



# A Project Manager's Guide To Laser Scanning

A Quantapoint White Paper

by

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## **ABSTRACT**

### Meeting Project Objectives Through Laser Scanning

Laser scanning is quickly becoming a common technique for the collection of as-built data for engineering and architectural design projects. The potential of laser scanning for saving time and money coupled with its ability to enhance the design process and reduce construction errors makes it an attractive alternative to manual data collection techniques. Project managers are being increasingly called upon to adopt this exciting new technology, but there has been little information available to aid the specification of laser scanning technology and services. This paper helps to address this need and is written for engineering and architectural professionals who have a need to create bid specifications for laser scanning services.

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## **QUANTAPOINT WHITEPAPERS**

As the acknowledged industry leader in laser scanning technology, Quantapoint has published several papers, some of which are listed below. These are available in the Resources section of [www.quantapoint.com](http://www.quantapoint.com).

- A Project Manager Guide To Laser Scanning
- Selecting a Laser Scanning Service Provider
- Seven Things Every Project Manager Should Know About Laser Scanning
- Specifying Laser Scanning Services
- Uncovering the Value of As-Built Laser Documentation for Engineering Firms
- Uncovering the Value of As-Built Laser Documentation for the Power Industry
- Uncovering the Value of As-Built Laser Documentation for the Processing Industries

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## Introducing Laser Scanning

Laser scanning is quickly becoming a common technique for the collection of as-built data for engineering and architectural design projects. The potential of laser scanning for saving time and money coupled with its ability to enhance the design process and reduce construction errors makes it an attractive alternative to manual data collection techniques.

Project managers are being increasingly called upon to adopt this exciting new technology, but there has been little information available to aid the specification of laser scanning technology and services. This paper helps to address this need and is written for engineering and architectural professionals who have a need to create bid specifications for laser scanning services.

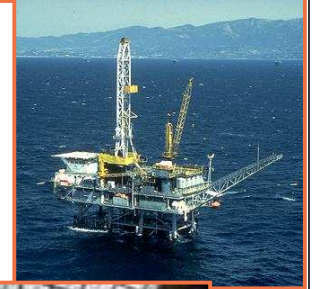
The goal of this paper is to help project managers gain a better understanding of the basics of laser scanning technology while learning what parameters are important to specify while not getting bogged down in the hype or in the confusing and contradictory set of hardware and software performance claims. It is possible, with some basic knowledge and early stage organization, to generate bid specifications for laser scanning services that are practical and which will result in positive project results each and every time. Note that this paper is specifically addressed to volumetric laser scanning of structures and buildings and does not concern itself with the specification of laser total stations or other traditional survey equipment or techniques.

The paper is organized into three sections. The first section is a primer on the basics of laser scanners and their application. The second section concerns itself with performance specifications and how these impact the success of your documentation project. The third section summarizes the document into a checklist for project managers to use when specifying laser services.

## A Laser Scanning Primer

### Some Definitions

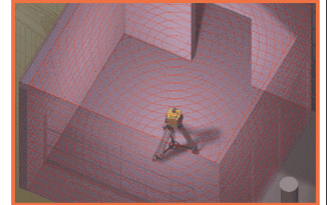
A *laser scanner*, in the context of this paper, is a volumetric measurement device that is comprised of a laser measurement device and a steering device to generate spatial information of a scene. It differs from traditional survey equipment in that it is specifically designed for high data collection rates and works in unstructured environments. For the purposes of this document the terms laser scanner, laser camera, 3D camera, and LIDAR will be considered to be equivalent.



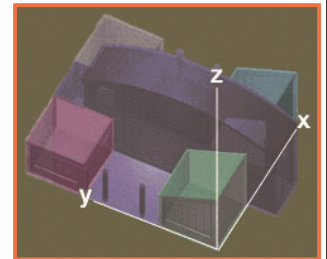
A *scan* is defined as a single data set collected by a laser scanner and is analogous to how the word picture relates to a photographic camera. The set of all individual measurements that are collected in a single scan is defined as a *point cloud* or alternately a *cloud of points*. Multiple point clouds, representing multiple laser scanner placements, are combined into a *registered point cloud* in which all laser scanner centers have transformations available to a single central coordinate system.



For the purposes of this paper, we will consider the world and scan coordinate systems to be spherical with the parameters of *range (r)*, *azimuth angle*, and *zenith angle*. A fourth parameter, intensity, is also defined. *Intensity* is the measurement of the amount of energy returned to the laser measurement device and is used for a variety of purposes including the creation of a photo-realistic image from the returned laser data.



*Registration* is the process of generating the transform between scanner placements required to create a single central coordinate system. This process is alternately called stitching or merging.



## Laser Measurement Fundamentals

The laser measurement device does the job of computing  $r$ , the distance to an object. So, what is laser distance measurement and how does it work? In simple terms, laser measurement is the process of using amplified light (a laser) to determine the distance to an object. There are two common methods used to perform this task. The first and most common method uses pulses of laser energy (*time-of-flight* or *pulse-based*); the second uses a modulated continuous wave of laser light (*AMCW* or *phase-based*).

In either case laser light is emitted from a transmitter, hits an object, and scatters. The light energy that scatters back in the direction of the path of transmission is collected by optics and is focused onto a diode. This is the first important point to understand – only the light that returns along the path of transmission counts towards the measurement. This is why these systems can perform poorly on objects that are shiny, extremely diffuse, or oriented at oblique angles to the sensor – regardless of the technique employed to calculate the distance!

### Pulse-Based

The most common type of laser measurement technique uses the time of flight of the laser to compute distance. In these types of systems a pulse of laser energy is emitted from a transmitter. At the time of emission a clock is started. The clock is stopped when the pulsed energy returns to the receiver. The elapsed time is then multiplied by the speed of light and divided by 2 to compute a distance.

### Phase-Based

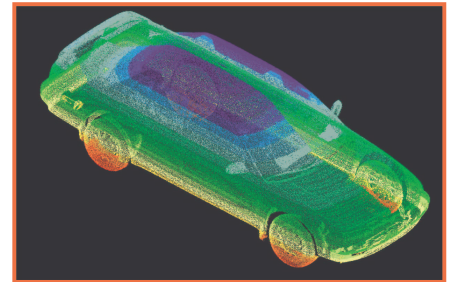
The second common type of laser measurement technique uses calculation of phase differences to compute distance. In these systems a continuous beam of laser energy is emitted, but the beam is modulated with a sinusoid in amplitude. The received laser energy is then compared to

the transmitted energy to determine the phase shift of the modulation. The phase shift is then used to determine how long the signal has been traveling which then provides a computation of the distance.

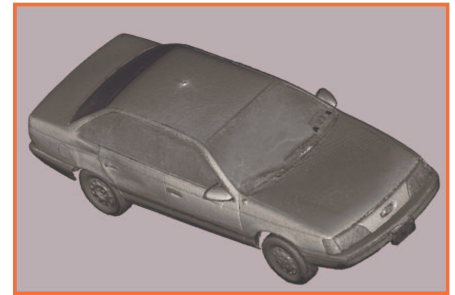
### Should You Specify the Method To Be Used?

Now that you know that there is more than one method used to determine distance, should you care as it pertains to specifying a service? NO! Both methods can work and both methods can fail – it depends upon the application and how the laser scanners are applied. Unless you specifically intend to buy a laser scanner for your own use, you do not care which type is used so long as the end result satisfies your needs. If you do intend to purchase a device then you need to determine your primary application as no device can satisfy all needs.

Pulse-based systems are relatively simple and have good distance properties but have low data rates (typically 1 to 20 kHz). If you require relatively sparse data at long distances (50 to 500 meters) for relatively small jobs, then this is a good technology to use. Example applications suited for this technology include quarries, tall towers, landscape features, and low detail building exteriors.



Phase-based systems can be sampled at much higher rates of speed (100 to 1000 kHz) but tend to be shorter range, are more complicated to build, and are limited in most cases by their ambiguity interval. An ambiguity interval is the length of one wavelength of the modulation frequency. Since a sinusoid is used to modulate the outgoing laser signal, it is not possible to exactly tell if an object is at a range of X or rather a range of nX from the sensor, where n is the number of wavelengths of the modulation. Given the properties of the phase-based system it is most appropriate for applications that require dense, short-range data (< 50 meters), such as building interiors and exteriors, process facilities, and other dense structures. This type of scanner is also good for performing large projects in short amounts of time due to its fast data collection rate.



Both methods use fundamentally the same physics and are subject to the same rules regarding light and optics. The absolute distance accuracy of both methods is comparable, however phase-based systems with their high sample rates can gain an accuracy advantage through averaging without substantially impacting performance.

### What About Temperature and Humidity?

Temperature plays a very large role in determining the accuracy of a laser measurement system. The wavelength of a laser will vary with temperature, as will analog processing electronics and high accuracy power supplies. It is essential that any laser measurement system be carefully temperature controlled and compensated. The effect of changes in temperature on a laser measurement system that has not been correctly compensated can be extreme – introducing inches of error in the output.

Do not use any laser scanning vendor that cannot demonstrate that they address this problem. If you are unsure then ask to see a test. Have the laser-scanner placed in a room with air conditioning or heat. Start at one temperature extreme and scan the room. Continue to increase or decrease the temperature of the room in increments of about 5 degrees until you have about 30 degrees of temperature change. Combine the resulting data together and observe the results. If all of the data lines up together, then you don't have a temperature problem. If the data has a "Russian doll" effect (stacks within each other) or if your data shows any warping between scans, then your laser device has not been properly engineered or calibrated and you should think twice about specifying this device for your application. If you don't have a room handy, you can scan outdoors over the course of a day from daybreak to midnight, assuming that there is a significant change in temperature over the course of the day.



Another aspect of temperature is the ability of the laser scanner to operate in intense temperature extremes, especially heat extremes. In process engineering it is not uncommon to find environments that are 110°F and above. As a project manager, you should identify these conditions before requesting laser scanning bids and be sure that these high temperature issues have been specifically addressed by the service provider. Most hardware is not designed for these types of environments and will prove unreliable or unstable. Checking on this before project award is a way to avoid problems later.

Humidity is another factor that can affect laser scanner performance. Project managers who require scanning in areas of intense humidity (such as the Gulf Coast in August) should specify that the equipment used be rated to handle condensing humidity. It is common for equipment to be rated to 95% non-condensing humidity but rarely is this ever tested in an environmental chamber. Areas of the US such as Houston in August go beyond this and are literally 100% condensing humidity much of the time with dewpoints over 80°F. If you contemplate working in these environments specify it in the bid request and ask that the vendor specifically address this issue.



### **Is Wavelength Important?**

The wavelength of a laser is determined by the material used to create the 'lasing effect'. Knowing the wavelength of laser used by the laser measurement device is important to understand its effects on your application, however you should avoid specifying specific wavelengths for applications so long as the device can be shown to satisfy your needs.

Laser measurement devices are available that operate in various parts of the energy spectrum – from green to infrared. Manufacturers select the laser wavelength for varieties of reasons, however the two most common reasons for selecting wavelengths are eye safety and noise rejection.

Lasers with wavelengths in the visible spectrum are typically selected to obtain a Class II eye safety rating, but they suffer from increased noise due to ambient light and measuring objects of the complimentary color can be difficult. For example, if you have a project with lots of red equipment and pipes, you will want to avoid laser scanners that use a green laser and will favor instead laser scanners using red or infrared lasers.

Near infrared lasers are typically selected because they are easily available and they alleviate many ambient noise issues. However even low power devices using these lasers are classified as Class III devices due to the nature of laser safety regulations. No device that operates outside of the accepted visible spectrum can be classified as a Class II device regardless of power or intrinsic safety [Do not assume that a visible laser will be class II eye safe just because it is in the visible spectrum. One laser scanner manufacturer recently reclassified their visible laser from class II to class III to gain regulatory approval]. Do not be misled by manufacturers that state that class III devices are hazardous. When used properly and when designed according to CDRH regulations, class III laser devices can be operated in a completely eye safe manner (the typical laser pointer for presentations is actually a class III device – check it for yourself).

### **CDRH What?**

The topic of eye safety is the most contentious and difficult aspect of laser scanning to correctly explain. Eye safety is an emotional issue and has been used by vendors as a marketing tool and has therefore added to the confusion and the hype in the industry.



In the US laser devices are regulated by the Center for Devices and Radiological Health (CDRH), a division of the FDA. The CDRH in conjunction with ANSI and OSHA publish standards for the safe use of laser devices. These standards create 4 broad classifications of lasers based on their potential for harm and the precautions required to prevent harm. A Class I device is always considered to be the best class as it requires no precautions by the user to be considered safe to use. A class II device is by definition a visible spectrum laser however a visible spectrum laser is not guaranteed to be Class II depending upon its output power. A Class II device requires a few precautions for safe use, including the concept that the eye will protect itself by blinking if the laser exposure is less than 1/4 second. Class III is reserved for low power lasers outside of the 'visible spectrum' and for visible lasers past a certain power rating. As in Class II, an infrared laser is not necessarily Class III. Certain wavelengths of the infrared spectrum are actually Class I. Confused yet – you're not the only one.

Let's step back and review why these regulations exist. The laser classifications are in place to provide the controls and procedures for safe use of laser devices. Therefore, no matter what the classification of the device, as long as the manufacturer and the user of the laser scanner are following the proscribed guidelines, the end result will be a safe product. This is the most important point! If the device complies with the CDRH guidelines and is used in the proscribed manner it is by definition eye safe. The correct terminology is actually to say "Eye safe to class IIIB" or "eye safe to class II" which indicates to the customer what procedures are being used to ensure eye safety.

So, how do you use this information to create a specification for your project? First, be sure that the laser manufacturer is reputable and can prove that they have satisfied US law with the classification of their equipment. Look for the correct tags and markings on the equipment and ask them to see their laser safety calculations. Every manufacturer is required by law to correctly identify their equipment and should be happy to comply with any request for verification of classification.

Second, be sure that the service contractor that will use the laser equipment is well trained in its use and has an established formal safety program in place to ensure compliance with all OSHA and CDRH regulations. Treat laser scanning as you would other craft professions. You do not have to understand the intricacies of the safety policies and regulations; you just need to be sure that they are being met and that a safe result will occur.

## Performance Specifications – Which Ones Are Important?

The typical laser scanner has a list of technical specifications as long as your arm. Laser power, spot size, reflectivity responses, linearity, and a host of other parameters compete for your attention. These specifications are designed for the purchaser of the hardware and do not readily equate to the performance of the laser scanner for a documentation project.

It is our belief that you – the Project Manager – need a different level of specifications in order to correctly specify and evaluate laser scanning for a documentation application. The parameters of interest to you should include measurement accuracy, spatial resolution, repeatability, variability, registration accuracy, temperature variability, and environmental considerations.

We do not claim that you have to create bid specifications for all of these parameters in order to properly execute a laser scanning project, however we do claim – after long experience – that if you take the time to write the specifications and if you require the types of quality control documentation that we recommend you will find that you will get consistent long term quality results that will provide a significant impact to your engineering organization. Furthermore, having quality control feedback will improve the confidence of your designers and will head off problems before they can start.

### Measurement Accuracy

What is the goal of a laser-scanning project for an engineering application? Typically it is to provide background information to allow new designs to be inserted into the existing plant while providing information on the precise locations of tie-ins and other interfaces between the new designs and existing equipment. So, how do you tell if a particular laser scanner or service provider can satisfy this need to your level of specification? You can't judge this by looking at the raw specification sheet. Instead you need to specify the measurement accuracy.

Measurement accuracy is the ability to generate physical dimensions using the point cloud data that are correct metrically to within a stated tolerance. This single parameter encompasses many other specifications into a simple, easy to measure, easy to evaluate specification that removes all of the confusion regarding laser scanning. Quite simply, can I measure a physical object and get the correct size and location in space using the data delivered from the laser scanner?

Measurement accuracy is specified as a +/- quantity, usually in inches, and will have a standard deviation attached to it. The lower limit on this quantity for practical purposes will be +/- 1/4 inch, however in particular applications it may be possible to achieve  $\pm 1/8$  inch over small local volumes. If a vendor promises better than this, ask to see this for yourself before you believe it on faith.

In order to satisfy this specification, the laser scanning vendor will have to show proof of calibration, perform repeatability tests, perform variability tests, control temperature variations, collect data with the appropriate spatial resolution, and show proof that they can register the data accurately. When your laser vendor satisfies the measurement accuracy requirement you can be pretty sure you are going to get a good final product.

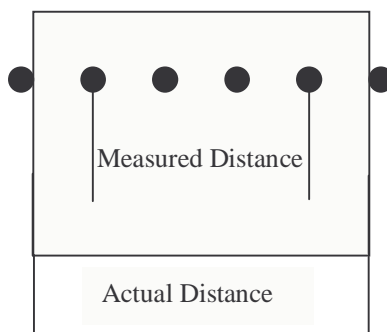
Notice that nowhere does this specification specifically mention point accuracy or pointing accuracy or spot size or maximum range or any other parameter normally found on a laser scanner specification sheet. Individually these parameters cannot be used to evaluate your project outcome. As the customer and end user of the laser data all you should concern yourself with is the delivered data product. When you specify traditional survey do you ever read the spec sheet on the total station? No – you specify what you want and let the service provider figure out the rest.

### The Effect of Spatial Resolution On Measurement Accuracy

When you create a specification for measurement accuracy you have also effectively set a specification for spatial resolution. We explore why this is so below.

Spatial resolution is the point spacing of the point cloud. Since a laser scanner is an angular device, this spacing varies linearly with distance from the scanner. Therefore any specification of spatial resolution must also be accompanied by a range value ( $\frac{1}{4}$  inch at 60 feet or similar) or a limit (no worse than  $\frac{1}{4}$  inch).

Few understand the close link between spatial resolution and measurement accuracy; but it is easy to show that without proper scan resolution it is not possible to accurately recover shape and size of physical objects. This is illustrated with the simple example below. In the figure we depict a typical column. Our task is to measure the width of the column. Keep in mind that laser scan data is digital data, therefore we have only the locations of the measurement points to work with – nothing between those points exists. Now, notice what happens at the edges. Suppose our point spacing was such that we just missed the edge of each side of the column with our scan line. This means that the first point we will find on the column will be inside the leading edge of the column by a distance of 1 point spacing. When we measure the column the result will be the real dimension minus 2 times the spatial resolution ( $d - 2*SR$ ). The only way we would have a chance of maintaining our measurement accuracy would be with a spatial resolution of  $\frac{1}{2}$  the measurement accuracy. Therefore if you specify a measurement accuracy of  $\pm\frac{1}{4}$  inch then you need to specify a spatial resolution of  $\pm\frac{1}{8}$  inch.



While this is a rudimentary example, if you extend this to an entire plant you begin to see the effect of spatial resolution on measurement accuracy.

Some vendors may argue that they fit models to the data and therefore fill in the gaps so it is okay to scan with less resolution. This is simply wrong as shown in the example. If the edges of a column are not captured no amount of fitting models will recover the data lost unless algorithms are used to “invent” data. This is a very dangerous precedent that can have many unexpected results. The same warning goes for filling holes. You risk modifying the scene by inventing anything that is not actually there. The only proper way to ensure the measurement accuracy in this regard is to collect enough data to properly sample the space. Any other approach cannot provide guaranteed repeatable or consistent results.

Along with specifying the measurement accuracy, it is a good practice is to specify the spatial resolution of the delivered data – that way you will be sure you can perform the measurement operations required for your project.

## Calibration

Every laser scanner is a collection of moving parts that contain optics, motors, and electronics. These devices require calibration to work properly. As with spatial resolution, specification of measurement accuracy implies proper calibration; however explicitly requesting calibration test information is an important component of quality control and should be part of any laser scanning project bid request.

So, how do you evaluate calibration? As a Project Manager you do not need to understand how a vendor calibrates their equipment. This is a very technical and perhaps proprietary process. Instead concentrate on the results of calibration testing.

Two test parameters can quickly find calibration errors. These are Repeatability and Variability. A calibrated laser scanner should undergo tests in a controlled environment for both of these parameters and the results should be supplied with the project deliverables.

## Repeatability

To properly perform a repeatability test, the laser vendor or service provider should take multiple images (more than 2) of a controlled scene and compare the results statistically to determine the amount of difference. It is not sufficient to have a qualitative assessment – a quantitative statistics based summary is really required to evaluate repeatability. The laser scanner must be repeatable to the tolerance required to make the measurement accuracy specification achievable. The laser vendor will set this tolerance but it should be defensible.

## Variability

Variability is a measurement of the quality of the calibration across the entire field of view of the laser scanner. A variability test is performed by taking scans of a controlled scene from multiple viewpoints but with a large degree of commonality. The scanner setups should be as dissimilar as

possible while still maintaining common coverage. Measurements are then made in the data between known targets in the scene and compared between scans. If a scanner is well calibrated then the measurement results between the different scans should be within a specified tolerance. This tests whether a physical object will be the same size when measured in multiple images. It is surprising how much this test will reveal about a laser scanner calibration and how many laser scanners will have difficulty with this test. Without this information you will be missing a key quality control checkpoint.

## Data Registration

When you specify measurement accuracy you are again implicitly specifying registration network accuracy. An individual scan may have superior data accuracy but if it is not placed into the global coordinate system properly then the resulting measurement accuracy may be horrible and will definitely have a large impact on your project results.

Notice that registration accuracy does not appear on any specification sheet from any laser scanner vendor. That is because the work process used in conjunction with the laser scanner hardware drives registration accuracy. There are many ways to perform data registration and we do not intend to detail all of them in this paper. Our goal instead is to make sure that you understand the importance of this issue and address this in your specifications.

So, what is an appropriate parameter to use to evaluate the quality of registration? There are probably many parameters that could be used, however any parameter or set of parameters offered up by a vendor should be checked for appropriateness and for full network coverage. The parameter that we specify for registration accuracy is the Chi<sup>2</sup> (chi-squared) test. The Chi<sup>2</sup> statistic, as applied to our registration network, is a well-known and accepted statistical measure of the quality of fit of a survey network and has been used in traditional survey practice for years. The result of the Chi<sup>2</sup> test is a simple pass or fail criteria. If it passes then we know that the registration network statistically fits to the tolerances we require; if it fails then it is unacceptable for delivery. This type of simple unambiguous test is exactly the easy to measure performance parameter that a Project Manager can specify to mitigate the risk of project inaccuracies and to evaluate deliverable quality.

Any credible laser data service provider will have a work process that correctly addresses the laser registration issues and should be able to provide proof to the end user regarding the registration accuracy. If a vendor cannot provide statistical, mathematical proof of their results, then be prepared to be disappointed.

## Common Problems to Watch For

### Rotation Error

Rotation error is the worst kind of error that can be introduced into point cloud registration. Translation errors are relatively easy to spot and correct but rotation errors vary with distance from the scanner center and can be disguised as all sorts of problems due to the inefficiency of human brains to process this type of information. Rotation errors are typically introduced through manual

registration techniques or poorly constrained target networks. If your vendor uses hand registration techniques, you will get rotation errors in the resulting data network – guaranteed.

## Error Propagation

Error propagation is the accumulation of small errors from scan to scan as registration takes place. Consider the problem if each scan is registered within a 1/4 “ specification. Locally the data may look pretty good but 100 scans down the line you have a potential for a 25” error! Couple this with rotation errors and you have got a real data nightmare. Fortunately there are methods available to correct both of these problems. Be aware and ask your vendor how they handle registration and ask specifically how they will guarantee that this won't happen to you.

## A Summary Checklist For Specifying Laser Scanning

The list below is a summary of all of the points made previously throughout this paper and will provide Project Managers with a reference to guide the process of specifying laser scanning technology and services. *The first and absolutely most important step in specifying a laser scanning project is to understand what you want to accomplish.*

- ✓ **Pick Work Process** – You must understand the work process you intend to use to incorporate laser data into your design workflow. This step is critical to project success. Without a clear plan of action with respect to using the laser data for design you will not realize the cost savings and benefits that you would anticipate.
  - Will pipe be field routed or will routing be performed in office?
  - Will design work be performed locally or shopped out remotely (overseas)?
  - Will you work in 3D to design pipe routes or in 2D and convert to models?
  - Is the design work already complete and you just want to check it before construction?

It cannot be emphasized enough that a good understanding of the work process to be used is essential for successful implementation of laser scanning technology. Involve the laser service providers early in the process to ensure good project planning and informed execution.

- ✓ **Require References** – Do not be overawed by technology. Before you trust your documentation project to a service provider check for references. How many projects have they executed? Have they ever worked in your industry before? What reference projects are available?
- ✓ **Require Proof Of Calibration** – Laser scanners are much more complicated than a total station or other survey instrument. It is very hard to see small calibration errors until you start working with the data and even then it may be hard to understand the source of errors. Poor calibration will result in inconsistent and incorrect project results along with significant headaches. As a precaution we recommend that proof of calibration be a requirement for every laser-scanning project. It is not sufficient for a vendor to claim that their device is self-calibrating nor is it sufficient to be given a calibration date or other notice of calibration. Proof of calibration should include results of tests on the calibration against a controlled environment that includes repeatability and variability measurements as defined earlier.

- ✓ **Require Proof of Temperature Compensation** – Be sure your laser scanning service provider is using an instrument that has been correctly compensated for temperature. Never use a laser-scanning device that does not include temperature compensation. The results will simply be inconsistent and typically wrong.
- ✓ **Require Proof of CDRH Compliance** – Protect yourself. Require proof of compliance with CDRH regulations both for the hardware and for the work process. Request a copy of the service provider's safety program and their safety records. Be sure the laser scanning hardware is correctly labeled and that the classification claimed is backed up with mathematical proofs. Eye safety is ensured if the service provider and the laser scanner manufacturer comply with existing regulations.
- ✓ **Require Data Registration Statistics** – Regardless of the quality of the laser scanner, if the data is not registered into a common coordinate system correctly, then nothing can be said about the ultimate accuracy of the deliverable. Registration accuracy can be checked against your specifications by requesting a registration report that provides statistical proof of registration fit quality. Without this statistical assurance there is no way to evaluate the quality of the deliverable until you find problems while working with the data on your project.
- ✓ **Specify the Measurement Accuracy** – This parameter is determined by your project requirements. This is an indication of the accuracy required of the final registered set of point clouds. It is a function of the engineering requirements and is specifically the absolute metric accuracy of measurements taken of physical objects within the scanned volume. This is where the rubber really hits the road. All those specifications and technical data sheets come down to this simple specification. You don't actually care what type of laser is used, what its spot size is or what the 2 sigma error against a 66% reflectance target might be; you care about how well you can use the data in the way you need to use it. This specification also encapsulates the work processes used to gather and register the data as well as the quality of the calibration. Care must be taken when generating this specification not to select a tolerance that is beyond the capabilities of the technology. Traditional survey techniques using prisms and multiple measurements of the same point are only good to  $\pm 1/8$  inch. It is unrealistic to expect results from laser scanning technology better than  $\pm 1/4$  inch.
- ✓ **Specify the Spatial Resolution** – Based on your determinations of require measurement accuracy, specify in the bid the requirements for delivered spatial resolution. This will ensure the project gets the amount of data required and will allow you to compare apples to apples when receiving multiple bids for services.

## Conclusion

Laser scanning is a powerful tool; the key to its use understanding. Quantapoint's in-depth knowledge of laser scanning and user needs has made us the acknowledged industry leader and a trusted business resource to our clients. To request more information, visit Quantapoint's web site at [www.quantapoint.com](http://www.quantapoint.com) or contact Quantapoint at 412-653-0100 or [info@quantapoint.com](mailto:info@quantapoint.com).

### Quantapoint, Provider of the World's Most Trusted and Accurate As-Built Documentation

- Advanced Technology
  - Patented 3D continuous laser scanning for capturing plant as-built dimensions
    - SceneManager™ technology provides both high resolution and fast data capture
    - Enables as-built data to be displayed as photo-realistic 3D image
  - Designed for plant usage
    - Compensates for temperature and humidity effects, which reduce accuracy
    - Custom mounts to enable difficult scans
- Experienced and Highly Trained Field Crews
  - Extensive expertise in rapid, safe and complete project execution in plants
    - Two man crew can document an entire unit in 2 to 4 days
    - All field crews receive rigorous safety and laser scanning training
  - World's most experienced provider of laser scanning services
    - Dedicated field crews with the most plant laser scanning experience
    - Crews trained to identify and prevent scanning "blind spots"
    - World's largest fleet of laser scanners that can be deployed on short notice
- Proven and Repeatable Work Process
  - Field proven and repeatable work processes that deliver trustworthy and accurate results
    - Equipment calibrated before and during project to ensure precision
    - Data reviewed prior to leaving plant to verify comprehensiveness
  - Advanced algorithms to integrate individual laser scans into as-built documentation
    - Based on real-world laser scanning and plant experience
    - Trust measurement provided to prove trustworthiness and accuracy
- Next-Generation Software and Value-Add Services
  - PRISM™, software that enables the Digital Plant
    - Ensure precision by extracting as-built information from an interactive photo-realistic 3D image
    - Increase design productivity and efficiency through quick and accurate generation of 2D drawings
    - Enhance design and constructability by displaying CAD models with the as-built documentation
    - Ensure clash-free project design and execution using advanced built-in clash detection algorithms
  - Value-add services to help extract greater value
    - 2D drawing generation
    - Link as-built documentation to existing asset data sheets

#### About Quantapoint

Quantapoint, Inc. provides the world's most trusted and accurate as-built documentation to the processing and power industries. Quantapoint has become the acknowledged industry benchmark for trust and accuracy by offering a unique combination of advanced technology, experienced and highly trained field crews, proven and repeatable work processes, and next generation software. Quantapoint's solutions have helped customers reduce construction rework to less than 1% of total installed cost and typically provide a greater than 10 times return on investment. For more information, please visit the newly redesigned website at [www.quantapoint.com](http://www.quantapoint.com).