Evans & Sutherland: A Model in the Simulation Industry

CROSSTALK Associate Editor Matthew Welker had the opportunity to interview David C. Janke and Kevin J. McLaughlin, vice presidents at Evans & Sutherland, a graphics pioneer in Salt Lake City, Utah.

David C. Janke is vice president of Strategic Marketing for the Simulation Group. He has been with Evans & Sutherland (E&S) since 1988 and has 25 years of experience in management of high technology systems. His broad experience includes assignments in business development, program management, engineering management, contract administration, and operations management. In recent years, he has presided over the rapid expansion of E&S into international markets, especially Europe and Asia. Janke holds a bachelor's degree in electrical engineering from Stanford University and a master's degree in business administration from Brigham Young University. His academic honors include election to Phi Beta Kappa, Tau Beta Pi, and Beta Gamma Sigma honorary societies.

Kevin J. McLaughlin is vice president of Shared Technology for the Simulation Group. He has been with E&S since 1987 and has worked in the engineering industry for 21 years. His assignments include managing product development, hardware engineering, application-specific integrated circuit (ASIC) development, system exploitation and verification, software development, and database modeling tool development. Products developed by Shared Technology include the Harmony image generator, Integrator synthetic environment software, and EaSIEST modeling tools. Prior to his assignments at E&S, he worked as a senior project integration engineer and senior electrical engineer for Eaton-Kenway. Previously, he was an electronics technician and instructor for the U.S. Army. McLaughlin has a master's degree in business administration from the University of Phoenix and a bachelor's degree in electrical engineering from the University of Utah. He is also licensed as a professional engineer.

CrossTalk: The evolution of modeling and simulation from sketch-pad style interfaces to virtual reality has happened at an astounding rate. What role has Evans & Sutherland (E&S) played?

Janke: Obviously, E&S has been on the forefront … David Evans and Ivan Sutherland, the founders of E&S, were pioneers of computer graphics who produced the first line-draw system, and who developed the very first algorithms for computers to draw pictures. Much of the progress in the industry has come about because of people who either worked at E&S or were students of Evans at the University of Utah. These people include Jim Clark, who started Silicon Graphics, John Warnock of Adobe Systems, and others who have spun off and pursued careers in the graphics industry.

E&S has been a breeding ground for graphics technology, either internally or from people who have some association with one of the founders. Our own progress within the company has been astounding as well. From the early days, our main business has been flight simulation. Although our first systems were for the military, we made our bread and butter in commercial simulation for civil airline pilots. The demands and requirements of the civil airlines pushed development at E&S in such areas as calligraphic capabilities, texture, complex shading algorithms, anti-aliasing, and other graphics technologies that have become common today. Although most of those early advances in computer graphics were driven by our flight simulation customers, our business today is much broader, and many of our newer developments are targeted toward other applications such as ground-based simulation, driving simulation, mission planning and rehearsal, virtual prototyping, and vehicle development.

Even today, as others have entered the industry, I believe we are the only ones for whom simulation is our core business. Our graphics developments are focused toward meeting the requirements of the simulation customer rather than meeting the requirements of the gaming industry, or the server market, or something else. Our chip design, and our software design are today focused toward our core simulation business.

McLaughlin: To put it in perspective, 14 or 15 years ago we could sell a system that had 200 to 250 polygons on a per-channel basis updated at 60 hertz. Today, we are achieving over 15,000 polygons. That is an astronomical amount of computations based on sheer horsepower. Again, 12 to 14 years ago was the advent of the use of texture. Now we have texture that is applied to everything and even gives a higher effective polygon capacity [3x-4x] than what we had in those days. We now also have features such as reflections, Phong-shading, and sophisticated texture algorithms. Realistic sensor (infrared, night vision, radar) simulation has always been something very difficult to achieve in a real-time simulation. We have now developed what we call Sensor Texture™ that allows the assignment of material attributes on a per-texel basis, which is something that is not possible with polygons. This allows more robust sensor simulation for infrared devices because you are able to work with different materials with texture to present a more realistic simulation.

The day-to-day advancements do not seem dramatic, but when you look at them over the past five or six years, it is actually incredible. The very first image generator system that I worked on would fill this conference room with numerous 72-inch cabinets. Now you can do the same thing in one cabinet [approximately 24 inches high] that is essentially PC-based.

Janke: I have seen dramatic progress in the 12 years that I have been with E&S. In 1990, we built a system for the German Air Force that had 20 cabinets and approximately 4,000 cards. The total cost was $6.5 million. Today, a single cabinet replaces all of that at a fraction of the cost.

CrossTalk: Can you compare the effort you spend on hardware as opposed to software? Which requires more effort? What are the biggest challenges in regard to cost, schedule, and quality?

Janke: Graphics have always been very compute-intensive. In

order to draw pictures with a computer, lots of mathematical equations need to be done very rapidly. To achieve real-time simulation, a new picture must be computed every sixtieth of a second. In the past, general-purpose processors were not powerful enough to do that, so we developed our own special-purpose ASICs to do all those rapid calculations. As special-purpose hardware was the only way for us to meet the requirements of our simulation customers, we were very hardware-centric with much emphasis placed on hardware design.

Now with the rapidly advancing power of general-purpose hardware, we have much less need for custom-designed chips, and we are able to more broadly utilize commercial off-the-shelf (COTS) hardware. For example, our highest-performing product, the Harmony™ image generator, incorporates standard Intel Pentium processors for the geometry portion of its graphics pipeline. However, the rendering part of the architecture, which processes the pixels that are actually displayed on the screen, still requires special-purpose hardware that we design ourselves. As the general-purpose hardware becomes more powerful, we are able to use it more and more in the total graphics pipeline. Today it is used in a portion of it; tomorrow it may be used more.

Simulated Images from Evans & Sutherland

As we use more and more commercially available hardware, our company is transitioning from hardware- to software-centrism. In fact, we have probably already crossed the line to become more of a software company than a hardware company. If you look at the number of people working on software and the amount we spend on software development, it is more than we spend on hardware.

McLaughlin: Actually, in terms of total dollars spent, we still spend more for hardware development because custom ASIC design has significant non-labor costs associated with it. But in terms of sheer labor, the ratio of effort spent on software compared to hardware is approximately 3:1.

Janke: We, of course, try to use COTS software as much as possible if it will do the job. If it will not do the job, we have to augment it with our own designs.

CrossTalk: Where do you find your COTS, and how big a role does it play? The graphics in simulation are so specialized, it is hard to imagine that [COTS] would meet your needs.

McLaughlin: We use several COTS applications such as: Versant, Multigen, ArcInfo, HTFS, 3-D Studio Max, Photoshop, SocetSet, RoboHelp, Vx Works, and the Windows NT operating system. For some of the operations of our database modeling tools, we use a product called XoX, which is an application that allows us to perform operations for clipping edges and planes of polygons. Utilizing this functionality allows us to access the proper computations without writing all the software ourselves.

CrossTalk: Do you obtain the source code for COTS? If so, are there any cost savings?

McLaughlin: There is definitely a cost savings when we use COTS software. Indeed, that is why we do it. Furthermore, if we do not have to develop a certain portion of the software code ourselves, we can allocate our internal resources more cost-effectively. We can focus our efforts on areas of the design that require our special skill or our unique intellectual property. I should note, however, that the use of COTS software has sometimes not worked out very well. There have been cases where we purchased a COTS package expecting it to have certain functionality and then later discovered that it did not. Or we found the COTS software to be extremely difficult to integrate into our overall product architecture. In those cases we were forced to spend tremendous unplanned effort and cost to make it all work. We have learned that COTS software can be very valuable only if we understand it well before we commit to a design.

CrossTalk: How does your SimFUSION product compare to the high-end Harmony™ product?

Janke: SimFUSION is our PC-based product that we offer at a very low cost. Of course, it also has lower performance. It is basically a PC with an E&S graphics card for the rendering side of the graphics pipeline. SimFusion is targeted at the low-end part of the simulation market. It is ideal for applications such as shiphandling simulators, ground warfare applications, driving simulation, human factor studies, virtual prototyping, engineering visualization, and modeling and simulation laboratories. It is fully OpenGL compliant and will run a wide variety of standard simulation software applications. SimFUSION is our low-end product and Harmony™ is our high-end product. Comparing the two products is difficult because they are targeted at different market segments. Although there are big differences in capability, each is the best in its class.

CrossTalk: How do you balance the high cost of R&D necessary to remain on the leading edge with the bottom line?

Janke: That is a very important question that we ourselves struggle with. It takes a tremendous amount of R&D investment to stay competitive in this business, yet we cannot spend so much that we jeopardize our profitability. When we prepare our operating plans for a coming year, there are many internal debates about how much to spend. Every dollar we spend on R&D affects our short-term profitability but may improve it in the long term. Achieving the right balance between short-term and long-term profitability requires vision and a willingness to accept some risk.

"The U.S. military has always been the world leader in adopting new technology and encouraging new developments in industry. However, on some critical simulation programs the interests of schedule and risk prevail, and more proven technologies are often purchased. Oddly enough, we are currently selling more of our high-end, state-of-the-art products overseas than in the U.S."

Historically our company has spent between 20 and 25 percent of gross revenue on R&D, which is a very large percentage compared to others in the industry. Yet we seem to have done the right thing, and we believe that our focused, market-driven R&D spending has been among the reasons for our success.

So how do we determine the right balance? First of all, we keep our fingers on the pulse of the market so that we understand the changing needs of our customers. What are their needs for the future? Where is simulation going? What kind of deficiencies in today's visual systems need correcting? It all starts with the needs of our customers and where we think they are going in the future. In developing our plan, we involve many groups within the company, including marketing, engineering, and project management. We consider where spending an extra dollar today will bring about greater sales or reduced cost tomorrow. There is much internal debate that ultimately leads to a prioritized list of R&D projects. Upper management then reviews the list and adds their perspective and vision for the future. In the end, we have a plan that usually hits the mark pretty well.

I would like to emphasize the importance of vision in developing the R&D plan. It takes years, not months, to develop new graphics products, and you cannot turn on a dime to react to changing market conditions. Although it is risky, you must commit to a development direction and stay with it. And such vision only comes about by staying close to your customers and listening to them all the time.

CrossTalk: As an aside relating to the market for your products, much of what you sell is to the U.S. military, but you also have a large customer base in Europe. Do you ever encounter a technology gap, or do you apply the same technological standards?

Janke: There is no question that the U.S. military is our single largest customer. And Europe is our second largest market. In most cases, the technology is similar between the two markets. In general, the fidelity of a simulator is determined by two things:

1. The capability of the aircraft or vehicle itself.
2. The customer's training doctrine.

There have been cases recently when our international customer actually demanded more from us technically than the U.S. customer. For example, our U.S. Air Force has much open, unpopulated land available to it for training purposes, and pilots would rather fly airplanes than simulators. Europe, however, is densely populated with little land area for training. Consequently, the European customer is forced to do a larger percentage of his training in a simulator, which puts more demands on the functionality of that simulator.

McLaughlin: The aerospace engineering laboratories, whether in the U.S. or Europe, also place heavy demands on us technically. In that kind of development environment, many what-if questions are explored and evaluated in order to come up with the most optimal aircraft design. Those labs often want to do things with the simulator that push the very limits of technology, that are real challenges for us.

Janke: The U.S. military has always been the world leader in adopting new technology and encouraging new developments in industry. However, on some critical simulation programs the interests of schedule and risk prevail, and more proven technologies are often purchased. Oddly enough, we are are currently selling more of our high-end, state-of-the-art products overseas than in the U.S.

CrossTalk: Rod Rougelot said, "E&S tends to be informal and tries to be less hierarchical, but much of the structure that we've had to establish is a result of dealing with the military." Bob Schumacker said, "With the military, you've got the user, you've got the agency that procures the system for the user, you've got one or two other layers or interpreters, you've got your prime contractor, then us." [from www.es.com/corporate/history.html] To what extent has working with the military aided E&S development? Can you characterize your relationship with the military?

Janke: Let me first speak to our general relationship with the military. It has been our strategy to market ourselves directly to the end user. Indeed, we have found that to be a key to our success. For example, we go directly to the Air Force customer and try to develop close relationships with the people who actually use the simulation systems. We try to understand what their needs are, and we try to show them how our products can meet those needs. Then when they need to buy a visual system, they think of E&S because they know that we can meet their training requirements.

Working with the government is much different than working with a commercial customer because the government tends to be very structured and organized in its procurement processes. And when you get a contract with the U.S. military, there are certain things you have to do to satisfy the demands of those processes. There are requirements for documentation, reporting, technical reviews, schedule forecasts, and so forth. Consequently, we have put into place the internal structure, the processes, and the organization needed to satisfy government requirements. But we have also worked hard to remain flexible and responsive. We do not want to become a big, stodgy, inflexible aerospace company. We intend to stay close to our customers, so we understand what their needs are, how they are changing, and how we should plan our product developments to meet those needs.

McLaughlin: An example is E&S's invention of global texture that was specifically designed to address the intelligence or the

special operations market that requires mission rehearsal capability. Now global texture has become almost a universal requirement for military and commercial applications. This is an innovation that we developed because we needed higher database fidelity in a short amount of time. It was an invention that came about in direct response to the needs of our military customer.

Another product that was developed specifically for the military customer is RapidScene, which allows the rapid 3-D visualization of photogrammetric source material. The product evolved over time as our government customer kept asking us, "Can you do this? … Is this possible?" or "Wouldn't it be great if … ?"

Janke: Last June, three technical people and I made a visit to the Air Force Labs in Phoenix, Arizona. Our purpose was to present our technology roadmap for computer graphics and display technology, and to get feedback on our plan for R&D spending for the next year. We wanted to hear from an important customer whether or not we were headed in the right direction to meet their needs for the future. It was a great exchange, and we made some important adjustments to our development budgets as a result of the input. We try to have such meetings on a regular basis with all of our military customers.

CrossTalk: Do you use the Capability Maturity Model® (CMM) or other process models?

McLaughlin: We are ISO certified, and we have a group looking into being CMM-compliant. We have not decided if we are going to go through the entire certification and validation process. What we want to do is improve our entire software development process so we get the most benefit for resources applied to development. Our main goal is to do things smarter and more efficiently. We are also considering some outside tools to help us in our development. A lot of people out there are doing similar things, so we might as well take advantage of it.

CrossTalk: Do you use any of your modeling and simulation tools internally?

McLaughlin: E&S essentially has two modeling tool packages for creating the virtual environment: EaSIEST and Integrator. EaSIEST is used for the ESIG™ family of image generators, and for Liberty™ image generator. Integrator is used for our Harmony™ and Ensemble™ image generators. There are also data conversion processes between them. The tools are used by our own engineers to develop databases for simulation and are also sold as stand-alone products for customers who want to do the development themselves. We augment our database modeling tools with third-party software tools such as Multigen, Photoshop, 3-D Studio Max, Erdas, or anything we believe can actually be of benefit to us, and that we can integrate into the package. I should note that our own development people are probably our best testers, our biggest critics, and our biggest fans.

CrossTalk: What languages and platforms do you use?

McLaughlin: Right now we do development on NT workstations, but we also do some development on Sun workstations. Our primary languages are C, C++, Visual Basic, and then we have some database management tools like Oracle, Ingress, Versant. We use VxWorks as our run-time operating system that resides on specific processors.

CrossTalk: How does E&S recruit and retain good employees?

Janke: We have an active college recruiting program at a number of top colleges and universities. Our retention rate is quite good, and our turnover is fairly low compared to other companies in the industry. E&S is known to have one of the finer work environments in this area. The work is state-of-the-art, exciting, challenging, and makes use of the latest technologies. These are things that are attractive both to recent graduates and to experienced engineers.

As a practical matter, we have slightly better success retaining people who are from the West than from the East. For someone from the East Coast, this is a long way from home, and the cultural adjustment can sometimes be a bit too much. On the other hand, some new recruits come here and see the mountains and say, "I'm not leaving." For a creative software guy who likes to ride his bike to work through some spectacular scenery, it is an ideal environment.

McLaughlin: We also have an open campus so employees can access the buildings 24-hours-a-day. It is not uncommon to come in here at 2 a.m. and find a whole team of people climbing over a problem they cannot let go of.

The work is exciting and some people come here because they cannot find this type of start-to-finish work anywhere else. A software engineer at E&S gets to work on a variety of projects and is able to see the overall impact of what he does. Unlike many companies, our work involves an engineer in all aspects of a complete system. It is very satisfying to make an entire system work rather than spend all of your time focusing on one small piece and not really understand why your work is important. For example, in order to implement light points for calligraphic displays in a simulator, a software engineer might begin with modifying an extension for a third-party tool such as Multigen. He then creates a database of the gaming area with the proper light attributes, modifies a data converter, incorporates changes into the run-time software, and then actually displays it on a calligraphic device to see the results of his work. His responsibility necessarily involves him in each step and each component of the total system. Such work is very satisfying to intelligent and creative technical people.

We, of course, also offer competitive pay and benefits. We try to be competitive with the local market as well as the national market. For all major companies right now, the demand for technical people is far greater than the supply. So we continuously review our salaries and benefits to be sure we can attract the better people.

I think it is interesting that many of our people who have left to join flashy companies developing 3-D games have eventually returned to E&S. They all came to realize that the work here is more challenging, and that our environment is not easily duplicated. Our intelligent, creative, and cohesive workforce is a big attraction that really helps to maintain high morale.◆

® The Capability Maturity Model and CMM are registered trademarks of the Software Engineering Institute and Carnegie Mellon University.