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USE OF COMPUTER-GENERATED VISUAL EVIDENCE IN AVIATION LITIGATION:
INTERACTIVE VIDEO COMES TO COURT

KATHLYNN G. FADELY*

I. INTRODUCTION

THE ADVENT OF broadcast television in 1936 irreversibly changed the way in which the world was perceived: what people saw, they believed. Similarly, the development of video and computer technology, through the media of both video disc and video tape, has substantially modified the way litigators will present not only complex, but also simple cases arising out of aircraft accidents.

Litigators have known for years that a picture is worth a thousand words. Photographs have been used for over a century to communicate what happened in an accident and to persuade a jury of one party’s particular version of the facts. With the advent of video technology, the “picture” became a movie played on a television monitor, which created a sense of realism and trustworthiness. With the development of computer technology and its ap-

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The views expressed herein are those of the author and do not necessarily reflect those of the Department of Justice.

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plication to the litigation arena, state of the art evidence currently available to litigators consists of actual recreations of an accident presented to a judge or jury. Computer technology provides litigators the means to depict not only why an accident happened, but also alternate scenarios of how the accident could have been avoided, in an attempt to show who or what was responsible.

This article describes different types of computer-generated evidence that may be developed for use in aviation litigation and then converted into a visual format for presentation to the finder of fact. The article also describes bases for the introduction and admissibility of this type of evidence and includes a discussion of potential objections to be overcome.

Experts have used computer technology for many years. The complexity of visual simulation, however, has required expensive computer technology and highly sophisticated operators. Only within the last five years have advances in technology and operations brought the development of these simulations out of the laboratories and universities and into the litigation arena. Although still requiring fairly sophisticated levels of operation, computer-generated visual simulation has now become cost-effective for use in the recreation of accidents at trial. With the development of laser disc technology, the medium used for presenting visual evidence has changed dramatically for the litigator.

II. COMPUTER-GENERATED VISUAL EVIDENCE AND METHODS OF PRESENTATION

A. Computer-Generated Evidence in General

Computer-generated evidence generally includes printouts (frequently consisting of either public or business records), summaries, projections, models, demon-

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1 General types of computer-generated evidence described herein and principles relating to their use may be applicable to any type of accident litigation, whether specifically involving aviation cases or not.
strations, simulations, and reconstructions. There are several different types of information that a computer can generate, and each type of output is capable of producing varying conclusions which can be converted into a simple yet highly dramatic visual display.

Basically, there are two different types of computer-generated evidence: information stored in a computer as a result of human input, e.g., data processing; and data stored automatically or generated by the computer itself. Computer data used in litigation may have been created in the regular course of business, either by human input or automatic recording. A computer may also generate data specifically for use at trial to reconstruct an event or simulate alternate theories for the cause of an accident. Differentiating between computer output that consists of simple data processing and evidence generated by a computer can be difficult because a computer creates information by taking input data and processing that data in accordance with a particular program supplied to the computer. The resulting information is presumably cre-

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2 See Comment, Guidelines For The Admissibility of Evidence Generated By Computer For Purposes of Litigation, 15 U.C. DAVIS L. REV. 951, 952 (1982). Although some commentators delineate the two types of evidence in a different fashion, it is generally accepted that evidence that is generated by a computer solely for use in litigation must receive special scrutiny because of its inherent lack of trustworthiness. Palmer v. Hoffman, 318 U.S. 109 (1943). Some commentators have segregated computer-generated evidence according to the input source itself. See, e.g., G. Joseph, Modern Visual Evidence § 7.01 (1989) (segregating evidence consisting of a reiteration of computer-stored human declarations from that which is recorded directly without human input). See infra notes 24, 63-70 and accompanying text for a discussion of the input sources of some types of computer-generated evidence. Id.

3 The two basic type of computers include digital and analog. "Analog computers ... measure continuously changing quantities by physical analogy to the phenomenon being measured" at the time. An example would be a thermometer or mileage indicator on a car. A digital computer performs the function of counting rather than measuring, using discreet numerical values to determine whether or not a value is present or has changed. Tapper, Evidence From Computers, 8 GA. L. REV. 562, 562 n.1 (1974). For a technical description of how computers perform, see 1 D. Bender, Computer Law, §§ 2.01-2.06 (1989); Roberts, A Practitioner's Primer on Computer-Generated Evidence, 41 U. Chi. L. REV. 254 (1974); Tapper, Evidence From Computers, 8 GA. L. REV. 562, 566-67; Note, Appropriate Foundation Requirements For Admitting Computer Printouts Into Evidence, 1977 WASH. U.L.Q. 59, 73-
Evidence that is generated by a computer for use in litigation may consist of statistics, numerical projections and models, demonstrations, simulations, and reconstructions. Although some cases and commentators use these terms interchangeably, they are distinguishable. A computer simulation is an artificially created extrapolation of an event represented by limited data or input that continues the event beyond the stated mathematical or factual basis; in other words, a simulation provides information about what would have happened or alternate theories of the accident. Mathematical data provide the source material for a simulation and consist of a numerical description of (1) an event or object involved in an event; (2) a physical position or orientation relative to objects over time (a definition of relative motion); or (3) a condition over time (a definition of a process of deterioration or failure). Mathematical data may be collected directly from an event or developed by an expert through the use of mathematical modeling. The latter process takes factual information about an event, assumptions made by an expert, or both, and uses mathematical algorithms to generate numerical descriptions of the event in question.

A computer-generated accident reconstruction, on the other hand, is an explanation of what in fact happened.
In computer reconstruction, known parameters, data, and facts derived from the accident investigation are entered into a computer. Based on this input, the computer may be able to supply missing information. To this extent, the computer processes involved in a simulation and a reconstruction are quite similar.\textsuperscript{11}

A classic example of event reconstruction in an aviation weather case is the use of a computer to process known data and then "fill in the blanks." This reconstruction is accomplished by a mathematical model of the growth and development of a thunderstorm or other weather conditions. The factual data upon which the reconstruction is based consists primarily of National Weather Service radar films from a given radar site. If a radar site takes pictures once every four minutes, for example, an expert can develop a mathematical description of the weather at the actual time of the photograph. A computer can then perform interpolations between these observations. The process is a relatively straight-forward mathematical calculation based on distribution of temperature, humidity, winds, and solar heating, subject to the constraints of the laws of physics.\textsuperscript{12}

\textsuperscript{11} Although one commentator insists that there is a difference, see A. Lipson, supra note 4, § 16.03, the practicalities of use at trial reveal a distinction without a difference.

\textsuperscript{12} Such a reconstruction was utilized in the litigation arising out of the crash of Delta Flight 191 at the Dallas/Fort Worth Airport on August 2, 1985. Delta Air Lines, its insurers, and two of the three cockpit crew members' estates sued the United States for the loss of the hull, contribution and indemnity, and wrongful death. The court found that no acts or omissions on the part of the United States proximately contributed to the accident. In re Air Crash at Dallas/Fort Worth Airport on August 2, 1985, 720 F. Supp. 1258 (N.D. Tex. 1989). Several computer-generated visual graphics were utilized by the United States during the fourteen-month litigation. Computer-generated graphics pertaining to the weather consisted of a recreation of the location and development of weather cells near the airport and cells that would have been depicted on the airborne weather radar of the L-1011 aircraft, had the radar been utilized at any of three different tilt settings. The basis for the reconstruction was National Weather Service radar film from the Stephenville, Texas radar site. Photographs of the radar scope were taken at 5:52 p.m., 5:56 p.m., 6:04 p.m., and 6:08 p.m., and were utilized by the government's expert in the fields of airborne weather radar and weather reconstruction to demonstrate information that would have been available to the crew through proper utilization of the airborne weather radar.
Computer-generated visual evidence is information which has been generated by a computer and produced in a visual format. Accurate two- or three-dimensional representations of objects in motion thus may be recreated and displayed in a variety of ways. All are simple yet dramatic means of telling a story.

Computer-generated visual simulation is different from traditional animation, which is composed of artistic renderings and commonly known in its most basic form as a cartoon. Animation traditionally involves an image projected on a screen and has characteristics of size, shape, color, and motion. By its very nature, animation frequently constitutes a form of highlighting and distortion.

Traditional animation presents several static images that are redrawn or changed rapidly, resulting in the illusion of movement.

Simulation, on the other hand, incorporates more than

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13 See, e.g., L. SELTZER, EFFECTIVE COMMUNICATION: SEEING IS BELIEVING, PRODUCT LIABILITY OF MANUFACTURERS, 597-606 (Prod. Liab. Inst. Litigation & Administrative Practice Series Handbook 361, 1988). Basic techniques in computer animation include two-dimensional and three-dimensional representations. Two-dimensional computer animation incorporates traditional concepts of animation. The two-dimensional animation has an image which cannot be rotated or viewed from a different position without an underlying drawing to support the new view. The three-dimensional computer animation is undoubtedly the most dramatic and powerful form of computer visual graphics. A full three-dimensional computer model of the object to be depicted is created. This process creates a fully defined image that can be viewed from any vantage point. The three-dimensional scene can be rendered to appear to the viewer as a two-dimensional scene. Then the graphic can be explored by moving through it, traveling around it, or operating it from any point of view desired. Use of this form of animation can actually reconstruct the events in question and put the viewer into the scene. One advantage of two-dimensional animation includes a short production time. Three-dimensional animation requires not only a mathematical model, but a substantial amount of input and communication among attorneys, experts, and the technical team producing the animation. Id.

14 J. BUCHANAN & C. BOs, HOW TO USE VIDEO IN LITIGATION: A GUIDE TO TECHNOLOGY, STRATEGIES AND TECHNIQUE 242-44 (1986).

15 A. LIPSON, supra note 4, § 16.05[6]. Lipson notes animation "constitutes a form of highlighting and distortion. Contests over admissibility are therefore likely to center on the fairness of the presentation." Id.
the visible characteristics of an event. It involves mathematical calculations of mass, velocity, and acceleration, consistent with the laws of physics, which result in a mathematically and physically accurate picture or result.

Once the underlying mathematical simulation or reconstruction has been formulated, the data are transformed or translated into a graphic or visual presentation. This transformation of data from printout to visual image presents no novel evidentiary requirements. The computer-generated visual evidence may be admissible as real evidence, depending on the underlying data or if it qualifies as scientific evidence. It may also be admissible in connection with the testimony of an expert or as demonstrative evidence.

There are several factors to consider in determining whether an event is conducive to visual simulations. The trial attorney should consider using computer-generated simulations when an event or object is difficult to visualize, when a presentation to the jury of real time is critical to the case, when the event is incapable of physical replication, when the event is technical and difficult for nonexperts to understand, or when critical facts are in question. Aviation litigation frequently presents most, if not all, of these factors.

B. Computer-Generated Evidence Available for Use in Aviation Accident Reconstruction

In the context of aviation litigation, varying types of information generated by computer are available to a practitioner to reconstruct an aircraft accident. This

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16 Id.
17 For a discussion of the admissibility of computer-generated evidence, see infra Section III of this article.
18 See, e.g., J. Buchanan & C. Bos, supra note 14, at ch. 18; A. Lipson, supra note 4, § 2.03[1]; L. Seltzer, supra note 15, at 600.
19 Computer-generated information of an historical or statistical nature which may be used in aviation litigation also is available from the FAA. This information includes data pertaining to airmen (qualifications and enforcement history), aircraft (ownership, repairs and/or alterations), operators (operations, enforce-
computer-generated evidence is taken from air traffic control computers and, depending on the type of aircraft involved, the aircraft's flight data recorder, whether in the form of the old foil recorder or the modern digital variety.20

Data from the computer at an air route traffic control center are recorded on a magnetic tape known as the SAR (System Analysis Recording) tape. The SAR, through the use of various computer programs, provides such information as the aircraft's altitude, transponder code, and location at various times.21 Another computer program available from Center radar, the Weather Fixed Mapping Unit (WFMU) program, provides information about precipitation that meets certain recording thresholds and

20 For an explanation of flight data recorder information, see infra note 29.

21 Information is received by the computer directly from the aircraft via its transponder. There are two types of computer programs which process this information. The NTAP (National Track Analysis Program) provides the following information geared to Universal Coordinated Time (UTC): the transponder code for the aircraft in question, the altitude of the aircraft rounded to the nearest one hundred feet, and aircraft location denoted in both latitude and longitude and X/Y coordinates. Another program available from a Center computer is the DART (Data Analysis Reduction Tool), which has the Log, Track and List sort options. This computer program provides, inter alia, the following in Universal Coordinated Time: information contained on the aircraft data block (transponder code, aircraft identification call sign, e.g. DL 191, ground speed in knots, whether a full or limited data block was on the target, and any message contents of the data block), the computer identification number (CID) of the aircraft, information sent to or from various devices at the position working the aircraft and X/Y coordinates of the position symbol representing the aircraft.
may be displayed on air traffic control radar.\textsuperscript{22}

Air traffic control terminal facilities with the ARTS-IIIA (Automated Radar Terminal Systems) and some selected ARTS-III terminal facilities have Continuous Data Recording (CDR) available. This recording system consists of a magnetic disc which currently provides in Universal Coordinated Time recorded information pertaining to altitude, transponder code, and the location of the target in azimuth and range from the radar site feeding the ARTS radar. This information traditionally has been plotted to present a two-dimensional depiction of the flight track of an aircraft.\textsuperscript{23}

While the above-listed information is generated in the regular course of business, it is not generated as a result of human input or other stored human statements, which would constitute hearsay.\textsuperscript{24} Of all the types of computer-generated information, public and business records stored and retrieved by a computer are the most easily admitted.\textsuperscript{25}

In an aviation case, visual simulation particularly is useful to reconstruct the complex world of aerodynamics for

\textsuperscript{22} A computer printout can be obtained showing data from both the NTAP and WFMU programs. A combined printout of WFMU and DART, supra note 21, however, cannot be obtained.

\textsuperscript{23} See, e.g., Teicher v. United States, 15 Av. Cas. (CCH) 17,538, 17,540 (C.D. Cal. 1978) (ARTS III readout used as source of flight data in findings of fact). These flight tracks also have been presented in video format for years.

\textsuperscript{24} It is well settled that a computer printout reflecting computer stored human output or statements is hearsay when introduced for the truth of the matter asserted therein. G. Joseph, supra note 2, at § 7.02; Comment, supra note 2, at 963. The computer readout from FAA air traffic control radar facilities, however, is not a result of human input but constitutes a direct feed from the generating device, i.e., the aircraft transponder, directly onto a computer disc or magnetic tape. Accordingly, this type of computer printout does not fall within the historical category of hearsay. For a discussion of direct entry of data and its admissibility as evidence, see infra notes 61-70 and accompanying text.

\textsuperscript{25} For a discussion of the admissibility of business records, see infra notes 69, 74, 95 and accompanying text; A. Lipson, supra note 4, § 16.05[2]. These FAA records, once certified, become self-authenticating public records and are admissible. Fed. R. Evid. 803(8), 902(4). For a discussion of the fact that some evidence is accorded public record status and is therefore admissible, see infra note 224 and accompanying text.
a judge or jury. One type of aviation case for which visual simulation is well suited is the mid-air collision. In this type of case, the critical issue is which pilot was in the better position to see an approaching aircraft. Another issue may be whether an air traffic controller was in a position to detect converging aircraft or their radar targets. If the pilots survive, their testimony, augmented by radar data, may be the basis for a simulation. If air traffic control is involved, this issue may be determined by testimonial evidence from the air traffic controller as to what he could or could not see, either visually or on radar, or from target information recorded by the computer. Additionally, other pilots and experts testifying about angles, locations, and other information may provide a basis for simulation. The use of computer-generated visual evidence can support testimony by accurately depicting what either party could see at any given time.

Another area of computer reconstruction that is particularly appropriate for use in aviation cases is reconstruction of the performance and/or flight path of an aircraft. Using aerodynamic coefficients, a three-dimensional computer model of an aircraft can be constructed. The "aircraft" then can respond to various computer inputs such as power, pitch, and winds. This process recreates the flight path of the aircraft in question. In accidents where flight data recorder (FDR) readouts are available, these

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26 Note, Ind. L. Rev., supra note 5, at 738.
27 By use of a computer program known as a "retrack," information pertaining to target depiction and location may be retrieved at certain facilities from a magnetic tape. The information does not necessarily reflect what actually was displayed on the controller's scope but merely what information the computer received from the aircraft.
29 Flight data recorder information obtained from an aircraft constitutes raw values that are recorded onto a magnetic tape and then converted into engineering unit equivalents through software programs written for the particular aircraft by the National Transportation Safety Board (NTSB). The only human input into the process of converting the FDR tape into computer printout includes (1) assignment of conversion algorithms used in the computer program and (2) manual
devices can be utilized to achieve a high degree of accuracy to recreate the final segment of flight. Adding cockpit communications obtained from the cockpit voice recorder (CVR) or air traffic control tapes results in a realistic and dramatic recreation.

Another notable advantage of visual simulation is the ability of the computer-generated model to provide either one view or a combination of views: overhead, front, and side views may be displayed alternatively or simultaneously. An eyewitness point of view may also be recreated. Because the timing of an event is often critical in litigation, visual simulations can show an event in real time as well. On the other hand, time may be compressed, stopped, or expanded to simulate events that may have taken place over extremely long or short periods.

retrieval and/or realignment of the data strain upon any resulting interruption (usually through electrical interruption, hardware intrinsic malfunction or damage resulting from impact). While FDR information historically has been available only in the event of an air carrier accident, new FDR requirements have been instituted by the FAA. As of May 28, 1989, all Part 121 carriers were required to replace the antiquated foil recorders with digital recorders. 52 Fed. Reg. 9636 (1987) (to be codified at 14 C.F.R. § 121.343). By October 11, 1991, Parts 125 and 135 operators and Part 91 operators of newly-manufactured aircraft of ten or more seats also must comply with the requirement to have a digital FDR (DFDR) installed. Additionally, all existing FDR recording parameter requirements must be upgraded by this date. 53 Fed. Reg. 26,134 (1988) (to be codified at 14 C.F.R. §§ 23.1459, 25.1459, 27.1459, 29.1459, 91.35(b), 121.343, 125.225, 135.152).

Such a recreation was utilized in the Delta 191 litigation discussed supra note 12. The NTSB recently has begun to convert DFDR data into three-dimensional visual recreations. This has been done in the investigations arising out of the crash of Northwest Flight 255 in Detroit, Michigan on August 14, 1987, and the crash of Delta Flight 1141 at the Dallas/Fort Worth International Airport on August 31, 1988. Once the computer reconstruction is made, it becomes a part of the public docket. The Australian Bureau of Air Safety Investigation (BASI) also has developed computer software to convert data derived from an accident investigation into 3-D animations, known as the Aircraft Accident Investigation System (AAIS). DFDR data are converted into high definition silicon color graphics. These animations constitute part of an official investigation and may be utilized in subsequent litigation. While this issue has not yet been addressed by the courts, admissibility should be achieved through the public records exception to the hearsay rule. For a discussion of cases dealing with public records, see infra notes 86-87 and accompanying text.

In the Delta 191 litigation discussed in note 12, weather reconstruction tapes were created to show views from the cockpit, the portside of the aircraft and a trailing view.
ods of time. In addition, items may be highlighted or de-emphasized by adding or deleting elements of the picture without hindering admissibility. The mathematical data can be modified to reflect a hypothesis in support of expert testimony or in accordance with conflicting testimony. The hypothesis then may be created visually. The advantages of computer-generated visual simulation, therefore, are endless and limited only by the attorney's imagination.32

C. Methods of Presentation of Computer-Generated Visual Evidence

The most common medium of presentation for computer-generated visual evidence is video. The use of this medium has increased dramatically in recent years.33 Video allows for ease of review by attorneys and experts during the course of its development and makes in court demonstrations easy to accomplish. A video presentation can be used to explain the operation of an instrumentality that allegedly caused the harm (a computer reconstruction of the traditional experiment or test)34 and can also illustrate the proponent's view of how the accident occurred or alternate theories.35

Once the underlying simulation or mathematical description of the subject has been formulated, translation of the data into graphic or visual information is considered merely a form of presentation of the information. The proponent must demonstrate that the video reconstruction, like any other photographic exhibit, is substan-

32 For an overview of the uses of computer-generated evidence, see M. Dombroff, Demonstrative Evidence ch. 9 (1983).
34 The computer-generated aircraft model constructed to recreate the accident also can be used to present to the finder of fact an illustration of basic principles of aerodynamics.
35 See, e.g., A. Lipson, supra note 4, § 13.02[3][a][iii], [iv].
tially similar to the conditions associated with the accident.\textsuperscript{36}

A video tape, like any other photographic exhibit, is admissible upon a showing that it fairly and accurately depicts that which it purports to depict.\textsuperscript{37} The fact that it has been edited does not affect admissibility as long as the video tape remains a fair and accurate portrayal.\textsuperscript{38} Video tape exhibits are generally admitted in both state and federal courts if they are fairly prepared, and courts have rejected the contention that video tapes are prejudicial merely because they have a far more powerful emotional impact than either testimony or exhibits in documentary form.\textsuperscript{39} While reconstruction video tapes were excluded in some earlier cases,\textsuperscript{40} the trend in recent years is to admit the video tapes as long as the reconstruction or simu-

\textsuperscript{36} See Nachtsheim v. Beech Aircraft Corp., 847 F.2d 1261, 1278 (7th Cir. 1988) (admission of manufacturer's video tape demonstrating manner in which ice accumulates on aircraft and is removed by de-icing equipment was proper, as video tape was not offered as a reenactment of the accident but merely to illustrate normal operation of aircraft in icing conditions); Champeau v. Freuhauf Corp., 814 F.2d 1271, 1278 (8th Cir. 1987) (admissibility of video tape experiment does not require similar circumstances if not intended as a recreation of an accident); McFarland v. United States, 20 Av. Cas. 18,460, 18,465 (C.D. Cal. 1987) (a video tape recreation of pilot's view admitted but discredited as not substantially similar to circumstances of accident), aff'd, 883 F.2d 1025 (9th Cir. 1989). Any dissimilarities, when not confusing or misleading, go to the weight of the evidence rather than its admissibility. Kelco Aircraft Co. v. Gates Learjet Corp., No. 50516 (Ohio Ct. App. Oct. 9, 1986).

\textsuperscript{37} For a discussion of the admissibility of video tape and video reconstruction, see infra notes 38-39 and accompanying text.

\textsuperscript{38} G. Joseph & S. Saltzburg, Evidence in America - The Federal Rules in the States § 13.5 (1987); A. Lipson, supra note 4, Ch. 13; J. Buchanan & C. Bos, supra note 14, ch. 15.

\textsuperscript{39} G. Joseph & S. Saltzburg, supra note 38, § 13.5. An exhaustive survey of the law on the admissibility of video tapes is outside the scope of this article, which seeks to address the admissibility of the substantive information contained in the tape, \textit{i.e.}, computer-generated evidence. Basic fundamentals for the admissibility of video tape evidence (addressing format and presentation rather than underlying materials) are the subject of many treatises. Recently-published treatises that are helpful include G. Joseph & S. Saltzburg, supra note 38, § 13.5; A. Lipson, supra note 4, ch. 13; G. Joseph, supra note 2, §§ 4.02-5.09; J. Buchanan & C. Bos, supra note 14, Pt. 5; M. Dombroff, Dombroff On Unfair Tactics § 14.18 (2d ed. 1988); see also McCormick's Handbook of the Law of Evidence § 214 (E. Cleary 2d ed. 1972).

\textsuperscript{40} See, \textit{e.g.}, G. Joseph & S. Saltzburg, supra note 38, § 13.5, at n.85.
lation is based on the proponent's version of the facts, and the tape fairly presents this version. A limiting instruction can be given to meet any objection of unfair prejudice raised under Rule 403 of the Federal Rules of Evidence. Additionally, the exclusion of any portion of the video tape does not render the entire tape inadmissible. If any portion of the tape is excluded, the remainder of the tape may be offered as evidence upon deletion of the excluded portion. The video tape, once admitted into evidence, may be replayed in whole, in part, continuously, or may be stopped for emphasis. This presentation provides a pictorial supplement to the expert's commentary. The mode of presentation is left to the discretion of the trial judge.

There are few litigators in the arena today who have not utilized a video tape exhibit, whether it is a day-in-the-life presentation, a view of an accident scene, an educational tape, or a video accident recreation. The recent development of the video disc, however, provides a new medium that significantly increases the presentation capabilities available to the trial lawyer.

The video disc was made widely available in the late 1970s and became widely used in the early 1980s for commercial films. The video disc is similar to a compact disc for a home stereo or a laser disc containing movies to be

42 FED. R. EVID. 611(a).
43 An extremely effective use of computer recreations can be made prior to trial for settlement purposes. Note, 9 COMPUTER L.J., supra note 5, at 117. A computer-generated animation reconstructing the release of hexane gas and resulting explosions was reportedly pivotal in expediting settlement of litigation involving the Louisville (Kentucky) Sanitation District, and has become a "classic" in the field of computer animation. Bloombecker, The Power of Animated Evidence, 6 CAL. LAW. 47, 49 (1988); Chernow, Video in the Courtroom: More Than a Talking Head, 15 LITIGATION 3, 6 (1988). If the video tape recreation is used at trial, it can be used to establish not only liability of the parties but also pre-impact fear experienced by a decedent in apprehension of impending death. See, e.g., Haley v. Pan American World Airways, 746 F.2d 311, 315 (5th Cir.), reh'g denied en banc, 751 F.2d 553 (5th Cir. 1984).
viewed on a television monitor. One side of a video disc can hold 54,000 individual pictures or frames. The normal playback speed of 30 frames per second gives the video disc a capacity of thirty minutes of running video. The power of the video disc, however, lies in its ability to access any of the 54,000 frames almost instantaneously, hold an image perfectly still, or play a specific video sequence at a given speed. Thus, the medium becomes a potential archive of both still and moving images. A video disc can be accessed and controlled either manually, much as one searches for a song on a compact disc player, or through a portable computer with a serial port to run the video disc player. Computer access offers maximum flexibility as the operator can directly access any single image frame or series of frames.

Production of visual material on a video disc and development of custom software to access the information via computer is known as interactive video. Control by the computer enables the expert or attorney to have virtually instantaneous access to any of the specific frames on the disc, to a specific exhibit, or to any specific section within an exhibit. The expert witness, attorney, or technician controls the computer.

The cost of converting video material to video disc and

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45 The playback equipment may be rented from commercial companies at rates comparable to other video equipment.

46 The accessor immediately may retrieve a specific document or part thereof by entry of a five-digit number into the remote control (the “address” or coordinates of the exhibit on the disc). The operator may then press the search button to retrieve the exhibit and “play” if it is video or “still” if it is a document. This access is accomplished without laborious searching for the appropriate digital number on the counting mechanism, having the display marred by flickering frame lines across the screen, or having the screen go to static because the programmed length that a video tape machine will hold a picture has been met. In the Delta 191 litigation, discussed supra note 12, the United States used interactive video in connection with the testimony of several of its expert witnesses. One expert had the capability to sit on the witness stand with a portable computer and easily move from one exhibit to another, or section of exhibit, at the touch of a fingertip. Other experts required the use of a technician. Another option currently available is the use of “bar codes” like those used on consumer goods in supermarkets. The bar code contains the coordinate and commands. With a single stroke of a small pen-sized scanner, information regarding the display of an
producing a master tape is approximately $500 to $1000. A single video disc then may be pressed from the master tape for as little as $300, but the product is likely to suffer degradation of quality. Additional copies are in the same price range. For the most professional quality, the cost of the initial video disc pressing is in the range of $1800, but additional copies are only $18 each.  

The cost to develop custom software to operate the interactive video disc system may range from a few hundred to several thousand dollars, depending on the amount and complexity of the video material. The total cost to produce an interactive video disc presentation generally ranges from $3000 to $6000 over and above the cost to produce the video tape material. While these figures may seem costly to litigators on a limited budget, proper design of the content of the video disc will include many still images in addition to sequential reconstructions. Thus, hours of material are available to the expert and attorney.

Admissibility of evidence contained on a video disc is governed by the same rules of admissibility as those governing the admissibility of computer-generated visual evidence. The information as depicted on the disc is no less admissible because of its form.

It is not recommended that the attorney work with only one copy. While video discs last for many years and even if scratched will continue to operate with little degradation of quality, they may be easily cracked or broken and even a small crack will render the entire disc unusable. It is recommended that a minimum of five to ten copies be made. Thus, copies are available for production to opposing counsel, for use in court, or for whatever purposes the court may require.

For a discussion of the expert and interactive video, see infra notes 271-276 and accompanying text.

See, e.g., Kucharek v. Hanaway, 714 F. Supp. 1499 (E.D. Wis. 1989). The plaintiff, a dealer of sexually explicit films and videos, brought an action to challenge the constitutionality of a state obscenity statute which referred only to "film," allegedly violating the equal protection clause of the fourteenth amendment by excluding video tapes from coverage of the statute. After an amusing intellectual discussion of the meaning of "film," the court rejected the attempt by the plaintiff to distinguish between a film and video by pronouncing that "a movie is a movie." Id. at 1511-12. The court further noted that a video tape "is merely
Production costs will decrease as more sophisticated computers reduce the cost of producing both the computer-generated data and the associated graphics. In aviation litigation, where the stakes are high and data are plentiful, the routine use of interactive video is just around the corner.50

III. ADMISSIBILITY OF COMPUTER-GENERATED VISUAL EVIDENCE

A. In General

The use of computer-generated visual evidence in the form of accident reconstructions or simulations has gained wide acceptance in recent years.51 There is a marked lack of reported cases, however, involving issues...
of admissibility and use of computer-generated visual evidence. The recent trend seems to allow admission of computer-generated visual evidence upon a showing of a foundation that is satisfactory to the trier of fact, with any deficiencies to be elicited on cross-examination. The finder of fact may then consider deficiencies in weighing the evidence. By contrast, there are numerous cases, articles, and treatises addressing admissibility issues of com-

52 In a New York case, the court refused to allow a defendant to play a computer-generated video in a trial resulting from a subway accident. The judge determined that the video would not help the jury, would prove both troubling and confusing, and, thus, was inadmissible. High-tech Video Banned on Centre Street, Manhattan Lawyer, July 11, 1989, at 11, col. 1. In what is reportedly the first use of a computerized reconstruction of an accident as evidence in a personal injury case in Florida, a Broward County jury rejected police testimony that a driver was to blame for an accident and awarded $7 million to a woman left brain-damaged when an 18-wheel truck broadsided her car. A physics professor from Queens College and a graphics computer named Iris generated a video tape simulation demonstrating that the truck hit the driver's car from behind as she drove on the Florida Turnpike, causing her to swerve into the path of the truck. A juror interviewed after the trial said that the more she looked at the recreation, the more she thought "it was a wonderful thing." Computer Simulation Sways Jury, Chicago Tribune, June 25, 1989, at 8, col. 1.

53 But see Dyer v. United States, 19 Av. Cas. (CCH) 17,895, 17,898 (D. Or. 1985). While not presented in animated form, traditional two dimensional computer graphics (called "computer snapshots" by the court) were utilized to demonstrate the development and decay of helicopter wake turbulence. Id. In Haley v. Pan American World Airways, 746 F.2d 311 (5th Cir. 1984), the court affirmed recovery of $15,000 for pre-impact fear and apprehension of impending death experienced by a decedent. In addition to the testimony of psychiatric experts, the evidence cited to support the award was a video tape simulation of the takeoff and crash of Pan American flight 759. In Douglass v. Delta Air Lines, Inc., 709 F. Supp. 745 (W.D. Tex. 1989), a computer-generated simulation of the accident developed by Delta for use in the litigation with the United States was offered by Delta on the issue of pre-impact mental anguish. The court did not allow the evidence to be presented, only because it had not been timely identified and because of the late designation of the expert witness who created the computer model. Id. at 759. In Baugh v. Gulf Air Transport, Inc., 526 So. 2d 1239 (La. Ct. App. 1988), plaintiff sought to use a computer-generated display as a basis for expert testimony. Plaintiff had failed to list the exhibit prior to trial, and the trial court barred its use. The appellate court upheld the exclusion as there was insufficient basis in the record to show either a full proffer or explanation of the proposed exhibit. Id. at 1241.

54 As one commentator has opined, "Delineating the foundation requirements for admitting computerized accident reconstructions is one of the most speculative of inquiries." A. Lipson, supra note 4, § 16.05[5], at 16-36. For a discussion of foundational requirements, see infra notes 189-270 and accompanying text.
computer data (projections, statistics, and mathematical models) in documentary form, i.e., computer printouts.\textsuperscript{55} Computer-generated graphics which utilize public and business records, such as aircraft location from air traffic control radar scopes, flight data recorder information, and cockpit voice recorder information from the aircraft itself, are admissible under the Federal Rules of Evidence or similar state evidentiary rules. They also may be admissible in connection with expert testimony or as scientific evidence under the \textit{Frye} standard which requires general acceptance in the relevant scientific community for admissibility.\textsuperscript{56} Computer-generated visual evidence may also be admitted as demonstrative evidence.\textsuperscript{57} The foundation required under each of these theories represents an effort to ensure that computer evidence is sufficiently reliable to aid in the determination of truth, and within each of these standards there exists a clear basis for admissibility of a visual simulation or recreation.

B. \textit{Admissibility As Tangible Evidence Under The Federal Rules Of Evidence And Similar State Statutes}

The primary approach for admissibility of computer-generated evidence is the relevancy approach under the Federal Rules of Evidence or their state counterparts. A determination of admissibility under the relevancy approach is made by application of Rules 401 through 403.\textsuperscript{58}

\textsuperscript{55} For a discussion of admissibility under various evidentiary statutes, see infra notes 58-59.

\textsuperscript{56} \textit{Frye v. United States}, 293 F. 1013 (D.C. Cir. 1923). For a discussion of admissibility of computer generated graphics with expert testimony or as scientific evidence, see infra notes 141-155 and accompanying text.

\textsuperscript{57} For a discussion of computer-generated graphics admissible as demonstrative evidence, see infra notes 182-187 and accompanying text.

\textsuperscript{58} \textit{FED. R. EVID.} 401-403. Rule 401 sets out the relevancy requirements: "Relevant evidence means evidence having any tendency to make the existence of any fact that is of consequence to the determination of an action more probable or less probable than it would be without the evidence." \textit{FED. R. EVID.} 401. Rule 402 retains a common law notion: In order to pursue the truth between disputing litigants, all evidence which bears on the issue must be admitted. \textit{McCORMICK ON EVIDENCE}, supra note 39, § 184. Rule 402 states that "[a]ll relevant evidence is admissible except as otherwise provided by the Constitution of the United States,
The complex nature of evidence in aviation litigation usually requires presentation through expert testimony governed by Rules 702 through 705.\textsuperscript{59} The relevancy approach incorporates a balancing standard based upon Rule 403: "Although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence."\textsuperscript{60}

Much of the case law pertaining to computer-generated materials addresses the admissibility of the computer printouts themselves. If these printouts are the product of information gathered or generated by humans, they constitute hearsay when offered to prove the truth of the matters contained therein.\textsuperscript{61} This analysis is inappropriate for data generated by a computer itself,\textsuperscript{62} such as data from air traffic control radar and aircraft flight data recorders. Cases involving telephone wire taps have recognized that modern computer technology generates its own data without human input. In \textit{People v. Holowko},\textsuperscript{63} a defendant filed a motion \textit{in limine} to exclude from evidence certain telephone "trap" or "line tracer" records made by the Illinois Bell Telephone Company.\textsuperscript{64} The

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\textit{by Act of Congress, by these rules, or by other rules prescribed by the Supreme Court pursuant to statutory authority.} \textit{Fed. R. Evid. 402.}
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\textsuperscript{59} \textit{Fed. R. Evid. 702-705.} Rules 702 and 703 govern the admission of expert and scientific evidence. Rule 702 provides: "If scientific, technical, or other specialized knowledge will assist the trier-of-fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." \textit{Fed. R. Evid. 702.} Rule 703 allows the expert to base his opinion upon firsthand observations, facts made known at or before the trial, or upon inadmissible facts or data so long as it is the type reasonably relied upon by experts in the particular field. \textit{Fed. R. Evid. 703.}

\textsuperscript{60} \textit{Fed. R. Evid. 403.} For a discussion of grounds for exclusion, see \textit{infra} notes 260-268 and accompanying text.

\textsuperscript{61} \textit{A. Lipson, supra note 4, § 16.04[1]; G. Joseph, supra note 2, § 7.02.}

\textsuperscript{62} \textit{G. Joseph, supra note 2, § 7.01.}

\textsuperscript{63} 486 N.E.2d 877 (Ill. 1985).

\textsuperscript{64} \textit{Id. at 878.}
tracer was an electronic device whereby a computer automatically recorded telephone numbers of calls coming into the "trapped" telephone. While the defendant conceded that the tracing records were business records, he sought their exclusion under a state criminal statute precluding admissibility of evidence if obtained during an investigation relating to anticipated litigation. The court denied the motion and found that computerized trap records were not hearsay evidence contemplated by a traditional business records analysis but were more akin to a self-generated record of operation like a flight data recorder.

The reasoning utilized by the court in Holowko is applicable to computer-generated records from air traffic control radar, as the information from the aircraft transponder feeds directly onto the magnetic tape of the appropriate air traffic control computer recording device. Accordingly, the underlying data are admissible. Similarly, data from a flight data recorder are directly recorded onto magnetic tape and then converted into computer data. As the data recording is done without human input, these data also should be admissible as real evidence under the Holowko theory.

If the court is not persuaded by this argument, the underlying computer data also are admissible under several exceptions to the hearsay rule.

1. The Public Records Exception To The Hearsay Rule

When underlying computer data have been stored or

65 Id. For discussion of admissibility of business records, see infra notes 95-106 and accompanying text.
66 486 N.E.2d at 879.
67 For discussion of aircraft transponders, see supra note 21 and accompanying text.
68 For a discussion of flight data recorder information, see supra note 29 and accompanying text.
69 Id. As noted, there may be some limited human manipulation of the data stream.
70 For a discussion of Holowko, see supra notes 63-66 and accompanying text.
retrieved by a government computer, printouts will be admissible as public records. Public records have long been recognized as an exception to the hearsay rule, both in common law and by statute. Computer printouts which are obtained from the United States for use in litigation are admissible in federal courts and state courts which have adopted provisions analogous to the federal rule excepting public records and reports from the hearsay rule. If introduction of these records is sought in a state court that has no analogous evidentiary rules, admission into evidence may be obtained under the Official Records Act. Computer printouts that constitute public records are considered to be trustworthy because of the public duty attending the discharge of the recordation of official functions and the necessity to avoid the inconvenience of presenting at trial government employees who have made statements in the course of their duties.

While none of the definitional provisions found in Rule 801 specifically embrace statements made by machines, Rule 803(8) has been held to apply to computer

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72 Fed. R. Evid. 803(8). Rule 803(8) provides that records, including data compilations, of public offices and agencies which set forth "(A) the activities of the office or agency, or (B) matters observed pursuant to duty imposed by law as to which matters there was a duty to report" are not excluded by the hearsay rule. Id. See generally Annotation, Proof of Public Records Kept or Stored on Electronic Computing Equipment, 71 A.L.R. 3d 232 (1976) (discussing proof of public records kept or stored on computing equipment).

73 28 U.S.C. § 1733 (1982), as amended by Act of January 2, 1975, Pub. L. No. 93-595, § 2(c), 88 Stat. 1926 (1976). The statute provides that records (A) of any department or agency of the United States shall be admissible to prove the act, transaction or occurrence as a memorandum of which the same were made or kept; (B) properly authenticated copies shall be admitted equally with originals; and (C) the statute does not apply to cases or proceedings in which the Federal Rules of Evidence apply. Id. While the Official Records Act applies only to records of a federal department or agency, Fed. R. Evid. 803(8) applies to any public office or agency, whether it be state, federal, local, or foreign. 4 D. Louisell & C. Mueller, Federal Evidence § 455, at 722-23 (1989).

74 United States v. Quezada, 754 F.2d 1190, 1193 (5th Cir. 1985); 4 D. Louisell & C. Mueller, supra note 73, § 454, at 719-21.

75 Fed. R. Evid. 801(A)-(C).
printouts. The public records exception thus provides two avenues by which computer data may be utilized in establishing a foundation for the admissibility of computer-generated visual evidence. Under Federal Rule of Evidence 803(8)(A), records which set forth the activities of the office or agency are an exception to the hearsay rule. This provision embraces records of a simple factual nature which focus on an agency's own activity and which were prepared for purposes independent of litigation.

Underlying computer printouts may also be admissible under Rule 803(8)(B) if the information contained therein represents matters which have been observed and reported pursuant to a duty imposed by law. Computer printouts utilized in the production of computer-generated visual reconstructions reflect facts which have been routinely observed or recorded as part of the operation of a governmental department or agency. While some commentators note that information falling within Clause (B) focuses primarily upon events or conditions outside of the

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76 United States v. Puente, 826 F.2d 1415, 1417 (5th Cir. 1987); United States v. Orozco, 590 F.2d 789, 793-94 (9th Cir.), cert. denied, 442 U.S. 920 (1979); D. LOUISELL & C. MUELLER, supra note 73, § 455, at 722; see also Comment, supra note 3, at 138-40 and cases cited therein.

77 United States v. Mena, 863 F.2d 1522, 1531 (11th Cir.) (records of Honduran ship registry were admissible in criminal action under Rule 803(8)(A) as the registration of Honduran vessels is a regular activity of the Honduran government), cert. denied sub nom. Brack-Brack v. United States, 110 S. Ct. 109 (1989); United States v. Hardin, 710 F.2d 1231, 1237 (7th Cir.) (graph from DEA statistical report purporting to show average retail price and purity of illicit cocaine admissible under 803(8)(A) as showing activity of agency and information compiled for non-litigative purpose of identifying national trends in the illicit drug market), cert denied, 464 U.S. 918 (1983); United States v. Stone, 604 F.2d 922, 925 (5th Cir. 1979) (Treasury Department Progress Sheet showing issuance and mailing of check admitted in prosecution for stolen mail); 4 D. LOUISELL & C. MUELLER, supra note 73, § 455, at 724; G. WEISSENBERGER, FEDERAL EVIDENCE § 803.42 (1987).

78 FED. R. EVID. 803(8)(B). Clause (B) also incorporates a specific exception, however, that matters observed by police officers or other law enforcement personnel cannot be used in criminal cases. This is known as the "law enforcement exception." Most of the cases address the issue of the violation of a criminal defendant's right to confront witnesses testifying against him when the introduction of public records and/or reports is sought.

79 For a discussion of FDR and SAR recordings, see supra notes 21 and 29 and accompanying text.
functioning of a public office or agency, cases demonstrate that this clause is designed to address records which are relatively concrete and factual in nature.

A record which is merely a recording of a routine matter or function has sufficient guarantees of trustworthiness because the data are not collected, observed, or recorded in an adversarial setting. The mere fact that the information was retrieved for use in litigation does not make it any less reliable than when it was first recorded.

Whether a particular item of evidence qualifies for admissibility within Clause (A) or (B) frequently makes little difference in civil litigation. Records such as those from the Weather Bureau and graphs based on aircraft flight data recorder information have been found admissible.

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\(^{80}\) G. WEISENBERGER, supra note 77, § 803.42.

\(^{81}\) United States v. Puente, 826 F.2d at 1418 (computer printout from Customs Service Treasury Enforcement Communications System (TECS) admitted to show when defendant crossed border and his automobile license number); United States v. Orozco, 590 F.2d at 793-94 (admissibility of Customs records indicating license number of cars crossing border upheld as Customs agent has no motive to fabricate entries into the computer and entry of the data is a fairly simple procedure); 4 D. LOUISELL & S. MUeller, supra note 73, § 855, at 726, 728-29.


\(^{83}\) See Puente, 826 F.2d at 1417-18 (5th Cir. 1987).

\(^{84}\) See Menas, 863 F.2d at 1522; Puente, 826 F.2d at 1415; Hardin, 710 F.2d at 1231; United States v. Logan, 641 F.2d 860 (10th Cir. 1981); In re Air Crash at John F. Kennedy Int'l Airport on June 24, 1975, 635 F.2d 67 (2d Cir. 1980); Hernandez-Rojas, 617 F.2d 533; Stone, 604 F.2d 922; Orozco, 590 F.2d 789; Grady, 544 F.2d 598; American Airlines v. United States, 418 F.2d 180 (5th Cir. 1969); Minnehaha County v. Kelley, 150 F.2d 356 (8th Cir. 1945); Elwood v. City of New York, 450 F. Supp. 846 (S.D.N.Y. 1978) rev'd on other grounds sub nom. Badgley v. City of New York, 606 F.2d 558 (2d Cir. 1979); 4 D. LOUISELL & C. MUeller, supra note 73, § 855, at 724.

\(^{85}\) Minnehaha County, 150 F.2d at 361 (Weather Bureau rainfall records properly received in evidence as an official record). See also Elwood, 450 F. Supp. at 871 (report by United States Geological Survey admissible to prove water temperatures).

\(^{86}\) American Airlines, 418 F.2d at 196 (foil recorder admitted without objection; graph plotted by CAB admitted as public record). But see In Re Air Crash Disaster at John F. Kennedy Int'l Airport on June 24, 1975, 635 F.2d at 72-73, in which the trial court's exclusion of NTSB chart showing actual flight path compared to glide slope was upheld as within trial court's discretion in application of Fed. R. Evid. 403. Of interest will be the arguments for and against admissibility of computer-
as public records. Cases discussing admissibility of flight recorder data in documentary or graphic form, however, frequently do not identify the clause under which admission is allowed or upheld.\(^8\)

For computer printouts which represent the recorded and stored information of aircraft altitude, location, and other variables,\(^8\) it is submitted that these records should be admissible under Rule 803(8)(A) since they represent a compilation of an activity of the FAA. In the alternative, these records would be admissible under clause (B) as matters "observed" and "reported" pursuant to a duty imposed by law.\(^8\) Computer printouts such as service difficulty reports and malfunction and defect reports\(^8\) also are admissible under clause (B) because of the require-

generated visual animations developed by the NTSB in the course of their investigations. For a discussion of these visual re-creations, see supra note 30 and accompanying text. As NTSB factual reports generally are admissible, it is submitted that the visual animations, as part of the NTSB public docket, should also be admissible upon the requisite showing of trustworthiness. *American Airlines*, 418 F.2d at 196; *Curry v. Chevron*, USA, 779 F.2d 272, 274 (5th Cir. 1985); *Travelers Ins. Co. v. Riggs*, 671 F.2d 810, 816 (4th Cir. 1982).


\(^8\) For a discussion of these types of computer printouts, see supra note 21 and text accompanying note 23.

\(^8\) Because the aircraft information is automatically recorded by a computer without any observation by a human, it is submitted that computer printouts of aircraft location and altitude, etc., are properly admissible under clause (A).

\(^8\) For a discussion of the types of the information available from the FAA, see supra note 19 and accompanying text.
ment for reporting this information.\textsuperscript{91}

Not only do the categories of Rule 803(8) frequently overlap, but there is also an overlap within the exception for the admissibility of business records in Rule 803(6).\textsuperscript{92}

When faced with the question of admissibility under either exception, some courts admitted government documents both as a business record and as a public record.\textsuperscript{93}

2. The Business Records Exception To The Hearsay Rule

Computer printouts generated in the regular course of business, such as computer data pertaining to aircraft location, altitude, and transponder, which are taken from NTAP, DART or CDR printouts,\textsuperscript{94} also may be admissible as business records.\textsuperscript{95} With the advent of computerized business records, courts had to reconcile application of traditional evidentiary rules and the realities of current

\textsuperscript{91} Repair stations are required by 14 C.F.R. § 145.63 (1989) to submit malfunctions and defect reports; similarly, manufacturers holding a Type Certificate, Supplemental Type Certificate, Parts Manufacturer Approval, or Technical Standard Order authorization are required to report malfunctions and defects to the FAA under 14 C.F.R. § 21.3 (1989). Operators are required to make Service Difficulty Reports to the FAA under 14 C.F.R. §§ 121.703, 121.705 (1989) (air carriers) and §§ 135.415, 135.417 (1989) (commuters). A proponent must establish the trustworthiness of the data, however.

\textsuperscript{92} For a discussion of admissibility of business records, see infra notes 95-97 and accompanying text. For an exhaustive discussion of the historical differences between the business records and public records exception, see Brown v. ASD Computer Center, 519 F. Supp. 1096, 1103 n.2 (S.D. Ohio, 1981), aff'd sub nom. Brown v. Mark, 709 F.2d 1499 (6th Cir. 1983).

\textsuperscript{93} See Logan, 641 F.2d at 863 (audit reports of the Bureau of Indian Affairs were admitted in evidence under both the business records and public records exceptions); Stone, 604 F.2d at 925 (Treasury Department Progress Sheet was admitted under both exceptions).

\textsuperscript{94} For a discussion of these types of printouts, see supra notes 21-23 and accompanying text.

\textsuperscript{95} This subject has received exhaustive treatment and will not be repeated herein; basic principles, however, are discussed. For a thorough discussion of this exception, see 3 D. Bender, COMPUTER LAW § 6.05 (1989); 4 D. LOUISELL & C. MUeller, supra note 73, §§ 446-449; G. WEISSENBERGER, supra note 77, §§ 803.28-803.38; Annotation, Admissibility of Computerized Private Business Records, 7 A.L.R.4th 8 (1981); Johnston, A Guide For The Proponent And Opponent of Computer-Based Evidence, 1 COMPUTER L.J. 667 (1979); Comment, supra note 2, at 964; Note, supra note 3, at 65-67; Note, COMPUTER L.J. supra note 5, at 105-13; Comment, supra note 3, at 132.
business practices utilizing computers. In *King v. State of Mississippi ex rel. Murdock Acceptance Corporation*, the defendant sought admission in a criminal action of computerized business records of balances due on notes. The records had been created by key punch onto cards which then were verified and stored on magnetic tape. The company considered the tapes a permanent record of the customer’s account and processed in the ordinary course of business. The issue before the court was whether the computer printout was an original record. In applying the common law shop book rule, the *King* court found that the records were admissible upon a showing of relevancy and materiality. In quoting Professor Wigmore, the court noted it must “cease to be pedantic and endeavor to be practical” when dealing with computerized business records in the form of computer printouts. This practical approach is widely accepted today, primarily because of the trustworthiness associated with records maintained by a business.

The admissibility of computer-generated evidence is not limited to data stored by computer for business purposes, but also extends to evidence produced by computer solely for purposes of trial. In the leading case of *Transport Indem. Co. v. Seib*, the admissibility of computer data prepared especially for use in litigation was based on the business record exception. The court found that it was sufficient to show that the system used to calculate,

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96 222 So. 2d 393 (Miss. 1969).

97 Generally, the common law shop book rule was codified by the Commonwealth Fund Act, 28 U.S.C. § 1732 (1982), which was used in federal courts to determine the admissibility of computer printouts until the codification of the Federal Rules of Evidence in 1975. States have accomplished the same purpose by adopting the Uniform Business Records as Evidence Act, 9A U.L.A. 506 (1965). For an exhaustive review of the historical development of the business records exception, see Johnston, supra note 95, at 669-79; Tapper, supra note 3, at 590-600; Comment, supra note 3, at 132-133; Comment, supra note 2, at 964-66.

98 222 So. 2d at 398.

99 For a discussion of the foundation to establish admissibility of a business record, see infra notes 236-240 and accompanying text.

100 *McCormick On Evidence*, supra note 39, § 314.

prepare, and store the data was utilized in the usual course of business.102

While Seib involved the admissibility of data generated in the normal course of business and retrieved for litigation, subsequent cases have upheld the admissibility of computer-generated business records created or retrieved solely for use in litigation,103 even though these records arguably lack inherent reliability.104 Courts have held it is sufficient for admissibility to establish that the system used to prepare, store, and calculate the information was used in the normal course of business.105 This premise has been extended even further, and computer simulations actually developed solely for use in litigation clearly are admissible.106

102 Id. at 875.
103 In United States v. De Georgia, 420 F.2d 889 (9th Cir. 1969), an auto rental company's computerized records were admissible under the Federal Business Records Act in a prosecution for interstate transportation of stolen automobiles. Hertz did not keep a contemporaneous written business record of rental and leased transactions, so the information was generated specifically for use at trial. Id. at 891; see also Comment, supra note 2, at 965.
105 See De Georgia, 420 F.2d at 889; Seib, 178 Neb. 253, 132 N.W.2d at 871; A. Lipson, supra note 4, § 16.05[2][A]; Comment, supra note 2, at 967-68.
106 The evidence is offered mainly through expert testimony. For a discussion of the admissibility of computer-generated evidence in connection with expert testimony, see infra notes 116-135 and accompanying text. The following cases involve admissibility of computer-generated mathematical simulations developed specifically for use in litigation: Sterling v. Velsicol Chem. Corp., 855 F.2d 1188 (6th Cir. 1988) (in action for damages as a result of chemical leakage, computer water models allowed); United States v. 1,606.00 Acres of Land, 698 F.2d 402 (10th Cir. 1983) (in eminent domain action, computer simulation used by expert to help determine fair market value of land); McDonnell-Douglas Corp. v. United States, 670 F.2d 156 (Cl. Cl. 1982) (in patent action, McDonnell-Douglas utilized computer simulation to support its claim that an invention was reduced to practice); Drayton v. Jiffee Chem. Corp., 591 F.2d 352, 362 (6th Cir. 1978) (economic projection of future losses based on computer projection); Perma Research & Dev. v. Singer Co., 542 F.2d 111 (2d Cir.), cert. denied, 429 U.S. 987 (1976); United States v. 2,175.86 Acres of Land, 687 F. Supp. 1079 (E.D. Tex. 1988) (computer model used to estimate timber volumes on condemned property in condemnation case); Kelco Aircraft Co. v. Gates Learjet, No. 50516 (8th App. Dist. Ohio, October 9, 1986) (expert in product liability case testified, based on computer calculations, that aircraft performance was in the flight envelop during time in question); Holland v. Dick Youngberg Chevrolet-Buick, Inc., 348 N.W.2d 770 (Minn. Ct. App. 1984)(computer simulation used by buyer to show inadequate truck power to recover damages under revocation of contract theory); Ideker, Inc v. Missouri
Computer-generated records such as the NTAP and DART data, when provided in the form of a certified copy, are self-authenticating under Federal Rule of Evidence 902(4). When combining the certified copy with either the public record or business record exception, there is virtual admissibility per se, assuming that relevancy has been established.

3. Admissibility As An Admission

Another basis upon which computer-generated information derived from non-governmental sources may be admissible is through an admission by a party. Computerized information of various sorts is maintained by operators and manufacturers and may be admissible as an admission against that party’s interest because of its trustworthiness.

State Hwy. Comm’n, 654 S.W.2d 617 (Mo. Ct. App. 1983) (computer simulations on haul cycles admissible; weight of evidence is for jury); Messex v. Louisiana Dept. of Highways, 302 So. 2d 40, 44 (La. Ct. App. 1974) (plaintiff’s computer study of stopping distance in automobile accident case was admissible but did not support her allegations of last clear chance). It is important to note that all of these cases involve computer-generated evidence in its documentary or printout form. These cases did not involve the question of admissibility of computer-generated evidence presented in visual or graphic form. Admissibility of the evidence in visual form, once the foundation is established for admissibility of the underlying data, presents no new hurdle.

See, e.g., G. Joseph & S. Saltzburg, supra note 38, at 44.

For a discussion of computer-generated information pertaining to aviation litigation, see supra note 19 and accompanying text. For a discussion of malfunction and defect reports, see supra note 91, and accompanying text.

Comment, supra note 3, at 131 n.80 (discussing Ferris v. Polycast Tech. Corp., 180 Conn. 199, 429 A.2d 850 (1980), in which a corporation’s computerized ledger sheets were admissible against the corporation as admissions by a party opponent). In United States v. Sanders, 749 F.2d 195 (5th Cir. 1984), the conviction of a pharmacist for medicaid fraud was upheld. The conviction was based on the computer records of the Texas Department of Human Resources, which reflected reimbursement claims submitted by the defendant. The court admitted the printout as a business record, noting that the claims forms submitted by the defendant were not hearsay since they qualified as admissions under Rule 801(d)(2)(C). Id. at 199. This reasoning similarly is applicable to records maintained by operators and manufacturers of reported defects or service problems.
4. Admissibility Under The "Catchall" Exception

The aforementioned exceptions to the hearsay rule will apply only to data generated by a computer in the course of business activity. For computer-generated evidence created especially for litigation purposes, the underlying data itself can come into evidence under the residual exception of the hearsay rule. When Rule 803(24) is used in conjunction with the Rule 901(b)(9), computer data generated for use in litigation may be admissible if the proponent can demonstrate the reliability of the data or demonstrate that reasonable persons conducting serious affairs would rely on the data. Many accident reconstructionists are now relying on computers to interpret existing data and to generate data in connection with reconstructing an airplane accident. The reliability of underlying data can be shown in order to qualify for admissibility as evidence under the residual exception to the hearsay rule. Even if this cannot be established, however, the opinions of the expert will be admissible upon a showing of proper foundation.

5. Admissibility In Connection With Expert Testimony

If admissibility of computer-generated visual evidence cannot be accomplished directly through the relevancy provisions, admission should be sought through the

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See, e.g., Dutschke v. Piper Aircraft Corp., 564 F. Supp. 359, 362 (M.D. La. 1983). In this case, the plaintiff brought a product liability action for property damage to aircraft and sought to use computer printouts of service problems reported to FAA by mechanics in the field. In a bench trial, the court gave little weight to this evidence, however, as the circumstances and causes of these failures were not shown. Also important to the court was the fact that the plaintiff's aircraft was not manufactured by Piper. Id.

112 Fed. R. Evid. 803(24).
113 Fed. R. Evid. 901(b)(9).
114 Comment, supra note 2, at 966-68.
115 This approach has been noted by Professor Weinstein. See 5 J. Weinstein & M. Berger, Weinstein's Evidence ¶ 901(b)(9)[02], at 901-113 (1989); see also Comment, supra note 3, at 143.
“back door” route of testimony by an expert witness. When a civil case is technical in nature, such as aviation litigation, it is essential that scientific, technical, or specialized evidence be admitted to assist the trier of fact. This evidence, in fact, is liberally admitted through expert testimony. Without expert testimony, it is likely that a case would fail because the technical and scientific aspects of the case would result in the inability of the finder of fact to comprehend the issues.

Under Federal Rule of Evidence 702, qualified experts provide technical knowledge to assist the trier of fact in understanding the evidence. Furthermore, an expert can base his opinion on facts or data which need not be admissible in evidence if the underlying data are “of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject.”

What constitutes the type of data upon which reliance is reasonable is the subject of foundation testimony, and the trial court must determine whether the reliance in fact is reasonable. If the reliance is reasonable, the testimony must be admitted and weighed by the finder of fact.

Experts in the area of aviation litigation

116 See Arnolds, Federal Rule of Evidence 703: The Back Door is Wide Open, 20 FORUM 1 (1984); see also supra note 106 and cases cited therein.
118 Because of the emphasis in the Federal Rules of Evidence on the particular helpfulness of expert testimony and its liberal use, any doubts about whether expert testimony will be useful should be resolved in favor of admissibility unless there are strong factors favoring exclusion.
119 FED. R. EVID. 702.
120 FED. R. EVID. 703. See Stevens v. Cessna Aircraft Co., 634 F. Supp. 137, 142-43 (E.D. Pa.) (expert in aeronautical medicine permitted to testify concerning stress that decedent was experiencing, and his reliance on statements by the decedent's friends, co-workers, and professors was found to be typical of experts in his field), aff'd mem., 806 F.2d 254 (3d Cir. 1986).
122 See, e.g., In re Japanese Electronic Products Antitrust Litigation, 723 F.2d
reasonably rely upon computer simulations, and these simulations should be admissible upon a showing that the degree of reliability of modeling technique employed is consistent with the state of the art.\textsuperscript{123}

Rule 403 balances Rules 702 and 703 by excluding evidence if the probative worth of the evidence is outweighed by a danger of "confusion of the issues, or misleading the jury."\textsuperscript{124} The decision whether to admit expert testimony rests with the discretion of the trial judge and will not be overturned on appeal unless clear abuse is shown.\textsuperscript{125} Furthermore, any weaknesses in either the qualifications or opinions of the expert affect the weight of the evidence or credibility of the witness, and not the admissibility of the testimony itself.\textsuperscript{126}

In aviation litigation, computer-generated data available to experts for the basis of forming opinions and inference consists inter alia of information generated from air traffic control radars and aircraft flight data recorders.\textsuperscript{127} This computer-generated data, which are intrinsic in the investigation of any aircraft accident, meet the standard prescribed in Rule 703, and need not be admissible in evidence. Ironically, it is by virtue of the status of this type of computer-generated data that it is admissible as substantive evidence.\textsuperscript{128} If an expert has relied on computer-generated data, whether recorded directly or interpolated, in an attempt to recreate what caused an accident, this testimony also should be admissible as rele-

\textsuperscript{123} See Comment, supra note 2, at 968-69.
\textsuperscript{124} FED. R. EVID. 403. For a discussion of the balancing standard based on Rule 403, see supra note 60, and accompanying text.
\textsuperscript{125} Salem v. United States Lines Co., 370 U.S. 31, 35 (1962); J. WEINSTEIN & M. BERGER, supra note 115, § 702[02].
\textsuperscript{126} 2 S. GARD, JONES ON EVIDENCE § 14.31 (1972).
\textsuperscript{127} For a discussion of this data, see supra notes 21-23, 29 and accompanying text.
\textsuperscript{128} See FED. R. EVID. 803(6)(concerning business records) and 803(8)(concerning public records and reports). For a discussion of the admissibility of computer-generated data, see supra notes 67-70 and accompanying text.
vant under Rules 401\textsuperscript{129} and 402.\textsuperscript{130} Admissibility assumes the safeguards of Rule 403\textsuperscript{131} and Rule 703\textsuperscript{132} are met. With interaction of these Rules, the underlying concern of reliability of the evidence is satisfied.\textsuperscript{133}

Some commentators also have noted that an expert may testify about the results of a computer simulation through use of the hypothetical question.\textsuperscript{134} This approach apparently has been utilized.\textsuperscript{135} Even if the visual simulation is not actually admitted into evidence, however, it can be utilized to illustrate the opinions of the expert, \textit{i.e.}, as demonstrative evidence.\textsuperscript{136}

C. Novel Scientific Evidence: The Frye Rule

An antiquated basis for admissibility used in early cases includes consideration of computer-generated evidence as novel scientific evidence. This basis for admissibility is very limited in use and this analysis will arise only in certain state court jurisdictions.\textsuperscript{137}

Novel scientific evidence is evidence which is derived from newly developed or applied scientific principles.\textsuperscript{138} Generally, scientific knowledge supplies the hypothesis needed by the expert witness to evaluate specific data and

\textsuperscript{129} \textit{FED. R. EVID.} 401.
\textsuperscript{130} \textit{FED. R. EVID.} 402.
\textsuperscript{131} \textit{FED. R. EVID.} 403.
\textsuperscript{132} \textit{FED. R. EVID.} 703.
\textsuperscript{133} For a discussion of the reliability of computer-generated evidence, see infra notes 251-254 and accompanying text.
\textsuperscript{134} 3 D. Bender, \textit{supra} note 95, § 5.01[3][d]; Note, \textit{supra} note 5, at 757-58.
\textsuperscript{135} \textit{See} 3 D. Bender, \textit{supra} note 95, § 5.01[3][d] (discussing the case of Messex v. Louisiana Dep't of Highways, 302 So. 2d 40 (La. 1974) (where a computer simulation was admitted in evidence to support the plaintiff's claim of last clear chance)). \textit{Cf.} 3 D. Bender, \textit{supra} note 95, § 6.09[3] (discussing the possibility that certain types of computer evidence may not be admissible because of the hearsay bar).
\textsuperscript{136} For a discussion of the use of demonstrative evidence, see infra notes 173-188 and accompanying text.
\textsuperscript{137} For a discussion of two cases where the Frye analysis was used, see infra notes 147-155 and accompanying text.
to testify about the data obtained.\textsuperscript{139} This evidence includes traditional scientific evidence such as polygraph analyses, psychological stress evaluators, voice spectrometry (voiceprints), blood splatter tests, infrared spectrographic analyses, and DNA mapping. Although computer technology no longer constitutes "novel scientific evidence,"\textsuperscript{140} there are some early cases involving computer-generated evidence which utilized the admissibility standard enunciated in \textit{Frye v. United States}.\textsuperscript{141}

In \textit{Frye}, the District of Columbia Circuit considered the admissibility of polygraph evidence in a criminal case. In a brief two page conclusory opinion citing neither authority nor explanation for adopting an evidentiary standard, the court held that polygraph evidence was inadmissible as no showing had been made that this scientific technique had gained general acceptance in the relevant scientific community.\textsuperscript{142} The court, however, was not able to give a clear indication of when a technique is deemed to have credibility.\textsuperscript{143}

\textsuperscript{139} \textit{See generally} McCormick \textit{On Evidence, supra} note 39, § 203 (discussing some problems in the use of scientific techniques and devices as sources of proof).

\textsuperscript{140} In \textit{State v. Robinson}, No. 56443 (5th App. Dist. Ohio, May 26, 1982)(WESTLAW), the court noted, "Certainly, computer technology is a part of scientific evidence which has gained general acceptance in the particular field in which it belongs." Computer evidence routinely is used in many types of civil cases without any challenge about the computer itself as a commonly-accepted method for creation of mathematical calculation. \textit{See Schaeffer v. General Motors Corp.}, 372 Mass. 171, 177, 360 N.E.2d 1062, 1067 (1977)(judicial notice of the reliable and widespread use of computers in many phases of contemporary affairs).

\textsuperscript{141} 293 F. 1013 (D.C. Cir. 1923). Later cases involving mathematical computer models and simulations have not considered \textit{Frye} in an admissibility analysis. \textit{See supra} note 106 and accompanying text. While it does not appear that a \textit{Frye} analysis has been made in any federal case considering the admissibility of computer-generated evidence, the reader should be aware of the \textit{Frye} rule, and anticipate an objection under it in some state jurisdictions.

\textsuperscript{142} 293 F. at 1014.

\textsuperscript{143} \textit{Id.} The court stated:

\textit{Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be}
The Frye rule adds a threshold requirement to the proponent's traditional burden of offering evidence. For novel scientific evidence to be admissible, Frye requires that the proponent must demonstrate not only relevancy and helpfulness to the trier of fact, but also general acceptance of the principle or technique in the relevant scientific community. It is important to note, however, that this standard was created within the context of a murder prosecution. The court excluded evidence based on a "systolic blood pressure deception test," a forerunner of the modern polygraph. On appeal, the defendant argued for admission based on traditional rules governing expert testimony. The Court of Appeals, however, rejected the argument and held that the test lacked the requisite "standing and scientific recognition among physiological and psychological authorities."

While the restrictive Frye standard of general acceptance is limited almost completely to criminal cases and civil cases in which admissibility of forensic evidence is at issue, two earlier state court cases involving computer-generated accident reconstructions required a Frye hearing to determine their admissibility at trial. Neither of these cases, however, involved a visual simulation.

In Schaeffer v. General Motors, the plaintiff brought an action alleging negligence in the manufacture and design of his car which caused it to cross a median strip and collide with another car. Plaintiff alleged that his car's controlled differential, which the car manual claimed made driving safer by providing additional traction, failed, causing the car to fishtail on a wet highway. The court admit-

sufficiently established to have gained general acceptance in the particular field in which it belongs.

Id.  

Id. The court left open the question of its future admissibility. Id.  


ted into evidence results of a computer simulation of the accident demonstrating that the differential was not the cause of the collision. In response to the trial judge's admission of the simulation into evidence, the Supreme Judicial Court of Massachusetts found:

We do not question the judge's observation that we are living in a computer age, nor do we dispute his taking judicial notice of the reliable and widespread use of computers in many phases of contemporary affairs . . . . 'Judicial acceptance of a scientific theory or instrument can occur only when it follows a general acceptance by the community of scientists involved.'

The court prescribed a two-part procedure for the trial judge to determine the admission of the evidence on retrial: (1) a hearing should be conducted in the absence of the jury on whether the evidence meets general acceptance standards, and (2) the basis for the admission or exclusion of the evidence should be put into the record by findings of fact.

In Starr v. Campos, an action for wrongful death, the Arizona Court of Appeals held that a computerized analysis of the automobile accident must achieve general acceptance of the relevant scientific community before it is admissible. Like Schaeffer, the Starr court required the trial court to follow a set procedure if the simulation were to be offered in a second trial: (1) determine, outside the presence of the jury, whether the procedure used to ob-

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148 Id. at 177, 360 N.E.2d 1062, 1067 (1977). A reading of the decision leaves one in doubt whether the simulation was a mathematical model or visual presentation. The author interviewed the expert whose testimony was admitted at the trial and was advised that the "computer simulation of the accident" mentioned in the court's opinion was merely testimony based on computer test results.


150 Id. at 178; 360 N.E.2d at 1067.


152 Id. at 796. The opinion referred several times to "data." Trial counsel advised the author that the computer simulation involved was a mathematical simulation rather than visual.

153 Id. at 257, 655 P.2d at 797.
tain the evidence is generally accepted among scientists in relevant fields, including accident reconstruction and automotive engineering; and (2) determine whether those of sufficient training and experience to judge are in general agreement that the program properly applies the principle in question (and any others it may involve) to automobile collisions. Thus, neither court excluded the computer simulation, but both required a Frye hearing prior to any introduction sought in retrial.

While Arizona had adopted the Federal Rules of Evidence at the time of the Starr decision, Massachusetts has yet to adopt these Rules. Other states have held that state rules of evidence patterned after the Federal Rules displace Frye. By contrast, in New York, which follows the Frye rule, the court found in People v. McHugh that it was unnecessary to conduct a Frye pretrial hearing. The court allowed the evidence to be introduced upon proper foundation for the tape and qualification of the expert.

Although both the Starr and the Schaeffer courts held that computer simulations may be admissible upon proper foundation, the different bases of these decisions demonstrate Frye’s greatest weakness — the vagueness of its standard of “general acceptance.” Case law is not clear as to whether both the underlying principle and the technique used in applying the principle must be “gener-

154 Id. 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. Id.
155 Id. at 257, 655 P.2d at 797-98 (1982).
156 Ariz. R. Evid. 702.
160 Id. at 560, 476 N.Y.S.2d at 722.
161 Note, IND. L. REV. supra note 5, at 747.
ally accepted” or only an application of one or the other. One need not look past Schaeffer and Starr to see the reason for this criticism.

In Schaeffer, the court was concerned with the “general acceptance” of the underlying theory of computer simulation — whether the simulated result can be “accurate and complete.” In comparison, the court in Starr was not concerned with the underlying theory of computer programs; in fact, the court suggested that the trial judge take judicial notice of the “underlying principle of the method.” Rather, the concern of the court in Starr was with the technique of the simulation model and 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.” Thus, both cases exemplify a judge’s application of an amorphous general acceptance standard.

The Frye standard is an expression of the reluctance of judges to make either an independent appraisal of the validity of scientific proof or to accept the individual word of expert witnesses in criminal trials. As demonstrated by the lack of cases on point, this reluctance is not as prevalent in civil cases and has not occurred in reported aviation cases.

Further vitality of the Frye standard has been called into question as a result of the codification of the Federal Rules of Evidence. In response to the growth of complex litigation, technology, and science, Congress recognized the need for expert witnesses and adopted in 1975 the Federal Rules of Evidence for federal courts. Federal Rules of Evidence 702 through 705 were enacted in order

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163 372 Mass. at 177, 360 N.E.2d at 1067.
164 134 Ariz. at 257, 655 P.2d at 797.
165 Id. at 258, 655 P.2d at 798.
to expand the admissibility of expert testimony and assist attorneys in their needs for technical proof in modern trials. At the present time, thirty-three states, Puerto Rico, and the United States Armed Forces have rules similar to the Federal Rules of Evidence. The result is modernization and near uniformity of the law of evidence among these jurisdictions.

The Rules, Advisory Notes, and legislative history are silent on whether Frye survived the codification. The issue is whether Frye's restrictive general acceptance test is still viable after the enactment of the Federal Rules of Evidence and its state counterparts. Commentators and courts are in dispute over this issue, and the current status of the Frye test is extremely difficult to assess. Commentators have called for the death of the Frye test, but some judicial support for it remains in varying degrees.

167 While the Federal Rules of Evidence apply only to federal proceedings, they may be influential in state proceedings. Alaska, Arizona, Arkansas, Colorado, Delaware, Florida, Hawaii, Idaho, Iowa, Louisiana, Maine, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Puerto Rico, Rhode Island, South Dakota, Texas, Utah, Vermont, Washington, West Virginia, Wisconsin, Wyoming, and the U.S. Armed Forces have adopted a body of rules patterned after the Federal Rules of Evidence. The reader is cautioned, however, that these jurisdictions have made a few modifications to the Federal Rules. The District of Columbia, Illinois, New Jersey, New York, Massachusetts, Pennsylvania, and Virginia have not adopted a comprehensive set of evidentiary rules patterned on the Federal Rules, but have adopted selected rules either judicially or legislatively. In addition, several courts in these jurisdictions have adopted the theories underlying selected Federal Rules. Despite setbacks, the trend toward adoption of rules of evidence patterned after the Federal Rules is becoming widespread, as happened with the adoption of the Federal Rules of Procedure in 1937.

168 Application of these rules as enacted in jurisdictions requiring a Frye standard eventually may supplant a Frye analysis. For an exhaustive analysis of the viability of Frye, see Giannelli, supra note 138; McCormick, Scientific Evidence: Defining A New Approach to Admissibility, 67 IOWA L. REV. 879 (1982); see also Mustafa v. United States, 479 U.S. 953 (1986) (White, J. dissenting, opposing a denial of certiorari on the grounds that the petition presented the opportunity for the Court to resolve the question of whether the Frye test was superseded by the enactment of the Federal Rules of Evidence).

This support, however, seems to be found solely in criminal cases and civil cases in which the admission of forensic evidence is sought.¹⁷⁰

Whatever vitality still exists in the applicability of Frye to an analysis of computer-generated evidence,¹⁷¹ this standard should not apply to computer simulations or reconstructions used in aviation litigation. A Frye analysis should be considered only if admissibility is sought in a state court that has no rules analogous to the Federal Rules of Evidence, the simulation cannot be admitted or utilized in connection with expert testimony, or admissibility of the evidence is sought to ensure that it will go into the jury room.¹⁷²

¹⁷⁰ See, e.g., Kluck v. Borland, 162 Mich. App. 695, 413 N.W.2d 90 (Mich. Ct. App. 1987) (trial court ruling in personal injury action that thermography was sufficiently accepted by experts was an abuse of discretion in light of experts' professional and financial interests in advancing thermography since they were neither disinterested nor impartial); see also Robertson v. McCloskey, 680 F. Supp. 408 (D.D.C. 1988) (in defamation suit, expert qualified in psychodynamics of memory and perception could not testify because the science failed to meet the Frye test as generally accepted in the scientific community); Neises v. Solomon State Bank, 236 Kan. 767, 696 P.2d 372 (1985) (insurer asserted defense of arson in mortgagors' action to collect on policy; court improperly admitted results of psychological stress evaluation (PSE) tests, since no evidence was presented to show that the tests had any standing in the scientific community); Haines v. Shanholtz, 57 Md. App. 92, 468 A.2d 1365 (1985) (in paternity action, results from genetic testing should be admitted as meeting Frye test on reliability and acceptance in scientific community; Maryland legislature had also recognized such validity, thereby removing burden from courts); Bureau of National Affairs, BNA Civil Trial Manual, Trial Practice Series § 91.851. An exhaustive survey of the status of Frye in state and federal courts is outside the scope of this article. For a compilation of state courts following Frye, see Giannelli, supra note 138; McCormick, supra note 168, and other authorities cited herein. For a comprehensive survey of the status of Frye in federal courts, see Comment, The Admissibility of Evidence and Expert Testimony Based on Science, Technology or Other Specialized Knowledge — Is the "Frye" Standard Consistent with the Federal Rules of Evidence? 4 COOLEY L. REV. 641 (1987); Note, supra note 146 at 787.

¹⁷¹ No case actually requires exclusion under Frye; a hearing merely is required to determine if the proposed simulation meets the Frye requirements. Note, IND. L. REV., supra note 5, at 748.

¹⁷² One key advantage to the formal admissibility of demonstrative evidence is the likelihood that the evidence will be probative and accepted for most contemplated uses. Demonstrative evidence, on the other hand, may not be acceptable for all or most purposes. For example, there is no automatic right for demonstrative evidence to be allowed into the jury room. A. LIPSON, supra note 4, § 2.07[2]
D. Computer Simulation Admissible Under Demonstrative Evidence Theory

Although computer-generated visual simulation is a relatively new technique, it is nothing more than another type of demonstrative evidence.\(^{173}\) Demonstrative evidence has been defined as "that evidence addressed directly to the senses without intervention of testimony."\(^{174}\) It is evidence consisting of tangible objects that convey a relevant firsthand sense impression to the trier of fact in order to illustrate and clarify.\(^{175}\) The theory justifying admission of this type of exhibit "requires only that the item be sufficiently explanatory or illustrative of relevant testimony in the case to be of potential help to the trier of fact."\(^{176}\)

The law of demonstrative evidence has not only been plagued by confusion over the definition of evidentiary terms,\(^{177}\) but, additionally, courts rarely have addressed differences in the manner in which a particular item of demonstrative evidence is to be utilized. Rarely is a distinction drawn between demonstrative evidence formally admitted as substantive evidence and that used only for demonstrative purposes.\(^{178}\)

The trial court judge exercises a great degree of discretion in deciding whether or not to admit demonstrative evidence.\(^{179}\) This nearly unfettered discretion is due to the fact that demonstrative evidence is admitted solely to

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\(^{173}\) M. Dombroff, supra note 32, ch.9, at 185.


\(^{175}\) Schertzinger v. Williams, 198 Cal. App. 2d 242, 17 Cal. Rptr. 719, 721 (1961); see McCormick on Evidence, supra note 39, § 212.


\(^{177}\) See A. Lipson, supra note 4, § 2.06[1].

\(^{178}\) Id.

\(^{179}\) Carson v. Polley, 689 F.2d 562 (5th Cir. 1982); Ballou v. Henri Studios, Inc. 656 F.2d 1147 (5th Cir. 1981); A. Lipson, supra note 4, § 2.06[2][a]; McCormick on Evidence, supra note 3, § 212; 2 S. Gard, supra note 126, § 15.2, at 5.
help the witness explain his or her testimony and has no probative force beyond that lent to it by the credibility of the witness whose testimony it is used to explain.\(^\text{180}\) Even if admissibility of a visual reconstruction is not achieved, the use of such evidence in connection with expert testimony is essential in complex litigation.

If testimony is being presented in an aviation case regarding the performance of an aircraft, an expert could be allowed to present an academic explanation of aerodynamics, including a description of both the actual performance characteristics and the flight path of the aircraft. Before the testimony turns to pitch, angle of attack, and indicated airspeed, however, the judge or jury may be confused. If the information, however, is computerized and a computer model "flies" the subject flight path in accordance with the physical evidence or theories of the expert, the finder of fact has a visual presentation that illustrates the highly technical and probably incomprehensible testimony of an aerodynamicist. The computer simulation is merely a dynamic graphic presentation of the underlying data and the opinions of the expert.

While there are no reported decisions pertaining to the admissibility of a computer-generated visual simulation in aircrash litigation,\(^\text{181}\) admissibility of a visual simulation under the demonstrative evidence theory was utilized by a New York court in *People v. McHugh.*\(^\text{182}\) In *McHugh,* the defendant, charged with second-degree manslaughter and driving while intoxicated, sought to introduce a computer reenactment of the fatal car crash to demonstrate that the accident was a result of weather and not intoxication. In determining the admissibility of the computer reenactment, the New York Supreme Court stated:

The evidence sought to be introduced here is more akin to

\(^{180}\) *Carson,* 689 F.2d at 579.

\(^{181}\) Although visual simulations have been utilized in recent air carrier litigation, see *supra* note 51, there are no reported decisions on bases for admissibility.

a chart or diagram than a scientific device. Whether a diagram is hand drawn or mechanically drawn by means of a computer is of no importance.

While this appears to be the first time such a graphic computer presentation has been offered at a criminal trial, every new development is eligible for a first day in court.

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.\^183

In *McHugh*, the district attorney had moved for a hearing under *Frye v. United States*\^184 prior to the trial to determine "whether the computer program, formulas, techniques, and processes of the model were generally accepted as accurate and reliable by the scientific community."\^185 The court found no extended pretrial hearing was required and the computer reenactment could be presented at trial upon laying the proper foundation and qualification of the expert who prepared the underlying data.\^186 The court further stated that the district attorney would be allowed to conduct a voir dire examination after the video tape was offered as evidence.\^187

Although demonstrative evidence is not treated specifically in the Federal Rules of Evidence, it has been considered in connection with Rule 702 and the admissibility of expert testimony. Under Rule 702, if the witness qualifies as an expert, then his testimony is admissible in the form of an opinion or otherwise as long as it assists the trier of

\^183 124 Misc. 2d at 560, 476 N.Y.S.2d at 722-23.
\^184 293 F. 1013 (D.C. Cir. 1923). For a discussion of the case, see *supra* notes 141-146 and accompanying text.
\^185 *McHugh*, 124 Misc. 2d at 559, 476 N.Y.S.2d at 721.
\^186 *Id.* at 559, 476 N.Y.S.2d at 722.
\^187 *Id.*
fact.\textsuperscript{188}

In sum, computer-generated visual simulations are admissible as demonstrative evidence. Given the highly complex and technological nature of aviation litigation, however, the accident reconstruction will be presented through expert testimony. Questions pertaining to the qualifications or opinions of the expert and accuracy of the visual presentation (including the accuracy of calculations or underlying data) will go to weight of the evidence rather than its admissibility.

IV. LAYING THE FOUNDATION

A. In General

Computer-generated evidence, whether it is in documentary or visual form, accomplishes nothing in substance that attorneys have not done in the past through documentary, real, demonstrative, or testimonial evidence. Yet computers do provide a new mechanism for presentation of the same kind of evidence, although on a grander and more dramatic scale. The absence of reported case law means no firm evidentiary rules can be given for the foundation necessary to insure admissibility of computer-generated visual materials.\textsuperscript{189} In discussing admissibility of computer-generated documentary materials, courts and commentators cite traditional evidentiary principles.\textsuperscript{190}

As noted by Professor McCormick, foundational requirements are based on logic rather than rules of art.\textsuperscript{191} Case law has not established that courts have adopted any standard analysis, and each case appears to be decided on

\textsuperscript{188} For a discussion of the relevant Federal Rules of Evidence, see supra notes 119-122 and accompanying text.

\textsuperscript{189} A. Lipson, supra note 4, § 16.05[5][a]; Comment, supra note 3, at 144.

\textsuperscript{190} A. Lipson, supra note 4, §§ 16.05[4], [5]; M. Domroff, supra note 32, § 9.11, at 200; G. Joseph, supra note 2, § 7.03; Johnston, supra note 95, at 667; Comment, supra note 3, at 115.

\textsuperscript{191} McCormick On Evidence, supra note 39, § 212, at 668 (3d ed. 1984).
an ad hoc basis. Courts initially viewed computer evidence with some skepticism, and even with a thorough foundation, admissibility was not assured. While early cases considering the admissibility of computer-generated documentary evidence required a more detailed foundation to be laid, these early requirements are overly detailed in light of modern computer technology, and the courts, commentators, and the Federal Rules of Evidence have recognized this fact. People rely on computers every day. This reliance has established a relative degree of trustworthiness regarding the ability of a computer to perform a requested function. Commentators agree it is appropriate for a court to take judicial notice that a computer process or system is accurate. A ruling favoring the admissibility of computer-generated visual evidence is likely today given the current judicial environment. Given the accuracy, speed, reliability and consistency of computer technology, there is a definite trend toward admissibility of computer-generated visual evidence.

Generally, courts express concerns regarding the authenticity and reliability of computer-generated data used as a substitute for traditional documentary, real, or testimonial evidence. Authority for admissibility of computer-generated evidence varies only with the imagination of

192 A. Lipson, supra note 4, § 16.05[1].
193 A study conducted by the American Bar Association of 150 trials that utilized some form of computer evidence (113 used computer-stored data; 33 used computer-generated data; and 4 used a combination of both types) revealed that objections to the computer-stored data were sustained 25 percent of the time and objections to the computer-generated data were sustained 40 percent of the time. ABA TORT INS. PRAC. SEC. The Brief (1982).
194 See Comment, supra note 3, at 144-46 and cases discussed therein.
195 Id. at 146.
196 See, e.g., Starr v. Compos, 134 Ariz. 254, 257, 655 P.2d 794, 797-98 (1982); Schaeffer v. General Motors, 372 Mass. 171, 177-178, 360 N.E.2d, 1062, 1067 (1977); Advisory Committee Notes to Fed. R. Evid. 901(b)(9); 3 Bender, supra note 95, § 5.04; Comment, supra note 3, at 149-50; Note, 9 COMPUTER L.J., supra note 5, at 109; Note, supra note 3, at 80 (“It is unnecessary for a party offering computer printouts into evidence to prove the machine's accuracy.” Id.).
197 For a discussion of the admissibility of computer-generated evidence under various theories, see supra notes 51-188 and accompanying text.
the attorney seeking admissibility. In addressing the judicial concern of reliability, however, a critical distinction between reliability and accuracy must be noted. To overcome objections, the underlying data, whether in documentary or visual form, must be proved reliable. While the information fed into the computer may be calculated accurately because of the scientific reliability of today's computers, this does not mean that conclusions presented by the data are accurate. The accuracy of conclusions drawn from processing the data goes to the weight of the evidence and will be proved or disproved by its foundation or by the opponent's cross-examination. Whether or not evidence presented is accurate is a question for the trier of fact.

Basic standards that apply to the admissibility of all evidence include relevance, materiality, and competency. Relevant evidence means that which tends to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without such evidence. Material evidence relates to an issue which is in some manner determinative to the outcome of the litigation. For evidence to be competent, it must not run afoul of any principles that might exclude it for statutory or policy reasons.

The foundation for admissibility of computer-generated graphics will depend on the type of underlying data that is involved in the visual depiction and the use for which it is intended. If the computer information was generated by a public agency or in the normal course of business, the underlying data itself will be admitted. If

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198 Comment, supra note 3, at 118.
199 Id. at 154.
200 A. Lipson, supra note 4, § 2.06[2][b].
201 Id.
202 Id.
203 For a fairly comprehensive list of foundation elements distilled from various cases see Annotation, Admissibility of Computerized Private Business Records, 7 A.L.R. 4th 8, 15 (1980); for checklists see infra note 242.
204 For a discussion of the admissibility of records, see supra notes 72, 76, 78, 81, 95, and accompanying text.
the computerized information was retrieved for litigation, it also will be admissible if a proper foundation is laid.\textsuperscript{205}

If the computer data are created specifically for litigation purposes, conclusions drawn therefrom must withstand closer judicial scrutiny. Depending on the type of data, the underlying information may be admissible in evidence. The data may be in documentary or visual form and can be presented as either demonstrative evidence or evidence in connection with the testimony of an expert.\textsuperscript{206}

The evidence contained in a computer is obviously useless without some type of record of its output, such as a printout,\textsuperscript{207} which is received in evidence as a matter of course.\textsuperscript{208} A meticulous foundation is needed to make the evidence more persuasive and to deal with anticipated objections to admissibility and weight.\textsuperscript{209} The foundational requirement for computer-generated evidence presents a dilemma to the trial lawyer: if too little foundation testimony is presented, the trial court may find the information unreliable; if too much information is presented, the trial court may be persuaded of its unreliability.\textsuperscript{210} One commentator has noted that the proponent of computer-generated evidence walks a narrow line between keeping authentication simple and quick and not providing so many details that suspicions are unduly aroused as to the reliability of the computer-generated data.\textsuperscript{211}

The foundation generally must include a showing of authenticity,\textsuperscript{212} which is a special aspect of the requirement

\textsuperscript{203} For a list of cases where computer-generated evidence was created for litigation purposes, see supra note 106.

\textsuperscript{204} For a discussion of admission of computer-generated evidence in connection with expert testimony, see supra notes 116, 188, and accompanying text.

\textsuperscript{205} King v. State of Mississippi ex rel. Murdock Acceptance Corp., 222 So. 2d 393 (Miss. 1969).

\textsuperscript{206} United States v. Foster, 580 F.2d 388, 390 (10th Cir. 1978). For a discussion of various theories under which computer-generated evidence may be admitted, see supra notes 51-188 and accompanying text.

\textsuperscript{207} Tapper, supra note 3, at 595, n.193.

\textsuperscript{208} A. Lipson, supra note 4, § 16.05[3][b].

\textsuperscript{209} Fed. R. Evid. 901.
of relevancy; relevancy; materiality; and competency. The foundation to be established depends on whether the underlying computer data are public records, have been generated in the regular course of business and are substitutes for business records, or were created and generated specifically for litigation. If the underlying data are public records or were created by a computer for use in the regular course of business, there is no unique foundation that must be shown merely because the traditional business record is computerized.

If the underlying computer data have been created specifically for use in litigation, the evidence is not inadmissible; rather, the proponent must establish a different foundation. The foundation required also will depend on the use for which the proponent is seeking admission of the evidence. If the proponent is seeking admissibility as substantive evidence, he must demonstrate that the evidence is not only authentic, relevant, and material, but also that it is not subject to an exclusionary rule. If the use is merely as demonstrative evidence or in connection with the testimony of an expert witness, the foundational requirements are less stringent. Once the foundation showing authenticity, reliability, and trustworthiness of the computer-generated visual evidence has been established, admissibility should be virtually guaranteed.

B. Authentication of Computer-Generated Evidence

Virtually every piece of evidence must be identified and authenticated before being admitted. Even self-authenti-
cating documents must be accompanied by some type of identification and foundation before use at trial.\textsuperscript{218}

Because of the rapidly accelerating technology in the field of computer-generated graphics, it is difficult for litigants to determine with any degree of certainty what a judge may require, whether governed by Federal Rules of Evidence or state rules of evidence. The key factor in authentication of computer-generated evidence, whether computer-stored data or evidence generated solely for purposes of trial, is the minimum requirement of Federal Rule of Evidence 901(a) that "the matter in question is what its proponent claims."\textsuperscript{219} This language establishes a variable standard of reliability depending on what the proponent of the computer-generated evidence claims the evidence is.\textsuperscript{220} There is a specific provision for computer evidence in Federal Rule of Evidence 901(b)(9) designed for a situation where the accuracy of a particular result depends on the accuracy of the process or system producing it.\textsuperscript{221} The Advisory Committee Notes refer to the recent development of the computer and state that the Rule does not foreclose taking judicial notice of the accuracy of the process or system.\textsuperscript{222}

If either the FAA or National Transportation Safety Board (NTSB) has produced the underlying data for use in an accident reconstruction,\textsuperscript{223} this type of data is accorded public record status under Federal Rule of Evidence 902 and is admissible without further identification

\begin{itemize}
\item \textsuperscript{218} A. Lipson, \textit{supra} note 4, § 2.06[2][c].
\item \textsuperscript{219} \textit{Fed. R. Evid.} 901(a). Rule 901(a) provides as follows: "The requirement of authentication or identification as a condition precedent to admissibility is satisfied by evidence sufficient to support a finding that the matter in question is what its proponent claims." \textit{Fed. R. Evid.} 901(a).
\item \textsuperscript{220} See, \textit{e.g.}, Comment, \textit{supra} note 2, at 960.
\item \textsuperscript{221} \textit{Fed. R. Evid.} 901(b)(9) Advisory Committee Notes.
\item \textsuperscript{222} \textit{Id.} Judicial notice of the ability of a computer to perform functions accurately is appropriate. See Schaeffer, 372 Mass. at 177, 360 N.E. at 1067; \textit{Fed. R. Evid.} 201; J. Weinstein & M. Berger, \textit{supra} note 115, ¶ 901(b)(9)(02), at 901-112.
\item \textsuperscript{223} For a discussion of information produced by the FAA and NTSB, see \textit{supra} notes 21-23, 29 and accompanying text.
\end{itemize}
or authentication.\textsuperscript{224} If underlying data have been generated for use in litigation, the programmer or expert can authenticate the underlying data.\textsuperscript{225} Any objection to authentication submitted on grounds of the Best Evidence Rule\textsuperscript{226} can be met by the production of a computer printout, since a computer printout is considered an original under the Federal Rules of Evidence.\textsuperscript{227}

C. Laying the Foundation

To be admitted, any evidence must be material and relevant to the litigation. The Federal Rules of Evidence define relevant evidence as evidence "having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence."\textsuperscript{228} As noted by the Rules, all relevant evidence is admissible except as provided by statute.\textsuperscript{229} Relevant evidence, however, may be excluded if its probative value is outweighed by dangers of unfair prejudice, confusion, or waste of time.\textsuperscript{230} Obviously, a recreation or simulation will not become relevant until the foundation testimony demonstrates that the proposed computer graphics illustrate crucial characteristics and factors present when the accident occurred\textsuperscript{231} or illustrate alternative theories of the expert proposing the testimony. The proper focus of foundation requirements is reliability of evidence and its

\textsuperscript{224} United States v. Farris, 517 F.2d. 226, 228-29 (7th Cir.), cert. denied, 423 U.S. 892 (1975); Fed. R. Evid. 902(4); 4 D. Louisell & C. Mueller, supra note 73, § 454; Comment, supra note 2, at 955, n.14.

\textsuperscript{225} One commentator has suggested the use of a test program with known results to demonstrate that the process utilized applies generally accepted principles of physics and mathematics. Note, Ind. L. Rev., supra note 5, at 753. See also J. Weinstein & M. Berger, supra note 115, ¶ 1002[2].

\textsuperscript{226} Fed. R. Evid. 1002. See also J. Weinstein & M. Berger, supra note 115, ¶ 1002[2].

\textsuperscript{227} Fed. R. Evid. 1001(3). See also J. Weinstein & M. Berger, supra note 115, ¶ 1001(3)[4].

\textsuperscript{228} Fed. R. Evid. 401.

\textsuperscript{229} Fed. R. Evid. 402.

\textsuperscript{230} Fed. R. Evid. 403.

\textsuperscript{231} Note, Computer L.J., supra note 5, at 116.
tendency, if any, to mislead. This is regardless of whether the evidence is real, scientific, in connection with an expert's testimony, or demonstrative.

Proof of the reliability and trustworthiness of an underlying data compilation that qualifies as a public record is easily accomplished. The public records exception often requires no foundation witness, since the self-authentication provisions in Rule 902 render live testimony unnecessary to prove that a document which purports to be such a record is in fact what it appears to be. Furthermore, courts seldom invoke the trustworthiness clause to exclude records which satisfy the requirements of Rule 803(8). Once the underlying data compilation is qualified as a public record, the burden shifts to the opponent to show the record in question is untrustworthy.

There is no unique foundation requirement for the admission of a computerized business record under the hearsay exception in Rule 803(6). The record should be treated as any other business record. General foundational requirements for a traditional business record usually are established through the testimony of a custodian

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232 G. Joseph, supra note 2, § 7.05[4].
233 4 D. Louisell & C. Mueller, supra note 73, § 454; G. Weissenberger, supra note 77, § 804.41. But see Flythe v. United, 405 F.2d 1324 (D.C. Cir. 1968) (refusal of lower court to admit weather observations for Washington National Airport was upheld because no witness was offered to explain what the document was).
234 When a record qualifies for admission under clause (A), whether trustworthiness must be shown is a disputed matter. It has been noted that there is no such requirement for a showing of trustworthiness under this clause. Brown v. ASD Computing Center, 519 F. Supp. 1096, 1103 n.2 (S.D. Ohio 1981), aff'd sub nom. Brown v. Mark, 709 F.2d 1499 (6th Cir. 1983). It has been suggested by commentators, however, that a restrictive reading is not warranted and there is no reason to assume records offered under clauses (A) and (B) are per se trustworthy. 4 D. Louisell & C. Mueller, supra note 73, § 456, at 764-67.
235 In order to establish such a showing, see 4 D. Louisell & C. Mueller, supra note 73, § 456.
236 United States v. Vela, 673 F.2d 86, 90 (5th Cir.) (prosecution laid the proper predicate for admission of computerized copies of telephone bills), reh'g denied en banc, 677 F.2d 113 (5th Cir. 1982); McCormick on Evidence, supra note 39, § 314.
of the record or other qualified witness\textsuperscript{237} who can attest that the electronic computing equipment used is recognized as standard equipment and that the entries were made in the regular course of business at or near the time of the event recorded. If the foundation testimony satisfies the court that the sources of information, method, and time of preparation indicate the data compilation is trustworthy, its admission is justified.\textsuperscript{238} Under the Federal Rules, a showing should be made that the data compilation was made at or near the time of the event from information transmitted by a person with knowledge; that it was kept in the course of regularly-conducted business activity; and that it was the regular practice to make the data compilation.\textsuperscript{239} This requirement may be met by the testimony of the custodian or other qualified witness and will be admissible unless the source of information or method of preparation indicates a lack of trustworthiness.\textsuperscript{240}

Factors to be considered in laying a foundation for computer-generated materials created specifically for use in litigation include the following: providing the opponent an opportunity to examine the program, including the proposed input data;\textsuperscript{241} showing the equipment is reliable (especially through brand names); and showing the software used is either widely accepted (a standard program) or demonstrating the program produced reliable results. This latter showing may consist of testimony from the individual(s) who prepared the program, their qualifications, an explanation of what the program is designed to perform, including any changes made in the


\textsuperscript{238} King v. State of Mississippi \textit{ex rel} Murdock Acceptance Corp., 222 So. 2d 393 (Miss. 1969). For a discussion of foundational requirements, see also United States v. Hutson, 821 F.2d 1015, 1020 (5th Cir. 1987), and United States v. Gasser, 773 F.2d 1553, 1558-59 (11th Cir. 1985).

\textsuperscript{239} \textit{Fed. R. Evid.} 803(6); \textit{Note, Computer L.J.}, \textit{supra} note 5, at 108.

\textsuperscript{240} \textit{Fed. R. Evid.} 803(6).

\textsuperscript{241} For a discussion of pretrial discovery of computer-generated evidence, see \textit{infra} notes 265-266 and accompanying text.
program, and measures taken in order to ensure accurate output.\textsuperscript{242} The foundation for a computer model designed for litigation should include more than just an explanation of variables used. Besides identifying the variables, the relationship between the variables should be described, including the weight given to any specific variable since this will affect the outcome of the simulation.\textsuperscript{243}

The foundation necessary to establish the accuracy of both the computer process and its resulting output generally requires proof of the same matters discussed in connection with the authentication of computer-generated evidence: reliability of the input, processing, and output stages of the process. Because computer-generated evidence is offered through the testimony of a trial expert, underlying data need not be admissible. If the evidence is to be used as demonstrative or illustrative of the opinions of an expert, a proper foundation by the party offering the evidence must be made.\textsuperscript{244} Determination of adequacy of the foundation is within the discretion of the trial judge.\textsuperscript{245}

A sufficient foundation usually includes qualifying the expert by establishing his qualifications and experience with simulation programs, showing the relevancy of the simulation to the case, and eliciting information about the accuracy of the results either from personal knowledge or by testimony that the process produces an accurate

\textsuperscript{242} For "how to" checklists see generally M. Dombroff, Dombroff on Demonstrative Evidence, supra note 32, § 9.12 (1983); Connery & Levy, Computer Evidence in Federal Courts, 34 Computer L.J. 266, 273-74 (1979); A. Lipson, supra note 4, § 16.05[3], [4], [5]. These checklists include not only the authentication of computer-generated evidence, but general guidelines for laying a foundation for its admissibility. Checklists for the cross-examination of computer-generated materials are found in A. Lipson, supra note 4, § 16.06; M. Dombroff, supra, § 9.14.

\textsuperscript{243} Note, Computer L.J., supra note 5, at 118.

\textsuperscript{244} See generally McCormick on Evidence, supra note 39, § 212 (3d ed. 1984); M. Dombroff, supra note 32, ch. 9.

result.246

D. Objections to Computer-Generated Evidence, Whether in Data or Visual Format

Once evidence is authenticated and is established as relevant, it must not be subject to an exclusionary rule if its admissibility is sought.247 While there are various types of objections to be anticipated,248 depending on the graphic presentation and underlying data, the following criteria generally must be met for all proposed computer-generated visual evidence.

1. Relevancy

Under Rule 401,249 relevant evidence is that which has any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence. Furthermore, all relevant evidence is admissible, except as otherwise provided by statute or federal rules.250 It is difficult to imagine that a computer-generated reconstruction of an airplane accident would not be relevant to a determination of the issues in aviation litigation. Relevancy objections having some merit conceivably could be raised against a computer simulation in which alternate theories of the accident have been developed by the computer. Given the scope of expert testimony allowable within the discretion of the trial judge and the commonly raised question in aviation litigation of what would have occurred if someone had acted differently, it is difficult to conceive that testimony based on alternate scenarios would be precluded by a relevancy objection.

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246 See, e.g., Note, COMPUTER L.J., supra note 5, at 110-11, 118.
247 Id. These guidelines are not applicable if the evidence is to be used merely as demonstrative evidence or as data upon which an expert has based his opinions. Id.
248 See generally Johnston, supra note 95 (discussing computer-based evidence).
249 FED. R. EVID. 401.
250 FED. R. EVID. 402.
2. **Reliability**

A critical hurdle that counsel must overcome in establishing a proper foundation for computer-generated evidence is the reliability of the proposed evidence. As noted, there are no judicial guidelines for establishing the reliability of computer-generated evidence created and retrieved especially for litigation.\(^{251}\) The degree of reliability that must be established will depend upon the type of evidence that is proffered. If the evidence is a public record or information stored by a computer in the regular course of business, it has a high degree of reliability and the proponent should have no difficulty meeting this standard.\(^{252}\) The standard of reliability that must be met by a computer simulation or reconstruction obviously must be lower, as the evidence does not purport to be as reliable as computer-stored data. A simulation obviously cannot duplicate with exactitude the subject matter which it purports to display, whether it concerns reconstruction of weather development, aircraft performance, or aircraft targets displayed on a radar scope. The nature of this evidence, therefore, precludes a showing of absolute accuracy. Upon a showing of the present state of the art in modeling technique and that the proposed evidence is consistent with that technique,\(^{253}\) an objection based on lack of reliability should not be sustained. Reliability is usually considered an issue to be resolved by the trier of fact.\(^{254}\)

3. **Hearsay**

Most of the computer-stored data available for aviation

\(^{251}\) For a list of cases discussing the admissibility of computer-generated evidence, see *supra* note 106. General guidelines are found in *Fed. R. Evid.* 901(b)(9) and the Advisory Committee Notes.

\(^{252}\) For a discussion of the trustworthiness of public records and records kept in the normal course of business, see *supra* notes 74, 100, and accompanying text; see also Comment, *supra* note 2, at 958.

\(^{253}\) Comment, *supra* note 2, at 958.

\(^{254}\) A. Lipson, *supra* note 4, § 2.09[4].
accident reconstruction are admissible. Data originally conceived as public records or for a business purpose and stored by the computer in furtherance of a public function or business purpose, but merely retrieved for litigation purposes, similarly should have the status as public or business records. Data of an historical or record-keeping nature maintained by owners, operators, and manufacturers may be admissible as admissions. Viability of this hearsay exception, therefore, is extremely limited upon a proper foundation.

4. Best Evidence Rule

The Best Evidence Rule requires a party seeking admissibility of a document to offer the original. The printout from a computer is considered an original. This objection also is easily overcome.

5. Rule 403: Unfair Prejudice, Confusion, Cumulative Evidence

Under Rule 403, evidence that is relevant may be excluded if "[i]ts probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence." In addition to demonstrating reliability, it is critical for the proponent of computer-generated visual evidence to ensure that the proposed evidence does not run afoul of Rule 403. While Rule 403 does not specifically enumerate

\[255\] For a discussion of the admissibility of computer-generated evidence under various theories, see supra notes 51-188 and accompanying text.\[256\] Comment, supra note 2, at 965. For a discussion of the admissibility of computer data retrieved specifically for litigation, see supra notes 76, 81, 101-106, and accompanying text.\[257\] For a discussion of admissibility by admission, see supra notes 109-111 and accompanying text.\[258\] See G. WEISSENBERGER, supra note 77, § 1001.1 and authorities therein.\[259\] FED. R. EVID. 1001(3); see also G. JOSEPH, supra note 2, § 7.04.\[260\] FED. R. EVID. 403.
surprise as a ground for exclusion,\footnote{See Fed. R. Evid. 403 Advisory Committee Note. The note points out that surprise is specifically omitted from the Rule, following Wigmore's view of the common law (citing 6 Wigmore, § 1849 (1985)). The Advisory Committee further notes that Professor McCormick lists unfair surprise as a ground for exclusion but suggests that exclusion is usually "coupled with the danger of prejudice and confusion of issues." Fed. R. Evid. 403 Advisory Committee Notes (citing McCormick On Evidence, supra note 39, § 152).} most courts and commentators agree that advance notice of an intent to use computer-generated evidence should be given,\footnote{See Shu-Tao Lin v. McDonnell Douglas Corp., 742 F.2d 45, 48 (2d Cir. 1984) (noting that the District Court had determined that defendant had been prejudiced by admission of evidence regarding future earnings of decedent because the computer methodology and data were not adequately disclosed during pretrial discovery); United States v. Russo, 480 F.2d 1228, 1241 (6th Cir. 1973) (quoting from The Manual for Complex and Multidistrict Litigation, the court found "[i]t is essential that the underlying data used in the analysis, programs and programming methods . . . be made available to the opposing party far in advance of trial."), cert. denied, 414 U.S. 1157 (1974); United States v. Dioguardi, 428 F.2d 1033, 1038 (2d Cir.) ("We fully agree that the defendants were entitled to know what operations the computer had been instructed to perform and to have the precise instruction that it had been given."); cert. denied, 400 U.S. 825 (1970); Douglass v. Delta Air Lines, Inc. 709 F. Supp. 745, 759 (W.D. Tex. 1989) (in action involving only the issue of damages, computer-generated animation of DL 191 accident disallowed as designation of expert and exhibit had not been timely); Baugh v. Gulf Air Transport, Inc. 526 So. 2d 1239, 1240-41 (La. Ct. App. 1988) (computer-generated display not allowed because of surprise to defendant); Tozer v. LTV Corp., 18 Av. Cas (CCH) 18,212, 18,214-15 (D. Md. 1984) (defendant's computer model excluded from evidence because it was made available to plaintiff too close to trial); City of Cleveland v. Cleveland Elec. Illuminating Co., 538 F. Supp. 1257, 1266 (N.D. Ohio 1980) (noting that authorities "have consistently recognized the discoverability of underlying data as well as plans and programming methods . . ."); Pearl Brewing Co. v. Jos. Schlitz Brewing Co., 415 F. Supp. 1122, 1139-40 (S.D. Tex. 1976) (court permitted depositions of nontestifying experts knowledgeable about the computer program used to produce plaintiff's computer model because the expert offering the model did not know what the coded symbols of the program meant; the depositions were ordered under the "exceptional circumstances" provision of Fed. R. Civ. Proc. 26(b)(4)(B)); A. Lipson, supra note 4, § 16.04[1]; Manual for Complex Litigation § 21.446 (2d ed. 1982); G. Joseph, supra note 2, § 7.06[2]; Jenkins, Computer-Generated Evidence Specialy Prepared for Use at Trial, 52 Chi.[.-]Kent L. Rev. 600, 608 (1976) ("the attorney should disclose to opposing counsel and the court at the earliest possible point in litigation an intention to use computer generated data."); Note, Disclosure of Expert Computer Simulations, 8 Computer L. J. 51, 72 (1987); Comment, supra note 2, at 961. But see Perma Research & Dev. v. Singer Co., 542 F.2d 111, 115 (2d Cir.) (trial judge did not abuse his discretion by allowing expert testimony based on computer simulation for which opposing counsel had not been given the underlying data and computer programs prior to trial and consequently did not have an adequate basis for cross-examination of the expert), cert. denied, 429 U.S. 987 (1976).}
even though Rule 705 does not provide for previous disclosure of the underlying facts or data upon which an expert will be basing his opinions. While the court has broad discretion to determine whether pretrial notice of access to computerized evidence is a prerequisite to a proper foundation, failure to provide such notice may not be prejudice if the program at issue is a simple and standard one. If a computer program has been developed to create evidence for use in litigation, however, it is better practice to disclose both the program and the input data to opposing counsel in order to lay a sufficient foundation and reduce the possibility of a successful Rule 403 objection. Moreover, because most courts require discovery and pre-trial disclosure of computer evidence, disclosure of the program and underlying data used should be made. If confidential information is used in the simulation, a protective order should be secured. Counsel should be aware that demonstrative evidence generally can be considered cumulative because of its very nature as an aid or illustration of other testimony or evidence. When a determination is made that the proposed evidence is cumulative, courts frequently have found that the evidence also would be overly prejudicial. Due to

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263 Fed. R. Evid. 705. "The expert may testify in terms of opinion or inference and give reasons therefor without prior disclosure of the underlying facts or data, unless the court requires otherwise." Id.

264 Id.

265 See Note, Computer L.J., supra note 5, at 120-21.

266 See Manual For Complex Litigation § 21.446 (2d ed. 1982); People v. McHugh, 124 Misc. 2d 559 476 N.Y.S.2d 721, 723 (1984) (to avoid trial delay, defendant's attorney was ordered to turn computer program over to district attorney for his review). But see United States v. Robinson, 783 F.2d 64, 69 (7th Cir. 1986) (failure of government to provide criminal defendant with computer program used to chemically analyze drug substances insufficient to require exclusion of test results); Perma Research & Dev. Co., 542 F.2d at 115 (allowing expert to testify in patent case about results of computer simulation when party failed to produce in advance of trial underlying data and theorems used not an abuse of discretion), cert. denied, 429 U.S. 987 (1976).


268 See, e.g., Johnston v. William C. Ellis & Sons Iron Works, Inc., 604 F.2d 950 (5th Cir. 1979), modified on other grounds, 609 F.2d 820 (5th Cir. 1980). The court found that a motion picture could be excluded if it was considered cumulative and
the complexity of aviation litigation, however, it is unlikely that an objection based on cumulative grounds will succeed.

In sum, counsel must describe the who, what, where, when, and how of the computer simulation process in order to lay a proper foundation and overcome objections that the computer-generated evidence produced is neither accurate nor reliable. Once the foundation has been established for the mathematical modeling process and resulting data, a description of the visual simulation process and data flow through the computer system also should be described. This demonstration will establish the reliability not only of the underlying data, but also of the visual simulation, thus rendering it admissible.

E. Use of Pretrial Hearings to Establish Admissibility

Before trial, counsel should attempt to establish admissibility of computer evidence through stipulation or a pretrial hearing on admissibility. Producing underlying data and making the computer expert available for deposition may well lead to a stipulation of authenticity with questions about accuracy to be answered on either direct or cross-examination.

If counsel cannot obtain a stipulation about the use at trial of a computer-generated simulation, the attorney should seek a pretrial ruling on the admissibility of the evidence. There are provisions in multi-district litigation procedures for obtaining prior admissibility rulings. Utilization of these procedures can result in a savings of both time and money.

potentially prejudicial because only a small portion of it portrayed the particular part of the machine involved in the accident at bar. Id. at 958.

269 See, e.g., FED. R. CIV. P. 16(c)(3). If provision for a pretrial ruling is unavailable, counsel should seek a Frye hearing, supra notes 137-172 and accompanying text, or a motion in limine. See also United States v. Downing, 753 F.2d 1224, 1241 (3d Cir. 1985).

270 MANUAL FOR COMPLEX LITIGATION § 21.642 (2d ed. 1982).
V. INTERACTIVE VIDEO: THE COMPUTER AND THE EVIDENCE - ITS USE IN THE COURTROOM

With the creation of computer-generated visual evidence, a litigator can arrive in court with a formidable arsenal of pictures to explain his client's version of what caused an accident. These pictures, initially created by the computer and transferred to video tape, should be placed on laser video discs\(^2\) for the most effective means of presentation. With the accompanying computer and program to access the information on the laser disc, the expert and attorney can have virtually instantaneous access to produce the visual materials in any sequence. Attorneys and witnesses thus are able to create new exhibits by immediate yet random access to exhibits which previously have been produced to opposing counsel.\(^2\)

In litigation arising out of the crash of Delta Flight 191 at the Dallas/Fort Worth International Airport on August 2, 1985,\(^2\) the United States and its experts produced simulations of approximately the last fifteen minutes of the aircraft's flight. By using the digital flight data recorder information from the aircraft, a computer animation was developed from forty different parameters such as acceleration, roll, pitch, and heading to recreate a descent profile of the aircraft, including a display of information that would have been available to the cockpit crew. Additionally, information from National Weather Service ground radar facilities, weather photographs, and other pilots' statements were analyzed by a weather reconstruction expert to develop an animation of the growth and location of weather cells in the vicinity of the airport; an animation of weather as it would have been depicted on

\(^2\) For a discussion on the use of video discs to present evidence, see supra notes 44-50 and accompanying text.

\(^2\) When this is done, it is important to have a record of what the witness is creating and discussing. During production, have the exhibit numbers superimposed on the materials to facilitate a description for the record of what the expert is describing in his testimony.

the aircraft's weather radar; and a depiction of the weather as it would have been viewed from the cockpit. Many of the scenes were synchronized with the cockpit voice recorder for a dramatic recreation. The pieces were created to run in both actual and accelerated time.

Several expert witnesses utilized these animations while on the witness stand and accessed them immediately through computer software to create a new exhibit illustrating testimony from previously-produced materials. Such a presentation is a highly effective and dramatic yet simple way to present a scenario of the size and location of a weather cell, the relative location of the aircraft, a depiction of what would have appeared on the aircraft's radar scope at that particular moment, and a depiction of the visual appearance of the weather. In the Delta 191 litigation, not only could a viewer see the movement of the aircraft in relation to the storm, but data displayed on cockpit instruments and radar could be accessed in rapid succession to create a feeling of being in the aircraft to see and hear what the crew experienced. By use of interactive video, different perspectives of what occurred at a particular moment were displayed. These depictions then were presented to show a precise chronology of events and explain the accident from the viewpoint of the United States.

Not only can visual documentary evidence be utilized by laser disc technology, but video depositions should be changed to video disc format. Having immediate access to a particular passage of a video deposition to impeach a witness at trial is a highly dramatic and effective technique that has a greater impact on a finder of fact than the reading of testimony. The judge or jury can compare the demeanor and spoken words seen on the video against that seen on the stand.

Another dramatic use of the interactive video system is during opening statement and closing arguments. With the permission of the trial judge or by stipulation of coun-
sel, exhibits may be utilized during opening statement. Real or demonstrative evidence that has been admitted may be used during closing argument. In lengthy and complex aviation cases, the use of key visual exhibits accessed on video discs instantaneously by a computer provides a free-flowing closing argument, avoiding the traditional pauses for exhibits to be pulled and put in front of the jury, or for tapes to be forwarded to a certain digital readout in hopes of locating the desired segment on the first attempt.

VI. CONCLUSION

The computer age has provided litigators a staggering capability to present their case in visual format. The virtually unlimited ability of the computer to process information combined with the communication power of television has transformed complex litigation from the world of chalkboards and posters to state-of-the art technology. The trial lawyer of today is limited only by imagination and budget. Even with the limitation on the latter, however, the capability to recreate for the finder of fact a complex accident scenario is available through interactive video. Computer-generated evidence presented in videotographic format eliminates the difficulty in presenting a smooth and flawless presentation, provides the expert and attorney the capability to create exhibits in the courtroom, and demonstrates a true commitment on the part of a party in presenting its evidence in court. In sum,

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274 1 F. LANE, GOLDSTEIN TRIAL TECHNIQUE § 10.05 (3d ed. 1984). This practice is becoming more common in aviation mass disaster litigation when cases are tried to a jury. Prior admissibility rulings were obtained in the ongoing multidistrict litigation arising out of the crash of Northwest Flight 255 in Detroit, Michigan on August 16, 1987, MDL 742, so that exhibits could be used during opening statement.

275 3 F. LANE, GOLDSTEIN TRIAL TECHNIQUE § 23.35 (3d ed. 1986).

276 In the Delta 191 litigation, counsel for Delta and the United States were given thirty minutes each to sum up the evidence adduced during the preceding fourteen months of evidence. Counsel for the United States utilized certain key exhibits in laser disc presentation to save precious minutes and eliminate completely the pauses that usually accompany the search for and exchange of exhibits.
people believe what they see. This old adage must be amplified to reflect today's computer environment. The story must be told simply, but with all the sophistication of high technology. Computer-generated visual evidence and interactive video are here to stay.