Table 1. Data Quality Measures (DQMs) or inter-swath goodness of fit measures

Nature of surface	Examples	Data Quality Measures (DQMs)/Goodness of fit measures	Units
Natural surfaces	Ground surface, i.e. not trees, chimneys, electric lines etc.	Point to natural surface (tangential plane to surface) distance	Meters
		Point to surface vertical distance	Meters
Man-made surfaces	Roof planes	Perpendicular distance from the centroid of one plane to the conjugate plane	Meters
	Roof edges	Perpendicular distance of the centroid of one line segment to the conjugate line segment	Meters

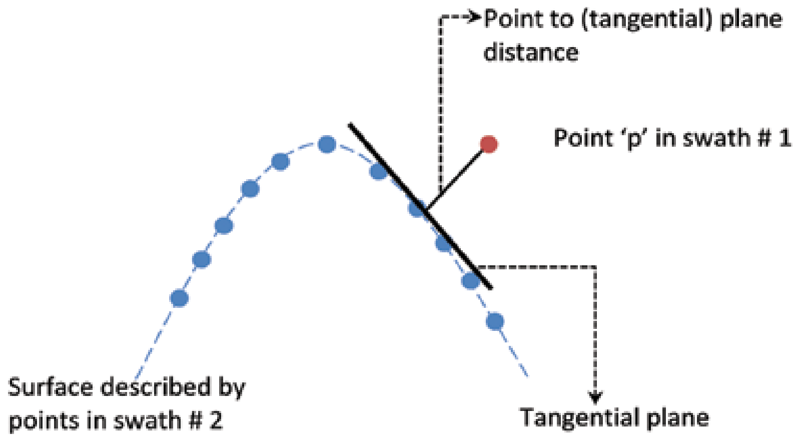

Figure 3. Representation of DQM over natural surfaces. Point 'p' (red dot) is from swath # 1 and the blue dots are from swath # 2

The DQMs are not direct point-to-point comparisons because it is nearly impossible for a lidar system to collect conjugate points in different swaths. It is easier to identify and extract conjugate surfaces and related features (e.g. roof edges) from lidar. The DQMs over natural surfaces and over roof planes assume that these conjugate surfaces are planar, and determine the measure of separation between a point and the surface (plane). The DQM over roof edges extract break lines or roof edges from two intersecting planes and measure their discrepancy.

DQM Over Natural Surfaces: Point to (Tangential) Plane Distance

This DQM is calculated by selecting a point from one swath (e.g. point 'p' in swath # 1), and determining the neighboring points (at least three) for the same coordinates in swath # 2. Ideally, the point 'p' (from swath # 1) should lie on the surface defined by the points selected from swath # 2. Therefore, any departure from this ideal situation will provide a measure of discrepancy, and hence can be used as a DQM. This departure is measured by fitting a plane to the points selected from swath # 2, and measuring the (perpendicular) distance of point 'p' to this plane.

DQM Over Roof Planes: Point to Conjugate Plane Distance

Where man-made planar features (e.g. roof planes) are present in the region of overlap, these features can be extracted and used for measuring the inter-swath goodness of fit. These planes can be extracted automatically, or with assistance from an operator. Assuming PL1 and PL2 to be conjugate roof planes in swath # 1 and swath # 2 respectively, the perpendicular distance of points used to define PL1 to the plane PL2 can be determined easily. Instead of selecting any random point, the centroid of points used to define PL1 can be determined. The centroid to plane PL2 (in swath # 2) distance can be used as a DQM to measure the inter-swath goodness of fit (Habib et. al., 2010).

DQM Over Roof Break Lines: Point to Conjugate Line Distance

If man-made linear features (e.g. roof edges) are present in the overlapping regions, these can also be used for measuring discrepancy between adjacent swaths. Roof edges can be defined as the intersection of two adjacent roof planes and accurately extracted. Conjugate roof edges (L1 and L2) in swaths #1 and # 2 should first be extracted automatically or using operator assistance. The perpendicular distance between the centroid of L1 (in swath # 1) to the roof edge L2 (in swath # 2) is a measure of discrepancy and can be used as DQM to the measure inter-swath goodness of fit (Habib et. al., 2010).

Absolute Accuracy of Lidar Data

The current practice of measuring the accuracy of lidar data is to collect GCPs in open horizontal regions and measure the discrepancy in the vertical coordinates from the lidar-derived surface. A disadvantage of using this method is that horizontal errors in the data are not accounted for. Specially designed and built targets are commonly used in photogrammetry, and can be used as a means to assess