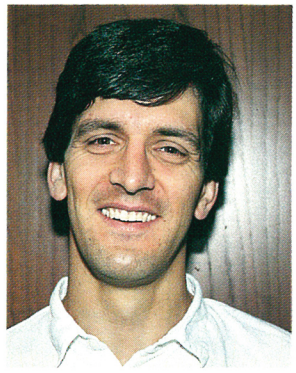
The Explosive! Action-Packed! Fantastic! Physics of Computer Games



BILL NUNAN

STEPHEN CRANE

The year is 1976—but not like you remember it. A devastating energy crisis has brought America to its knees, and a terrorist plot now threatens to topple the government. All hopes for the future rest in the hands of a tiny band of hardcore vigilantes, who set forth in their heavily armed muscle cars to do battle with the enemy.

This is physics?

For Bill Nunan and Stephen Crane, two physicists who work for the computer game firm Activision, it definitely is. In the above scenario, which comes from a game called Interstate '76, the user experiences the action as if strapped inside one of those muscle cars, cruising along highways and across desert terrain while blasting away at terrorists. Making that experience seem realistic is part of Nunan's job as a game programmer. Crane's job as vice president of technology is to oversee the Los Angeles–based company's technology development, bringing together the various elements of production, design and programming that go into a computer game.

Real physics, cartoon physics

It's somewhat surprising to learn that neither Nunan nor Crane found much use for computer or video games while growing up. "I was probably too cheap to invest all those quarters at the arcade," Nunan says. But as adults, they've discovered that a computer game can offer plenty of intellectual challenges.

"There's a lot of physics in action games," Crane says, "which almost invariably has to happen in real time and on not very big processors. So there's a real artistry to making things appear to be physically reasonable—an airplane flying, liquid splattering, a football bouncing—when in fact you're doing egregious approximations to make it so. It's a mixture of real physics and cartoon physics."

At the moment, Nunan is engrossed in simulating car crashes, which have something in common with the computational plasma physics he was doing before joining Activision. "Just as in plasma particle simulations, the time scale of the collision is much shorter than that of other dynamical processes. But in car simulations, there is a very heterogeneous collection of objects, and the vehicle can collide with any one of them." Conservation laws are not always obeyed at a macroscopic level, but serve instead as "valuable clues to what will make the simulation look plausible."

The project team working on Interstate '76 is divided up into production staff (who arrange for equipment and licenses and keep things on schedule), artists (who create the game's three-dimensional objects and environments), designers (who create the story line, including the game's objectives and characters), and programmers like Nunan.

"There's a lot of overlap among the groups, and I get to work with all different kinds of people," says Nunan. "Which is nice: It's not as much of a monoculture as a physics department."

The time pressure is constant. "In academic research, there's no emphasis on finishing a problem *per se*," Nunan observes. "Each problem leads to new problems, which lead to other problems; there's no real point when you'll be done. Whereas in this industry, you're concerned about things like what is fashionable and not fashionable, and when does this product have to be brought to market." Success is judged not by grants received or papers published but rather by how well the product sells.

From fusion to games

Only a year ago, Nunan was still firmly planted in academia. Having recently completed his PhD in electrical engineering at the University of California, Los Angeles, he was looking for work. Although he cast a fairly wide net, searching within his own specialty as well as related fields such as semiconductor plasma processing and even electric car design, nothing seemed too promising.

As a boy growing up in New Jersey, Nunan had dreams of being a great inventor like Thomas Edison. That, and an interest in energy, led him to major in electrical engineering at MIT, where he completed a five-year coop program and received his BS and MS in 1984. But during several summers working at RCA Astro Electronics in Princeton, New Jersey, he made the disappointing discovery that engineering "wasn't really about starting with a blank slate and inventing things from scratch." So he switched to plasma physics and enrolled at UCLA. For his thesis, working under John Dawson and Francis Chen, he created a particle-in-cell computer simulation of current in tokamak plasmas.

In the midst of Nunan's job hunt last year, a group at Activision happened to call the UCLA physics department looking for someone with experience in computer modeling of physical systems. Figuring he could do some part-time consulting work until something else came along, Nunan sent in his resume. In his interviews there, he was honest about his lack of experience with computer games, but he seemed to meet all the other qualifications. The company offered him a full-time job.

When Nunan told his group at UCLA about the offer, reactions were polite if subdued. "People would say, 'That sounds interesting,' and they seemed to mean it," Nunan recalls. "But I still got the feeling that this isn't what they would want to do." He weighed the job against working as a postdoc, maybe having to move every few years and always worrying about funding cutbacks. He considered what was best for his wife, Eve Ahlers, a PhD electrical engineer who works in

semiconductor processing, and for his two young sons.

But what ultimately decided it was interviewing with Crane, who like Nunan had graduated from MIT, gotten a PhD in physics and wound up in computer game development. "Somehow the idea that somebody like me was doing stuff like this made it a more plausible option," Nunan says.

From geophysics to games

Unlike Nunan, Crane did not jump directly from academics into the game industry. He took a more roundabout path, working with spectroscopy, 3-D graphics, special effects and educational products.

As a child, Crane recalls, he had "the usual fascination with the world at its most fundamental level." At MIT he majored in Earth and planetary sciences, earning a BS in 1974, and then entered the geophysics graduate program at Scripps Institution of Oceanography, where he did his thesis on the crystal chemistry of marine manganate minerals. "Not the most thrilling topic," Crane says with a laugh. But the spectroscopy technique he used, extended x-ray absorption fine structure, or EXAFS, did have appeal. "We were building the equipment from scratch, working out the math associated with it and using the synchrotron radiation that was emitted as a side effect from the linear accelerator at Stanford."

He continued to use spectroscopy during a postdoc at Caltech, working with John Baldeschweiler, and on into his next job, as a senior scientist with Teknekron, an engineering consulting firm in Berkeley. At Teknekron he also got involved in a project for Chevron, which wanted a 3-D computer display of its oil fields, showing layers of rock, pools of oil and so on.

Once again Crane found the technology more interesting than the application, and so in 1982 he and a coworker decided to start a company to build 3-D computer graphic systems, which at the time were virtually unknown. Cubicomp eventually grew to a 100-person operation with $8 million in annual sales. That experience taught Crane "how to build products—something an academic background just flat out doesn't prepare you for."

In 1987 Crane joined Digital F/X, which built systems for doing special effects for television and movies. "Remember those scenes where a superhero would point his finger and lightning bolts would shoot out and zap the bad guy? Those were our effects." Though the clientele came from show business, the work itself was highly mathematical. "Like spectroscopy, doing video special effects involves lots of Fourier transforms and digital filtering of noisy data."

From there Crane went to Electronic Arts, to head up a new division for CD-ROM games and educational products. "By then I had young kids," Crane recalls, "and so educational software, which had never been of the slightest interest to me, now suddenly looked like a worthwhile thing." After about a year and a half, he became vice president of development at Knowledge Adventure, another educational software company.

Crane joined Activision last year, having realized that educational software "wasn't very much fun." He prefers the intellectual stimulation of game development but admits the day-to-day demands can be exhausting. "The hours are ridiculous, and the pace is very difficult to sustain into your forties." Although his current job is managerial, he maintains some connection to physics by writing science fiction, under the pen name Stephen Kraus. "I still get to design planets and do orbital mechanics and that sort of stuff."

Recently, Crane has had discussions with faculty at a California university about creating an academic program in game design. "One of the nice things about game development is it encompasses so many different disciplines. There's physics simulation and computer science, of course, and traditional artificial intelligence and cognitive science, which is very important because you want the characters to behave in a recognizably human way. And then there's also art, sound, storytelling."

"A game can be a means to an end," Crane says, by introducing problems "that almost constitute pure research and are interesting in the abstract, like creating artificial life on the computer or understanding the dynamics of a race car. Ultimately, recreating life or recreating a world inside the computer forces you to understand that phenomenon in real life."

For his part, Nunan likes what he's doing. "While I don't get to play with field theory anymore, which was one of the things I liked about plasma physics, I still get to do classical mechanics." He can appreciate the irony of his position: As a plasma physicist, he chose not to pursue defense work for ethical reasons, only to wind up working on a product that lets people blow each other up, albeit on-screen. "Last night my five-year-old drew a picture for me and he said, 'Here, Daddy, it's a car—with a gun on the top!'" Nunan laughs, then sighs. "Talk about mixed emotions."

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