Image from the onboard camera Terrametrix Scan vehicle showing the density of the foliage along the rail corridor.

Multiple Return... Multiple Data

Multiple return 3d LiDAR scanners are one of the greatest inventions replacing Land Surveyor tasks… unless you are one of the traditional few who like to cut thru brush. Sometimes you just need more than the drip line. Sometimes ground truth traditionally is no more accurate than the penetration of the tip of the rod into the soil. And, sometimes leaf off conditions can lead to project delays.

Time of flight LiDAR is an active remote sensing technology that can essentially "see through" vegetation by emitting multiple pulses until there is no return collecting everything until there is nothing else to "see". Multiple returns occur when a laser pulse strike a target that does not completely block the path of the pulse and the remaining portion of the pulse continues to the next seen object. Remember, this is still line of sight acquisition. LiDAR systems with multiple returns can detect the elevations and distances of several objects and complicated reflective surfaces both on and above the ground surface: vegetation, buildings,

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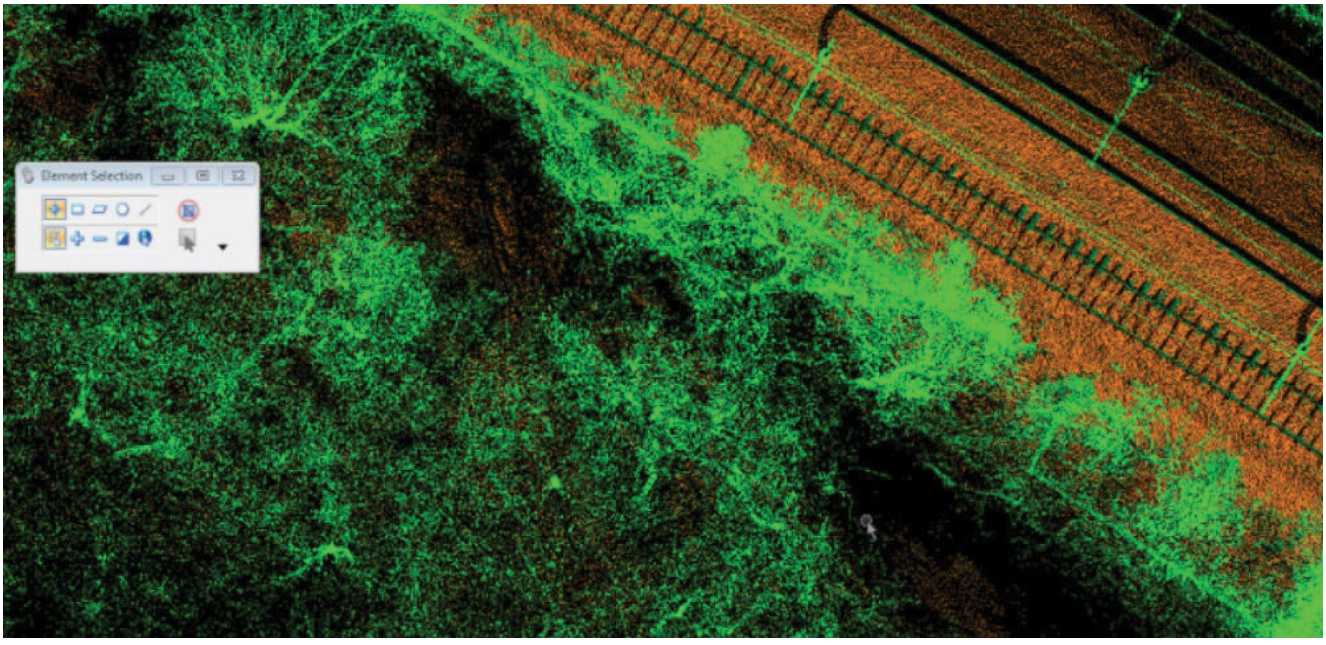

LiDAR point cloud data captured from the Terrametrix scan vehicle traveling on the rail using 3d looking down vantage point.

bridges, etc; by penetrating until there is no return. Traditional passive distance technology emits a single pulse and return with the distance of the first object hit. The pulse is returned and is detected by the sensor giving the range from the object. This is how LiDAR earned its name—Light Detection and Ranging. The total station is a perfect example of a single pulse return, older airborne LiDAR systems are another.

But, mobile LiDAR systems acquire vegetation from a different point of view than airborne LiDAR simply because of the angle of the scanners and post processing techniques. On a mobile system the scanner(s) are mounted at a 45 degree angle (+ or -) to the earth surface. An airborne system is looking straight down. The benefit of airborne for ground truth is that the angle of acquisition is 90 degrees to most surfaces including the canopy. The benefits of mobile LiDAR acquisition are that the scanners are mostly under the canopy. Both collect three dimensional points: latitude, longitude, and ellipsoidal height, and both have their expertise. Survey-grade mobile LiDAR excels at highway and rail surfaces for design, analysis and asset inventory because they acquire that data closer to the surfaces collected. Airborne excels at wide corridors and tops of buildings because of their vantage point.

"One of the most common questions we get in survey grade mobile scan acquisition is… Can we find bare earth? That answer is the last return will not always be from a ground return." explained Terrametrix mobile scan technician, Todd Gnuse. "The first returned laser pulse is the most significant return and is associated with the highest or closest feature in the landscape. The first return can also represent the ground, in which case only one return will be detected by the LiDAR system. 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."

Terrametrix used Riegl VQ 450 scanners collecting 300,000 points per second each on an Illinois rail project in June. The 3.2-mile rail corridor route involved thick vegetation perpendicular to the rail alignment to the toe of the slope in some places 8' below the top of rail. The Class 1 invisible beam eye safe scanners collected point cloud data classified into ground, low vegetation, medium vegetation and high vegetation registered to project coordinates.

"The client was not looking to obtain a dense ground network in the vegetation, just something comparable to what can be obtained with conventional survey

at 100' sections," said Michael Frecks, PLS, Terrametrix President/CEO. "The result was an RMS error report of 0.017' to 44 control points every 1/8th of a mile with a 75' reach from centerline of track. Multiple return greatly increased the density of useable points."

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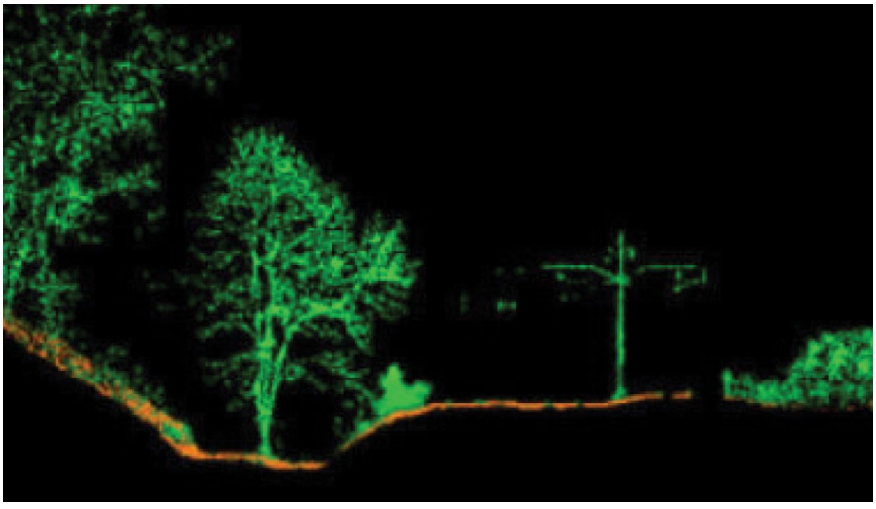

Cross section of Multiple return point cloud scan data captured from a moving platform by Terrametrix at survey-grade accuracy.