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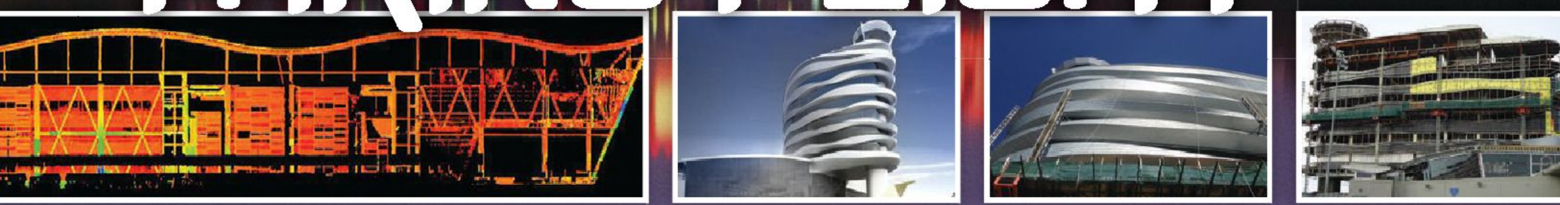

Edmonton Airport Project Depends on LiDAR to Become Reality

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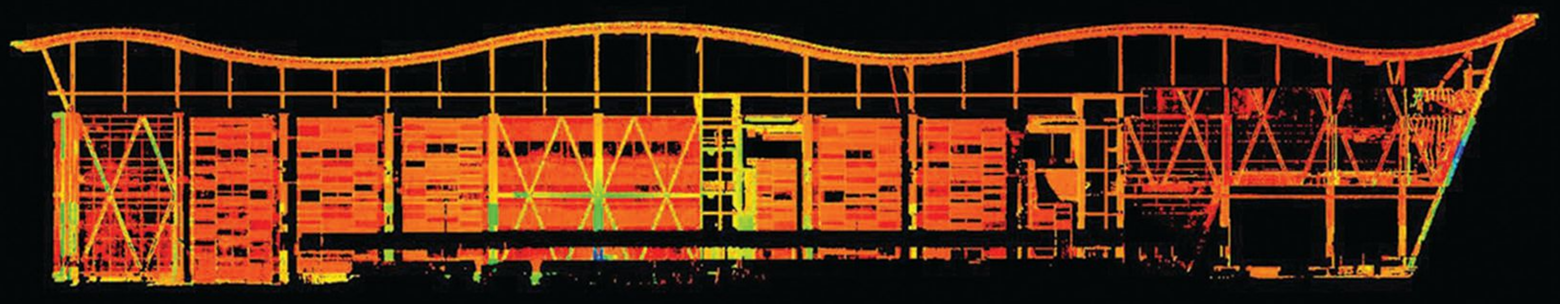


The Promise of SCANNING

Tronnes Surveys uses LiDAR to Help Realize a Beautiful Building

By Angus W. Stocking, L.S.

Tronnes Surveys has practiced in Alberta, Canada, for more than 40 years. President Stephen Tronnes took over from his father, not without a little resistance; "I went into it kicking and screaming," he said, laughing. "And now I've been here 20 years."

Before joining the family business, Tronnes majored in business and computers and said he was "a tech guy, a bit of a programmer and a database designer, and I later saw the need to take a survey law course." That background shaped him and shaped Tronnes Surveys, now a 25-person firm. Under his guidance, Tronnes Surveys has become one of Canada's most technologically progressive survey firms, using LiDAR, GNSS, GIS, robotic and reflectorless total stations, building information modeling (BIM) and point cloud solutions, and whatever else is needed to serve clients in construction, rail (Canadian Pacific Railway is a major client), roadway infrastructure, development, and municipalities. Interspatial Technologies, an aligned company also headed by Tronnes, develops and supports GIS solutions for African states from its headquarters in Nigeria.

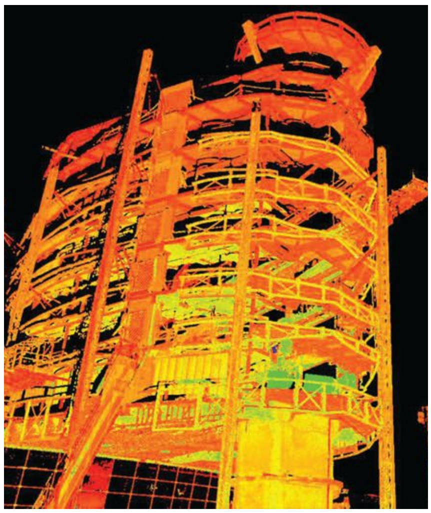
The company has been leading the way in BIM for several years. "We're ahead of some architects," Tronnes said. "We've really embraced it; on the civil side, we used Leica Cyclone, AutoCAD Civil 3D and BIM on 13 major interchanges on the Calgary Ring Road project, using the model as a way to get information to engineers, and then taking data from the model to use in layout. On the building side, we use Cyclone, and Revit, and that's really being driven by contractors, not so much by architects."

An all-Leica shop for 15 years, Tronnes Surveys keeps seven Leica Viva TS15s busy, along with multiple Leica GS14 and GS15 GNSS receivers. The company has been interested in laser scanning since they tested a Cyrax 2400 in 2002. In 2004, Tronnes Surveys took the plunge and purchased a Leica ScanStation 1. The firm now uses a Leica ScanStation C10.

"It's funny, we use our scanner every day," Tronnes said. "What we've done is just incorporate it into our day-to-day workflow." Tronnes compared scanning now to the early use of GPS receivers. "Initially, a lot of people were skeptical of GPS for surveying, and felt it was impractical. They didn't want to pay specifically for GPS use. The solution was to sell survey solutions, not technologies, and use GPS to accomplish those solutions more efficiently. And that's what we're doing with scanning; our clients don't need to know how we're meeting their needs, they just need a deliverable that works and, fairly often, scanning is the best way for us to do that."

In 2011, the firm's scanning expertise was relied on heavily when Tronnes Surveys was asked to step in on a tricky project involving the Edmonton International Airport's (EIA) new Combined Office Tower (COT), which includes offices and the air traffic control tower in an eight-story building. And it's an exceptionally beautiful building: A sleek, undulating zinc cladding system, meant to evoke Edmonton's sweeping plains landscape, cocoons the COT and strikes a very modern, distinctive note. It's the crown jewel of EIA, but actually installing the COT's cladding was a significant challenge for the surveyors and contractors.

Above: Tronnes Surveys views laser scanning as an integral part of BIM. Left: EIA's Combined Office Tower features an undulating zinc cladding system.



Above and left: Tronnes used the Leica ScanStation C10 laser scanner to capture accurate as-built data on the EIA Combined Office Tower.

WHAT MADE THIS PROJECT CHALLENGING? LET ME COUNT THE WAYS…

Tronnes Surveys was hired for the project by Thermal Systems KWC Ltd., the building envelope contractor and a regular client. Tronnes was actually brought in mid-project, when EIA accelerated building enclosure deadlines.

Thermal Systems also hired another subcontractor, Gehry Technologies, Inc. as an exterior fascia consultant. Gehry's role was to design and oversee the fabrication of the intricate truss-based mounting system that would hold the zinc scales in place; done well, the cladding would achieve the designer's graceful curvilinear vision … done badly, it could be an awkward zinc mess.

Gehry's trusses would all be individually designed and were to be mounted on hollow structural sections (HSS) installed by Thermal Systems. Picture 12,000 lineal feet of square tubing wrapped around the base structure, offset several inches by knife plates. Early on, Gehry made the (in retrospect, absolutely crucial) decision to work from an as-built survey of the HSS, rather than plans. That's where Tronnes Surveys came in; they were responsible for an as-built survey performed to 6 mm (about a 1⁄4 inch) tolerance that would locate all of the HSS's welded angle points and knife plates–ultimately, about 8,000 points.

The team faced a number of challenges:

- The COT building protruded into the tarmac of an active international airport, which imposed several restrictions–access to the tarmac was granted only in 30-90 minute intervals and only when no nearby flights were arriving, an airport security guard had to accompany crews at all times, and work could only be done when no planes were operating nearby.
- Unavoidable rooftop setups on nearby buildings had to avoid puncturing waterproof roofing membranes, and were also slightly unstable.
- Especially on higher levels of the COT building, access restrictions made angle-of-incidence an issue.
- Control was local, and somewhat complex due to contractor decisions.

As a final complication, the prime contractor (not Thermal Systems) was skeptical of scanning technology and resisted its use. But Tronnes didn't see any other way; "Conventional surveying would have required the gathering of about 8,000 points on the outside of a building, either with reflectorless technology, or with lifts," he said. "Mostly due to the access issues, neither option was very good. So we insisted on scanning the HSS." Tronnes won that argument, but winning meant he was now moving forward with a project that was not only challenging to begin with, but was taking place in a skeptical atmosphere.

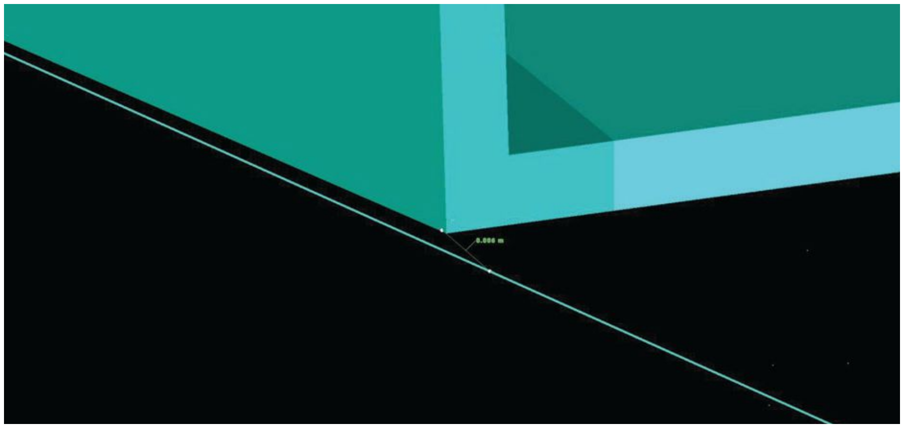
However, as later events proved, scanning was not only the right solution for this project … it might have been the *only* technology that could have delivered a successful outcome.

WHY AS-BUILTS ARE AWESOME

Work began with the establishment of a solid 3D control network based on punch marks on steel barrier posts (bollards) and drill holes in the tarmac. To make setups on adjoining rooftops practical, "mud slabs" were used as tripod rests; this prevented damage to the roof membrane and stabilized the ScanStation. Tronnes also established a policy of staying 10 feet way from the scanner during operation. Setups were always based on resections, with substantial overlap between scans so that registration could be used as a check on position.

Tronnes did catch one break: A coating used on the HSS reduced reflection, angle-of-incidence and scattering–this made the dataset tighter and more precise. Once control was established and setup issues were solved, the scan went relatively quickly. "In our first visit to the site, we completed the full scan of the seventh floor in eight setups that took less than half a day," said HDS Specialist and Sr. Project Manager Kent Nicholson. That was on Sept. 9, 2011; eleven days later, the first dataset was delivered to Gehry Technologies.

Gehry's analysis of the as-built data set uncovered a problem that contractors and surveyors know well: substantial variations between the plan and the constructed building. In this case, the variations were both vertical and horizontal, with an important difference between the two. The vertical difference was small, just 13 mm (about half an inch), and consistent; a global adjustment to the site's benchmark scheme resolved this issue to everyone's satisfaction. But the



The as-built dataset revealed substantial variations between the plan and constructed building, helping the contractor avoid expensive rework.

horizontal variations were larger–more than one foot in some cases. They were inconsistent, and they seemed to be caused by installation discrepancies in main structural components. This was contentious; had Gehry Technologies used plan dimensions for truss design, the rework costs would have been astronomical.

Nicholson said that laser scanning really proved its worth in this instance: "Likely, without scanning, we wouldn't have known that the main structure was not built exactly to design because of the building's unique, non-regular shape. And individual points in a conventional survey would have been questioned endlessly. But with the point cloud available, we were able to produce any measurements needed to make our case. Scanning may not have been ideal from the prime contractor's point of view, but it was definitely the best solution given the constraints, and in light of the variations revealed by our as-built survey."

Ultimately, onsite scanning was performed on 12 occasions over 17 months, often in less-than-ideal conditions. "The temperature swing during our scanning operations was 57ºC (102ºF)," Nicholson said. "The warmest day was 30ºC (86ºF) and the coldest, with wind chill, was a blistering -27ºC (-16ºF)." Despite these extremes, the scanner performed flawlessly.

PROCESSING THE DATA

Tronnes Surveys had contracted to send very specific information to Gehry–the lower surveyed edge of HSS truss rails and the vertices of that edge at deflection points and knife plates.

Extracting edges, vertices, and breaklines from point cloud data is a challenge that has only recently been solved in the latest editions of software. This project's tight tolerances, and the sheer quantity of edge detection that needed to be done, made line extraction a daunting task. "We struggled with the edge detection routine due to the many slight deflections in the actual HSS–often the edge fitting missed small deflections or skewed away from the steel," Tronnes said. "It was very time consuming; basically, every line and point provided had to be compared to the point cloud to be sure we were within 6 mm."

And the work really couldn't be avoided; Gehry Senior Project Consultant Jason Sidelko said, "With these types of projects, there are subtle differences of form, so precise geometry makes all the difference."

Fortunately, soon after processing began, Tronnes' Leica supplier, Spatial Technologies, set up a trial of Leica Cyclone-MODEL, which enables direct processing of point cloud objects into models. This helped substantially. "We reduced our data processing time by half with modeling," Tronnes explained. "It was easier, using models, to find points of intersection between pieces of steel." Edge extraction was still tedious, especially on upper levels where angle-of-incidence issues led to more "noise" in the point cloud. But various software tools, and plenty of man-hours, ultimately produced a very tight, useful data set. To keep things organized for Gehry, points were color coded by building level. Also, variations from plan, additional joints and plates, and potential points of conflict were described and highlighted.

FITTING IT ALL TOGETHER

Having detected plan variations with scanning, and having worked through the edge extraction issues, the actual layout of truss locations was relatively straightforward. Tronnes crews were able to do the work in just nine days. "We found that the designed truss locations, which were extracted from our model and centered on the HSS rails, fit very well," said Nicholson. "We were able to set out all truss locations from just three setups, and the layout points deviated from actual centers by 0-15 mm (0-0.6 inches)."

Using Tronnes' solid dataset, Gehry designed nearly 1,000 trusses and had them fabricated offsite. They were produced in just seven days–much less time than would have been required by onsite fabrication–and during installation, only one truss had to be field fitted. That's extraordinary success for this type of cladding work, and it made a difference in the final appearance of the tower building. "The incorporation of scanned, as-built steel data into our digital design environment allowed us to perfectly calibrate our trusses to existing site conditions," said Gehry Consultant Brendan Sullivan. "Without this step in the process, the smooth curvature of the final ribbon (cladding) surfaces would not have been achieved."

This was a successful project, despite major challenges, and it made a believer of the prime contractor. He requested as-built information of window mullions for glass installers, which could be extracted from the HSS scan, and he later contracted for a separate as-built survey of the air traffic control tower that tops the COT building. "He was impressed by the speed at which we could go from field to deliverable," Tronnes said.

All in all, the Edmonton International Airport Combined Office Tower project is an excellent example of the promise of LiDAR in building design and construction. This was a scanned survey that could not have been practically accomplished by any other means, and the survey was a big part of the successful realization of a beautiful, complex building.

Angus W. Stocking, L.S. is a licensed land surveyor who has been writing about infrastructure since 2002. For more information about Tronnes Surveys, visit www.tronnessurveys.com. To learn more about laser scanning for BIM, visit www.bimlearningcenter.com.