# Technology White Paper

## Large-Volume 3D Laser Scanning Technology

### Overview

Industries and users who traditionally work with two-dimensional plans and schematic diagrams are increasingly discovering the advantages of three-dimensional planning and documentation tools through the use of 3D laser scanners. Traditionally, measurements are collected using a combination of tools such as measuring tapes, total stations, digital cameras, and laser range finders; however, the use of 3D laser scanners allows companies to gather measurement data with a single solution while significantly reducing data collection errors and streamlining the overall workflow.

Capturing high resolution three-dimensional images of complex environments and geometries, large-volume 3D laser scanners provide a fast, efficient way to capture millions of data points for use in comprehensive 3D models or detailed reconstructions. Used in applications ranging from forensic and crime scene investigation to surveying, facility management and historic preservation, 3D laser scanners are a versatile, accurate solution that allows companies to obtain data they previously couldn't, helping them to make more informed decisions while saving valuable time and money.

### Types of Laser Scanners

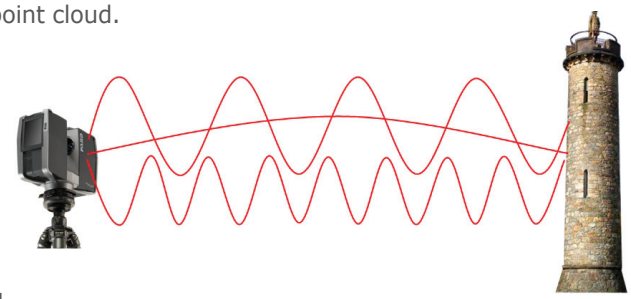
Laser scanners are non-contact devices that use either time-of-flight or phase-shift measurement technology to capture millions of discrete points of a real-world object or environment. Time-of-flight, or pulse measurement systems emit a single pulse of laser light, determining the distance to the surface by measuring the time of flight needed for the reflected light to come back to the distance sensor.

Similarly, phase-shift systems also emit a laser light; however, in phase-shift technology, the laser is emitted at a specific frequency, and the reflection of this wavelength is "shifted" or "displaced" by its impact on a surface. The displacement of the reflected wave allows for the precise calculation of the distance between the point of impact and the scanner. In general, phase-shift scanners are faster, more accurate, and provide higher resolution data in comparison to time-of-flight scanners.

## How It Works

Laser scanners use infrared laser technology to produce exceedingly detailed three-dimensional images of complex environments and geometries in only a few minutes. The resulting images are an assembly of millions of 3D measurement points, known as a point cloud.

The laser scanner works by emitting a beam of infrared laser light and reading the energy reflected back to the scanner to place a point in 3D space.



The laser is sent from the scanner onto a rotating mirror that projects a flat plane of laser light out from the scanner. The entire head of the scanner then rotates, sweeping the laser across the desired area. Objects in the path of the laser will reflect energy back to the scanner and the scanner will place a point in 3D space.

The density of the points collected is controlled by the rotation speed of the scanner. The slower the scanner turns, the denser the pattern of points collected, while the faster the scanner turns, the resulting point cloud is less dense.  In this manner, millions of discrete measurements can be collected in a matter of minutes.

The use of reference targets or objects in the scan environment can be used to tie together multiple scans, each on their own coordinate system onto a single, aligned coordinate system.  This allows extremely complex environments to be documented quickly and accurately.

## Comparison to Other Methods

Traditional methods for capturing complex 3D environments include steel tape measures, piano wire, plumb bobs, laser range finders and total stations. All of these devices work well within the role for which they have been designed: single point measurements. These traditional methods of collecting data can be extremely user intensive, time consuming, and can result in inconsistencies in measurement across different users.

The process of documenting a complex 3D environment using traditional methods can take days, weeks, or even months, and at the end of this process perhaps only thousands of measurements have been collected, which is a relatively small number to thoroughly document an environment. In many cases, traditional methods of measurement result in missed data points, and return site visits must be completed in order to gather all the necessary measurements required to provide comprehensive documentation.

Using 3D laser scanner technology, millions of discrete measurements can be captured in every scan. Light weight and easy to set up, a laser scanner can access hard to reach overhead areas without the need for complex scaffolding and can operate in low or even no-light environments. By collecting multiple scans from

various positions, a complete project may contain hundreds of millions or even billions of points, recreating the complex spatial relationships of the 3D environment.

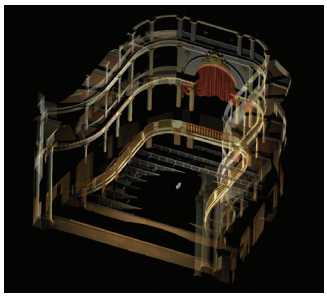
## Main Industries and Applications

The versatility, ease-of-use, and accuracy of a 3D laser scanner allow it to be used across a multitude of different industries and applications.

*Law Enforcement:* For law enforcement officers, laser scanning is a highly effective tool for forensics, crime scene documentation, and accident reconstruction. Preserving a digital replica of a scene that can be measured and analyzed later minimizes the time necessary for an officer to spend on-scene, while producing a highly effective visual for use in the courtroom.

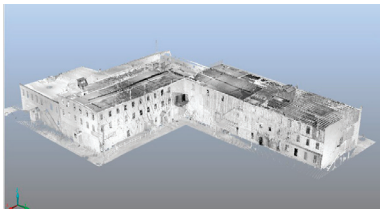

*Oil & Gas / Piping Documentation:* Laser scanning is very effective at documenting oil platforms and refineries to aid in engineering, maintenance, and planning processes. Complex piping structures can be accurately captured, providing clash detection and avoiding costly on-site installation issues.

*Heritage & Historical Preservation:* Capturing 3D as-built documentation of fragile, historic structures with laser scanners allows archaeologists and researchers to gather necessary measurements with a non-contact device – reducing the risk for further deterioration, and pinpointing areas for restoration and conservation.



*Surveying:* For surveyors, 3D laser scanners can be used in place of, or in conjunction with traditional tools such as total stations to fully capture manmade or natural objects for a variety of uses including volume calculations, as-built surveys, and topographic surveys.

*Architectural & Civil Engineering:* Implementing 3D laser scanning to capture as-built documentation of existing buildings and structures such as bridges provides architects and contractors with exact dimensions, which can then be used to develop Building Information Models (BIM), or used in retrofit projects to ensure in-process quality control.



*Asset & Facility Management/Documentation:* 3D documentation of complex factory and plant installations provides users with very precise 3D CAD data for use in facility management, maintenance and asset documentation.

## Summary

Providing a highly efficient and accurate way to capture three-dimensional snapshots of environments, 3D laser scanners help to streamline workflows across a number of diverse industries. By allowing critical surfaces and environments to be measured with a level of confidence and speed not possible with traditional tools, 3D laser scanners provide users with a way to deliver robust models that can revisited digitally at any point in time.

## The FARO Solution

FARO has used their extensive knowledge of real-world applications to develop a revolutionary, easy-to-use, large-volume laser scanner. The FARO Focus3D is a high-speed, non-contact laser scanner, offering the most efficient method for 3D documentation. The scanner's compact size and weight, combined with advanced sensor features including a compass, height sensor, and dual axis compensator, enable it to provide a comprehensive, robust solution that helps streamline the overall data collection process, from scanning to registration. Delivering photorealistic color scans through an integrated color camera and an intuitive touchscreen display, the FARO Focus3D is a leap in 3D laser scanner innovation and efficiency.

To learn more about the Focus3D, please visit: www.faro.com/focus