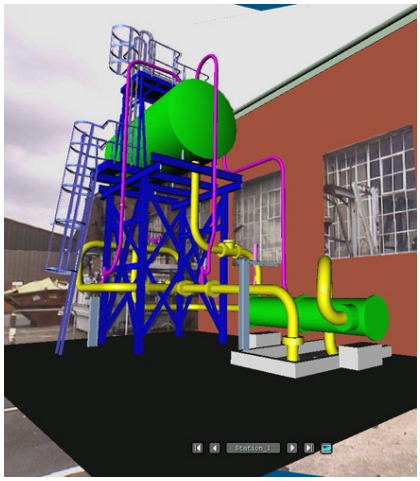

TERRESTRIAL SCANNING

How 3D Laser Technology is Transforming Civil Engineering and Land Surveying

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HIGHLIGHTS

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Terrestrial Scanning - How 3D Laser Technology is Transforming Civil Engineering and Land Surveying

For decades, there was only one way to survey land, buildings or underground spaces – with a sturdy tripod, an unobstructed line of sight, a dependable camera and the steady hand of a trained surveyor.

While this traditional method continues to serve its purpose, it isn't without limitations. As recently as the 1990s, data collected through technology-enhanced traditional methods was still hard to manipulate and could take weeks before it was fully analyzed. Even today, the restricted sight range of conventional survey methods means that surveyors have to work in close proximity to the site, sometimes leading to dangerous conditions on roadways, crumbling hillsides or other hazardous worksite conditions.

New technologies have dramatically changed the surveying landscape in the last decade. Propelled by sophisticated computerized capabilities, surveying is beginning to experience a transformational shift away from conventional methods. Today, it is moving toward innovative 21st century methods that provide detailed three-dimensional drawings and images that can be analyzed within hours.

Terrestrial Scanning, also known as 3D laser scanning, is at the forefront of the surveying revolution. It is quickly becoming the surveying tool of choice for commercial and industrial developers, municipalities and government entities, energy providers and others who are interested in obtaining precise drawings with long shelf lives – at a cost that adds value regardless of project size or complexity.

L.R. Kimball Shares Terrestrial Scanner Expertise

Bringing more than 50 years of architectural, engineering and consulting experience to every project it manages and every client it serves, **L.R. Kimball is one of the few firms in Pennsylvania and surrounding states to offer this service as a compliment to aerial mapping and surveying.** This whitepaper, developed by members of our terrestrial scanning team, will introduce you to scanning technology, illustrate its benefits and challenges, and demonstrate how it is being used in a wide range of industries and market segments.

HIGHLIGHTS

- Untapped resource
- State-of-the-art mobile unit equipped with sophisticated laser technology and software
- Operated by a specially trained surveyor
- Quickly and precisely collects high-density 3D geospatial data
- Millions of data points create a "point cloud" that captures the entire scene, not just specific reference points
- Raw data can be processed into universally accepted formats, often the same day
- Beneficial to any industry and nearly any project

Because of its technological complexity, a terrestrial scanner generates the best and clearest 3D results when operated by a surveyor who is specially trained and experienced in its use.

What Is a Terrestrial Scan? Understanding This Critical Technology

As with Global Positioning Satellite technology, terrestrial laser scanning took root in the 1980s when the US military began using the first generation of this technology primarily for surveillance, tracking and recognition as an alternative to microwave radar systems (Hovanessian, 1988, p. 36) and (Reshetyuk, 2006, p. 14). As its technical capabilities improved, terrestrial scanning expanded beyond its military scope and into the engineering field. Since the start of the millennium, terrestrial scanner use has slowly and steadily increased. But it remains an untapped resource, one that can dramatically improve surveying results and deliver unparalleled 3D drawings and images for strategic analysis.

State of the Art Laser Technology for High Density 3D Data

Terrestrial scanners use the latest in laser technology to obtain high-density 3D geospatial data. Using specialized equipment outfitted with sophisticated software, surveyors can scan the entire targeted area, collecting real-world measurements at many thousands of points per second. While the technology is similar to that used in robotic total stations, its effectiveness dwarfs the capabilities of traditional methods. For example, total stations can provide approximately four distances per second in direct mode. In contrast, a 3D laser scanner can measure up to 5,000 distances per second – more than 1,000 times the number of distances of conventional robotic stations.

The Most Comprehensive View of the Site Available

3D measurements create millions of data points of the scanned building, landscape, dam, power plant or other existing site. Referred to as a "point cloud," these collective data points capture the entire scene, not just specific reference points, giving architects and engineers the most comprehensive view of the site available. Through high-speed innovations, the raw data points can be quickly processed into detailed drawing files for a wide range of use in nearly any industry. Depending on the need, the files can be exported and processed into several usable formats, including ASCII, DWG, DXF, IGES, STEP, AutoCAD, CATIA, Pro/Engineer, SolidWorks and UG.

The accurate and high-definition 3D drawings prove especially helpful for:

- Site planning and inspections
- Designing
- Reverse engineering
- Renovations
- Historic preservation
- Difficult topography
- As-Built documentation
- Quantity surveys
- Creating GIS Plans

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HIGHLIGHTS

Overview:
Commercial Development
Precision + Speed = Action

PROJECT HIGHLIGHT

When a landslide occurred, potentially taking with it plans for a major retail development; L.R. Kimball was called to the scene to perform a thorough analysis of the landslide, including the site's stability.

Using its 3D laser scanner, the L.R. Kimball team met with the client offering to closely and safely monitor the ground movement over specific intervals of time. Their extensive inventory of precise and detailed findings could be made available within hours of each scan, enabling the developer to objectively evaluate the evolving conditions of the site and its possible recovery.

Terrestrial Scans Make an Impact in Nearly Every Industry

Terrestrial scanning is proving invaluable, especially for complicated projects that require a comprehensive data set that leaves no room for assumptions or generalizations.

Applications of the terrestrial scanner easily cross industrial boundaries, whether it includes site planning, inspections, reverse engineering or renovation. Without question, the volume of precise and accurate data sets that can be quickly and safely generated through 3D laser scanners has made the industry stand up and take notice.

Commercial/Industrial Development

One of the most common applications in the Commercial/Industrial arena is the large-scale scanning of complicated structures. These can range from complex exteriors of manufacturing plants for retrofits to historic interiors for reverse engineering purposes.

Terrestrial scans can also provide critical topographical data for site developers. The sophisticated laser technology can:

- Detect and map out subtle ground movements over time
- Identify contours that can remain concealed with traditional surveying methods
- Provide extremely accurate topography when required

Using detailed 3D models generated by the terrestrial scan, architects and engineers can determine how much work will be required for the specific project and what it will entail, and develop realistic site plans and timetables that meet client needs.

Energy

Three-dimensional laser scans can have dozens of applications in the energy sector, especially as the nation's inventory of energy plants ages and experts consider more efficient, cost-effective energy alternatives.

The nature of the energy industry often requires extensive reverse engineering, an area in which terrestrial scans excel. As architects and engineers look toward renovations, retrofits and facility upgrades, the unprecedented 3D imagery becomes an essential tool for the accurate calculation of:

- Column lines
- Concrete pad elevations
- Mechanical system locations
- Pipeline retrofits

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Overview: Energy
Safety + Accuracy = Mission Accomplished

Measuring the volume of ash in a subterranean power plant pond is uncomfortable, messy and dangerous.

High-speed 3D laser scanners have turned this cumbersome job into a one-person, one-day project that enables surveyors to capture thousands of precise images that accurately measure pond volume. With up to a 300-meter range of sight, 3D technology also keeps surveyors out of harm's way.

"Traditional methods generate only a handful of 2D drawings," explained Jason Wilkinson, CADD Technical Leader. "But with 3D laser scanning, L.R. Kimball produces thousands of precise, 3D images in one day that can be analyzed right away or archived for future review."

3D laser scans can also be used to examine hard-to-reach scrubbers; the circumference, span and condition of piping infrastructure; to provide information otherwise unobtainable; or to act as a resource for GIS applications.

The long sight range of the 3D laser scanner also allows surveyors to capture precise datasets of areas that, in the past, were nearly considered off-limits or too unstable to survey. These can include:

- Ash pond volumes
- Stockpile volumes
- Hazardous material areas

In addition to interior applications, terrestrial scanners can also provide important topographical data to wind energy developers, such as topographic data for permitting.

Local, State and Federal Government Initiatives

The ability to bring terrestrial scanning expertise to a government project is quickly becoming the expected standard for many state and federal government initiatives. With this in mind, it is only a matter of time before 3D laser scanning is mandated at the local level as well.

With an abundance of civil engineering projects and a longtime familiarity with the benefits of terrestrial scans, government entities are putting 3D laser technology to widespread use.

On the state and federal level, the long sight range of the 3D laser scans are changing the way Departments of Transportation conduct business. With surveyors situated a distance away from active highways, roadways, runways, rail lines or toll booths, transportation venues can remain open and unobstructed. While maintaining the flow of car, truck, rail and airline traffic, surveyors can quickly, accurately and safely complete a range of services, including precise evaluations of:

- Bridge deck elevations
- Bridge supports
- Concrete barrier widths
- Joint stability in roadways

3D laser scans can help obtain railroad and airfield information without entering controlled areas.

At a local level, municipalities are using the 3D scans as they work to:

- Preserve the intricate details of historical community structures
- Construct or renovate waste water treatment plants
- Monitor topographical movement of local dams, hillsides
- Compliment existing GIS information

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Can the Cost Always Be Justified?

Terrestrial scanning sometimes tends to cost more than traditional surveying methods. In many cases, the savings generated through lower labor costs and a reduced need for repeat site visits can more than make up the difference. In addition, a comprehensive and precise data set, coupled with rapid data turn-around times, can be invaluable.

But terrestrial scans may not be appropriate for every project. In a limited number of cases, its benefits may be disproportionate to the cost of the sophisticated scan. Clients should always evaluate the value-added and cost-savings components before approving its use.

The precise imagery from the point clouds creates accurate 3D models of buildings, roadways, parks and neighborhoods. These highly visual models help government and community representatives better understand the project scope, including any potential obstacles and the opportunities that come with development, renovation and preservation.

These sectors are just some of many examples of industries that are using terrestrial scanning for site planning, inspections, design, reverse engineering, renovations, historic preservation and as-built project management.

Benefits of Terrestrial Scans
Taking Surveying to the Next Level

Diverse industry sectors are attracted to 3D laser scanning for the multiple benefits it brings to a project, no matter its size or complexity. Value-added benefits of terrestrial scans can include:

- Precise 3D data collection of the entire site
- Massive amounts of data, including abnormalities, irregularities, contours, facility controls, 3D building dimensions and comprehensive site documentation that are not available through traditional surveying methods
- Unprecedented speed, ranging from scanning capabilities that can be up to 1,000 times faster than total robotic stations to raw data that is often available within hours of the scan; data can also be reviewed in real time, in the field, as needed
- Improved safety conditions stemming from the scanner's extensive range of sight, no longer requiring the surveyor to be in close proximity to the site
- Archived images that can be quickly retrieved to evaluate site or structural changes at various intervals, and serve as critical reference points during site expansion or renovation
- Technology that complements and validates data obtained through conventional surveying methods

Cost-saving benefits are an added incentive and include:

- Reduced labor costs, the result of efficient scanning technology that:
  - Captures significantly more data points in less time than conventional surveying methods
  - Typically requires fewer surveyors to complete the job
  - Scans hard-to-reach areas, eliminating the need for surveyors to try to access restrictive areas

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Projects that are well-suited for terrestrial scanners include:

- Transportation surveys
- As-built designs
- Volume measurements
- Historical preservation
- Large datasets are required

- Fewer site visits to collect additional data since the 3D scanner captures the entire site, not just select specific reference points; allows the team to revise the project as needed without multiple return visits
- Flexible data usage, where raw data can be made available for the client to review or it can be processed into a specific format that meets client needs

Collectively, these benefits can save clients time and money. At the same time, they provide clients with extensive archived data sets that can guide the construction process, as well as future build-outs and renovations.

The Right Tool for the Right Project
When it Makes Sense to Use a Terrestrial Scanner

Without question, terrestrial scanning is becoming more widespread. A growing number of commercial and industrial contracts now include clauses requiring its use. In addition, many state and federal agencies, including some state Departments of Transportation and the US Army Corps of Engineers, currently mandate its use for most projects.

Its precision, safety benefits and unparalleled levels of rapid data collection make 3D scanners the survey tool of choice for a wide range of projects. But its ability to quickly and accurately gather data in challenging or unrelenting environments is often the deciding factor for companies or agencies that are considering their options.

In general, terrestrial scanners are best used for projects that:

- Require extremely precise data for mechanical adjustments, additional construction, and building remodeling
- Are impossible or difficult to access by foot or by air, including unlit, underground or underwater sites
- Are characterized by open topography, enabling the scanner to work more quickly, efficiently and cost-effectively than conventional survey tools

Specific projects that are well-suited for 3D scans include:

- Transportation surveys (Roadways, airports, rail lines):
  Survey results reported in The Spatial Resources noted approximately 75 percent savings in labor costs; long-range abilities also offer improved safety for surveyors and do not require highway, runway, toll booth or rail line closures/ redirections
- As-built designs:
  Provides accurate framework for reverse engineering concepts, design and execution

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Recreating the Past

Recently, a company approached L.R. Kimball with a dilemma. They needed to make specific site adjustments to an old plant but lacked blueprints. The survey area included a very large battery of high-temperature coke ovens that couldn't be shut off.

Using its 3D laser scanner, the team generated precise, high-resolution views of every aspect of the building. The scanner's 300-meter range also kept surveyors safely away from the ovens.

The team completed the top-to-bottom scan within 48 hours. Two days later, they submitted raw 3D data. A few years earlier, the same job would have required at least a week of inferior 2D scanning and two more weeks to process the data.

The volume of data, its precision and the rapid turn-around enabled the company to quickly make its adjustments. Today it remains a competitive force in the industry.

- Volume measurements:
  Often critical when analyzing and calculating pond volumes, stockpile quantities and borrow areas
- Historical preservation:
  Essential for the accurate re-creation of historical building features and 3D modeling for client presentation
- Where large datasets are required:
  In many cases entire areas could be scanned and only currently required data can be "harvested". As the project progresses, other areas can be processed and delivered without additional field expenditures

It is important to note that 3D scanner data can also complement information obtained through more conventional methods, including Geodetic and Airborne GPS, reflectorless robotical stations, digital orthophotography and photogrammetric mapping.

Terrestrial scanners are less effective with new construction since building plans for new construction are typically current and other methods may serve better for demolition use.

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