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PEERING THROUGH TIME

Peering Through Time with Laser Scanners

Sophisticated as-built surveys gradually reveal the mysteries of gothic cathedrals.

They have been revered and studied for nearly 900 years, but Gothic cathedrals remain mysterious. Documentary evidence for decisions made about design, engineering and construction is sparse at best. There are very few original plans, and those produced by modern scholars are of limited value, because it's hard to know what was actually measured, and how the measuring was done.

But just as laser scanning has been revolutionary in modern as-built construction surveying, enabling much more accurate design and speedier installations; it is also capturing highly accurate measurements of Gothic cathedrals and providing the basis for new insights into their design and construction.

> "I learned on Leica Geosystems machines, which are always rock solid."

Andrew Tallon is a leader in this field, and one of its few practitioners. As early as 2001, working as a graduate student on a team headed by Stephen Murray and Peter Allen, professors of Art History and Computer Science, respectively, at Columbia University, he saw firsthand a big Cyrax scanner as it captured France's Beauvais Cathedral, one of the most complex and daring examples of Gothic architecture.

Tallon continued to pursue his interest, after several more very positive experiences working with Murray, Allen and his graduate students, and eventually began to produce some of the earliest accurate 3D representations of Gothic cathedrals—with millimetric precision. These models are providing a window into the minds of the original builders and, after centuries, helping today's art historians to better answer some of the key questions raised by medieval cathedrals.

Left: Andrew Tallon scans Beauvais Cathedral from the roof with a Leica ScanStation C10.
Photo by Nicole Griggs

BY ANGUS W. **STOCKING, LS**

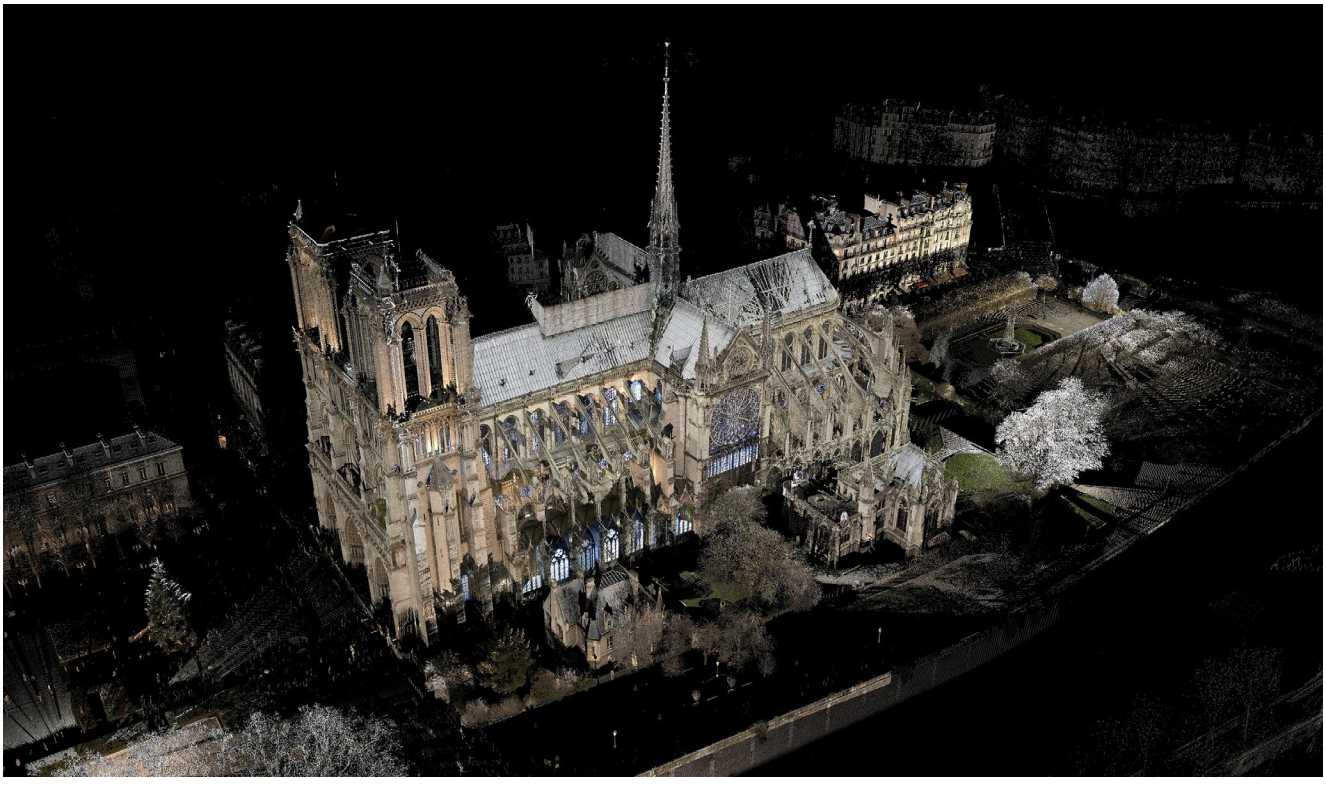
A colorized point cloud of Beauvais Cathedral in northern France.

The Cathedral's in the Details

Over the past 10 years, Tallon has become a laser scanning expert by any standard, primarily as a result of practical experience derived from dozens of scanning projects. In 2008, for example, Tallon, working with Allen's graduate students, took nine days to scan Bourges Cathedral in 52 scan stations. In 2013, he returned to Beauvais with his French colleague El Mustapha Mouaddib and graduate student Nicole Griggs and was able to perform a scan of 74 stations, with a twentyfold increase in measurement density, in just three days.

But Tallon is quick to point out that he has had a lot of help from others. Most of his work is funded by grants,

Tallon captures flying buttresses on Chartres Cathedral, also called the Cathedral of Notre-Dame, in Chartres, France. *Photo by Nicole Griggs*



A colorized point cloud of Notre-Dame.

and invaluable expertise and labor have been provided by fellow academics Murray and Allen as well as Paul Blaer, along with expert assistance from French surveyors Pierre Antoniotti and Antoine Billault. His students at Vassar College have also made key contributions. One has just completed CAD renderings based on the laser scan of Bourges Cathedral, for example, which will become the official plans used by the building architect; another student will soon begin to analyze a 94-station scan of Canterbury Cathedral, undertaken recently by Tallon with a ScanStation P20.

Leica Geosystems has also been integral to Tallon's success. "The people at Leica Geosystems have been great," he says. "I learned on their machines, which are always rock solid. I learned Cyclone [software] early on and still use it, and they've been very generous with equipment and expertise. [Leica Senior Technical Support engineer] Andrea Fournier has always been there for me with good answers and with impressive patience—especially since I've no official training in all of this."

> "In the field of architectural structure, this is the closest you can ever get to proof."

Tallon also singles out Jeff Hull, the rental manager for Leica Geosystems in the U.S., and Benjamin Outrey, the sales manager for Leica Geosystems in France, for their invaluable assistance.

After his initial scan with the Cyrax machine (the manufacturer, Cyra Technologies, was acquired by Leica Geosystems in 2001), Tallon worked with the Leica HDS3000 on a 2005 scan of Notre-Dame. "Notre-Dame presents a lot of questions about how it was put up, and how it stays up," Tallon says. "For example, the moment at which flying buttresses were first used here was an open question—and by studying deformation patterns revealed in the scans, I was able to produce new and

compelling evidence to back up the claim made by my mentor, Stephen Murray, that the buttresses were conceived and used there earlier than previously believed. With the scan, I could really demonstrate this. In the field of architectural structure, this is the closest you can ever get to proof." Since 2008, Tallon has also completed scans with the Leica ScanStation C10 and P20 laser scanners, using Leica Cyclone point cloud processing software to process the data.

A colorized point cloud of the north elevation of Bryn Athyn Cathedral.

The Spiritual Importance of Plumb

With these tools, Tallon continues to learn more about Gothic construction techniques and the architectural principles that informed their design. Some aspects are obviously inspired directly by religious principles. Floor plans, for example, are typically cruciform, and the very vastness of the interiors and the suffused, colored light resulting from the unprecedented use of huge stained glass windows was intended as a representation of heaven.

Tallon's research into a less well-known aspect interface between spirituality and architecture, a link made in the Middle Ages between mural and moral rectitude, has taken him back to the United States. William Henry Goodyear (son of the inventor of vulcanized rubber) was a respected authority on art and architecture, and curator of fine arts at the Brooklyn Museum. He was also a passionate advocate for the idea that the Gothic designers deliberately introduced slight leans and curves in the structural members as a means, he believed, of correcting problems of perspective and to introduce warmth and life to what might otherwise be coldly symmetrical spaces.

Goodyear was correct in his assertion that many Gothic cathedrals were measurably out of plumb; however, the action was not deliberate. Using his scans, Tallon has been able to show that the deformations now found in Gothic cathedrals are the result of movement over time. So Goodyear wasn't detecting higher orders of perfection, he was simply observing the impermanence of man's best efforts to achieve perfection with available technology… and perhaps that is fitting.

Angus W. Stocking, LS, is a licensed land surveyor who has been writing about infrastructure since 2002. Andrew Tallon is an associate professor of medieval art and architecture at Vassar College. For more information about laser scanning solutions, visit hds.leica-geosystems.us.

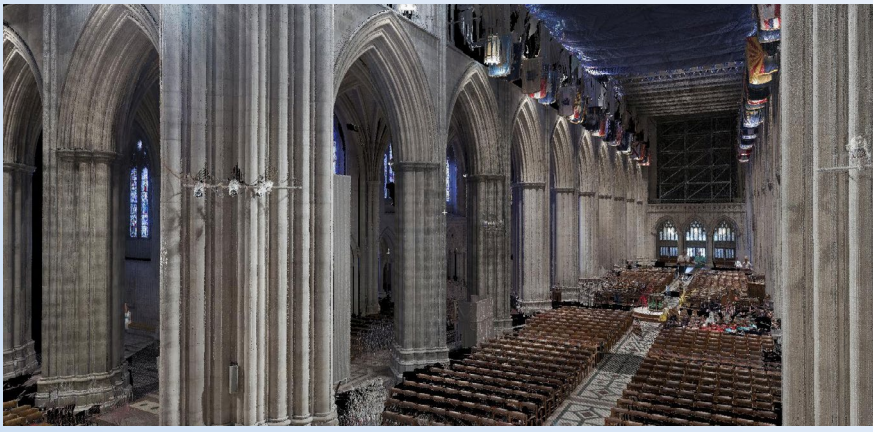
Try It Before You Buy It: The Benefits of Rentals

Architects, general contractors, builders and other professionals increasingly recognize the value of using highly accurate point clouds captured with 3D laser scanning to inform and validate their models. Laser scanning is a fast, easy and accurate way to provide quality assurance checks, capture progress milestones, perform completed work assessments and create as-builts for facilities management. With laser scans, project managers and engineers can easily compare real-world construction against the model to identify any deviations before they impact the schedule and budget. Laser scanning is the best way to create a true as-built record as work is performed in the field, providing data for assessing work completed at specific points in the schedule and visibility into every system even after drywall and finishes are installed and throughout the life of the building.

Despite the documented benefits, however, many companies still balk at the initial price tag. "There really ought to be a way to try out laser scanning on a project, to see if it's the right fit for your firm," says Jeff Hull of Leica Geosystems.

Hull manages a rental program for the 3D laser scanner manufacturer that aims to do just that. The program keeps 16 Leica ScanStations in circulation, with flexibility being a main feature of the program:

- "Straight up renting, for individual projects, is a great way to go," Hull says. "Instead of a capital expense, rental of the scanner becomes an operational expense which can be transferred to the project, rather than absorbed."
- Alternatively, companies can rent with the intention of owning. "Many of our customers will rent up to a point, then convert to purchase," Hull says. "We have very generous incentives where we credit most or all of the rental fees—renting becomes like a long term demo in that way."
- It's possible to buy the necessary software, such as Leica's Cyclone point cloud processing software, while continuing to rent scanning equipment. Hull says, "This is a great way to learn more about scanning, while renting strategically for early scanning projects. Even without a scanner in the shop, firms can be working with point clouds, preparing high quality deliverables and creating value for their clients."
- "It's not just scanning," Hull points out. "Many construction firms are wondering if robotic total stations are the way to go, and working with a Leica Nova MS50 MultiStation is a great way to settle that question." This innovative solution, which was introduced in 2013, combines a fast, high-precision total station with a high-definition laser scanner. The point clouds captured by the integrated scanner don't require registration, making it an easy entry point into 3D laser scanning for teams without prior point cloud processing experience.



A colorized point cloud of the interior of Washington National Cathedral in Washington, DC.

The rental program is also one way that Leica Geosystems participates in projects that are historically interesting or have a public good that outweighs consideration. For example, "We were happy to get involved with Andrew Tallon's scan of the Washington National Cathedral (see article)," Hull says. "It was an interesting project in itself, and learning more about the history of one our great buildings is clearly a good thing."

Firms that are interested in 3D laser scanning but aren't quite ready to make a capital investment can still reap the benefits of using highly accurate point clouds in their projects. "Renting is an easy, cost-effective way to get into scanning," Hull says.

Learn more at rentals.leica-geosystems.com.