagery is to reduce the inputs that go into producing the highest yield and highest quality food. This is a food security and food sustainability project. The reduction of fertilizers and the optimization of water usage and the reduction of pesticides, or perhaps just the application of pesticides at just the right time and only if necessary, those things are directly enabled by what Jacobs is doing in the Midwest over millions and millions of acres of crop corns and things like that.

You expand even further out and look at satellite constellations like the ones provided by, for example, Planet. Their imagery is used over very wide areas to do forecast predictions for whole regions. It's done both in the US and in Africa and in other emerging parts of the world to do forecast predictions, to look at deforestation in areas where you and I couldn't wander in too easily, the Amazon, for example. Then other aerial remote sensing and space-born remote sensing capabilities can lead to biomass estimation and measurement for forestry. This list goes on and on, including ice cap production monitoring, and things like that. Sustainability is one of the really, really neat goals that remote sensing is almost uniquely able to impact as we move forward.

Paul: No, that's very fascinating. I'm sure that there's going to be no shortage of use cases that emerge here and that the years and even decades to come. Now, Andy, as Scott was talking, I was thinking about precision agriculture. I was thinking about topsoil erosion and about how the chemistry of the soil has been changing and new nutrition is depleting out, things like that. I've been wondering if there's ways to combine remote sensing with tracking on the ground and using emerging technologies to track how things are progressing in a certain area.

Precision Ag is just one area, but I'm really wondering, I guess more broadly what I'm asking is, are there ways to take remote sensing and combine it with things such as artificial intelligence, digital twining, predictive analytics, and that sort of thing to really take the technology in a whole new and exciting way and really ramp things up?

Andy: I think AI has done great things for imagery and remote sensing in general both at the drone scale and the satellite scale and everything in between. It's machine learning 101 practice to label some items in an image and then train your AI to find them. I think what is really interesting to me in this area is the grounding of those algorithms in scientific validity, engineering validity, which you can only do by proving their performance, by having ground truth and an understanding of what the scientist really needs to prove with that algorithm.

We're in an interesting phase there where everybody has their flashy demos and things. I really hope that companies like Jacobs can harness it to be a higher-end product, something that you can actually rely on scientifically. I think to be in the running for that, you have to have the expertise, the people in the field to check on things. I'm excited to be at Jacob's to watch that unfold. Then in digital twins, similar to my prior answer, remote sensing is good at large scale. There's always going to be something that can get more fidelity.

I think what's going to be really interesting for digital twins is how do you fuse those different scales together? How do you get an initial wide-scale view through your remote sensing but then keep tying it and updating it over time as new measurements come in that come from wildly different sensing sources and databases and stuff like that? That's the challenge, is, how do you move from a visual twin that might come out of your initial remote sensing into something that is usable and manageable and predictive over time?

Paul: Then what do you see, Andy, are some of the shortcomings that currently exist in the use of remote sensing?

Andy: I think probably the one that a lot of people would point to is practical large-scale UAS adoption and usability. Everyone's fairly aware that the FAA interaction with crude aircraft and passenger aircraft and things creates a real challenge for getting to drones that can fly higher than 400 feet. There are only so many things you can do above 400 feet. Then after we solve that, there's going to be a period where we have to figure out the cost. How do you get, at the moment, a large scale drone, which we have used in more military settings? They have a logistical footprint that exceeds that often of the crude aircraft.

I think it's going to be some time here till we really solve this. You probably don't see the big cost benefits of UASs workforce large-scale remote sensing until you have individual people being able to manage swarms, multiple drones. You can beat down the cost that is going the upfront cost that's going into all that high technology that you need to bring to bear.

Paul: Then, Scott, my last question how is remote sensing going to evolve in the future? Where do you see it going?

Scott: I think ultimately those challenges for the deployment of UASs will get figured out. The regulatory environment will devolve and it will point out that we're still allowed to fly around with very limited avionics, for example, just under regulatory permissions. That actually inhibits the deployment of UASs in some areas. Ultimately, that's going to impact remote sensing. On the space side, it's a very interesting progression. Back in the 1990s, the US government was trying to start to push the commercialization of remote sensing, which up until the previous decade we could say had been almost exclusively the domain of the US government and other allied governments and our adversaries.

Then SpaceX came along ultimately and really opened up the territory up in the low earth orbit in particular. We've seen this proliferation of low earth orbit satellites. The business model really changed such that now there are constellations of a couple hundred or more small satellites that sometimes provide, in a couple of cases, synoptic view of the entire globe every day at 3.7 meters, for example. That continues to go on, but I think what we are seeing trend-wise is a push for better and better resolution, actually, because the commercial industry has had a hard time extracting value in some cases from some of these, we'll say, lesser quality, but higher volume systems.

They have an interesting role to play, particularly back to that sustainability question, particularly in terms of total coverage of the globe and what large changes are occurring to the land masses. We're seeing companies like Maxar launch satellites that are getting better and better resolution down to 50 centimeters. Other companies are launching even finer resolution. There's a company called Albedo, which got plans to launch a satellite that they claim will compete with aerial imagery at 10-centimeter resolution.

Now, their coverage rates and their tasking and a whole host of other complications are going to make it such that they're not really going to compete with aerial imagery. It's a fascinating trend to see what was an explosion of medium quality, low quality, shall we say, comparatively from a technical perspective, pushing towards higher quality satellites. Then a really interesting transition has occurred with respect to synthetic aperture radar, which is a radar that is collected over a period of time and from which you can generate imagery where you don't need sunlight, for example, to be able to take images. That's a major difference.

Synthetic aperture radar can see through clouds, can operate at night because it generates its own energy with which it then actually produces the imagery through some very sophisticated processing. Over the past five years, there've been four or five different synthetic aperture radar satellite providers coming out. That's probably going to be persistent because they're the companies that can have a consistent view of, let's say, a port or the docksides for how many ships have pulled up, et cetera, regardless of the weather. SAR is very interesting.

Then obviously Andy just talked about artificial intelligence and machine learning, and that's going to be one of the consistent trends as far as implementation goes here moving forward. Really, having AIML guide what images are taken where based on what they've seen on the previous passes, et cetera. Then I think coming back down from orbit into the aerial domain, and this is where Andy probably has far more wisdom than I do to pass on about where the trends are, but there are more and more sophisticated sensors being built by companies that are trying to vertically integrate in many cases.

They're trying to combine sensor development with operations and AIML and analytics so that they can provide a full value chain, and really go after niche areas. I don't know. Andy, any other thoughts on aerial domain initiatives and trends?

Andy: I think that vertical integration is interesting and I think the next place it's going to happen is with lidar. I think that we've seen EagleView and now Nearmap bring a different business model to aerial imaging where they're out there collecting independent of customers and then selling it many times. I'm really interested to see where Lidar goes at the moment. Lidar has been held back by expense and by the data that comes out of it being unwieldy, very large, these point clouds. There's so much value there that as we find solutions to that, and I think we will, not only will people use it more, but I'm really excited to see how the analytics can develop around it.

I think there's a lot you can get from a point cloud, and there's even more you can get from fusing information coming out of a point cloud with imagery. You get the highest resolution 2D view from your imagery and the 3D representation of the object much better from the Lidar. It really just comes down to your analytics need that full picture to be able to do the same thing that your human brain can do in interpreting what things are and what their condition is, and all that sort of thing. That's what I'm excited about, Lidar scaling up.

Paul: Excellent, Scott and Andy, I really appreciate you taking the time to sit down with me today and talk about remote sensing. I think it's a fascinating technology. Especially when you can combine it with some of the other emerging technologies, I think it's going to be a real game changer. Appreciate you both spending time and sharing your insights today.

Andy: Great. Thank you.

Scott: Yes, thanks.

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