By Shawn Billings, LS

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Leica Disto 3D

I've never really done a survey of an interior space. On numerous occasions I have set up total stations in the office or in my home to measure interior objects and have always found the process to be a real pain. Finding a suitable location for the instrument that allows me to move behind it and at a sufficient height to permit collimation of various targets by looking through the scope can be difficult. Add to that using a 30x scope to find the target in a room that isn't particularly well lit and the process becomes quickly irritating. I can't imagine how cumbersome it must be to do surveys for a living in truly challenging and confined spaces with conventional instruments. Such surveys are often performed to meet a myriad of needs (construction layout, as-built for any number of design needs, and forensic support come quickly to mind). Since the invention of the total station, the synergistic marriage of theodolite and electronic distance meter, there have been a few dramatic enhancements–data collection interfacing, internal data collection, robotics, reflectorless distance measurement, and (more recently) integrated digital imaging.

The new Leica Disto 3D is one of the most ingenious devices released in the past decade, partly because it includes each of the enhancements above, while also addressing the deficiency in working with total stations indoors. I had the opportunity to spend a few weeks with the Disto 3D and found myself convinced that this will be a popular item in the construction industry and that surveyors and investigators will surely find a device like this to be a handy tool for accident reconstruction and crime scene investigation (perhaps even lending support to close-in photogrammetric modeling).

The Leica Disto 3D is a compact, servo-driven total station tailor made for interior spaces. The touch screen tablet stores data and controls the Disto 3D wirelessly (or cabled). The thumb drive allows for easy upload and download of project data.

The Leica Disto 3D is actually the very functional combination of several existing technologies. The EDM (electronic distance meter) is, at its heart, the same as that found in its Disto cousins–the D8 and the D5. The difference is that the EDM is mounted on a servo motor driven base, rotating on both a horizontal axis and vertical axis. Furthermore, the 3D is mated with a 5 megapixel digital camera and WiFi. In this, Leica has merged three technologies it already has considerable experience in: portable, reflectorless EDM; servo guidance; and correlated digital imaging. The result is a piece of hardware that is well thought out and executed.

According to my contact at Leica Geosystems, John Anderson, the development team set out to build a device that was capable of point positioning with an accuracy of ± 1 millimeter in three dimensions at a range of 10 meters. Because of the capability of the EDM and angle accuracy of 5 arc seconds both in horizontal and vertical, at the maximum range of 50 meters, the anticipated accuracy is still only

While the ceiling of this auditorium is well beyond reach, the Disto 3D was able to measure the distance along the stage light bracket at 20.5 feet and the size of the vent on the far wall at 13" by 17".

Because of the Disto 3D's design, I was able to set it up on this organ and measure most of the interior of this auditorium. Because it has no scope, I did not need to worry about how I would move around it.

The Disto 3D builds on Leica's wildly popular Disto series of handheld reflectorless EDMs. The family resemblance becomes a bit more apparent here.

4 millimeters (a little more than an eighth of an inch or one hundredth of a foot). It is difficult to conceive of practical architectural or forensic purposes that would require more accuracy.

Leica went to great lengths to create a product that builders and designers would actually use. The appearance is neat, looking as much like a modern rotating laser than a total station. Instrument set up is simple, though not particularly suited to setting up over a control point (such as would typically be done with a conventional total station) as it has no plummet, revealing a definite preference in work flow toward resections. This isn't to say that a set up can't be made on a control point. There are four prominent hash marks at the four quadrants of the instrument base to facilitate such set-ups. With a proper X mark on the floor (with the crossing members carefully perpendicular to one another) the 3D could be set up with the quadrant marks lined up over the extended lines of the X, however I doubt this will be done much in practice. While the Disto does not have a tribrach, the base is fitted with a 5/8 inch x 11 thread female receptacle for affixing the unit to a conventional tripod. While this diversifies the set-up options to the user, I never once set the 3D on a tripod. I found that placing the instrument on a firm, level table, or even the floor worked perfectly and was far easier–requiring less space than a tripod and often allowing me to work without a lot of rearranging. Leveling the instrument, using the spirit level in the top of the base, need only be done to within 3 degrees at which the internal compensators correct any remaining error.

Because the 3D does not require the user to look through a scope (and in fact has no scope at all) the instrument doesn't have to be set up at a convenient height or in a place the user can move around to operate. It can easily be placed on the floor in a corner if such placement affords the best view of the points of interest. "With no scope, how does one collimate targets?" you may be wondering. This aspect is truly ingenious and could likely be a trend in many future total stations. The Disto 3D is equipped with a five megapixel coaxial digital camera.

The image from the camera is transmitted at around ten frames per second to a remote touchscreen device, similar to a small tablet computer or large smart phone. This transmission can be made via hard wire connection or through WiFi. Because video requires a great deal of bandwidth, WiFi becomes the only license free wireless option. Typically the downside to WiFi is range, however the anticipated operating range of this device (about 50 meters) is well within its reach. The images allow for real time target acquisition. Virtual crosshairs are superimposed on the video feed so the user can line the instrument up on a specific target (such as a light switch plate screw). These images also allow for

documentation of what was measured. The user can take a picture of the light switch plate screw and surrounding area at the same time the measurement is made. Four levels of zoom are available, from 1x – 8x. Zooming in on a target is accomplished digitally as there is no zoom lens, thus resolution is sacrificed with higher magnification.

Some places are simply too dimly lit for the camera to be of much use, or the range exceeds the practical use of the camera. This is a likely scenario for many interior construction projects, particularly in new construction if the electricians haven't installed the lighting yet. The laser pointer then fills the gap. The Disto series of hand-held distance meters all use a visible red dot laser and the 3D is no exception. Simply look at the red dot projected on the target (such as the above hypothetical switch plate screw). Because the operator doesn't need to be at the instrument, he or she can stand right by the target and see the red dot up close. Working the controls of the remote, the user can adjust the location of the red dot until the dot is properly centered. I found this method particularly handy, and while my video gaming childhood drew me to controlling the 3D by video image, I believe the red dot is generally more functional. Having both is a wonderful combination serving different lighting conditions and ranges.

Power is supplied by on-board battery or by external power. The battery is ample for even long days, but with most interior spaces likely being electrified, the option to power up from a 110v outlet is great. At about seven hours, the recharge time is pretty lengthy for the Disto and the hand-held controller so a user would do well to keep close tabs on the battery status if they are working on a site with no power available.

The hand-held device works well for the purpose. The size is reasonable for its intended purpose of controlling the instrument and storing data, and it was easy to work with. The software Leica has on the hand-held works well and covers most of the basic operations a person can perform with the unit. However, the ultra utility of the device becomes a bit of liability with respect to the software. With so many potential uses for the Disto 3D, it becomes virtually impossible for Leica to develop software that will accommodate all of them. Hopefully Leica will ultimately develop drivers that other software developers in various industries can utilize in custom software. The control software can already be put on a laptop allowing a user to control the instrument from a computer. With other software possibly on the computer geared to a specific purpose, the cooperation is already within reach. Integrating the Leica driver directly into a CAD software or 3D modeling software, though, could make the work flow even better.

While this may seem somewhat critical of the software for the 3D, it certainly is not and reflects the incredible versatility of the unit and the difficulty of conceiving each potential use and the routines that would simplify those uses. Regarding software, some of the things Leica got right in a really big way are the data stor-

The laser dot is useful for determining where the instrument is pointed, particularly when the streaming video image becomes more difficult to use. In most interior spaces the dot will be easily visible. Seen here, the laser is collimated on a supplied paper target for a resection.

age formats and the automatic controls for the instrument (such as for resections, room scans, and point projections). On the issue of data storage, uploading and downloading data from the hand-held to computer is done by USB thumb drive. No cables, no download software. Simple. Complimenting this simplicity are the data formats. Instead of proprietary file formats, points and linework are stored in .dxf files, raw data is stored in comma delimited .csv and .txt files, and images are stored in compressed jpeg format. Leica did well here.

Controlling the unit is very intuitive. Leica's robots have for years been able to correlate images to angles. Leica's 1200 robot does not have to be perfectly aligned to the reflected signal of the prism for accurate angular measurement. The slight offset from the cross-hairs to the prism can be calculated from the "image" of the returned signal on the CMOS camera. Similarly, pixels of the image displayed on the Disto 3D hand-held can be converted to angular measurements, allowing the user to tap a spot on the picture shown on the touch-screen which prompts the unit to quickly calculate what angle to turn horizontally and vertically and turn to the selected point. If the point to be measured isn't within view of the camera, the user can swipe the screen with the stylus and the unit will turn accordingly. (The unit can also be manipulated horizontally or vertically simply by turning it by hand).

The automatic routines are brilliant in 3D. Room scans are fantastic. For a horizontal scan, turn the instrument to the elevation you wish to scan along (it need not be the same elevation as the instrument, determine the spacing of the scan points, and how far around you want to scan and then set the instrument to the task. At a rate of about one point per two seconds the Disto 3D collimates each scan point and records the measurement. If the Disto comes to an area you don't want in the scan, you can pause the scan and continue beyond that area. The amazing part of this process is that the unit is actually calculating (based on the previous two shots) where the next point will be to maintain the elevation you've established. If the wall is consistent, the prediction will be very close and require very little, if any, adjustment to the turned angle. If, however, the unit comes to a new wall or column, or some other abrupt change, it will adjust the horizontal and vertical angle to maintain the elevation along the new plane. The trigonometric exercises, together with the measurements required to make the adjustments, are carried out almost instantly and the Disto is back to work on the new plane. The end result is a line scan, at a near perfectly consistent elevation (+/- a fraction of an inch), regardless of the elevation of the instrument itself. Horizontal scans similarly track along a defined vertical plane. The instrument need not be in that plane. Thus, a steel column/truss can be scanned with the instrument sitting on the floor 10 feet from the vertical plane of the truss, and the Disto will automatically turn to points along the defined plane. Again, the trigonometric prowess of the instrument is fantastic!

In the "Measure" part of the controller software, a point can be measured, and the user can command the instrument to turn to a point five feet horizontally to the right and two feet above the measured point and within a second or two, the red dot is trained on a point five feet right and two feet up from the last point. In the same part of the software, the user can measure two points and determine the horizontal distance, vertical distance, slope distance, and slope percentage between them. From a builder's perspective these two applications would likely be the most commonly used. A contractor could quickly determine if a column is actually plumb or if a beam is level. He could quickly determine if the vertical difference between the floor and HVAC duct agree with the plans or if the slope of the handicap accessible ramp is within specifications of the American's with Disabilities Act. Most importantly, none of these measurements would require that a room be square or that a floor be level to accomplish, as might otherwise be the case.

The designers also did a great job regarding resections, which are the primary way the instrument is positioned within an existing job. The user is completely removed from the rigorous calculations and statistical analysis of the results of the resection but is given a sliding scale of desired positional accuracy–from ¼ inch to 2 inches, depending on the operator's needs. As this device is targeted to people who may not necessarily be professional surveyors, this approach seems prudent. The software

requires a minimum of three points for a resection (up to as many as five), even though a unique position can be determined by only two. Once the first two known points of the resection are measured, the instrument automatically turns to the remaining control point(s) for minor tweaking before measuring. The software then determines if the resection falls within the desired accuracy, allowing the user to continue to other routines or requiring corrective action.

The Leica Disto 3D is revolutionary. I know that "revolutionary" gets thrown around way too much, but what Leica has done in simplifying a total station and making it more functional for working in relatively tight enclosures, empowering untapped professionals with its benefits surely qualifies the Disto 3D to such a distinction. Doing all of that by simply putting a new twist on existing technology makes it an even more impressive feat. I can easily see a day when builders everywhere will have a device like this in their tool box and most police departments will have them on hand. I can also see a day when this design will find its way in surveyor's total stations as well. No doubt, even high quality digital cameras are cheaper to produce than high quality lenses and prismatic mirrors in total stations, making for a tempting transition in manufacturing–particularly if there are any perceived advantages to the user for doing so. The scene of a surveyor hunched over a scoped instrument may soon be replaced by that of a surveyor hunched over touchscreen tablet.

The Disto 3D allows users to store images for collected points for archival. This is the view from the Disto of the paper target shown on the previous page. In smaller spaces, particularly those that are well lit, the camera trumps the dot. Having both dramatically increases utility.

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