

Laser Scanning for Forensic Investigation (Part 1 of 2)

By [Bruce Jenkins](#), Senior Analyst, Spar Point Research LLC

A murder scene, an auto accident, a collapsed building, a dilapidated stairway where a fall led to severe injury – Paul Francis has used laser scanning to document these and other scenes for the Toronto Police Service, and for private investigators seeking evidence in civil suits. Francis, vice president of [Northway-Photomap Inc.](#), Toronto, showed [SPAR 2005](#) attendees how evidence gathered with laser scanning can be more compelling for juries than simple photographs – his firm has created 3D animations of scenes,



Image Courtesy Northway-Photomap Inc.

Figure 1: Rapid-prototype model of auto accident scene generated from laser scan data

and even 3D physical models that can go into the jury room [Figure 1]. 3D digital models also help investigators analyze what happened in a crash – measuring the vehicle deformation helps determine speed at impact and other contributing factors. Scene capture that's both fast and complete is another advantage – the need to capture all relevant information is constrained by time pressures to reopen traffic lanes, finish demolition of hazardous structures, move objects in a crime scene to seek bloodstains or other evidence. Too, investigators typically revisit a crime scene between 8 and 12 times, according to Francis. Having the digital “scene” on their desktop lets many return visits be made virtually.

Forensic calls can be to a homicide scene, a traffic accident or any other happening that either police or private investigators need to document. Forensic projects have five stages, Francis says. On each call the team must (1) prepare for the visit to the scene, (2) document the scene as required by the client, and

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to their own satisfaction, (3) assemble the data to recreate the scene, then analyze the data, (4) prepare and present the final deliverables, and (5) wait for possible follow-up requests. SPAR 2005 attendees learned what procedures Northway-Photomap has developed for each step.

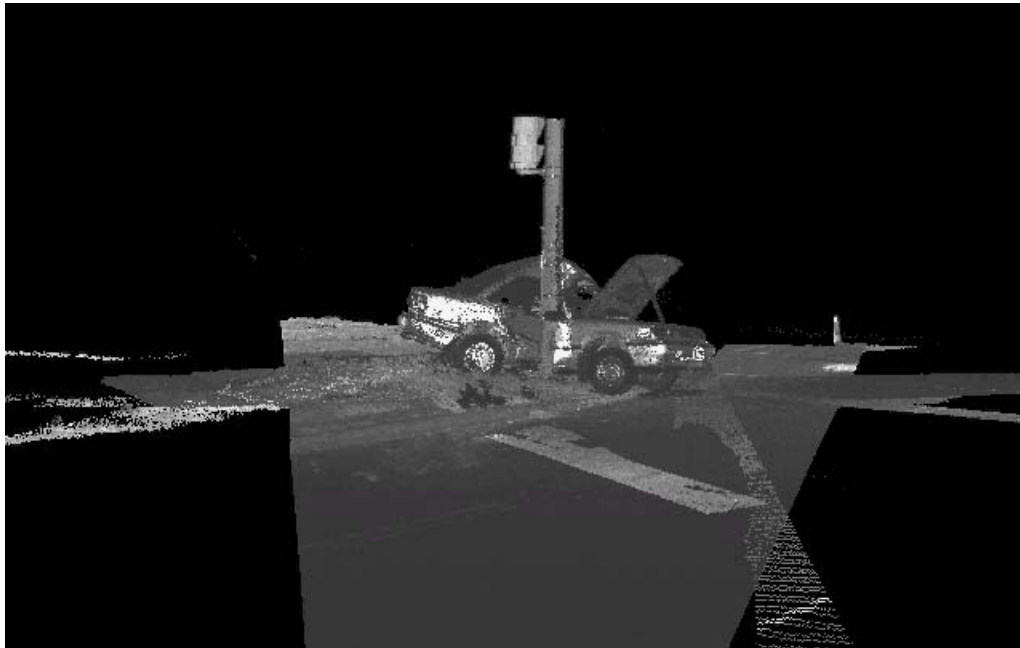


Image Courtesy Northway-Photomap Inc.

Figure 2: 3D laser scan of auto accident scene

Preparation

Preparing before the scene visit is as important as the visit itself, according to Francis.

Staff selection. Sending the right people to a scene is critical. First, “the team has to know the scanner, and the software for processing the data, inside and out.” Unlike laser scanning of industrial facilities or civil infrastructure, “There’s not a lot of preparation you can do” on forensic projects. “Typically when you get a callout to do forensics work, it’s going to be a middle-of-the-night call, or it could be a couple of days’ notice, but that’s about it.” Most preparation has to take place on site, “because when you go to a scene you don’t know what to expect.” When a call comes in, “you basically have to get to the scene, then you may have twenty minutes to plan what you’re going to scan, and how. Then you start your mission of data capture.” This means the team should be “a very smart crew that can go out, look at the scene, and figure out how they’re going to present the data even as they’re capturing it.”

Only required staff is permitted entry into a crime scene, and in many instances must be listed on the search warrant. Staff should be aware that attending a crime scene “basically deputizes you. You will be in the scene control center and will often learn much more that you wanted,” Francis says. “Staff must understand that every bit of information learned while on the scene is confidential and they have an oath to secrecy.”

Project staff must be alert to the type of scene they are attending. “For crime scenes such as homicides, staff must be aware they may find gruesome, R-rated situations.”

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Also important is to know how not to contaminate a scene – touching something and leaving fingerprints, moving or dropping something within the scene. “If you go into a scene and faint, because you’re overheated or because of the scenery you’re looking at, you’ll contaminate the whole scene,” Francis observes. “And you probably won’t be asked back.”

Staff selection is equally important in non-police-sanctioned forensic work – “collecting evidence for civil cases,” says Francis. “Cases where the scan target is on private property, and the owner is not your client, are important cases for the selection of the right staff.” He describes two such cases: “In November 2001 we remotely scanned data describing a set of stairs, which are the proposed cause of an individual falling and becoming a quadriplegic. On the second occasion, data describing a highway was captured so it could depict that if a drunk driver was going the wrong way on a divided highway, an oncoming driver would have very little time to react.”

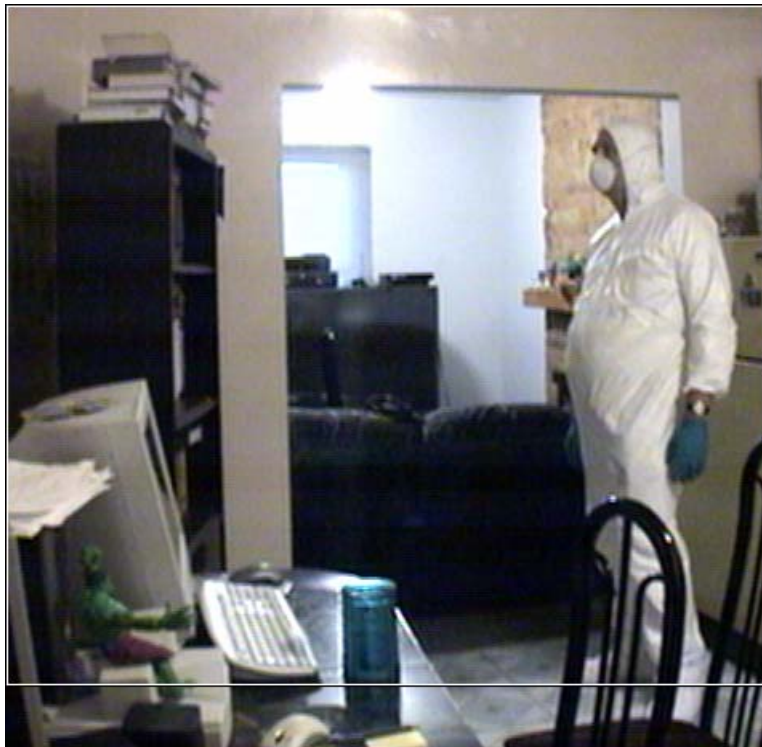


Image Courtesy Northway-Photomap Inc.

Figure 3: Tyvek-suited scan team member in homicide scene

Attire. In most situations Francis has attended, the callout agency supplies any special attire required for the scene, and also reiterates the necessary precautions for preserving the crime scene. Preparing for the additional wear is important. “If you present yourself at a scene and the need is to wear a Tyvek suit on top of your clothes, you must be prepared.”

“In this June 2003 scene [Figure 3], we were required to document the inside of an accused murderer’s flat prior to forensic examination.” In the photo, says Francis, “the fellow with the mask and gloves is me. We were the second team to go into the crime scene. They had arrested the suspect on a Friday. On Saturday and Sunday they did a hair and fiber removal. Then they asked us to go in and capture the

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placement of everything in the flat, so there would be a record of where everything was – not only a record in pictures, but also a digital record so we could take measurements. Later that week, we were also required to collect the exterior of the neighborhood such that a virtual walkthrough of the crime scene could be created for use by the investigators and the jury.”

What’s the value of this? A rule of thumb in police work is that “three months from now, when new evidence comes out, you don’t know whether the bottle of vodka sitting beside the sink is going to be important. If they don’t take a measurement before the forensics team goes in and tears the apartment apart looking for blood or other substances, then they’ve lost that evidence.”

Equipment checklist. In forensic callouts “you don’t know what you’re going to need, so in your preparation stage, you want to have a checklist of all the equipment you may need.” Francis’ checklist includes not just the firm’s [Optech](#) ILRIS-3D scanner but also such items as a battery charger, generator, fuel, waterproof boots, knee pads, climber’s helmet, flashlights and the like.

QA/QC scans. Upon receiving a call from an agency, Francis’ team executes a test scan of the front of Northway-Photomap’s building, whose dimensions are known, immediately before being dispatched. Then, immediately on returning to the office after a project has been completed, a second scan is executed to ensure consistent results are being recorded. These two scans are used to document that the scanner maintained its accuracy during data capture at the scene; these results are reported to the client along with the final project findings.



Image Courtesy Northway-Photomap Inc.

Figure 4: Digital photograph of Uptown Theatre collapse

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Data capture – documenting the scene

Time frame. After arriving on the scene, an important first step is to find out how much time is available for data capture. In December 2003 Toronto's Uptown Theatre collapsed during demolition [Figures 4-8]. "Somebody cut the wrong girder at the wrong time," Francis recounts. "The existing brick walls caved in on an adjacent school and killed a fellow. So we were called down to document it." In this case, data collection took precedent over time. The client anticipated that the scene could be captured in some six scans over about four hours, "but the Ministry of Labour, which was in charge of the accident investigation, turned it into 17 scans and 8 hours." Final demolition of the theatre was delayed until scanning was complete. "We collected about 32 million data points to describe the scene, then we put it back together as a virtual model for the client," Francis says. Scan data was processed with [InnovMetric PolyWorks](#), then sent to a [Z Corporation](#) rapid prototyping system to create a 3D physical model. The scans, which captured structural details of the collapse, "will be going to the Coroner's Inquest."

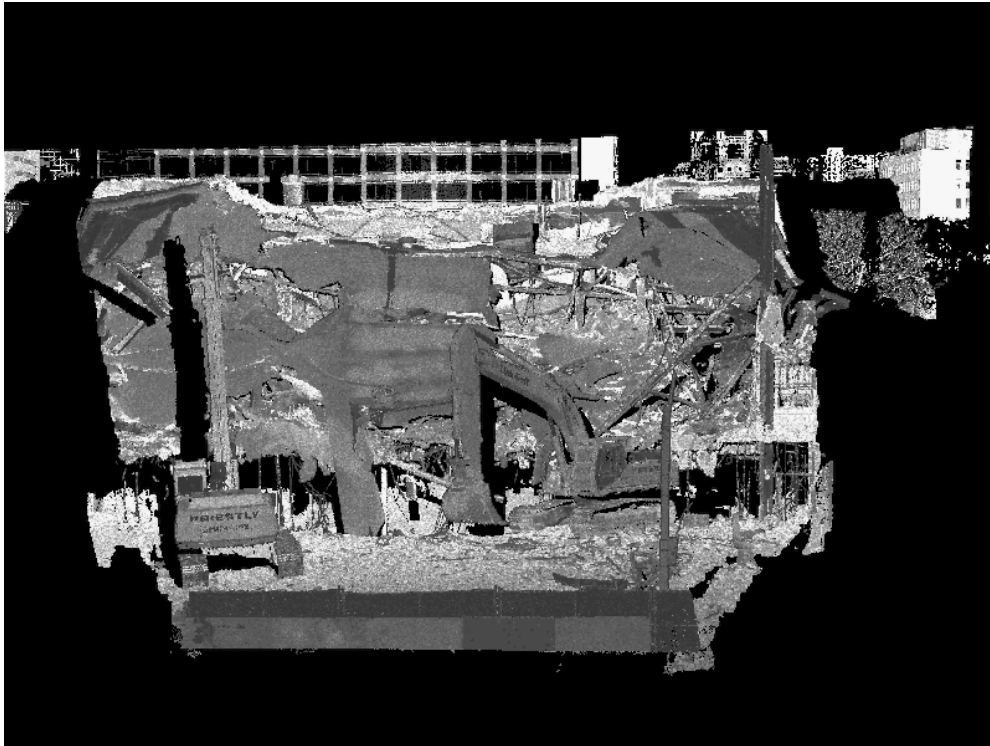


Image Courtesy Northway-Photomap Inc.

Figure 5: 3D laser scan of Uptown Theatre collapse

Relevant detail. "In some cases the police will hold off for you to finish your work," Francis notes. But in other cases, for example a traffic accident, "they want that highway open as quickly as possible." A time-saving technique is to "concentrate on capturing the details of the accident" while the scene is fresh and traffic is stopped. "Later, after cleanup and removal of the involved vehicles, you can come back and capture the background data to infill." Also, in some cases this is better "because the crowds have moved on and are not impeding data capture."

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Image Courtesy Northway-Photomap Inc.

Figure 6: Rapid-prototype model of Uptown Theatre collapse (front view)



Image Courtesy Northway-Photomap Inc.

Figure 7: Rapid-prototype model of Uptown Theatre collapse (top view)

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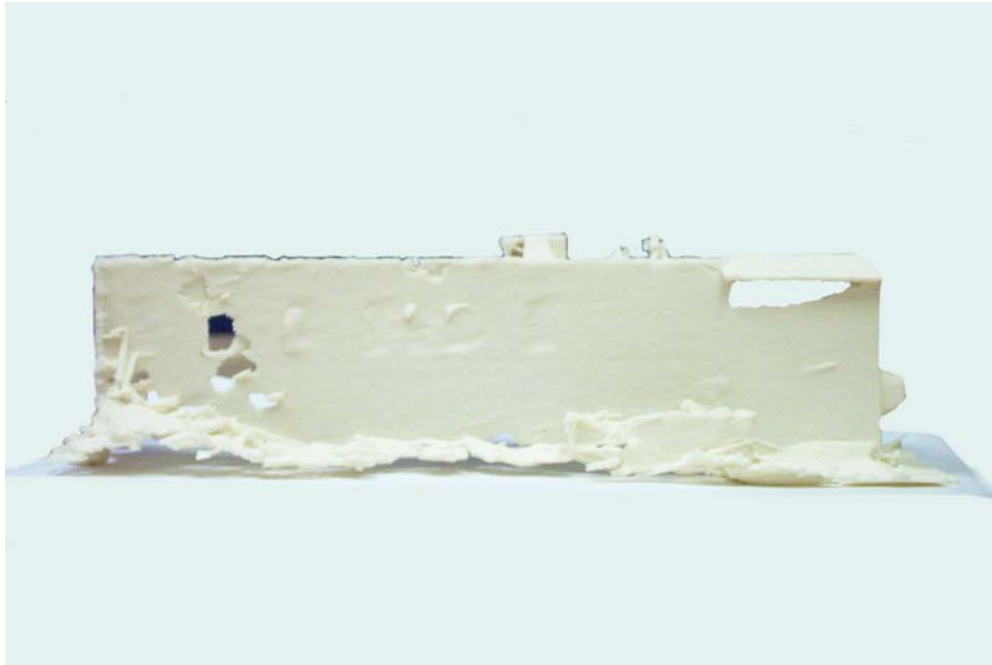


Image Courtesy Northway-Photomap Inc.

Figure 8: Rapid-prototype model of Uptown Theatre collapse (side view)

Coverage. “It is better to get more data than required, as long as we can stay within the provided timelines,” Francis advises. “You do not know where technology is going, or what the client may need in the future. The crew must have the intuition to ensure that all the ‘black holes’ are covered. Black holes leave questions in juries’ eyes.”

For greatest coverage, Northway-Photomap has deployed its ILRIS-3D scanner from several platforms: the typical surveyor’s tripod, planted from a variety of positions – dangling over the edge of a 32-story building, in the Uptown Theatre case – from the rear of a pickup truck on railway line projects, and from a truck-mounted pneumatic lift that can raise the scanner 25 feet above the target for a better angle of view. The lift can also be removed from the truck and wheeled inside buildings.

Escort. Francis recommends the scan team use an escort on police-sanctioned projects. These individuals are trained in the collection of evidence and can oversee the scanning process, and can testify in court about the activity of the scan team. Besides protecting the operator from contaminating the scene, “escorts are also important because as you’re going around the scene, they’re going to be telling you what’s really important. Most of the time, when they’ve arrested someone, they’ve already got a theory of what happened in the case and they usually share that with you.”

At the same time, “the largest hindrance the scan team will encounter on site is interested people” – part of the client’s team, other police officers or other authorized personnel within the crime scene area. Nonetheless, in some cases this can be an opportunity to develop new clients – the coroner’s office, or other departments investigating various aspects of the scene. “Your staff in the field is your most important sales force.”

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Preliminary deliverables. The ILRIS-3D system records the scan data in a file which, when parsed, yields four other files: a point cloud, a digital photograph, a log file detailing the scan specifics, and a calibration file. These files are created and stored in directories on a CD or DVD, along with a point-cloud viewer that lets the client walk through the scan data as needed for the investigation. “On a typical case, the investigator goes back to the scene between 8 and 12 times” – being able to “walk through” the 3D scene at their desk cuts down on return visits.

Before leaving the scene, Francis’s team cuts two CDs or DVDs with the scan data, sealing the case on one and leaving the other accessible. Both these CDs or DVDs are handed to the client on the scene. The sealed version is considered the original evidence, and remains sealed until needed at trial; in court the data can be unsealed and used to prove the validity of the deliverables created from the scan data, if required.

[To be continued next week.]

About Northway-Photomap

[Northway-Photomap Inc.](#) has provided aerial photography, control surveys and topographic mapping services since 1946. In March 2001 the firm decided to add terrestrial 3D laser scanning services as an alternative to aerial photography for clients’ mapping needs. “We got tired of advising our clients to go away because no photo existed of their site” – that’s how Francis explains it. The firm uses laser scan data to create high-accuracy topographic mapping deliverables for capital works projects, landfill site monitoring and more, and has applied scanning to architectural projects, capturing as-built conditions prior to expansion development or moving a historic structure. But “the most interesting of our scanning projects have been in the field of forensic documentation and analysis,” Francis reports. The firm took delivery of an Optech ILRIS-3D scanner and InnovMetric PolyWorks software July 16, 2001. After emailing all police agencies in Ontario about its capabilities, Northway-Photomap landed its first forensic project in August 2001. (Francis advises the sales process takes time, as most clients are on a fixed budget.) The company has executed approximately 15 forensic projects to date, working for the Toronto Police Services and more recently the Coroner’s Office as well as for private investigation agencies.

Laser Scanning for Forensic Investigation (Part 2 of 2)

By [Bruce Jenkins](#), Senior Analyst, Spar Point Research LLC

A murder scene, an auto accident, a collapsed building, a dilapidated stairway where a fall led to severe injury – Paul Francis has used laser scanning to document these and other scenes for forensic investigation. Last week we looked at how Francis and his team at [Northway-Photomap Inc.](#), Toronto, prepare for the scene visit, then go to the scene and capture it. This week follows the team through the rest of the process: assembling and analyzing the data, preparing and presenting final deliverables, and waiting for possible follow-up requests.

Data analysis

The first step in data analysis is to assemble the data from the firm's [Optech](#) ILRIS-3D scanner into a virtual scene. Northway-Photomap aligns and merges data from multiple scans using [InnovMetric Software's](#) PolyWorks. "In our police-sanctioned forensic work, the formation of a single virtual scene is the current final product," Francis reports.

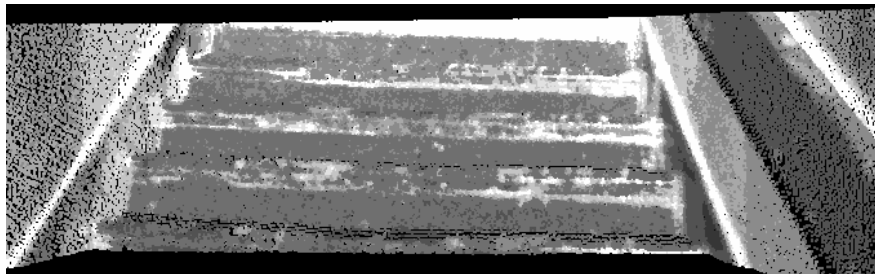


Image Courtesy Northway-Photomap Inc.

Figure 1: 3D laser scan of stairway (personal injury scene)

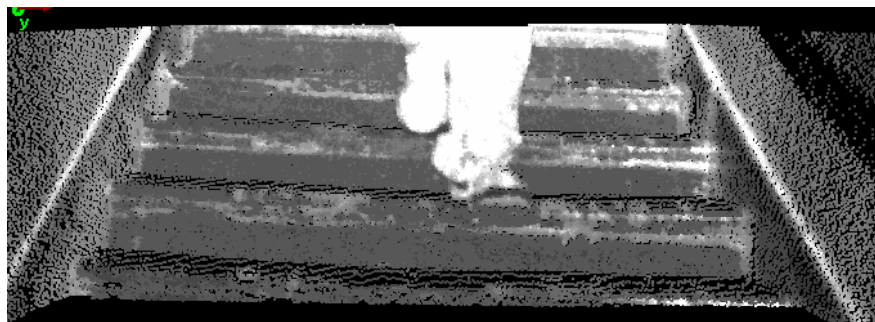


Image Courtesy Northway-Photomap Inc.

Figure 2: 3D laser scan of stairway under load

But forensic projects are not always associated with police work. "We have numerous clients who are forensic engineers or insurance companies," according to Francis. "These are projects where the analysis of the data can become our work. Determination of slopes – on sidewalks, pool slides or roads – can be

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work brought back to your office.” PolyWorks can be used to create PowerPoint presentations, AVI files, or more detailed analyses of the scan data – this varies according to the kind of project.

In traffic accidents, the depth of impact – the degree of vehicle deformation – indicates impact speed, and is a parameter needed for accident recreation. Also, Francis reports, “We have found that most policing agencies work in 2D – they want a single 2D line showing the outline of the vehicle.” Adding the third dimension “allows for much more in-depth analysis” but often is not requested – “an open door for scanner operators,” Francis believes. “When you start making deliveries to them, you have to go in and work with them to understand what they’re taking out of an accident scene.”

In one project Northway-Photomap scanned a set of stairs after an individual fell down them and become a quadriplegic [Figure 1]. The client wanted the scene documented because the stairs were going to be torn out. “The stairs weren’t in good shape – they were crooked, angled, and it was difficult for us to walk up them when we got to the scene.” On the scene it occurred to the team to scan not just the stairs, but also how they behaved in use. “We scanned the stairs with no one on them, then we scanned them a second time with a 225-pound volunteer” standing on the treads [Figure 2]. Processing the data in PolyWorks allowed Francis to show how far each tread flexed under load. “This was possible because the operator knew the ability of the software and hardware, and applied it to the situation on the scene.”

Again, “this portion of the project is not defined until you arrive on the scene, with your knowledge of your system, and become a consultant to the client,” Francis advises. “If this is a new client, make sure you keep them informed on the future uses you can see for the data.”

Creating final deliverables

The initial deliverable is presented to the client immediately on completion of data capture. Final products are delivered after much discussion with the client. “In some cases, knowing that you have the data is sufficient, and we are not called on again,” according to Francis. “However, in other cases the final product is something needed for a courtroom, and often that product is much different than anticipated.”

Within one week of data capture, Northway-Photomap delivers a project methodology, presentations of each individual scan, and a virtual site tour of the data captured. The methodology, typically presented in PowerPoint, includes an explanation of the technology and how the system works. “Remember that the client who hired you for the project understands the technology, but others viewing the data may need a layman’s understanding.”

The PowerPoint file also presents each individual scan completed. “We take this opportunity to expand upon the uses of the scan data in an attempt to further develop the market,” Francis notes. “Some scans are shown as simple grayscale point clouds, some as color point clouds, and some after being processed into a solid model format.”

A high-impact way to present data to juries is 3D physical models created with rapid prototyping. “Any evidence entered into a court must be able to go to the jury room for further examination,” Francis explains. “Say you’ve presented a project using special software to manipulate the 3D data – you need an operator who can do that. But you can’t send the operator into the jury room. So we’ve created physical models that can go right into the jury room. Jurors can look at the model, see the detail, for example how the car wrapped itself around the pole.” In one case, the collapse of Toronto’s Uptown Theatre, the physical model is being used in the coroner’s inquest. [See images in last week’s issue.] Northway-Photomap uses a [Z Corporation](#) rapid prototyping system to produce these models.

Last, “we present the final virtual tour of the site, allowing all the scans to be viewed at the same time. This deliverable is typically passed throughout the organization, and is viewed by many more than anticipated.” Often this presentation or some variation is the final deliverable.

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Wait period

Police work involves a lot of “hurry up and wait,” according to Francis. “So you capture the data, you deliver it, and if they need anything else you’ll get a call. You may get called to court; you may not.” In fact Northway-Photomap has yet to present its scan data in a courtroom, Francis reports. In several civil cases its data was used to help reach out-of-court settlements – some were settled “due to the existence of our scanned data, and the overwhelming graphical presentation that scanned data provides.” Meanwhile, in the three murder cases it’s been involved in so far, some have not yet reached court while in others the accused pled guilty. The firm is confident that “one day we will take our data to court and prove its reliability and accuracy.” Francis sums up, “They’re using lasers to catch people speeding. I take that as acceptance of the technology – in essence we’ve just added a couple of mirrors.”

Northway-Photomap normally works on a lump-sum basis for projects quoted in advance. “But if they call us and say, ‘We need you here right now,’” both data collection and post-processing are provided at an hourly rate.

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