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Autodesk and DLT Solutions Special Edition

LiDAR FOR DUMMIES®

Learn:

- Exactly what LiDAR is
- How LiDAR works with government projects
- The different types of capture techniques

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James Young

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LiDAR FOR DUMMIES®

AUTODESK AND DLT SOLUTIONS SPECIAL EDITION

by James Young

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Introduction

Ah, the good old days of photogrammetry. Planners and builders have been using photos to figure out geometric properties of objects and places for as long as there have been photos — at least since the middle of the 19th century. Yeah, it takes a while and it sure isn't getting any cheaper, but it's tried and true.

It's also increasingly obsolete, thanks to the growing use of LiDAR. Laser pulses replace photos, automated computer calculations replace slide rule number crunching — it's faster, cheaper, and all-around better. With each passing year, LiDAR's accuracy and cost-effectiveness are growing, and the potential uses in the transportation industry are huge.

LiDAR virtually puts you on the site without having to leave the office. Combining imagery with LiDAR point cloud data is the next best thing to being there. Plus, it's fast, accurate, and affordable.

About This Book

LiDAR For Dummies, Autodesk and DLT Solutions Special Edition, spells out the basics of LiDAR, including what it is, how it works, and what those letters stand for. You'll learn the main capture techniques along with some details about how LiDAR is used and how it will help you pinpoint different features in the environment.

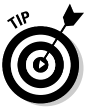
Icons Used in This Book

Throughout this book, you'll find several helpful little icons in the margins.

REMEMBER

You may want to write this down. This info is important.

Sure, the whole subject of LiDAR is rather high-tech; you'll get the extra-techie details next to this icon.



Make a mental note of this info, which may save you time or help you understand things much more easily.

Chapter 1

What Is LiDAR?

In This Chapter

- Introducing LiDAR
- Looking at LiDAR system parameters
- Understanding areas of interest
- Calibrating your system and project

Who doesn't know about radar? You check it on TV or online to see if that big storm is headed your way. Law enforcement uses it to deter speeding. You're familiar with the figure of speech that something is "not on your radar screen." But were you aware that the word "radar" started out seven decades ago as an acronym? The fact that RADAR stands for "radio detection and ranging" is probably not on your radar screen.

REMEMBER

LiDAR is, in certain respects, a lot like radar. Like radar, it's an acronym, short for *light detection and ranging*. And like radar, it's a technology for determining what's out there.

But while radar systems emit radio waves and measure what bounces back, LiDAR uses light waves. It's a powerful data collection system that provides 3-D information for an area of interest or a project area. Among many things, it's useful for such tasks as surface mapping, vegetation mapping, transportation corridor mapping, transmission route mapping, and 3-D building mapping.

It may use light waves, but you can't see LiDAR in action any more than you can see a police officer's radar waves bouncing off your front bumper. The light waves are well past the visible spectrum that the eye can see. For the record, though, a LiDAR system can see in the dark.

LiDAR 101

To understand whether LiDAR might be appropriate for your agency's surveying project needs, you'll need a thorough understanding of the accuracy and data requirements for the project at hand. By mapping out these critical components in advance you'll be able to get a handle on the appropriate LiDAR solution, including the hardware, software, and ground control.

Why? Because a thorough understanding of the type of project you're undertaking will help you determine the ground control of the project. For example, a corridor mapping project will be conducted differently from a county-wide collection. A mobile-mapping collection is a whole different animal from a terrestrial or airborne collection.

LiDAR is really no different from conventional surveying in this regard — you always need to set the requirements for the LiDAR project upfront. This will allow you to determine whether you need to collect your data through aerial, terrestrial, or mobile methods (read more about these collection methods in Chapter 2).

Likewise, you need to take the seasons into consideration — a corridor collection can sometimes happen when the leaves are still on the trees, but sometimes it can't, depending on the application. While there are some scenarios, like timber assessments, that involve forestry where you'll be doing a full "leaf-on" collection, some locations never have full "leaf-off" conditions. If you're conducting a transportation or transmission collection, an environmental impact assessment might be required.

LiDAR's pretty powerful, but it's not Superman. It can't "see" through stuff. It can't peer through clouds; it's foiled by fog; and it can't see if there's smoke. If it's wet out, it's going to rain on your LiDAR parade.

Learn to Speak LiDAR

Here are the most common system parameters of a LiDAR sensor that will impact the data collected. Get to know these terms and you'll feel a lot more fluent in the language of LiDAR:

- **Repetition rate:** This is the rate at which the laser is pulsing, and it'll be measured in kilohertz (KHz). Fortunately, you don't have to count it yourself, because these are extremely quick pulses. If a vendor sells you a sensor operating at 200 KHz, this means the LiDAR will pulse at 200,000 times per second. Not only does the laser transceiver put out 200,000 pulses, the receiver is speedy enough to receive information from these 200,000 pulses.
- **Scan frequency:** While the laser is pulsing, the scanner is *oscillating,* or moving back and forth. The scan frequency tells you how fast the scanner is oscillating. A mobile system has a scanner that rotates continuously in a 360 degree fashion, but most airborne scanners move back and forth.
- **Scan angle:** This is measured in degrees and is the distance that the scanner moves from one end to the other. You'll adjust the angle depending on the application and the accuracy of the desired data product.
- **Flying attitude:** It's no surprise that the farther the platform is from the target, the lower the accuracy of the data and the less dense the points will be that define the target area. That's why for airborne systems, the flying attitude is so important.
- **Flight line spacing:** This is another important measure for airborne systems, and it depends on the application, vegetation, and terrain of the area of interest.
- **Nominal point spacing (NPS):** The rule is simple enough — the more points that are hit in your collection, the better you'll define the targets. The point sample spacing varies depending on the application. Keep in mind that LiDAR systems are random sampling systems. Although you can't determine exactly where the points are going to hit on the target area, you can decide how many times the target areas are going to be hit, so you can choose a higher frequency of points to better define the targets.

Information collection overload?

Just because a LiDAR system can operate at a particular repetition rate, cover a certain amount of area in a given time, or provide a certain amount of returns per pulse, it doesn't necessarily mean that you will need data that is as detailed as your system can produce. Choose your needs wisely, and don't feel like you have to go overboard.

- **Cross track resolution:** This is the spacing of the pulses from the LiDAR system in the scanning direction, or perpendicular to the direction that the platform is moving, in the case of airborne and mobile systems.
- **Along track resolution:** This, on the other hand, is the spacing of the pulses that are in the flight direction or driving direction of the platform.
- **Swath:** This is the actual distance of the area of coverage for the LiDAR system. It can vary depending on the scan angle and flying height. If you're flying higher, you'll have a larger swath distance, and you'll also get a larger swath distance if you increase the scan angle. Mobile LiDAR has a swath, too, but it is usually fixed and depends on the particular sensor. For these systems, though, you might not hear the word "swath;" it may instead be referred to as the "area of coverage," and will vary depending on the repetition rate of the sensor.
- **Overlap:** Just like it sounds. It's the amount of redundant area that is covered between flight lines or swaths within an area of interest. Overlap isn't a wasted effort, though — sometimes it provides more accuracy.

Taking an Interest in the Area of Interest

You're going to get a great data set when you use LiDAR, but you need to understand what the data set is going to be used for — oftentimes the terrain and vegetation in question will dictate the necessity for a higher data point. As mentioned before, the higher the number of points within the data set, the better the definition of the data set is going to be — and for that matter, the accuracy of the data set plays into the picture as well.

Consider, for example, the flood plain maps that the Federal Emergency Management Agency (FEMA) creates using LiDAR. Typically, this kind of mapping project will need a point sample spacing of 1.4 meters, which means that you'll be mapping a point roughly every 1.4 meters on average. This is a large area, and you're typically going to need to achieve an accuracy of about 0.5 meters horizontally and 15 to 18.5 centimeters vertically. You'll also achieve a 2-foot contour specification.

But in some cases, terrain and vegetation will be such that you'll have to collect data with a higher point density in order to achieve the required accuracy specifications. For example, electric utility companies and the engineering firms that work for them usually require between 20 to 40 points per meter in order to properly map power lines.

REMEMBER

These kinds of collections are typically done with helicopters, though it is becoming increasingly common to work with fixed-wing aircraft (planes), depending on the accuracy requirements. Transportation engineers often require engineering-grade information. Mobile mapping LiDAR can achieve this, provided that adequate ground control points within the project are also utilized for high accuracy data calibration.

TECHNICAL STUFF

What kind of eyes does a LiDAR have? The collection sensor uses a powerful laser that includes a transceiver and receiver, along with a geodetic-quality global positioning system (GPS) receiver, an inertial measurement unit (IMU), and a scanner. The laser typically operates at 532 to 1550 nm on the light spectrum, but this varies depending on whether you're operating an airborne, terrestrial, or mobile mapping system.

The transceiver emits the LiDAR pulses, and return pulses are picked up by the receiver. The GPS reports the location of the platform of the sensor, such as where the aircraft is that's carrying an airborne system. The IMU measures the attitude of the sensor on its platform — what is known as the roll, pitch, and heading of the platform. Typically, a terrestrial scanner doesn't have an IMU (find out more about the collection process for this type of scanner in the next chapter). A mirror attached to the scanner spreads the pulses across the surface the system is mapping.

See the forest for the trees

LiDAR can essentially "see through" vegetation to the same extent that humans can — for instance, when no foliage is present. If the point sample spacing isn't high enough or if the vegetation is very thick, odds are lower that the LiDAR system will be able to emit pulses through the vegetation.

TIP: The best way to map through vegetation is to do it when there are *leaf-off conditions.* The fewer leaves on the trees, the better the representation of the ground under the trees will be. If you're mapping an area of evergreen conifers, you're not going to get a leaf-off condition, so you'll need to greatly increase the concentration of points to have a better chance of getting to the ground.

In cases of vegetation mapping, the typical point sample density will be 8 to 12 points per meter. In areas of light vegetation, the sample density can be less because the points will better represent the ground.

Flat as a pancake?

The flatter the surface in an area of interest, the easier it is to map and the smaller the number of points you'll need to define that area. That's fine if there's not too much vegetation, but if there is, the LiDAR system will have trouble getting to the ground and more points will be needed.

TIP: Areas with higher relief — that is, more fluctuations in elevation — are more difficult to map, for a number of reasons. For one thing, high relief areas often tend to be high vegetation areas. Beyond that, the fluctuations in elevation mean the point spacing will change based on the distance to the ground from the LiDAR sensor. To adjust for this, you'll have to fly these areas with more overlap between flight lines. That allows you to sample the areas twice from two different angles. This also increases the ability to get through the vegetation.

Mapping (or ignoring) those man-made features

LiDAR systems are very good at mapping man-made features, but as with other scenarios, you'll need to tailor the LiDAR collection parameters to the application. If you want to map the man-made features, you'll need to use a different collection process than you would if you want to remove them.

Calibrate Those Sensors

As with just about any technology that requires precision — from gas pumps to inkjet printers — you can't count on LiDAR collection without proper sensor calibration. All sensors should be calibrated routinely, and calibration is recommended after every installation into a platform. How you calibrate depends on the system and the LiDAR provider, but the results are similar.

In airborne systems, there's not a big difference between the calibration processes for fixed-wing and helicopter-mounted systems. Terrestrial LiDAR scanners, however, have self calibrations that take place before every collection.

REMEMBER

In addition, all LiDAR systems (whether in the air or on the ground) are initially calibrated by the manufacturer in a lab and during field trials. Whenever a hardware component is repaired or replaced on a LiDAR sensor head, the system should be calibrated. Just as the brake shop will test drive your car after replacing the pads and turning the rotors, all LiDAR providers will do a calibration test flight or drive after doing any kind of repair to the LiDAR sensor.

System calibration

It takes a good bit of flying to do a system calibration for an airborne system, typically at three different altitudes based on the LiDAR system configuration. The calibration flight will include a series of lines flown over an object, such as a building or a runway. The process usually involves flying one or more flight lines in opposing directions to determine differences in all the LiDAR calibration parameters. These differences or errors will be corrected by using the relationship between flight lines and ground survey information.

The things that get corrected the most are roll and pitch differences, though additional corrections will be made to heading, range correction, pitch slope error, and scan factor or torsion. If you want to understand *scan factor* or *torsion,* imagine if a LiDAR swath was profiled perpendicular to flight direction. The scan would appear to have what looks like a frown or a smile, when in reality the scan should follow the terrain. *Pitch slope error* is detected by seeing a building at *nadir* (or vertically below) in relation to the scanner in two opposing flight lines. The placement is exactly replicated with both flight lines but, at the edge of the swath, buildings or objects are offset in flight direction.

Range error occurs when the range or distance of the pulse isn't correct from the sensor to the object it is hitting. This is often confused with an *elevation correction* of the sensor, which is a uniform difference of the absolution elevation of the survey of the ground and the reading of the LiDAR system of the ground.

Project calibration

The project calibration is typically an abbreviated version of the system calibration. Generally, you'll fly this at the project base of operation (for example, the airport), at the project collection elevation, or on a series of cross flights flown over the project location before and/or after the project collection for a given mission. This helps reference all the flight lines together so that mismatches of the flight lines will be eliminated or minimized.

Most specifications require a relative accuracy of between 5 and 10 centimeters vertically. The relative accuracy is the relationship of all the points and flight lines within itself.

Chapter 2

One if by Land, Two if by Air

In This Chapter

- Flying high-altitude airborne LiDAR
- Getting detailed with low-altitude airborne LiDAR
- Moving along with mobile mapping LiDAR
- Standing still with terrestrial LiDAR

The LiDAR *capture technique* refers to the way you obtain your data. Different capture techniques offer different accuracy ranges, uses, and costs. There are four primary LiDAR capture techniques, which can involve flying, driving, or just standing still.

Flying High with LiDAR

Perhaps you're planning a county and state mapping project. If you're collecting data across a wide area like that, odds are you'll want to use high-altitude LiDAR sensors. Usually this involves a sensor mounted in a fixed-wing aircraft, flying somewhere between 400 to 2,500 meters above ground level, depending on the type of system and project configuration. These sensors *can* operate at higher altitudes, but most requirements and sensor performance limitations will keep your surveying no higher than 2,500 meters.

REMEMBER

In general, the higher you fly, the lower the accuracy of the sensors, particularly compared with lower-flying LiDAR operations. Accuracies for a high-altitude project are in the neighborhood of 9.25 to 18.5 centimeters vertically and 20 centimeters to 1 meter horizontally. As technology continues to improve, expect to be able to fly higher altitudes while still hitting the accuracy requirements you're seeking.

To do their job, high-altitude systems will require differential ground reference GPS stations. Typically, you'll need two or more GPS stations during a flight. The GPS control information can come from virtual reference stations (VRS), continuous operating reference stations (CORS), national geodetic survey (NGS) points, or established points that are referenced to a network. Base stations are set within a certain radius of the aircraft at any given time, so several points may be used during a project, depending on how big an area you're mapping. Typically, the radius will range from 20 to 80 kilometers, depending on accuracy and project requirements.

Even if you're covering a large territory, the flight line lengths are usually limited because the inertial measurement unit (IMU) tends to drift over time if you're continuing in a straight line. The IMU needs movement to find itself, so you'll typically fly the project with opposing directions from flight line to adjacent flight line. Operating this way helps verify the relative accuracy of the data or the relationship of one flight line to another.

REMEMBER

It almost goes without saying that as LiDAR technology has developed, the size of LiDAR projects has increased dramatically. Plus, these systems have improved significantly in accuracy, efficiency, and performance.

Flying Under the LiDAR

If your project involves a transportation corridor — such as road surveys, rail line surveys, transmission surveys, and pipeline surveys — you're more likely to make use of a low-altitude airborne LiDAR system. Not only are the altitudes much lower than other airborne LiDAR sensors, these devices are typically mounted in helicopters rather than fixed-wing aircraft.

These sensors can be flown at altitudes as low as 50 meters above the target and as high as 800 meters, depending on the application. They tend to operate at much higher repetition rates, and the point sample spacing is much higher than the high-altitude LiDAR projects. The typical point density is between 20 and 100 points per meter, depending on application.

Because of all of these differences, the accuracy is higher than the typical high-altitude project.

For corridor mapping projects, several base stations might be set up along the project corridor. Depending on the accuracy requirement, these base stations are often located much closer together than those used for high-altitude surveys. The GPS base station points used for these operations are the same as with the high-altitude systems. More often than not, extensive ground surveys will facilitate the LiDAR collection, to increase and verify accuracies.

The IMUs used in these systems are very similar to the ones used in the high-altitude systems. Typically, these LiDAR systems are coupled with additional sensors to provide more data for the applications.

Going Mobile with LiDAR

Mobile LiDAR sensors are used in situations where large areas need to be mapped with high accuracy. Mobile mapping LiDAR systems contain many of the same components as airborne LiDAR systems, but there are some key differences.

These systems are mounted on the back of a vehicle. The laser scanner rotates 360 degrees continuously during operation, rather than oscillating back and forth. The systems can contain a GPS antenna or two, as well as more than one laser. Also, most mobile LiDAR systems contain a DMI that provides additional velocity information.

TECHNICAL STUFF

These sensors are the newest type of LiDAR sensors and typically operate at 1,550 nm. They can operate on a variety of ground-based platforms — not just an SUV, truck, or van, but also a rail car, boat, or ATV. Mobile sensors provide higher accuracy than airborne sensors. The distance from the target may be as little as a few meters or up to about 200 meters, and the typical point densities are between 1,000 and 4,000 points per meter.

TIP

You'll find that planning a mobile LiDAR collection is similar to conducting an airborne corridor collection. One key difference is that you'll have to consider traffic and safety conditions while driving along a given transportation corridor.

You might even need a moving barricade. You'll also need to think about collecting additional ground check points because you're typically seeking much higher-accuracy data, ranging from 1 to 3 centimeters.

The base station control for mobile LiDAR in most cases is significantly more rigorous than that for airborne LiDAR. The accuracy requirements are based on engineering requirements, and to achieve these parameters you need a lot more control. Typically, base stations are set at the ends of the project corridor but no further than 10 km from the sensor at any given time. For longer projects, you'll need several base stations set up along the project corridor.

Most mobile mapping LiDAR systems include two to four cameras that capture up to three frames per second. By the time you're finished, your system will have collected billions of points and thousands of images. With that much data, the detail of the information is exceptional.

Phone Home with Terrestrial LiDAR

Terrestrial LiDAR scanners don't move. They're not mobile and they're not airborne. They are, however, highly accurate and comparatively simple and inexpensive.

Use terrestrial LiDAR for a very specific area of interest, such as scanning underpasses and bridges. The accuracy of these systems is very high, but the ability to collect information is limited by the fact that they're stationary. Thus, while not as efficient for large-scale mapping projects as the other three types of scanners, they are a great way to survey very detailed and accurate projects in a short period of time.

A terrestrial scanner operates on a survey tripod. There's no need for an IMU, but they sometimes have a GPS. The scanner scans in a horizontal and vertical fashion across the area of interest.

Chapter 3

Dealing with All That Data

In This Chapter

- Extracting and manipulating raw data
- Creating your initial LAS unclassified data
- Turning unclassified data into intelligent data
- Finishing the process

So you've done the survey. You've flown the airborne LiDAR collection, wrapped up the mobile survey or finished up with the terrestrial project. You've been very thorough, and now you're buried in data — what are you going to do with it all?

The tools you'll use for processing LiDAR data are typically the same for all LiDAR providers, depending on make and model of the system you're using. The techniques may vary somewhat from one provider to another, but the steps are pretty much the same.

The Recipe for Raw Data

Before you do anything else, you need to extract the raw data. This process is sometimes called *pre-processing*. You'll be pulling the data in its raw format from the system — first the laser data and the positional raw data, then the ground base station data, and finally the raw GPS and IMU data, which is extracted from the positional information. But while raw is great for vegetables and sushi, when it comes to LiDAR you need to spend some more time in the kitchen.

First, you'll process the GPS data, using the airborne GPS data if you have it, as well as the ground GPS information. You'll need to determine the coordinates for the ground GPS data, and how you do that is based on the type of points being used. Once you have processed the GPS data, you'll combine it with IMU data, processing the two sets of data into trajectory files.

A *trajectory file* includes the GPS location information as well as the attitude information from the IMU. You'll also want to do additional analysis on the accuracy of the gyro and accelerometer to make sure they're functioning correctly, along with the positional components.

With that step down, the recipe moves on. You'll combine the processed trajectory file with the laser data, and carefully stir in the software calibration files that were adjusted during system calibration as well as the intensity tables provided by the manufacturer. If it sounds like a tricky operation, you'll feel better knowing that the LiDAR hardware manufacturer usually provides software to handle the slicing, dicing, and mixing.

Once this pre-process is completed, the project calibration is accessed and adjustments to the calibration files will be made. The LiDAR is calibrated and output in LAS format, the standard format for most LiDAR systems, used almost universally throughout the industry. Then, you'll move on to the *post-processing*.

Making Sense of the LiDAR Data

Now that you have pre-processed the LiDAR raw data and served up the LAS data, you're faced with another series of operations to move the data into a format usable by engineering and mapping solutions. The exact approach may vary, depending on your applications and intended uses. In general, the process is known as *data extraction* and it typically follows these steps:

1. Using ground survey control, you'll further adjust the raw LAS data to match the ground control. This is a quality control process allowing you to determine the true accuracy of the LiDAR data set.
2. If you gathered imagery during the LiDAR collection process, you can mix it in with the raw point data in real world coordinates. Use this imagery for backdrop information or combine it with the raw LiDAR points to update the red/green/blue (RGB) values of the points so that they reflect the imagery. This allows further point and feature classification during your data extraction process.
3. Using the various attributes contained within your LAS data file, you can automatically change the point classification from undefined to whatever the points actually represent. Points may be bare earth, vegetation, buildings, or countless other things. This will help your engineering and mapping applications to build surfaces and closed shapes from the classified point types, displaying such things as a bare earth surface.
4. After classifying the point types, you can create linear features from the data. These might be the edge of pavement, striping, curb lines, and any other type of linear feature that you can deduce from point-to-point relationships. Put simply, you're connecting the dots. You can also create linear features by digitizing onto the classified points, using the triangulated model to obtain the elevation value for the linear features, all the while using your backdrop imagery.

Once you're through this process, you'll output the data into various formats, including fully classified LAS files, contour drawings, GIS features, and 3D image files.

TIP: Autodesk has data extraction solutions available today that will accommodate LAS data sets in the billions of points. The data extraction software is designed to provide the required engineering and mapping information that can be directly used by Autodesk's engineering and mapping solutions.

Choose your LiDAR

Here are two examples of data collection and the LiDAR solution that makes the most sense for each. It gets a little bit technical here:

Roadway Resurfacing Project

- Your accuracy must be .03 feet horizontal and vertical, and the coordinate values must be absolute coordinates tied to a project datum. Subsequent machine control will be used during the construction stage of this project.
- The end product is a triangulate surface model, with 3-D lines representing the line stripes and edges of pavement. These will be used to determine the existing roadway conditions and to establish the overlay requirements for the roadway.
- Recommended LiDAR solution: Your best bet is terrestrial or mobile scanning with high order x/y/z survey control monumentation for data calibration. Control markers will need to be set along the roadway to enable post-processing calibration in order to bring the LiDAR data into the extremely high accuracy requirement.

Statewide (Flood Plain) Contour Map for Large-Scale Drainage Basin Determination

- The accuracy requirement is 10 to 20 centimeters in the horizontal and vertical dimensions.
- Your end product is a contour map, breaklines, and DEM with 2-foot accuracy standards.
- Recommended LiDAR solution: High altitude aerial data collection with mid-level controls throughout the state, similar to what you would use for a photogrammetry solution.

Chapter 4

Top Ten Questions You May Have about LiDAR

In This Chapter

- Understanding the importance of LiDAR
- Answering your technical queries

It wouldn't be a *For Dummies* book if it didn't have this final chapter. What better place to take a stab at some of the FAQs about LiDAR technology?

Why Is LiDAR Such a Valuable Tool?

The value of LiDAR lies in the fact that it virtually places you on your target site without having to leave the office. Combining imagery with LiDAR point cloud data is the next best thing to being there. Plus, it's fast, accurate, and affordable.

Can I Collect Other Information While I'm Gathering LiDAR Data?

You name it — cameras, video imaging systems, multi-spectral and hyper-spectral imaging systems can all be mounted on and operated with most current LiDAR systems. Because you can operate these multiple systems using the same components, you'll save time and money, a big benefit to corridor mapping projects such as transportation, pipeline, and transmission mapping. Mobile mapping systems typically include two or more cameras within the system. One drawback: These passive systems require a light source, which means your collection times are limited. Unlike LiDAR, they can't see in the dark.

Do I Need Breaklines If I'm Using LiDAR?

Not necessarily. It all depends on the requirements of the product you're generating. Typically, LiDAR is very good at defining the surface, as long as the sample spacing is adequate and there isn't too much vegetation. Most features and terrain are very well defined in LiDAR data. The rule of thumb relative to breakline usage comes down to edge recognition needs in the surface. If you have key elements, such as a back of curb line or a lip of gutter line, you will want to collect breaklines. If you're only producing large-scale contour maps, you may not need the accuracy that breaklines provide.

Where Can I Find an End-to-End Solution for LiDAR Data?

Try Autodesk. Specifically, you'll find an end-to-end solution in AutoCAD 2011, AutoCAD Labs, AutoCAD Civil 3D, Map 3D, and Navisworks products. Another robust data extraction solution for feeding all these applications with classified LAS and featurized GIS is the Virtual Geomatics solution.

Classical Photogrammetric Data Collection Works for Me — How Does LiDAR Compare?

LiDAR is about 40 percent less expensive than classical photogrammetric collection. And it takes less time to collect, process, and extract the needed information from LiDAR compared with traditional methods.

Is LiDAR Data Accurate Enough to Use on Road Overlay Projects?

You bet, as long as you use the appropriate collection method with the sufficient survey control. Just be careful when you pick your method and plan the control.

What Is Corn-Rowing?

You can't eat it. The term *corn-rowing* refers to an artifact of LiDAR sampling that typically occurs at the edges of scans and overlapping data areas. It's caused when LiDAR points are sampled close together and the difference in the sampled points is greater than the relative accuracy. With proper collection and filter processes that remove the points causing the trouble, you can minimize corn-rowing.

What Type of LiDAR Data Do I Really Need?

The best way to determine what LiDAR products you need is to really understand the application for the data. Call a qualified LiDAR collection agency for a recommendation on the appropriate collection methods based on your specific requirements. Here's the info you'll need to pass along:

- Accuracy requirements for data.
- Extraction requirements — do you just need points, or linear features, too?
- End products you'll require. Do you need a triangulated surface, a classified LAS, and/or GIS features?

What Is an Intensity Image?

An *intensity image* is a *monochromatic* (shades of gray) image of the *illumination* (energy) returns from the LiDAR system. These images can be used for generating planemetric and breaklines by using LiDARgrammetry. The intensity image is typically a Geotiff, and the accuracy of the image is a function of the horizontal accuracy of the LiDAR, along with the interpolation of the point to a raster image.

You Just Said LiDARgrammetry— What's That?

LiDARgrammetry is the process of using intensity images to generate synthetic stereo pairs, much like the stereo pairs used in photogrammetry. The data generated from LiDARgrammetry tends to be only as accurate as the LiDAR from which it's generated. There are varying opinions regarding the usefulness of this information and how accurate it is. Still, it's a good byproduct of LiDAR, and whether it's useful to you just depends on the scope of your project.


Point YOURSELF
in the RIGHT
direction...

LiDAR puts you onsite without having to leave the office!

LiDAR For Dummies, Autodesk and DLT Solutions Special Edition, spells out the basics of LiDAR, including what it is and how it works. You'll learn the main capture techniques along with how LiDAR is used and how it helps you pinpoint different features in the environment.

- ***Get the lowdown on LiDAR* — find out exactly what LiDAR is and how you can use it in your surveying projects**
- ***How LiDAR works* — there are several different LiDAR capture techniques; knowing what they are will help you determine which one you should use**
- ***Working with data* — LiDAR data sets can come in billions of points; proper extraction and manipulation of LAS data is important**

Open the book and find:

- **How calibration works**
- **Information about high altitude, low altitude, mobile mapping, and terrestrial LiDAR**
- **The different processes that data needs to go through**
- **A list of questions and answers about LiDAR**
- **Examples of data collection projects**

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