Computer Aided Design (CAD) Pioneer Workshop
Day 1 Session 4: Applications of CAD Products and Systems (1960-1980)

Moderated by:
David C. Brock
Burt Grad

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David Brock: Well, we have less than 30 minutes left for our conversations today. And I wanted to see if we could kind of map out our goal for this open discussion. It is about CAD applications -- your ideas about the key application areas of CAD up to 1980, and any thoughts on the general impact and growth of the industry to that time. We've talked about a variety of different areas where CAD technologies were applied so far in the day, but I wonder if there are any areas we haven't discussed, any gaps that we need to fill in.

Increased Use of CAD by Smaller Companies

Jon Peddie: Yes. I think there is, and it does start in the 1980s, and it was led by Autodesk and Tom Lazear, and that is the democratization of CAD, which made it possible for smaller companies to engage in computer-aided design, which gave them a stronger competitive position against the larger companies. And simultaneously with that, it opened the door to the DIY and the maker market. And that brought in a whole bunch of new people who were designing crazily-inventive things. In fact, Carl [Bass] put together a program with-- and he's going to remember the names better than I can-- but with a bunch of maker-farms I'll call them, for want of a better description around San Francisco and other places. I don't know if he funded it totally, but he put a lot of money into it, to put machineries in there, and CAD programs and other things, so that Joe Schmo off the street, who had an idea to come in, got taught how to use the stuff, do something with it, and turn it into a small business where you go out and sell stuff in the market. What did you call that, Carl? What was that called?

Carl Bass: Well, we did a whole host of programs. And the generalization of it, Jon, would have been that the early 1980s, with the split in the market from CAD and its ecosystem supporting the very largest companies, to going out to middle-sized companies, all the way down to mom-and-pop shops. I mean, that's really the beginning, and it has stayed with us today, that if you look at the programs they buy, the hardware people buy, how they get service and support, the seed for that is born in the early 1980s with the introduction of the PC and CAD that runs on microprocessors, like there's VersaCAD and AutoCAD and Bentley Systems, and all these things that run on low-end machines. And to some extent, SolidWorks continues the trend on 3D mechanical CAD, that same thing of selling through resellers, working on PCs, being available to a broad audience. And completely different than, I mean, remember this picture of the IBM salesman in the suit with white shirt and tie.

You know, it's just a completely different way of approaching that market. And it even continues to this day. One of the things I always laughed about is, like Autodesk has about 10,000-plus seats of software at General Motors. When we sold software to them, we delivered it to Unigraphics employees, now Siemen's employees, because they provide the IT for engineering. So the craziest thing, our nominal competitor is the people that we work with to provide a large customer with it. Because Autodesk, as a company, decided that services and consulting was not really part of the menu, whereas in some of the other companies, it's a huge part. And that whole split really starts in the early 1980s.

Dave Kasik: Yeah, let me add a little bit to that. So I think the bifurcation and separation of more applications than surface design and the like from the design perspective does start around 1980 or so. It includes the design of facilities, and the Boeing company is also one of Autodesk's huge customers, because all of the facilities have been designed using AutoCAD, it's unbelievable to see what these guys have done. And it ranges from facilities to the layout of passenger accommodations to figure out how to install seats in an airplane fuselage. But the one thing that I think we're missing is, around that same time, the 3D world is starting to get hot in terms of art and entertainment and movies. And the entire ecosystem that is now well-served primarily in SIGGRAPH is starting to spin out companies that are based on the same geometric forms, and a few others, that started out in the CAD world. The other part that is often missed, I'd argue, is how those systems affected GIS that I think we're missing a lot of in the whole world, as well as petrochemical.

Peddie: Yeah, we discussed GIS.

Kasik: It's unbelievable how much petrochemical plants and the like are designed, and their layouts are designed using computer-aided design tools.

Burt Grad: You're all talking about the post 1980s and afterward. There would seem to me to be only three major applications of things in the 1960s and 1970s.

2D vs 3D Geometry

Peter Marks: Yeah, Burt, I want to bring us back to that timeframe as well. The geometry that was predominant in the 1960s to 1980s was 2D geometry. The paybacks of applications came from using geometry in other applications. I think as a generalization, you could say that the applications were a little bit siloed in the 1960s to 1980s. So the finite element guys were developing their own geometry to solve their own problems. The rendering guys were developing their own geometry to rendering. Now, there was some use of the data that's out there. But it was only later on that we began this huge bonanza of taking the geometry we created as we moved from 3D and from surfaces to solids and other applications. So in this pre-1980 time period, I think it was drafting, documentation and probably visualization that were probably the heart of the uses. Dave, I saw you shaking your head. Does that ring true to you?

Kasik: I think there was enough internal surface design, Peter, in automotive and aerospace..

Marks: And driving your CNC [Computer-driven Numerical Control], you think, by that time?

Kasik: Yeah, especially in places like General Motors.

Marks: Not commercial products at this point. This was just your internal development.

Kasik: This was the internal use, people forget just how valuable 3D was in internal use in automotive, aerospace and space program.

Marks: I saw that, too. But that didn't become commercialized until the 1980s.

Kasik: Well, not broadly commercialized by any stretch of the imagination, but the importance of computer-aided design to worldwide enterprise was clearly done in the 3D world. That's not to say it was hugely consumed by large numbers of users, but if you look at the effect of product design build piece, the rubric generally that I've heard is you spend about 20 percent on design, but you commit 80 percent of the cost. So the big deal is that you're starting to get cost reductions because you're able to design much better in 3D. Daniel [Llach] hasn't said a whole lot about what has happened in the AEC market, because the AEC market has been very difficult to penetrate for the overall world of CAD. I think there are still a lot of 2D applications in AEC. Is that true, Daniel?

Daniel Llach: I would say that the transition was over the last 20 years, and now the standard is to have some kind of 3D environment for the design process. But what we see in the construction arena remains connected, to a large extent, to the drawing in 2D. So even if the design process is kind of managed in 3D, in many cases the construction documentation and the contractual documentation remains 2D.

Michael Payne: There's a good reason for that.

Bass: That's almost identical to manufacturing, in that starting 20 years ago, the design part of architecture moved to 3D. There were early things, then followed by Revit as documentation and stuff. But even today, I'm sitting in my machine shop today, the high-tech space guys down the street come down here and deliver us blueprints. Talk all you want about fancy surfaces. And by the way, these are parts for JPL. It's not like they're unsophisticated. There's still a downstream part of every industry, where the information gets dumbed down into digestible form.

Payne: No, it's not always dumbed down, it's put in the form that those guys need. You want to do the reflected ceiling CAD with a 3D model.

Bass: I'd say it's both of those, Mike. I think it's sometimes both of those. It's a more convenient form, and a little dumber.

Importance of Surface Design

Peddie: I'm just curious-- this is a diversion from where you guys are headed, but I haven't heard anybody talk about constructive geometry yet, and I was wondering if you wanted to interject that element into CAD or not.

Marks: If I could just maybe jump in a little bit before we move to that, responding to Dave's point about the X percent spent early on and the benefits later. Just as a little historical thing, British Aerospace published the original chart that showed two lines on it. And it showed the engineering spend, and it showed the final value. And basically, what it said is that by the time you spent five percent in design, you've committed 80 percent of the final performance of a product. And SDRC, about 1980 was when our UK managers sent that across. We started using that. And I could follow the diffusion of CAD throughout the industry. Every time an SDRC person left the company, they brought that chart with them. And pretty soon, all the analysts and the things were showing the same chart with no attribution to British Aerospace. But it was about this 1980 time that the notion of the decisions we make early, and the geometry we create early has such a powerful increase that we really started working on the added applications.

Kasik: Okay. So hence my point on the importance of surface design in the 1960s and 1970s. Okay?

Marks: And British Aerospace was probably kindred to you in that.

Kasik: Absolutely. The big deal is that we all felt that it was our competitive advantage to have our own geometry, right? But the ancillary point about that and we'll get to constructive geometry in a minute, but those 2D drawings are a really big deal. Boeing, for the 777, designed everything in 3D. but they had to wind up, publish the engineering drawings in 2D to satisfy the FAA. Until 15 years later, for the 787, it was OK numerical control to have 3D drawings available, even though everything was designed in CATIA version five. But there still had to be drawings that had all of the text and annotations on them. It was unbelievable in terms of it. And the last thing that I'll say is about the cost-benefit for doing everything in 3D for the 777. Boeing saved something like 75 percent in engineering rework, because the first version of the mockup actually flew for the 777, because everything fit so well. You can't do the analysis of interference and space allocation in 2D, and Boeing spent tons of money making sure that the 3D geometry fit before it was ever built.

Mathematics and CAD

Bass: No, one of the things I think that's just an interesting point for going back and looking at this history is how closely the fabrication techniques and the underlying mathematical foundation line up. So it's no accident that there's this development of this whole line that we've argued about, discussed, tried to remember about polynomials representing surfaces-- NURBS, B-splines, whatever-- and the fact that it was driven by auto and aero that had fabrication techniques and the advent of CNC machines that could actually machine those things. You're seeing a little bit of it right now, just to jump way fast forward, so all of a sudden now you have a collection of companies doing totally different foundational math with volumetric modeling, with kind of voxel-based stuff, and with it you have things like additive manufacturing. So you're having this next thing where all of a sudden the fabrication technique and the mathematics line up again. And we saw the same thing in architecture, as you got representations in CAD of curved surfaces. It aligned as skyscrapers went to having things like curtain walls as just an adornment for the outside of the building, and no longer a structural element. So there is this parallel thing where the mathematics line up with the physical artifacts that are eventually going to get built.

Brock: That's really interesting.

Kasik: And in a lot of cases, the math in CAD systems that are available today don't align, necessarily, very well with additive manufacturing.

Bass: Really poorly, most of the time.

Kasik: Indeed.

Bass: Yeah, which is why you have a dozen small companies, kind of 1960s-like, doing all this volume-based modeling, because that stuff lines up kind of perfectly with it. And also, the third component of it that I didn't bring up is that it actually aligns with the computer architectures of the day. So back then, we were generally running on CPUs. We did some things on integers. We eventually needed floating point, and now all of a sudden almost all the calculation for these modern systems is being done in GPUs[Graphics Processing Units]. And almost nothing is running on the CPU. So it took 50 years to start a new branch. None of us is smart enough to know whether it will be a long-lasting branch, but you can see this alignment of the different elements, and that's when I think it gets some amount of momentum behind it.

Peddie: And GPUs love voxels.

Marks: Yeah. Maybe two quick things. One is HP, back when it had the ME10 and ME30, I used to rib them about every single product they built looked like a rolling ball fill. It was the only capable of that. There was a limitation of the geometry in terms of delivering what customers wanted. And the other thing is Dave Albert, who wrote the first STL format. And he did it over a weekend, and he keeps saying, "I would have done it right if I'd known it would become popular." So we have the equivalence of QWERTY keyboards in a lot of our technology, too.

Brock: Well, it looks like we're at half past the hour. Thank you everyone for such a wonderful conversation today. I'm really looking forward to tomorrow's session.

END OF DAY 1 SESSION 4

