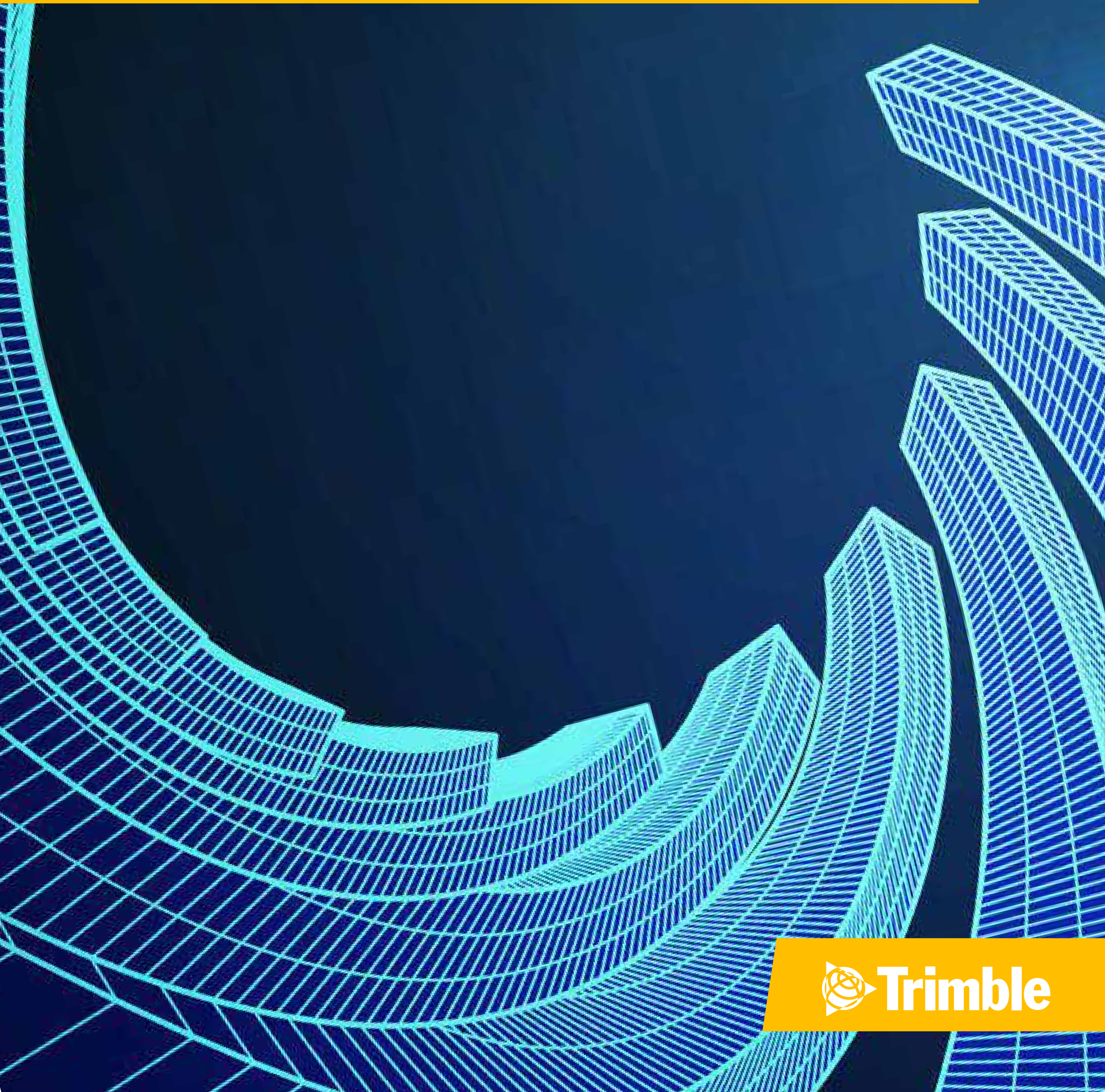
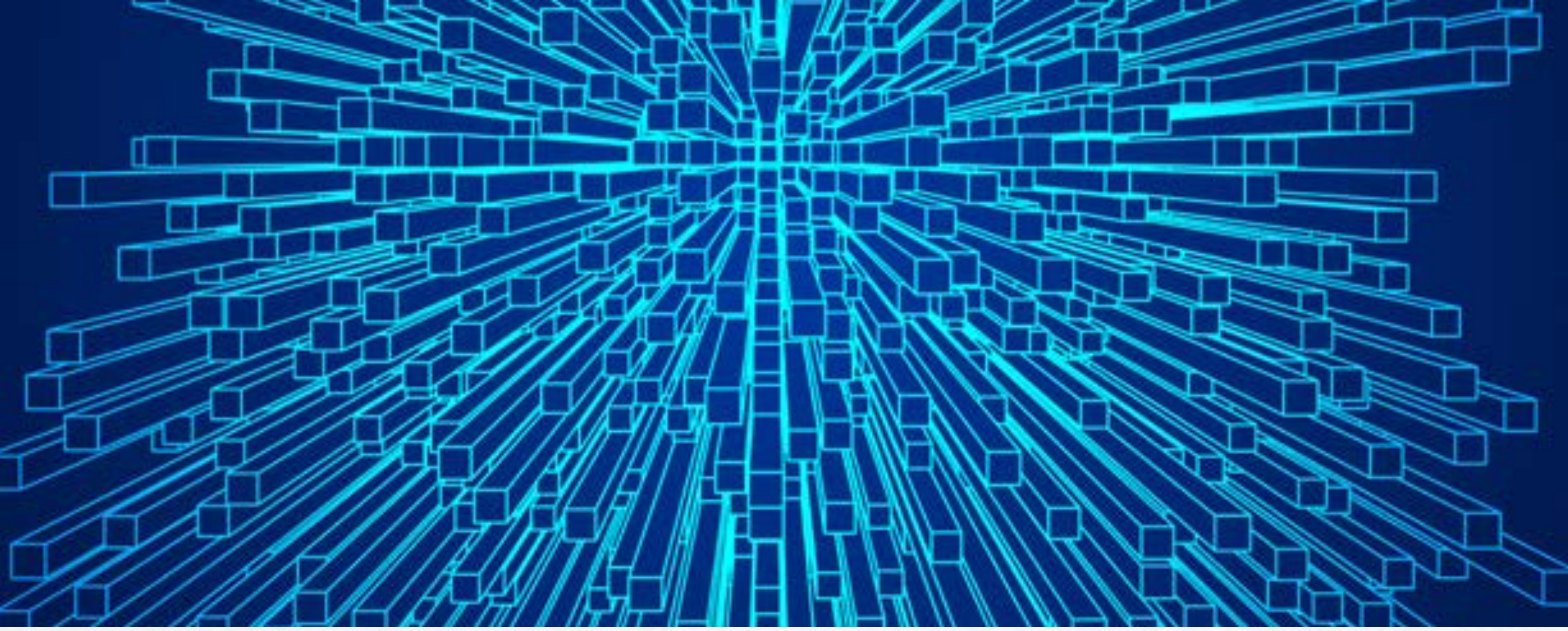
THE EVOLUTION OF 3D LASER SCANNING:

PAST, PRESENT, AND PREDICTIONS



Trimble



A study of the evolution of 3D laser scanning is very much a study of tech development in microcosm. It's the story of seemingly outrageous ideas and the ingenuity that made them reality — the race between imagination and technology, each struggling to keep up with the other. It's the story of a powerful set of hardware and software tools that have finally reached that optimal balance between potential and practicality, which is where 3D scanning in construction stands today.

But, before we talk about the exciting opportunities available for construction pros today, let's take a walk down Memory Lane to see how we got where we are, and what that can teach us about where we're going.

IF I HAVE SEEN FURTHER, IT IS BY STANDING ON THE SHOULDERS OF GIANTS.

— ISAAC NEWTON

THE COLORFUL HISTORY OF 3D LASER SCANNING

The basic problem that 3D laser scanning solves is not a new one: In order to properly understand and affect objects, nature, or anything else, we first need to fully understand what that object truly is, right now. Many innovations in science and technology came about specifically to address that need.

Likewise, scientists, engineers, and laypeople have long understood the powerful potential behind digital design and drafting as a tool to enhance the construction workflow. But, for many years, that potential couldn't be realized because the ideas outpaced the technology. The following is a brief history tracing that journey.

The 1950s

In 1953, the United States military began experimenting with an optical measuring device using light and high-speed shutters. They assigned the project (and the device) the name LIDAR before lasers were even invented.

Meanwhile, across the Atlantic, the Ferranti Company of Scotland released an electronic probing machine for precise measurement called a Coordinate Measuring Machine (CMM). The first to be released was a 2-axis version.

These two projects, realized thousands of miles apart, form the technological basis of what would eventually make 3D laser scanning possible.

The 1960s

Building off the invention of the laser early in the 60s, the U.S. Military upgraded the LIDAR system to integrate lasers for precise distance measurement in topographical and investigative scenarios, including portable and airborne devices (beginning in 1963) such as the XM-23. This portable laser-measuring device was soon declassified and became popular in civilian applications as well.

Meanwhile, DEA in Italy had designed a new 3-axis CMM which offered a more robust coordinate measuring system for physical objects.

The 1970s

Within just a few years, as the 70s dawned, Italy's DEA had integrated remote computer control to their 3-axis CMM, creating a faster, more precise probe-based "scanning" option for industrial use. The system was still far too slow for highly detailed applications, but knowledge of its potential spawned a lot of innovation in subsequent years.

Using DEA's probing concepts, but in a much more time-intensive process, students and professors at the University of Utah's Computer Science department developed wholly new algorithms to allow a computer to effectively translate 3D models based on real world data. They then manually plotted and measured points and lines across the surface of a 1968 VW Beetle in 1972.

"They mapped out polygons right on the Beetle itself, and measured every line in what must have been that uniquely scientific mix of tedious and exciting. The resulting dataset was entered into Sutherland's programs, and produced **this first 3D wireframe model of a car. Actually, the first 3D model of any physical-world thing, ever."**

Also in 1972, the people who would eventually found Pixar Animation Studios created the first example of 3D computer animation with a short film entitled, "The Human Hand." As highlighted in the film itself, this impressive feat involved a combination of intensive software development and the use of a computer-connected probe scanner similar to what DEA had created.

The 1980s

As the various technologies that led to modern 3D laser scanning continued to evolve — mostly separate from each other — it became apparent that the physical limitations of the available hardware and software presented a practical ceiling that was going to hold innovation back artificially.

As processing speed, memory capacity, and display technology began evolving faster and faster, those limits slowly rose to reveal the full potential inherent in the technology.

Early in the 1980s, the "stripe" method of optical scanning was developed, proving to be both faster and more accurate than "point" or "area" methods. As a result, "stripe" became the preferred scanning method for commercial scanning applications developed later on.

In 1984, a great milestone came when Cyberware Laboratories of Los Angeles, California released their "Head Scanner," a stripe-based laser scanner designed to create a 3D computer image of the human head to be used for animation purposes in the entertainment industry. This same technology eventually evolved into a full-body scanner design which is (with appropriate updates and enhancements over the years) still in use today.

Table 1: Typical specifications of the components of commercial image processing systems

Year	CPU/RAM	Image memory	HD capacity	Camera resolution
1980	64 KB	512 KB (*)	5 MB	(**)
1985	512 KB	2 MB (*)	20 MB	256 KB
1990	2 MB	16 MB (*)	100 MB	1 MB
2000	200 MB	100 MB	GB	4 MB
2010	4 GB	2 GB	TB	8 MB
2014	64 GB	32 GB	10 TB	16 MB

(*) with special memory architecture
(**) video cameras with camera tubes

The 1990s

In 1992, the French company MENSI (now a Trimble company), introduced the S-series 3D laser scanners, primarily used in industrial applications such as nuclear power plants. In 1993, Cyra Technologies produced the 3D laser scanner that was fast, accurate, and inexpensive enough to gain wide acceptance among surveyors and engineers in the field. In comparison to today's scanners, these artifacts were incredibly slow and imperfect. But compared to manual surveying and measurement techniques routinely employed at the time, it was a huge step forward and a sign of what the increase in computer performance and storage had made possible.

The very next year, 3D Scanners released the REPLICA, the machine representing an incredible leap forward in speed and accuracy for highly detailed scans. It also gained wide adoption in the industrial field.

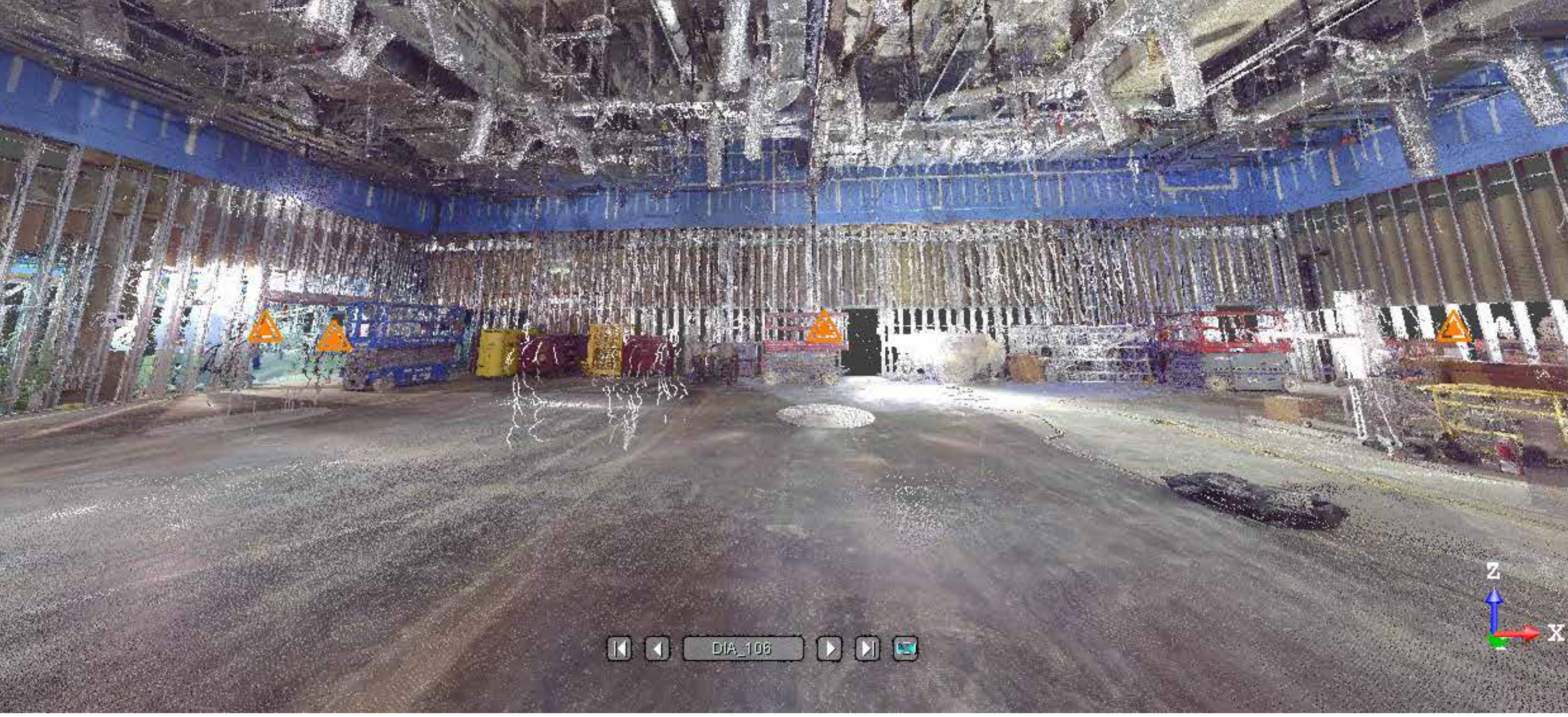
Two years later, in 1996, 3D Scanners perfected the design with ModelMaker, a combination of manual digitization and stripe laser scanning widely accepted as the world's first Reality Capture System. ModelMaker was able to accurately produce complex models and digitize those models with texture and color in just minutes.

The 2000s

As the 21st century began, ModelMaker remained the gold standard in 3D laser scanning, with numerous similar designs appearing from various manufacturers. The real measure of growth in the early 2000s involved the explosion in computing speed and power, making incredibly complex and detailed scans both possible and practical for many industries while simultaneously reducing the price of even the most cutting edge scanning technology.

In 2001, MENSI released the GS-series laser scanners that were the first to rotate 360 degrees horizontally, making laser scanning more acceptable for Geomatics applications such as surveying. In 2005, Trimble released the GX-series the first laser scanner that offered a true surveying workflow with the inclusion of compensation allow the instrument to be set up over standard survey control. In 2007, low level scanning technology was combined into a standard robotic total station with the release of the Trimble VX. This was followed in 2016 with the Trimble SX10 that combined powerful scanning, imaging, and total station technology into one instrument, making a true transitioning for everyday use of scanning for surveyors.

The closely-related field of 3D printing saw similar rapid growth based around computing ability and the dropping cost of the technology. In December of 2014, NASA made history by emailing the results of a 3D laser scan to a microgravity 3D printer aboard the International Space Station (ISS), resulting a specialty ratcheting socket wrench being the first object to be designed on Earth but manufactured off-planet.



TODAY'S 3D LASER SCANNING CONSTRUCTION ENVIRONMENT

Today's construction workflow is highly dependent on technology. From BIM-related design and detailing to software that aids in the management of complex projects, construction firms and MEP professionals can't be competitive today without relying heavily on hardware and software solutions designed to increase efficiencies and automate processes throughout the entire project lifecycle.

Appearing at various points along that workflow for different types of projects, modern 3D laser scanning has proved an invaluable addition to the tech toolbox used by architects, designers, detailers, and many other professionals to inform their construction plans and provide valuable as-built data before and during the project.

With today's computers offering incredible storage and processing speed, along with unprecedented mobility at a very low price point, the modern commercial-grade professional 3D laser scanner used in the construction trades offers scan detail and options that were unheard of just a few years ago.

The Hardware

For example, the **Trimble TX6 3D laser scanner** offers state-of-the-art speed, and high precision, creating the high quality results needed for comprehensive worksite data collection. The Trimble TX6 lets contractors gather data more quickly from each setup while the long range capacity reduces the number of setups needed to get the job done, all while providing high levels of accuracy and flexibility.

Whereas Trimble's first forays into 3D scanning offered a top speed in the realm of 74 points per minute, the TX6 boasts an average speed of 500,000 points per second, along with WiFi for remote control of the scanner. The **Trimble TX8** model doubles that speed and also incorporates WiFi for wireless control via a smartphone app upon completion of a scan.

While the TX models are powerful tripod-based static scanners, the **Trimble DPI-8 Handheld 3D scanner** provides unmatched speed and accuracy in a convenient handheld laser scanner that's optimal for tight spaces and unique conditions.

In all these cases, powerful hardware provides exceptionally fast but precise scanning with a keen eye for detail. But, left in a vacuum, the vast amount of data these scanners collected would be of no value. That's where 3D scanning software comes in.

The Software

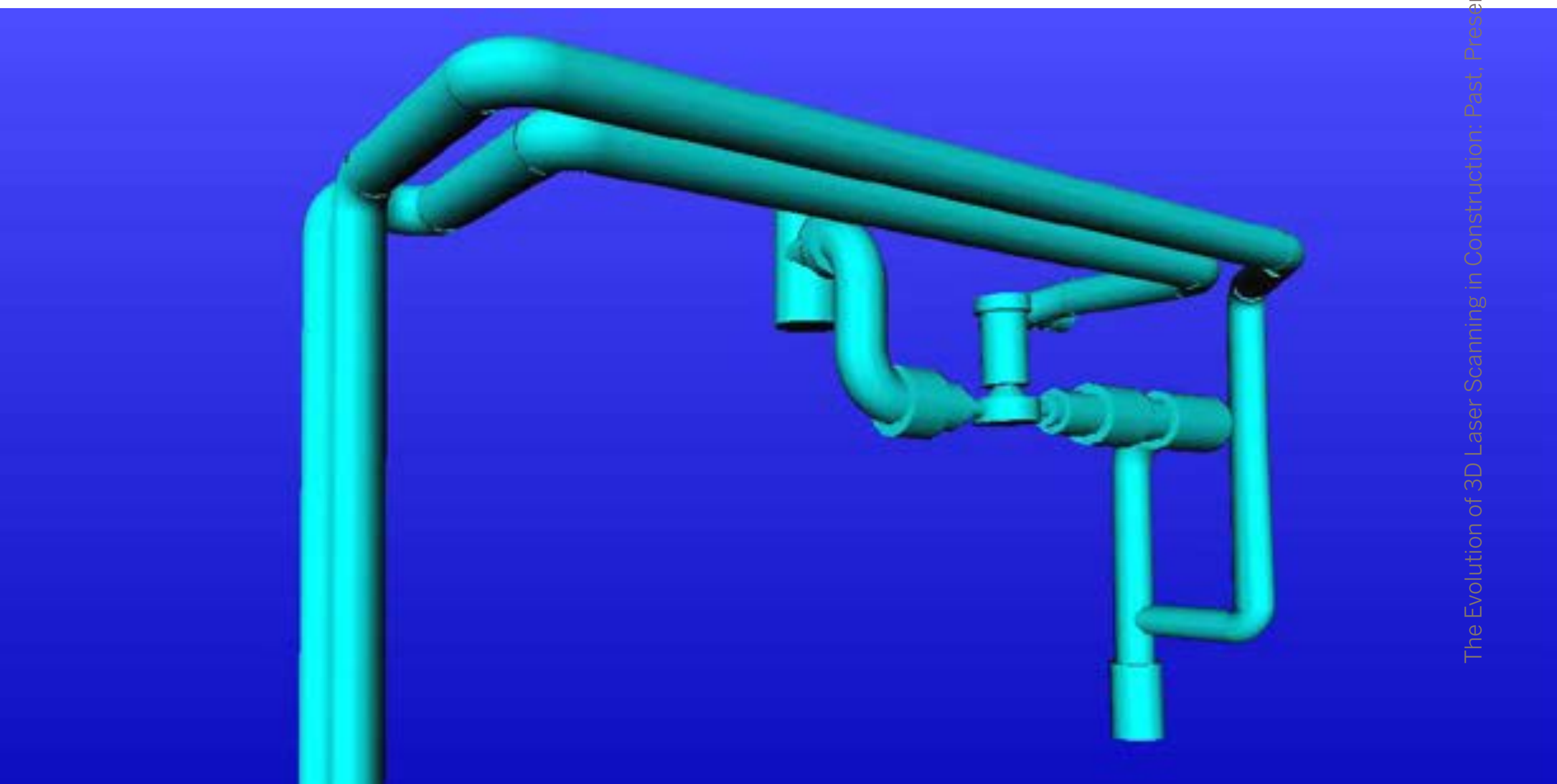
The job of 3D model rendering software is to make sense of raw 3D scanning data and manipulate it into information designers and other professionals can use.

Trimble RealWorks is a state-of-the-art rendering software that automatically registers point cloud data from laser scanners, offers tremendous power and versatility for enhancing and augmenting the scanned data for greater detail and clarity, then facilitates export to popular CAD and BIM packages for detailing work.

Trimble EdgeWise takes that middle step even further with greater flexibility and modeling acumen, allowing professionals in the field to produce BIM-ready models faster. By automatically identifying pipes, conduits, and other structural components, EdgeWise quickly and accurately models them based on a vast built-in library of common elements.

At the other end of the scanning-rendering-modeling workflow is the CAD or BIM software itself, which estimators, designers, and detailers use to **create fully functional 3D models** based on accurate as-built data from the 3D laser scanners.

The speed, accuracy, and efficiency of the modern BIM-based construction workflow — including all that goes into 3D laser scanning — has transformed the construction trades over the last several years.



THE FUTURE OF 3D LASER SCANNING IN CONSTRUCTION

It doesn't take a prophet or a bold futurist to see where laser scanning in construction is headed. It's merely a common sense trajectory based on what's already occurred in the past and what's happening right now:

CONTINUED EXPONENTIAL GROWTH IN COMPUTING SPEED AND POWER

There's no sign of the increases in computing speed and power stagnating or even slowing down anytime soon. As the hardware continues to improve, it will make 3D laser scanning faster, more accurate, and more affordable, opening applications up for more and more people to take advantage of.

RAPID FORECASTED MARKET GROWTH

For the reasons noted above, we can expect 3D laser scanners, along with the hardware and software supporting them, to continue growing in adoption across construction and many other industries. As the technology becomes more affordable, smaller companies and even individuals will begin taking advantage of the power of laser scanning.

CREATIVE INCREASE IN USE AND APPLICATIONS

Another natural offshoot of lower prices and market growth will be new and exciting ways to use this powerful technology, both inside and outside of the construction industry. No doubt, current experts in 3D laser scanning will need to continue to learn and expand their horizons to keep up with what will be possible in the years to come.

INTELLIGENT POINT CLOUDS

The next major step in rendering software will eliminate the current manual aspects of the point cloud registering process. While today's software does an excellent job of identifying structural components most of the time, there is still a margin for error, which leads to manual verification on nearly every portion of the scan. Combined with powerful component libraries built into the software, a skilled BIM professional can quickly pull together a flawless rendering of the scanner's point cloud data.

In the near future, the manual aspects of the process will become obsolete as AI-powered intelligent point cloud rendering software reaches 100% reliability.

The future of 3D laser scanning in the construction trades is truly exciting to contemplate. If you'd like to learn more about what's happening today in construction industry laser scanning, or if you'd like to be a part of that exciting future, **contact Trimble today** to speak with an expert who can help.