TIM VANAST: So good morning, everybody. My name is Tim VanAst. It's a pleasure to be here. Since AU last year-- well, actually-- did you jump ahead already?

JAY SHOEMAKER: There.

TIM VANAST: OK. Welcome to Battle Royale Round 2. We are looking at different approaches for using simulation Moldflow. Well, hold on. I'm getting way ahead of myself here.

So first of all, since last year I am actually a new employee of Autodesk. So I'm happy to be here, has been a great move so far. My role within Autodesk is to actually do training as well as consulting work. But very specifically, we are not trying to necessarily compete with the other folks who many of which are in the room here, Ana Maria, guys at Beaumont.

But very specifically, we're looking to do things as far as helping customers to adopt the software, right? When you get software, how do we make sure that you're able to use it, get it implemented within your group and within your company? So that's kind of the focus of my work at Autodesk.

I have the pleasure, as always, to work with Jay Shoemaker. Introduce yourself.

JAY SHOEMAKER: I'm Jay Shoemaker.

TIM VANAST: Excellent. If you don't know Jay, meet Jay.

JAY SHOEMAKER: I've been around a while, 32 years running Moldflow either as Moldflow or as Autodesk, head trouble maker, mischief maker.

TIM VANAST: Very much so. So last year, we did round one. And we really talked about the different approaches. We had a specific problem. It was a part. We gave it to five different users who were experienced and we've known for a long time.

And we sort of gave them some constraints, so they didn't do any old thing. But we also left it kind of open in the middle as far as their approaches. And what we found as a result was that we basically got five different approaches to the way they approached it.

And I think it was pretty interesting. Because, again, as experienced users, you'd think, oh, there's probably one way to do this particular problem. But we found that really the analysts' experience and the company they work for, the things they did, were some of the things that really affected the way that they approached it.

For example, one of the users really focused on making sure the part was packed out really well. And his approach was based on that, because the company he works for, they do a lot of chrome plating. With chrome plating, you need this part to be packed out very well for good surface appearance.

Now, in this particular problem, it may not have been that important. But that's sort of what colored his approach as he did. Go ahead.

So when we're done, we're going to look at basically some different approaches. Very specific to this year, we're looking at the way that warpage is looked at. And that was one of the, actually, outcomes from last year. As we worked through the whole project, when we got to comparing warpage, it actually became very clear that based on all of the different approaches, we really weren't comparing apples to apples at that point.

So it actually was an outcome. Hey, we should do this again, but just look at warpage. Go ahead.

So this year, we gave a specific part to two users. Everything was already completed as far as the simulation goes. And we just wanted to look at the different warpage results themselves. So this year, we have a consultant, which is very boring. So go ahead. So we've got to come up with something--

COMPUTER:	Timmy.
TIM VANAST:	Do that again.
COMPUTER:	Timmy.
TIM VANAST:	So we don't just have a consultant, we'll call him Timmy. Jay, go ahead.
JAY SHOEMAKER:	So clearly we've changed this a lot.

TIM VANAST: Yes. So the consultant has given this job. Go ahead, Jay. And we're looking for specifically warp criteria, right? Is this part within tolerance or not?

COMPUTER: Timmy.

TIM VANAST: So we need to evaluate these different criteria. Go ahead. So we've got basically the part, a print, got some dimensions.

COMPUTER: T-T-Timmy. Timmy. Timmy.

TIM VANAST: So there were basically six different things we asked of the users to look at. And we had actually posted this out in the forums to get feedback from people. And so we were looking for, hey, what are the different ways that people approach this when we have a specific thing.

So let's go and move forward with this. So one of the first things we want to do as well today is we're looking for interaction. All right. So we have feedback from users already. But what we want today is feedback from you guys.

So when we look at this specific problem, we're actually going to have your feedback. And then we're going to put Jay on the spot, because he's going to hop in the software live and actually show how he would then do that. So if we look at this first problem, we're talking about the rim of this part. And we want to understand how parallel that is.

It within the tolerance 0.1 millimeters to the datum A, B, and C. So let me ask the question. How might you measure this? And let me put this out there. You don't have to have the perfect answer in the first place.

We really sort of wanted to look at what are ways you could measure it, what are the upside of those, and what are the downside of those different approaches. And then we'll sort of work towards what we believe to be the best way to do this. So anybody? Bueller? How might you measure this?

AUDIENCE: I just don't understand what A, B, and C is.

TIM VANAST: So we did show that earlier. So A, B, and C, actually, there's some bosses that are on the inside there. And so datum A, B, and C are on three of those. Mike, any suggestions? What's a good way you might measure this?

AUDIENCE: First of all, [INAUDIBLE] maybe [INAUDIBLE] overall idea.

TIM VANAST: Best fit, good point. Which one did I pass you? Nerds. Do you know I passed you Nerds? Because they don't make a candy called injection molding simulation geeks. So, best fit. Jay, you want to hop into-- well, actually, let me write a few of these down.

JAY SHOEMAKER: So you don't want me to hop into the software quite yet. Is that what you're telling me?

TIM VANAST: Correct

JAY SHOEMAKER: OK. Anybody else? How might you measure looking for parallelism of that rim to those three datums?

AUDIENCE: So you can cut the [INAUDIBLE] on the three datums and it would then scale it by [INAUDIBLE] we can zoom in on that Rim only and just look at how does that Rim link to the [INAUDIBLE].

TIM VANAST: OK. Excellent. Anybody else, what other ways we might look at this?

AUDIENCE: [INAUDIBLE] do a [INAUDIBLE].

TIM VANAST: Yeah. So basically looking at your z deflection, but doing a path plot of the nodes around that. OK, Jay. Now, we'll put you on the spot.

JAY SHOEMAKER: OK. So the first thing that Mike brought up was best fit. And I think we all recognize that's the default setting, right? You do display deflection. It comes up in best fit. And we could look at the rim.

Of course, we could go through and use some examining. [? Gail, ?] I think you mentioned examine is part of that. The trouble is best fit, with that, we're looking at a very small region relative to the overall z deflection of the part.

So we're looking at the deflection of this plane right here that I can't drag my mouse across straight. But you get the idea. So that's pretty tough.

TIM VANAST: --to pick examine on that. [INAUDIBLE] four, six points or something.

JAY SHOEMAKER: Yup. So I could come up here and go around. And am I exactly getting on the right plane? I think I am. But I could definitely go around and do that. And I forgot to hold the Control down.

There we go. Get more at the same time.

AUDIENCE: It's OK. We know how to use the software.

JAY SHOEMAKER: I'm nervous. Thanks, Mike.

TIM VANAST: Right. But when you do this, even if you were to pick every point around there and look at highs and lows, you could get a range then of what your deflection is. But in this specific case, what are we missing, Jay?

JAY SHOEMAKER: We really have not defined parallelism yet.

TIM VANAST: Right.

JAY SHOEMAKER: So this is really assuming just the z deflection from the global. But we don't know how or datums are currently to that global plane. So it's closer to flatness rather than parallelism.

So to kind of go along with that, this plot is best fit. And I played around with the scale, so I could get the range within that. But, again, that's still flatness.

And it's only here when I've defined that plane on those A, B, and C datums. And I did go back through and tinker with the scale. And I coupled that really. How did I get the scale is I turned off all my layers except the rim.

Let's do it this way. That's how I worked on getting it. Whoops. I forgot to turn this back on. That's how I work at getting this.

So path plots we definitely could do as well to get this. But we would still need to identify those anchor locations. Questions?

AUDIENCE: [INAUDIBLE]

TIM VANAST: I want to give you Nerds.

JAY SHOEMAKER: What was that, John?

AUDIENCE: The main model is only grabbing the [INAUDIBLE]. It doesn't have to grab the other

[INAUDIBLE].

JAY SHOEMAKER: Right. Right. OK. I lost my mouse.

TIM VANAST: So does that make sense as far as measuring that anchor points, that you can use scale? Path plot, also. You could definitely do that same thing keeping your anchor points on using a path plot for all the nodes around that.

Again, that would also give you those same values in order to select that. And that, again, because you've got your anchor points on, it would give you your relative, and therefore your parallelism that you're asking for. So path plot would be a good way also to do that. All right, Jay.

JAY SHOEMAKER: Oh, next slide.

TIM VANAST: Next slide.

JAY SHOEMAKER: You want the next slide? Come on.

TIM VANAST: Next slide.

JAY SHOEMAKER: Yeah, well, I'm working at it.

TIM VANAST: There we go.

JAY SHOEMAKER: Running in PowerPoint.

TIM VANAST: So this is one thing, too. In the discussions as we were putting this all together, there were actually a number of people that were saying, well, no, no, no. Because even the fact that the design itself that the datums and that rim were parallel, that just getting a flatness would be appropriate. And that would give you your parallelism, because they're defined that way based on the geometry.

And so I did this to kind of say, well, if we have the flatness of that, if we assumed there was

this one really thick wall, we know that will shrink more. And so that will actually shrink up. And so our bottom would be definitely skewed. So that was the way of sort of explaining how just finding flatness would not give you your true parallelism.

Because based on the part-- now, this part of course is very uniform in wall thickness and design. And so most likely, you know, your numbers would have come out very closely as far as flatness versus parallel. But it is possible based on the design that that's not true. Right. So that's what your difference would be.

OK. Second one, we're looking for the straightness of an edge. So we're looking for from point D to point E for the straightness of that. Suggestions? How might we measure that? Doesn't have to be the perfect answer.

AUDIENCE: I got [INAUDIBLE].

TIM VANAST: Path plot?

JAY SHOEMAKER: Is that the quickest and easiest way to get started?

AUDIENCE: I guess it's the quickest way if you just put [INAUDIBLE].

JAY SHOEMAKER: Single anchor? Miss. Ana Maria says three anchors. Is that what--

TIM VANAST: Three points, two points? So anchors, we got one point, we got two points, we got three points. OK. We can look at that. What about just measure? What about just examine?

No. Ana Maria is saying no, no, no, no. So if you did the two points, I would agree. But what about three, the one point, the middle point, and the far point?

Wouldn't that give you your relative? Anything else? Any other ideas of ways you might measure it? Apparently not. Jay, show them how to do this.

JAY SHOEMAKER: OK. Quite frankly, the first way you'd start out is just the deflection plot best fit. Now, we're interested in just this one edge right here. And we could examine, as Tim suggested, at one datum, the second datum, the one in the middle for y deflection in this case.

That would, in fact, get us started. But it has issues with it, because we have not really defined

that line. Best fit doesn't allow us to define that line.

OK? I've put on my anchors. So we discussed using one anchor, two anchors, or three anchors. OK. One anchor, you can see where I put my first one in right here. Clearly, if I put just that one in, it zeros out that location. So I know that is zero y.

That's a great start. Now, the problem with that is my other datum, which is where my x anchor is at, I'm only assuming it's on the global coordinate system. In other words, it has not moved in y.

For that matter, I'm assuming it hasn't moved in z either. So this is pretty reasonable. But it still does not address the tolerance I'm giving. Does anybody know why?

AUDIENCE: Because your A, B, C, [INAUDIBLE] that goes through [INAUDIBLE].

JAY SHOEMAKER: We only have two datums. We said straightness. of a datum there and a datum there. OK. I am not defining how that line is moving, how my deflection is moving out of that theoretical line.

OK. So it could go in y, which it mostly does. But I could also be moving in z. And that's what this plot is missing is I have no information about z.

So it really comes down to understanding how this particular warpage criteria was defined. It was defined with a geometric tolerance of straightness. And so I've got to consider how any of those points along that line move in the global y and z.

TIM VANAST: And why not x?

JAY SHOEMAKER: And why not x is because it's down. The line is in the global x.

TIM VANAST: Right. So any x dimension would actually be a shrinkage value, not a deflection value.

JAY SHOEMAKER: So really the best way to get after it is to plot with a path plot both y and z. And then we have to do a little trig potentially. And we say potentially, because if I take my maximum value, call at this point right here, and its corresponding z value, if the sum of those two is under my tolerance, I'm golden.

So if the maximum one on y is above my tolerance, I know I'm out of tolerance. The question

then becomes is the sum between the two out of tolerance? Then you have to do the trig to see if the trig is in intolerance.

And then if it is, you're still darn close. And you might want to consider addressing it to get it farther away from the tolerance. Does that make sense? Yeah, Gail?

AUDIENCE: So how are you going to measure when it comes off of a machine? What are you going to do? How are you going to measure it in the real world?

JAY SHOEMAKER: Well, in the real world, you've got lots of different things. But according to the drawing, I've got two datums. So say I'm doing it on a CMM. I've got to identify those two datums. And then I've got some other method to then check that location.

For instance, I could design a manual fixture where that identified those datums and have maybe some sort of plunge indicator to get y and maybe another plunge indicator to get z or something. So there's lots of different ways you could physically measure the part. Of course, you know, hey, we're all about 3D scanning. We could do all of that.

So it all depends on your circumstance. So it really boils down to how is the real part going to be measured. What tools do I have in Moldflow to measure them? Can I get them so I'm really looking at the same thing? Really, the set of questions that Tim and I are trying to address with this presentation-- I saw someone else.

AUDIENCE: [INAUDIBLE], can I ask it had datums on [INAUDIBLE] so was that just a boss plane or [INAUDIBLE]?

JAY SHOEMAKER: It was the plane at the top of the boss tower.

AUDIENCE: If you had holes behind the [INAUDIBLE] part to those holes, and then you had [INAUDIBLE].

JAY SHOEMAKER: For here, I absolutely could. But that's not how my drawing is set up. So, you know, it goes back to what that drawing is. I won't go into that story, because we'll run out of time. But when I was in college and working for my dad in a machine shop, I built a fixture based on an easy way to measure holes.

But that's not how the print was done. The print was done in a horrible way that no one in their right mind should do. But because it was that way, I had to redo my fixtures.

TIM VANAST: Yeah. I mean, that's definitely a huge point, though, again, this struggle between measuring in reality versus what Moldflow shows, right? I mean, how many times have all of us seen this? Oh, Moldflow's way off. You're warpage predictions are wrong.

Well, how did you measure what you did? Well, we did this. And we clamped this thing down in 12 places. Well, you just totally deformed your part. Right? Moldflow doesn't deform my part after we've run through the warpage calculations. And you do.

And that's going to affect-- well, order did you use all these clamps and everything? So I mean, there's a huge potential disconnect there between how they actually measure versus comparing it to this. I've seen it in a few applications where when they built their fixture, they built it with Moldflow results in mind.

And they had basically three clamps on a door panel type of a part. And they did that to use that data to compare to Moldflow results. And then when they were done picking those things, then they put the rest of their 12 clamps and deformed the part even more and used that for their assembly deflection values or tolerances.

So that's something else to keep in mind of, you know, connecting those two things. Because they are not always so easy to connect. I mean, again, many times, you know, whatever's on the print, is there a fixture actually measuring it that way?

JAY SHOEMAKER: Yeah.

TIM VANAST: Sometimes yes, sometimes no.

AUDIENCE: Ultimately, I think that's what we need to do. To give our results to our customer, we need to tell them in a language that they can relate to. And what they relate to is have their [INAUDIBLE].

TIM VANAST: Right. And that gets back to, in some ways, chicken or the egg. As analysts, we need to understand how they are going to measure it and really grasp that. Again, it doesn't mean we have to be an expert at that.

But we need to lean on the people who are the experts at that and who's going to build this gauge and how are they planning to measure this. And if they're looking for really precise values, that's when we need to correlate those two and measure things differently in Moldflow

to give them the correct answer to their questions.

JAY SHOEMAKER: Ted?

AUDIENCE: So the scenario that I have is a lot of times we're looking at using this analysis up front. But sometimes we don't have the GD&T. A lot of times you have parts that's like a C shape, so you get clam shelled. Which way would you recommend that we look at that reflection?

JAY SHOEMAKER: Not an easy answer. But where I would start to go down that line is how have you measured similar geometries that are already in production where the design is done, tool's built. You're running them. How do they measure those parts?

And use that as a basis to inform you how should you look at it in Moldflow before you have GD&T. That would be my thought process is going down along those lines.

TIM VANAST: Again, it comes back to, like you said, sometimes you're way early. You don't have any this. You don't have prints. But if you do understand how they do that-- or, if you don't, just understanding or being able to verbalize well to whoever your customer is Moldflow is showing this. But realize what this is showing you.

Right? This is just best fit at this point. And I'm just picking a point. There's value in that. But it's only answering a specific question when you show that result versus, hey, I put an anchor on this.

I put two anchors. I put three anchors. I did all these things. Then that gives you a different answer to whatever question they've asked.

AUDIENCE: I think something to keep in mind is warpage isn't actually changing from a results perspective. It's just how you're measuring it. So when you do a comparison with something that you don't necessarily know when exactly how it's going to be measured, that's OK. In a design standpoint, what you want to measure it against is the accuracy of Moldflow, then that's a different topic altogether. But when you're comparing two things that are design based, the assumption is that your measuring it in the same positions. So you're still making accurate decisions based on that.

TIM VANAST: Right. Directional decisions. Right. If I do a single anchor point on both parts, it's going to zero both parts at the same point, but best fit everything else. So if I do that and this one has less

warpage than this one, directionally this is a better way to go if that's the exact area I'm looking for.

And, again, it really is a huge part of all of this, right? In this area, we've started with an actual print with GD&T. But if you don't have that yet, I mean, directional decisions are very valid and very good to do.

JAY SHOEMAKER: Yeah. It's a good point. To what both Matt and Tim said, you know, where's our starting point? And what are our assumptions? Early in the design phase, you're more interested in change from one study to the next to the next.

So consistency is the key in how you're measuring it, even though they may not be measured that way once you have your GD&T established and your assembly criteria established. May not be measured the same way you did, but you're consistent when going from study to study, which is important in that phase.

AUDIENCE: Yeah. It's just that in that particular situation, [INAUDIBLE] we are looking at adding deflection [INAUDIBLE] based off our simulation. And sometimes we're just looking at it in one direction. [INAUDIBLE]

JAY SHOEMAKER: Yup.

AUDIENCE: The clam shell and some of the other directions. So this is kind of the box shape you know that that product design was going to work like that and identifying the best criteria. [INAUDIBLE].

JAY SHOEMAKER: Yeah.

TIM VANAST: Most definitely. Nice work, Ted. A few others. All right, Jay. Let's bring it back. So that one's with looking at straightness of the edge.

Let's look at the next one. So this, we're looking at the hole, right? We're looking for the circularity of this hole.

We want to know is it going to fit within the tolerance of that. So anybody, how do we measure how circular that hole is on the top of the part? What are some of the basic things we need to include when we're setting up the measurement of this?

AUDIENCE: [INAUDIBLE]

TIM VANAST: Yup.

AUDIENCE: [INAUDIBLE]

TIM VANAST: Anything else that somebody might include?

AUDIENCE: [INAUDIBLE]

AUDIENCE: [INAUDIBLE]

AUDIENCE: [INAUDIBLE] If you didn't have already set up the local coordinate system before the analysis, is it possible to add that after the analysis of the [INAUDIBLE] results?

AUDIENCE: Yes.

AUDIENCE: [INAUDIBLE]

AUDIENCE: Yes. You can. And I think you can have as many as you want.

JAY SHOEMAKER: Yes. And you can do it after the fact.

AUDIENCE: And it doesn't delete the results?

JAY SHOEMAKER: It does not delete the results. Yeah.

TIM VANAST: It did at one point, right?

JAY SHOEMAKER: No. It never did.

TIM VANAST: It never did.

AUDIENCE: [INAUDIBLE]

TIM VANAST: That was just me.

AUDIENCE: [INAUDIBLE] in the center of that.

AUDIENCE: You can't create a [INAUDIBLE].

AUDIENCE: Exactly.

TIM VANAST: Ah, right.

AUDIENCE: [INAUDIBLE] know that point.

TIM VANAST: But if you know the coordinate of it, you could put it based on the coordinates versus creating a node which wipes out the-- OK.

JAY SHOEMAKER: Yeah. So to be clear, you can create a local coordinate system after the results are done. But you have to know the coordinates. If you try to create a node there, that blows away the results. But you can create a local coordinate system by just coordinates at any time. So you can have the results run, add the local coordinate system as needed, and you're good to go.

TIM VANAST: Which might mean simply duplicating your study, adding that node, blowing up the results of your duplicate, figuring out the coordinate, and going back, adding it.

JAY SHOEMAKER: Yeah. Now, I remember adding a node also assumes I've got geometry there. I've got a through hole. So I have no place to put a node. I could put a node there.

But it's not connected to a mash. So it still doesn't do me any good. for this. So I've got a through hole. So adding a node is just irrelevant for this problem. Yeah.

AUDIENCE: What can't you just do a simple [INAUDIBLE] and the [INAUDIBLE]?

JAY SHOEMAKER: Sure. Absolutely.

TIM VANAST: You could do that as well.

JAY SHOEMAKER: I could do an x deflection, a y deflection, and start examining a lot of nodes around there. Absolutely, you could do that.

AUDIENCE: I want to suggest something, an alternative for [INAUDIBLE] coordinate system, which is best fit on just the nodes around the [INAUDIBLE] circle.

JAY SHOEMAKER: OK.

AUDIENCE:	[INAUDIBLE] best fit doesn't have to be on the whole model. You actually saw it [INAUDIBLE].
JAY SHOEMAKER:	Absolutely true. We can do best fit on a selection of nodes around there absolutely. So there is a slight problem with that. It's been a long time since I have played with that. But I think it won't quite get us what we want.
	I could be wrong on that. So Franco's putting my feet to the fire. Thanks, Franco. Jeez. But to Franco's point, right, I'm almost positive several years ago I've played around with that, and it just didn't make sense to me.
	What we haven't discussed yet with local coordinate systems, we still have to do what Franco just said. We have to do a best fit. So you're stealing my thunder now, too.
AUDIENCE:	Oh, [INAUDIBLE].
TIM VANAST:	Good work.
JAY SHOEMAKER:	Jeez.
TIM VANAST:	No, you're not. So we have to define that local coordinate system, and then use best fit for the nodes around there. We'll explain that a little bit more. So was there anything else?
AUDIENCE:	Your best fit was because of [INAUDIBLE] because [INAUDIBLE]. It's all depending on the amount of shrinkage you get.
JAY SHOEMAKER:	Not entirely. Don't give me that look.
AUDIENCE:	[INAUDIBLE]
JAY SHOEMAKER:	OK. Yeah.
TIM VANAST:	Jay, you've got one more over here, too.
JAY SHOEMAKER:	Yeah.
AUDIENCE:	The best fit function-- and I'm totally ignorant of it. But, you know, when you get into CMMs

and so forth, you have multiple [INAUDIBLE] best fit average, [INAUDIBLE]. What do you guys have here? Is it a best fit average? Or--

JAY SHOEMAKER: So let me describe it. And when I screw it up, Franco will correct me. So it's based on deflection results. So when we do best fit, most of the times, it's all nodes on our part. And what the best fit tries to do is minimize the deflection for all nodes.

And so realistically, it looks like the part shrinks towards the center, call it center mass, center of geometry. That's what it looks like. But behind the scenes, it's trying to minimize the deflection for all nodes.

So for in this context, what it's doing, as Franco said, OK, take the nodes around the perimeter. We're going to do a best fit of that. What that's essentially trying to do is establish a zero at the local coordinate system in the center of the hole for us.

So now when I'm explaining that, I'm wondering if Franco is more right than me about not needing a local coordinate system. So now, I'm nervous. But in any case, that's sort of where we're going here. So I know some of you have more GD&T experience than I do. Is there anything wrong with that drawing?

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: OK. Let me say what I think. It is a little inconsistent. I've got the tolerance on the outside diameter of that. And I'm pointing to the inside diameter. So I did that at some point. Several weeks later, I'm going through my problem with a fresh perspective, since I forgot what I had done before. I'm getting old. I forget things.

And so I wasn't sure. Did I really mean the diameter of the outside of that? Did I mean really the entire perimeter of that hole? So I think my drawing is a little inconsistent, because how I pointed things out. That was sort of my perspective on it.

TIM VANAST: Hop into the software, Jay.

So when I look at the local coordinate system-- or, sorry-- the cylindrical coordinate system that I need, I need to define the origin for that. And the local coordinate system helps me do that as well as the best fit of those holes. Now, what I've got now is I've isolated the interior wall of that hole, and then the edge into two separate layers.

And I get different results. So if I have that edge on, I get one set. And if I have the sides, the side and the edge like I've got there versus just the top, I actually get slightly different numbers, because of that and how I've set it up.

Now, in fact, I said roundness rather than cylindricity in terms of a GD&T. And that does make a difference. So this is actually closer to the roundness.

And I would have to pick either the nodes on the outside to look at or the nodes on the inside. So if it did the max and min, max to min here, and if I'm well within tolerance, I'm golden. Any more questions, discussion? Yeah, Joe.

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: Stealing thunder again. Yes. So Franco was kind enough several years ago to create a script for flatness and roundness, which we will show. And that clearly could be done.

TIM VANAST: Yup. Definitely.

JAY SHOEMAKER: Come on.

All All right. So this next one is this sort of-- I think it's-- about a 45 degree angled bevel there. But we're looking for flatness of that surface itself. So, again, not relevant to datums or anything, just flatness of the surface itself. So what are ways that we could measure the flatness?

AUDIENCE: Anchors on [INAUDIBLE].

TIM VANAST: Yup. So anchor points, you could put three anchor points somewhere on that surface.

AUDIENCE: And then look at the z deflection in the [INAUDIBLE].

TIM VANAST: Correct. Yeah. So with the anchor points, right, looking at z then. Or, zed, either one. Yes. What he said, yes. Anything else? How else might we look at the flatness of that?

AUDIENCE: I think [INAUDIBLE]

TIM VANAST: OK, Jay, you want to--

JAY Oh, you're waiting for me now?

SHOEMAKER:

TIM VANAST: I am now. Let's look at flatness on this.

JAY
SHOEMAKER: Here I was getting set up.

TIM VANAST: Right. So one of the easiest things to start with is layers. If you take the elements on that surface and put that into its own layer, first of all, it just helps hide the noise. But when you use layers also, your scale will automatically set to what's visible and not to what's off in a layer. So that also helps.

So in this example-- right, Jay-- so we put the three-- well, in this case, we've got two different things showing. Right?

JAY
SHOEMAKER: Yeah.

TIM VANAST: You've got anchor points defining that plane. And you also have the local coordinate system.

JAY
SHOEMAKER: Yeah. The local coordinate system in this case is not active. It's just displayed. So the deflection we've got is based on those three anchors.

TIM VANAST: Yup. So if you look at those three anchors and based on the scale, you can see the high and low points. You can then determine if it's within scale. One of the things that's potentially an issue with doing this-- and in this example, it's a pretty flat plane. So I don't know that it's such a big deal.

But on this one, when you use your anchor points, one of the issues is if one of those points ends up on a spot that has a high amount of deflection. You can potentially vary your results pretty significantly, right? I always like to use the banana example.

Right? If I've got one spot that's very much on a highly warped area, you can vary the way that this is displaying no matter which way that is. So, again, if they were generally all pretty uniform, then about any of those points works pretty well. But it's possible if you had a one spot.

As the example, if that top corner happened to warp significantly, you'd be better to have it over here on this point if it didn't. Because leaving it in the highly warped spot, you're going to

suddenly make this other corner lift highly. So, again, in this example, I think it's fine.

And this gets back to what is your result. If you look at your tolerance versus what your result is, if it's under your tolerance, then it almost doesn't matter if it's got deflection very much there. Because you're well within in. And you're golden no matter what you do.

If you're significantly over your tolerance, well, again, unless you had a really strange one, you're probably way over no matter what you do. But if you're looking for very fine, if you're close to that tolerance-- so.

JAY SHOEMAKER: That's where it's going to be a rub. Now, Tim likes his banana example. I like to think of a twist. Take a piece of wood here or something where it's got a slight twist down the length of that board or whatever.

So if I pick any three out of those four corners and anchor it down, that fourth corner is going to move a out of plane versus just letting it twist however it wants to be. It gives you a different perspective. And Tim is absolutely right.

So by doing three corners with anchors, potentially that fourth one, in this case, that fourth corner has got the most negative value. If that is well within tolerance, I am great. It's way out of tolerance, I've got a problem. But the anchor system that I chose gave me the adequate information that I need to go forward. It's only when you're close to the tolerance when you really have to think about am I measuring my warpage in the most appropriate way based on, in our case, part print. OK? Yeah, Ted.

AUDIENCE: So I've noticed a lot of the [INAUDIBLE] layers and when we're going analysis, we're doing a lot on [INAUDIBLE].

JAY SHOEMAKER: Yep.

AUDIENCE: And my question is, is the things that we're seeing here we can still see that without the layers. And what's the benefit as far as time lost by making all this [INAUDIBLE] versus [INAUDIBLE]?

JAY SHOEMAKER: Good point. By isolating on layers, it does tend to-- well, it does automatically scale our results, so I don't go through and do this. So if I had the entire part on, this doesn't get the entire part turned on. OK.

But notice my scale changed radically, right?

TIM VANAST: Most definitely changed.

JAY SHOEMAKER: So now, I have to use the examine command and be a bit more careful to pick locations. And it is not obvious to me what the highest areas on this plane are versus the lowest areas. So if I take the time once to isolate that plane to a layer, and now it's easy, right?

We've got these selection tools. You can select an element on that layer, and then say pick all other elements on that same plane. It selects them all at once, pop it on a layer. You can do this after the analysis is run.

You've got it there. Then when you Duplicate or Save As, you've got it for all your future work. And it makes comparing one result to another a lot easier.

So your point is actually quite insightful from my standpoint. So setting up areas of interest on different layers initially will take a little longer. But you're going to do 2, 3, 5, 10, 15 different analyses looking at different things on this. If I've got that layer set up, then it becomes very easy. You just isolate everything else on the studies, turn it on, and bam. You've got that scale figured out for you. Gail?

AUDIENCE: So what about [INAUDIBLE] review? Are people just not using [INAUDIBLE] review for working?

JAY SHOEMAKER: Sure. People are. And scaling by layer with 3D is a little more problematic, right? Because you've got the volume effect. And scaling to selecting elements to put on that layer, in this case, I would have some 3D effect.

But if within my 3D effect I'm still within tolerance, I'm golden. Again, if I'm close to that tolerance, that's when I'm going to start using examine or maybe a path plot or something else to do the same thing. So now that I have isolated that and I've seen where the highs and lows are, I could make a half plot of those points, all those nodes, and then look at that.

And the nodes wouldn't necessarily have to be in any logical order. I could just select all nodes on that plane. They would get an alphabetic-- or, alphabetical order-- numerical order. And my line might look like that. But then I could take the high and the low and compare those.

So, again, it's creatively thinking about your problem and what works best for me and my

situation. You know? That's hopefully what we're trying to convey is there's lots of ways in which we can look at our warpage results. We have to think about what really our problem is and how can we best look at it.

In pretty much all of these examples, there's multiple ways at which we did it, some better than others. But it comes down to what's most realistic for the problem. How close am I to that tolerance?

TIM VANAST: So now, you talked about anchor points. What about a local coordinate system with no anchor points?

JAY SHOEMAKER: OK. Franco, you had a question or a comment.

AUDIENCE: I was going to offer a comment, which when you're talking about grabbing all those elements and putting them in the [INAUDIBLE] or selecting all the nodes around the rim, I just wondered whether everybody's familiar with the relatively new tools that were introduced in the last two years that facilitate that and make that really easy and just make it like a [INAUDIBLE] thing with all the elements on that surface. It's not like manually having to sort of use the [INAUDIBLE] fiddle around. You know, you can just go [INAUDIBLE] expand all the elements on the same plane and you've got them all ready.

JAY SHOEMAKER: Yeah. So let me--

AUDIENCE: [INAUDIBLE] ways to say that.

TIM VANAST: I think those are 2017 and 2017 R2. Is that correct? I don't--

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: No, 2016 it started.

AUDIENCE: [INAUDIBLE]. Yeah, '16 maybe.

TIM VANAST: 16 OK. Ah, right, right.

JAY So here's the set of tools that Franco is mentioning. So I went to the mesh, but I could also go

SHOEMAKER: to the Geometry menu. I started by picking an element.

And then I've got those. And I would pick the top one on the planar elements. But I could also do triangles on the same surface. Tetra's on the same surface for Gail.

AUDIENCE: Those are awesome.

JAY SHOEMAKER: Yeah.

TIM VANAST:

AUDIENCE: Yeah.

TIM VANAST: Truly, truly.

JAY SHOEMAKER: Ted?

AUDIENCE: The only thing I would point out is when you're using these tools-- because I've used them a lot, too-- is the [INAUDIBLE] gaps. So if you know there is an area and you don't select that, you're going to want to take the gradients off that area [INAUDIBLE].

JAY SHOEMAKER: Yup. Yup.

AUDIENCE: And also [INAUDIBLE] 2017 [INAUDIBLE].

JAY SHOEMAKER: OK. Anything else before we move on?

TIM VANAST: So the next problem we had here, we asked for, again, similar to the last one. But it's actually the port angle which is, as far as the surfaces that are regular to x, y, z, this is on an angled one and an angled of an angled surface. So it's completely irrelevant to any kind of normal coordinate system.

So same thing, though. The question is if we're looking for flatness of that-- and the surface, that port angle, is actually two separate surfaces. The question is how does that change how we would measure this versus the other one?

AUDIENCE: [INAUDIBLE]

TIM VANAST: Jay, you want to use the mouse a second and sort of show where the--

JAY SHOEMAKER: Sorry. The port angle is right there.

TIM VANAST: And then show what the last one was, the bevel. Right. So it's a lower surface versus that top one. But the question is, does it make a difference where they're at? You're shaking your head no.

AUDIENCE: [INAUDIBLE]

TIM VANAST: So I would agree. The reality is when we kind of looked at this after we'd done this, the ways that we've already talked about measuring on the first one really followed through completely with this second thing. If nothing else, it shows the point that it doesn't matter where it's at in space, it doesn't have to be on an x or y or z plane.

If we're looking for the flatness of a surface, it's selecting that surface. It's using three points potentially. You want to show that a second, Jay? On Right. Again, in this case, we've isolated it. You wouldn't have to isolate it.

But, again, it's much easier to see your scale at that point. It makes it a little simpler. But you could do this same thing and just do an examine to a number of the points on there. Again, if your values were really close to your tolerance, maybe you'd take a few more steps to grab all the nodes or something. But if you're way under, close enough. If you're way over, close enough that you're not going to get it no matter what, you're not going to hit that tolerance.

But in this example, again, we isolated the layers. We put the three anchor points. There's the potential here to grab a spot that has a high area of deflection which could potentially skew your data. But in this example, it doesn't.

So the last problem, there's actually two parts to it. But the question is are these dimensions within the tolerance? So we've got the horizontal and the vertical. We're basically looking at the [INAUDIBLE] that are on the part. The question is, are those within tolerance? So, again, my question to you is how would you measure this?

AUDIENCE: [INAUDIBLE]

TIM VANAST: Examine, what?

AUDIENCE: [INAUDIBLE]

TIM VANAST: Difficult. So Mike said, examine. Any other way? Layers, local coordinate systems. In this example, examine.

JAY SHOEMAKER: Yeah.

TIM VANAST: Show them how it works, Jay.

JAY SHOEMAKER: So that the dimension goes to the center of the holes. OK? Now, it does turn out-- I didn't plan this-- but I do have node's exactly in the center of the holes. But I'm not going to use that.

It's very hard to see this screen from this angle here. So what I will do is pick on just the top side of the hole here maybe, or maybe not.

TIM VANAST: You might have to zoom in. One of the other things I noticed, Jay, is your part seems to match perfectly to your deflection. You have values. But there's no shadow of the original CAD. Why is that?

JAY SHOEMAKER: Live demos, got to love it.

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: No, but they don't need to be. Try this again.

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: OK. So sometimes weirdness happens. But we have a backup slide.

TIM VANAST: Yes, we do.

JAY SHOEMAKER: So anyways, my intent was I pick above the hole. So it's the same, in this case, x position of my dimension on both places. And what I will do is I will look at that undeformed dimension relative to my part tolerance. We have a PowerPoint we can pull up to show that in a second.

TIM VANAST: Yup.

AUDIENCE: If you pull it off to your left, [INAUDIBLE] negative space relative to the home, right? If you look at your monitor [INAUDIBLE] slide that over there to your right and back.

JAY SHOEMAKER: Yeah, no such luck. So I'm going to blame this on my computer, because it was very sick yesterday morning.

TIM VANAST: It's not the software, couldn't be. Never. But, yeah, so in this case, actually simply the examine will get us our dimension. We're not looking for anything that's happening in between those values. It's just this point to that point. What is that dimension? And so the examine actually works very well.

And And we'll come back to that.

TIM VANAST: Yeah, we'll come back to that.

AUDIENCE: Jay, do you know the node number?

JAY SHOEMAKER: Yeah, in fact, I do have those node numbers isolated on a layer. Thank you, Joe. I could type those in. But I don't want to take the time. We're running a little bit behind. Are we done yet?

TIM VANAST: Are we done yet? No, we're not done yet. Keep going here. Yeah, so some of this stuff we ought to think about. Again, you know, the tolerance can be measured.

It's all the stuff we've already been talking about. It's how are they measuring reality versus simulation? What else? Yup. Oh, so this is a good one. Does our model represent the part, the CAD? Or, does it represent the tool?

So we're talking about expanded data. So this is always a question, right? When you run your part-- I guess there's a few different options, right? You can run it as is based on the CAD.

It's very simple. It's easy. You take the CAD. You mesh it, you run it. You don't have to worry about expansion. You run the analysis. You look at your values.

But, of course, those values will be different than if you take your tool data, which is an expanded data, mesh it, run it. Obviously, those are different sized parts in the first place. And so if you analyze those, they will be slightly different.

Within the warpage results, you can use the shrinkage compensation tool, which kind of factors that back in based on your CAD. But there's definitely questions, you know? Which is better? Which is worse? Which one should you be doing?

JAY SHOEMAKER: Speaking of that, one of the things that Tim mentioned about last year is everybody looked at warpages differently. Peggy-- not to pick on Peggy-- but she used the shrinkage compensation. Mike, he expanded the data.

Tim and I gave the data set out as part dimensions. Mike went ahead and expanded the data and used that. So I decided to take a look at how these change.

So I started with a nominal part dimension. And then I looked at no compensation. Guess what? I have a fair bit of positive shrinkage on the part. And then I went through and did what Peggy had done and used the automatic shrinkage compensation.

So I got a different value for x, y, and z. And the width, at the end of fill, that automatic shrinkage compensation nailed it. So it got right back to its starting point, which is sort of what we want.

And the length was pretty close. But then the width by the gate under predicted. And so then I said, OK, most of the time, toolmakers are going to pick a single value. And based on the automatic stuff I got, I picked 0.9. And I used that.

And then I said, OK, what if I go back in and expand my data to 0.9. And guess what? Got the same numbers almost exactly. So that kind of helps me understand how all those different methods related to one another.

I had never done before really looked at what we can do it in the plot properties and do the shrinkage compensation and compare that to expanded data. The numbers are basically the same. So that was-- whew.

TIM VANAST: Yeah. So using that shrinkage compensation is a pretty great tool. Because first of all, you don't have to think ahead and do it beforehand. Where if you're doing the expansion of your CAD geometry, you need to do that before.

But, again, it's all part of this process. If you don't do it and you just use your CAD data, when you get your cooling lines in, what's that done? Because your cooling lines will be an expanded space. So how close are those? And how much of a difference does that make?

You could at that point, of course, scale your part up. You could take your cooling lines and scale them down. There's a whole variety of ways that you could do that.

But it's all part of that, again, understanding some of the finer details when you're trying to compare these. Again, if I did not use either of those and I just used my nominal part, if my values are well under, I'm good. If they're way over, I'm good.

It's not going to matter. Changing and putting this extra effort in the details won't affect whether I'm in or out of tolerance at that point. If I'm really close, than I do need to obviously look a little more closely at some of the details.

AUDIENCE: I think it's more relevant of the size of the [INAUDIBLE].

TIM VANAST: Good point. So Mike said size of your part makes a big difference. If my part is this big and I include or don't include that, it's far less important than if I'm doing this entire chair. Because that percentage then will add up.

And suddenly, one end to the other end, it's going to be off by a half an inch. Well, a half an inch is the hole width of this [INAUDIBLE] part. So yeah, clearly that makes a large influence, especially on the large parts.

JAY SHOEMAKER: So few slides ago, or my live demo where I couldn't click on my model, this is what the output looks like. And the question is, do I have expanded data or not? And one of the things you can look at is what's this number. This is my before. And this is considerably larger than my print, so I know my data is expanded. OK.

TIM VANAST: Look at the ways to do it.

JAY SHOEMAKER: Yup. Why we do it. So realistically, we have talked about all these 10 methods already. And this is kind of summarizing what we have already done in terms of just putting on the z deflection. And it's really difficult to tell if it's intolerance or not.

So I could go a little bit further and do my examine and get multiple dimensions. The question is, do I really have the high spots and the low spots? It's difficult to tell, again, because of the overall z deflection values.

So one of the things that I played around with is can I use just a single anchor on the rim. And you know, I kind of struggled with it for a while. And I was stuck on this concept between

parallelism and flatness.

If my tolerance was flatness, this would have been OK. But because it was a parallelism--that's why we put in that one slide that Tim described of, hey, what happens if this one wall shrinks in height a lot? Because it's a lot thicker, that means my A, B, C datums are no longer anywhere close to parallel to my rim. And so we can't assume that.

And so one anchor in examine just didn't get there. And so now we have the three anchors that define that reference. And then we can find that max and min on this. And this particular plot, you know, I played around with the scale, and then decided to show the entire part.

We talked about isolating two layers. It's just very, very convenient once you've got the layer set up. I can turn on and off layers. And the scale automatically changes unless you have manually set the scale ahead of time.

OK. Setting up path plots definitely requires a little work. And it requires a little more work when we're doing deflection plots. In addition to identify the locations, when we want to use it with anchor planes, we really have to have on that shaded plot. Otherwise, the anchor planes will not be active.

TIM VANAST: Right. There's the--

JAY SHOEMAKER: Stop. Yay. So if I was to not have the shaded image on the anchor planes that I had used, even though I might have gone in there and said, OK, use anchors with this path plot and until I have my shaded image on, they're not active. One of the things that I do with path plots and deflections is I really want to double check my work.

And so what I have found that I really like is I try to have anchors in the path plot. And I know they will be then zeroed. So in this case, I have my starting and ending in my path plot. And so those are exactly zero. And so now, I absolutely know my anchors and path plot are set up the way I had intended.

So, again, cylindrical coordinate systems. On this particular case, the local coordinate system was dimensioned relative to the global origin. So I could enter in the number. And then to set up the plot, I needed to define that local coordinate system and then define the zero around that local coordinate system to get my anchors to work.

So, again, what my little video showed is I planned ahead of time. I had selected those nodes

ahead of time, put them on a layer. So when it came to selecting them, all I had to do is band select, and I got just the nodes I wanted.

TIM VANAST: And with layers, too, you can also add. You can create layers and move things around after you've run the analysis and not blow away results.

JAY SHOEMAKER: So here, I'm using a local coordinate system to define the angle for that plane. And so I put on the local coordinate system. I defined the deflection plot to be relative to that local coordinate system.

So the numbers right now on the global, they're one set. Then when I apply the anchor-- or, sorry, the local coordinate system-- the numbers changed. So they're still not zeroed out to that plane. But now it's active to that local coordinate system rather than the global.

OK. You can use local coordinates systems and anchors together. Very, very rarely have I found a need to do this. But what important to remember, and this illustration down here attempts to define it, the local coordinate system itself defines the x, y, and z directions. That first anchor location defines the zero.

So the local coordinate system itself does not tie a zero deflection. It just defines the directions. And when we first had the ability to use local coordinate systems and deflections-- jeez.

Somewhere on the order of 15 years ago or so, my head hurt for a while trying to figure out plots. How is this really working relative to one another? It took me a while.

OK. So Franco and Joe both had mentioned scripts relative for looking at things. Franco made some great scripts for both flatness and roundness. They're very easy to use.

But we do need to select our nodes ahead of time of interest. And then we typically would open the command line, and then type in flatness or roundness. And the script will run in a matter of a second or so and give us information on that. So quite frankly--

COMPUTER: Timmy.

JAY SHOEMAKER: Whoa. Quite frankly, that may be the easiest way to look at flatness, because that flatness script is not dependent on any global coordinate system. It can be a plane that's totally non-orthogonal and work. So we haven't actually said if any of these dimensions were in or out.

So the first one with the flatness of the one plane is actually out of tolerance. It's almost double the 0.1 tolerance. So the second one, where we used the straightness of the edge, we found that it was in tolerance.

Now what was convenient is-- I sort of talked about this before. I took this maximum value and added its corresponding z deflection. And the sum of those was under 0.5. So I knew my trig would work out. And I was going to be way under tolerance, so I don't even bother with the trig.

So when I looked at my roundness, I was just out, 0.07 millimeters with a tolerance of 0.05. Again, looking at the local coordinate system, best fit with nodes around those holes. And, again, when we look at the bevel, we showed three anchors. And that would work.

Here's the flatness tolerance. And this is a CAD model. I've actually 3D printed this assembly to kind of demonstrate flatness. So this one over here is a twist. And I've set it up with its three little bosses to sort of represent best fit.

So it's angling. This corner is angling up the same amount as that one. And that's one way to look at it. But this is like putting an anchor in three corners. So those corners are parallel to ground, making that fourth one really warp up.

And this, I think, for me really helps visualize the impact of our choice of anchors when we have a twist on the part. And hopefully in a year or so, I'll have an injection mold where I can make these parts. I've got some students wanting to do a senior project. And they want to build a tool for this.

So we also kind of talked about flatness before. Here's support bevel. This is the same example that we used, three anchors. And we're 10% of the tolerance, so no problems there. And so here's an example, again, of what I couldn't demo is picking nodes on our part and looking at, in this case, the total deflection and ensuring that it's well within tolerance.

You need to be careful when measuring dimensions. Sometimes you want the overall. Sometimes you'll want a specific direction. So, again, you have to be careful what problem am I really trying to address. Are we don't yet?

COMPUTER: [INAUDIBLE]

AUDIENCE: [INAUDIBLE] that last slide-- go back. If we were required to measure from the center of hole

	to center of hole, what steps would we do, maybe prior to [INAUDIBLE], to do that?
JAY SHOEMAKER:	Yup. So Don asked what if we're required to measure center of hole to center of hole. Well, the first question is do I have a mesh that crosses the center of the hole. Then if you do, what I would make sure is before you ran the analysis, move a node to the center of that hole. OK. In fact, in this part, I was able to do that. But I chose not to.
AUDIENCE:	[INAUDIBLE]
JAY SHOEMAKER:	Yeah. That was at the base versus the top. Now, my dimensions aren't tied to the top or the bottom of the boss. It's really center of the boss. And I interpreted that as the base of the boss. OK.
	But Don has a good point. But what I chose to do is, say, in the y direction, which is kind of vertical on this slide, is I chose a node at the edge that was at the same coordinate as the center of the hole. Now, sometimes you don't always have that. Brian, did you have--
AUDIENCE:	[INAUDIBLE]
JAY SHOEMAKER:	The roundness calculation does give you the center of the hole, yeah. So you can see how that center has, in fact, shifted. But that's not exactly the question if we're looking at linear dimensions between one boss and another. It's strictly a linear dimension.
AUDIENCE:	[INAUDIBLE]
JAY SHOEMAKER:	Yeah.
AUDIENCE:	[INAUDIBLE]
TIM VANAST:	Look at the two centers.
AUDIENCE:	Would it be possible [INAUDIBLE]?
AUDIENCE:	[INAUDIBLE]
AUDIENCE:	[INAUDIBLE] or connected element to a center node? And would it be included in the warpage?
JAY	Don is asking can we work ahead of time, put a part beam--

SHOEMAKER:

AUDIENCE: Or a connector.

JAY SHOEMAKER: --or a connector to the center. I've never tried that. A part beam, you might run the risk of modifying the warpage a little bit. A connector, I don't know.

AUDIENCE: [INAUDIBLE]

TIM VANAST: Yeah.

JAY SHOEMAKER: Yeah.

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: Ana Maria?

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: Again, you could set up a critical dimension. But that doesn't really buy you anything unless you're using an algorithm. A solver that needs that normal warpage isn't one of them.

So I think examine. And especially to make it fast, Joe brought up a good point. Know what those node numbers are. And then I'll put them in the study notes, so I always have them and then copy and paste them into there. So I'm very consistent. And I don't have to pick each of time. Are we done yet?

TIM VANAST: Are we done yet, maybe?

COMPUTER: [INAUDIBLE].

TIM VANAST: Carry on.

AUDIENCE: So, no?

JAY SHOEMAKER: Sadly, yes.

TIM VANAST: Yeah. Yeah, we are. Cool, huh?

JAY SHOEMAKER:	We have 10 minutes.
TIM VANAST:	We're good. Yeah. Again, we're just kind of summarizing. Jeff, you should be happy about that. But, you know, when we're looking at this, it really is a question of what are we doing, what are we trying to answer. If we measure it in a simple way, but it comes out well under or well over, we really don't need to dig into the details necessarily.
	When we're looking at one study to another directionally, I don't know that we need to go into all that detail necessarily. Sometimes you do. But not always. You can directionally say this one's less than this one. We'll go in this direction.
	Go ahead. So this is the other thing, too. One of the takeaways for sure is, I mean, everything beyond best fit takes more work. it takes more effort. But you will get a very detailed answer by going beyond best fit. So best fit's great, certainly directionally. But if there are specific tolerances, best fit just generally won't get you to an exact number for that.
	Right. And again, it just depends, right? Lots of different things you can do it. There are a number of ways you can approach it. I mean, no different than our project last year.
	There are a number of ways to approach a project. There are a number of ways to approach when you're looking at tolerances and dimensions. Some are less detailed and quicker. Some are more detailed, take more effort either before or after the fact.
COMPUTER:	[INAUDIBLE]
JAY SHOEMAKER:	So for those of you that don't know George Thompson at [? LAX, ?] he participated last year, but couldn't come to AU. He wanted to come this time, couldn't.
TIM VANAST:	This was the best we could do to get him here.
JAY SHOEMAKER:	This is the best we could do.
TIM VANAST:	Go ahead.
JAY SHOEMAKER:	Yeah.

TIM VANAST: Besides that--

AUDIENCE: [INAUDIBLE]

TIM VANAST: That's Mike over to the right, by the way. We're not sure what he was actually thinking at the time. But I'm just saying.

First of all, thanks to everybody who did help. Because we used the input from folks when we were comparing this. We appreciate that. In the downloads, we actually referenced a presentation from 2013 that, again, had some other details on looking at warpage. So there was good information there also.

JAY SHOEMAKER: While we're there, show of hands. How many people found this very useful and insightful? OK. Don, come on. Jeez.

AUDIENCE: [INAUDIBLE] that door.

TIM VANAST: Right. And it's truly one of the topics, right? Hopefully, you all learned a ton from this. And you're still going to walk away going, wait, did that mean this? And especially when you get back to the office and you have the next problem, you're going to be like, oh, I'll just do the-- well, it don't seem to fit perfectly.

I mean, it takes effort. It takes time. It takes practice with some of these different tools. And sometimes you need to get creative to try to mix and match these.

AUDIENCE: If I could add a comment, the things that I've learned working with customers as a [INAUDIBLE] supplier is you don't want to get too far into the analysis to discover what the customer's required [INAUDIBLE]. I always find it most helpful to run just a [INAUDIBLE] the first baseline simulation, then review those results. Even if the gate's in the wrong location, try to communicate and understand what they're looking for.

And then by doing that, you know, I've learned from my mistakes where I've got into a simulation-- I ran 12 iterations on a 3D model. And I had 5 million elements. They come back, and they want to see flatness on a [INAUDIBLE] surface. And I had hand picked 400 metals to do a tripod.

But I have all 12 iterations prepared. Now, I had to go back and pick those same 400 nodes on all 12. So [INAUDIBLE]. Now, had I known that upfront, I've learned from my mistakes.

I define all of those node layers, all of the different element layers. And you figure all those things out that you may check. That way, every time you duplicate that study--

TIM VANAST: They're there.

AUDIENCE: --you're prepared to do the class.

TIM VANAST: Yeah. Great, great points.

AUDIENCE: [INAUDIBLE]

TIM VANAST: Yes.

AUDIENCE: No, you're absolutely right. In the first one, you [INAUDIBLE].

TIM VANAST: Right. [? Gail. ?]

AUDIENCE: I mean, it depends on what they're looking for.

AUDIENCE: So we're doing more and more with 3D scanning, and I wonder if others are. And I've think 3D scanning has some of the same issues. And I think the tools that are being used might be worth taking a look at for the development team [INAUDIBLE] graphics.

Almost everything that we have scanned always gets oriented to a datum set. And all the measurements are then based on that. We do a lot of cross-sectioning with 3D scanning and actually factoring linear distances. [INAUDIBLE] it's a lot more tricky to do the flatness and the straightness with 3D scanning. I mean, it's the same three-dimensional data.

TIM VANAST: Correct.

AUDIENCE: [INAUDIBLE] CAD. Unless we stop crossover there. And our customers are using 3D scanning, so that they're used to seeing those kind of results. And I can't generate them. Like, if I could, I know that it wouldn't relate to what they're seeing in another space.

JAY SHOEMAKER: Yeah.

TIM VANAST: I would agree with that definitely.

JAY Yeah, Ted.

SHOEMAKER:

AUDIENCE: Well, my experience has been you have to have a conversation with your [INAUDIBLE]. Because depending on how they're picking up their datums versus how you're picking up your datums--

JAY SHOEMAKER: Exactly.

AUDIENCE: --you get different results. And I've run into that personally.

JAY SHOEMAKER: Yeah. Absolutely. It kind of gets back to those prints that I had. If the CMM guy is using the same print, hopefully you're on the same page. But I'd forgotten who'd brought up do you have prints. So where's this data coming from originally?

So, again, it does boil down to you as the analyst doing warpage versus whoever is measuring the part. You got to be on the same page. And it's exactly what Gail was talking about with her 3D scans.

AUDIENCE: Are the scripts that you mentioned on the flatness and stuff, are they within the program? Or are they add-ons [INAUDIBLE].

JAY SHOEMAKER: Yes. Both the flatness and the roundness scripts are installed with the software.

TIM VANAST: In the downloaded version of the presentation-- yeah, the downloaded version we actually have a slider [? two. ?] You might be able to find that. But it's actually a slider [? two ?] that shows kind of how you do that and easy ways to do it, where it's located and everything.

JAY SHOEMAKER: So if you go up into the View menu and you go to User Interface Command Line-- mine popped on the other screen. There we go. We get a command line now if do-- if I could-- I really can't type.

TIM VANAST: Nope. There you go.

JAY SHOEMAKER: It's complaining.

AUDIENCE: You didn't select the nodes.

JAY SHOEMAKER: Because I didn't select my nodes. And I did that on purpose.

AUDIENCE: Yeah, sure.

JAY SHOEMAKER: That's my story, and I'm sticking with it. Thank you very much. So it's more or less friendly. It told me what I'm doing wrong, and then I can do it again.

AUDIENCE: [INAUDIBLE]

TIM VANAST: Yeah. Assigning it to buttons is a great one, too.

AUDIENCE: You've got 10 buttons there, and I typically have the [INAUDIBLE].

JAY SHOEMAKER: Tools.

AUDIENCE: Flatness, roundness, you know.

JAY SHOEMAKER: Yup.

AUDIENCE: So block 1, 2, 3, 4.

JAY SHOEMAKER: Exactly. And so I go in here, the command line and enter the command I need. Or, I come up here and select its location and define it.

TIM VANAST: Yup. Like I said, the downloaded version of the presentation actually has some of the directions for that.

JAY SHOEMAKER: Along with the downloads, so I showed a number of embedded videos in my PowerPoints. We're supposed to save out a presentation as a PDF. I wasn't able to save in the PDF those videos.

But we did include those in a zip file that goes along. And it references this is video for slide 57 or whatever. So you can go back and look at those videos. Jeff?

AUDIENCE: Actually, I wanted to add on to that-- for you guys. [INAUDIBLE] I wish I could take credit for the comment, but I can't. One of the guys in our [INAUDIBLE] group in Detroit went and got a preview of this and said, "This is awesome content. I totally agree with it. I think this is great.

I thank you guys for putting this together." He said, "But this really highlights how intelligent we need to be, and then how we have to communicate back to our customers. We have to be able to figure all this stuff out." And then I love how he put this.

He said, "We have to talk to third graders in order [INAUDIBLE]." So it's a great mechanism for a highlight of how we have to understand what [INAUDIBLE] software, how we pull data out. But he's right-- we also have to remember the people we're talking to are not multiple experts [INAUDIBLE]. So we have to remember how that goes [INAUDIBLE].

JAY SHOEMAKER: Just to dovetail on that, I work on the group formerly known as LX, or Learning Experience. And I'm in the process of taking the same sort of information, and it's going to be incorporated into the help for the deflection plot. So when you hit F1, you get help on deflection plots. A whole series of discussions in a much deeper dive of using anchor planes and the kind of concepts that we talked about here will get in the help sooner rather than later.

AUDIENCE: My question was, have you guys figured out what you're doing next year? Because I want to see what you guys [INAUDIBLE].

JAY SHOEMAKER: Thanks for the question. Jeff is asking what we're doing next year. Tim and I have not talked about it. But we would love some input on what you guys want for next year. So does anybody have any ideas now? Milan? What would you like for next year?

AUDIENCE: I want [INAUDIBLE]

AUDIENCE: Shrinkage compensation.

JAY SHOEMAKER: Shrinkage compensation. OK. We can deep dive into that a little bit. That's an interesting idea. Laura?

AUDIENCE: [INAUDIBLE]

JAY SHOEMAKER: On scanning data?

AUDIENCE: Yeah. [INAUDIBLE]

TIM VANAST: That would be cool.

JAY OK. Anything else? Yup.

SHOEMAKER:

AUDIENCE: I like Jeff's idea [INAUDIBLE] talking to the person that's [INAUDIBLE] and telling them what they need. There could be a short segment on [INAUDIBLE] what are they actually trying to accomplish? [INAUDIBLE] that helps them do that. I mean, it's a pretty deep conversation. But it's a similar example might be [INAUDIBLE].

AUDIENCE: [INAUDIBLE] no one knows why [INAUDIBLE].

AUDIENCE: Yeah. Or, maybe [INAUDIBLE].

TIM VANAST: Cool.

AUDIENCE: [INAUDIBLE] possibly comparing the [INAUDIBLE].

JAY SHOEMAKER: Yeah. Don suggested assemblies and fits. We almost did that a little bit more last year as sort of a side thing. But, again, I think that's something else that dovetails nicely to this.

Because we went just to a single part in a print. And we didn't really consider, OK, now this is assembling to something else. Do we need to look at something differently?

TIM VANAST: And any ideas you have, we don't have to be the ones giving them. You guys could do that. With that, thank you, appreciate it. A couple of things, we've got the bags up here. Please come grab one of these.

We also have your stickers that gets you into the public house tonight--

JAY SHOEMAKER: Where'd my Frisbee go?

TIM VANAST: --for basically a simulation gathering. So make sure you get one of these. With that, thank you, appreciate it.

[APPLAUSE]