Reconstructing Property and Casualty Events Using Digital Evidence
The Role of a Forensic Expert Investigator

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There is good reason to believe that the role of the forensic expert investigator in resolving disputes probably dates back nearly 4,000 years. Today's forensic expert investigator and witness is, by a large measure, the product of sweeping changes in regulations, laws and rules of legal procedures and evidence promulgated in the late twentieth century. Over that relatively brief time period, the forensic expert witness profession has evolved to meet the expanding needs of a myriad of clients to resolve complex and often technical differences of opinion involving the cause of, among other issues, property and casualty loss events.

Reconstructing the property and casualty event through forensic expert investigation has become a key factor in the analysis of complex claims in preparation for a successful settlement and provides the basis for a subrogation or recovery action. The forensic expert investigator now has access to very accurate and persuasive digital evidence with which to reconstruct the event and effectively visualise expert witness opinions to aid the trier of fact.

Experience has shown that the most favourable outcomes are achieved when the forensic expert investigation firm are selected quickly and:

- Instructed upon first notice of the claim to participate in strategic response planning;
- Appointed to a leadership role among other investigating parties of learned colleagues;
- Given custody, upon release of the scene, of all physical evidence and relevant information from the outset of the forensic investigation; and
- Encouraged to collaborate with a team of multi-disciplined experts that are available to address specialised issues.

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Although the specific issues and technology continue to evolve, the process of forensic expert investigation has remained fundamentally the same. The forensic process involves the scientific method, objective deductive reasoning and liberal application of common sense. Specific objectives of the investigation will vary depending on the needs of the client who may be the claimant or plaintiff, subrogee, defendant, or actually the Court as in the case of a single joint expert (SJE) now in its eighth year of practice in England and Wales.

In 1999 a great many reforms were implemented in the Civil Procedure Rules (CPR) for the County Court and High Court of England and Wales under the guidance of Lord Woolf, Lord Chief Justice, now known as the Woolf Reforms. Among the new rules is Part 35 which applies specifically to the role of the expert witness.

Under the new CPR's, the role of a Court appointed "single joint expert" who acts for and on behalf of the Court for both sides in litigation was established. Separate expert witnesses continue to be assigned to the larger and more complex matters as determined by the Court. Although the US Court system allows for a "court appointed expert," it is seldom used.

In all courts the burden of proof as to claims made rests with the claimant or plaintiff or the subrogee, not the defence, thus, presenting a more defined set of objectives to the subrogation or recovery forensic expert investigator. It is a common role of the defence forensic expert investigator to objectively challenge the claims made and to present alternative causation opinions whilst identifying weaknesses and errors in the claimant and subrogation forensic expert's work.

Moreover, the objectives of the claimant and subrogation forensic expert are quite different, aside from the burden of proof issue. Issues of insurance claims and recovery law will influence the priorities of the forensic expert retained in a subrogation case. It is, therefore, very desirable for the forensic expert to have specific knowledge and experience with subrogation matters. However, objectively meeting the burden of proof remains a key requirement.

When first retained to investigate a property or casualty loss, regardless of the jurisdiction, the forensic expert investigator must conduct all investigative work with the anticipation of

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ultimately giving evidence in court. All physical and recorded forms of data are considered to be evidence and may be used as a basis for opinions. However, evidence must be obtained and/or created in a manner acceptable to the anticipated forum of resolution, such as a court of law. The forensic expert may come from nearly any profession or area of special knowledge including: engineering, science, medicine, accounting and economics, and emergency response services. Major casualty events, by their very nature, most often require and benefit from a team of forensic experts to respond effectively and to cover the multiple disciplines of technology involved. Proper structure and leadership of the forensic expert team must be established at the outset, and maintained for the duration of the matter to its final resolution. Property and casualty events require an initial quick response by the team and its continued availability to respond throughout the life of the claim. Selection of the forensic expert team members will usually be based on experience in the investigation and analysis of similar casualties, and giving effective testimony. In addition to the requirement for each team member to have demonstrated analytical ability and technical expertise, they must also possess high integrity, proper demeanour, and objectivity.

The role of the forensic expert investigator in the reconstruction of a casualty event can involve one or all of the following tasks to:

- Determine the cause;
- Determine the extent of damages;
- Identify and expose fraud;
- Identify contributing factors;
- Differentiate causes of damages;
- Identify potential recovery issues;
- Assist in legal proceedings; and
- To provide valuable empirical data for underwriters and risk managers.

Basic questions of what, when, where, why, and who must be answered to complete the reconstruction of a property and casualty event. Investigation and analysis of such events by forensic experts generates copious data, much of it is now digital. New methods must be utilized to locate and sort digital data from various storage devices during discovery. Digital data generated by forensic expert analysis activities must be preserved and ultimately

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admissible. At the completion of the analysis as to cause, the forensic expert must be able to visualise the property or casualty event reconstruction including all findings in a time sequence whilst consistent with the facts. Hence, the scientific method of testing the hypothesis is applied, leading to visualisation of the reconstructed event that can be used to demonstrate the expert's findings to others.

The quality and effectiveness of reconstructing property and casualty events with digital evidence, as presented in North American Courts, has advanced significantly over the past two decades and is now being successfully introduced into courts in the United Kingdom and Australia. This advancement is due almost entirely to the explosion of computer technologies and the growing acceptance by the courts to admit such evidence after proper judicial review, based on precedence, over that same period of time.

Of the forms of digital evidence developed, none has advanced as much as engineering and scientific computer animations, or demonstrative digital evidence, used to explain and reconstruct an accident or failure. Nearly all disciplines of science, and all fields of engineering, have developed unique computer programmes and digital analysis systems to conduct new research, analyse accidents and failures of existing systems, and to design new systems. From this wealth of new technical capabilities, the expert witness has a twenty-first century set of tools to produce excellent demonstrative digital evidence at reasonable costs.

In a very real sense, the past is prologue to the future of scientific and engineering animations as demonstrative digital evidence. Existing technical experience and legal precedents, as well as significant and recent amendments to civil procedure rules, have set the stage for an exciting and significant role to be satisfied by these highly effective and admissible visual statements in the twenty-first-century courtroom. Another factor that will impact the future of such evidence is the increasing presence of judges who grew up with, or are now proficient in, the use of computers; and, as practicing trial attorneys and barristers, may have actually used them in the courtroom.

At the same time, the visual experience and expectation level of potential triers of fact will advance as well. Whereas the complex trial of the twentieth century may have been dominated by the "battle of the experts," the same trial in the twenty-first century will be shared with the

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"battle of the demonstrative digital evidence." Leading the charge will be the expert witness with an engineering or scientific animation to reconstruct the casualty.

If the effectiveness of animations to demonstrate simulations and reconstructions were to be measured only by their relationship to the number of settlements prior to trial, their value would be obvious. As a producer of thousands of animations for US Courts, RTI's extended experience has shown that most matters settle, and only 10 to 20 percent are actually presented in trial, with a high percentage of those cases settling before going to the jury. Both in the UK and abroad, the focus on settlement and the need for more efficient trials will create an enhanced interest in their use in settlement negotiations and reduced court time requirements for expert witness testimony.

Twentieth-Century Scenario

During a brief retrospective visit to a late twentieth-century trial in progress, we find the insurance company's expert witness about to present an engineering animation of the casualty event. Some of the more subtle signs of the effectiveness and impact that such a computer reconstruction very often has on the court are about to be revealed.

> *After four long days of testimony from various fact witnesses, accompanied by the usual admission of numerous exhibits, the jury has just heard two hours of expert testimony, halfway through day five. Familiar reaction patterns have set in. Although the jurors have been doing their best to be attentive and stay alert, there have been limited times when all were at that listening level. This is a normal situation under the circumstances.*
>
> *The subrogation attorney, who is experienced with trials, has carefully planned to end the weeklong direct presentation of the case in chief, with the showing of an animation of the accident reconstruction, through the engineering expert witness on the stand. Familiar jury patterns are about to change.*
>
> *As the trial continues, expert testimony provides the foundation for the animation. After strong but unsuccessful defence challenges as to the authenticity and relevance to keep it from being admitted, the Court rules in their favour and allows the animation to be shown. Turning to the*

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jurors, the judge announces that they are about to see a computer animation for the sole purpose of illustrating the opinion of the claimant's expert who is giving evidence.

As the court bailiff moves the video monitor into position, the jury members begin to stir. The judge admonishes them to hear and consider all of the evidence yet to come from the defence before reaching their conclusions. All jurors are now focused at the same level of concentration in anticipation of viewing the animation whilst following every movement of the video monitor with eager eyes. Some of the jury panel members shift to the front edge of their seats and sit up straight to ensure a good viewing position. From that moment until the animation ends, only a few minutes later, the jurors are literally transfixed by the monitor screen.

Their reactions are varied, from a slight nodding of understanding to facial expressions of appreciation directed toward the claimant's table. At the same time, the defence table receives a 'what will you be showing us' look from at least three jurors.

The jury has been rejuvenated, and the plaintiff has made an indelible impression in a few short minutes. During a brief recess, whilst defence counsel is preparing exhibits and collecting notes to cross-examine the plaintiff's expert, the judge receives a note from the jury foreman requesting that the animation be shown to them again.

In bench trials the judge has been known to react in a similar, albeit somewhat less obvious manner, with a request for a copy of the animation to use in his or her deliberations.

Courtrooms and hearing chambers have experienced this scenario, or one very similar, for nearly three decades involving a wide range of subjects in litigation. However, it now seems clear that animations, as the most sophisticated demonstrative digital evidence and visual presentation system available today, are finding their way into most major legal proceedings, especially those centred on technical issues involving complex casualties, time and motion, and the need for various observation perspectives.

This should come as no surprise. Man's need to visually depict a story of moving objects can find its origins in the prehistoric cave-dweller etchings of large animals at full gallop, yet frozen in time for many centuries; the message remains clear today.

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Engineering Animations as Digital Evidence

Engineering and scientific animations have been generated for use in the courtroom for varying reasons:

- To present complex technical concepts with very specific tutorials;
- To demonstrate the results of test data;
- To reconstruct a sequence of dynamic events (a casualty) from real-time data recordings; and
- To illustrate the opinions of an expert witness.

The common elements used as the basis for the development of engineering animation presentations include:

- Established and published scientific and engineering principles;
- Technical data, drawings and specifications;
- Site inspection and evidence findings;
- Verifiable test results and calculations;
- Black box data or equivalent event recordings; and
- Peer-reviewed scientific and engineering analyses.

Thus, they are best described as scientific and engineering animations of property/casualty events and other event reconstructions and/or simulations.

An animation presentation usually refers to a sequence of many still computer frames or images that present the impression of realistic motion when shown at 30 frames per second. Actual content of the frames must be accurately scaled and depicted fairly, and the actual sequence must be supportable, independent of the computer-generated animation.

A simulation or reconstruction presentation is based on a sequence of images depicting the results of computer calculations related to a calibrated time base. All technical data used to produce the simulation or reconstruction must be accurate, authentic and verifiable, thus meeting the rules of evidence standard.

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Nearly every field of engineering, and most areas of science and medicine, has been represented by animations in litigation. Since the demonstration of time-related moving materials and objects is most often helpful for the trier of fact, animations have been selected to illustrate and provide a basic understanding of various dynamic phenomena. Included among the illustrated dynamic events involved in recent court proceedings have been:

- Aircraft accidents;
- Chemical processes;
- Construction and structural failures;
- Explosions and fires;
- Electrical accidents and equipment failures;
- Environmental contamination;
- Mechanical equipment failures;
- Medical procedures;
- Product-related accidents; and
- Vehicle accidents involving highway, marine and rail systems.

Admissibility

The US Court experience with digital evidence, both computer data files and the output from programs that display the data files in various formats and applications, precedes the experience here in the UK and falls under the **Federal Rules of Evidence**. The process to gain admission begins by establishing authenticity under **Rule 901(a)**. Once authenticated, relevancy under **Rule 401** must be established. Then the rules pertaining to expert testimony come into full play to provide the requirements and standards to be met for an expert witness to render an opinion in Court. Finally, **Rule 704** provides that a computer animation may conclusively depict an ultimate issue in dispute, providing the animation is otherwise admissible.

Although animations of reconstructions and simulations have been generally used as illustrative evidence, they were first challenged by the *"Frye Test,"* based on *Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923), the scientific evidence standard until the first US Supreme Court ruling on scientific evidence, *Daubert v. Merrill Dow Pharmaceuticals, Inc.*, 509 US 579 (1993). The very recent Supreme Court decision of *Kumho Tire Co. v. Carmichael*, 119 S.Ct. 1167 (1999), extended the *Daubert* decision to all experts. Thus, any ambiguity has been removed, and the trial judge has been appointed as the gatekeeper to assure that expert testimony including exhibits admitted as evidence are both reliable and relevant. Moreover, the judge must also assure that the same

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level of intellectual rigor is employed in considering the admission of exhibits which characterize the practice of the presenting expert in their respective professional field.

Experience by both those who produce such exhibits as engineering and scientific animations and those who proffer them to the courts have reduced the risk of an unfavourable ruling on admissibility. Procedures for authenticating the basis of an animation's content, and establishing its admissibility, have been sufficiently published, such as in *Modern Visual Evidence*, by Gregory P. Joseph, and ample legal precedent exists for the present level of material being offered to the Courts.

There are six primary foundation issues that must be satisfied to qualify a computer animation reconstruction as to its authenticity and hence admissibility in the UK and US Courts, they are:

1. The computer animation and/or simulation experts;
2. The computer hardware systems;
3. The computer software programmes;
4. All input data sources and quality;
5. Calculation accuracy of the computer system; and
6. Accuracy of the presentation animation as to content and motion.

Animations introduced into UK Courts have been challenged against those foundation issues as to admissibility. The Court's position has been that animations and digital evidence may be admissible under **s. 1(1) Civil Evidence Act 1995** in the same manner as other forms of hearsay evidence. It has been reported that the first instance of computer-generated graphics or animation being used in a British Court took place at Oxford Crown Court in September 1994. Since 1994, increasingly sophisticated animations have been admitted to other UK Courts, as well as used successfully in settlement hearings to assist in the resolution of claims.

Computer Reconstruction and Animation of the DuPont Plaza Hotel Fire

A fire at the DuPont Plaza Hotel in San Juan, Puerto Rico on 31 December 1986, was intentionally set in an accumulation of fuel (crated furniture) stored under a balcony in the main ballroom. Three hotel employees intentionally set the fire in the furniture because of labour dissatisfaction. The area of origin in the ballroom did not have any active fire protection or detection systems so that the initiating fire grew at an unchecked rate. Air supplied to the fuel was

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unimpeded since one wall in the room of origin was partially enclosed by moveable partitions of light construction, another wall by windows; and since the main ballroom, separated from this space by the partitions, was open to the outside. The fire accelerated to involve all available combustible materials, spreading smoke and flame to the occupied adjacent occupied areas. Because of the extremely rapid-fire growth, escape was not possible for 97 guests and employees who were killed, and 146 others who were injured.

RTI were instructed to conduct the computer fire-modelling component of the investigation to reconstruct the early development and spread of the fire. Specifically, RTI were requested to provide details of the effects of the fire that grew in the south ballroom on combustible products present in the north ballroom, particularly the portable platforms stored just outside the Rio Lama room on the balcony above the room of origin. It was understood at the outset that the results of the computer model would not only be a critical analytical tool and work product of the forensic expert investigators, but also could provide the basis for an engineering animation to illustrate their opinions in support of testimony given in court.

During the course of the forensic investigation in the DuPont matter it was established by facts in evidence, and subsequently stipulated to, that all of the deaths and injuries were the result of heat and smoke generated from the first ten (10) minutes spread of the fire.

The basic processes for these efforts require that the analyst have accurate information about all parameters that controlled the fire dynamics. To this end, much effort was expended in defining fire-site geography, geometry, and combustible materials. This required an exhaustive site survey, extensive testing, and both physical and analytical computer modelling.

RTI conducted fire testing, computer modelling, and data analysis for the development and early spread of the fire at the San Juan DuPont Plaza Hotel. RTI specifically analysed the effect of the fire, which grew in the south ballroom, on the combustion behaviour and response of the portable platforms that were stored on the balcony of the north ballroom. The key elements investigated were the timing of the involvement of the platforms as the fire spread to the casino, and any toxic products they produced which resulted in the fatalities. RTI assembled a team consisting of a fire scientist, fire protection engineer, chemical engineer, aerospace engineer,

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computer animation specialist, and pathologist under the leadership of an experienced fire analyst to accomplish this complex task.

A wide range of traditional fire testing and specially developed testing was performed by RTI on the portable platforms to determine their flammability characteristics, and to correlate the resulting test data with the computer output data. In addition, the testing and analysis of the fire-induced breakage of the foyer window plate glass in the room of origin determined the timing for this input.

Boundaries of the fire model included the south and north ballrooms, and details of the balcony area. The model was geometrically correct and allowed for the opening of doors as related by the eyewitnesses. The stored furniture in the south ballroom became the fuel pack for the fire. The computational grid was adjusted to provide as much information as possible in the areas of interest, to prevent the solution from becoming unstable, and to not require extremely long computation times with the available hardware. The limiting grid size became 27,000 grid nodes or data points, based on these limitations.

Initially, the computer geometric model was built and refined. The time sequence requirements and other factors were established to ensure a converged solution through the 10-minute fire development time. Three test cases were computed. The cases used different parameters in order to account for the impact from consumption of the combustible partition wall by the fire and the changes resulting from thermal breakage of the plate glass window at the west-end of the south ballroom.

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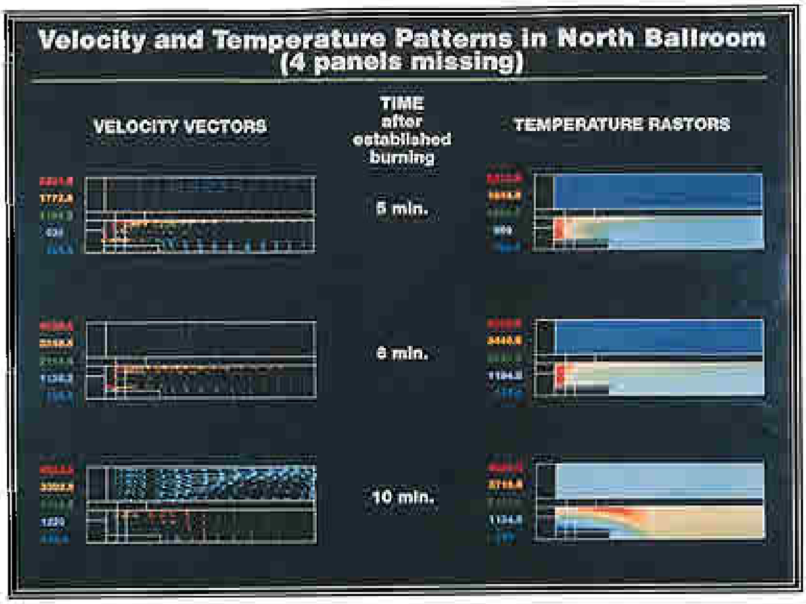

Figure 1. Sequence of Fire Growth, Velocity and Temperature Patterns

The standard output available from the computer fire model that describes the spread of fire was in the form of isothermal surfaces; temperature-scaled velocity vectors in various planes as well as lines and colour raster plots of constant temperature, oxygen percentage, and other parameters. This output could be produced for selected time sampling rates, but it had to be computed throughout the entire grid, and although clear to an engineer or scientist it was not particularly well-suited for the lay trier of fact.

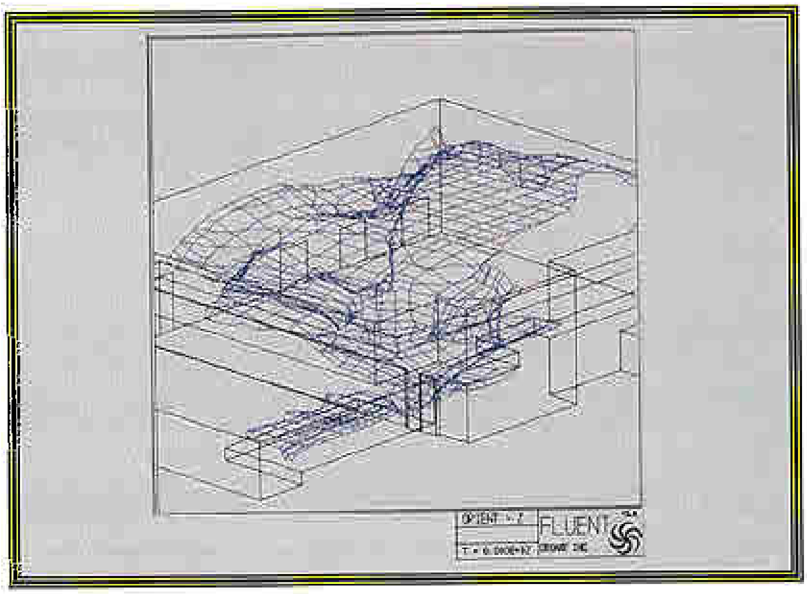

Figure 2. Computer Fire Model Output of High Temperature Isotherm Layer

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A fly-through, three-dimensional computer model of the hotel was developed for orientation of the jury to understand the complex site of the fire. This simulation also provided a means to effectively illustrate the time-dependent fire development from various viewpoints using the fire model results. This was accomplished by initially showing the progression of a selected isothermal surface through the south ballroom. The more enlightening displays show the time-dependent temperature development at two planes simultaneously, the second floor balcony location of the platforms, and the first floor window plate glass. The combination of the "state-of-the-art" field modelling with the computer-building model very clearly illustrated a most significant conclusion. The platforms did not become involved in the first 10 minutes of fire spread until after it had swept through the casino, and therefore they did not produce smoke or toxic products that contributed to any of the fatalities. It is important to note that the Dupont Plaza fire animation did not attempt to illustrate smoke or flames for which there were no technical data to support their appearance and behaviour at the time. Such an inclusion would have been subject to vigorous and indefensible objections leading to a debate of Motions in Limine.

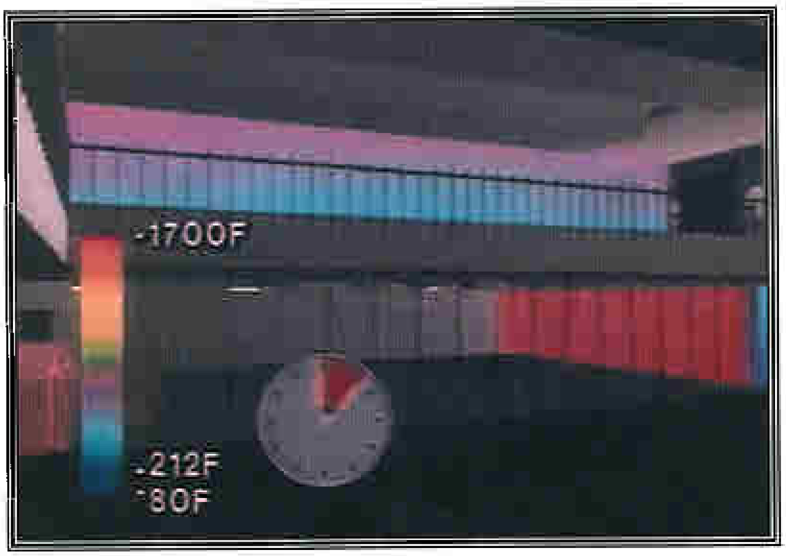

Figure 3. Computer Fire Reconstruction Sequence at Mid-Point

Trial was held in San Juan, Puerto Rico, during 1989 in the US Federal District Court for the Commonwealth under an MDL, or multiple district litigation, procedure for complex cases. The San Juan DuPont Plaza Fire animation by RTI was admitted by the Court to be shown to the jury. During the direct presentation of our client's case in chief, and just prior to the display of the animation, opposing counsel called for a recess to review the animation again in the judge's

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chambers. Opposing counsel then expressed concern that the animation was very effective, and would not only be detrimental to their position with the present defendant, but would "poison the jury" for their position against other parties yet to come in the months-long trial. As a result, a very favourable settlement was reached for the platform manufacturer.

Twenty-first—Century Digital Evidence, Animations

A special engineering simulation of an aviation property/casualty event was produced for the Inns of Court School of Law in London for use in a series of mock trials conducted in several venues, including at the Lloyds Training Centre in London, the William & Mary School of Law in Williamsburg, Virginia, and the Judicial Division Conference at the American Bar Association Meeting in Atlanta, Georgia. *Figure 4*, an image of a frame from the animation, known as *Air Apparent, Flight 71*, shows the aircraft in flight just after the inboard left engine has exploded, with smoke trailing out from behind.

This animation represents a full application of the current leading-edge technologies in engineering simulations. The aircraft computer model was of a non-production wide-body design, but in an actual case would be constructed from the manufacturer's dimensional and aeronautical data, as well as verified with the digital dimensions of an exemplar aircraft.

Motion of the aircraft in flight was produced in reverse of the normal analytical procedure used to reconstruct the final flight path of accidents from the black box, known as the digital flight data recorder or DFDR. In this case, the flight simulator was flown over the desired path, and the simulator black box recorded the aircraft motion data for *Air Apparent, Flight 71*. Air Traffic Control (ATC), radar data, and radio communication and cockpit sounds were also included as important sources of data.

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Figure 4. Air Apparent, Flight 71

This simulated *Flight 71* black box data was used to drive the flight path reconstruction for the animation. ATC data was used to establish position and to synchronize the DFDR and cockpit voice recorder, or CVR, data. Ground topography was provided by actual satellite images of a portion of the state of Arizona while en route to the city of Los Angeles.

All of this data was integrated into a well-established professional 3-D animation software programme with simulated cockpit and cabin audio that would normally be provided by the actual CVR. Any proposed or actual use of an original CVR would be controlled under the privacy act for such materials.

Crash sequence details are reconstructed from extensive crash site mapping and debris analysis, as well as eyewitness accounts. These details must be carefully included only when they can be reliably verified and reproduced.

Thus, the *Air Apparent, Flight 71* simulation was based on the same methods and equipment used to produce a flight path computer reconstruction or simulation of a major commercial aircraft accident when the highest detailed level of computer animation may be desired.

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On the other hand, when it is desired to reconstruct a property and casualty event, limited details may be sufficient, with the attendant benefit of a lower cost, or, less data may leave little choice. In some cases, an engineering animation with limited details may in fact be a better choice based on advice from a litigation consultant or for other reasons.

Literally thousands of forensic animations have been produced for US Courts and with increasing frequency in British Courts. Figure 5 illustrates a power utility application to aid in understanding the operation of an environmental protection system to remove soot particles from boiler exhaust gases that was used in a large property claim dispute. It was critical in this instance to understand how an electrostatic precipitator normally operates and to see inside whilst soot particles are being removed from hot exhaust gases passing through the internals. This is only possible with such an animation.

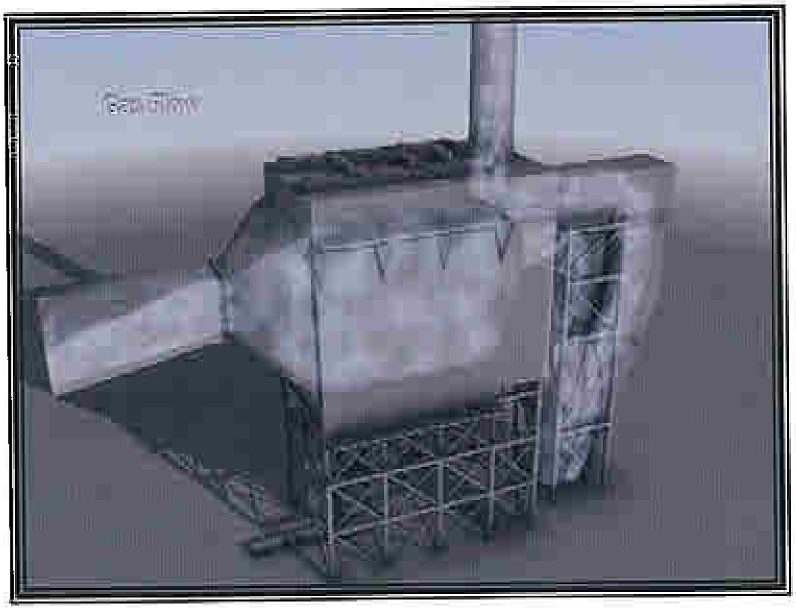

Figure 5. Digital Model of Power Plant Electrostatic Precipitator Used in a Property Claim Matter

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Conclusion

Today, and for the foreseeable future, the role of the forensic expert investigator will be to properly apply new and evolving forms of digital technology for the investigation and reconstruction of complex technical property and casualty events, and later for demonstration of their evolution through an admissible and very effective computer animation presentation. Digital evidence in the courtroom is becoming more commonplace. Therefore, it is vital to obtain forensic experts who are competent and experienced in all its aspects. Those who commit to make the best and proper use of digital evidence will have both the technical and strategic advantages.

The twenty-first century holds many opportunities to improve existing, and create new, digital demonstrative evidence based on experience gained and advancements in science and engineering, particularly in the field of computer science and imaging. Analytical techniques will provide new tools to develop more comprehensive data for simulations and reconstructions. Presentation technologies will provide access to larger and higher resolution images along with enhanced virtual reality systems. With proper controls for admissibility applied by the British Courts, scientific and engineering animations using digital evidence will play a significant role in the accurate and objective reconstruction of property and casualty events to enable efficient resolution of complex claims in the 21st Century.

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