FAST FACTS

- $4,950 list price
- Uses standard Android tablet
- Uses Primesense™ depth sensor/ camera
- On-tablet processing

QUICK SPECS

- 0.6 – 3.3m range
- 0.2% RMS accuracy
- Near-IR wavelength
- 20cm x 24cm x 6cm size
- <1kg weight

ON THE DOT

Collecting 3D data with a novel handheld imaging device

Figure 1: DPI-7 Scanner - Front & Back

The DOTProduct DPI-7 is an interesting offering in a growing market (e.g. Tango, Matterport, Structure, etc), of handheld 3D scanning systems. By integrating sophisticated software (Phi.3D) with readily available off-the-shelf sensors and tablets, it appears that DOTProduct has been able to create a very effective and professional-grade product. Astoundingly, all processing is completed entirely on the tablet. LIDAR News took advantage of a recent opportunity to evaluate this new product. Overall, we were very impressed with the capabilities of the DPI-7. Our findings are reported here.

BY BILL GUTELIUS

Background

Founded in 2012, DOTProduct, LLC was formed by Rafael Spring, Mark Klusza and Brian Ahern. With seed investment from Intel, DOTProduct was able to jump start development of a new approach to spatial data collection software.

According to Tom Greaves, Chief Marketing Officer, DOTProduct is really a software company where they are "hardware agnostic". The DPI-7 is finding a foothold in many industries, but Greaves pointed out that building-information-modeling (BIM) is currently underserved and therefore represents the greatest opportunity for growth.

Some of the representative markets/ industry verticals served by the DPI-7 are:

- BIM/MEP
- Asset management
- Industrial facilities, plants
- Security, law enforcement, forensics, insurance
- Construction & custom renovation
- Heritage conservation
- Education

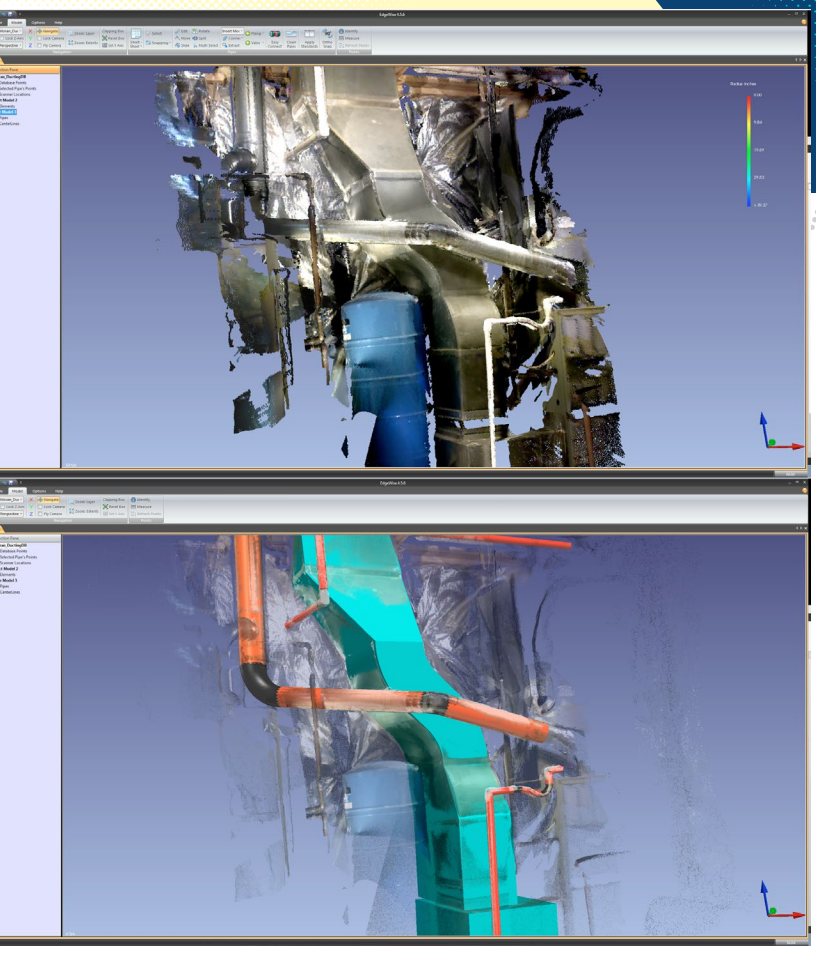


Figure 2: Edgewise Duct Extraction – Point Cloud & Model

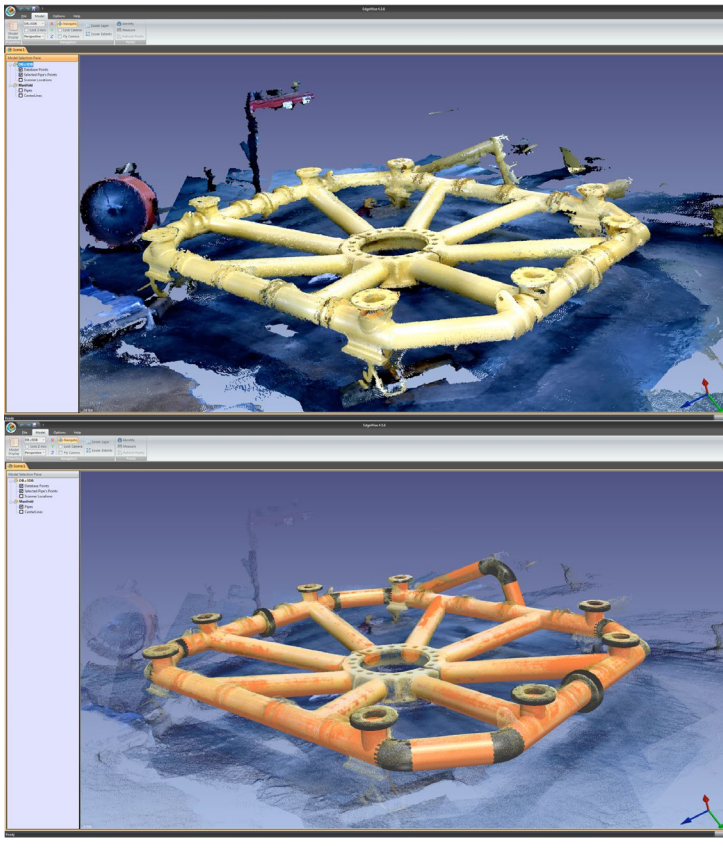


Figure 3: Edgewise MEP Extraction – Point Cloud & Model

Workflow

The typical workflow for DPI-7 data is analogous to that for terrestrial laser scanning. Binary output files (DOTProduct's proprietary format) are supported by Autodesk ReCap which is the path to Revit, AutoCAD 2014/2015, Navisworks, etc. Additionally, the binary file format (.DP) is supported by AVEVA LFM. PTS, PTX and PLY are available as industry standard for all other packages. Most CAD products ingest these formats directly.

Some examples of packages that read PTS, PTX, and PLY are: FieldPipe from Intergraph, and also Bentley MicroStation. We performed the bulk of our off-tablet analysis in Cloud Compare—a powerful, but free point cloud software tool.

During the product evaluation process, we participated in a webinar presented by ClearEdge3D where they worked with DPI-7 data. The example dataset included a very irregular duct in a complex configuration of MEP objects. Owing to the high detail and relief provided by the DPI-7, the duct was quickly extracted using the Edgewise software tools. **Figure 2** shows this unique duct, while **Figure 3** shows a pipe manifold also extracted from DPI-7data.

Technology

As mentioned, the DPI-7 relies on inexpensive, off-the-shelf hardware. The current version of the hardware consists of:

- 7" HP Slate Tablet (they have recently begun shipping kits with the 8" NVidia SHIELD tablet with 2GB RAM which we did not test)
- Primesense depth sensor and camera (similar to the original Kinect)
- Simple mounting plate and camera handle
- Phi.3D software

This integration of low-cost hardware components helps keep the cost down. Alternative tablets can be substituted and DotProduct's Phi.3D software supports other sensors including the Google Tango.

DOTProduct has leveraged the processing advances in GPUs available on tablet devices. Multiple, overlapping image frames are depth-mapped using the near-IR sensor. The images are then registered using a proprietary simultaneous-localization-and-mapping (SLAM) algorithm. All processing of

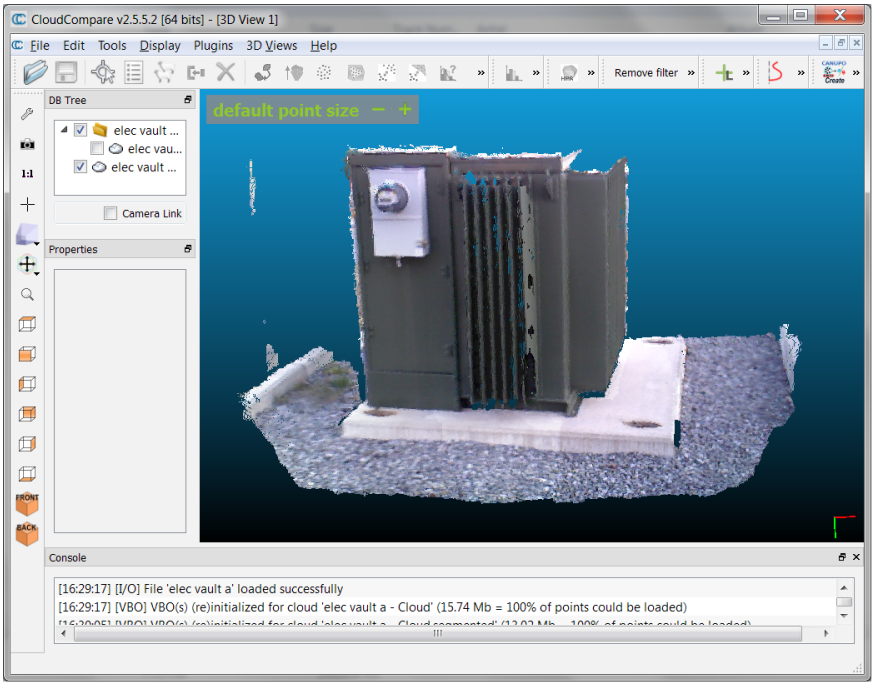
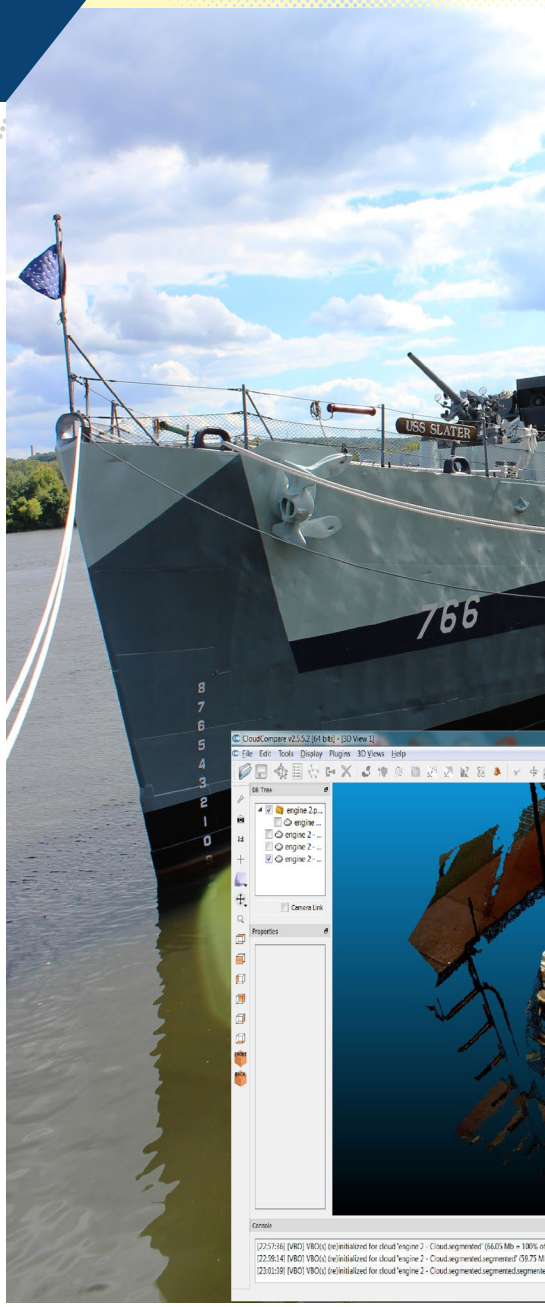


Figure 4: Outdoor Electrical Vault On Pad



the data is performed completely on the tablet. There is no need to post-process in the cloud or on a separate computer.

Tests & Results

Once again, the "noob-test" was employed in evaluating the DPI-7. Ease of use is a major criterion for measuring the effectiveness of any 3D scanning instrument. We quickly figured out how to manipulate the point cloud right on the tablet within minutes and without training.

It's important to understand that the DPI-7 is significantly range-limited. The device is intended for near-field applications where objects and scenes are not more than about 3m away (2-11 feet).

Electric Vault

While the DPI-7 depth sensor operates at a wavelength typically saturated by direct sunlight, we took advantage of an overcast afternoon to scan a large electric vault at a local high school. The sensor had no difficulty at all in getting returns from the vault. An example of the results can be seen in **Figure 4**.

Ship's Engine

The USS Slater (WWII destroyer escort vessel) is a floating museum on the Hudson River near Albany. We took the DPI-7 to the engine room to see how it would perform in a cluttered environment many MEP challenges (see **Figure 5**).We observed that the DPI-7 had difficulty in the pilot house and other areas where there was direct sunlight, but in the bowels of the ship it worked very well.

Building Renovation

Another application area is buildings under renovation. We scanned the interior of a 150yrold mercantile building undergoing a complete renovation following a fire. The plaster and lathe walls were removed exposing large timber framing. The DPI-7 performed very well in this instance. Due to the geometry (joists, studs, columns and other pronounced geometric features) in the building, the scanner never lost tracking and scene fitness remained good ("green") throughout. An example of a height measurement of the support beams can be seen in **Figure 6**.

Figure 5: USS Slater Destroyer Escort—Point Cloud of One Engine

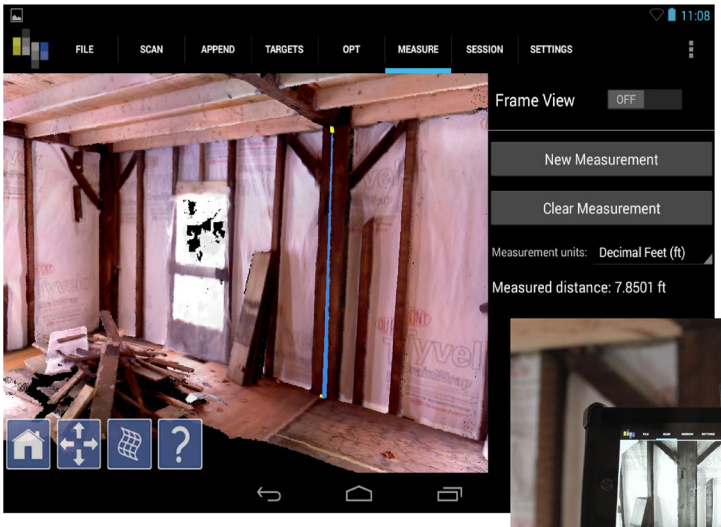


Figure 6: Building Renovation—Beam Height Measurement In Point Cloud

Living Room

To simulate a forensics scenario, we scanned a medium sized residential room (**Figure 7**). Again, with the dispersed furniture in the room, the DPI-7 consistently kept track. The only difficulties encountered occurred when we had to transition the scan across an open doorway. For these situations we used the "Append" function and placed objects within the doorways (as suggested in the operator's manual). In addition to the DPI-7, we scanned the room with a handheld LIDAR unit. The comparison of the point cloud images is presented in **Figure 8**.

Observations & Impressions

In certain cases we found it difficult to move quickly through a room. However, the device warned us, in real time, whenever we swept the sensor too fast. Tracking was lost every once in a while, but unlike other handheld scanners we have tested (Sense), reacquisition was fast and easy. The speed of the survey was entirely dependent on the scene geometry (intersecting planes and objects across the field of view). Where features and intersections lacked, we had to move much slower, but in the case of pronounced geometry we could speed up without loss of tracking.

Features & Benefits	Limitations
Real -time results and registration	Max range of 3.3m
Append to existing data sets in real-time	Indoor only[1]
Light weight/handheld	RAM limits of tablet
Inexpensive hardware	Warm-up time required for sensor
Very efficient proprietary file compression	
Powered by tablet battery, long endurance	
Hardware "agnostic"	

1 While the manufacturer recommends that the sensor primarily be used under indoor lighting conditions, we found that by operating in very early or late times of day or under heavy overcast, we could still obtain reasonably good results out-of-doors. (see **Figure 4**)

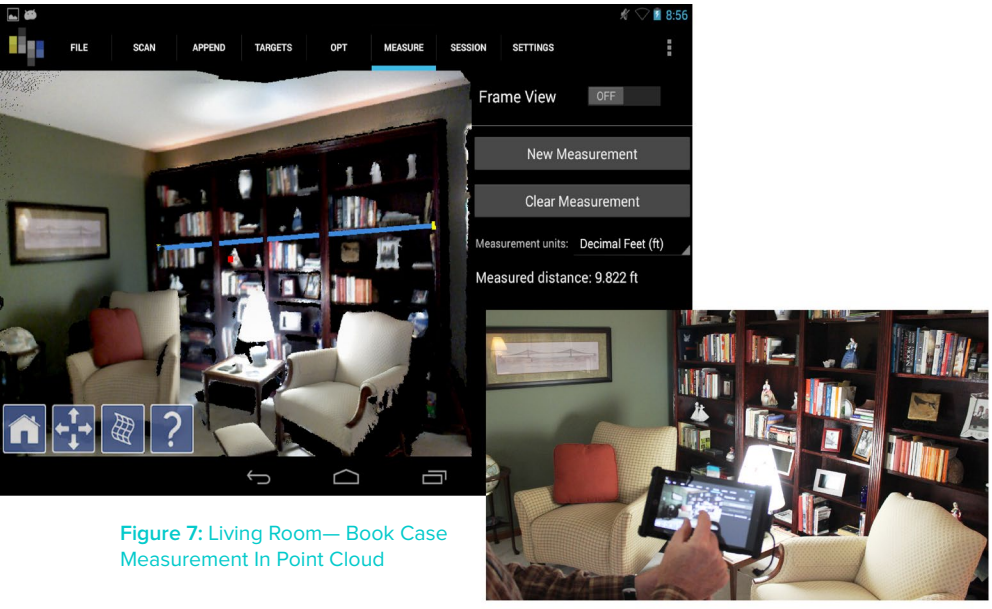


Figure 7: Living Room— Book Case Measurement In Point Cloud

Range is definitely a limiting factor. While the near field limit minimum of 2 feet represented little problem, finding ways to quickly cover large areas at the maximum of 11feet was difficult. For example, in one test we attempted to scan a typical room, but the onboard RAM was filled before we could complete the entire room. We were able to get around this by using the "Append" feature (more on this later) which allowed us to continue scanning while registering the new scans to the prior scenes coordinate frame.

One area where the DPI-7 really shone was in trying to capture 3D imagery of the ship's engine room. Individual ducting, pipe work and engine features (along with control panels and other ancillary equipment) were easily discernible and could be individually extracted from the point cloud for ingesting in CAD packages. The previous examples provided by ClearEdge3D show how it is possible to pull-out individual pipes and other engine features.

We found that there is a trade-off in maintaining tracking (for the SLAM algorithm) when widening the field of view by using greater stand-off distance from the target area. By being further away, the operator can cover a greater number of textures and features in the scan scene (thereby enabling better tracking), but this resulted in introducing the potential for greater distortion.

The ability to see coverage in real-time, as well as the quality of the coverage, provided a very high-degree of confidence in knowing that the survey area was scanned completely and accurately. This should be a real benefit to operators who can then leave the field knowing with certainty that they won't have to re-visit the site and that the data will actually be useable.

Documentation is comprehensive and detailed. It is also well written and easy to follow. We were able to figure out some of the more advanced features and capabilities by simply following the steps outlined in the DPI-7 operator's manual.

We obtained better results in accuracy (scene fitness) by following the manufacturer recommendations to maintain orthogonality (of the scanner) to surfaces. As in traditional laser scanning, quality was reduced when the angle became very shallow/oblique.

It's worth noting some of the particularly interesting features and capabilities we encountered while testing the DPI-7:

Append

The Append function is a very unique feature of the DPI-7. We were very impressed with this innovative tool and used it extensively. There are 2 main aspects to this feature that make it extremely useful:

1. In the case of missing or incomplete coverage following a scan, the operator only has to select the "Append" tab, line up a previous frame (from a selection of image frames) and then start scanning again. The DPI-7 automatically localizes on the features that it finds in common between the selected frame and the new scan.
2. The other important capability is the appending of DPI-7 data to 3rd party laser scan data. For example, a data set from a Faro or Leica scanner can be imported into the DPI-7 and then the Append function is selected as in the example above. This time the reference "frame" is data from the other scanners rather than the DPI-7.

Measure

Using the Measurement function, the operator can perform basic linear measurements right on the tablet screen

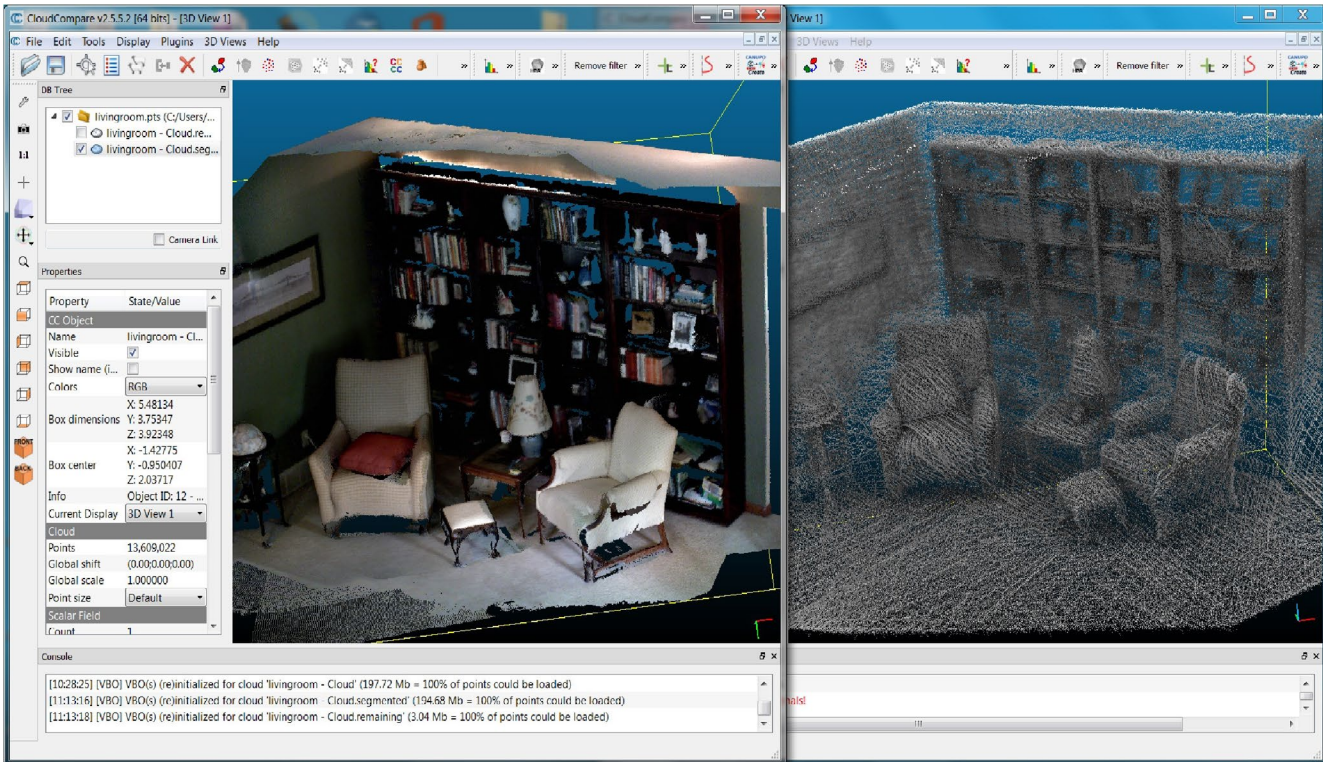


Figure 8: Comparison of DPI-7 to another handheld (LIDAR) scanner in Cloud Compare

in real-time. Under this function tab is a slider that enables switching between 2D frame and 3D point cloud/mesh view. This allows easier placement of measurement points. We found it was rather tricky to pinpoint the exact spot so we had to flip back and forth between 3D and 2D (frame) setting to get a precise measurement.

Image/Point Cloud/Mesh Manipulation

On screen manipulation was truly impressive. This was our first exposure to working with point clouds and meshes on a tablet rather than on a laptop or workstation. The standard Android one-finger/2-finger movements were all that were required for zooming, translation and rotation.

There are several advanced features ("Target" and "Optimization") available in the software that are very interesting, but would t too much discussion for this brief review.

Conclusion

Given the low price and enhanced feature-set, the utility function of the DPI-7 is very high. Additionally, having the ability to ensure completeness and accuracy in real-time, before leaving the field, is incredibly valuable. This contributes directly to lower survey costs.

We were very impressed with the ease-of-use. After so many years of using traditional scanning systems where the time-to-point cloud was hours (if not days), it was very refreshing to be able to have the ability to interrogate the data in real-time. At $4,950, the DPI-7 is a bargain. Yes, range is restricted to small areas and nearby objects, but the device seems to us to be a must-have for firms engaged in facilities/asset management and BIM production.

Note: A longer text version of this review appears at www.lidarnews.com.

Bill Gutelius is the President and co-founder of Active Imaging Systems (AIS). In 2007 he formed AIS where he consults for commercial and government clients on active and passive imaging technologies and their applications.