The Reference Library

LIDAR Quality Levels – Part 1

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The LIDAR community has been gradually adopting the terminology "Quality Level" to categorize airborne LIDAR data. The idea is to use a simple scheme to characterize the more important features of a LIDAR data set into a few broad groups designated QL*n* where *n* is the quality level.

The first unified idea of this scheme was introduced by Dr. David Maune of Dewberry in the 2011 time frame as part of his National Enhanced Elevation Assessment report. His recommendation for QLs were:

QL	***Density (pts/m^2)***	***NPS (m)***	***Vertical RMSE (m)***
QL1	8	0.35	0.0925
QL2	2	0.7	0.0925
QL3	1 – 0.25	1-2	0.185
QL4	0.04	5	0.463 – 1.390
QL5	0.04	5	0.927 – 1.850

There are two major criteria in the Quality Level rating: point density and vertical accuracy. Point density is simply the average number of points per unit area. I like to use meters regardless of the horizontal units of the data and thus tend to characterize this as points per square meter (ppm^2). Another way of looking at this criteria is the average distance between points, the nominal point spacing (NPS). In practice, NPS is difficult to measure because LIDAR point spacing is inherently non-uniform. The second significant criteria is the vertical accuracy. This is expressed as the root mean square error (RMSE). It is a measure of the absolute (as in absolute value) deviation of the data from some known vertical datum, usually surveyed ground locations.

For the USGS 3D Elevation Program (3DEP), several additional criteria are added; *precision* and measures of vertical *sheer* at LIDAR swath overlaps. Precision is the repeatability of a measurement (in fact, the USGS specification uses this term for precision). These two criteria, as it turns out, are critically important for improving the reliability of automated feature recognition algorithms.

The USGS quality levels (as documented in the LIDAR Base Specification, Version 1.2 by Karl Heidemann) are:

QL	***Density (≥ pts/m^2)***	***Precision (RMSE ≤ cm)***	***Swath Overlap Difference (RMSE ≤ cm)***
QL0	8	3	4
QL1	8	6	8
QL2	2	6	8
QL3	0.5	12	16

Notice that I have dropped the Nominal Point Spacing from the table and added the precision and swath difference criteria. Also note that Karl has added a QL0 with density the same as QL1 but tighter vertical specifications.

So enough of the specifications! The real question I want to address is the value of buying up from QL2 to QL1. The difference in density is a factor of 4 while the precision and swath criteria remain the same. By the way, Karl was rather clever with this portion of the specification, I think. Tightening a precision and/or vertical swath difference requirement can add substantially more to the cost of a LIDAR data acquisition than the incremental cost of increasing density. By the way, we are working with Karl and Dr. Qassim Abdullah (of Woolpert) on a tool in LP360 to measure LIDAR precision regardless of the slope of the reference plane. A beta of this appears in our 2015 EXP release. It is a point cloud task called "Planar Statistics."

I would say, in a nut shell, that upgrading from QL2 to QL1 enhances urban analysis and planning as well as enabling the application of a broader array of automatic feature extraction tasks. Perhaps the single best example is the automated extraction of building "roof prints" by detecting the planar nature of these structures.

In Figure 1 is depicted a set of buildings extracted from 2 point per square meter (ppm^2) LIDAR data (QL2). These data are from Davidson County, Tennessee and are courtesy of the USDA. These buildings were automatically extracted using LP360's Planar Extraction point cloud task. The good news is that our extractor will find the planar roof surfaces with high accuracy, even at 2 ppm^2.

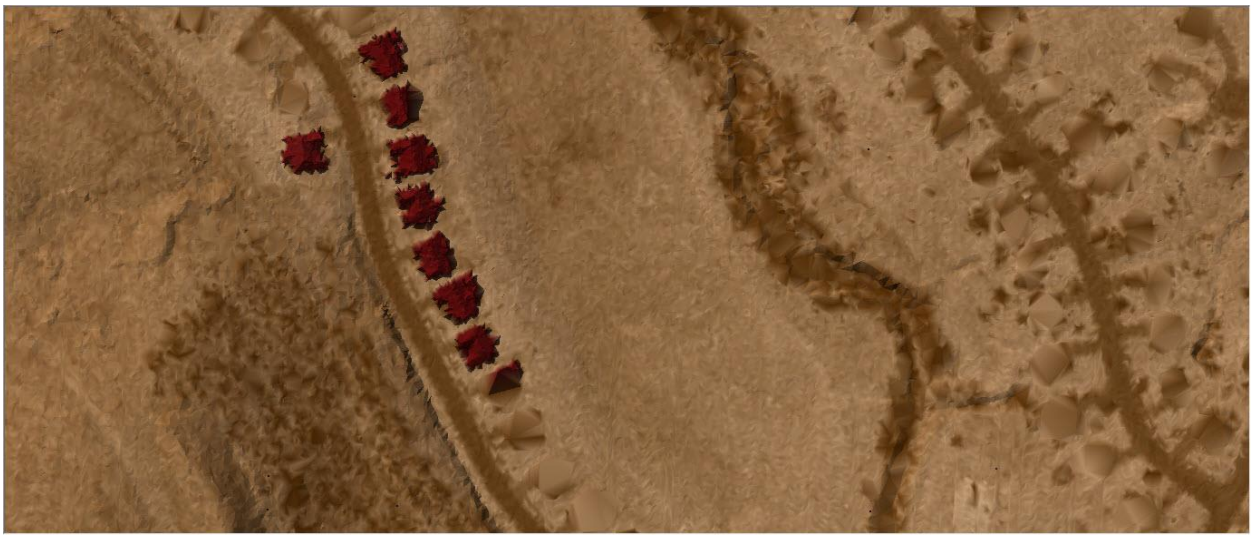

Figure 1: Buildings automatically extracted from 2 ppm^2 data (Courtesy USDA)

However, as shown in the zoomed in view of Figure 2, the definition of edges and slope changes are not very distinct. This makes accurate vectorization (outlining) of these data a real challenge.

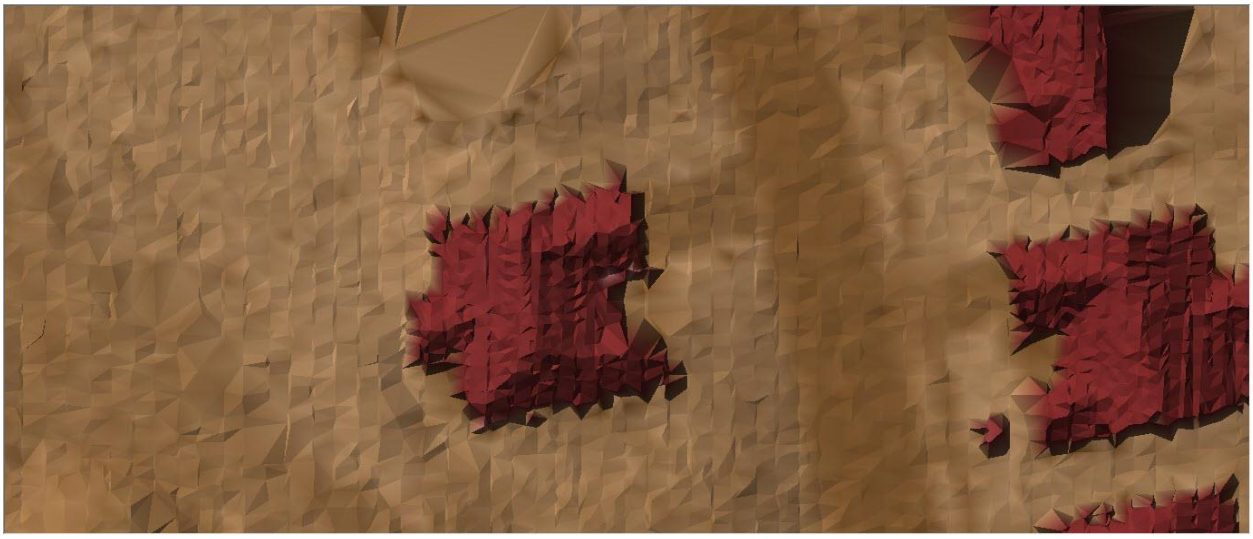

Figure 2: Zoomed in view of extracted buildings in 2 ppm² data

In Figure 3 are depicted transmission lines at 2 ppm². Again, the positive is that these wires are clearly visible. The negative is that this level of detail would not support precision extraction such as determining the connection points of the wires to insulators at the towers.

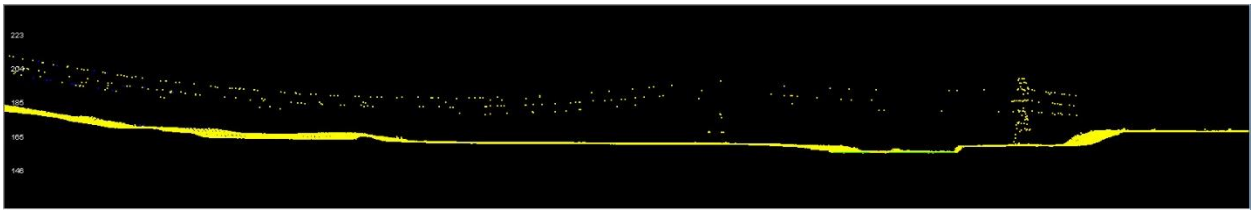

Figure 3: Transmission lines in 2 ppm² data

Compare this to the approximate 8 ppm² QL1 data shown in Figure 4. This is an LP360 rendering in the Map View with the data colorized by class. Ground and Building points are rendered via the surface renderer (as a TIN) whereas other classes are shown as points superimposed on the TIN. The entire scene is then 'modulated' by the intensity of the LIDAR return, providing details such as roads. Note the extremely sharp detail of the building roofs with clearly discernable roof edges and slope joins. Note also the detail in the point rendering of the trees. I think this is simply a gorgeous rendering, providing an almost color ortho view of the scene. This is a data set provided to us by Dr. Al Karlin of the Southwest Florida Water Management District (SWFWMD).

Figure 4: Buildings shown in 8 ppm² data (Courtesy Southwest Florida Water Management District)

Of course, least you get concerned about QL2 data, consider a sample of 1 ppm² shown in Figure 5. The high level of quality of QL2 data is readily apparent when you compare these data to those of Figure 2.

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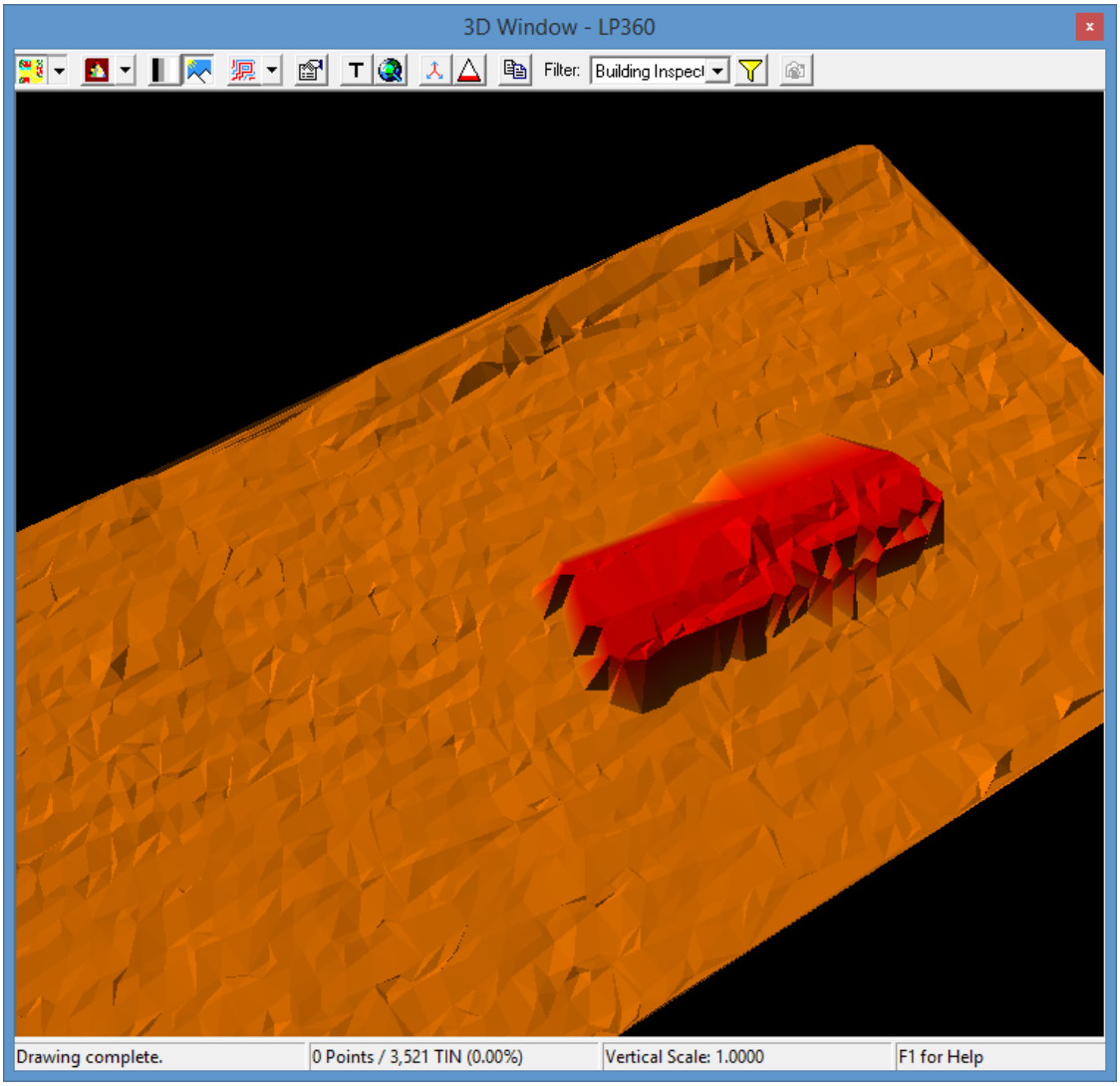

Figure 5: 1 ppm² data (between QL2 and QL3)

By the way, our new Live View tool in the 2015.1 Experimental Release (EXP) makes the construction of these hybrid point/TIN views very easy to both construct and save. Those of you who need to frequently change the viewing filters are going to love Live View!

In next month's issue of GeoCue Group News, I will provide a table of analysis and data extraction tasks mapped to QL2 and QL1 data. The "qualitative" summary for this session is: QL2 data are terrific, QL1 data are fantastic!!