

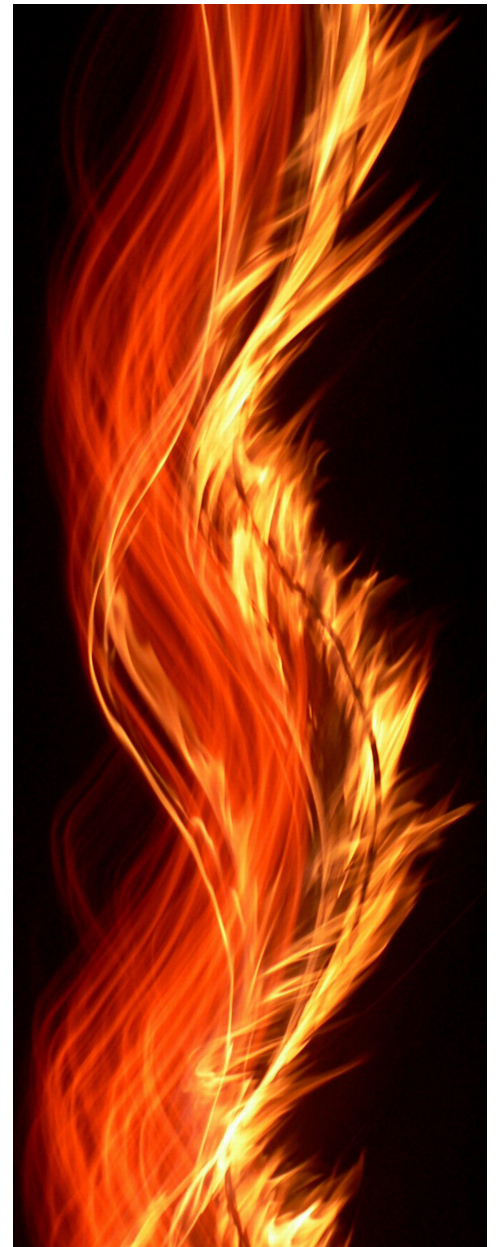
## Forensic Fire Scene Documentation and Reconstruction

### 3D laser scanning and photogrammetry as forensic documentation / re-creation for fire, explosion, crime and accident scenes.

In this article we will be looking at the next generation of investigation tools and systems that are systematically changing the face of forensics. Primarily this will be an introduction to laser measuring devices, photogrammetry, the virtual scene or 3D working model, a few of the agencies and individuals successfully using the technology-their deployments/case history and consideration of the technology as a future documentation tool, that provides the base for forensic animations. Oh yes, and the obvious and inherent skepticism.

### Introduction to Laser Measuring:

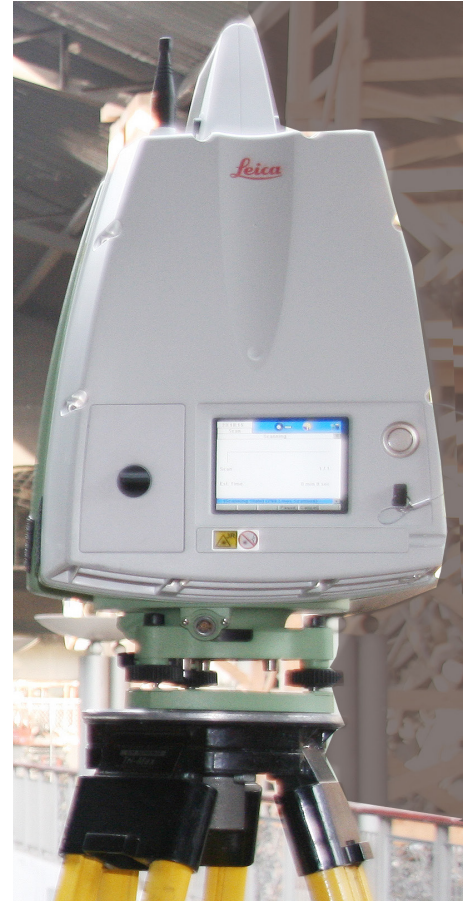
Traditionally when measuring a scene, one would use a measuring tape and put the “dumb” end on an anchor and measure to our objective, manually recording the distance, making two data points. Then one uses a square or protractor (for extra accuracy) and pulls another measurement and the geometry starts. This works for a modest number of measurements, but how does an investigator proceed when the scene is more complex or warrants a bit more accuracy or thoroughness as in a fire death, major loss, multi-fatality scene or the worst, a Line of Duty Death (LODD) of an emergency responder. Laser measurement advantages include its speed, accuracy, portability and with Daubert an ever present concern, admissibility. The technology is ideally suited to fire/explosion, crime and accident investigation. Measurements can be collected day or night, while the scene is still actively under investigation and on large areas open to the public. In a matter minutes, millions of measurements are “in the can” and will be stored into perpetuity.



## Laser Measuring Continued

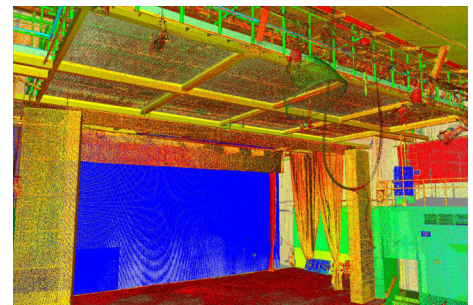
The scan data or “data point cloud” is then “stitched” together through a process called registration. For each of the data points, segments of corresponding photographs can be overlaid during the registration and rendering processes. The result is a spatially and visually accurate 3D forensic virtual scene. All members of an investigative team can see, evaluate and measure evidence. They may “fly-through” the scene or choose to view the scene from the perspective of any and all scanner set up locations. This data is available via a secure ftp site and can be viewed on any PC/lap top. With point cloud data from a 3D laser scanner, deliverables include everything from a simple 2D scene diagram to a jury-ready, fully animated reconstruction based upon accurate evidence and expert analysis. For sample animations visit: <http://precisionsim.com>  
For a sample of “Tru-view” virtual scene, get a free plug-in at: <http://scansw.leica-geosystems.com/public/forensic/>

Authors note: The laser based “Total Station” is a valuable and accurate tool. The inherent limitations are based on its manually operated use. It can and is used by many forensic professionals. The operation platform of the scanner does not make them obsolete, but do eclipse their use, when and where a scanner is available.



## Photogrammetry:

The scan data or “data point cloud” is then “stitched” together. If the relative locations of five or more points in a given photograph are known, the other evidence in a photograph can be measured/calculated. This process is exceptionally efficient when coupled with the use of laser scanned scenes. This technology allows old or stagnant cases, where evidential locations could not previously be determined, to be reworked in a way never thought possible. This technology is enabling experts, working closely with forensic animators, to accurately reconstruct events that would have been impossible or financially prohibitive just a few years ago.





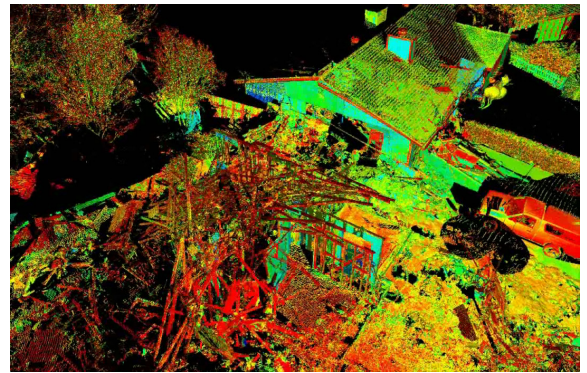
# The 3D Working Model

The expert can use the working model to determine what was available to be seen or happened and what could not have happened or been seen, by emergency responders and witnesses alike. Analyses can often be done on the computer, which substantially reduces the cost and time required, as compared with actual on-site simulations. An additional advantage of computer generated 3D reconstruction is that when additional information becomes available, the working model can be updated to include the new information. When opposing attorneys develop new ideas of what could have happened, they can be quickly tested in the working model to determine if they are consistent with the other scene data.



## Debris VS. Evidence:

When investigating a significant scene, especially during the early hours of an assessment, investigators are less able to identify conclusively, everything important to document. Subjective decisions are made about what will be located by photograph and measurement and what will not. The fuel can, area of origin and fire patterns are obvious and it is expected their location will be noted. But what about other less obvious objects?



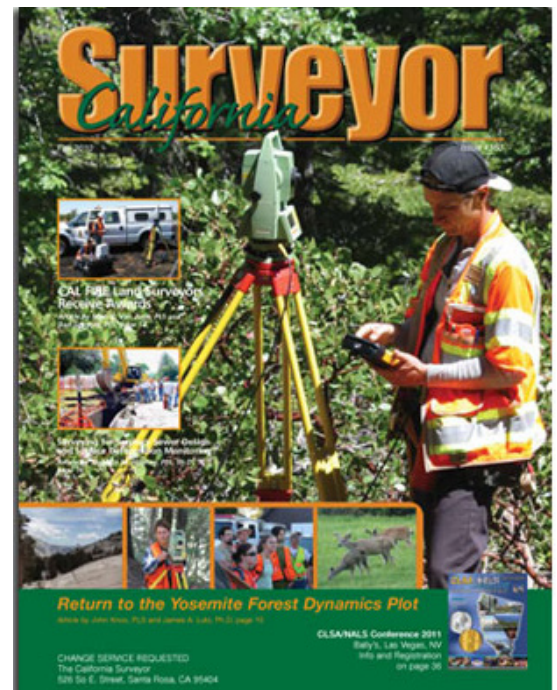
The inherently destructive process of fire suppression and overhaul coupled with scenes that might initially be “non-suspicious” inevitably allows for debris piles in the driveway, to contain crucial evidence. Laser scanned scenes assure accurate measurement/placement of physical evidence in a scene. Evidence that has been moved can often accurately be placed back into the virtual scene allowing hypotheses to be supported or debunked.

All visible and some “invisible” evidence is recorded. Specific to fire investigation, it has been noted that the varied affects of heat flux on a given area of gypsum/sheetrock (calcination) are often visible to the scanner, less to the naked eye. The laser return is based on reflectivity of the laser and a degraded section of gypsum has a different return (depicted as a different color) than that with undamaged paint/paper or areas of minor heat exposure. The variations are automatically mapped and can be distinguished between burn patterns and destruction by suppression companies hose stream application. It should also be noted that many of the areas where calcination has taken place, are often difficult to record by photography, as they are mixed with smoke deposits, char and tend to absorb available lighting. Additionally, the scanner can also record something with as little mass as blood splatter, this is also possible based on variations in reflectivity. Part II of this article will discuss animations, recent cases, testing and the associated findings to this discussion.

## Current Users

The list of users is growing, both in public and private sectors at National, State, Regional and local levels. US Attorney generals offices, DOJ offices, State and City Police and Sheriffs offices with private investigators are using 3D laser measurement technologies at an ever increasing rate. A few of the specific organizations include, the California Highway Patrol Multi-Disciplinary Accident Investigation Team (MAIT), law enforcement agencies in Albuquerque NM, Orlando FL, San Antonio, TX, the Georgia Bureau of Investigation, Fresno County Sheriffs office, Alameda County Sheriffs office, Pennsylvania State police and LA County Sheriffs office, the California District Attorney and City of San Francisco Attorneys office just to name a few.

The types of cases are being studied with these technologies are many. Initially used forensically to reconstruct and animate crime scenes (particularly shootings); vehicle collisions and industrial accidents, the areas of use now include commercial and residential fire and explosion scene documentation, wildland fires, tank ruptures and fatalities of every measure.



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California Surveyor Magazine

## Users Detailed

Documented in The California Surveyor Magazine, Fall 2011 Issue 163; In 2009 CAL FIRE issued the Directors Superior Accomplishment Award and Innovation Award to members of the Technical Services Team for their work with legal staff in the support of the Civil Cost Recovery program. These awards are for members whose superior performance results in an exceptional contribution to the department and/or demonstrate unique creativity, inventiveness, and innovation in the resolution of problems; and whose accomplishments demonstrate the ability to achieve objectives despite budgetary constraints.

The awards primarily focus on the teams work in two incidents; the first investigation was the Witch Fire that started on the evening of October 21, 2007. The second investigation was for the Camp 16 Burnover and Fatal Vehicle Accident, which was part of the larger Station Fire that started on August 26, 2009.



Courtesy Mark R. Van Zuuk PLS



## Users Detailed Continued:

These awards were possible after Calfire's 10 million dollar award in 2007, having used a scanner as part of an investigation and subsequent cost recovery effort, in the 2001 Poe fire of Butte County. In the Poe fire investigation, the utility company was determined to be at fault for failure to maintain clearance to high-voltage lines. Cal Fire quickly moved to purchase the Leica Scan Station 2, where it is now regularly used on fire, accident and survey investigation needs. In a then press release, now retired Chief of Law Enforcement for CAL FIRE, Tom Hoffman stated "We're very excited about having this tool readily available to our investigators and law enforcement personnel. Our goal is to find the truth by determining a reliable and accurate representation of the actual events. Laser scanning can help us do that. Ideally suited to fire investigation, it's quick, very mobile, highly accurate, and most important, provides clarity of evidence in a visually friendly way."



Courtesy Mark R. Van Zuuk PLS

## Private Parties

Private parties that are also using the tools include renowned criminalist and fire investigator Dr. John DeHaan, co-author with Dr. Dave Icove of multiple editions of Kirk's Fire Investigation and Forensic Fire Scene Reconstruction. His work with the laser includes multiple scene and test scene deployments.

Of note is a request to Precision Simulations, Inc. (PSI) to assist in the documentation of the Fatal Rancho Cordova gas and home explosion in December 2008.



DeHaan is quoted as saying "Laser scanning is the future of fire investigation". His recent lecture on the value of this technology at the International Leica Lasers user conference can be viewed at [http://www.leica-geosystems.us/forensic/video\\_11.html](http://www.leica-geosystems.us/forensic/video_11.html)

With Fire Cause Analysis (FCA) taking the lead, several of the West's largest and most experienced private fire and explosives investigation firms, working with the affected insurers legal counsel, sought deployment of PSI and their scanner team at the October 21st 2010 Westfield Galleria Mall fire. The data collected includes more than 1 billion measurements, from seventy different locations, throughout the damaged area. Investigators who have access to the data can revisit the virtual site at any time to develop measurements, develop hypothesis and make evaluations on the more than \$50 Million dollar loss. Further development of the data can be from 2D drawings to sprinkler diagrams to animations.

## Top of the Industry:

Some of the best materials engineers, fire scientists and fire and smoke modelers are deploying laser scanners to document scenes and subsequently expedite development of 3D working models for use with CAD/(FDS) Fire Dynamic Simulator, Pyrosim, Smokeview and other fire modeling programs and applications.

## Wildland Fire Applications

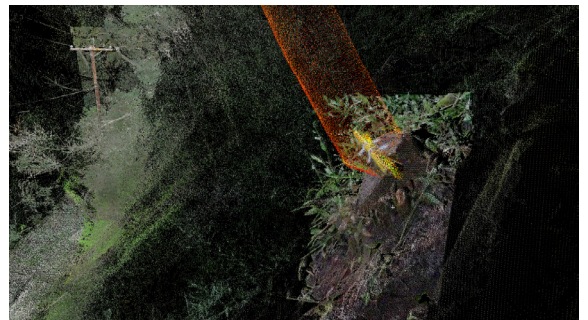
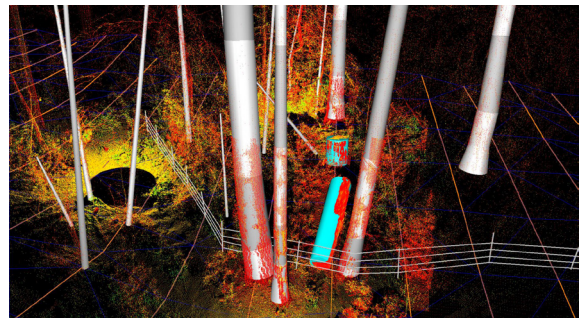
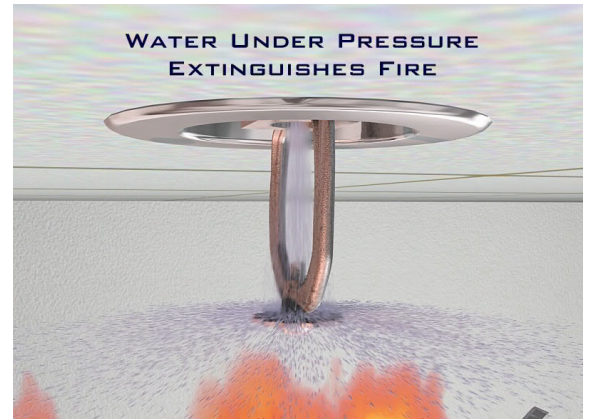
The opportunity to provide exacting documentation and reconstruction of wildland scenes is an area with where scanners have scene multiple deployments. Fires caused by wire strikes are a relatively common occurrence and scan data assists by allowing reconstructionists to place limbs and trees back into the “virtual scene”, even years later.

## Stats and Cost VS. Value

In the mid 90s, when laser scanners were first introduced as forensic tools, they weighed in at more than 100 pounds and scan speeds were measured in 4 digits. The new generation Leica Geosystems C-10 is the size of a bread box, carried in one hand and capable of speeds of 50,000 points a second, 3 million in 1 min. For objects of a relatively close proximity, the phase based scanner which sends out a fan of lasers instead of the typical single beam is capable of more than 60 million measurements per minute. Scanning the scene captures all visible surfaces, up to 900' distant, to one quarter inch accuracy. It is difficult to compare the cost and value when the hourly wage for an investigator fails to be translatable to millions of measurements per minute. It's like comparing apples to orange groves.

For prospective entities and individuals where a long-term program is desired, initial cost for a manually targeted “total station” starts at 3k. For a program-mable forensic friendly 3D laser scanner, 150K provides a top shelf scanner with software and training.

With the current budget trends it is important to note initial costs may be offset in whole or in part by grants such as UASI (Urban Area Securities Initiative), part of the Homeland Security Act. As initial start up skills will need development and on going training is needed, one should consider other providers while this technology becomes more common.





## Stats and Cost VS. Value Continued

For the most cost effective measurements and immediate or urgent documentation of a single important scene, consider the deployment of a QUALIFIED and EXPERIENCED team. DOJ labs may be able to deploy for jurisdictions having authority and multiple private firms offer scene capture for a range of prices and deliverable packages at a fraction of the “grant to own” program.

## Limitations

Digital technologies can not replace boots on the ground, digging out scenes, flammable liquid analysis; it is simply an adjunct and an adjunct with limitations. Laser measuring can not see around corners or under items (unless turned over). Laser tools do not see INSIDE objects, although compartments that can be opened and quickly documented. While competitive pricing can be sought by vendors of both hardware and technological services, it is not free and Laser measurements are not warranted in the “average” fire. At time of press Apple has not YET released an app, patience.

## Skepticism

“Fire investigation does not need that accuracy”. With NFPA 921 and NFPA 1033 calling for complete documentation of scenes, using all available technology, it begs the question, “when this level of accuracy is available, is there a time when it IS needed?” According to the USFA’s 2011 report on National Fire Incident Reporting System (NFIRS) data, from 2004 to 2006 an estimated 210,300 intentionally set fires occurred each year in the United States. These fires resulted in an average of approximately 375 deaths, 1,300 injuries, and \$1.06 billion in property loss each year. Which of these death cases have a suspect, motive and a prosecuting authority that could be benefited by these accurate, admissible and compelling digital technologies?

When the local crime lab received the gold standard on glass analyzing, they may have heard skepticism on the lack of need. The glass analyzer can distinguish if a given glass sample was manufactured in a given kiln and when, +/- 2 weeks. The device ablates an area of glass evidence the diameter and thickness of a human hair, the sample otherwise untouched. Previously investigators might have just asked to have the glass examined, to know if the glass appeared similar in color, thickness, clarity and if fractures or fissures of one piece matched another. Once a prosecutor or investigator uses this level of detail and accuracy; it would be hard to imagine them wanting to go back. So what shall we do with the accuracy available in a 3d scanner?

## Conclusion:

The validity of investigators findings, witness statements and photographers perspectives are under ever increasing scrutiny in the legal arena. As the need for exacting scene documentation increases, these tools will to excel as the standard for important scene documentation and preservation. In than the large loss fire, the fatal intentional fire or a tragic LODD, this is the standard by which all documentation will be judged.

## Second Opinion

Original article in the Richmond Journal of Law, excerpt used with permission of: Author, Thomas R. May "Fire investigative methodologies in general, and fire pattern analysis particularly, suffer from reliability deficiencies due to an abundance of under-educated practitioners, an underdeveloped scientific foundation, and obsolete capture and documentation methodology. The judiciary has not been an effective gatekeeper in disallowing suspect and unsupported fire-related testimony. Skepticism is mounting, and change is inevitable. As it has in other areas of criminal law, 3D technologies will be used to document the spatial characteristics of fire scenes and multi-resolution databases will be utilized for the analysis of evidence. Digital imaging technology, utilized by properly trained and educated investigators, will simultaneously revolutionize fire investigations and blunt future criticisms. And computer analysis will enhance the reliability and accuracy of fire pattern analysis. Rapid forensic technological progress related to increasingly complex fire investigations is beginning to blur the role of the fire expert and the fire investigator. In spite of this, the emerging revolution in forensic 3D imaging technologies will provide solutions to remedy unreliable and subjective fire investigative and reconstruction practices. The combination of technological advances in photogrammetric measurement systems and the rapid progress in the areas of laser scanners, machine, computer and robot vision have opened the way to new applications for optical static and kinematic measurement techniques. Together, these new methods and technologies will revolutionize fire scene investigations."



### About the Author:

Kirk McKinzie, CFI is a Fire and Emergency services Consultant with Precision Simulations Inc. PSI pioneered the use of 3D Laser Scanning in forensic reconstruction in 1999. PSI has never been excluded in trial. A 25 year fire service professional, he continues to gain experience in the field, as Captain at a central California Heavy/Technical Rescue station.

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