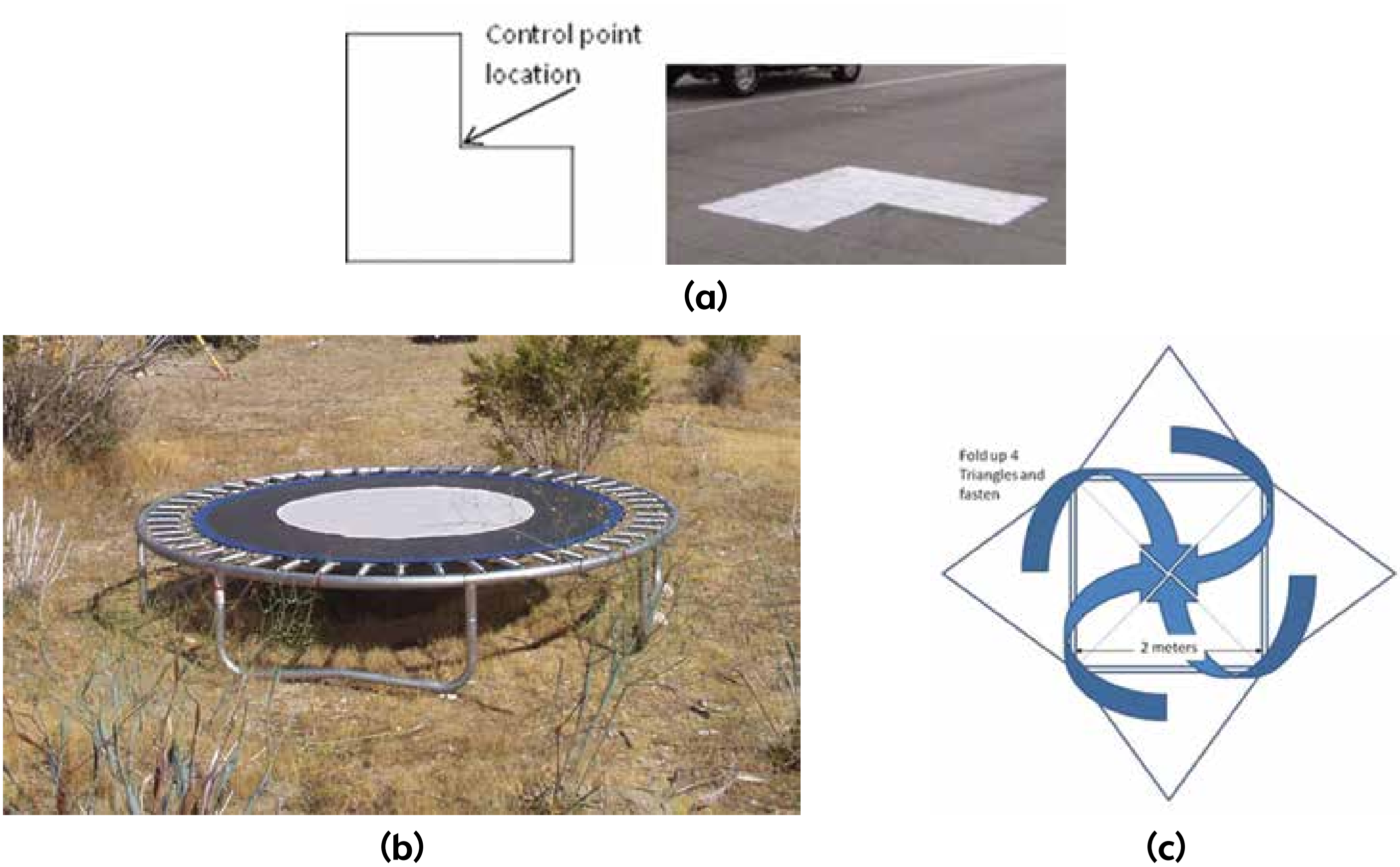

Figure 4. Design of targets (a) Painted Targets (b) Elevated Targets and (c) 3D Targets.

the horizontal and vertical accuracy of lidar data. The targets must be designed such that they can be extracted from lidar data. The targets shown in Figures 4 (a) and (b) have been used for lidar horizontal accuracy assessments (Csnayi and Toth 2007; Bethel et. al., 2006, respectively) while the target shown in Figure 4(c) (Stoker, unpublished, 2011) is in the design phase, and will be tested in 2014.

The use of targets is not new to the geospatial industry as they have been used in conventional surveying, photogrammetry and also microwave/Synthetic Aperture Radar (SAR) based mapping. Alternatively, planar features of as-built structures can be measured using a total station instrument, and the surface be used as a target for measuring absolute accuracy. Another method of using GCPs surveyed in open terrain (both horizontal and sloping terrain) is currently being investigated.

Sensor Model Based System Calibration

While the above two processes are recommended for QC of lidar data, for Quality Assurance (QA), it is recommended that a lidar system be calibrated using rigorous or semi-rigorous sensor modeling. Rigorous calibration methods are based on determining parameters describing the sensor model completely. Since many parameters associated with a complete sensor model are proprietary, software to perform rigorous calibration can only be provided by the instrument manufacturer. Rigorous methods of calibration are often a two-step process, decoupling the georeferencing portion (lever arm) from the range and boresight measurements. The rigorous calibration approach is robust, and since the process is automated the resulting swaths of data are consistent with each other and with external control.

A semi-rigorous sensor model calibration assumes a generic sensor model, and depends on the instrument manufacturer to convert parameters of their proprietary sensor model to parameters of the generic model. Examples include the Universal Lidar Error Model (ULEM) developed by NGA (NGA 2012), and Quasi Rigorous sensor model developed by Habib (Habib et. al., 2010). However, these generic models may not have the ability to completely capture all the intricacies of the original sensor model.

Current Status and Concluding Remarks

The USGS led ASPRS Cal/Val Working Group recognizes that the proposed QA/QC procedures are a departure from the currently practiced process. Before recommending these procedures to be adopted for data procurement, they have to be tested against real data sets. Hence, a prototype software tool has been developed that implements the DQMs over natural surfaces. A comprehensive test plan has been prepared and distributed to data vendors. Currently, this tool is being tested on different data sets, collected under different conditions, instruments, and by different vendors. The goal of the testing process is to test the efficiency and validity of DQMs as indicators of the goodness of fit from lidar system calibration. The lidar system calibration can have