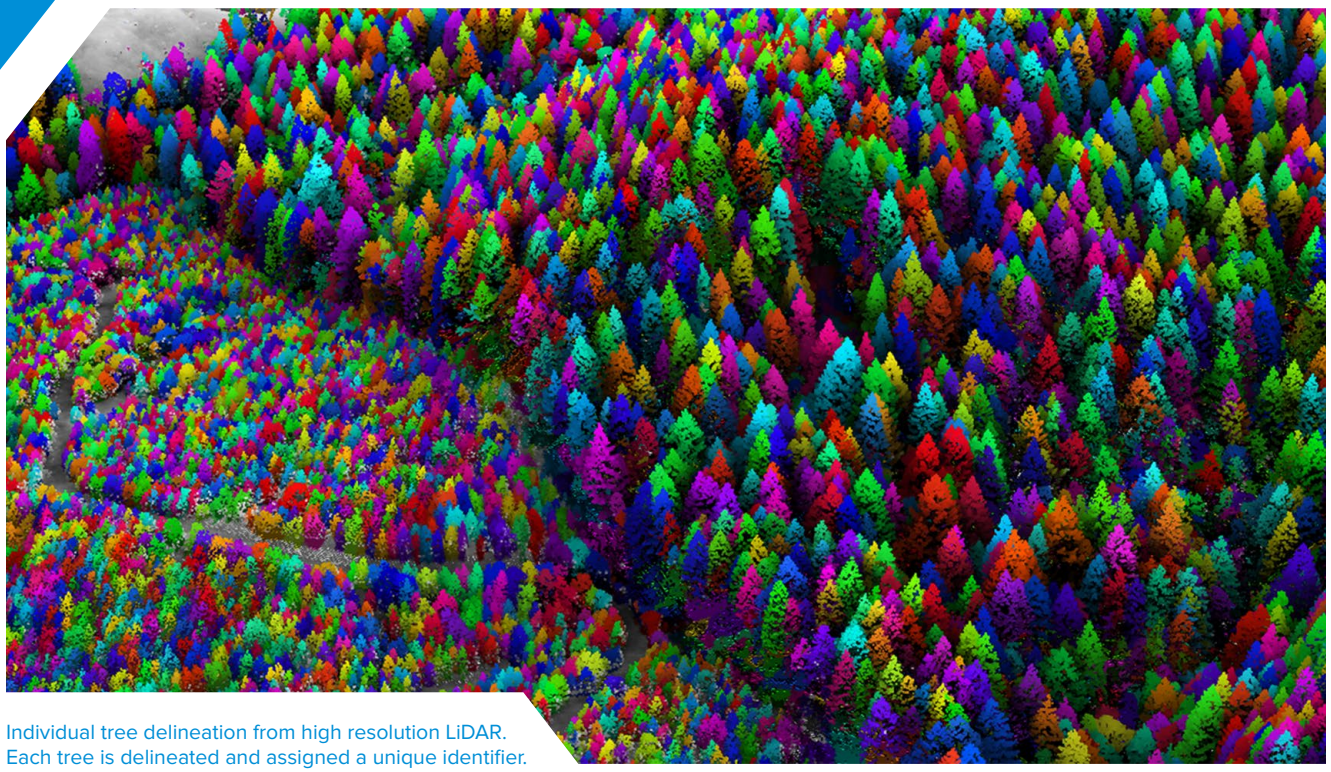


Individual tree delineation from high resolution LiDAR. Each tree is delineated and assigned a unique identifier.

ADVANTAGES OF HIGH RESOLUTION LiDAR

Defining High Resolution

High resolution LiDAR data can be defined in many ways. The definition of high resolution LiDAR for this article is defined as any LiDAR data with a nominal point spacing (NPS) of 8 points per meter (ppm) collected using a fixed wing or helicopter platform. The NPS for fixed wing for this definition would be 8 to 32ppm. The NPS from a helicopter platform would range from 8 to 150ppm.

This NPS could be determined by a single pass spacing of 4ppm with double coverage typically indicative of 50% or more side lap or 8ppm single pass spacing with less than a 50% overlap. The way the flight parameters are configured or the processing of this point data can vary by LiDAR firm and it should be clear to the user what parameters are used in both collection and processing.

For example, a firm could collect data at 4ppm single pass spacing with double coverage and cut the data at seams, the resulting processed data set would not be considered 8ppm in terms of the advantages discussed here. This would mean that the definition should also include the statement as follows: The NPS of 8ppm would be that density or higher of usable data for analysis and product generation. The usable data points would be fully calibrated and all these points would meet all relative and absolute accuracy requirement of specifications for the data sets.

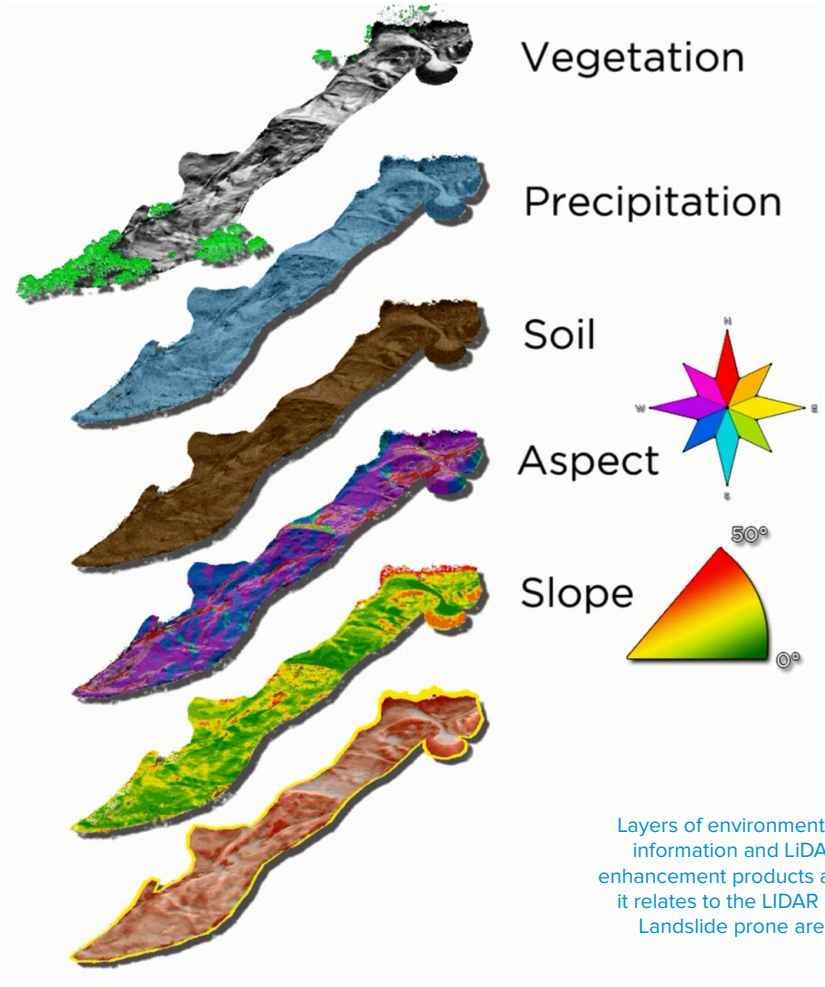
BY JAMES WILDER **YOUNG**

Advantages

Traditionally, the cost of high resolution LiDAR has been an issue when trying to get a project executed. This is not so much the case anymore. Over the past 20 year the price of LiDAR has dropped significantly through improvements in processes and advances in LiDAR hardware technology. The cost continues to drop while point resolution continues to improve. High resolution LiDAR provides many advantages that low resolution LiDAR does not. The applications and uses are much broader than just the intended use of a given project.

Through automation as a result of mathematical algorithms that manipulate, edit, and generate the data deliverable provide extensive cost savings to the end user. Why you say? With 8ppm or more, algorithms can be run to automate much of the processes that would have to be done manually with lower point resolution data sets. Additionally, the math behind the algorithms for automated classification processes work better with high resolution data versus low resolution LiDAR because all of the features and the ground are better defined so the math resolves feature extraction much better and with more accuracy. Consequently, additional uses can be realized as a result of the improvements in automation, available math models and higher point resolution. Additionally, some consideration should be given to future uses of the data set and the shelf life of the data. Current shelf life of LiDAR depending on use and is estimated at 5 to 20 years. The higher resolution LiDAR data will have a longer useful life than a lower point resolution depending on use.

High resolution LiDAR data sets can be collected and processed for a very similar cost to widely accepted low resolution LIDAR data sets. The advancement in LiDAR hardware available today provides the ability to fly higher at higher repetition rates providing efficiencies of 30 to 50% depending on requirements. The automation of processes as a result of mathematical algorithms cuts the cost of the most expensive component of production process. This would be the manual editing and quality assurance steps of the process which accounts for about 40 to 50% of the labor. Additionally, LiDAR data sets that provide additional usefulness as a result of higher resolution provide more value to the end users.

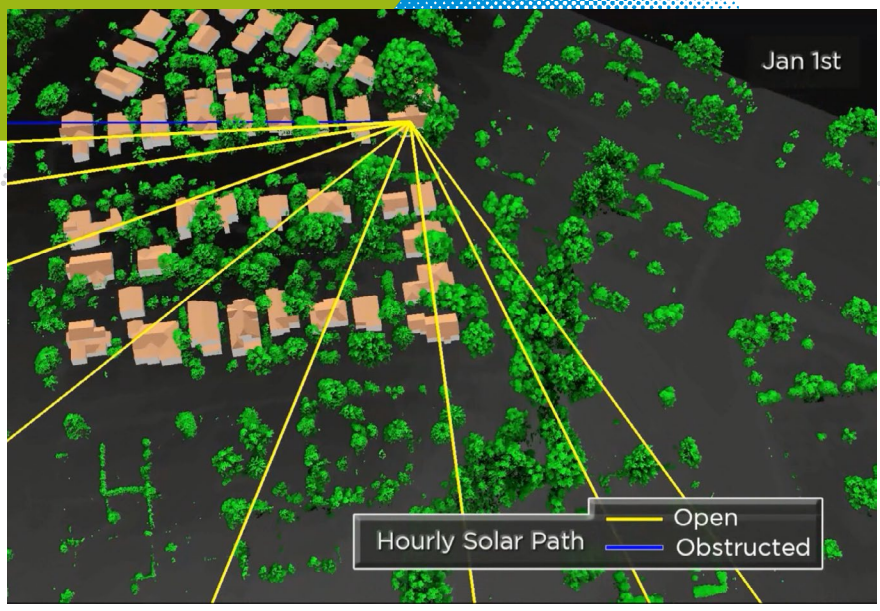


Layers of environmental information and LiDAR enhancement products as it relates to the LIDAR in Landslide prone area.

Applications

The classification of vegetation from LiDAR has been marginal at best until recently. Historically speaking, the misconception of vegetation classification is predominate throughout the profession. Vegetation in the past is simply a classification of vegetation points by height. The classifications are described as Low, Medium and High vegetation but they are simply defined as a height as it relates to ground. So a tall tree will be defined as three vegetation classes.

Let's say I have a tree that is 50 feet high and the definition for low is everything from ground to 6 feet, medium is 6 feet



Solar mapping extraction from high resolution LiDAR data set showing the hourly solar path of a given house on January 1st of a given year.

to 12 feet and high is 12 feet and above. All points of that tree that are 6 feet and less are classified as low, all points between 6 and 12 feet are classified at medium and every point above 12 feet is classified as high vegetation. This might be of use to some but is it really vegetation classification? It seems that a tall tree, short tree or any tree should be classified as an individual tree and segmented as such for true analytics. This is now possible with high resolution LiDAR data. This now provides innovative solutions for the broad range of applications such as arbor, transportation, distribution and transmission.

The generation of breaklines as they relate to hydrologic and planimetric extraction has been realized as point resolution and processes improved over the course of LiDAR evolution. In the beginning hydro flow was represented by stair stepping breaklines that were uniform in elevation whereas now the hydro breakline follow the terrain and drop as a river would flow without stair stepping. The process has evolved significantly over the course of technological advancements in the profession and now many automated processes exist to do this but these automated processes require high resolution LiDAR data. Additionally, as a result of recognizing geomorphology uses from manipulation of LiDAR data such as enhanced relief models, automated breakline extraction and impervious surface generation is now realized. The techniques used are accentually a by-product from this involving data use.

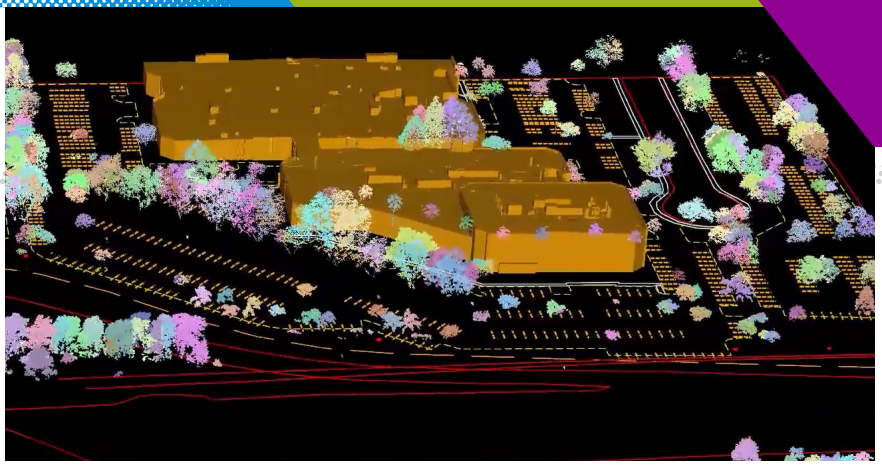
The generation of breaklines has always been a contentious subject as it relates to LiDAR, because before LiDAR the generation of surface models was largely dependent on breaklines, but LiDAR provides so much more surface information than imagery. There are several professionals that argue that more breaklines are needed regardless of source material, whether it is LIDAR or imagery. Additionally, in the case of LiDAR versus Imagery, it could be said that the requirement for breaklines as it relates to high resolution LiDAR data is much less than that of low resolution LiDAR. More points better define a drainage feature or to be fair greatly improves the probability to define that drainage feature or any feature for that matter. The cost to generate the breaklines by automation and need to generate as it relates to high resolution data is greatly reduced providing efficiencies and potential cost savings.

When discussing high resolution LiDAR we can't forget the benefits of really high resolution LiDAR data found in mobile LiDAR (thousands ppm) applications. The benefits of high resolution LiDAR from fixed wing and helicopter platforms has been realized for some time, but mobile continues to be recognized. All these technologies can feed off each other. The processes developed and applied to one technology can lead to innovations in the other technologies. For example, semi-automated curb extraction processes used in mobile LiDAR can easily be applied to high resolution LiDAR. The methodologies applied to high resolution LiDAR are and continue to be applied to mobile LiDAR.

Typical Projects

The accuracies associated with high resolution LiDAR are much greater than those from low resolution LiDAR. This is a result of several parameters. The flying height is becoming less a factor as a result of the improvement of the hardware technologies. For example, a LiDAR mission recently flown of a county in Illinois at 10,000 feet Above Ground Level yielded a vertical accuracy of 6.096 centimeters. The job was specified to meet a 9.25 centimeter vertical accuracy.

Most firms are now comfortable signing up for vertical accuracies of 7 centimeters or better with fixed wing platforms and 1 to 3 centimeters with helicopter platforms. The horizontal accuracies vary based on height above ground, LiDAR hardware and sensor settings but it is reasonable to expect horizontal accuracies at typical heights to be 20 cm or better depending on configuration. The accuracy of the data is a function of a combination of the flying height, beam divergence, scan



LiDAR extracted information from a high resolution data set.

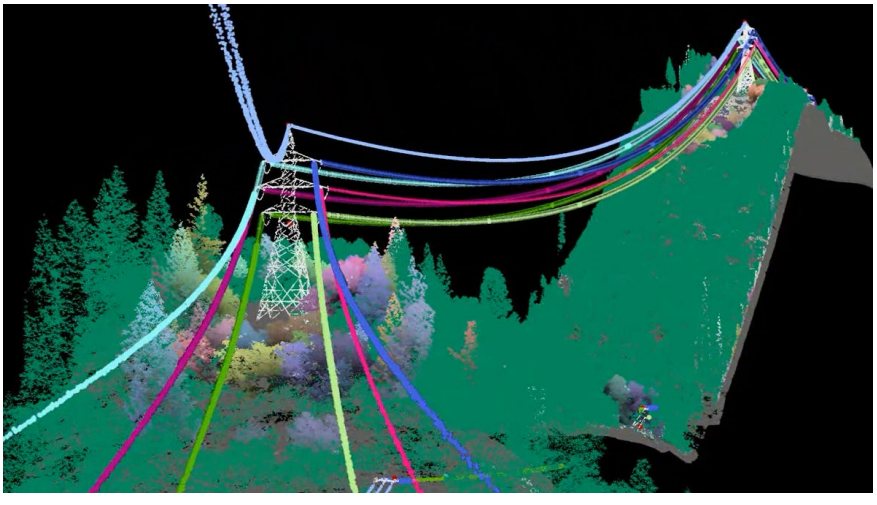
angle, scan frequency and air speed. This would apply to both horizontal and vertical accuracy.

In addition to the common applications of LiDAR that are well accepted within the profession and used every day, high resolution LiDAR provides a vast amount of additional applications and uses that are limited by low resolution data sets. The high resolution data sets can be modified to better serve several of these common applications and it should be noted that flying high resolution is not the answer for everyone, but if it can be provided at an equal price as the historic lower resolution data sets it makes sense given the additional uses of this data. Continually, the users of the data provide new applications through analysis of the data such as sage grouse habitat mapping, fish habitat mapping and complex solar mapping. These applications were realized as a result of the users having this resolution of data. More data provides more solutions and problem solving capability.

Furthermore, the data set being produced using low resolution data are greatly enhanced by high resolution data sets. Instead of generating vague, less accurate elevation, planimetric, building, utility and tree information, the high resolution data set can provide much more accurate and detailed information at or near the same cost.

Transmission and distribution clients have been using high resolution LiDAR from helicopter platforms for some time and as a result of the NERC regulations a large part of the profession adopted this technology. Now that the NERC work is winding down, we as a profession have to find other ways to get the most out of this market space and find ways to utilize the technology.

Recently, as a result vast improvements in technology, automation and increased point density, other market spaces such as transportation are beginning to utilize high resolution data from both helicopter and mobile platforms for engineering grade work.



Classification and extraction of necessary information for a Powerline mapping project.

Return on Investment

High resolution LiDAR data provides extensive advantages to the LIDAR market space. Its use should be explored based on the drastically improved collection and processing workflows that have resulted from recent hardware advancements and automation. In most cases the return on investment is much greater than initially realized and the users continue to find new applications as a result of the high resolution data sets.

It should be noted that it only takes four points to map a table. Is it necessary to map the desert with high resolution data or is it necessary to map an area in Arizona lacking vegetation with high resolution data? The fact is the high resolution data set provides much more information even in these areas. The applications recognized today and being discovered in the future also might suggest so.

James Wilder Young is Vice President of Technology for Quantum Spatial. He has been working in all phases of LiDAR including sensor development, data acquisition, data processing and applications development since 1996.