ATDI

High Resolution RF Analysis: The Benefits of Lidar Terrain & Clutter Datasets

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High Resolution Terrain & Clutter Datasets: Why Lidar?

There are myriad methods, techniques and technologies for obtaining elevation and earth cover information through propagated signals. Those technologies may be based on sound, radio and light and also vary in resolution, difficulty, expense and process. Overall, most of these sensing technologies are based on the time delay of a reflected or scattered signal, though traditional passive sensors can also be used and rely on natural radiation.

Lidar systems illuminate a target with lasers, then receive and process the reflected and/or scattered signal. Modern Lidar systems are compact, precise, and efficient and provide many advantages over traditional photo-based techniques. They allow for sub-1 meter data collection and improvements in post-processing aid in the ease of use of the data. Most post-processed Lidar data is classified by return number and category, further shortening the conversion process from raw data to datasets that are usable in RF propagation tools.

Another advantage of Lidar data collection is that the data may be collected both day and night unlike traditional methods which require collection during daylight. Lidar not only offers high accuracy, but allows for the collection of elevation information in areas of dense vegetation. Since a Lidar pulse can have multiple reflections, it will reveal both surface elevation and terrain elevation at any point. Most other collection techniques only gather information about surface heights. Furthermore, modern Lidar data collection systems are compact and are easily mounted onto light aircraft for data collection over large areas.

Obtaining Lidar Data

Lidar, or light detection and ranging, can be used to quantize terrain, ground clutter and ground occupancy. Airborne Lidar systems are typically used for the purposes of scanning large areas and are composed of a laser and a rotating mirror that is used to sweep the area of interest. The airborne Lidar system then acquires data points by bouncing a laser signal off of the earth, buildings and vegetation. As the airplane flies, the Lidar system quantizes the terrain and ground clutter below in a zigzag pattern, as pictured in Figure 1.

The acquired data points are reflections of the laser signal from obstacles in its path, and there may often be multiple reflections of a single emitted signal. One reflection may be produced by buildings, the ground and other solid objects. Trees and vegetation may produce several reflections as the laser signal propagates through the leaves and reflects off of branches and ultimately the ground. Thus, it is common to have multiple returns for a given transmission.

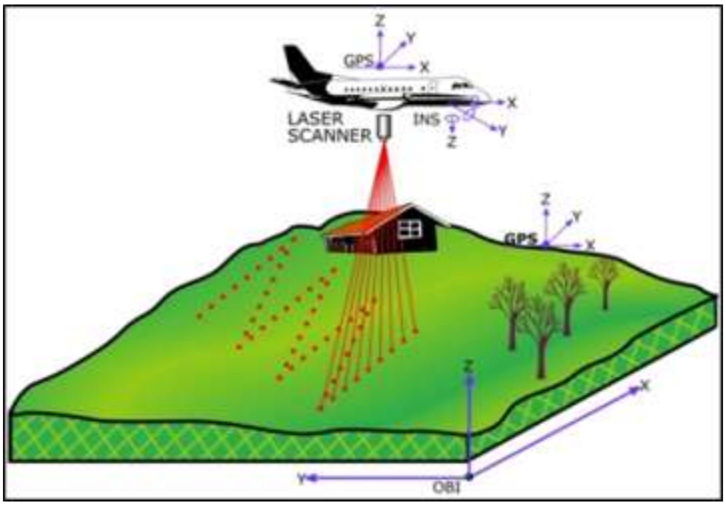

Figure 1: Airborne Lidar scanning (SOURCE: ASPRS)

To compute the distances between the airborne Lidar sensor and the reflection point and thus the elevation of the reflection point, calculations are run using the elapsed time and the speed of light. This data is correlated with the GPS positioning of the aircraft along with inertia sensors or gyroscopes to accurately create the environment of three dimensional points that are a Lidar dataset.

Lidar Data Format

Lidar information is typically obtained and stored in ASPRS LAS format. Not only does the LAS format contain information about surface heights, but it also provides header information that contains technical information such as return number, classification, and scan angle, among others. The user may then employ or develop software that sorts through the Lidar data (often in the realm of Gigabytes of data) to create the desired datasets based on required criteria, such as return number or classification.

Once the Lidar data has been sorted as desired, the data can then be manipulated as necessary. In most cases, this involves interpolation of the dataset to create a continuous model without non-return pixels. Lidar data is, by nature, discontinuous since individual measurements are based on specific geographic points. These points are then stored in the LAS file. In essence, a LAS file is a list of measurement information per geographic point. In Figure 2 the image on the left shows a dataset where only the first return is shown. Any areas in black are points where Lidar data was not obtained during the measurement campaign. In the image on the right, the dataset is interpolated into a continuous dataset that can be used in radio frequency planning and analysis software as a digital surface model.

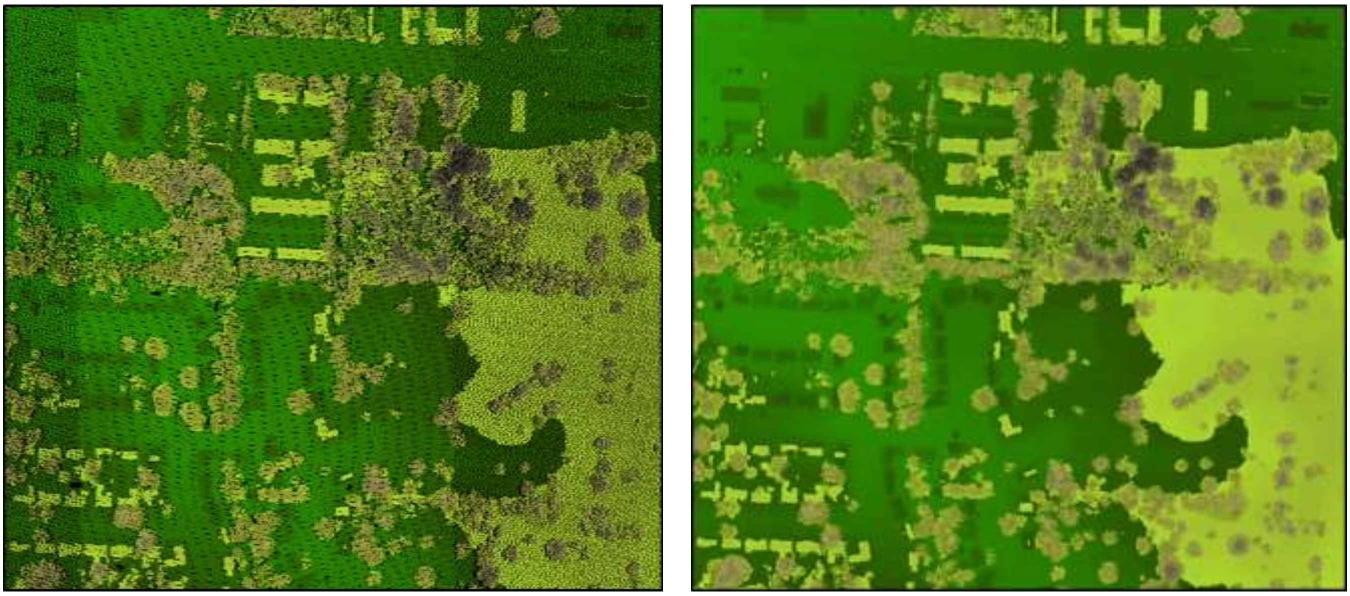

Figure 2: Discontinuous raw Lidar data (left) and continuous interpolated lidar data (right)

Lidar Dataset Preparation for RF Analysis

The images in Figure 3 and descriptions that follow show how ground occupancy and clutter are generated using processed Lidar data:

Aerial Image: The first image is an aerial photo of the area of interest, showing the presence of roads, vegetation, buildings and unoccupied ground.

Bare Earth Image: The second image is a bare earth model that was extracted from the ground points of a Lidar dataset and then interpolated into a smooth, continuous dataset. The bare earth model is also known as the DTM, or digital terrain model, since it contains only ground elevations. The DTM is derived from a Lidar dataset by removing all points but those classified as ground points and then interpolating the data to create a continuous dataset.

Figure 3: Aerial image (top left), bare earth (top right), first return (bottom left), and ground occupancy (bottom right)

First Return Image: The third image is a first return model that was extracted and then interpolated into a smooth, continuous dataset. The first return model may also be called a DSM, or digital surface model, since the heights and elevations it contains are the maximum elevations for the ground and any ground clutter at each point. The DSM is derived from a Lidar dataset by removing all returns but the first return and then interpolating the data to create a continuous dataset.

Ground Occupancy Image: The final image is a clutter dataset, obtained by subtracting the heights in the digital terrain model from the heights in the digital surface model, leaving only buildings, vegetation and any other ground clutter within the file.

Areas in black represent a lack of clutter, where the digital elevation model and the digital surface model are equivalent.

RF Analysis Using Lidar Data

Once the Lidar data is processed and converted to the appropriate formats, the user may load the datasets into radio frequency propagation analysis software to run simulations.

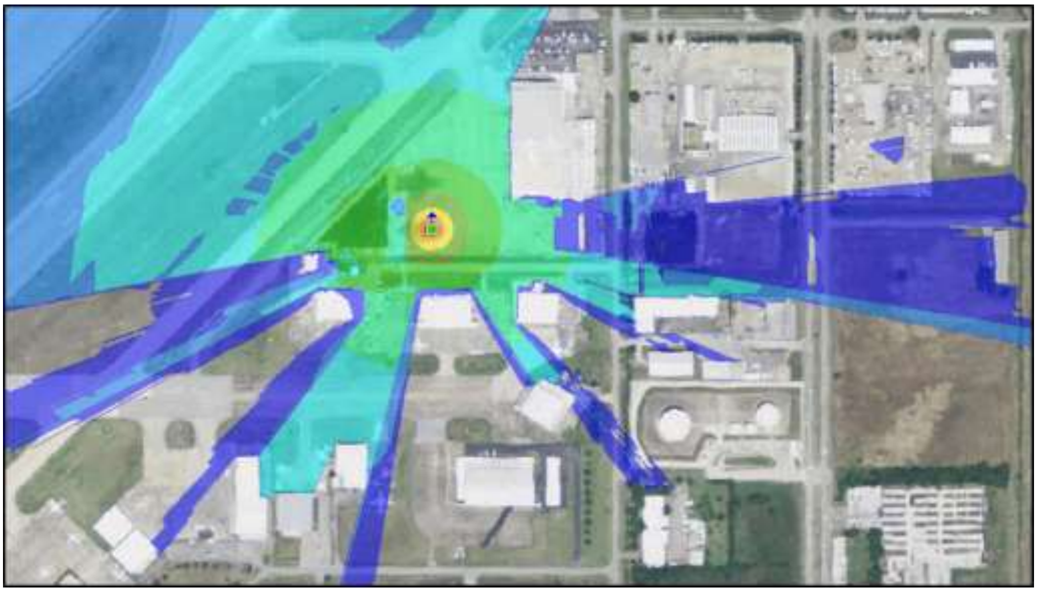

Figure 4: Two dimensional display of RF propagation analysis results

Figure 4, above, shows the results of an RF propagation analysis in two dimensions when 1-meter resolution Lidar data is used. Both transmit and receive antenna heights are set to low values to show the signal blockage characteristics that buildings and vegetation have on the RF signal. The high resolution Lidar dataset provides for highly precise modeling with sharp blockages.

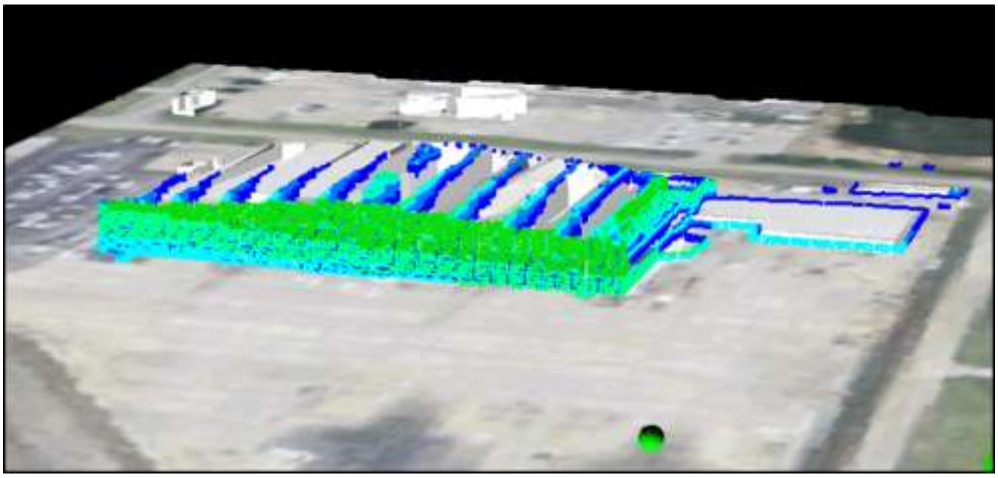

Figure 5: Three dimensional coverage calculation on building exterior

The final image, Figure 5, is a three dimensional visualization of how the sample RF signal is incident upon the exterior of a large building. The color variation across the building's facade and stepped roof represents varying power received levels of the RF signal.

The Case for Lidar Datasets

While traditional terrain and surface cover collection techniques and technologies yield resolutions that often range in the tens of meters and can be as accurate as 3 to 5 meters, Lidar allows for sub-1 meter data collection. As a highly precise and detailed terrain and clutter format, Lidar data is well suited for high-resolution RF analysis. Not only is the user presented with unparalleled accuracy for propagation over bare terrain, but also for propagation over and through ground clutter.

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