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| ID | TIMESPAN | CONTENT | SPEAKER |
| 1 | 0:00.0 - 2:39.6 | Nice to meet to you ID09 ... [introduction to the interview]  ... We would like to know about your general experience about design for additive manufacturing, roughly how may products or components have you designed for additive? | Interviewer A |
| 2 | 2:39.6 - 3:36.2 | In terms of actual manufacturing products that have reached the market place, a very small number. We have probably worked on one particular project which I’ll talked about at the moment which is to do with radar systems which was using designed, used additive manufactured SLS parts on the internal components that was back in two thousand and seven. The majority of parts that we have made have been either for very, very small short run products which are sort of pre-production prototypes kind of ideas or they have been for research projects which are exploring design guidelines for additive manufacture, but we haven't designed that many products which are actually commercially sold using additive manufacturing techniques. Probably two or three is the simple answer to that. | ID09 |
| 3 | 3:36.1 - 3:40.1 | And how often have they come up? | Interviewer A |
| 4 | 3:40.0 - 4:58.2 | Quite rarely is the honest, again, is the honest answer to that. We tried to use the additive manufacturing whenever we can, when we are talking to clients, but in many cases the cost of the parts is prohibitive and is only really when we are talking to high technology, low volume, high value manufacturers like scientific equipment or defence equipment or things like that kind. When additive manufacturing is economically viable for them. because for most other people they will go straight to injection moulding or they go straight to other mass production processes, because the majority of things we are working on as product designers are high volume, mass produced products, so the economics don't tent to work very often, but if we are looking at a specialist product or a particular device that might be a small component that is economic to manufacture using additive manufacture then that's when it comes up, but it is quite rare in reality. | ID09 |
| 5 | 4:58.2 - 5:27.9 | Well if you have to consider the proportion of these projects comparing all the projects you are working with additive, so for instance is one-hundred percent the all projects you are working on, what proportion of these projects are on series production, what proportion are on prototypes or one-off and what proportion are on tooling? | Interviewer A |
| 6 | 5:27.9 - 7:14.7 | What in terms of one-hundred percent of the three printing projects and how do we break them that down into. I would say probably eighty - ninety percent of those are research in development projects and probably sort of fifteen to twenty percent are going to be manufacturing project that either are long term manufacturing projects, i.e. the product is always going to be made using additive manufacture or they’re short term, because they’re using additive manufacture as a preliminary process before they start to use conventional parts. So for example we have worked on projects where in order to get the product into the market place, we will use additive manufacturing methods but then as soon as it is established, they will switch to conventional high volume processes like injection moulding or whatever, casting, so the vast majority of the projects we have worked on have been experimental development projects, most of which have been funded by research projects like the 'Saving project' that was part of the work that we did with the TSB or Innovate UK as it is now, programme to work with Exeter university on looking at the design of metal sintered parts. So the vast majority of our work has been looking at research components and looking at developing guidelines rather than actual manufactured parts. If that is disappointing, but this is the truth. | ID09 |
| 7 | 7:14.6 - 7:18.4 | Do you think that - this is changing? | Interviewer A |
| 8 | 7:18.3 - 11:32.7 | Yes, I do. Clearly it is changing, I mean the thing that is, I mean there are many issues that relates to the viability of additive manufacturing as a manufacturing process per se, not least is the surface finish, the aesthetic qualities, the acceptability of the appearance of additive manufactured part to a consumer without spending a large amount of money on post finishing and making the part look good, that is one of the biggest issues; but where that kind of thing isn't relevant or isn't a big factor, then additive manufacturing is really, I believe, starting to make a significant impact and in particular I have noticed now that Mercedes have just announced this week that they are gonna start additive manufacturing spare parts for their trucks. I think that's the perfect example because if you’ve got a part that goes under the (bollet) of an engine component on a truck, the aesthetic value of it don't really matter that much and as long as it is purely about function, then that's the perfect example where additive manufacturing can be economically viable compared to holding massive stocks of every spare part that there is. So I think that is a very good example of, where additive manufacturing is growing in importance, the ability to be able to make parts straight away like that or indeed the ability to build and make parts in a local situation and with. I have been working with a charity that I helped start in twenty five years ago called Motivation and they just got a grant from Goggle to explore using additive manufacturing for making parts for wheel chairs in third-world countries where they are going to have a ruggedized, tropicalized 3D printer that they can use in, say, somewhere like Nairobi to manufacture parts for wheel chairs on demand. So somebody needs a particular component or they need a particular splint or brace or thing to help them with their mobility then they can just do that straight away. I think those kind of things are very existing and I think that's part of the growth of 3D printing. But I do think the aesthetic issues are vital because, as we know, when you look at a typical SLS component that is straight of the machine or you look at the typical FDM component that is straight of the machine, you know, they are not very attractive, they are very rough, the surface is poor. And companies like freedom of creation can make a benefit of that in terms of their light fittings and the beautiful things they have done with SLS and that's great, but that is a specific market and I think for general consumers and the general. And certainly talking to the clients that we talk to, if we present them with a very granular surface to part, again typical SLS, and say that is finished component and the first time they put an hand on it, it picks up dirt and finger marks and everything that SLS does, they won’t accept that, they want an injection moulding. So I think the vast majority of people are still very much focused on the idea of wanting an injection moulded part which is just smooth, nice to touch and easy to keep clean, but for a specific applications like components that are spare parts or functional components on a wheelchair or whatever, then I think processes like SLS and FDM have fantastic potential to be a very serious manufacturing process. | ID09 |
| 9 | 11:32.7 - 11:35.1 | Thank you. In my email I asked if you could identify some components or products you have been designed which have been produced in series using additive. What are the products or components that you have chosen? | Interviewer A |
| 10 | 11:48.6 - 38:10.4 | Well, I know this is recorded, so regardless what you say, you cannot see this on recording -- but I just give, just a bit of show you the sort of things I mean. Right let me just start this PowerPoint and would be able to explain to you the main things we worked on. I will be happy to have a copy of this if you want more. This is going back a long way, this is when I first met Richard Bibb actually at a TCT conference back in about 07, I think it was? Basically one of the main things that we worked on, again, apply the same approach of saying this is a non-aesthetic part, it is an internal component, the final product - the aesthetics do not matter because it is hidden. It was a system that we were working on for this company called Navtech radar who are making radar short beam radar systems for detecting intruders and things like that kind. We worked on a series of different designs for them and worked on different ways of making things but we particularly started to look at using SLS as a manufacturing process because it was durable enough, the parts are quite small so it wouldn’t be too expensive. And we already got quite a bit of experience in working with products like this which is a prototype for an antenna for a smart car. And other components that we built as prototypes rather than as manufacturing parts. So we already got quite a bit of experience in designing with SLS parts, we knew some of the limitations but not many. So, we started to look at this and our initial concerns were the cost, the consistency of the parts with different built types, what would happen to the parts over a long period of time, would they wear badly, would they break up, would they become brittle and fracture; the surface finishing - the quality bit. And at the time, there were no guidelines for design and we were looking at this thing which without going into the details, it is just basically a slow spinning system that guides and focuses a laser beam to able to track people, animals and whatever. The company at the time were making these out of very expensive stainless steel machined parts. And we thought we could reduce weight and simplify production by switching to SLS. So we become to look at this and one of the first issues that we looked at was the whole question of how do you make it strong and how do you make it affordable and that came down quite quickly to how you oriented the parts in the build chamber. So for example, as they’re shown in the bottom right, if make parts verticals because the layer is going through the part as it thinnest section, it is going to be quite brittle because the layers, if they are not fused correctly, it is just gonna snap and break in the centre. Whereas, if you make it horizontally, the layers are going through the long axis if you like of the part and that makes the all thing a lot stiffer, a lot stronger so that was the first thing. The second was how do they stack within the build chamber in terms of what is the maximum number you can get from each build process. So we started to talk to 3T about this and we came out with this design and again, it doesn’t work, I know it is recorded, but basically the product is basically a motor in place and a vacuum formed dome and series of parts on the inside most of which are designed to be SLS to guide the direct radar beam as the all thing spins. And what we were able to do, was to use some of the inherent benefits of SLS to make parts that work for example, that came up pre-assembled so you the pivot points were already build in, we didn't need to assemble the product. This arm which is this part here comes across there, which lifts it up to deflect the beam that goes around. This, you build the pivot into the part and that came out to one assembly straight off the machine, which is great because it reduces assembly time and but the concern -- there were several concerns about that, one is: what happens when you got a very thin section in the middle of that pivot point, because again one of the critical things that seems to worry us about SLS as a process, is that despite the fact that you said already, that we are told to -- we can do anything we like, you are only limited by your imagination, additive manufacturing can do absolutely anything. Yes, well it can but it won’t necessarily be any good. And one of the things that is true for SLS is that if you end up with very thick sections, where during the process of sintering you get a massive heat build-up in more particular thick section, where the heat from the laser was retained in one section as the part cools, it bends, it deforms or can deform because the cooling process isn't regular and so the thick sections stay hot longer and that will cause the part to bend as it cools. So in effect I believe that one of things that is quite important is that just as with injection moulding and most other processes, having a consistent wall section is actually quite a good thing because then the heat build-up in the part is consistent throughout the component, you don't end up with very hot spots and relatively cool other spots. So we had to deal with that as part of this process and that was one of the lessons we learned from that. The other thing we learned was about wear and wear characteristics. And this pivot point was quite interesting because we tested that by building a test rig and attaching it to a power drill and putting it through a couple of millions of cycles to see what would happen as we used the part. We found actually that was incredibly durable and the SLS, in effect, worked hardly to become glassy on the surface, so didn't wear away, it was an incredibly strong bearing surface so that was a very positive thing and the part effectively didn't have any wear at all after that three million pivot cycles. So that was a very, very positive thing we discovered in terms of wear characteristics. And then the other thing was that in order to control the lens that is used to guide the radar beam. We used the inherent flexibility of SLS part, the flexibility, the springiness of SLS parts to create a design that guide the lens back into position when it was push up by the arm, it would then be pulled back down by the these strong arms. So we were able to use quite a few of the inherent qualities of SLS part to create a manufactured component that did a good job as far as the device was concerned. This is what I mean about the wear characteristics, that the highlighted part of the centre and you can see on the right there, there is a motor and the (count) flicking at (round). That is the point on the left where the (count) was active on the arm and after a fifteen million cycles simulated using a high speed drill that was all the wear that we got. So very positive. So we were learning a lot of things from that. So when we got all of these components designed, we then started looking at how you could nest them together and build them into the build chamber because the all thing with SLS to me and with any additive manufacturing process is that unlike conventional manufacturing, you cannot just considering in isolation with the manufacturing process, the design of the part and the way is made are completely interlinked. Whereas in injection moulding, they are kind of slightly more separate relationships but provided you can meet the standard expectations of draft angles etc., etc. But with this, we spent quite a lot of the time nesting all these parts together, so this is several sets of parts nested together in a build chamber so the wall sections were not too thick and the parts next to each other didn't get big heat build-ups and the whole process could work in a relatively smooth and efficient way so that the -- when the parts were cooling, they cool down at the same rate consistently across the build because again when we had the parts as prototypes for SLS, one of the major problems that we had is that we would get a prototype made on Thursday and it would be perfect and we would get a prototype made on Friday and it is bent like a banana, and the reason is, the reason, second was bent like a banana was because somebody put it in the build right next to a big heavy section of another part. So when you are just stuffing parts into a SLS build, that does not work, you got to think about the thermal characteristics of what is going on within the build chamber because otherwise part B could affect the way part A is made. And there were several other things like that even just ambient temperature could make a difference. We’ve found parts made where they are different, two different days and one day was a heatwave and the next day was quite cool. And you know the calibration of the machine is good but it isn't good enough to compensate for big changes in the ambient temperature. So there are all the kind of issues like that I think that are really, really important. These things don't matter when you are using it for prototyping but if you are using it as manufacturing, they are critical, absolutely critical. So that's what I mean - is that the whole thing again of not crossing the line of the build chamber, this part is still crossing the middle end point of the build chamber. Again, it distorts the build so the more consistency you got into within the build chamber the better in terms of consistency of parts. So a conclusion that we came to, this is again back in two thousand and seven, so it is a long time ago now, it is ten years really, but our conclusion was that there weren’t the design rules and at the time this was very unwelcome. At the time there was all the excitement about 3D printing - not 3D printing, because nobody was talking about 3D printing - but people was talking about additive manufacture and they were into that – yeah, you can do anything, build anything, do what you like, it’s fine. And we were actually saying – no, you cannot because it won’t come out right and it won’t be consistent. So I am () beyond thermal performance which I think it’s happened and we were saying at the time and again I think this has happened since that attitude to design production need to change in order to make sense of it. So that's (why) area and the main lessons from that project were consistency of geometry and the importance of the build process itself to the part, not just to the design of the part, but the other parts you are putting into the build chamber is really important to maintain the consistency and I am not sure I am able to find this, but let me see if I can bring something that would help explain. The other project we worked on quite recently, well relatively recently which is relevant to this, which unfortunately I haven’t got too many details of here but I can talk you through what we did and was this project for Makielabs. This is a couple of years ago, I have not got the other -- I should have brought more details but I can send them to you. This is quite interesting because it underlines what I have been just said about SLS and consistency. Makielab are a classic sort of millennium sort of start-up type of company based in London. These very interesting things and they came out with the business model that was essentially making customized dolls about this sort of size but one-sixth scale dolls with only size heads. And the whole idea was that they built a fantastic interface where you can go and modify the heads, you can change the expressions, you can move the eyes closer or further apart, you can change the colour, the nose, the mouth, I mean, it was pretty well infinitely customizable. The bodies were very similar, but the heads particularly were very changeable and the whole idea was you could design and make your own doll and then order online and was about ninety quid so quite acceptable sort of price if you are into that sort of thing. It is quite bizarre because you get loads of people making Mini-Mes and on the website you see pictures of people sitting on the park bench with the exact sort of version of themselves sitting next to them on the park bench, it is quite weird; but the whole thing was based on the idea that we have snaps together joins for the arms that we can position the doll in different positions. And they based that on some Lego parts that they found which had snap together joints which could then be moved and rotated (()) stayed; but so far so good that's was fine. What happen was that they chose to use SLS as the manufacturing method for this and initially looked good. They designed things that would snap together a bit like a Lego joint but then they started to sell the initial sample and people started to complain after a couple of months that the joints didn’t stay where you put them, they just, they just basically went flopping and some of the parts were not as tight as well positioned () from the new as others. And so they spoke to guys, one of the guys from EOS who makes the SLS machines and he asked me to go and talk to them, which I did. And it really just underlined the fact that with SLS as a production process: A – you cannot be certain that you are gonna get perfect consistency every time; and B – it is not as reliable a process as injection moulding, because you cannot control the tolerances in the same way and the surface finishing is critical. So what was happening with this was that there were very small variations in the design of the joint that made it loose in some cases and in particular even if it was tight to begin with, what was happening was that over a period of use, it was polishing up and you know that previous picture that I showed to you of the pivot point on the radar system that became polished. Well the same thing happened to the dolls when they joints became polished, they just went loose, because the quality of the joint was initially dependent on the granular surface of the SLS, the rough surface and on the rough surface was polished off after somebody play with it for, you know, ten hours, twelve hours, it didn't work anymore. And it is very hard to explain, but I can send you the information, it’s not a secret, but what we came out with, was, if I say so myself, quite a clever idea and what we came up with at the end was hollowing up the (linnens), so hollowing out the arm joint and making a cylindrical hole in the arm and sliding a piece of silicon rubber roll about 3 millimetre, 4 millimetre diameter into that recess so it was projecting out of the hole. When you snap the thing together the silicon rubber was providing the friction so it was no longer dependent on the SLS for the friction and the friction was provided by the rubber spring in it. And as far as I know, that's fixed and they are fine. But the thing that is relevant about that is that again, you have to design around the limitations of the material and in this case the limitations of the material were: A – that there wasn't, the process is not totally consistent so if you going for precision, you are not going to get it, you are not going to the get the kind of fine precision that you would do the Lego moulded part. It’s just not able to repeat things on that level and the other thing is that, as you use the components they wear very, very slightly and the mechanical characteristics change. So you got to decide around that and the solution in this case was to create this rubber dump part that was very simple to do, very cheap. As far as the user was concerned that was invisible and as far as we know it solved the problem very well and I think it is a good example of where you can use additive manufacturing, but you got to design around these limitations. Because it has limitations. So that's another example and I can send more details about it if that is useful. Just trying to think what else, so with SLS that's probably it. I know we are talking about plastics not metals but I would just quite like, just a sort of talk you through another project which is metals because I think again there are some relevant issues here but it won’t take long. This is about the SAVING project. This was set up by Exeter University with the money from TSB which is now Innovate UK which was consortium of ourselves, University of Exeter, 3T, Plunkett Associates, a software house called Simpleware, Delcam and the people who make the kit EOS. The whole point of this project was to find ways of reducing carbon emissions using additive manufacturing, which is a very tough geek because, as we know, additive manufacturing machines use a lot of power, they are above as far as from the opposite of green as you can get, particularly when you are melting metals, the energy consumption is horrendous. So the only conclusion we came to, is the only way to make additive manufacturing green, was to make long-life parts that would save energy in their use, not in their manufacture. In their manufacture, they would be very, very energy intensive and very inefficient, but if you can make them last a long time and if you can make them a lot lighter and therefore save energy that way then ultimately you save a lot of greenhouse gasses and that was really the point behind this. So we looked at the design of an airline buckle to try to reduce the weight of an airline buckle using additive manufacturing and again what was interesting about this and this is again not as true for SLS because you are supported by the powder, but that it is for FDM when you got to put supports in, that designing any part to minimise support removal is a good thing because if you got lots of supports that have to be removed, you are wasting time, you are wasting energy and you are wasting material because you are just throwing away a lot of support material. And in the case of metal parts, that's quite significant because you are throwing away a lot of titanium. So we worked on this thing and tested it and have some detail FEA analysis to look at the strength of the part and then we created this for our design. But this was all designed to be built using metal sintering and eliminating or virtually eliminating the support structure that goes into it and I think the same thing can be true for FDM. If you are building parts that are coming in like that, if you are avoiding horizontal downward with facing surfaces. If you are avoiding anything that is facing downwards and needs supports, it’s a good thing and so again it affects the design. If the design is always managing to support itself by going like an angle, then that's a more better solution than trying to do something that is trying to be horizontal and that it needs a lot of support underneath it. Just quickly something else which might be a bit longer to that. This is a Makie thing. Just to give you an example of what’s actually how it means. With this, I was just trying to look at some of these things like part orientation in terms of strength of the part so it’s gonna be the same thing I talked about earlier, the horizontal thing is stronger. If you put the same part vertically, it will be weak, because the grain of the part is running in the wrong direction. And that again, it’s a fundamental obvious thing, now but it wasn't before. The idea that an SLS part was going to be completely homogenous and it wasn’t a strength issue. But there are weird analogies between additive manufacturing, conventional and even traditional methods and in this case, it’s the grain of wood. Now if you imagine these parts made of wood and the grain of wood is running in this way, then obviously that is gonna be quite strong because the grain is running along it, so it is not easy to break. But if the grain is running that way, it’s just going snap like a tweak. So, you know these are pretty basic things, but they are still things people need to consider and the whole issue of trying to get detail in terms of the way the part is oriented, again this idea that we were talking about is cost where you got to think about the stacking of the platform, whether it’s FDM that you are trying to make a number of parts in one go or SLS that you want to stack parts within the chamber. There are issues like that. And very clever things like FOC I have done with things like the Lilithlab where, that was genius really, where they made one part inside the other so they make the small lamp inside the big lamp and just pull the part and then assemble it when they build it. That kind of thing is extremely clever design to exploit the process. Anything else -- surface finish obviously is crucial. I think it is probably it. So does that help? | ID09 |
| 11 | 38:10.4 - 38:12.5 | Very much. | Interviewer B |
| 12 | 38:12.5 - 38:40.5 | It does.  I got some questions that may repeat what you have said. How did you decide to produce in series the product or component you already showed us? How did you come that you decided that for this product, additive was the best option? | Interviewer A |
| 13 | 38:40.5 - 44:22.6 | I think it really it came down to two thing, one was the quantities, because as I say, I mean, one of the things I find a bit weird about the idea that additive manufacturing is going to replace injection moulding on a big scale. I mean that's true if you’ve got lots of tiny little parts, dental coping is the perfect example, again that's metal, but hearing aids, the classic hearing aids example. If you’ve got lots of customized hearing aids that are going to be made in a batch then makes completely sense. But if I want to make a million pens, I am not gonna do with additive manufacturing because I can do it at a fraction of the price by injection moulding and I can’t see that's even going to be any different personally because it is just different processes, not different benefits. And the benefit of injection moulding like that is that when you paid for the tooling, the components are coming out at a couple of pence each. If you got to 3D print, even if you can -- unless you can 3D print like the mini machine, like the new Carbon machines where they are beginning to create systems that can manufacture geometry quite fast or very fast; but it is entirely possible to imagine that in a few years’ time, 3D printers may be able to work at the same speed as injection moulding machine; but it is a big jump; a very big jump and at the moment because of time taken to 3D -- to additive manufacture a part, if you got the option that’s moving to injection moulding then that would always be or an equivalent injection moulding, die casting, whatever it may be. But if you got the option of going to a high volume process that's going to be low cost, I cannot see why anybody would not do that, compared to additive manufacture. But if you are making a relative small number of specialised parts; then additive manufacture makes complete sense and the numbers of that are going a change as time goes by. So when we were looking at that radar system in 2007, the parts were expensive but they only wanted to make only a hundred of systems a year, so it was not a big deal. They could not afford to injection mould it because there was no point in creating an expensive injection mould tooling to make one hundred of things a year, so in that sense the economics worked fine. And that's changing as the process is getting quicker, as the process is getting cheaper; then more things that are currently conventionally made will be additively manufactured, but it is all about the cost balance between the time it takes and the cost of the part. So production volume is one critical factor for choice and the other one really is surface finish which is still an issue as far as I can see, because if the part you are trying to make is an aesthetic part, i.e. if it’s a visible part, it’s the top of your laptop or it’s the microphone casing or your phone case, unless you can make rough surfaces fashionable which is someway Freedom Of Creation have done with their lamps and that's very clever. But unless you can make a rough surface part of the deal, part of the aesthetic offering, people are going to reject it, they don’t want a rough surfaces, they want smooth surfaces, they want nice things that you can clean. So unless it is buried inside an engine compartment or behind a dash board or somewhere else. So in that sense, and I think that would continue to be the case and the problem has always been and still is to an extend that additive manufactured parts are quite hard to get looking good and it is quite an expensive exercise to clean them up, rob them down, tumble them, blast them, whatever it may be. Obviously with FDM parts you can vapour blast them to try to homogenously smooth the surface but it’s still never gonna look as good as a proper injection moulding. And the problem with trying to make an SLS part look good it can more than double the price of the part, to give an acceptable paint finish because you gotta spend so much time rubbing it down and filling it, rubbing it down, filling it. So the cost of making SLS parts look aesthetically acceptable in a conventional market is, I think, too high. For me the two main reasons for choosing to go with additive manufacturing would be at the moment if the production volumes are relatively low, and if the aesthetic values are also relative low, and as much as the parts are not going to be seen or used as a direct customer facing part, unless you can make it fashionable like Freedom of Creation have done. | ID09 |
| 14 | 44:22.6 - 44:36.7 | In the project that you showed us before the radar system, do you remember what were the main considerations for using additive manufacturing? | Interviewer A |
| 15 | 44:36.6 - 46:03.5 | I think in that one, it was kind of perfect example because the main considerations were lightweight, because we wanted to minimise weight and SLS was perfect for that, durability and again the process, using SLS was incredibly durable. It had inherent flexibility because we could use it to create springs, which was really helpful and the cost was acceptable because of the quantities that we were making. Those were the main reasons but that was quite a rare example of something, it was a perfect case really. | ID09 |
| 16 | 45:25.9 - 45:30.7 | And you told before that the radar system was previously made with injection moulding right? | Interviewer A |
| 17 | 45:30.6 - 1:33:46.5 | No, the radar system was previously made by very expensive machined parts. So the parts were previously machined from stainless steel, because again the production volume was low so they could not justify injection moulding and also because parts are quite big so we were replacing quite heavy machined components that were also very expensive. So again the economics worked as well as the technical side. | ID09 |
| 18 | 46:03.6 - 46:19.0 | So, how did the design, you showed us before in these slides, how did the design of the radar system, change after it was decided to be made in additive manufacturing? | Interviewer A |
| 19 | 46:19.3 - 46:59.8 | We would make it more compact, which is great. We were able to make it fewer components, that was also great because we could combine parts into one SL Spart, which again maybe more reliable. So it's really about reliability and durability and reducing the size. | ID09 |
| 20 | 46:59.8 - 47:37.5 | So, now I'm going to use a metaphor and ask you to immerse yourself again in the experience of designing the radar system. Let's imagine that you have video recording all the development process of the radar, and we are going to play again all the recording of the development. So how did you come about with that design? How did you design this radar system? | Interviewer A |
| 21 | 47:37.5 - 50:54.2 | Uh, I mean, I think in this particular case, it's not a good example in as much as purely functional. You know, we won't try to make it up statically beautiful. That was not a consideration in this case because it's all internal parts. So what we were trying to do was really define exactly what the system had to do. And then using the freedom of the design that additive manufacturing does. You know, it does definitely give you freedom of movement to design things in an unconventional way. Then we could begin to actually answer the technical limitations and technical problems without having to worry about whether you could mould it or you could machine it. In that sense, the idea that you can do anything with additive manufacturing is true. The geometry can be virtually anything you like. And some ways, the biggest issue for particular designer who's had some experience, shall we say, the biggest issue with this thing is unlearning the methods that he's used before, because most designers who have been around for a while will automatically think about things like draft angles, which are true for injection moulding. They will think about assembly methods, which are true for fabricated parts. You know, they will think about, you know, various other conventional manufacturing methods. And that's kind of deeply ingrained in someone who's been practiced for a few years. But, with additive manufacturing methods, there are rules that you have to observe, but there are completely different set of rules to the conventional ones. So you are gonna forget the conventional rules and begin to think about the new rules. Some of them are quite similar, like very thick sections, I would argue, that might not be, you know, other people might have different views of that, but our experience has been that thick sections are a problem. In that sense, that's quite similar to a conventional design. But lots of things, like having to worry about the mouldability something, well something is manufacturable using moulding processes, you can forget about. So in the case of the radar system, we had a lot of flexibility to add bits of geometry on where we needed them to, make it stronger here, added a bit of extra material there, changed the section of the parts, and not had to worry about whether it was manufacturable because it was layers. So that is fantastic. There is no doubt that within additive manufacture, there is a lot more design flexibility, provided that you can forget about conventional methods. But in that particular case, the design was driven entirely by the function of the parts, not by appearance. | ID09 |
| 22 | 50:54.5 - 51:10.7 | Do you remember, what were the design considerations at the 'conceptual' stage, so when you were generating ideas about the radar system? | Interviewer A |
| 23 | 51:10.7 - 51:14.7 | Well, in terms of the 3D printing? | ID09 |
| 24 | 51:14.6 - 51:27.2 | Yeah, when you were designing the system, the radar system, and you were thinking how to design it, how to generate new ideas, what were the considerations? | Interviewer A |
| 25 | 51:27.2 - 52:25.3 | Well, one of the main things was trying to combine components into a pre-built assembly. As we were looking at the parts and how they were made, had pivot points already built into the part and it came out of the machine. It has springs built-in to it at the top to bring the lens back into position. In the previous design, all of these had been separate parts. They had to be assembled, they had to be made separately, put together. And you know, the great thing we were able to do at the concept stage was to be able to combine several parts into one part, which make it more durable, which make it easier to build, it make it easier to assemble. And that was the main thing, was conceptually being able to make the entire thing as one pre-built assembly in S L S, rather than have to make it out of ten different parts which then had to be bolted together. | ID09 |
| 26 | 52:25.3 - 52:32.7 | And do you remember what were the design considerations at the embodiment and detail design? | Interviewer A |
| 27 | 52:32.6 - 53:47.3 | Uh, I mean, with that, more or less, (it ain't) really went through one iteration on that, I mean, that particular case because it was a simple mechanical device. Once we got the concept right, the rest of it just followed from that really. There were a few changes in terms of adding mounting points, pivot points and small details to the design. But the basic design came out pretty much as per the original concept. I mean, in some ways, the detailing is more relevant to the work we did on the Makielabs thing where we were trying to work with the limitations of S L S, and coming out with ways of detailing the parts so it was able to still (slide) together and work correctly. But working on a long term way, and then we had to do a lot of work on the detail of the joints to make those joints click together correctly. But using the additional, use of this silicone spring to create the friction on the joint, I think that involved a lot more detail work than the radar system. That depended on the detail work. | ID09 |
| 28 | 53:47.3 - 54:01.0 | Can I ask you to quantify this more detail work, in terms of, roughly how many iterations, or how many times do you spend detailing that drawing? | Interviewer A |
| 29 | 54:00.9 - 55:54.5 | With the drawings on the Makielab product, again, a little bit like the other one we built the test rig to test the, whether the joints could remain durable after many thousands or hundreds of thousands of movements. We went through; I think we went through five different versions. Originally, it was a different design just using SLS. That was trying to be more flexible and with more inherent adjustability. And then we went through a different version of that and a different version of that again. And then we used mechanical spring, I think we used a metal spring to try to create the tension of the joint. And in the end, we came up with silicone rob, which is a great opportunity. But that project went through, probably like many design projects; it went through five or six iterations of trying to come up with a refined design that'll work correctly. With the radar system, it was a lot quicker actually. We only really went through two different versions of that and everything was pretty much finished. But obviously the great benefit of additive manufacturing or rapid prototyping is the ability to test ideas incredibly quickly and that is, obviously that was one of the first things that rapid prototyping was known for, was the ability to iterate designs very quickly. And obviously that's still true now and more continued to be so. I mean, that's one of the main reasons we use it in our day-to-day work. We use additive manufacturing techniques with S L S, FDM or whatever, not for manufacture but for design development. It's the ability to quickly make a prototype, is fantastic. | ID09 |
| 30 | 55:54.5 - 56:18.9 | Thank you. Now I want to ask you something more on these two projects. I mean, there were any considerations when you started to produce the radar, when you started to produce the joints for the Makielab. So there was any change when you actually finished the design process and started to going to production? | Interviewer A |
| 31 | 56:18.9 - 57:15.3 | Yes, I think there was with the radar, we'd already tested things like durability but we needed to change things like assembly methods, manufacturing methods and how we joined the S L S parts to the chassis, that was, you know, that was quite simple. With the Makielab ones, once we'd been through all that development process, we tested it in with our own test rig. It went straight, as far as I'm aware, it went straight to production using that method. The annoying thing about that was by making short or long silicone springs, you could increase or decrease the tensions so it was a very easy thing to modify. But I think once we finished that development process, that went into production as exactly as it was originally intended. | ID09 |
| 32 | 57:15.3 - 57:29.0 | Ok, so, now, when you were designing the radar system and the Makielab, did you follow any specific design guidelines or design rules? | Interviewer A |
| 33 | 57:29.0 - 59:24.3 | Nope, because we had to make them ourselves. I mean, that was, the whole point to that, that presentation to TCT in 2007, was based on the fact that the conventional wisdom at the time was you can do anything you like. And we realised that wasn't true. I was working very closely with 3TRPD at the time, who were pioneering of an SLS product then. They've got some biggest machines and they still have. But what we'd realised from prototyping was that parts were not consistent and so a lot of the work we were doing on that project was try to find out why parts weren't consistent. That was really what we were discovering, was that the whole question about sections, about how you lay out the build chamber, how the parts themselves are configured. So, no, at the time, as I said, the conventional wisdom was there were no design rules at all. And in fact, you know, I made myself quite unpopular at one conference, my suggesting that, you know, there needed to be design rules for the 3D printing or additive manufacture. Because it was just a strong idea at the time, particularly by certain people within the additive manufacturing industry, the design rules were thing of the past. Especially some guys from Loughborough actually, at the time, and their whole thesis was that you forget about design rules completely. So there were none and that was part of what we were trying to create with emerging design rules, really. | ID09 |
| 34 | 59:24.3 - 59:33.1 | Now I want to ask you a very interesting question. How did you learn these design rules, these design guidelines? | Interviewer A |
| 35 | 59:32.8 - 1:01:54.3 | Experimentation, really. I mean, as I said, we were working with 3T on parts. We had quite a lot of prototype parts made as part of our normal work. We noticed that certain parts come out well, certain parts come out badly. And it was (by) interest, try to analyse why these parts came out well, why these parts came out badly. And then really, just applying a little bit logic to it. Because, as I said, particularly when you look at the process and you look at the heat that is applied during that process, the whole question of how that heat then dissipates and how the parts cool down, again there was an idea of 3D printing or additive manufacture that the parts are magically made, suppose if it's FDM, it's quite trivial 'cause you can see the part being made in front of you and then it is finished. With SLS, you are building that part within a chamber of the powder. That chamber has to be allowed to cool for, I think, for at least12 hours. And that cooling process is as important as the building process. It seems to us that if you put very, very heavy things next to very light things, then they are gonna distort. It's just logic, really. So some of them was questioning conventional wisdom, a lot of them was questioning conventional wisdom, and most of it was about saying 'ok, we can make one of those now, but if you wanna make 60, 100 or 2000, how do we have to do that? Can we just make repeated examples of one? Or how do we actually stack it within the build? How do we make multiple parts? What are the issues within the build process that would affect the way of the parts that came out. Those were some of the main things we were considering at the time.  [ID09 is now chatting] How're we doing? I'm tired. It's quite a hard work. | ID09 |
| 36 | 1:01:54.3 - 1:02:08.6 | Did the introduction of additive manufacturing knowledge change the design of other components in the radar system? | Interviewer A |
| 37 | 1:02:08.6 - 1:02:32.9 | Yes. The parts that we designed were totally different to the conventional parts. As conventional parts were made of fabricated components that were much heavier, much more complicated. Many more individual parts were in system. So we were to dramatically simplify it by using additive manufacturing. | ID09 |
| 38 | 1:02:32.8 - 1:02:45.3 | And the other component you showed us, for instance, the dome were made in thermoforming, did the other components which were not made in additive change, because they are internal components? | Interviewer A |
| 39 | 1:02:45.1 - 1:02:57.7 | Only in this as much as we were able to make it smaller, really. We were able to reduce the size of the whole product, so the whole thing was more compact. But it didn't make a big impact on the other individual parts. | ID09 |
| 40 | 1:02:57.6 - 1:03:11.6 | Ok, so, for the radar system, are there any drawbacks or limitation as a result of this being designed for additive? | Interviewer A |
| 41 | 1:03:11.6 - 1:06:04.4 | Yeah, I think the client [sounds like the name of a person, i.e. the person ID09 was working with] was concerned that they wouldn't be strong enough. They were worried about the strength. So it wasn't the limitation, it was more a concern (). No, I don't think there were limitations actually. Not in a practical sense. We've proven that it'd work. We've proven that it'd be durable. The mechanism would work repeatedly over a long period of time. I think ultimately, one thing that didn't become an issue for them was cost. Because I think they'd found, they could make some of the parts more easily, or more cheaply using conventional methods. So I think the cost was an issue. And really, it's always gonna be a fact, because again, unless you are making a high volume consumable product like the lighting things made by FOC, which you can sell for nice premium, in my case, 100% of my clients have one major concern and that's reducing cost. That is the thing they're concerned about, particularly now. So anything that increases cost is a bad idea. So I think that, in that sense, additive manufacturing is still in many situations, obviously with kick start project with people building things online and being able to make little gadgets and widgets using FDM and stuff like that, that's fine. But in terms of mass production, and in terms of the consumer market, I'm still struggling to see where additive manufacturing fits that at the moment. Obviously in specialist areas, in aerospace, in car parts, I could see there is a huge potential for that, particularly in small specialised markets. But it's gonna be interesting to see the extent to make additive manufacturing can get a real foot hold in consumer products, because I still think that, for a foreseeable future, conventional processes are gonna be cheaper, and cheaper as what people want. So, cost, I think the biggest limitation with additive manufacture is still, it's basically two things, its cost and surface finish. I think there are two problems that additive manufacture has, that prevent widespread uptake of these processes in the consumer industries. | ID09 |
| 42 | 1:06:04.4 - 1:06:12.2 | Did the use of additive manufacturing change your design process or practice? | Interviewer A |
| 43 | 1:06:12.5 - 1:06:49.6 | Yes, yes, absolutely, again, mainly because we were trying to integrate parts together. Something you can't do when you're using conventional methods. Conventional methods, you also have to make separate component and then you got to find (where's) assembling things. One of the most powerful things about additive manufacture is the potential to make things, you know, as a complete assembly in one part and that requires a completely different mind-set, a completely different manufacturing process. | ID09 |
| 44 | 1:06:49.6 - 1:07:00.8 | Ok, so, we are on the general reflections on additive. If you want, we can take a little break and drink some water? | Interviewer A |
| 45 | 1:07:00.8 - 1:07:08.3 | Yeah, we could do that. Not sure how long I've got this room for, actually. If we press on, I think we can () [too strong background noise] 12'o clock. I'm ok, so, yeah. | ID09 |
| 46 | 1:07:08.3 - 1:07:17.7 | What are your views about additive manufacturing as a production process for end user products or components? | Interviewer A |
| 47 | 1:07:17.7 - 1:11:15.6 | Uh, well, as I said, we've covered quite a bit of that, but I think there are several issues really. One is from the manufacturing production point of view, in terms of Mercedes making parts for trucks, that is happening, it's gonna happen more and more. What's more interesting is some ways that are the potential for people making their own parts. The widespread of introduction of 3D printing into offices, factories and (indeed) homes, I mean, a lot of apps at the moment are just producing more and more crap in terms of dragons models, bits and waste in plastics, you know, it's not a good thing. But as time goes by, I can see that there will be more and more people who will be making their own parts at home or for office or for workshop. I think one of the things that excites me the most is the potential to use additive manufacture, as I say, in third world countries where you need to make a part for, let's say, you've got a car (breter) part for a Land Rover and you are in the middle of nowhere rather than send for that part and wait 6 weeks for it to arrive. If you've got a 3D printing, additive manufacturing facility, you can download that component on web and print it locally and fit it to your vehicle and you (). Just like the military doing where they're using 3D printing in the battlefield to create spare parts and things. I think that's a very exciting area. In terms of manufacture, I think there are all sorts of potentials for customised parts like the hearing aid model, for specialist components for people to make on their own design or modified version for their own design. So in a weird kind of way, (we're growing its) potential for additive manufacture is kind of craft model. It's not so much a mass production model. It's more traditional craft artisan model. There are so many things about additive manufacture, which kind of counterintuitive to me, but one of them is the fact that, you know, one of the biggest growth areas is the ability to be able to customise components or to make personalised phone case and in all that something () [sounds like 'rubbish']. But that level is more akin to a traditional craft based manufacturing model, then it's to an industrial manufacturing type. So, the one area that I've struggled with is the idea that, it's gonna be, I still believe it's still gonna be some time before we can walk into Curry’s and 3D print a (cattle) if ever that happens. But I think, you know, the idea of using additive manufacturing for mass production, because of the cost problems, which will improve as the technology gets faster, but because of the cost problems and the surface finish problems, which again will improve as the technology improves, but I think those developments are probably at least ten years away, hesitate to say that 'cause it'd probably be three, but it's still some years away before additive manufactured parts, you know, look as good as a conventional manufactured part. When you think I watch emphasis of people put on the quality of their design of their kit and the quality of the finish of their kit, you know, I think that's gonna be crucial, personally. | ID09 |
| 48 | 1:11:15.6 - 1:11:23.8 | So, in general, what do you think designers need to know for designing effective parts for additive? | Interviewer A |
| 49 | 1:11:23.7 - 1:13:14.2 | I think they need to understand the process. In some way is more certain than the conventional manufacturing. I mean, designers always need to understand the process. In order to create a good injection moulding, you need to understand what happens when molten plastics enter the mould and cools down; you need to know that in order to do it well. But it's even more important with additive manufacture, you got to understand the layers process, you got to understand the orientation of the part within the build, you got to understand the relationship between parts next to each other in the build. If it's like a FDM part, I think you need to understand the relationship between supports and the part, and particularly for cost is an issue, because removal of support takes time, cost money, makes the whole thing more expensive. So I think, unlike a lot of manufacturing processes, when you need to have a basic knowledge of how it works. I think, to design well for additive manufacture, you need to know exactly how the process works. So I think in that sense, designers need to understand the process in detail. And fundamentally, they need to understand the principle of layer based manufacture that you are laying down whether it's sintered or fused, you are laying down layers of material and that has an impact on strength, it has an impact on appearance, etc. and etc. So I think it's vital that design is understanding exactly how the process works in order to be able to use it effectively, and to understanding implications of those things. So, you know, the fact that the layers make it weak if it's a tall thin thing, and then make it strong if it's horizontal. It's fundamental things but they are really important. | ID09 |
| 50 | 1:13:14.2 - 1:13:19.4 | How did you learn how to design for additive? | Interviewer A |
| 51 | 1:13:19.4 - 1:13:23.2 | Trial and error. | ID09 |
| 52 | 1:13:23.2 - 1:13:27.1 | And you came up with your own rules? | Interviewer A |
| 53 | 1:13:27.1 - 1:13:39.6 | Yeah, particularly for metals. I know we are not talking about metals but the biggest contribution I had to this whole process is being able to do with metal sintering. But obviously we are not talking about that. | ID09 |
| 54 | 1:13:39.6 - 1:13:43.0 | How did you develop these rules? | Interviewer A |
| 55 | 1:13:43.0 - 1:14:37.1 | Again, try and error, really. It's about, thinking about the basic, I guess it's thinking about the basic physics of the process that you're fusing or you're melting a layer of material. And you know, what is the logic of that, in terms of how it works? You know, you're laying down a layer of molten plastic in FDM, or you're fusing a layer of powder with a S L S machine. You know, how is that gonna work? And as I said before, things like heat build-up in S L S, different thermal characteristics of the process cools down. Those are the issues really we've considered. So we've taken a very, I suppose a scientific approach, to try to work out how it all works. But from the very () of approach 'cause I'm definitely not a scientist. | ID09 |
| 56 | 1:14:37.0 - 1:14:40.2 | So how did you prove them? | Interviewer A |
| 57 | 1:14:40.4 - 1:15:35.6 | Prove them? Well, I mean, again, sorry I know it is not very relevant to our conversation, but with the metal processes, we came up with, again, according to scientific methodology, we came up with a theory, which I build some parts and see if they work and we test the theory in practice. And some story for plastic parts, we did some tests where we built very heavy sections next to thick ones to see if it would distort, and it did and it did consistently. We tested the strength of the material by putting it through millions of iterations of a wear cycle. So again, it is really just about practical research and experimentation. | ID09 |
| 58 | 1:15:35.6 - 1:15:52.0 | Thank you so much. Thank you very much for your time and your thoughtful observation. It's been very helpful. So before we go, I just want to ask some brief information about your background. What is your education background? | Interviewer A |
| 59 | 1:15:52.0 - 1:18:10.1 | I did a BA on Industrial Design brackets Engineering [i.e. industrial design (engineering)], which is a standard industrial design course back in the 70s. I then somewhat unusually spent ten years designing and making equipment in third world countries. So very, very hands-on engineering stuff, so I've got quite a bit of background in practical hands-on engineering, welding, fabrication and stuff like that. I then went back to do a postgraduate degree in product design, industrial design at the Royal College of Art, just has the computer aided design was coming in. So I was a, although I didn't know it at the time, I was in earlier adopter of CAD Techniques in design process, I thought I was gonna learn stuff everybody already knew. It turned out they didn't. So I got involved in CAD quite early, and then actually when I finished the postgraduate studies, I actually applied for a job with the first additive manufacturing bureau in the UK, they were just setting up and they were looking for a CAD person to do their CAD work for the additive manufacture. And that basically established the relationship with a guy called Tim (Plumkit) who went onto set up the earliest 3D printing additive manufacturing bureau in the UK, and who then went on later set up 3TRPD in (Newbridge) who are the specialists in S L S and the metal sintering as well. So I got involved with 3D printing and additive manufacturing at very, very early stage because I just happened to bolt into the guy who's setting up the first bureau in the UK. So in that sense, I've been working with it very, very early. I mean, we were working with additive manufacturing in 1990. | ID09 |
| 60 | 1:18:10.3 - 1:18:14.8 | How long have you been working as a professional designer? | Interviewer A |
| 61 | 1:18:14.8 - 1:18:18.8 | Since 1990. | ID09 |
| 62 | 1:18:18.8 - 1:18:30.1 | Ok, so, can you confirm that it is ok for us to take pictures and have copies of the drawings and also the presentations you showed us? | Interviewer A |
| 63 | 1:18:30.1 - 1:18:32.1 | Yeah, that's fine. | ID09 |
| 64 | 1:18:32.1 - 1:18:35.1 | Are these projects in the public domain? | Interviewer A |
| 65 | 1:18:35.1 - 1:18:49.6 | No. () because they were research projects for things might be () things as part of the TSB. But I don't see a reason why that information is anyway private. | ID09 |
| 66 | 1:18:49.5 - 1:18:56.9 | Can we use the radar system and the Makielab as case studies? | Interviewer A |
| 67 | 1:18:56.8 - 1:19:50.0 | I think the answer is no. You will need to talk to people. As far as I concern, there isn't a problem but you will ultimately need to get the permission from the company involved. Now, with the radar system, they used the additive manufacturing method for a while and they eventually, I think, for reasons of their own, went back to conventional manufacturing. So it wasn't used for a long, long period, but it was used for some time. So in that sense, it's not a fabulous and strong case study. The better one, in many ways, would be the Makielab one, which I think is very much still a live thing and it's still happening. And I can put you in touch with the people who run Makielab, but you need to talk to them, really. It's their intellectual property, not mine. | Interviewer A |
| 68 | 1:19:50.0 - 1:20:21.3 | Ok, so, in the following weeks we will transcribe the interview and send a copy to you. So if you want to change anything, or update or cancel anything, feel free to do that and we will update it. We have just one last question, () we are going to publish and use these materials in the paper, in the report. Do you prefer to be named or to be anonymised? | Interviewer A |
| 69 | 1:20:21.3 - 1:20:25.5 | Happy to be named. | ID09 |
| 70 | 1:20:25.5 - 1:20:57.8 | I'd like to ask a question. You mentioned that, in the very beginning that, you know, some people use additive manufacturing to make some prototypes to test the ideas of their designs. And then eventually they go to the conventional manufacturing processes. So, any change, any design change after the, yeah, because they use additive for prototyping and then they go to conventional? | Interviewer B |
| 71 | 1:20:57.9 - 1:23:25.3 | Yeah, interesting point, I mean, I think, that's a very interesting point, because there are two completely separate approaches there. One is you design for conventional process, use additive manufacturing to prototype it and then you carry on using the conventional process, so you are not designing for additive manufacturing in that sense. That's designing for conventional, but you're simply using the additive process to prototype the part, which is like the conventional model. The other one is you're, which is the radar kind of thing or the Makielab thing or 3D integration or other similar things, that you're designing from day one to suit and to work with the abilities and limitations of the additive manufacturing process, and you're taking the advantages and benefits of it, but you're also dealing with the limitations. So, you know, I think there are two completely separate models there, you know. One is you're simply using additive manufacturing to prototype a conventional design and the other is you're working to create a design that is specifically intended for use by additive manufacturing. And the issue for designers is that most people, I don't know whether this is still true but it's certainly true to me a couple of years ago, most people didn't accept or understand that there are design methodologies that are strictly applicable to certain, you know, additive manufacturing processes, they just think you can do anything you like. You know, I've seen really a lot of literature now, and more and more people are saying that there is a particular way of designing for FDM, there is a particular way of designing for SLS, there is a particular way of designing for whatever it might be. And that's great, that's where it needs to be. You know, the stuff I've written and that stuff in that guide on our website, particularly is my sort of, if you like, first attempt, that coming from some ideas of some design guidelines. If you're gonna design for the process, and manufacture it using the process rather than simply use it as a prototyping (media). | ID09 |
| 72 | 1:23:25.3 - 1:23:37.9 | Right, so according to what you said, when the production volume increases, the design should be changed, because initially the design is for additive manufacturing? | Interviewer B |
| 73 | 1:23:37.9 - 1:26:06.1 | Yeah, if you design for additive manufacture, and you then ultimately injection mould it, then usually you are gonna have to make some changes. But most people, I don't think most people would do that. But it is an interesting point, because, again, one of the things that we do as product designers is that we, the first thing we will say to a client, almost the first thing, is how many of these do you wanna make. Because whether it is additive or conventional manufacturing, you know, if somebody wants to make six million of those [ID09 was talking about a ball pen], then instantly that's injection moulding, no question. If they want to make, I'm thinking of a better analogy, but you know, a more conventional product, it could be that, the best way of doing it is to fabricate it. It could be the best way to do it is to cast it or you know, use one of a whole (raft) conventional manufacturing processes. So the quantity you are gonna make and the value of the product are absolutely the key, because that'll almost dictate the manufacturing methods that you should use in order to get it economically viable. And having defined those economically viable manufacturing processes, that then tells you how to design it. So it's that way around, it's not the other way. You don't sit down and say, we want to design a laptop and we'd like it to look like this. The first thing you say is I wanna design a laptop but only want to make five of them a year, so we're gonna have to machine it from solid or we're gonna have to additively manufacture it. Ok, if we're gonna additively manufacture this laptop case, what options does that give us? What limitations does that give us? What freedom does that give us, if we're gonna use that process? Similarly, if I'm gonna cast it from aluminium or as Apple do, machine everything from solid, what are design limitations that suggests? So that's why, in my terms, knowing how you are gonna make it is the most important thing. Then you design to suit process that makes the most sense economically and practically. Does that make sense? | ID09 |
| 74 | 1:26:06.1 - 1:26:06.9 | Yeah. | Interviewer B |
| 75 | 1:26:06.9 - 1:26:50.6 | You know, that's where, again, that's where the whole laptop thing comes from, is that, you know, the whole machining from a block, case for a MacBook Pro for example, you know, that's a very unique manufacturing method, but they exploit it to create a, you know, sort of design that they've got. But they start out with that, other than the other way around. So somebody wants to do something at a relatively low volume or very low volume, and it's quite a high value, and then additive manufacturing makes a lot of sense. You need to design to suit that. But if somebody then said, right, we want to make millions, then you'll have to change the design to suit a process that will suit to millions. | ID09 |
| 76 | 1:26:50.5 - 1:27:04.5 | Right, just one last question, because you started the radar system design about ten years ago, so, do your views on additive manufacturing as a production process change over the last ten years? | Interviewer B |
| 77 | 1:27:04.5 - 1:28:13.8 | A little bit. We approached the whole thing with Navtech [sounds like a company name] of radar system, thinking this is the future for low cost, for low volume manufacture. But in our experience, it hasn't been quite like that. We've talked to several other low volume manufacturers about it. And I think, you know, at the moment, our experience's been that people don't tend to trust it. They prefer lots of machined metal. Now, obviously that's different to different industries in the car, in motor sport or whatever. You know, that is changing. But we haven't seen a huge enthusiasm amongst the clients that we work with to use additive manufactured parts. I think people are still quite suspicious of the technology and they're worried that it's not gonna be durable, they're worried that it won't last long enough, they're worried that it's not gonna be stable. And in some case, they've got legitimate concerns. | ID09 |
| 78 | 1:28:13.8 - 1:28:21.9 | Sorry, if I interrupt you, are these clients looking more for plastic components or metal components? | Interviewer A |
| 79 | 1:28:21.9 - 1:31:18.8 | Plastic. The Makielab thing is a classic case. Frankly, the guys and the girls in the Makielab kind of stumbled into that, because they read the hype and they read all the exciting articles about 3D printing is the future or that stuff. And they started manufacturing their dolls from that process without really exploring what the limitations and problems were. They were just sort of incredibly enthusiastic and pursued the potential and all the benefits weren't genuine benefits. But what they hadn't appreciated was some of the limitations because at that stage people weren't talking about limitations. There were limitations, apparently. Again, you can do what you like, you know, it's not a problem, you can make millions of things repeatedly to the same standard, to the same tolerances. And you make a million additive manufactured parts and they'll all be absolutely identical, it's not true. It depends on so many factors and that's been particularly true in metal additive manufacturing, repeatability's been a nightmare so far. So they sort of stumbled into it with lots of enthusiasm but not a lot of knowledge. That was why the Makielab thing was quite an interesting example, as far as I concern, because it's got tremendous benefits, customisation, modifiable heads and modifiable features and that's fantastic to be able to make one-off dolls in that way for a reasonably acceptable price. And hopefully, if I were still working, we (were able) to help them find a way of resolving some of the limitations of the process. But what designers need to do in the future is to understand all these benefits of additive manufacture, you know, customisation in all aspects. There are all these benefits over here but at the same time, there are all these limitations over here. When you are designing, as you are with any process, you got to work with both the abilities and the limitations, and work with them to make a finished part. You know, injection moulding has many limitations, but designers just accept that and they work around those limitations to come up with a product. Exactly the same thing needs to be true for additive manufacture. This is the myth that there aren't design limitations, and that's that gradually gets challenged, then I think it's gonna become a more valuable technology, actually, not less. | ID09 |
| 80 | 1:31:18.7 - 1:31:33.3 | So, how do your clients choose additive manufacturing? I mean, there are quite a few additive manufacturing techniques, so, how do they choose this specific one, SLS or FDM? What are the criteria? | Interviewer B |
| 81 | 1:31:33.3 - 1:33:07.4 | Most of clients we have don't really know, I mean, we have more client who always refers to any additive manufactured part as a rapid, that's rapid. It's just a shorthand for an additive manufactured part and they don't necessarily know the difference between SLS, SLA, FDM. All they know is that they send the part away and four days later they get the part back. So, there is not a lot of, you know, in a lot of industries, there is not a lot of huge amount of knowledge as to which processes and other most appropriate. But as we were saying earlier, for the vast majority of things that were developing as additive manufacturing products, it's come down to FDM or SLS. And inclusively people've got their own kit in house, which is both good and bad thing, because cheap 3D printers are very low, poor resolution and they make pretty crap parts, really. So in order to get a really high quality part, we need to be talking to somebody with a big and expensive machine. If we are talking about a manufactured component, then, you know, it's really come down to SLS. I don't know many people who make a high quality manufactured part using FDM. |  |