DANIEL MCKINNON: All right, well, it looks like the door's closed and people are getting settled. So let's go ahead and get started. I'm Dan McKinnon. I'm the director of product at 3D Robotics. We make a drone solution for scanning construction sites. And I'm here to talk about how that works and how that works with all these Autodesk tools that you've come here to learn about.

So I want to get a quick just background of this audience before we get started. How many of you guys are using drones right now? So probably a good half. And just to get a general flavor, who's using them just for aerial photography kind of marketing type purposes?

OK, and who's doing scanning and photogrammetry and things like that? OK, about half. And then is there anything else that anyone's doing-- inspection, monitoring things like that? OK, cool. That is awesome.

So I just want to give you a little background about 3DR very briefly. We were founded in 2009. This makes us a stegosaurus of drone companies. We've been around a really long time. This was the company that really kickstarted this DIY drones movement.

So the first products we made were parts and software. So these were autopilots that ran different types of boards, beginning with an Arduino and moving on to more advanced processors that anyone could buy and create this unmanned vehicle around our technology. So that was the software that ran the drone and then the autopilot that actually let you plug in all the motors.

And this was really cool because this 3DR core technology was able to power a lot, a lot of development and manufacturing of commercial drones. So we saw a lot of our platform partners go out and build these products and start to build this technology into these specific verticals.

That led us into 2012s, where we made this processor more powerful. And this was something that became more plug-and-play. And you no longer had to be a hardcore hobbyist and be able to solder things and write code to be able to get a drone to fly. That was this product called Pixhawk that's actually flying essentially every commercial drone that's not DJI today. So pretty much everything you see out there runs on top of this guy and our software stack that we built.

And then we started releasing some ready-to-fly vehicles, so this Iris product that was used in essentially every research lab all across the country, machine vision and monitoring, and different kind of control theory. We released a really cool consumer product about two years ago called Solo that let us get our technology into the hands of the mass market.

And then about a year ago, we released Site Scan. Six months ago, we released Site Scan, which is our solution for autonomous construction site-scanning. So you pull out your mobile app and you draw a shape around your site, and the drone will automatically go up and take a bunch of high-quality photos with this Sony camera, which is the best camera in the sky. And then the photos will get wirelessly transmitted to the cloud, where you can analyze them and the associated data products in the Autodesk stack.

And we're going to talk a lot about that today but just wanted to give you a brief background on us. We are by far North America's largest drone company. There's about 750,000. This number is actually from about six months ago, so I don't know what it is right now.

But there's about 750,000 vehicles running our code, the core technology we developed. And that's everything from the highest end commercial and delivery drones by some of the tech giants you're familiar with to low-end cheap toys that also have adopted this software stack. It's a really robust ways to power a drone.

We've got three pillars to our product that are pretty differentiated. We have the hardware, and the software and the support. And they're all stuck together to make sure that you're successful. So this is the hardware right here. This is our Site Scan with the Sony camera right here, which is a 20 megapixel APS-C sensor that carries a very high-quality aberration-free lens.

We have the software, which is the Site Scan software we'll go over today and talk to how that goes into these Autodesk work flows. And then we have the support. We have an awesome support team that gets connected with every customer and activates new customers and walks them through every step of the process, because I know that drones can still be a little intimidating. And people are people are just dipping their toes into the water.

We're a really close Autodesk partner. All of our software works seamlessly with the entire Autodesk stack. All the results push into A360 Drive. We're doing work with the BIM 360 team to make sure that the drone data can move seamlessly in and out of those field products.

We're using the reality capture photogrammetry engine that has a booth on the floor. And we're using some of the design automation tools to make sure that your designs can get onto our system and you can use them to, say, fly the drone or analyze your data with them afterward. And we'll talk about that in a bit.

And finally, we're a Forge Fund portfolio company. So Autodesk Forge, they announced it at AU few last year. It's this movement to get all of their products available as web services online. So it's a really, really cool idea. So all of these desktop tools that you use, maybe your workflow-- I've seen this a million times. Your workflow goes from 5% Civil 3D to 10% 3ds Max. And then you push it back into Civil 3D and you export something. And then your final sheets come out in AutoCAD or Revit or something like that.

I've seen a lot, a lot of this. And what Forge lets you do is take those pieces from each one of these products, have them online, available as a web service, and then build a nice flow together. And so that's, to some extent, what we've done here.

Oh, no. I absolutely hate using PCs. So just briefly to recap what it is we make and where we stop with Autodesk is we make the hardware. So we're a full-stack drone company. The drone itself, at this point, is just a piece of plastic or piece of metal or carbon fiber or whatever with four rotors. There's nothing particularly interesting about a drone these days.

It was a big struggle back in 2010 to get these things to fly. Now it's not a struggle anymore. Anyone can get a drone to fly. What you need with your piece of hardware is a really high-quality camera so you're able to create the crispest, sharpest, most precise and accurate data products using this drone.

So again, this thing flies itself. It flies by itself, and it takes these 20-megapixel APS-C sensor. So an APS-C sensor is a very, very large sensor with a high signal-to-noise. And it takes these images of your site.

We have a mobile app that's used to control the drone. So anyone not even particularly familiar with technology in your field staff can go out and use this. In this case, our ideal user is the site superintendent who, depending on the site, may or may not be a technology enthusiast-- likely not. And we've been out on site with dozens of these guys, and they pick it up and they use it just like they would any other iPhone program.

And what we're going to talk about a lot today is how you review the data and what you do with

the data from the drone, because that's the most critical thing. The ability to take really high-quality pictures, that's awesome. The ability to have a smooth workflow where the data transmits wirelessly from the drone to the cloud, that's awesome. The ability to make it easy to fly, that's awesome. But where the real value lies-- and I imagine why you're all here-- is to talk about what you do with the data.

Another quick question, how familiar is this audience with Part 107 and new regulations? OK, cool. I want to really briefly touch on that even though it's not totally related to Autodesk workflows. But this is super important when it comes to drone stuff.

So about a year ago, the FAA decided that it would be wise to remove their blanket ban on flying drones commercially and implemented what was called the Section 333 process. So to fly a drone on your construction site, you had to fill out probably a 70-page document. And then you had to have a private pilot's license that was later lowered to a sports pilot's license. There was an incredibly high barrier for flying one of these things on site.

Just to give you an example of the insanity behind that, you actually don't need a private pilot's license at all to fly an ultralight aircraft with less than five gallons of fuel. So they were really imposing some serious regulations on this. But the FAA realized that this is the future of America. And by this, I mean new technology and new tools to increase our efficiency and let us build better.

And in August, they said, we're going to scrap that, and we're going to change. And they issued something called Part 107. And now anyone can go and fly a drone commercially on a construction site after having passed a 40-minute test on knowledge about the national airspace.

So we as a company were really happy about that. You all as drone users should be really happy about that because you can get the guys in the field who will be operating the drone. You can send them to a two-hour long seminar about the national airspace. They can go to an airport. They can take the exam. And then they can be totally above ground using these kinds of technology on site.

Oops. What is going on? Cool. So I want to talk a little bit about why the construction industry. We're a drone company. We're here. Obviously, Autodesk is a very close partner. This is somewhere we've been working for about two years right now.

And I was hired about two years ago now to start 3DR's enterprise products group, so determine, what are the types of products that we could sell to commercial users? We had sold to hobbyists. We had sold to consumers, and we knew drone technology could be used for many, many applications in the commercial space.

My background before that-- for about two years, I ran a company that did surveying in agriculture using drones. And so that was the natural, at that point, thought, at least by our CEO, what we would do for a product.

And I spent probably three to six months on customer discovery trips. So I visited mines. I climbed cell towers. I inspected roofs. I went to farms. And I really wanted to understand what were these pain points that existed in these various industries that could be solved using drones.

And construction was the one that really leaped out at me. Where every single other industry, it was-- this is a cool toy. I need to see if I can figure out how I can justify getting this onto my work site. Whereas construction, it was like, oh my god. We need this right now. We are so information-starved. These data that come off this drone are helping us make decisions today.

A couple of stats that some of you are probably familiar with-- construction's a $8 trillion a year industry but has horrendous margins. Those margins are totally eaten up by things like rework requests and little surprises that come up. McKinsey just released an awesome study. It's called "Imagining Construction's Digital Future." It's really, really good. I highly recommend you all read it. It's probably the best document I've read about the future of construction.

And they studied the top 20 construction firms and their major projects. And what they found is the average project had an 80% cost overrun and a 20-month delay. This is insane. And in that same study, when they analyzed the European sector, they found that actually one in three of these European companies lost money last year because of these things like cost overruns and rework requests.

But based on this journey, we think that we can help. And a lot of this cost overrun and a lot of these delays are driven by the starvation of information. Let me elaborate a little bit more deeply. On this background, this actually isn't showing up that well, but this is the plumbing plan for a fairly complex commercial building. And you can see that individual sections of plumbing, individual pieces of trench work, are just highlighted, and they're signed off by the super's name.

So his workflow is he would go out multiple times a day. Obviously, there's many subs on site. It's a $100 million project. He'd go out with this plans-- and this is what we've seen replicated over and over again-- and say, OK, well, that looks like that trench is there. That looks like that trench is there. I'm going to sign off. And let's continue to move forward.

What you all are intimately familiar with is that just because you've got the plan in your hands and you see the trench right there doesn't mean the trench is dug in the right spot. It doesn't mean it's dug to the correct depth. It doesn't mean there even should be a trench there at all. And unless you have a survey crew sitting there right next to you when you're doing all this work, you actually have no idea. This is an approximation of what's going on.

And it's seemed crazy to me at first, but now this is something that I've become very used to and have worked a lot in this industry now is how these monster projects are just being run with pencil and paper. This is something that is super, super unfamiliar and would really like to help out and change. So it's a monster industry.

There's some clear issues with how they get information from the site back to the office and back to the site. And we think we have a solution that they can help fix it. And again, this is using all of the drone tools and Autodesk tools that are here today.

So how does this work? You collect the data. And likely, this is your superintendent on site. It could be a project engineer. It depends on the level of technology enthusiasm on your site.

This user goes out every morning in the site. And he's or she has a helipad painted out. So it's a very repeatable process. There's no guesswork. There's no questioning. Our success services team helps set up the optimal workflow.

The drone is placed there. The iPad is pulled out. You pull up a previously flown mission. So you can use the mission that was flown yesterday and the day before and the day before and fly the same thing every single day. So you make sure the data are repeatable and precise and consistent every day.

Presses Go. This is literally two taps on an iPad. That worker, because of these FAA regulations, is actually required to stay there and keep an eye on that vehicle. But this is generally a 15-minute flight for an 30-acres or so construction site. You might need to do two flights for a larger site. But generally, they will get covered in one battery.

The imagery is wirelessly uploaded from that camera up into the cloud. This is a really, really powerful feature that, because of this partnership with Sony, we can do and none of our competitors can. There's no SD cards. There's no data management. There's no pulling things out.

It goes straight from the camera to the iPad, and then once you get an internet connection, up to the cloud, or onto your desktop if that's how you prefer to do it. So this is something that eliminates the super finishing flying, forgetting to tag SD card, forgetting it somewhere. So the data is just-- it's a seamless pipeline from the site to the cloud.

And then within Site Scan Manager, we have a number of different analytics workflows. But also, we've built this pipe directly into the Autodesk platform. So all of the data go into A360. We're working on pulling data in from BIM 360 Glue so you can bring your same coordinate systems and your models in, and also being able to export back out to Field. But for now, all these desktop apps do a great job of helping you analyze the drone data.

So I just briefly want to show you what this workflow looks like in a video since I can't fly the drone in here. This was actually filmed by our mobile engineers, which was really cool. Actually, they released 1.0 in the app. They thought they'd have some fun at this aggregate yard right next to our office. And they asked me to be the actor, so I apologize for the horrendous acting.

But basically, you just open it your helipad. You pull it out. And you spin the props on and turn it on. And then the mission planning is done through a really simple polygon. In this case, I didn't re-fly a previous mission.

You're given a checklist that makes sure that the drone is ready to go and you know exactly what the state of the vehicle is. All the individual photos are assigned so you can make sure you're repeatably taking the same photos each time. After the survey is complete, they're wirelessly transmitted to iPad. And then you can review them there.

And then you go home. So it's a super, super simple workflow.

This was probably five to 10 minutes of work every morning for the super. And then what you get out, once you've finished that step, you get four different data products out, all of which you know how to use. And you know how to use them in these BIM or VDC or design tools that

you use.

So they're really, really high resolution orthorectified imagery and imagery elevation models. So these are great for, say, pulling into Civil and using as a base map, for pulling into InfraWorks and doing your virtual design-- I'm going to run through that at the end of this class-- for taking measurements, for verifying progress. We have some tools built in our web app I'll show off in a second that will allow you to do this.

You'll also get a 3D mesh. And again, these are all in these nice Autodesk formats as well. So you can do everything from create beautiful visualizations for a proposal to take simple measurements off the meshes, which we'll take, to even putting them in a virtual reality world. So there's actually a presentation by my colleague Brent this afternoon, and he shows how you take these meshes and you put them into a virtual reality world for a project proposal.

And there's actually a great story from one of the Autodesk strategic account guys in Australia who talked about how his client was actually able to win-- it was a monster job. I think it was a $200 million public transit job-- because they showed up with their designs and their project portfolio using a VR rig. They showed off how this project would really look to that client. And then their competitors showed off with a stack of blueprints, and they won this job. So these kinds of technologies I think are going to get a lot more traction in the future.

And there are, of course, point clouds that you can do all of your design work off of. And then we also export contours that you can use for your Civil papers.

So now let's talk about specifics. What do you do about this? So our customers are using Site Scan at essentially every stage of the construction process. And we're going to go through a quick example of each one of these. Actually, I should make sure that we have time to do this.

And the first step is this estimation in BIM. So this is-- actually, I was just with a customer on site. I go on site probably about once a week to make sure that I'm really up to date with what our customers are doing and what are the features that they want coming down the pipeline. Estimation and bid, this is a super, super classic use case for a drone.

I'll just describe what this customer is doing in particular. And I think you will all empathize. There was a large parcel of land-- this was actually residential-- that his client had purchased and was sketching out some different design ideas. This was a super wealthy homeowner that wanted a very, very nice custom home.

And this customer didn't have the updated survey data. He didn't have the updated aerial imagery. And the customer, the client who was building the home, wanted to know how imaginative they could get with their ideas. He wanted to know, if I put this little tower here, what would my view look like out of this two-story tower that they're building, this little view post.

So what this customer did was actually scan the drone and then took some manual photos, and put together a really nice package that was a proposal of the actual topography, so the existing conditions, with a Revit model on top of that so you could see exactly how that Revit model sat in the real space, and then in addition, augmented that model with some photos from the drone from various windows so the client could see what it would look like in the morning looking out this window. And this is an ongoing project, but we see this all the time where you can use this technology to capture a 3D point cloud of the existing conditions and then build your design on top of that.

Earthwork-- so very early in the process when you're moving around all this dirt, this is actually a very standard use case for drones. And I think this is going to become universal in the very, very near future. Instead of having to generate your own contours or do some kind of aerial photogrammetry or other techniques to generate the surface model, you can do this in 10 minutes with a drone. So you can build a point cloud.

From that point cloud, you can filter it using some tools in InfraWorks. You can generate your contours. And then all of a sudden, you're able to calculate your cut and fill zones. You're able to understand the number of volumes.

I recently had a-- I believe it was one of our audience members last night was talking about how they were paying by the truck for earth to get moved off site. And they wanted to make sure that they were filling those trucks up all the way to the brim. And you're able to see how much earth you're moving around.

I was on site with another customer and they had done a huge sewer line. This was maybe a half mile long sewer trench, big sewer main. And they excavated a lot of earth. And they had no idea how long it would take them to get rid of all that earth so they could proceed with the next step of construction until they flew with the drone. And then they determined they had, I don't know, some tens of thousands of cubic yards-- I don't remember what the number was. And then from there, they calculated exactly how many trucks they needed and exactly how

long it would take them to do that.

Maintenance and inspection, this is another totally bone simple use case that our customers are using this product for. If there's something high up and you need to take a picture of it, you need to understand, is your glazing getting installed correctly? So in this case, there was recently a story. It was actually all over in the news in Texas. It was pretty cool.

Austin commercial is building a new skyscraper in Dallas-- super confusing. And they were installing the glazing. And has anyone done vertical construction here? OK, cool. So they've got the swing stage. I believe it cost them-- correct me if I'm wrong. I think they said it cost them about $20,000 to drop that swing stage every time.

This-- sorry. For everyone else, the swing stage is, it's basically the swing that comes down, the windows that you're putting against the structure of the skyscraper. And there's a gasket that sits around the windows. The building has to be sealed. The building envelope has to be sealed. And it's actually pretty hard to get all of that right.

And what they'll do is they'll inspect it from the inside, but they really need an exterior inspection to understand if it was done properly. And what these guys were doing is actually replacing a lot of their swing stage drops with a simple drone inspection and being able to check off that windows were installed correctly. And then, of course, this goes to equipment on the roof and ongoing maintenance. So there's tons of great user stories there.

Preliminary design, this is also awesome-- is you can take these existing conditions and you can just bring them into your designs. This can make sure you're not introducing any clashes, any kind of massive earthwork changes that need to be done. This is another area where drones and reality capture, whether it's an interior renovation or an exterior building, will absolutely change the way that construction is done.

And finally, progress-- this is my favorite one right now, because this is the one where we have customers calling us up, saying, I can't actually do my work without this product anymore, which as somebody who is running product is super, super powerful. And the ability to track your progress and make sure that it's going according to plan is something that I'm going to show off first.

So now you've gotten a central overview of these. So I'm just going to go through some simple examples of all five of these workflows, some of them in Autodesk tools, some of them in our

tools. And yeah, [INAUDIBLE].

So first we're going to talk about progress because this is my favorite one. So Autodesk, and by extension, us, has this model of a model and a site. So the model is what lives inside Revit, which lives inside Navisworks. And then from there, you export these layers of CAD files. And that, in theory, determined what happens on site.

So any modern building is done with all these BIM techniques. This is why we're all here. And ideally, your clean model that is clash-free and everything is placed according to plan is totally translated onto the site. And that's actually not the case at all.

What happens, as you all know, is this model actually doesn't always get translated right to the site. The site is messy. You're walking around on site. You're not actually sure if an individual piece of the model is placed properly. You're not actually sure if this is going according to plan.

And then you sort of have this arrow back into the model after something is built on site. So there's this iterative process. So just to provide a concrete example, this looks like this is a picture of a trench study.

So here, you go from this model. This prescribed some kind of-- in this case, this was some heating work. The model prescribes that there's a trench next to this foundation and there's a pipe that is actually designed to heat the foundation that's laid in there. And then you see that, from the ground, that that pipe may or may not be installed properly. It's really kind of hard to tell.

And then it gets signed off. Perhaps you're using digital tools, like BIM 360 Field. Perhaps it's a pencil-and-paper workflow. It depends on the individual site. And then that gets fed into the model.

If some kind of aberration is determined-- maybe the trench was dug in the wrong place, or maybe there wasn't a heating pipe going through the right sleeve in the foundation-- then the team site will either make a decision. They'll say, we're just going to leave it like that and we're going to put in an "as built." So then they'll go back to the office team and say, OK, we actually built it this way.

Go ahead and change the model. And then you can update all future clashes for the next generation construction. Or say, OK, we have to fix it. But this bottom arrow is really, really broken. It's not clear how well that site gets translated back into the model.

But what we wanted to build is this tool that would let that bottom arrow get completed for this construction progress monitoring use case. So the idea is that you can press this one button to measure this world so you can manage it. So this actually isn't a construction use case, but this is a stockpiles customer.

They have all of these different stockpiles. They have no idea what's going on. Their resource management system was a mess. It was a total estimate of what kind of resource they had on hand.

And then every day, they click the button. They scan the site. And all of a sudden, they have a nice point cloud from which they're determining all their volumes, and they're actually able to do their accounting right. So we wanted to apply the same thing to site monitoring.

And this isn't just us. This is many other people who believe this. So PCL is one of our favorite customers here. Bill Bennington, who's probably here, who I haven't met. Is Bill here? He's not. OK, somebody from PCL was on the audience list.

I wasn't down here for this one, but they're just saying, the quicker you spot this stuff, the quicker you can change your model, the more money you save. And this is something we've seen again, and again, and again.

An Autodesk testimonial-- actually, it doesn't mean that much. But Aaron is my friend who runs the recap team. And he came up with this nice moniker, which of course plays nicely into recaps strategy. But "A scan a day keeps a change order away."

And this is true. This is really true. Because if you're able to get this reality of your site, whether it's with lasers or UAVs, every day and compare it to what you're supposed to be doing, you can catch these mistakes so, so much faster. And we'll go over some specific examples coming right up.

So again, the idea is that we're actually building this bottom arrow. So the model prescribes something. Something gets built on the ground that is ideally a close representation of what we'd like to get built but sometimes can be dramatically off. For example, here we're showing a clash. Then this feeds right back into the model. And you can do this all with a drone by clicking it with a single button.

So this workflow is throw down your ground control points, which is you either can set it

yourself or use ground control points that are used by existing surveyor. This is actually a really important point to make when it comes to UAVs is probably the number one thing, aside from passing your Part 107 test and general knowledge and things like that, a determining success in using drones in your job site is using ground control points.

This allows you to get from an accuracy of sometimes several feet off in terms of both absolute and relative, meaning this point is actually right here on the ground. Or I can take a measurement between two points on my site, and I'm guaranteed that that's going to be within about a tenth of 1%. Both those numbers need to be good, and you need ground control for those.

Site Scan every day. And then the last piece here is to overlay this imagery with your CAD files, so pulling your piles straight from your architect or straight from your designer, and then making sure that they overlay with what's going on. And I'm just going to go over a couple quick examples about that. OK. Actually, I'm not.

This is how it works, is these images all get sent up to the cloud. These are all individual images of this construction site. They're sent off to the recap engine. We're using actually a brand new version as of last week of this engine. It's really, really good. So I've been super impressed with the progress there.

And then these are turned into-- in this case, I mentioned we had the orthos, the meshes, the point clouds and the contours. In this case, for this use case, these are turned into the orthomosaic image. And then from there, we actually are able to pull all of your plans into the same reference system.

So this is something that we've built and no one else has built before, which is really cool. It's taking these vectorized design files and then pulling them into the exact same coordinate system as your orthomosaic imagery. So what this lets you do, all of a sudden, is compare this site to this model in a really, really easy nice way.

So this is within our web app. You can immediately see what might be a deviation from a model. For example, this footing is not poured correctly. This is a real site. And this is something that really had to be corrected.

And when we first started doing this, the response that we got and the response that I gave was, well, this isn't right. This plan isn't right or this footing isn't right in terms of the photo.

These actually just aren't lining up correctly. This is an accurate enough to make those assessments.

But every single time, initially, we bring surveyor out. We would check this. We'd bring tape measures out. We would check this. And yeah, it's right. This is a real tool that you can get couple inch, low, single-digit inches precision. It depends on the quality of your ground control point.

But in this case, we measured. We were a couple inches off here. But this is a 7-inch overpour right there that was going to lead to a big clash with the heating pipe. This pin actually in the center-- you can't quite see it on this screen-- was misplaced. And they actually had to saw off those threaded pins and have a plate come in and slide them over.

But this is real. All of a sudden, you're able to get-- you took 10 ground control points, and you're able to multiply them by basically 10 million. And you've got a 100 million little survey points on your site that you can say, is this particular object in the right spot? And that's just what it looks like in the app. Let's talk about a couple just little use cases.

This is the same site right here. That's actually the same footing right there. And what happened is they didn't fly before they poured the concrete. Actually, one excellent lesson today is, always fly a drone before you pour the concrete. The number of errors that we've seen where from tens to hundreds of thousands of dollars of cost overrun is added because of bad concrete pours, it's crazy.

And these forms aren't quite lined up right here. So this led to this overpour, which led to the sub who was about to put in the heating pipe here saying, I can't do this. There's a concrete footing in the way. I actually can't dig this trench. Then this sub has to go to the super on site, who is juggling a million other things, and he has to drop what he's doing and then now figure out what's going on with this footing.

The survey crew isn't on site. So he has to call them back. They couldn't come back that afternoon. Come back this morning. And just this little tiny thing ended up dragging the project back about two days. For this particular project, they said that was about an $8,000 a day mistake. So just this little guy right here was about a $16,000 mistake in labor alone by keeping this from going.

In this case, the surveyor came out and said, yep, that's right. That heating pipe is actually

surveyed correctly. This is right. This footing has been overpoured by about seven inches. The cement sub had to come back in, cut that footing down so the next stage of construction could begin.

This is a relatively minor issue. But this is something that-- you just overpour your cement a little bit. This happens all the time because you're not surveying all four corners of every single footing. You just say, OK, there's the center. And then they'll measure three feet out from each one. And just a little, little things happen like this. And oftentimes, they don't matter and it's not a big deal. But in this case, they did.

There was another much more major issue that was on this site the same day. This is actually the top-down view of that pipe I showed in the earlier picture where I said the site was messy. And it's extremely obvious what's going on here when you're looking at it using Site Scan and overlaying the ortho and the plans, but it's actually not obvious at all when you're on the site.

So when you're on site. You're walking. You see that-- let's see. I don't know how this thing works. You see that there's a slight bend in that pipe right there. And it's kind of bending around this footing. And there's two sleeves that that heating pipe must go through. There's the sleeve through the foundation wall here. And there's a sleeve through a wall that's not on the picture right now.

And it was prescribed to go through the sleeve closest to the footing here and the sleeve closest to the footing on the other side. But what that yielded was this weird bend in the pipe. And that was troubling. But what was even more troubling is this heating pipe had to, by law, be within 12 inches of that concrete foundation. The reason is that there's a minus 20-degree freezer that's going to sit on top of this slab they're about to pour.

And this is built in the south. And when it's hot and you have something cold on top of it and you're in a really moist climate, that's really, really bad for concrete foundations because you get this freeze/thaw damage that can take down the building. And you have to actually build this heating system underneath the freezer to keep the foundation above freezing at all times.

So what was really troubling is this heating system was three feet one inches, not 12 inches from this foundation. And no one could figure out what was going on. This had already caused a three-day delay, which again, just based on labor rates and stuff, this is about a $8,000 a day mistake. And everyone thought they were doing the right thing. The heating pipe was going through the right sleeve on both ends, but it had this weird bend.

And then what happened is after this customer flew this site and after they overlaid the plans, it immediately became clear. So the pipe was supposed to go through where the green line is right there. And there was actually a concrete sleeve underneath the footing overpour.

So everyone did what they thought they should do. The heating guy put the heating pipe through the sleeve that was closest to foundation on both accounts. Everything was surveyed correctly, but one little overpour-- here, they didn't catch it immediately like they did before-- actually lead to a cascading series of errors.

And in this case, this was left uncovered while construction all around was proceeding. And this little piece of the project was delayed. And the second they flew Site Scan, they actually printed this out and they went out to the different trades on site and said, we need to fix this right now. And they did. So after one flight, it was pretty cool for me to see them fixing that.

And then the final one, this is also from this same day. This was one day, and this was a really nice site too. We've seen ones that are far worse. It's just like the little things, is this trade right here, this plumbing trade, the pipe is supposed to go here. The trench was dug like this. He gets here, and he says, I don't actually have that curvature of pipe. I can't do that.

So here, it was spotted immediately that it was resolved. It was like, OK, this trench was just dug incorrectly. We have to come back and we have to dig a new one. But these are the kind of things that you can see using aerial imagery and plans.

Cool. So that was the progress one. Now I want to talk a little bit about the earthwork one. And how many of you are heavy Civil users? Cool. Well, I'm not going to use Civil because I'm not a heavy Civil user and it's really hard to use. But you all know that you can bring these point clouds into Civil and do all of your cut and fill zones and your topographies and things like that.

But what I want to show is just a little demo using ReMake that's a much easier way to get at a similar result. So let me get out of here and go into ReMake. Has anyone used ReMake before as a tool? OK, yeah. Cool. So it's basically Autodesk's super simple mesh editing and mesh visualization tool. And it's a nice way to fake some of these Civil workflows.

So what I have right here is I actually have a coal plant in Missouri. There's a power plant right here, and this is their stockpile. So while this isn't technically an earthwork use case, the principles that are involved in this are essentially the same as what you would use for heavy

Civil earthwork.

So this coal plant-- and this is something that is always a little confusing for me because they know how much coal they're ordering and they know how much coal they're burning, but somehow, they have no idea how much coal they have. So actually, they'll survey this pile every now and then. And they want to determine what the volume of this pile is.

So I'm just going to go over how you would do that. So this mesh right here was generated from the drone data from Site Scan. And what we can do using this tool is we actually can just go ahead and select what we want, which is just basically this pile. OK. Oops. OK. This is being really slow right now. Oh, there we go.

And then we can invert the selection so we get rid of everything that we don't want. And then now, now we're left with basically this pile. And when we have this pile, there's a bunch of nice little measuring tools built into this. So I want to know how long my conveyor belt is. That's a 60 meter long conveyor belt. If I want to know what an area is, I can do that.

But in this case, these guys are interested in volume. So what you have to do is actually fill this whole coal pile with something. So this is the same as setting that bottom plane in Civil. So you can take this and you can-- let's transform our plane here. And then you can make sure your base plane is roughly level. And I'm actually not going to do a great job at this because there are some pretty serious lag on this computer with the display attached.

But we can go ahead and slice this and apply that. And what we're basically doing is we've got our top surface that the drone has generated. And then we're putting the bottom plane. And then we're going to calculate how much volume is between these two surfaces.

And we're going. I have a feeling my hard drive filling up might be contributing to this. And this is something that initially-- OK, cool. So now we got it. And I didn't quite get rid of everything. So let me just get rid of these guys, get rid of these guys.

And then now what we can do is now that we have this pile-- and if we wanted to be more careful, we of course could do a better job and we could grab subpiles or whatever. And we can just go and we can select it. And we can run our measure report. And this is giving us a 103,000 cubic yards.

And we've done this a million times with a bunch of different tools with comparisons comparing with traditional survey and laser scan. And it's like spot on. It's really hard to see which one is

right and which one is wrong because we've actually never done this totally calibrated where I have some dumptruck full of 1,000 cubic yards of material. Of course that wouldn't work because of settling and all this stuff. But these kinds of volume measurements will only deviate within a couple of percent of both a laser scan we've done for comparison, and then traditional survey, and as well as all the techniques that you all are familiar with-- rule thumb estimations and conical approximations and things like that.

So this is my ReMake demo for volumes. And another thing that's really cool in ReMake as well is you also can use this tool to create some of these pre-visualizations and some of these presentations. So one thing that I really like using ReMake for, and a lot of our customers do as well, is the ability to export a video.

So what this is really cool to do is you can open this mesh that's generated right off the drone, and you can do a fly-through video. So this one is a turntable. This one might be nice, but I think these are actually less helpful, is-- oops. There we go. It makes me wait the full 15 seconds. But you actually can select individual keyframes and fly around this model just like it were something real on site.

So you can say, I'm really interested in this particular pile here. Again, a dirt pile isn't exactly the best-- oh, no. This is a screen that I see far too often. OK, well, you're just going to have to take my word for it. You can make nice videos with ReMake.

So now let's talk about the next example, and that's the estimation and bidding phase. And this and the preliminary design are oftentimes linked-- is you need a preliminary design to do your estimation and bidding. Your customer's going to ask for an estimation and bid when it comes to preliminary design. But what we're able to do right here is we're able to take the context and the existing conditions of a proposed project and put it into this digital world, whether you're doing it in InfraWorks or whether doing it in Revit, and be able to deliver that to the clients.

So what we're going to show right now is how this works with InfraWorks. So let's go ahead and fire up InfraWorks. And I'm going to just kind of skip over a few things regarding the import of the data. It's very simple. There's actually a tab in here for A360. You can just go straight from your account, so basically go straight from the drone into your A360 account.

And just going to show off a few little examples of what I did with InfraWorks and how this works. So staying with this coal plant example, just because I think it's kind of a funny one,

what I did here was I actually built a model with InfraWorks. And this is going to be my proposed new development for actually a row of hipster coffee shops in Missouri, because I don't think they have enough of those.

So what I did here was I took the existing context for this area. So you can see our power plant is right here. This is actually the Mississippi River. They're actually draining from this coal plant right in the Mississippi.

And I took the latest orthophoto and digital elevation model, and I overlaid it. So when their building this development of coffee shops, they'll actually be able to use the existing conditions of the site. So they're dumping coal onto this pile every day, and they need to make sure that they actually can build these coffee shops correctly according to plan.

So then what I did was I put together my proposal right here, which is I want to build a road from this existing infrastructure, this rail track, to this existing road right here. And I'm actually able to then show what my row of coffee shops will look like here on the real topography and the real terrain model. And obviously, this is a silly example and I'm not an InfraWorks expert, but it's really, really powerful to be able to show what your designs look like in the real world when they're scanned by that real world.

So right here, I would be able to deliver this vision to the client that we're going to build all these coffee shops on this coal pile with the actual state of the world that day relative to now here's my Google Earth tile and here's this old survey data I have. And this is approximately what it's going to look like. I actually know, with a pretty darn good approximation, how much work it's going to take to get all the foundation work for these and all the cut and fill down on for these coffee shops. And I can give a pretty good approximation for the client as to what that final project is actually going to look like.

And next, I want to talk about maintenance and inspection. And this one is great because it's really simple for you and it's really easy to deliver this powerful imagery from the drone. So I'm continuing with the coal plant example.

These are actually some images that were just pulled off the drone after this autonomous flight. And in this case, I wasn't on this particular visit but they were really interested in looking at the state of these stacks. And the reason that they were looking at the state of these stacks is that there's really, really hot gases coming up through that.

This is a coal power plant. They have very expensive scrubbers that live inside these stacks, and they're operating in extreme environments. And this plant actually needs to get shut down once a year to be inspected.

These really hot gases are really hard on materials. There's some nasty chemicals inside them, and they need to make sure that there's no cracking and there's no damage to these stacks. So what they do when they do this is they actually erect scaffolding and go and inspect it by hand.

But what they're able to do now, they think-- this isn't a real program for this particular case. This is a pilot. But they think that they're going to be able to reduce the frequency of those manual inspections by looking at drone photos like these two. So they're actually able just to look right down the barrel of the stack to inspect it inside and out. And these are things that basically just come for free with flying an autonomous vehicle with a really good camera.

So finally, I want to talk about preliminary design. And this is being able to take your model and put it a design tool like Revit and build something based on that tool. And since I'm running out of time, I'm going to basically totally fake this one and just open up a silly project that I already have and just show it to you guys. Where is my project? OK, we'll try this guy.

And again, sticking with the coal plant, I decided I wanted to build a mansion on top of the coal plant. And so I just did a very silly, rough design this morning that actually looks terrible. Uh-oh, this is coming back to haunt me right now. I'll try this one.

OK, since we're running out of time, I'm just going to stop and take some questions. But it's really nice that you can take the point clouds. You can put them into Revit. And what I did is I basically set all of my levels in Revit at various different places in the point cloud. And what I was able to do is-- I'm nothing even close to a Revit expert-- is I was able to build a pretty nice house that actually would penetrate into the back of the coal pile and was able to match that topography in a way that you really couldn't do unless you had the latest point cloud.

So let me turn it over for questions. Thank you all for listening, and it was really nice to share all of this. Yeah?

AUDIENCE: How do you deal with participants and non-participants on a construction site?

DANIEL MCKINNON: Yes, so that's a great question. So the question was, how do you deal with participants and non-participants? And this is specifically referencing something in the Part 107 rules about,

you can't fly over people who aren't participating in the operation.

What I have told clients to do-- and I can guarantee that they're doing it because I'm not on site-- and what I've done when I've been on site is just fly in the afternoon. So typically, you fly at 3:30, and there's no one on site.

When it comes to more complex projects, like that Austin commercial skyscraper, we actually sent out a notification. And it was just, if you're not a participant in this operation, you shouldn't be on site for this 15 minute window. But that's super rare. Usually, finding a window, either very early in the morning or in the afternoon, to fly has not been a problem. Yeah?

AUDIENCE: What file type did you get for [INAUDIBLE]?

DANIEL MCKINNON: Yeah, that's a great question. So Autodesk is in this strange position where they're this CAD company that's got a really strong background there and they're slowly moving into GIS with tools like InfraWorks. That particular file was a georeferenced GeoTIFF and a georeferenced digital elevation model. Are you familiar with the digital elevation models? OK, cool.

What you also can do to get the topography information is import the point cloud itself. What happens, though, is-- what I think you're getting at is that the RCS point cloud file format for Autodesk does not actually include the GIS information, which is heartbreaking. They say they're fixing that.

And what you can do, as a workaround, is there's a little text file that comes with every single point cloud that we generate in our product, and it has the GIS information that you copy and paste into InfraWorks. So if you want, after, I can show you some that I've dropped in that way. It works pretty well.

AUDIENCE: Awesome. Thank you.

DANIEL MCKINNON: Yep. Yeah?

AUDIENCE: [INAUDIBLE]

DANIEL MCKINNON: Yes.

AUDIENCE: OK. Does it use all the [INAUDIBLE] as well as the [INAUDIBLE]?

DANIEL MCKINNON: Mhm.

AUDIENCE: It does?

DANIEL MCKINNON: Mhm.

AUDIENCE: OK. [INAUDIBLE] accuracy of your data [INAUDIBLE]?

DANIEL MCKINNON: Yeah, so we have a pretty in-depth technical paper up showing all the different ways you can do it. It's actually not that easy of a question to answer. But let's just say off the drone, without any ground control points, you're accurate to about GPS plus a correction signal. So it's about three feet.

With ground control points, you get down to about three inches. You can get better than that, but conservatively say three inches.

AUDIENCE: OK. [INAUDIBLE]

DANIEL MCKINNON: It doesn't use RTK. And actually, some papers have been written recently. So for the audience, RTK GPS is a correction GPS you can do that's accurate to about a centimeter, meaning you know where you are to about a centimeter. But that doesn't actually translate that well into the final point cloud or photogrammetric data product.

This is a pretty active area of research and there's some nice papers that have been written recently. But we have found, through our own research and working with universities, that the RTK GPS should be on the ground, not on the vehicle. And that's how you get that couple inch. And then you can get it down, if you're really, really careful, to basically accuracy equals GSD, which is about half an inch. But that's a little bit of a special case. Yeah?

AUDIENCE: I read about an integration between Site Scan and BIM 360?

DANIEL MCKINNON: Yep.

AUDIENCE: Is that something that exists, or is that [INAUDIBLE]?

DANIEL MCKINNON: We're working on it right now. So the idea is that all those plans you saw that were overlaid onto the orthos, right now, those were uploaded manually. So there's a box that says, upload your plans here?

What we'd like to do in the future is just have your BIM 360 Glue account have all your plans and your models, and you can pull straight from there. And then the final PDFs we generate go right into BIM 360 Field, so you can attach those to individual issues if you're a field user. Yeah?

AUDIENCE: You mentioned one of your [INAUDIBLE] was contours. What are you using to generate those?

DANIEL MCKINNON: So technically in the back end, we're using a library called GDAL. Are you familiar with that?

AUDIENCE: No.

DANIEL MCKINNON: OK, so it's the same library that [INAUDIBLE] uses and Google Maps uses. And I'm actually not sure if Autodesk uses that same algorithm in Civil 3D or not. I would be somewhat surprised if they didn't. That's like the really low-level technical answer.

At a higher level, we're not filtering the point clouds beforehand. So if you want them filtered to some extent, there's a great tool in InfraWorks. And that's something we'd like to include in our product in the future. Cool. Well, thank you all for listening.

[APPLAUSE]