STEVE SCHAIN: So this is 3D Printing, Examining the Reality and Possibilities. This class, I have about a slide a minute. I'm going to go through some fairly quickly. And I want to sort of open up a discussion towards the end of the class about some pretty serious topics that are going on with 3D printing. And not just keep this a lecture. So let's wait until they close the doors to get everything started. Does Anybody have any questions before we start? We've got a couple of minutes.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: 4D Technologies is a company out of Bedford, New Hampshire. We have a website called www.CADlearning.com, and it is an online training portal for all Autodesk products. As a matter of fact, we just announced, in a press release that as of December 1st, our online fusion course will be free. So if anybody is learning fusion, go ahead and get on there, register, and you can get that course for free.

So my name is Steven Schain. I'm the Post Production Supervisor for 4D Technologies out of their Asheville office. I'm also their Media and Entertainment Content Developer. I develop their content for 3ds Max, Maya, Mudbox, and a host of other media and entertainment programs, but primarily I'm a 3ds Max guy. From days gone by, AutoCAD and inventor, designer, and now happily living in Asheville, North Carolina. It's a beautiful state, beautiful place, up in the mountains. They say attitude is attitude, right?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: What's that?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: I didn't, but one of the girls that works with me lived in Chicago. You were here two years ago. So this class, I'm not going to read this. It's in the handout, it's online, they tell you to put it in here, but if anybody's been to the Evelyn Wood's speed reading course, you can probably read it. Let's get this thing to work.

So what we're going to talk about today is really about where 3D printing is, breaking through

the hype of 3D printing. What you can do with it, and some pretty serious topics that are happening in the world of 3D printing. Everybody get by. We'll also cover some tools, just software that you can use to design parts for 3D printing, whether it's mechanical or industrial. How many people are using inventor or any of those? I think I actually have that slide up later, but I'll ask now. And then we'll talk about the future of 3D printing as it relates to the real world. So this is sort of a cutting through the hype class of 3D printing. There's a couple of seats up this way if you all want.

So welcome. I'm glad everybody made it. Thank you for attending the class. Hope you enjoy it. So let me ask a question, has anybody had experience with a 3D printer before? So quite a few. Has anybody not had? A few, anybody had, let's say, more than five years experience? So one or two, a couple of people. This printer, just FYI, this is a Fusion 3 design F400 3D printer. They're a company that is out of Greensboro, North Carolina.

In my former life, I owned a 3D printer sales and service bureau. I started it and transferred ownership to a friend of mine last year when I came on board with 4D Technologies. So that's my background in 3D printing is my first 3D print was done in 1994 for a project for the Coast Guard, and I realized then that it was an amazing technology. I didn't really know how it worked. You sent the file off to somebody, and they sent it back to you.

So 3D printing, additive manufacturing, rapid prototyping, if you've heard each one individually, they're all the same. They will be different in different industries. So 3D printing you hear more, that's more of a layman's term for what we do. Additive manufacturing in the design and engineering space. Additive manufacturing is a big, big word for it. And then rapid prototyping is also the same thing. They're all synonyms.

So, what's all the hype? Has anybody heard hype 3D printing? Anybody raise your hand. What have you heard, just something?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Anybody else?

AUDIENCE: [INAUDIBLE]

AUDIENCE: Apollo 13 was [INAUDIBLE]

STEVE SCHAIN: Yeah, food, Yeah, that you're going to be able to print a sandwich. They have a pizza printer. I'm not sure why you'd want to 3D print your pizza, but somebody made one. You can, yes. So the hype has been based around science fiction of what we think 3D printers can do right now. Everything from printing replacement body parts, to just sort of reading your mind. And going, I want this, and 3D printing it for you in all these materials. The reality is it's not really that exciting. It's cool, and it's amazing to use, and there is some really, really leading edge, bleeding edge tech going on. We'll talk about that later. This thing does not want to work,

So let me talk a little bit about the process. 3D printing is, in and of itself, just a mechanical process. You lay down layers of material and build a part up that way. As a matter of fact, I'll pass this around. This is made out of brass and PLA material. And this is the award, I'll show you guys at the end but, this is the big brain on campus award that 4D Technologies is giving out this week. And this is all 3D printed. The top part is glow in the dark material, and this was printed on a bunch of different printers.

So the process goes, you plan, it's really a standard process. What 3D printing does, in this part of it, is greatly accelerate this. So you plan, you design, you print it. And then you test it, and you go back in circles until, at a certain point, it's like art. A design is never finished. You, at a certain point, abandon it, and say it's ready for whatever I'm going to do with it. How many people are artists on the side? A couple of people. You ever feel like your artwork is never quite finished? You just say you all right somebody is going to buy this one.

So the traditional workflow isn't really different, with 3D printing or additive manufacturing, than it was in the past. The biggest difference is this part right here. This is a very linear process. And it's not to say that today's process is not linear, but what happened is, in the past if you had a prototype, if you had to design, whether you're an architect, an engineer, a consumer products developer, it doesn't matter what it is. You sent that part out. You sent that part out to get made somewhere at some fab shop. Right? And if you did it in-house, it was done out of cardboard or Gator board or polystyrene or whatever it was that you were able to clay, whatever you could sculpt. So that would take weeks.

I'm going to do a lot of show of hands. Has anybody done that experience, where you send a part out, it takes weeks to get back? I had a roommate, when I first moved to Florida, who did architectural models for architectural companies, architects, and designers. And he would build the model in the middle of the living room with Gator board, and the shingles were all rough sandpaper. And it would take him three months to build a model that I could now 3D

print in just a couple of days.

And that's really the difference is this process now allows you to do something we've never really been able to do in the past. And that is iterate your model so much, between the time it's developed and the time it gets to market, that you can eliminate a good majority of the flaws. You could have a product that's better, and it works the way you want it to work, and it's designed the way you want to be designed. Because you can go from one model in three weeks to a model a day. And just think about that iteration process. So if you're able to do one part a day, even if you're just tweaking it a little bit, making this slightly bigger, this slightly smaller. You go, I don't really like this curve. You could make those changes, and get a much better product to market.

The other part is you now have an enhanced workflow where you didn't have one before. So your products go to market faster. You get a better product out of it, and you reduce your cost. Did that work? Yes. Significantly. So a part that you got from a machine shop would be several thousand dollars. Now, with 3D printing, you could bring that down to just a few dollars. If it's a few hundred dollars, that's pretty expensive for the average 3D printed part. This right here probably has $3 worth of material in it, and it took maybe five hours total to print all the parts for it.

The hardest part to print actually was the nameplate, because I had to print the base, swap material out for the different color, and then continue printing it. And that was quite a bit of experimentation to get it to look right. I wish I had a printer that had more than one color, that's out there though. Yeah, there's actually a few printers out there that do multi-color. I actually talk about some of the printers that are out there and technologies.

So this is another slide that really shows the difference between traditional manufacturing and manufacturing with 3D printing. With traditional manufacturing, you have 10x. And how many people have seen that slide before in other presentations or in school? Whenever you go to the next step in the process, it's on average a 10-fold increase in cost, so 10, 100, 1,000. With 3D printing there's no added cost for any step of the process. There's no tooling, there's no reworking and assembly line, there's nothing. If you get a product to market, that's a different story. Because once you get a product to market, if there's a failure in that product, then just look at Volkswagen. And sorry if anybody is working from Volkswagen here.

So tools for deployment. And I'm going to give us some time towards the end, I'm going to go

through these a little quick. So tools for deployment, how many people have used CAD software? Everybody? Anybody use it for more than five years? I'm going to skip down to the bottom because everybody raised their hand. Who's an inventor user? Revit? Civil 3D? Anybody using Navisworks? Fusion? Cool, it's all us young people.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: What's that?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Oh, 3C, Yeah. You know that's my Alma mater, I forget about that. 3D Studio Max? A few. How about Maya? Anybody using some of the visualization tools? What's the game engine?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Yeah, unity. So there's quite a few. I mean you could probably spend an hour just naming all of Autodesk's products. So there's Autodesk Inventor. That's sort of their star mechanical design program, although Fusion's quickly becoming pretty powerful. I've been an inventor user since day one, when you'd curse the software every day. But it's one of the best products for developing 3D printable models.

One thing that Autodesk has done that's really nice is they have incorporated 3D printing capabilities into pretty much every product now. So Revit, Inventor, 3ds Max, Maya, they all have the ability now to export. Well, you can export STL files, so an STL file is the universal, it's like the PDF of 3D printing. It's just a data format that has points and polygons. And there's a new format called 3MF, that was developed by Microsoft. That will incorporate digital rights management, as well as a lot of other information, like color.

Fusion. Fusion is sort of the new one out of the box. It's incredible for any kind of design work. The one part thing I like about fusion is it's really easy to teach, and it's really easy to learn. So I taught a class in Asheville which is a 3D printing with Fusion class, and it was really a Fusion design class. And every student in the class, within the first two weeks of class, was able to do basic design in Fusion. It's a really intuitive interface, it's very easy to learn. And if you're an entrepreneur or you're a student, Fusion is free. They now have, I think as of the last release, they now have two different versions. They have Fusion Ultimate, and they have the Fusion standard. And the Ultimate has some additional tools incorporated into it.

So this one is fun. This is 123D Design. How many people have ever played with this? Couple of people. This one's fun, If you come from real design software background, you look at this, and you go, I'm not going to use this. This is Tinkercad to me, but this is Tinkercad. Yeah, this one is fun, and Tinkercad is interesting because it's about as simple as a CAD program can get. Right? Put two pieces together, and do you want this piece to be a negative, be a cut out. And you can make simple things, and people have spent the time and made really complicated things in Tinkercad. It sort of boggles the mind. It's a really easy program, and it's really a great way to get stuff out for kids.

My old company works with Habitat for Humanity, and every year we do a Christmas ornament competition. So this year it's open to everybody and it's HabitatOrnamentContest.com I think is the name. But this year there's a focus on working with students, so we've gotten out to all the students in Buncombe County, all the counties around Asheville, North Carolina. And last year, a student won the competition. And it's a lot of fun to see what these kids do, and a lot of them use Tinkercad in the classroom. Of course, a lot of them don't understand that you can't print things that don't connect. But it's a lot of fun to see what they do, and there's some interesting ones.

How many people have ever played with Remake or 123D Design? So Remake is the professional version of 123D Design. 123D Design is an application that does photogrammetry. Well they, both do photogrammetry. It's a little bit like Recap, where you can go out, take photographs of something, feed it into a processor, and it will figure out, based on control points and all those photos that overlap, It will develop a 3D model for you. I've had success with a couple of them, but there's some caveats with these. You can't do anything clear, can't do anything reflective, shiny surfaces don't really work that well.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Yeah, anything that's dark is no good. You sort of want middle gray, flat, and sculptures are great for that. Most sculptures like at a museum. I was at the museum, in the Natural History Museum in Washington DC, and I decided that I would try and do a sculpture that they had there. So I had the app on my phone, and the nice thing about the app is it guides you around to take the photos that you need to take for that. And it actually came out pretty good, I wouldn't say it was-- I wouldn't print it, but it actually came out pretty good. Yes?

AUDIENCE: Was the app Remake [INAUDIBLE]

STEVE SCHAIN: The app is for 123D Catch. Remake is a cloud centric program that runs on your desktop. So you have the interface that runs on your desktop, and all the processing is done in Autodesk's cloud. So you send your file up there. It uploads your images, and it's really designed for professional use. I forget how much it costs. It's not inexpensive, but it's not terribly expensive, and it's a subscription per year.

So some resources for deployment, and these are also resources for finding models. A new one, that really just came out not too long ago, is this 3Dx-us. How many people use part libraries for developing their designs, whether it's industrial, mechanical, architectural? So this is essentially an online part library with over 9 million parts, so screws, nuts, bolts, fasteners, pistons, ball screws, whatever you need. There's parts in here you could probably find, it's like the McMaster-Carr library or Thompson. Was that the other one?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Too far away. How many people have used GrabCAD? GrabCAD is a lot of fun. Not only is it fun, but it's really useful. So if you're in the middle of a design, and you want to find a part, whether it's for inspiration, because we don't copy, we get inspired by something. Whether it's inspiration or just something that you want to look at and see how somebody did it. A lot of times you can download like an IPT file or an assembly file. A lot of times they'll have the step you might have the SolidWorks file.

But you can download those and open them. And if they have the history of that file, like if it's an IPT file, you can usually see how they built it, and what the process was that they went through. And complicated files are good to look at just to get an idea of how'd they put this together. You know, what they do? It's free, you don't have to worry about any costs with this. And also if you want to upload models, you're more than welcome to upload models, and have your own channel there.

Thingiverse, how many people have heard of Thingiverse? This is, right now, the number one site for finding 3D printable models. They're not CAD models, most of them are STL files. Some people will post the original CAD file with that, so you can modify it. It's just a fun place to go. There's pretty much everything you could think of from pumpkins, to Christmas ornaments, to laser eye patch, skulls, and I think I must have captured this when it was Halloween. So we got all Halloween stuff in there.

And then CG Trader is another one. CG Trader is a site that allows you to upload your model

for sale. There's quite a few of these. There's also My Mini Factory. That allows you to do that. There's probably over 100 sites that allow you to upload models, to sell your models, or to work with the models that they have. CG Trader is nice because you can get 3ds Max models, you can get Maya files, you can get STL files. Some people will put up the CAD file, if they use a CAD program for it.

Other times, like for some of these like a horse, was 3ds Max file that's fully textured, renderable, and animatable. So if you're using 3ds Max, and you need a horse, you could buy it for $100, or you can try and make it. And it will probably cost you $10,000 to make it. The horse I would make, even though I've been using 3ds Max for a while, might not look like a horse.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Oh here? Yeah, yeah, it does. But it's interesting, they just have a lot of files that you can browse through, and look and see what they have. So this is getting into practical applications of 3D printing. What can you really do with it? So this was the very first thing I printed. When I started my company, I was strategist's reseller. We sold their uPrint line, and I needed something that I could show people, a practical application of a part that came off the uPrint and went directly into work. So the original part is this wheel right here with the clip. This is my dishwasher, and this wheel was missing. It's like socks, where do they go? They're not in the dishwasher. I never took it out of the dishwasher.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: They're what?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Oh, you know, that's totally possible. So I took the original wheel off, reverse engineered it, put it in the Autodesk Inventor, and printed it. And to my extreme amazement and delight, the very first time it printed, I was able to put it on there. The clip was even designed and printed based on the original clip, and this is just abs plastic. So I had to figure out a way to print it so it didn't break. But I got it printed, snapped the clip on, snapped the wheel on, and I was like, wow this worked. And it was in my dishwasher, it's still in the dishwasher. I moved out of there, but it's probably still in there.

AUDIENCE: Did you model it yourself or--

STEVE SCHAIN: No, no, I modeled it myself. Yep.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: No, a good set of calipers. I went to Aldi and found a $10 pair of calipers at Aldi, and surprisingly, they are very accurate. They are not very smooth, but for $10 what do you want. A little graphite goes a long way though. So that was the first practical application of 3D printing that I really started to look at and explore other avenues. This is just a G-clamp that's on Thingiverse. It's printed in multiple parts and snapped together. And you're not going to print this and use it for heavy duty work. But if you need a clamp that needs to hold for light duty, actually I could print this out of carbon fiber, and it would be pretty darned strong. So we have a printer that we use that we can print carbon fiber with, and it would be pretty strong. What's that?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Well there's one that's out there that is designed for long strand carbon fiber, which, I think, that's like a $9,000 printer. But the printer that my buddy uses is a Stacker, and we use the Colorfabb carbon fiber. They're CF20, which is a powdered carbon fiber. And it allows for a stronger part, but it's the compressibility of the part that's much stronger, because the powder is not like the long strand stuff. So those are some practical applications, you can think of a million of them.

Replacement parts is a big one. The replacement parts industry is really starting to undergo this massive, oh my god, what are we going to do. Because now they're realizing somebody could download the STL file for a clip for their refrigerator, print it, and use it.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Right.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Right, he scans his, and prints them.

AUDIENCE: [INAUDIBLE]

AUDIENCE: Oh, he will?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: So there's that, there is also one of the jobs that I did was for a guy who runs a Porsche club. And the bumper, where the tie down is when they're shipped, is a little hole that goes in the bumper, it's got this little plastic insert. That tends to break over the years and fall out. So he designed this plastic insert, and I printed it for him, shipped them, 200 of them. And he sold them to all his buddies in the club, and he's like I need 38 more. So he sands it down. It's all abs plastic, he sanded down, primes it, paints it, polishes it, puts it in, and it looks exactly like the original part. He sent me a photo, and it looked exactly, actually it looked better than the original part because it looked new.

So this is a turbine blade prototype that's printed using metal printing. So this is selective laser centering or selective laser melting. I'm not sure exactly which process that was, but this is a process where it lays down powder and basically welds one layer to the next. So prototyping is now the number one use for 3D printing, whether you're prototyping architectural models or industrial models, it's really the same. There was a gentleman who was here last year that I saw give a talk about 3D printing from Revit, or he was talking about 3D printing from Revit. And he had developed, or somebody had developed, a plug-in for Revit that took your model.

And if you think, if you 3D print a model that's the size of a building, and you want to 3D print the walls. The walls are not going to print because they're going to be so thin. So what this script did, or this plug-in did, is it re-adjusted all the wall thicknesses for the scale you're going to print it at. So that it would print with a wall thickness that was at least printable, which I thought was fantastic. So assembly fixtures is another one. One Of the earliest adoptions of 3D printing was on the assembly line.

A friend of mine in Florida has a company out of the Space Coast called Rapid Prototyping Services. And his biggest clients are aircraft manufacturers, and one of the big products that he has is a company that makes joysticks and gimbals for small aircraft. When parts were coming down the assembly line, people were actually picking the part up off of the existing fixture and putting electronics in it. And then putting it back in the fixture, and letting it move down the line. That's a problem because now they're only working with one hand. So they designed a fixture, printed it, put it in place, and within three days the company had ordered 3D printed fixtures to replace every single one that they had on the line. Because they realize

that this design fixture was perfect because it was made from the original CAD file, and they could print 100 fixtures for the cost of one original.

This is investment casting is another one. So investment casting is another industry that is starting to look at-- how many, does anybody do any kind of casting in here? Yes, no, yes. So the casting industry is another industry that's really looking hard at 3D printing. There's a number of materials that are out there that are investment casting quality materials that will work just like the wax that you're using now in casting. The nice thing is, it eliminates the need to create a mold, and you just print the part. If there's a design change, you print another one. This goes back to that, how much does it cost to make a change.

So when you print a part and cast it, the rework that you have to do is slightly more, depending on the material and quality of the print. So it's hard to tell here, but see these horizontal lines right there, that are in that part? And you can actually see there's the resolution of that STL file wasn't quite high enough, and you could actually see the polygons. And see that the polygons there, can you make that out? It's in the cast part, so that's one thing that they're starting to realize is, when they send an STL file out to get printed, it's got to be super high Res. Because that's going to be seen in the casting, every flaw is seen in the casting. Now it doesn't really matter, this is just a pump housing. But if you're doing something that's going to be out where people are looking into it, or looking at it.

So these are these Porsche parts. This is just one example of the run, and in nine hours, you could print six pair. So he needed 200 pairs, and it took quite a while with only one printer. But it's easy to do, and he had made a change halfway through, and I said, OK well, next run, I'm just going to run the next design through. There was no cost. And that's really, when you think about 3D printing, it's all about cost, cost and speed. Those are the two things that 3D printing really makes a difference.

The other one is a new way to visualize designs. So this is sort of the old method of visualization, 3D rendering. This is the older method, but now a new method once again. So you would make a model like this once, either machined, or you'd make it out of clay, you'd make it out of-- whatever you'd make it out of, whether it's polystyrene or anything. Now you're taking the CAD file here, and 3D printing it as an assembly. And some of these are printed all as one part, some of these are printed as assemblies, some of these are printed individually and screwed together. For this model, they didn't need it to work, they just wanted it to look good.

So some non-industrial, there's a lot of artists that have taken on 3D printing. Actually the very first part I ever printed was a sculpture for an artist in Asheville, and he had designed a sculpture in Rhino. Anybody use Rhino? So Rhino is a design program that uses NURBS, allows you to do really intricate designs. And he designed it, this is not it unfortunately. Somewhere I have photos of it, but I couldn't find him for this class. That's, I think, the bane of digital photography is you have so many photos, you're not sure where they are.

So this is Voxel Studio, this is a 3D printed lamp that they put an LCD lamplight inside of. These are printed with the Kubo3D, it's an SLA printer. This is the original print. This was the casting, and then that's the finished product. So they go through a couple of different steps. I work with a jeweler in Asheville. We were on a panel together, and we were talking about that, and that's what he does. He got away from hand sculpting jewelry altogether. His wife uses a program that is designed for jewelry designers, and they 3D print them. They have a service bureau do it. He doesn't want to get involved with printing parts, but he'll get the model back, he'll cast it, clean it up, make it look nice, and then sell it.

Cosplay is another one, and this is where 3D printing in the hobbyist realm has really taken off. This is just one example, but we printed a six foot axe that has a two foot wide head. It was done in seven pieces with just a PVC pipe running the length to keep it all together. We've also printed the Wonder Woman costume for a friend of ours, who then painted it and was Wonder Woman for Halloween. And then just fun and games, and the one thing I don't have on here is marketing. Marketing is a big one to now.

So 3D printed little ball game, these are fish fossils that, when you take it off of the build plate, they're floppy. They're actually designed to be flexible right off the printer. And then the other thing is companies are now using 3D printing to do a lot of marketing material. And I guess that little thing that's going around is actually a badge holder, an accessory that goes in the back of your badge. This is for the class we're doing this afternoon, so if anybody is in that class I'm going to give you a hint, you'll get one. But this is designed in Fusion, and printed on quite a few printers. So let me go ahead here.

So medical knee implants, a friend of mine just had her knee implant done with a 3D printed knee implant. She said the original implant hurt for three months, and the new one didn't hurt for more than two days, and it feels a lot better.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Uh-oh.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Yeah.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Surgical visualization-- and it fits a couple of business cards in the back. Surgical visualization, anybody read about the recent separating the conjoined twins? They were attached by the head. That's the model of the skull right there with the brain and all the veins in there printed in color. And it allowed the surgeons to really look and see how they were going to do this. And they were able to take it apart, see where all the veins ran through, and they could literally do the surgery physically without touching anybody. So it was really interesting.

AUDIENCE: How is that possible?

STEVE SCHAIN: It was a CAT scan and MRI. And a lot of the CT scan software now, the high end CT scan software, a lot of the high end CT scan software now will output a 3D model. So you can--

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Yeah, yeah, do you have a question?

AUDIENCE: What about the material? [INAUDIBLE]

STEVE SCHAIN: No, I think this was just done as a plastic model, just so they could visualize and see where everything was. So the most active technologies right now are-- this thing does not want to work. Here we go. Right, so the most active technologies right now are-- why the video's not playing, I don't know, but, of course, these always work the night before. Let's see. That do anything? Oh well, here let's see. I'm not going to worry about it.

Anyway, this is FDM or FFF, it's fused deposition modeling, which is trademarked by Stratasys. FFF as the common name Fuse Filament Fabrication. And the easiest way to think about it is, it's a computer controlled glue gun that you feed weedwacker line into. And it's what printed out the badge accessory. It's what printed this out, and it builds in successive layers. They all build in successive layers, one just does it with a moving printhead, and the other one

does it with-- Boy, this thing does not want to go. This does not want to go.

This is a Formlabs Form 1, this is stereolithography. This is SLA printing, it uses a photopolymer that is just a liquid goo that is UV cured. And once you take it out, you put it in a UV curing chamber, and it will cure the rest of the way and harden it. And then select laser centering or jetting. These are either powder bed processes, or they're an inkjet process, where it lays down a UV curable resin. And the powder bed process, the one nice thing about that is, the powder is the support. So you can do a fully working assembly without needing it to hold it up with additional support material. They all have their limitations, and they all have their capabilities. But the most popular right now is the FDM FFF, because the cost of the printers are so cheap.

So here's where I want to have a little discussion. The important issues that are happening today, the number one issue right now that is going on is intellectual property security. Right? So IP protection, how many people have intellectual property in their company that they don't want to get out? The problem with 3D printing and 3D scanning and programs like 123D Catch and others like it is I can be anywhere, I can take my camera, I can photograph an object. And if I'm a really skilled designer, I can just reverse engineer it, like I did with the wheel. And I can reprint it and have essentially a duplicate of that part, and I can bypass all of the time and effort that a company has gone into making a part and selling it.

So that's a big deal, and a lot of companies are looking at that, not only from a consumer level, but more really on an industrial level. If you think about companies like GE that do all kinds of stuff. I mean they make jet engine parts, they make trains, they make power generation equipment. And pick any other company that is their rival, somebody goes out onto the flight line, grabs a part, scans it with their phone. Takes it back to the office, takes it into CAD, designs around that part. All of a sudden now that tightly controlled intellectual property is no longer tightly controlled.

Another one that actually is covered by the-- it's all covered by the Digital Millennium Copyright Act. But it's a problem because an STL file I can get out there and circulate around, and a company can lose control of their intellectual property very easily. So that's what Microsoft and some other companies the 3MF really is sort of the answer to that format because it allows you to do DRM. Let's get closer.

Security and hacking, this is another interesting one that's really just come up recently. Has

anybody been in a company that's had a hack happen? Has anybody had their information stolen from a website that's been hacked? This is happening on this mass level. Well one thing that's starting to come to light is 3D printers are not quite as secure. If they're on a local network, then they're secured by that network. If they're on a wireless network, they're secured by that wireless network.

But what's interesting is, if somebody wants to, they can introduce a flaw in the G-code that runs that printer and introduce gaps. They can introduce purposely in set flaws for critical components that don't work the way they're supposed to. And since 3D parts now can be made as a complete assembly, as one part, Space-X is a rocket component that used to be 100 parts is now one. So they're concerned with people getting in and hacking into their printers and actually inserting a gap or a flaw or something that shouldn't be in there that causes a problem. Think about turbine blades. They're spinning at tens of thousands of revolutions a minute. You don't want a flaw in any of those, they have to be perfect. Of course, they're not going to go into a plane if they're not inspected and X-rayed

And material safety is another one. So material safety is how do you handle the material. So Fuse Filament Fabrication, it's a filament that goes in, but when it comes out the hot end, there's fumes that are let out. So if you're printing with PLA, it's fairly harmless. But if you get into ABS and some of the more exotic materials, you get fumes that are harmful to people and potentially toxic.

So what's the real future? So the real future-- that's the right slide-- is faster speed. So 30 years ago, the technology SLA and 28 years ago FDM, those technologies, they haven't changed a bit. They're pretty much exactly the same. A few tweaks here and there to the quality and the type of materials available. The number one change has been speed. Has anybody seen, it's called clip technology? Couple people. They've now increased the speed of SLA printing, which is the stereolithography by 100-fold.

There's another company, but their printers are $40,000, and you can't buy it, you have to lease it. There's another company that makes a $3,000 printer that is equally as fast. And what they've done is they've bypassed the need for a laser or a video projector, and they use an LCD panel that sits on top of a bank of UV LEDs. They're coming up with ways to print faster, bigger, and that's really the number one thing that's happening in printing is speed.

Because printers are getting faster, you have mass manufacturing. So that mass

manufacturing is allowing companies to go in and 3D print parts that they would have normally had to make fixtures and molds and casts for. Now they need 5000 parts, they just send them off to be printed.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: It is RedEye. Yeah, that's the Stratasys RedEye in the background there. And these are Fortis-- I forget the model number-- but those are Fortis printers. They're FDM printers, and they can print with a material called ULTEM which is super high strength.

AUDIENCE: It looks like the 150 or 400.

STEVE SCHAIN: Yeah, I'm not, I can't read that from there, but yeah. One thing that I thought was really interesting, I saw an application. I saw an application that used super high strength 3D printed material, I think it was ULTEM, to do high pressure bladder forming, metal forming. And they take the mold, put it in a chamber, this chamber closes, a high pressure bladder pushes the metal into the form. But before, they were machining all those molds, costing thousands of dollars, and they'd get several thousand compressions out of it before they had to replace it. Well, now they're 3D printing the molds for like $200, getting a few hundred impressions out of it, and they're still saving like 40% to 50% of the original cost.

The other one is materials. Right now there's quite a few materials that you can print, but it doesn't compare to what you can do with real manufacturing. So real manufacturing, you can pick whatever material you need. With 3D printing, you're still limited to the number of materials, but those are increasing all the time. And you have people that are dedicated solely to developing new materials. There's a company called Colorfabb, they make all different kinds of materials for 3D printing, everything from PLA, to high temperature, to carbon fiber. Another company called Taulman makes a different nylons. And costs are coming down dramatically.

So when I started 3D printing a part this big was like $1,100. So when we sent it out in 1994 or 5, this was $1,100. I could probably print that on my desktop for like $2 now. So that's really the big thing is these costs are coming down. You're going to start seeing, over the next probably 10 or 15 years, the 3D printing industry is going to the printer model. Where the printers become cheaper, but the materials get more expensive. Yeah, it's the same, inkjet, toner, you're going to see that change over here. I don't know, I couldn't tell you maybe 10, 20

years, but it's going to happen. A 3D printer is going to be a tool, and you're going to get film for it or material for it.

And then the other one is unique applications, like Organovo is a company that right now 3D prints liver tissue for testing. So they print live, living liver tissue. I have no idea how they do it. That's why they do it. And they print it, and people can use it for testing products on liver cells, to see what happens to the liver cell. They just got a $12 million grant, or $12 million to actually develop this and to be able to print a fully functional implantable liver. And they're thinking it's like 10 to 12 years away to being able to do that. So sign up now, and then you can drink as much as you want.

So, just in conclusion, talking about what 3D printing is. Talked a little bit about tools for creation and deployment, some practical applications, and important issues, and what the real future of 3D printing is. There's a lot of pie in the sky stuff out there about 3D printing. Like 3D printing you're going to go to a restaurant, and you're just going to order your food, and it's going to get for you printed at your table. I've heard that. I don't think we're ever going to see that in our lifetime. It would be cool to have a restaurant that does that though. Yeah, chocolate. Yeah, they're doing that. I mean chocolate printers are out there now. There's quite a few of them, and there's other printers that do pastries, and anything you can squeeze out of an injector tube, you can print.

AUDIENCE: You can 3D print lasagna. I made lasagna on my computer.

STEVE SCHAIN: Yeah, it'd be interesting to 3D print pasta though.

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Oh yeah, yeah, and you're not doing that. And if you did it I probably wouldn't taste like lasagna. So I want to thank you for your time. If I had something to bribe you all with I would, but fill out the survey. It's important for Autodesk. It's important for me to see what you guys liked about the class. Don't forget, stop by booth 2804, and test your knowledge. And if you're a winner, you could win one of these. And I think there is a, don't quote me on it and don't guarantee, but I think there's a $100 gift card that goes along with it. And a one year subscription to the entire CAD learning content library. I think there's over 40,000 videos in there. Any questions?

AUDIENCE: I got one.

STEVE SCHAIN: Yeah.

AUDIENCE: [INAUDIBLE] study that shows capability over cost [INAUDIBLE]

STEVE SCHAIN: Yeah actually, if you want to hang out after class, I can go over that with you. And we can talk, and I'll give you my card. Thanks. Any other questions? no, yes?

AUDIENCE: [INAUDIBLE]

STEVE SCHAIN: Yes, 2804, and my email is Sschain@cadlearning.com, so if you have any questions from the course, you can get a hold of me through-- I believe you can get a hold of the speakers through the AU website, but also email me directly. I usually try to get back within 24 to 48 hours. So if I miss a day, don't get mad at me, please. And don't forget the answer bar. They're doing that again this year. Oh, that's my timer. It's the best free app ever. So I want to thank everybody, appreciate your time.