**Manipulating Geometries in VSim**

Hello, everyone, welcome back to our second presentation of our final day of TWSS2021. Today's-This presentation is going to be given by Mark Durant. He's actually worked off and on with Tech-X since 2008. And he's going to be discussing saying how you can manipulate geometries in VSim and some best practices. If you have questions throughout the presentation, there is a Q&A box at the bottom of the screen. Please go ahead and type them in. We'll probably hold the questions until the end. But I want to make sure that we get them answered for you. Thanks so much. And Alright, Mark, over to you.

All right. Thank you. Yeah. Welcome, everybody. Thanks for joining. I'm excited to go over some of the existing and new features in VSim. And there's quite a lot of content. So we'll get right into it here.

So really, when you're starting a project, you have to figure out how you're going to get started with the geometry. And part of it is dependent on what you're trying to investigate. That will dictate what sort of model you need. And then you may have a variety of source material. If you have a CAD model from a collaborator that may or may not be useful, or you, you might be able to use it as your simulation geometry, or it may have some shortcomings that need to get fixed. Or you may be working from just a documentation of a device, or you may just have a mental picture of something that you need to work with.

So if you are working with a CAD file, of course, you can import that CAD file and then perhaps adjust it to make it work for your particular simulation. Otherwise, your best bet is to create your geometry from scratch using something called constructive solid geometry or CSG. The idea of CSG is that you have a set of basic shapes. And you combine those shapes using one of three operations. The operations, if you're familiar with set operators, they're effectively the same thing. You can also think about them as sort of arithmetic. So we have difference, union and intersection. For those who aren't familiar, difference is everything in the first shape, except where the second shape exists. So a box, subtracting a sphere, and you get a box with a spherical divot in it. Also union all of the first shape and all of the second shape, so you get a box with a bump. And then intersection where both shapes overlap a box intersecting with the sphere, you get the bottom half of the sphere, that's where they both overlap. So in VSim, we have a number of available shapes listed there. A new feature that we have is hollow shapes. It used to be that if you needed to make a hollow shape or a thick walled shape, you'd have to make an outer shape, and then an inner shape, and then do the subtraction to create that hollow shape. We have that built in now. And then each of these shapes has a number of controls on it. So you can customize the size, the location, the orientation, and then several of the shapes have specific parameters. For instance, the truncated cone, you can determine how much of the point should be truncated. So let's take a look at what CSG looks like in VSIM. I have open one of our built in examples. And this is a great way to get started with something in VSAN that perhaps you're not as familiar with. You can look at Through our list of examples and try to find something similar. And then you can look at how it's done in that in this case, I did a File, New from example. And this is from the VSim. For microwave devices section, pillbox cavity. So we have a geometry visible here on the in this 3d view, it's a little tricky to tell exactly what's going on with it. It's clearly a pillbox, with the channel through the middle, but you know, I can't see inside, I'm interested in the structure. So while we're here, I'll just show you another feature we have called a clip plane, I turn it on by pressing this clip button. And it creates an axis aligned plane at a given intercept. So in this case, the plane is the x y plane, and is intersecting the z axis. And that gives us a cut through the middle of the object so you can see what's inside. Now, I happen to know this little box right here is actually the current distribution. So I'm going to hide that for now to avoid confusion, I can do that by just unchecking the box next to it, or checking it to turn it back on. Also, you'll see when I select that object, it turns orange in the view to show that it's selected. So that can help when you're trying to figure out what you're looking at. So we'll turn that off. And then your geometries are located in this geometries section in this tree. And in this file, we have CSG. So I will open that up. And we can see that there are a number of parts here, some of which are already hidden, and then some of which are shown. So let's just isolate one. So here's just the pillbox cavity with the two through the middle. And this was made using CSG. So let's, let's look at how that was done. Actually, let's look at the analytical object, it's a little bit simpler. There you go. This is just a cylinder. Effectively, it's a hollow cylinder. So with the new hollow cylinder feature, we probably would have just made a hollow cylinder. This is a little bit of an older example. So if I click on that object, I can see how it was created. So it was started with cylinder, one large zero, which is this object here. And then we subtracted cylinder, one small zero. If I show those shapes individually, here's the large shape. This is the outer shell. And then there's the smaller cylinder on the interior,

right here.

So if I combine those two using subtraction, I get the pillbox cavity. Let's actually start just a new simulation. And I'll show you really how to do it from the beginning. So in a new simulation, the first thing you'll see here is actually the grid, the simulation grid, and you don't need to worry about that. So I'm just going to hide that for now. And leaving just the axes. And actually, while we're here, this is a new feature that I think is pretty cool. We have the axis indicator up here in the left side of the screen. You see it rotates with the shapes or with the space here. And especially when you're zoomed in and you've lost your sense of reference. This little axis hint up here can be very useful for staying oriented. So we'll go to geometries, we'll go to CSS. And then I am going to right click on CSG. And that's often how we access functionality in the sim is by right clicking on the objects in the tree. In this case, we get the option to add a shape, a primitive shape, or a hollow shape. I'll just add a simple box. And you can see it's we're a little confused. Now because I zoomed in before we're actually inside that box. If I right click on that box, I can choose zoom to fit, which will try to zoom out and orient the view to show the shape that was created. So you can see we have a box here. And down in the properties of you, we see the properties of this box. So the length width, and height, position and X, Y and Z. The width direction is actually it's an orientation. So you can think about it like a local axis system relative to the box's origin. And then angle of rotation. And these are editable. So for instance, if I wanted to make this a cube, I can double click on the height here and enter one we'll see the shape adjust. And I can make the width one as well.

So zoom to fit.

There we go. So we've got a box fantastic. With that add another shape.

Right click, add primitive. Let's let's just do a sphere, we'll keep it simple.

Oh, there we go. So the sphere is oriented, you can tell actually that the the origin of the shape depends on what the shape is. So this the origin of the sphere is the center of the sphere. The origin of the box is this lower corner of the box. So if we look at the sphere, we have some different parameters, we have radius angle, angle is nice if you need just a particular arc, for instance, a 32 degrees slice of a sphere, like so. And now to do a Boolean operation on these shapes, I'm going to select both shapes. And then I'm going to right click, and I have a new option which is Boolean operation. Let's do the intersection of the box and the sphere. So those original two shapes are now hidden. They're still there so that if I want to change something, this new shape will actually adapt to it. And then we have a newly created object, which is this box zero intersects sphere zero. And of course, we can give that a custom name if I double click on it. to type in my name, there we go. And one of the really powerful things you can do with CSG is to make these shapes parametric. So for instance, let's say I was going to do a parameter scan on the radius of this sphere, I can create a constant which is a fixed number, or a parameter which is a calculated value. For now we'll just do a constant so I can right click Add User Defined. I'll name it your radius just for sanity. And we'll give it a value of one. Now something I should note here, by default v Sims units are in meters. So what we're looking at right now is going to be a sphere with a one meter radius. Go back down to my sphere object. I can right click on the radius. Choose assign constant. Choose my sphere radius. And we'll see it update. So now if I change my value of my constants,

the CSG shape will change as well. Okay, so let's go back. So advantages of CSG, we've seen some of these already, you have complete control over the shape. One of the key factors is that you are guaranteed that your result is going to be well formed. It's a watertight object, there are no holes or strange overlaps, or some of the other things that we'll see in the CAD files later. They're easily editable, and they automatically update. Obviously, you can make them parametric. The CSG files are integrated into our project files, it's not a separate file. So there are no large geometries to worry about, and there's less file maintenance. And then this last one, it's a bit of an intangible, but if you create your object from CSG, you get more familiar with the specifics of it, so you know exactly where it is in space. You know what the units are, you know what the sizes are. And this can pay off later when you're trying to add instrumentation or fields or things that require specific coordinates. So disadvantages, of course, that making a complex ship can be very difficult. It's amazing what you can do with CSG. But it is a different way of thinking about creating things. And it can be very, very challenging. And there are certain shapes that you really can't even do, which is a perfect time to talk about CAD files.

So with a CAD file, you're working with geometry that you have received, potentially from a collaborator or for some outside source. There are a huge number of different programs that create CAD files SolidWorks, AutoCAD SketchUp. And they all have their own formats. But we support a number of the most common interoperability formats. Lately, we have added support for step in STL, one of the most common kind of base level geometry formats. We've also been improving our GDS to which is more for etching and photonics, we have a few more formats. Advantages of CAD is clearly it's it's going to be easier for complicated geometry, with some caveats. And then it's more precise communication with the people that you're working with. You know, if an engineer sends you a CAD file, that's a lot simpler than them telling you the location of every single corner and every radius of curvature of all the objects, that sort of thing. So it can be a quick way to get started. However, while here's an example actually of this is a CS, a CAD object, this is a C 130. Airplane for engine cargo airplane created from a CAD file clearly would be a challenge to create to this level of detail with the CSG. Disadvantages of CAD CAD models are often going to need repair, they have missing parts or they have parts that overlap that shouldn't overlap. And a lot of this depends on what the original model was created for Or if it's an engineering model, it may have way too much detail things like threads on bolts that you don't really you're not concerned with. But it might be missing some other detail that that you need, for example, maybe precisely antenna locations or things like that. So depending where you've gotten your model, you may run into some of those issues. For example, here are three different models of a bolt. The one on the left, obviously was modeled with threads, full threading, and a bevel across the top of the head. A reasonable abstraction might be the bolt in the middle where it's got just a hexagonal head, and a cylindrical body. Or maybe the third model is what you want, which is, in this case, no model at all, you don't care about the bolts, you're going to ignore the bolts, you would just have a smooth surface.

So

when you first get a CAD file, it can be challenging to isolate the parts that you need to do your simulation. So let's take a look at one of our tools called separate surfaces. And I'll show you how you can get oriented on a new CAD model. So I'm going to start a new simulation will turn off the grid. And to import a CAD file, I go to the File Import menu, choose geometries and then navigate to my file. There we go. Well, she's what, I can't tell what happened, something just happened, but I don't see anything. Let's look at my geometries. Okay, I have a new object under my CAD geometry section. I will right click on it, and I'll zoom to fit, we'll see where it is in space here. Okay, so whoever created this CAD model clearly was not using meters as their unit of measure. Because this airplane, perhaps it's a model airplane. But it is not accurate to real size. So if we look a little closer, you can see that the surface is really just kind of weird, we have some of these orange spots and black spots. And this is actually a symptom of a mismatch between the size of the model and what v Sam thinks we're working with. So I have a grid right now that's on the meter scale. And then I have this model of an airplane that's fairly small. One way I can address that is with our scaling feature. So I'm going to turn on show scale by pressing this button up here. And I have a slider now that allows me to change what units are used in this graph in this window. So let's turn it down to millimeter level, you'll see that the axes are now labeled in millimeters instead of in meters. at the origin, we have a little hint 10 to the minus three that tells us what units were working with. And you'll also notice that those strange artifacts have gone away. So the visualization system here now knows what we're trying to display and what scale we want to display it at. So it can do a better job of creating the the underlying representation. But this is a clearly a complicated model. There's a lot going on. And I might only be interested in part of it, or perhaps, you know, a simplified version. So let's use the separate surfaces tool now You'll see, in fact, I'm going to open up all the levels here, this file has three levels of hierarchy. The top level one will show you the file name of where this geometry was loaded from. And it also has some useful controls, I can, I can reposition this model by editing, by giving it a translation value, I can also rotate it and I can scale it. So we're getting sidetracked from separate surfaces. But this is a cool feature. So we'll do it. So if we wanted to scale, we have a new ability now to do non uniform scaling. So if I click on non uniform, I can specify a scaling along each axis. And look at my little axis hint here, the airplane is aligned with the x axis. So just for fun, let's, let's make it a longer airplane. There we go. It looks like the old SST more now.

Right? So in this way, we can do some basic manipulation of an imported CAD model. The next level down in the hierarchy is a solid. So this is where we expect if this STL file was really obeyed the conventions of STL. This should be a single, solid object. To test that, I'm going to right click, and I have a number of options here, I'm going to choose two separate surfaces. This is a tool that will analyze the geometry and find out how many pieces there really are things that perhaps overlap or aren't connected, or don't connect in a meaningful way. The first step is to analyze the geometry, which takes in this case, just a few seconds. And now Okay, this does not look good for us. 430 open surfaces with a varying number of polygons, which in this case is triangles. 371 closed surfaces. So an open surface with a single, a single polygon is just a single triangle is not connected to anything else. This, this model in particular, is not going to be a great option for us because it just hasn't really been constructed with our needs in mind. We can still look at some of the capabilities of this tool, though. So the idea now is if there were parts of this model that we really wanted to isolate, for example, let's say we wanted to remove all of the open surfaces, and just keep the closed surfaces, hopefully that would give us something that will, will help. So I'm going to choose closed surfaces only, which means it's going to ignore the open surfaces. And then let's also ignore all of the surfaces that are really small. I just want to see what the biggest pieces of this model are. And you can see as I update this, it tells me how many surfaces I'm ignoring. And how many surfaces are going to be separated or saved out. Yeah, so there are quite a lot of large objects in here. Grouping governs how these surfaces are going to get saved into the file. None means that each of the services will be created in a new file. I'm just going to let's just do all surfaces in one group just to show how this works. So we have a new object now. I'm going to turn off the old object.

Okay, so we can see

These are the only objects in this model that are could really be used raw in a simulation without any repair. So that's going to be a challenge. If possible, at this point, I would go back to the engineer or whoever gave me this CAD file, and I would ask them for a simplified model, perhaps they have an external shell. You know, this is clearly some sort of a visualization mock up more than it's an engineering model. So let's step take a step away from this airplane. And we'll look at one of our examples. Let's look at, let's see, let's look at the dish antenna.

Alright, so oops,

there we go. So this example, naturally has a very well formed geometry in it. If we look a little more closely, we can see under CAD, we have a dish antenna. It's all of this orange. There's also this little box right here, which if I click on it, will tell me that's a current distribution. So I'm going to turn that off just for convenience. And if we look at the ditions header, we can see it came from a step file. And it has a number of sub assemblies. There's a wall brackets, there's a bolt naturally, we have the actual receiver here. And then we have the dish assembly with some brackets on it.

So

let's say that this isn't a built in example of VSIM. And instead of this nice step file, what we actually have is just an extract. So I have imported an object that I made earlier by by deleting the brackets off of addition to enter. So you can see we have just that dish now. And on the backside here, we can see that there are some holes where the brackets were deleted. So if we do that same puts, that's the other one. Here we go. If we do separate surfaces on this object, we'll see that it has one open surface with 1800 polygons. So that's we're in good shape there. There isn't a lot of extra detail in this file. But let's do something about these holes. So I can right click again and go to repair surfaces. Very similar to the separate surfaces tool operates on the same engine. We'll start by analyzing and it has identified two holes in the object. I can focus on each hole by pressing the display button. So this 24 edge hole is right here in the center of the screen. And then this 18 edge hole is here. Now can be tricky depending on your model. The automatic display might not perfectly give you the best angle, but you may just have to rotate around to find the best angle and then go back to your repair surfaces dialog. And then I can repair these holes if I click repair. Next at a particular hole it will be replaced with a patch or I can just hit repair all which will do all of the holes. And then I can save this so I can export it into the entire geometry into a new file. Or I could also export just the path suggest the triangles that were created to fill that hole. But in this case, I'll just export the healed geometry, we can see it has been automatically re imported for us. So I'm going to hide this original one. And you can see, here's the healed geometry. So we're now ready to take this into our simulation effectively. Okay.

So, yeah, shortcomings of CAD files, holes. And this especially happens when people are switching formats. So if they, they have a file in one format, they translate it into another one, then they translate it into another one, and then you get it. The models often accumulate errors during those during that transit. So common shortfall.

And yeah, as you saw in the right click menus, I know I went past those quickly. But you'll see that there's quite a lot of functionality in there. Turn off and on, I'll talk about in a minute. Create array, this can actually be useful. Both for CSG. And for CAD. Let's see here. solid object, right. So as you saw, I started at this top level object. That's not where the command is. It's on the solid object. So create array. And I can, let's say instead of one antenna, let's say I had multiple dishes. So let's, let's add three, or we'll create an array rather of three dishes. And we'll space them half a meter, I forget, there we go, half a meter overlaps a little bit. So I can go back in and I can edit that array. Let's say I really intended to be three quarters of a meter, I can edit that value, now have three copies of that geometry, evenly spaced. In the model networks for CSG as well. You can also create a clone which is effectively an exact copy of that object just once. And then you can orient and translate that clone as as you need it.

Separate surfaces repair surfaces, we looked at a cut sell mesh we'll talk about in a second show hide all is the same as checking or unchecking the box so if I uncheck the box, it hides by check the box that unhides I can also do it on individual elements. So show hide all hides them all. And your friend zoom to fit. Anytime you get disoriented. And you're you're or you're trying to navigate to a particular item, right click on it, do a zoom to fit and you should be taken to it. Okay, so positioning CAD models showed this translate rotate, scaling uniform and non uniform and creating arrays. And now, I'd like to show how to export geometry. This is pretty simple. But especially let's say if you made an object with CSG, and then you wanted to share that with somebody else, you would want to export that into a format that you could share with them. So we we support a number of the most common interoperability formats.

Yo, here's that dish. And if I go to File Export geometries, I get this warning, it says some geometries are hidden and hidden geometries will not be exported, that is exactly what I want. And so you'll see here, if you want to isolate and export just a piece of your geometry, all you have to do is hide the other pieces. And we will only export what is actually visible. So sure, I'd like to continue. I can choose what format to export into. And of course, where to export it. That's a default name. For your own sanity, I suggest giving it a more user friendly name. And I can save it. And there's my file on my desktop where I created it. Now I could send that to a collaborator or I could keep it as a backup if I needed to.

Okay, so how do you think about how this geometry is going to interact with the actual VSim engine before you can do that by calculating the cut cell mesh. And so we looked at that a minute ago, we saw that in the in the right click menu. So let's go take a closer look at that. Now, the cut cell mash is a function both of your geometry and of your grid. So let's look let's turn the grid back on. And the grid in this case is probably customized for that original antenna. It's a little bit big for me now. So I'm going to right click on the grid and resize it, which will make it automatically fit the current bounds. In this case, we still have the distributed current box. In here, if I turn my grid off, you'll see that the box is up here. That's why the grid is the particular size that it is. And to calculate the cut cell mesh, I will right click on my solid object. And I'll choose Create cut cell mesh. I get this message meshing in progress message that just went away. And then I got a new imported object. So we'll look at that in a second. We'll turn off,

turn off the grid.

And we'll turn off the source shape. And we can see that the cut sell mesh actually looks pretty good, we lost a little bit of detail around the edge. Clearly the bolt heads ended up being distorted because they're very fine feature. And that can actually be to your advantage, depending on exactly what you're trying to do. If you choose a grid spacing, that's larger than some of your tiny details, those tiny details will effectively be you know, ignored or sort of glossed over in the cut cell mesh. And you can use that to your advantage if you need to simplify a surface. Of course that's that's also a little bit risky, because if you forget and then you change the grid size to be smaller or finer, rather than you'll lose that effect. It's better to have just the right model to start with. And one thing that I will also share is that you may try to create the cut, sell mash, and your geometry may not really be compatible for some reason. For example, if you had a mesh with holes in it or it's it's malformed in some way, in which case, this new surface would not have appeared. And instead, you would get a warning message in the log. So I'm just Gonna show this, this is a not specifically about geometry. But it can be very useful when something happens that you don't understand, show the log, and then take a look to see if there are any error messages. error messages will be colored differently. The black text is just informative. But if you open this up and you see some orange warning texts, then it will give you a hint as to what's going on. One last feature I wanted to show is turning geometry off and on. So this is distinct from showing and hiding. So just showing and hiding governs what's visible in this window. But when we're talking about vorpal, vorpal is going to see, quote, unquote, see any geometry that has a particular materials assigned. So the old way of hiding an object from vorpal was to assign a material that then was not used in the simulation. But we have a new feature now that allows you to turn off or on particular geometries. So if I choose turn off, you'll see that the text of that geometry object is now grayed out, I can still see it in my display. And I can control its visibility to me. But it will not be visible to vorpal. Right, talked about that. And so I covered a lot of information, and there is a lot more information out there. There's also a lot of nuance in some of these tools. So if you need more, more information. The example files that come with VSim are an excellent source of reference material, trying to see how other people have done things best practices. The VSim User Guide is available online and directly in in VSIM, if you click on the Help tab on the left hand side of the sample window. And of course, we also have application engineers at Tech x, you can contact our tech support technical support. If you think that you've discovered a bug, or if you're having some trouble with a particular piece of geometry, you can contact us and we will one of the application engineers will help you out. All right. Let's see if we have questions.

If you have any questions, it looks like we have one.

Yes. Did did I use v similar? Well, okay, well, you caught me there. I am a software developer. And by habit I run the latest version. So this, this version of the sim that you saw, is fairly close to being v Sim 11. But it is not exactly the same. It's it has some development features in it. And then can we do Boolean of a CSG and imported CAD? I believe Yes. But the trick is that it's going to depend on it's going to depend on the CAD. So let's, let's give it a shot. And if I'm telling you something wrong, it will be immediately obvious. I'm sure that somewhere one of the other developers is telling me not to do this, but I can't hear them because I'm in a different state. So let's see we have cylinder here we have the dish antenna. And okay, I'm afraid I was wrong. No, at least in this case. I cannot do the Boolean operation with this geometry this came from this is my cut cell mash. Let's see here. This one is the STL.

Okay,

if I'm wrong about that, we'll post the correction.

Okay, and I saw

another Q, can the same correct all the open surfaces automatically in one action in the c 130? model? Short answer No. The C 130 model in particular, is really a disaster. It is. I showed it more as an example of how something can look very good in CAD, but then then really not be appropriate for simulation.

And so you could,

you could open it up and then just hit repair all on all the open surfaces. And VSAN will do the best it can to create closed surfaces, but they will probably not be meaningful closed surfaces, you might end up with pieces of the airplane. That don't really make sense. So when you get a model that's really in that bad shape. You're either going to want to get a different model, or use that CAD file as a reference to create a CSG object that's more tailored to your particular

situation.

And I see some activity in the chat here.

Okay, nevermind.

Let's see here. Save me function. Okay, I am I am being told that I can do a Boolean on CSG and CAD. So we'll wrap back around to that in a minute. And yeah, let's Okay, I have another good risky suggestion here to show how tessellation changes the visit of the antenna. So let's actually let's let's back up a little bit, I'm going to

clean up simulation.

And then we'll just let's just do a clean one. New from example, dish antenna.

Yeah, so this, this really is a good example to have. You know, I've been an engineer on this project for a number of years. But obviously there are many more people working on it. And so I am not entirely

familiar

with all the features, which can be exciting and also risky when we're doing a live demo. But that's what we're here for. We're here to have some fun.

Okay, actually while we're prepping that let's see Do we have a plan to make functional geometry available? I that is a question that is above my paygrade I know that functional geometry can be very useful, very powerful. We have it in vorpal. The vorpal engine itself can do it. I but we do not have an integrated with The CSG at the moment exposed in the cell.

Looks like we have another question. Did you that can be some correct all the open surfaces automatically in one action?

Yeah, I touched on that a little earlier. The short answer is, yes. But you wouldn't want to, I would do it live for you. But I can tell you that it would take takes longer than the amount of time we have for to try to fix all those surfaces. It's a lot of a lot of surfaces.

This has been such a great talk mark, I can, I mean, we've been really well done. And this, I want to let everyone know the videos are getting put up on YouTube, our keynote presentation is already available. This talk by the end of next week will be on our YouTube channel as well. I learned that we can now get transcripts from our videos, we're going to be able to have those available as well for anyone who would like to be able to translate them and follow along. So hang tight within a week, we should have this available for people to refer to. And I think at that point, we have another talk coming up in just a few minutes. So I think we'll have to hold off on the rest of the questions for now. And I just want to thank you, Mark. Really good, really solid presentation.

Yeah, thanks for having me. Um, and just two really quick follow ups. Yes, I am being told that we can do CSG between, I'm sorry, a Boolean operation between a CSV and a CAD file. I was trying to do it on the wrong level of object. So this is one of those cases where choosing the right object in the hierarchy is really important. So look for that in the documentation. I will go inform myself about that as well. And I'm also told that we do have some people working on functional geometry. And we're curious about, I forget who asked the question. But if the person who asked about functional geometry would like to tell us what usage they had in mind. We'd love to hear it.

Absolutely. I mean, part of what you get with every BCM license purchase is access to our application engineers and they are trained, you know, to two of them have PhDs in plasma physics or one of them has a PhD in astrophysics. So these guys are here to help you with this kind of stuff. So if there's a specific request or something we didn't get to today, just reach out to us the email is sales at TX Corp COMM And we can certainly help you out because it looks like this is a discussion we could we could continue for a little while. So on that note, yeah, we're done if anyone who would like to request an evaluation of the sim 11 go to TX Corp COMM And you can request a 30 day evaluation. And all right mark, I will remove you from the hot seat now and I will bring on our next speaker who is going to be Tom Jenkins. Thank you Mark.