ANNOUNCER: Ladies and gentlemen, please welcome Roman Mars.

[MUSIC PLAYING]

[APPLAUSE]

ROMAN MARS: [LAUGHING]

Welcome back to the third and final Innovation Forum at AU, 2015. How many people have been here for all three?

[SCATTERED CHEERING]

I salute you. Well done. In our first two sessions-- the first session, we talked about how technology was changing consumer demand and how designers were rising to meet that challenge. And the second, we talked about how technology was changing the actual design process itself, creating technology that made customized footwear, and kick-ass cars, and advanced appliances, and rethinking the way we tell stories.

In this third and final forum, we're going to talk about innovators who build. I like people who build things. And I love the built world. Especially, I like the overlooked and unlovable bits of the built world.

This is probably my favorite in San Francisco. It's the Alvord Lake Bridge. It's on the eastern edge of Golden Gate Park. If you go hang out in Haight-- go to the very end of the Upper Haight, and it's there. I don't recommend you hang out there too long. Those guys are pretty much always there.

You might be wondering why this is my favorite place in San Francisco. It's good place to buy drugs. But that's not it, because you can pretty much do that anywhere in San Francisco. Here's another view of it from the western side. The reason I love this dumpy little bridge, this pedestrian tunnel, is because this is the oldest piece of reinforced concrete infrastructure in the world.

This is one of the most important innovations in construction of the 19 and 20 centuries. It's the ancestor to every concrete structure with rebar in it. This ugly little thing is, quite literally, the bridge to the modern world. If didn't think it could get uglier, here's the inside. It kind of looks like a colon.

[LAUGHTER]

No one notices things. No one cares. But I care, and that's why I tell stories about the built world. Innovations in materials and construction are pretty invisible to us. And that's OK. They're supposed to be invisible. That's their job.

I do a show about architecture and design. It's called *99% Invisible*. And it's called that because good design is meant to be invisible. If it works, you don't notice it. But we're here today to slow down and to tell the story of innovative design in the built world.

This afternoon's presenters demonstrate creative and business savvy, disruption of construction. So just like Ernest Ransom, he's the person who designed and built the Alvord Lake Bridge, they are building tomorrow's world. But they're using robotics, they're using additive manufacturing, they're using organic materials, they're using Internet of Things, prefabrication and modular construction, and they're using the cloud.

Of course they're using the cloud. The cloud will save us all, moving through the error of connection with new means of physical production. We have a designer who combines organic materials with cloud-based product development process to create sustainable, socially-responsible lighting products.

We have a manufacturer using the Internet of Things to move from subtractive to additive manufacturing. We have construction, engineering, and a real estate group who did a complete 180 in their business by applying manufacturing-- additive manufacturing-- at the building scale, a building technology company disrupting steel construction with advanced manufacturing techniques.

And this would not be an innovation forum without drones. So we have a tech expert who is going to talk about using drones to improve infrastructure and building projects. Please welcome our first speaker to the stage.

ANNOUNCER: Please welcome Danielle Trofe.

[MUSIC PLAYING]

[APPLAUSE]

DANIELLE TROFE: Good afternoon. My name is Danielle Trofe, and I'm a Brooklyn-based designer. I incorporate innovative technologies and material sciences into the design process to create sustainable solutions. In short, I grow lamps out of mushrooms-- specifically, mushroom mycelium. I look to nature's intelligence to model my designs and processes.

We are on the brink of a materials revolution. Professor Sarikaya, Material Science and Engineering Professor at the University of Washington, states that biomimetics will significantly change the way in which we live. And he is not alone in believing that fungal mycelium is at the forefront of this revolution. So what is mycelium?

Mycelium is the vegetative part of a fungus, consisting of a mass of branching thread-like hyphae. In simpler terms, it's the root structure of mushrooms. Rapidly regenerative, it weaves a tight network, digesting and binding to natural substrates. It's nature's glue, and it's no small organism.

In eastern Oregon, one continuous growth of mycelium was found that is 1,665 football fields in size and 2,200 years old. That's no small mushroom. So how do we go from the world's largest organism to a lamp?

How many people in the room here are scientists? Raise your hand. That's what I thought, not many. Many people in the room are not scientists? Raise your hand. I am not a scientist. I'm a designer. I hardly know the difference a shittake and oyster mushroom. But luckily, these guys do.

Ecovative is a biomaterials company located in Upstate New York. They specialize in the research and development of mycelium-based products. At the time I reached out to Ecovative, their material, Mico Foam, was being used mainly in the packaging industry as a replacement for Styrofoam.

I took one look at this material and I envisioned a lamp shade. So a collaboration was born. So how do you use fungal mycelium to make a material? Well, I can tell you that the process is easy and clear at this equation, but it looks a little more like this.

First, the agricultural waste, like corn stocks and seed husks, are received from local farmers. Next, the agricultural waste is cleaned, and the mycelium is introduced. It begins to digest the crop waste and starts to grow. When the materials is ready to be used, it is reground, breaking up the material and placed in custom tooling.

Depending on the size of the part, the material will grow for three to seven days. Once it's reached this final stage, it's de-molded, and then placed to heat and dry to end the growth cycle.

Mushroom material has many valuable properties. However, the traits I was most particularly interested in was the fact that it's rapidly renewable, derived from a natural byproduct, and it's biodegradable at the end of its life. The materials received a Cradle to Cradle Gold Certificate.

So that brings us back to this diagram, which looks a little more refined now. It's here that we asked the what if. What if instead of making our materials out of petroleum-based plastics and non-renewable materials, we used natural, sustainable materials? Instead of our good ending up in a landfill, they could biodegrade in your backyard compost.

What if instead of manufacturing products, we grew them? So to recap, we've got this really innovative material. It's redefining how we approach the concept of sustainability. Now, how do we adapt the design process to make with this material?

Typically the design process is pretty straightforward. You're designing a product with a specific material, and then you'll design a mold based on the manufacturing process. When working with the mushroom mycelium material, the process looks a little more like this.

Rather than unnaturally demanding that materials bend to the will of the manufacturer, an alternative approach was used to create an environment conducive to be natural formation process of the material. The challenge for me was balancing the use of external influence-- in this case, a mold-- with the biological programming of the material itself, the mycelium.

So this is where Fusion 360 came in. I use the software not only to model the lamp shades, but the mold needed to grow them in. These organic shapes require a powerful free-form tool to create and visualize, and the sculpt feature met that need.

Here you can see a lamp shade that requires a four-part mold in order to work with the raw, loose material, the beginning of the molding process, and then to be able to safely de-mold the material, the solid mushroom material at the end of its growth. Here you can see I'm working with the raw substrate, comprised of corn stocks, seed husks, and hemp.

The mulch-like material has already been inoculated with mycelium. Each lamp is molded by hand in custom, 3D-printed molds. Just like the one you see there, that is the same mold that we used to grow these lamp shade in.

Once the raw substrate is packed into the mold, the part is left to grow for several days. Speed that up, there you go. All the white that you see is the mushroom mycelium that is growing and binding together the agricultural waste to create a solid form. The lamp shade is then de-molded and left to dry.

The final stage will be baking the material to end the growth cycle. As you see in the video, the use a 3D printing to create custom molds is a rapid and cost-efficient method, not only to prototype, but also to produce the first-production run. I really enjoy it the export function that streamlines right into your platform for 3D printing.

Another great tool in Fusion is the animation feature. Using the software, I was able to visually communicate a new series of lamps that use one universal shade. The lighting fixture is designed to convert from a hanging lamp, to a floor lamp, and then, finally, a table lamp, all with a minimal amount of components that can be assembled by the consumer and ships flat.

The animation tool can also be used to communicate assembly instructions to the end user, in lieu of a traditional instruction sheet. And here are a few images of the Mush-Lume Lighting Collection. This image is a 24 inch diameter dome pendant. This is the same lamp shade that was used, the four-part mold.

So this is the iconic lamp, table lamp. This was really the jumping-off point for the collection. It's a playful take on the material from which it is grown.

I like to think of this chandelier as an eco-chic take on Mid-Century Modern. This is the same-- sorry-- a hand-blown glass element. The modular series that you see here on stage. A cluster of pendants hang over a dining room table in a home in the Hamptons.

I hope that my story and work with mushroom mycelium can inspire and encourage not only a departure from non-renewable materials, but to seek sustainable production processes. And I invite you all to reexamine and to reinvent so that you may shift your own industries into a new paradigm. Thank you very much.

[APPLAUSE]

ANNOUNCER: Please welcome Joel Neidig.

[MUSIC PLAYING]

JOEL NEIDIG: The Internet of Things, it sounds a little intimidating, doesn't it? But is it just like another buzz word that we use? And is it something that we can really harness? Is it something that can make our lives better and make the world a better place?

Today, I'm going to actually talk about, more specifically, the industrial Internet of Things. And there's four ways that it can help a maker harness that power of the industrial Internet of Things-- communication, design, the community around us, and actually making, with augmented reality, the enhanced reality around us.

So you're probably all wondering, what does Itamco do, and why is Joel up here? So Itamco makes brake discs and clutch plates, OK. Although, we do do a little more than that. We make climbing pinions for offshore oil rigs. We make land-based positioning systems, like gears, that swing the radar around. We make the hubs that hold the blades of a wind turbine in place as it swings around.

Autodesk is so cool. They make our products look awesome. So here is one of our gearboxes. It's a front transfer case for a concrete mixer. And we used the whole gamut of Autodesk products. So from factory, all the way to HSM works, who are actually manufacturing using the CNC G-code to machine our products. So here's the real thing.

So obviously, the showcase makes it look pretty cool. You can make segments and take a look at the inside of the gears. But there's over 200 components in this gearbox. And Autodesk-- from building our factory, to leaning on ourselves, putting our equipment in place, and then actually designing an inventor-- we get this in product.

One of the cool things we had the opportunity to do was manufacture some of the robotic test joints that built the International Space Station for NASA. In the bottom right-hand corner there, you can see astronaut, Richard Covey. He oversaw the projects and was able to come to our facility.

The gentleman standing in the middle there is my dad, and he's here today. In 2005, August

29, Hurricane Katrina hit. It destroyed over 100,000 homes and killed countless people. The Army Corps of Engineers said, this is never going to happen again. They made a promise.

So they partnered with ABB, a partner with Itamco, to manufacture the most advanced gear motor and pump system in the world. This pump system can pump, in six seconds, an Olympic-size swimming pool. It can pump 1,800 cubic feet per minute of water.

Here's a time-lapsed video that shows it all been assembled at our facility in Argus, Indiana. One of the interesting things about this project is we didn't know how much power this 5,000-horsepower motor would take when we first turned it on. When we first turned it on, it actually browned out the local municipality. They were not very happy with us. Since then, we've adjusted our soft start parameters, and it works a lot better now.

So, as I said, we don't just make clutch plate and brake discs. We also make the swing gears that go in mining shovels. We make the wheels that go on the haul trucks. But it's not always all fun and games. A lot of people, every year, are hurt and injured, and even killed, in haul truck mining accidents.

One of the coolest things is the Internet of Things now. We have ways that we can put GPS, Lidar, which is land-based radar, we can put cameras. Rio Tinto, one of the largest mines in the world, has now outfitted over 200 of its trucks, that can drive-- just like drones-- in the air. They can actually drive on land and not have drivers anymore. So it's pretty cool.

So we can't talk about the Internet of Things without talking about protocols, everybody's favorite thing to talk about. With all those things that we're trying to connect, even our houses and our manufacturing facilities, we're running out of IP addresses. Gartner Technology has estimated that there's going to be 26 billion Internet of Things devices by 2020. That's huge.

So they've come out with a way to be able to expand the IP addresses by coming out with IPv6. We now have enough IP addresses for every single atom of Earth's surface, plus 100 Earth-like planets. So with all of those IP addresses, and all these Internet of Things devices, how in the world are these all going to communicate with each other? That's something we really don't see.

There's a protocol. And I want to say, maybe, it's kind of like a protocol, one to rule them all. It kind of sounds like *Lord of the Rings* or Middle Earth-ish. But really, we have all these different languages that our devices communicate with. And before MTConnect, the world kind of looked like this.

We have applications, and we have different machines, or different PLCs communicating, all speaking different standards and different protocols in different languages. You can think of MTConnect as kind of like Bluetooth for industrial devices. Now, it looks like this. All the machines and all the different applications can now communicate in one homogeneous protocol.

It's kind of like Google Translate for our mobile devices. We speak different languages, but we have to have a way to translate that information. Even just like, the iPhone that you have in your pocket, you want to communicate to a MakerBot. Well, how is that going to communicate, when an iPhone speaks one language and maybe the MakerBot has a different EPROM that speaks another different language?

And even when it comes down to design, when we're connecting our ERP systems and we want to be able to scan an item or a manufacturing order and be able to virtually view that information right on our smartphone. We developed an application that connects with Microsoft SharePoint, in Vault, and it actually can open up items right from Inventor Publisher.

So the decision now is do we design in 2D, or can we iterate multiple things, using virtual reality, and simulation in 3D? What's really cool Autodesk Factor is the plug-in capability, the APIs. Autodesk factory now has a plug-in that uses MTConnect protocol, and you can actually connect all different machines in your facilities, or manufacturing devices, right into Autodesk Inventor.

You can see what is happening on the manufacturing floor, as it happens. You can even connect all these different other IOT devices, like Kinect for Windows, Oculus Rift, or Elite Motion.

So we had a problem. We've talked about design. We've talked about the communication. Now, let's talk about the people in the community that we have.

At Itamco, we had a problem because our workforce was dwindling, our skilled labor. We didn't have the people that knew how to manufacture or run the CNC equipment. So I'm going to show you a video that kind of tells the story and what we did to make that happen and to connect with our community.

[VIDEO PLAYBACK]

-In just a few short years, you will be staring your 18th birthday right in the face. And with it will come some choices. Do I go to college and initiate my indebtedness with college loans? Or do I look for a great career that I can start right after high school and possibly still combine it with the two-year college degree?

Not sure? Then you need to look the Advanced Manufacturing Class offered by the Career and Technical Program now taking applications from students for the next school year. And with this class, you will receive six hours of credit Ivy Tech State University. When you graduate from high school, you can finish your degree, work, or work and finish your degree. The possibilities are endless.

[MUSIC PLAYING]

A career in advanced manufacturing allows you to work with some of the world's most advanced technology, and gives you the opportunity to work with your hands and your mind. Advanced manufacturing leads to any number of quality jobs, and they are jobs that matter. Manufacturing provides the jobs America now leads the world in.

[END PLAYBACK]

JOEL NEIDIG: So here's a way that you can get involved. Both companies and students can now gather together. You can go to challenge.gov, and the Department of Defense is actually offering $33,000 in prizes for the best teams that come up with applications that use the industrial Internet of Things Communication Standards, like MTConnect, to basically create a better world in how we communicate.

So now, we've talked about the communication, the community, and the design. So let's talk about how we actually make the product. We developed a really cool application that connects with MTConnect and to your manufacturing floor, using Google Glass and augmented reality. We've open sourced this application on our website, so you can go there and download it today.

And we've partner with UI Labs, DMDI, and GA Aviation to build pilot programs that they can use to do workflows and connect with their machine tools. So I'm going to show you just a short video of how that works and a perspective as you're walking around the shop floor.

[VIDEO PLAYBACK]

-OK, Glass, let's revolutionize manufacturing.

[MUSIC, THE KISSAWAY TRAIL, "NEW LIPSTICK"]

-Hey, Ben, how does this setup look?

-Yeah, that looks great.

[END PLAYBACK]

JOEL NEIDIG: So I want you all to check our website. Also check out [INAUDIBLE] where you can learn more about the industrial Internet of Things and get connected.

[APPLAUSE]

Please welcome Jos Mulkens and Jeroen Pat.

[MUSIC PLAYING]

JOS MULKENS: Whoa, school. Two years ago, I was asked to save Voorbij, Amsterdam. That company was basically dead. We tried our best with what we had. But after a year, I went back to my shareholders and told them we have to make a crucial decision. Do or die.

Our choices were to continue and end up bankrupt, to wrap up the company and give up now, or to invest one last time and see where it may lead us. We decided to make a go of it. And look at us. Here I am, presenting to you, in this venue, on the largest date in Las Vegas, to tell you our story.

When I became CEO of Voorbij, it was a traditional company employing 180 people. We precast concrete elements for houses, offices, tunnels, bridges, sound barriers, elements for the nuclear industry-- both in Europe and the US.

Our market was much too diversified. Our lead times were long, up to five weeks. Our customers were rarely satisfied. And even though the products were good, we were in deep trouble due to the continuing and serious losses. One slide back, please.

Searching for a solution, we got into contact with Autodesk. Together with them, and other partners, we created the finest state-of-the-art prefab factory in Europe, maybe even the world. Autodesk invited us to come here, in Vegas, and hopefully inspire you by telling you our story.

There is our factory. As you can see, the Voorbij production plant is located in Amsterdam. Over the last year, we narrowed down our market to housing and some specials. The precast concrete elements for housing that we now produce are much more sophisticated than we used to make.

They include made-to-measure reinforcements, door and window frames, all the wiring, and the pipes. So how did we achieve that? My story is the story of switching from a labor-intensive approach to capital-intensive approach, deciding on a real focus in the company, deciding on real partnerships and serious out-of-the-box thinking.

Basically, everything we do is what the customer wants-- inventive thinking, with forward-thinking partners. Partners with the daring and courage to think differently and to operate differently. In just nine months, we moved a traditional production company right into the center of today's digital world, ready for the future, and with amazing results.

Revit. Autodesk 3D design platform for building preparation became the digital point of departure for our concept. It controls the creative process and also the whole production line, just like a 3D printer-- but with one big difference. The 3D printer on the left needs 24 hours to finish a house.

In our robotized factory in Amsterdam, we produce the prefab elements for 18 houses in the same time. So preparation time of the new digital production takes 80% less time, not five weeks, but five days. The casting moles can be made in a fraction of the time we needed before. It used to be two days, and now this is down to six minutes, with guaranteed accuracy down to millimeter.

Generated Design. Generated Design combines the expertise of five specialists. Our new process means that we no longer need these specialists. Revit software calculates unit construction recipes, does [INAUDIBLE], organizes the production, generates a schedule, and manages the robots in the factory and the logistics.

So what's the biggest advantage? Every item can be 100% customized without changing the production process. And the result is a product of much higher quality, made with far more sustainable methods. The results are truly amazing. With the help of Autodesk, Voorbij is revolutionizing the building sector.

We have a short clip that shows how the process works. Have a look.

[VIDEO PLAYBACK]

-The predictability of the world is changing. An increasing number of disruptive players has managed to go from nothing to market domination in just a few years. Take Airbnb, or booking.com, which are turning the hotel market upside down, or Uber, that is completely transforming the taxi market. These companies are entirely focused on making everything as easy, flexible, and fast as possible for you.

A major change is also taking place in housing construction. Up to now, to be perfectly honest, producers like us in construction have not been particularly known for our accessibility, flexibility, and speed. In fact, ordering a product from us has meant supplying us with every last detail weeks in advance, even though it's not always possible to plan everything so many weeks beforehand.

Sometimes, there are last-minute adjustments, such as buyer's alterations, or you need to place an extra order. Until today, that was an impossible undertaking in the construction industry. To address this change, to become more focused on service as a production company, we've had to make a huge turnaround as a company.

Take, for example, the amount of paper and labor that came with producing prefab walls. The files in which the building plans were supplied needed to be converted into technical drawings, a time-wasting process that, of course, caused frustration. The technical drawings were printed, worked on with marker pens and pencils to then be incorporated into manufacturing designs, which were printed out in large quantities to be made into workbooks.

The human factor led to the risk of differences in interpretation, and consequently, the threat of errors on the work floor. To prevent this, we started performing checked after check, more loss of time, inefficient production-- in short, wastage. To construct the mold for one single element, before the concrete could be poured into it, took us two whole days.

And this craftsmanship was repeated over and over again for every new type of wall-- at least up until now. Because we have developed into a game changer, redesigning the process and allowing the individual clients and wishes to be central. We think from the clients' perspective. To do so, we have developed the equivalent of 3D printers for building elements.

Instead of people doing everything by hand, we have an ultra modern system of robots that perform the whole process we millimeter precision. We have a direct link with several CAD applications, such as Revit, a program enabling us to convert building plans into 3D.

With this application, just like you would supply the building plans, we make them production ready, no paperwork, everything digital, less failure costs, a reduction in human error, improved quality, and with everything tailor made and just in time.

The mold for your module element is built in just a few minutes, including construction features and installations. Every element is now made uniquely for you. Walls, facades, and tops can be reproduced interchangeably. So what does that mean for you?

A simple process to get you from your drawing environment to the delivery of your walls. A flexible process with just-in-time production. Pull, a short lead time, meaning that the time between order and delivery is extremely short, high quality, high accuracy, and cost efficient.

Even just a few weeks before the start of production, the purchaser can still choose to make adjustments to his construction walls and facades. We are extremely proud that we, as Voorbij prefab, can make this accessible to the world.

Our very own top team worthy of the Champion's League is ready, trained to help you with every possible aspect of prefab, with speed and flexibility, fully equipped with an ultra-modern system. From a company focused on production, we have become a true service provider. We've embarked on tuning the construction world upside down. Will you join us?

[END PLAYBACK]

[APPLAUSE]

JEROEN PAT: So this is good. This is great, to be here. Jos just talked about thinking and acting differently and how to revitalize his company. And I'm going to talk about the change made possible by technology from Autodesk. Well, let me summarize the innovation.

First, we used to work with separate consultants that didn't collaborate. They make separate analysis, and they make one just with their favorite calculations, separately, and it took weeks to get a report. This changed 180 degrees. We have thousands and thousands of calculations in just one minute. And all possibilities are considered.

And the system gives the best integral culmination to us. Just like in *CSI: Las Vegas,* we identified the DNA of all consultants and incorporate it in our system which algorithms within Revit. The profits are big, and the smart solutions are much smarter. And this is only the first step in our development.

You can see we represented, as a funnel on our sheet, with Revit on it. I want to know, how many Revit users are here? Please raise your hand. Ha. I will make you happy.

But first, I have to take you to one sheet and I want to point out that you have to look at the Split button on the left-hand upper corner on the screen where the magic happens. I will show you a short clip of one of our engineers working with the new system.

Here, we have Revit. In normal [INAUDIBLE], we push the magic button, and all the recipes and all the DNA of the consultants, and from the factory, is placed in the elements. You can say there is a new model being generated. Everything is in, and all possibilities are considered. And the best integral combination is presented to us.

In the past, we found all the bottlenecks during production. We now have a complete visualized model. And when our problems, or bottlenecks, as you say, we can make adjustments accordingly. We are happy that we have come so far and so soon. But there are more things that we did.

We connected Revit directly to our production environment. A production environment that was labor-active, with 180 people, and went down to a robotized environment of less than 12 people. And yet, yes, you could say it's the biggest 3D print them of Europe. And we're just beginning. We have a new era of possibilities.

We are now looking at sensors that measure humidity and temperature and add it to the process. With that, we can make a better quality of concrete. We are also connecting, with Google, traffic information and logistic information from our systems to really, really make just-in-time delivery without the stock-- so also, just-in-time production.

You really can say Voorbij is a game changer in a construction world. We're stretching our brain and brawn to the max. And we hope that we can do it with you. In Amsterdam, we are willing to give you a round trip, and connect with you, and think about all new possibilities.

Another thing that we already have added is functionality of BIM 360 Field. Our quality control, pictures of every state of the element being made, is photographed and connected to our BIM 360 environment, making it a complete book, what could be digitally produced, to the field. And when on the field, it could be controlled by quality control.

The robot Jos just mentioned is here. It's not 1 millimeter precise, it's 0.5 millimeters precise with the mold. And it lays down a whole wall in six minutes. I thank you for your time and Autodesk that we could present here. Bye. Thanks.

[APPLAUSE]

ANNOUNCER: Please welcome Bob Simmons.

[MUSIC PLAYING]

ROBERT SIMMONS: Well, thank you all for being here this afternoon. I know this is the last one of these innovation forums, and hopefully it's worth your while coming here and spending some time with us.

And we're honored by the opportunity to share our little nuggets of innovation with our fellow innovators in an environment here that-- it's almost humbling to see how much innovation is going on around us and how we all have the opportunity to participate in this innovation of how the world of the future gets built.

And this all started out as a pretty simple exercise for us, as we wanted to come up with a better way to build structures. And we kind of started in wood, gravitated to concrete, and then we chose steel, kind of an iterative design process because of some of the characteristics that we thought we would get out of steel that we weren't getting out of wood and concrete.

And one with the dimensional stability, the ability to span long distances with fairly slender elements and the strength-to-weight ratio. So we took some momentum that we'd gotten in structures and took it into the steel environment without having any of the knowledge, or really, the constraints that the conventional industry brought with it to doing steel structures conventionally.

And so we wanted to develop a chassis. And we wanted to have something that was very, very simple to put together. And we were actually scared of the work. We were scared of the complexity of the conventional structure, the massive amount of shop drawings and detailing, and the craftsmanship involved in it.

And we were also scared about the safety. When we got in this business, 10 plus years ago, we went to get insurance for ironworkers at a workers' comp basis. And the rate was $50 per $100. And that told us for every $100 we pay the ironworker, we have to put $50 away to fix them. Because the industry knew that we were going to hurt them.

And so those are some of the fundamental driving elements that were in our minds as we tried to come up with a better way to build. And what we came up with was a fairly elegant chassis. And what we realized is that every structure has columns that has beams, and if we had a way to connect them together, and if we could connect them together in a rigid manner then we could create a rigid frame.

And then we could define space on a very, very kind of manufactural basis. So we had to treat this space, that we wanted to create out of steel, we had to treat it as a product. And that space that we get every day in a building is typically done by a lot of discrete services that are compiled together by a team that are put together.

And not all of their objectives are completely aligned, because they have different bottom lines, different shareholders. But they try to come together and deliver the best possible space they can. So we had to look at this space as a product. And how can we improve every aspect of it?

Because to be able to make this thing competitively viable with conventional steel, or even other structural solutions, we had to come up with a way to be much more efficient than anybody else and much more flexible. And the basic concepts, the kind of advances we wanted to be modular, to a point, so that we could have instrument and configurability.

In some earlier experiences that we had in modular, we realized that the bigger the modular element, even volumetric modules and structural modules, start to show up in the structure. And the minute the modules start to show up in the structure, you have a lot of resistance from an architectural design community. Because you start to limit your constraints, because now you start to influence the architecture.

So coming up in a system that was architecturally agnostic and infinitely configurable-- you could change the spans, the floor-to-floor height, move stuff around-- not having any braces or shear walls gave them a lot of program flexibility in the space. It was a system that we felt that we could advance. And we wanted to be able to take that model space and reproduce it in real space every time.

And so we had to come up with what we call the mating surface simulating fixturing, so that we take that model space and we reduce it to fixturing on the shop floor. And we produce our elements, every time, in a fixture that simulates mating surfaces. So as we go out there in model space and we're creating model space, in manufacturing space, so that it fits every time.

And we're holding, basically, zero tolerance in assembly because everything is hard, to hard, to hard. So that the tolerances that we have to maintain when we manufacture the elements are tolerances there weren't achievable doing stuff conventionally. And then what we learned is we'd be able to do deliver this digital chassis to the design team very early in the conceptual stage so that it gives them a contextually relevant environment to which to bring other digital content together.

So that, just like in the building when you're building it in the field, you build a structure first, and everybody brings their systems and components and attaches them to the building. If we could do that in the design phase, too, we could make that design team even more efficient. And what we came up with was our standard connection.

And we standardized this connection around this lower and lock concept. And this is a small aluminum model of the system technology, made out of aluminum so it's easy to carry around. But it basically simplifies and standardizes that connection. It connects the beams with the columns in a very repeatable, manufacturable way. And it's also safer.

Because immediately, upon that gravity interface, you've got those six axises of fixity. You've got the X, Y, and Z is fixed, pitch, tilt, and roll is fixed. So that structure becomes increasingly stable as you set pieces together, just by the gravity interface. And that addressed, directly, some of the safety concerns that we have we got into the business.

And what we found-- we started out in a high-density residential, because that was a market segment that I had the most experience with-- but what we found is the physics, and the science, and the loading, and the metallurgy, and the manufacturing actually has applications in all other industries.

We started out putting heads in beds in a residential building. But then we put pipes and pumps in industrial buildings, data centers, health care, military housing, student housing, student academic facilities, and even in the health care.

And this is a small example of what we're building now. When it goes up, it goes up vertically. So we're running full-height columns. We're doing up to nine-story columns full height. So we can put roof beams on there, literally, by break time on the first day on the job. We've got roof beams on the ninth floor.

Over here on the right, you can see a picture of how compressed the assembly is so that you can get a lot of other trades working much earlier. So we're starting multiple critical paths, so it actually makes a significant difference in the overall performance, the efficiencies of our fellow stakeholders on the job site.

This is a little short video of what they call an Alberta module. It was built up a Northern Alberta. This is what they build down in the Edmonton area and transport up to the oil sands because of the caustic environment that they have to work in there.

This was actually done at a day that was well below zero, 50-plus kilometer winds, on frozen ground. And on a project up there that we were being advanced by the owner, we weren't getting credit in the local assembly community for the productivity that we're going to bring up there.

And they said, well, just because you could do it in California, when you go to Alberta, it's harder to work up here, it's colder, and the workers aren't nearly as efficient. So we actually went to the local union all there, used entirely local labor.

And this structure here, you can see the running clock on the right-hand side. It was just over six hours we put this structure together. That would be seven-plus days in the conventional environment up there, even in the module yard, not even counting the additional challenge they have when they get out into the field.

And what is even more kind of telling, as far as the safety aspect of it, multiple big super major oil company owners sent their HSE guys to the site because they heard we were coming there. We've been able to build faster. And everybody was convinced up there that if you bring speed to construction that you bring additional risk to it.

So their HSE guy-- six HSE guys were there with us-- they actually became our biggest advocate, because they saw that we actually changed the work. We didn't add some more prescriptive rules that go in a three-ring binder that goes on the shelf in the trailer that the safety officer pulls out and tries to make sure that everybody's compliant with as they're out there trying to stay warm in this caustically-cold environment.

But this thing, by noontime, we were able to sign off on the structure. It was safe enough to take those company's executives up on top of that structure. So I think that the innovation opportunities that we have ahead of us, because we've tried to productize this space, gave us additional opportunities to bring additional efficiencies and change the way things are done conventionally in the existing siloed kind of delivery that we're so used to being a part of.

Everybody's looking after their own silo very, very well. They're working together as a team, somewhat productively. But they're not really looking at it as a whole product. And we kind of took this whole concept of framing space as a product to see what we have to do to make that possible.

Part of it was to be able to deliver those dimensional tolerances that we're talking about. We had to bring in some manufacturing concepts that come from a lot of other industries that are used successfully-- for years, they've been used. On the left-hand side there is a C&C manufacturing machining center that we make our connectors out of.

That thing's been running lights out for over 10 years. 30 days after renting the first factory and getting set up, we've been running lights out. Running lights out is part of driving some of the costs and efficiency-- or the cost and inefficiency-- out of the process. Because you have a process that's completely repeatable, even in the dark.

Specialize featuring, the mating surface simulating this fixture in the center there simulates four columns coming together-- four beams coming together in the space around the columns. So we're building the column inside a simulation of four beams coming together in engine block type tolerances.

The picture on the right is the same mating surface simulating fixturing containing a beam that puts it in the right relative spatial relationship to each other so that we can do the additive manufacturing of adding welding wire, welding deposits to that beam. It all seemed pretty easy from the manufacturing design sides.

Then we come up against the codification, and the adoption, and to be able to deploy this in multiple jurisdictions. So it came down to, there was no clear path of accepting our technology into an industry that had been used to do and stuff so conventionally for so long that we had to develop a full-scale testing apparatus. Because for the hospitals in California, they required full-scale testing.

We couldn't find any university that could do 3D full-scale testing. Because of the 3D connection, they wanted to connection test it on both axises. So as you can see there, the factory wasn't very full at the time because this was a major hurdle that we need to get over. And so we had to build this test facility to be able to load the column to simulate the vertical loaders on the column.

We had a load it orthogonally, like if there was a full earthquake force going perpendicular to the frame. And then we had to move it through a displacement test on the primary axis that we were testing. And then we got a little bit of push back from the industry because, well, that's not fair. You guys are doing your own testing. Well, we had to do our own testing, because nobody else was set up to do it.

When we did talk to some universities, they said a test would take, typically, a quarter or maybe a semester. And we were successfully-- now, we can do tests in 24 hours. So to be able to do multiple tests-- we've done over 90 full-scale tests. 60-plus of those tests have been peer reviewed.

So we invite the community into our testing facility, because that's part of what we have to do, I think, to be able to go out there build confidence in the engineering community. Even though we're different, we've actually de-risked the process, probably more so than conventional design.

And sustainability is a word that has kind of creeps into our industry over the last several years. And there's the social aspect to it. There's a political aspect to it.

But it's the economical aspect and building a business case for sustainability is what's really going to give it a sustainable case for sustainability. I think that just driving all these other inefficiencies and wastes out of that process allows you to advance your case for sustainability on a sustainable nature.

And because we have this modular chassis, we have the ability to enable and integrate other modular opportunities. We're working with MEP providers to come up with MEP modules, exterior cladding, and envelope providers to do modularized exterior, modularized rooftop structures. There's a lot of opportunity when we have a standard repeatable predictable chassis to better engage the rest of the community.

The digital workflow is a big deal, because everybody's working in their silos and having a common and kind of digital interchange format so you can productively, with a high level of confidence, be able to exchange the digital data so that you don't lose anything in that data transmission. Because that's a big risk, because you don't see it going on.

So it's real risky if you don't have a good kind of common format to be able to exchange, even within our own organization, so that we're working on multiple different platforms. And I think Autodesk has done a tremendous job trying to integrate those platforms so that you have a better way to kind of commonize or neutralizer your data transmission so that all the stakeholders can use the same data over and over, at a high degree of confidence.

We've developed family toolbars for Revit so that the designer that's working in Revit can actually have a drop-down menu. We've given them anatomically correct precise digital content. We've developed a configurator within the Revit API so that the connection-- so we're delivering a level 350 model at the earliest concept stage.

So while the design team is very often still working in a programmatic phase, even in the sketch up, or some less-robust program, we can give them a true digital chassis. So as a design starts to mature, that the chassis is inside of there. So it gives them opportunity to bring additional digital content that they've been using on prior projects and integrate it in a more contextually-relevant basis.

This is an example of a health care project that we're doing, a standardized chassis. We can get most of the program space, the standardized repeatable space, in a very simplistic format and be able to put on a hard point so that the design team can continue to develop additional architectural features that have a modular way to come back to that structure.

Because ultimately, whatever you hang on the outside of that structure, somebody's got to detail it and design that load path back to the primary structure. And if we make provisions for it when we're productizing that primary structure, it decouples a lot of this complexity that happens in a conventional building design world.

And back to the opportunity, when you get the digital chassis in there very early, it gives the opportunity for the cladding manufacturer, the curtain wall manufacturer, even volumetric rooms, exam rooms, treatment rooms. Because you're more defined from this digital chassis at the earliest design phase, it leaves the rest of the team to work in a contextually-relevant way so they can actually have time, during that fast-track design phase, to be able to integrate some opportunities that you couldn't do in the conventional way.

If you go through the complete design cycle and you start adding modularity or off-site prefabrication that ripple back and forth through that system, a lot of times it adds unacceptable delays to the project. And I think that we all should be happy that we're here and sharing our kind of common interests in innovation and changing the way the world builds.

Because these are just some of them. And I know there's a bunch that are not even listed here, like Formit, and Dynamo, and Plant 3D, that I know we're working in on a daily basis. And I think that we all should be excited about the effort to Autodesk is putting in, giving us that digital ecosystem to be part of changing the way the world builds. Thank you very much.

[APPLAUSE]

ANNOUNCER: Please welcome Keith Warren.

[MUSIC PLAYING]

KEITH WARREN: Hello. I'm here to go over the UAV, or the Unnamed Aerial Vehicle. I'm based out of here in Las Vegas. I work for Autodesk. And basically, my job is to help owners be more innovative with the infrastructure and design that they do.

So a little history. I've worked in the industry for over 30 years. And over the last 10 years, I really focused all my time on the smart city modeling. And with the smart city modeling, that kind of covers a lot of stuff. It's sustainable cities, it has to do with underground infrastructure, we did ground-penetrating radar on a lot of the projects.

One of the major projects that I got a chance to work on was this here, in Las Vegas. So the whole downtown corridor, we rebuilt that with infrastructure design. So we did all the underground utilities. We took all the structures that they had for buildings and we plugged it in.

Now, if we had buildings that were from architects, we would use irreverent models. If we had other models that were done from, we'll say, Cyber City, we would use as collateral information around the outside. Part of the data that we used was Lidar, reality capturing.

And with that, we were able to model to ADA requirements for sidewalk slopes, floorway heights, be able to call out every single power line with sags, which they would use to build their street lights and know what kind of clearances they would have. But with that data, the most important part was the fact that that was a starting point. We needed the existing information to build the proposed information from there.

So today, we're here to talk about UAVs. And it's one of the most innovative and cost-effective ways, today, to collect information. People look at this and they say, wow, that must be really expensive to get that kind of drone, some people call them, or UAVs.

But in actuality, the base model runs right around $3,000 for a professional version, where you have GPS connected to it, and you have video capturing and photo imagery capturing at 4K values, with a flat lens. So that means you don't have distortion around the outside.

So here's some of the current uses today. So before I came to Autodesk, I worked for a company that was a geomagnetic company. And they did a lot of the high-end technologies. So if it was collecting data at a lake, we did [INAUDIBLE] metrics. If we were doing photogrammetry, we had our own photogrammetry department.

We had our own Lidar scanning department. With that Lidar scanning, we did static, So we had stationary. And then also, what we would do, is we would do mobile scanning, collect a lot of data in a short period of time, process it for the client, and they have sustainable data to kind of move forward.

So with that being said, we were looking at the drones as a possibility to be able to collect that data and be able to use it. One of the major clients that we had approached were the mining industry. So here in Nevada, especially in Northern Nevada, they owned-- almost 80% of the whole population up there is covered by mines-- gold mines, Barrick mines, Newmont mines.

And so their main staple is earthwork and quantity takeoffs. So if you can have a drone fly a site in little to no time-- a couple hours-- download that data, do earthwork quantity takeoffs, it's going to keep them way ahead of the curve on what they're spending and what's going out.

So how many surveyors do we have in the room? We have a handful, OK. My opinion is, on surveyors, is that-- you guys are probably all from Missouri, right? It's the Show Me State, because you guys have to be proven that stuff works, and it has to be geolocated in the right place.

So there's a group of guys at Autodesk that went out and did a study. And they called it Project Ground Truth. And this study was to evaluate stationary, conventional surveying, compared to Lidar scanning surveying, to the UAV to find out what level of accuracy were close.

Now, a lot of people don't realize this, but some drones, or some UAVs, you can actually have RTK values inside those. So it's tracking your coordinate system through the whole process. So with that being said, instead of me talking through these slides and showing you all this great imagery, what if I just show you a quick video on some of the stuff that we're doing.

[VIDEO PLAYBACK]

[MUSIC PLAYING]

[END PLAYBACK]

KEITH WARREN: Pretty cool stuff, right? So I want to leave you with these last little tidbits of information. So this is a new, evolving industry. And with this evolving industry, laws and regulations are changing daily. So to put up here and say, this is what the laws are today, they would probably be different tomorrow.

So if you're interested in doing this, definitely go out, check with the FAA in your area, get legal, get registered. The next thing I would recommend is definitely go and take courses. Find a UAV training course, take some schooling, and be safe and responsible pilot.

And for us at Autodesk, what we want you guys to do is get out there and start building tomorrow's world. Thank you.

[APPLAUSE]

ANNOUNCER: Please welcome back Roman Mars.

[MUSIC PLAYING]

ROMAN MARS: I'm supposed to give you some closing thoughts about innovation. And then they handed me a T-shirt cannon, and now all rational thought has left my brain.

[LAUGHTER]

So let me just leave you with this. It's easy to be here, to be inspired with all these cool people doing cool things. And then, when you leave, all that goes away, and you do your normal job, and you forget about it.

But let me just sort of remind you that AU doesn't have to end here. You can live AU the rest of your lives, out there in the world. And just think about how to be in an innovation forum next year.

So now, I'm going to shoot some T-shirts. So who wants a T-shirt? Stand in the middle there, because I only have one shot. But I got two T-shirts in it. Does anyone want to-- should I try it here? OK, go to the middle there. I'm going to try this for the first time. Here we go.

[POP]

Holy moly.

[LAUGHTER]

That was all right. All right. Thank you for coming. We appreciate it.

[APPLAUSE]

Take care.

[MUSIC PLAYING]