Admissibility of a Computer Simulation

by Louis A. Lehr, Jr.

In a society that has grown up with Disney and now dotes on computer games, less enlightened members of the bar think of all computer-generated graphics as nothing more than animated cartoons which have no place in a courtroom. The apparent problem with the introduction in evidence of a computer simulation is that many courts, and perhaps the lawyers offering it, do not understand what it actually is.

The key to admissibility lies in the fact that computer simulation, unlike animation, is a tool used to make an engineering analysis and that this use is generally accepted in the scientific community. It is therefore important to distinguish between computer animation and computer simulation.

Animation is a set of images on a computer screen that follow some prescribed order. The order of images is dictated by the programmer and may or may not represent the actual physical phenomena.

Simulation is the result of a computer analysis of a model which represents the actual structure and is subject to the relevant physical laws governing its motion. The programmer does not dictate the outcome of the analysis; this is dependent upon the model itself and the input data.

As an example, consider a book falling off a table. Three distinct types of reconstruction are possible for display on a computer.

Pure Animation. An artist or engineer may look at many books falling and construct a set of time-step images that represent the event. Whether the book rotates or opens and its final position after hitting the floor are under the total control of the illustrator. Moreover, the book's velocity and its center of gravity at every instant during the event are disregarded, as long as the final depiction appears plausible. This is equivalent to building clay or plastic models of vehicles and creating a series of photographs as the models are moved from location to location on a surface representing a highway.

Stereographic Photography and Animation. In this case, one or more books are photographed falling from a table. These photographs, through stereoscopic technology are converted to a computer rendering of the image which then accurately portrays how a particular book fell. The trajectory, velocity, mass, etc., are implicit in the images. The limitations of this method are that it is valid only for the particular book photographed, and it provides no quantitative information on impact velocity or forces.

Computer Simulation. Here the engineer provides, as input to a model, the size and weight of the book, and the height of the table. The computer then calculates the position of the book at every instant in accordance with the laws of physics. The engineer has no control over the final results, and cannot make the book spin about so it "looks more realistic." As long as the model and input file are accurate, the calculated fall of the book is accurate and true.

History of Computer Simulation

It is important that both the court and the jury understand the history of accident reconstruction and computer simulation — the court for admissibility and the jury for acceptability.

Prior to the 1970s, motor vehicles were rather simple by today's standards. They were designed by inventorengineers and craftsmen who often built parts themselves and personally evaluated their designs on the test track. At that time, accident reconstruction was an art in which experience, simplified physics and engineering calculations, and field observations were the primary tools. The central issue in accident reconstruction was "what happened," and the process of reconstruction was based primarily on known or assumed physical evidence with limited regard to confirmation by rigorous analytical methods. The use of computers during this period was limited to solving design equations too complex for the engineer's slide-rule and for parametric studies that investigated different sizes and configurations of components.

The 1970s were especially challenging to the automotive industry. Safety and fuel economy legislation, and the beginning of a global automotive market, resulted in more complex and expensive vehicles. As vehicle complexity increased, design and manufacturing became more specialized and prototype cost rose. This made it imperative that analysis of designs be done prior to building and testing or crashing of prototypes.

In the 1970s, computer simulation of a complete vehicle was primitive, and primarily regarded as a research and marketing tool. Furthermore, there was no established history or confidence in the ability of computers and modeling software to predict the behavior of complex vehicles. Even so, the actual simulation could take longer than it took to build a prototype and send it to the proving grounds for full scale evaluation. Actually, computers were still used primarily as drafting aids. The much-acclaimed CAD/CAE (computer aided design/computer aided engineering) efforts were really automation of the traditional drafting process.

Early Computer Animation. For reconstruction specialists, the late 1970s and the early 1980s could be called the computer graphics era. Data was collected from accident scenes the old-fashioned way by measurement, photography, and trained observation of the physical evidence. Thus, through observation and calculation, the path of a vehicle or movement of a mechanism was proposed. The best reconstruction specialists would then build paper-mache or accurate plastic scale models and use photograph or crude computer animations to further test their theories against eyewitness recollections and available physical evidence.

These early computer animations were also effective means to stimulate eyewitness recollection and for validation and hypothesis testing. The computer artist could construct a three-dimensional model of a house, highway, vehicle, mechanism, etc. which fit all the observable details. The model then could be manipulated and viewed and dissected from any angle. This was persuasive in demonstrating that, for example, someone in location A could never have seen an object located at point B.

While computer animation, video and photographic techniques, or even stereoscopic reconstruction, are relatively sophisticated means of presenting accident data, they only represent the expert's simplified calculations and opinions. Although this "age of computer graphics" was a quantum jump over the 1970s approach, its techniques were vulnerable to two criticisms: that the computer animations are merely "cartoons" created by a computer artist, albeit directed by expert opinion; and second, that the animations are static in the sense that they only represent a "what happened" approach.

Simulations Developed. Around 1980, the first reconstruction and simulation computer programs were developed. Typical examples include EDCRASH and EDSMAC (Engineering Dynamics Corporation, Lake Oswego, Oregon), designed for use on personal computers to perform two-dimensional analyses using data from traditionally reconstructed accidents and analysis of experiments. These codes are used to analyze the effect of an impact on the motion of a vehicle or occupant, or to describe the reaction of a vehicle to braking or sudden changes in direction.

At the time these first computer simulation programs were developed, global competitive pressures further shortened product development times and increased prototype costs. Automotive firms began forming special project teams seeking to set up the technology that would allow design, testing, and "what-ifs" to be evaluated by computer. This computer simulation technology allowed cost cutting and reduced lead time to a finished product.

The significant power of the simulation is that it can allow "what if" exercises. For example, once the book-table-floor model is established, one may examine effects of varying table heights, book sizes and shapes, etc. on the process of falling. From an accident reconstruction perspective, another important aspect of dynamic simulation is the confidence that the simulated event follows the laws of physics.

Computer simulation provides the opportunity and ability to isolate the contribution of a single component to the behavior of the complete vehicle. For example, the engineer can evaluate the subsequent behavior of a tractor trailer after it hits a pothole, or a sudden break in a suspension element. The possibilities are endless.

Supercomputers. Since the early 1980s, a profound and fundamental change has been occurring in both vehicle technology and accident reconstruction. This change has been made possible by the availability of supercomputers, three-dimensional simulation codes, and the validation of model analyses using these tools.

Supercomputers are capable of performing several hundred million calculations per second. This computational capability is 50 to 100 times faster than conventional computers, and allows the use of more complex codes in calculating a vehicle's motion. Powerful three-dimensional simulation codes like ADAMS (Mechanical Dynamics, Inc., Ann Arbor, Michigan) provide a means to accurately describe complex systems like automobile suspensions, and can account for both static and dynamic forces like tire-to-pavement friction and wind. Past analyses using ordinary main-frame computer resources resulted in simplified two-dimensional models in about a twentieth of the time. Although a specific model and dynamic event may not have been validated, similar models have been analyzed and the results validated by comparison with actual experimental data. Thus, the expert has confidence that for a class of phenomenon previously validated, his model will provide a true rendition of the actual event — and he can so testify.

Although the engineer can employ the supercomupter and three-dimensional analysis codes as routine analytical tools, the hard-copy results are not usually amenable to interpretation because of the complexity and volume of data produced. Therefore, interpretation is usually simplified by displaying the results with a series of small time-step images to describe the real-time event. This video-format output can be combined with selected numerical data to provide an easily displayed and interpreted record of the event from beginning to end. For the courtroom, visual enhancements such as solid shape rendering and coloring provide a lifelike quality and can make the simulation analysis appear like a motion picture of the actual event.

The Law on Admissibility

What have the courts had to say about the admissibility of computer simulations? There is little case law directly on point. One of the earliest decisions is *Perma Research & Development v. Singer Co.*, 542 F.2d 111 (2d Cir.), *cert. denied*, 429 U.S. 987 (1976). Perma claimed that Singer had breached a contract to use its best efforts to perfect, manufacture, and market an automotive anti-skid device covered by a patent that Perma had assigned to Singer. One of the Singer defenses was that the Perma device was not perfectible. To counter this defense, Perma presented expert testimony predicated on a computer simulation that the device was indeed perfectible.

The Second Circuit court held that the trial judge did not abuse his discretion in allowing the experts to testify to their ultimate conclusion based on this computer simulation. The court did say that it would have been "better practice" for opposing counsel to arrange for delivery of all details of the underlying data and theorems employed in these simulations in advance of trial. 542 F.2d at 115. See also *Shu-Tao Lin v. McDonnell Douglas Corp.*, 574 F.Supp. 1407, 1412 (S.D.N.Y. 1983); *City of Cleveland v. Cleveland Electric Illuminating Co.*, 538 F.Supp. 1257, 1266 (N.D.Ohio 1980).

The dissenting judge in the 2-1 *Perma Research* decision criticized at length the trial court's acceptance of conclusions based on computer simulations. 542 F.2d at 121-126. He opined that such data is inadmissible hearsay, and that it is speculative, conclusory, and of unproven reliability and accuracy. In short, "I am not prepared to accept the product of a computer as the equivalent of Holy Writ. Neither should a District Judge." *Id.* at 121. This comment by the dissenting judge is typical of that made by jurists who do not have, nor have been given, the necessary background information to understand what they are actually dealing with. As indicated earlier, it is the function of trial counsel to educate the court in this regard.

A few months after the Second Circuit's decision in *Perma Research*, the Supreme Judicial Court of Massachusetts, in *Shaeffer v. General Motors Corp.*, 372 Mass. 171, 360 N.E.2d 1062 (1977), required that computer simulation meet the test for admission of scientific theory; i.e., it must have found general acceptance in the appropriate scientific community. See *Frye v. United States*, 293 F. 1013 (D.C.Cir. 1923).

In *Schaeffer*, plaintiff sued General Motors, claiming personal injuries arising out of a "controlled differential" on plaintiff's Cadillac. The trial judge submitted the case to the jury only on the issue of negligent failure to warn of unreasonable risks. Over objection, the court admitted defendant's evidence of the results of a computer simulation of the accident. The court said (360 N.E.2d at 1067):

> Our concern is not with the precision of electronic calculations, but with the accuracy and completeness of the initial data and equations which are used as ingredients of the computer program. More generally, we feel that the standard for admissibility of scientific tests may not have been met in this instance. That standard was clearly enunciated in *Commonwealth v. Fatalo*, 346 Mass. 266, 269, 191 N.E.2d 479, 481 (1963): "Judicial acceptance of a scientific theory or instrument can occur only when it follows a general acceptance by the community of scientists involved."
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> . . . If such evidence is again offered at any retrial of this action, it is essential that the trial judge should (a) conduct a hearing in the absence of the jury on the question whether the tests conducted and results ascribed thereto meet the prescribed standards for the admissibility of such evidence, and (b) that he put into the record, by dictation, for the transcript or otherwise, the findings of fact made by him as the basis for the admission or exclusion of the evidence in question.

While the Massachusetts court did not cite *Frye v. United States*, it obviously applied the standard announced by that case to computer simulations: i.e., "the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs."

The *Frye* standard was also applied by the Arizona Court of Appeals in *Starr v. Campos*, 134 Ariz. 254, 655 P.2d 794 (1982), where the plaintiff's son was killed when the automobile he was driving collided with a truck which turned across the path of the car. The reviewing court was concerned whether or not the court used the appropriate standard — the *Frye* test — in admitting evidence of a computerized analysis of the accident. The court pointed out that scientists need not be in universal agreement as to the validity of a technique nor agree that the results of the procedure will always be correct. However, there must be general acceptance by the relevant scientific community. "The scientists need only agree that the procedure has a sound scientific basis and is capable of producing a result that can be used, with awareness of any limitations, for scientific purposes." 655 P.2d at 797.

The court pointed out that, while whether the use of computer simulation of automobile accidents has achieved general acceptance among scientists in relevant fields is a factual question, "it is one susceptible of appellate resolution." However, since the case was being remanded on other grounds, the court said that the question in this case should be resolved by the trial court and gave the following directions (*id.*):

> If this evidence is offered in a second trial, therefore, the court is directed to apply the *Frye* standard and determine specifically, in the absence of the jury, whether the procedure used to obtain that evidence is generally accepted among scientists in relevant fields, including accident reconstruction and automotive engineering. In making this determination the court may take judicial notice of the ability of a properly programmed computer to perform mathematical computation and of the general acceptance of the underlying principle of the method, the law of conservation of linear momentum. It will only be necessary to determine whether those of sufficient training and experience to judge are in general agreement that the program properly applies that principle (and any others it may involve) to automobile collisions.

In *People v. McHugh*, 124 Misc.2d 559, 476 N.Y.S.2d 721 (1984), the court held that a computer re-enactment of a fatal car crash was admissible in a prosecution of second-degree manslaughter and intoxication while driving. The District Attorney moved in advance of trial for a *Frye* hearing and the court held that this was not required. The court apparently viewed the computer re-enactment of the car crash to be demonstrative evidence, and thus admissible at trial.

The New York court took a favorable attitude toward the use of computer simulations in litigation. It said (476 N.Y.S.2d at 722): "Whether a diagram is hand drawn or mechanically drawn by means of a computer is of no importance. . . . [E]very new development is eligible for a first day in court." It concluded with these reassuring words for lawyers who wish to use computer-generated material as evidence:

> A computer is not a gimmick and the court should not be shy about its use, when proper. Computers are simply mechanical tools — receiving information and acting on instructions at lightning speed. When the results are useful, they should be accepted, when confusing, they should be rejected. What is important is that the presentation be relevant to a possible defense, that it fairly and accurately reflect the oral testimony offered and that it be an aid to the jury's understanding of the issue.

Conclusion

Without a doubt, any offer by the defense of a computer simulated accident reconstruction will be the subject of a motion *in limine* or a trial objection by plaintiff. A brief on the issue should be presented to the court in advance of the trial or the hearing on the motion. Even in a non-*Frye* jurisdiction, the scientific acceptance of computer simulation as a long-accepted analytical tool by engineers should be stressed.

In federal courts and in jurisdictions which have adopted similar rules, keep in mind that the Federal Rules of Evidence establish a relevancy requirement for the admission of evidence (Rule 401). Moreover, Rule 901(b)(9), dealing with proper authentication before admission as evidence, illustrates that a process or system may be authenticated by: "Evidence describing a process or system used to produce a result and showing that the process or system produces an accurate result."

The goal is to have computer simulation received as substantive evidence. The fall-back position is admissibility for demonstrative purposes as an aid to the jury in its understanding of the scientific principles involved in the litigation. In either instance, admissibility by the court as evidence may well depend on its understanding the difference between computer animation and computer simulation. The challenge for counsel is to convince the judge that the simulation can be used as an engineering tool, and is thus admissible.

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