Leica Nova MS50
White paper

- when it has to be right
September 2013

David Eugen Grimm, Hans-Martin Zogg
Leica Geosystems AG
Heerbrugg, Switzerland
Leica Nova MS50
The new dimension in measuring technology

Abstract
Outstanding and enhanced total station functionality, GNSS connectivity, high resolution digital imaging and 3D laser scanning; this is mergeTEC a key component of the Leica Nova MS50.

mergeTEC not only merges the technologies it also merges the data. Images are referenced to total station measurements, total station measurements are complemented by 3D point clouds, which, themselves are colored by the image information. All data perfectly fits within the same coordinate system, globally referenced by GNSS measurements or by measuring known points.

How the Leica Nova MS50 – the world’s first MultiStation – can combine total station functionality, GNSS connectivity, digital imaging and 3D laser scanning in a single instrument and how the separate sensors work will be presented in this white paper.

Introduction
Leica Nova MS50 embodies 90 years of innovative thinking of Leica Geosystems to develop precise, reliable and flexible technologies.

The Leica MS50 is part of the Leica Nova solution which contains:
- outstanding surveying instruments, built on the latest technologies,
- integrated dataflow, straightforward and easy to understand workflow,
- services and support, accessible worldwide.

Faster, Better, Smarter, Simpler. These key words describe the benefits of Leica Nova; a unique solution that covers the complete process from capturing and visualising data, taking decisions and delivering.

The Leica Nova MS50 includes precise 3D laser scanning, extensive and precise total station capabilities, digital imagery and GNSS connectivity. Thanks to mergeTEC, the Leica Nova MS50 not only combines the hardware but also merges the data itself; images are synchronised with 3D laser scans and the scans tied into total station measurements.

Leica Nova MS50 – the world’s first MultiStation
The Leica Nova MS50 is the world’s first MultiStation and features outstanding precision, accuracy, efficiency, quality and versatility. The MS50 provides an angular accuracy of 1” (according to ISO 17123-3) and a new optical-distance measurement system (EDM) based on wave form digitizing technology. The EDM measurement accuracy is 1 mm + 1.5 ppm onto prism (according to ISO 17123-4) and 2 mm + 2 ppm for measurements onto any surface.

Table 1 Measurement Performance

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Accuracy/Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>angular accuracy</td>
<td>1” Hz and V</td>
</tr>
<tr>
<td>distance measurement accuracy</td>
<td>1 mm + 1.5 ppm</td>
</tr>
<tr>
<td>onto GPR1 prism</td>
<td></td>
</tr>
<tr>
<td>(according to ISO 17123-4)</td>
<td></td>
</tr>
<tr>
<td>distance measurement accuracy</td>
<td>2 mm + 2 ppm</td>
</tr>
<tr>
<td>onto any surface</td>
<td></td>
</tr>
<tr>
<td>(according to ISO 17123-4)</td>
<td></td>
</tr>
<tr>
<td>distance measurement range1 onto</td>
<td>1.5 m up to 10,000 m</td>
</tr>
<tr>
<td>prism</td>
<td></td>
</tr>
<tr>
<td>distance measurement range2 onto</td>
<td>1.5 m up to 2,000 m</td>
</tr>
<tr>
<td>any surface2</td>
<td></td>
</tr>
</tbody>
</table>

1 Overcast, no haze, visibility about 40 km, no heat shimmer
2 Object in shade, sky overcast, Kodak Gray Card (90% reflective)
The new PinPoint R2000 EDM measures distances to any surfaces up to 2,000 m and distances up to at least 10,000 m onto a single prism.

The new EDM not only enables extended measurement range onto any surface, but also significantly reduces measurement time. Onto prisms, the distance measurement time is reduced by around 50% which has a time saving impacting the overall measurement time.

To withstand harsh conditions, the Leica Nova MS50 MultiStation fulfills IP65 standard and the MIL standard blowing rain test.

The mechanical design of the MultiStation has been developed for highest protection against environmental conditions. The Leica Nova MS50 fulfills IP65 standards and withstands the MIL standard blowing rain test. This is the highest protection for any robotic total station currently available.

The MultiStation emphasizes high-dynamic automation with its best-in-class speed and acceleration capabilities. Furthermore, PowerSearch functionality supports the Leica Nova MS50 to find the target points quickly and efficiently. A combined USB – RS232 interface at the non-rotating part of the MultiStation as well as Bluetooth and WLAN ensure fast data transfer. A long-range Bluetooth radio handle can be connected to the MultiStation and ensures remote working ranges up to 1,000 m.

For fast and flexible data transfer, the Leica Nova MS50 MultiStation features WLAN, USB, RS232 and Bluetooth interfaces.

The Leica Nova MS50 offers enhanced imaging functionality by implementing two cameras: the overview and the telescope camera. Both cameras deliver 5 megapixel resolution images for accurate image assisted surveying and high quality documentation.

The overview camera is located in the upper part of the telescope, while the telescope camera is located in line with the optical axis and has the full 30x magnification of the telescope optics.

The live video stream, which is provided with up to 20 frames per second on the display, can easily be switched between overview camera and telescope camera.

Autofocus functionality increases the measurement efficiency and reduces the fatigue of the operator’s eyes.

A unique functionality of the Leica Nova MS50 is 3D laser scanning. The scanning functionality is seamlessly integrated into the standard workflow of a total station. This allows the 3D laser scans to always be in the current coordinate system of the MultiStation. Known setup routines (e.g. set azimuth, known backsight, resection) are used and the point clouds are automatically registered directly in the field. The onboard 3D scan viewer allows the user to verify and check the point clouds for completeness directly in the field. Scan shadows can be identified on site which minimizes the necessity for costly returns for re-measuring. Surfaces and volumes can be calculated with the QuickVolume application. Additional single measurements from the setup complete the data.

mergeTEC
mergeTEC is the fusion of the latest innovative technologies and combines:

- enhanced and outstanding total station functionality
- GNSS connectivity
- digital imaging
- 3D laser scanning

Consequently, mergeTEC enables the user to select the appropriate measurement technology for the corresponding measurement tasks within one instrument. mergeTEC also guarantees that the captured complex 3D data is referenced to each other. The user does not need to care about referencing data among a multitude of scans, images and TPS measurements. He can use known TPS setup routines such as “set orientation”, “known backsight” or “resection”.

Figure 2 mergeTEC, merging technologies and data

4 | White paper Leica Nova MS50
Figure 3 Cross-section of the Leica Nova MS50 MultiStation
Enhanced and Outstanding Total Station Functionality

The Leica Nova MS50 emphasizes enhanced and outstanding total station functionality. The motorization, based on Piezo-technology, allows very fast telescope movements without any noise pollution. Furthermore, the fast motorization and the automatic target aiming technology ATR (automatic target recognition) enable best tracking performance onto a moving prism.

The Leica Nova MS50 uses a distance measurement system which allows highly precise and fast measurements. Ranges onto any surface are possible up to 2,000 m and onto a single prism up to at least 10,000 m.

The Leica Nova MS50 uses the SmartWorx Viva field software onboard. The SmartWorx Viva field software is well-known from Leica Viva total stations and is intuitive and easy to operate. SmartWorx Viva ensures the complete integration of the new measurement technologies such as imaging and 3D laser scanning into the standard measuring workflow. This makes it easy for the user to learn and to operate the instrument. Dedicated onboard software applications (e.g. for tunnelling, rail, road) extend the application area of the Leica Nova MS50.

GNSS Connectivity

GNSS is fully integrated in the workflow and the data structure. The Leica Nova MS50 allows SmartStation and SmartPole setup with several Leica GNSS smart antennas. This enables direct georeferencing without need for sighting known points. Thanks to enhanced Leica Geosystems GNSS technologies, the position can be defined quickly and reliably.

Digital Imaging

mergeTEC and the Leica Nova MS50 also address the widespread trend towards digital image integration. Digital imaging has become a central element in the measuring process. Therefore, the MultiStation features two high resolution 5 megapixel digital cameras – the overview camera and the telescope camera which is located in the optical axis of the telescope.

Looking at the live video stream, the user always knows where the instrument is aiming even during remote operation.

The live video stream can be shown on the instrument’s display or on the controller and can easily be switched between overview camera and telescope camera. When standing at the instrument, the user has the choice between looking at the live video stream and looking through the telescope.

Digital imaging on the Leica Nova MS50 enables enhanced image assisted surveying and image documentation. Digital imaging improves the measurement efficiency, quality and documentation of the field measurements.

<table>
<thead>
<tr>
<th>Table 2 Technical data of overview and telescope camera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overview Camera</strong></td>
</tr>
<tr>
<td>sensor</td>
</tr>
<tr>
<td>field of view (h, v)</td>
</tr>
<tr>
<td>magnification / zoom</td>
</tr>
<tr>
<td>live view update rate</td>
</tr>
<tr>
<td>focus</td>
</tr>
<tr>
<td>sensor pixel – angle relationship</td>
</tr>
<tr>
<td>display resolution</td>
</tr>
</tbody>
</table>

Image Assisted Surveying

Image assisted surveying supports the operator with Tap&Turn and 3D data overlay functionality, making the measurement process faster, simpler, and more comprehensible. Tap&Turn is a comfortable and efficient way to measure using the live video stream. The instrument turns to where the user taps on the display, directly at

Figure 4 Leica Nova MS50 as SmartStation setup
the instrument or from remote with a controller. The 3D data overlay functionality increases the measurement quality in terms of completeness by displaying measured points and points from the job as 3D data overlay.

The overview camera helps the user to roughly aim onto the target. By using the telescope camera, the target can be precisely aimed based on the live video stream and the 30x magnification (Figure 5). An angular accuracy of 1” (according to ISO 17123-3) of the measurement can be achieved by using the live video stream from the telescope camera to aim onto the target.

### Telescope Camera

To enable precise measurements based on the live video stream, the telescope camera is located on the optical axis of the Leica Nova MS50. Thus the full 30x magnification of the high quality optics of the telescope is available on the live video stream.

To maximise the working comfort, reduce the fatigue of the user’s eyes or to enable focusing from remote, mergeTEC comes with autofocus functionality. The autofocus functionality is executed either as a single autofocus or as a continuous autofocus which always ensures a sharp image.

**High resolution images can be captured during measuring for documentation and for photogrammetrical measurements.**

The telescope has been designed such that a focussed image is simultaneously available on the live video stream and on the optical path through the ocular (see Figure 6). Parallel use of the display and looking through the ocular is therefore always possible.

### Image Documentation

High resolution images can be captured with the overview camera and the telescope camera. These images can be directly be linked and referenced to the measurements. The possibility to capture images of each measured point improves the documentation of the field work. Furthermore, sketching functionality allows making notations directly in the images for better understanding of what has been measured. The high resolution images from both cameras can be used for photogrammetric processing. The photogrammetric resolution of 1 pixel of the telescope camera corresponds to 5cc which results in a resolution of 2 mm @ 200m.

**Figure 5** Scenery displayed once with live video stream of overview camera and once with live video stream of telescope camera

**Figure 6** Live video stream and optical path through the ocular delivering simultaneously focused and sharp image

Best optical quality is guaranteed by high-precision optical elements (see Figure 7) such as the porro-prism, which reflects the incoming light onto the CMOS sensor of the telescope camera and directly to the ocular for visual aiming. The focusing module (focusing lens and slider bar to move the lens along the optical axis) require micrometer tolerances in the production process to guarantee 1” angular measurement accuracy of the MultiStation.
Adjustment and calibration processes are key factors to achieve the highest quality of the imaging functionality. Compared to pure time-of-flight measurement systems, the WFD technology results in better measurement performance, which shall be explained in the following.

<table>
<thead>
<tr>
<th>Table 3 Comparison of the different EDM technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
</tr>
</tbody>
</table>
| WFD | - fast measurement time  
- small laser spot size similar to phase-shift  
- high measurement accuracy  
- long ranges  
- configurable: accurate but more time required or fast with less accuracy |
| time-of-flight | - fast measurement time  
- large laser spot size  
- lower measurement accuracy  
- no measurements if signal to noise ratio is too low |
| phase-shift | - long measurement time  
- small laser spot  
- highest measurement accuracy |

The WFD based EDM sends out signals. When a signal is sent out, a small part of each pulse gets directly guided onto a photo detector and serves as internal calibration measurement. This pulse is called the start pulse. The rest of the pulse is emitted out of the telescope and reflected by the object. The returning pulse is called stop pulse. For every measurement, an internal calibration measurement is done.

The new EDM combines the advantages of different technologies for fast, long range and accurate distance measurements.

For longer distances, the energy and therewith the signal to noise ratio (SNR) of one single returned pulse gets very small. This makes it difficult to extract the stop pulse. Therefore the WFD accumulates signals to the same target multiple times. As more signals are sent out and received, the better the stop pulse can be digitized (see Figure 8). The final distance is defined by the time difference between the start and stop pulse, digitized by the accumulated signals. For quality control, the shape of the start pulse is taken into account when digitizing the stop pulse. If the shape of the stop pulse is not similar to the start pulse, the distance measurement is not valid. This can happen when e.g. an object passes through the laser beam or the angle of incident of the laser beam on the object is very small.
The high quality of the Leica Nova MS50 scan can be recognized by the low range noise values (below 1 mm @ 50 m). The range noise describes the standard deviation of the scan points’ residuals to a modelled surface plane. Depending on the scan mode, the scan noise can even be reduced (see Figure 11).

The SNR gets improved by the square root of the measurement time. A measurement time of 9 s for example has a three times better SNR than a measurement time of 1 s. The selection of the measuring time therefore has an impact on the distance measurement accuracy.

The fast distance measurements, combined with high accuracy and long ranges which are provided by the WFD are prerequisite for 3D laser scanning.

**Scanning Workflow**

The close integration of the scanning capabilities into standard total station routines makes it very straightforward to use the 3D laser scanning capabilities of the MultiStation even for operators without scanning experience.

The scan area can be precisely defined using the live video stream to scan only the needed area (see Figure 9).

Different scan modes allow the user to get the best data within the available time and object properties such as range and surface. Depending on the scan mode, ranges up to 1,000 m can be measured. The EDM based on wave form digitizing allows extending the measurement time to accumulate more signals which results in a longer scan range and also lower range noise.

The Leica Nova MS50 features four scan modes with a maximum measurement frequency of up to 1,000 points per second. Figure 10 shows the maximum scan ranges for the different scanning frequencies.

The high quality of the Leica Nova MS50 scan can be recognized by the low range noise values (below 1 mm @ 50 m). The range noise describes the standard deviation of the scan points’ residuals to a modelled surface plane. Depending on the scan mode, the scan noise can even be reduced (see Figure 11).
For an even higher point cloud quality, there are two additional point cloud filter settings available. The **outlier filter** removes single points which can be caused by unwanted reflections or objects passing through the laser beam while scanning. A so-called **mixed-pixel filter** removes scan points which get a mixed distance if the laser beam hits two surfaces at the same time (see Figure 12).

Based on known setup routines (e.g. set azimuth, known backsight, resection), the point clouds are automatically referenced to the actual instrument setup. There is no need to setup and scan additional reference targets. Furthermore, atmospheric and geometric corrections are applied to the point cloud in real time during the scanning procedure.

The Leica Nova MS50 offers a 3D scan viewer which allows the 3D visualization of the point clouds. By zooming, panning and rotating the point clouds, the completeness can be easily be verified. Doing the completeness check directly in the field can avoid a costly revisit of the site and expensive re-measuring of the object.

**Data Flow**

The data handling from the field to the office and vice versa and the data processing in the office are crucial for a successful project.

Leica Nova offers a seamless data flow including data processing software for the office:

- Leica Infinity
- Leica MultiWorx
- Leica Cyclone
- Supporting programs from software partners

Leica Infinity – the new office software from Leica Geosystems – supports the processing of the various measurement, imaging and 3D laser scan data from the Leica Nova MS50. The 3D map view allows handling 3D data sets including 3D point clouds. Leica Infinity enables the adjustment of single measurements from the MultiStation and updating the 3D point clouds accordingly. Leica Infinity support standard scanning file format such .e57 and .pts.
Leica MultiWorx is a plugin for Autodesk’s AutoCAD and Civil 3D and enables users to work with rich 3D point clouds in their familiar CAD environment. Leica MultiWorx provides simple and powerful tools for navigating point clouds and creating deliverables.

Leica Cyclone – the powerful point cloud processing software from Leica Geosystems – features the direct data import from the Leica Nova MS50. Advanced point cloud users can directly combine MultiStation point cloud data with point clouds from Leica HDS scanners.

**Summary**

In a single instrument, with the size and weight of a total station, the Leica Nova MS50 combines total station capabilities, digital imaging, GNSS connectivity and 3D laser scanning.

mergeTEC combines the most advanced measurement technologies and the resulting data. A thought-through workflow assures complete performance during all steps, from the data collection and verification, processing, to the deliverables.

**Enhanced Total Station Functionality**

The new fast and accurate distance measurement system reduces the measurement time up to 50% and increases measurement ranges. Combined with fast motorisation high dynamic tracking is possible.

**GNSS Connectivity**

GNSS is fully integrated in the workflow and the data structure enabling direct georeferencing. SmartStation and SmartPole setups increase the flexibility in the field.

**Digital Imaging**

Enhanced digital imaging technology including an overview and a 30x magnifying telescope camera enables accurate image assisted surveying at the instrument or remotely and extended image documentation.

**3D Laser Scanning**

3D laser scanning is fully integrated into the regular measuring workflow and can be combined with survey data, measurements and images. Extended onboard functionality delivers results in the field.

Leica Nova MS50 delivers a new dimension in measuring technology enabling the user to make the right decision in the field.
Whether measuring objects on a construction site, or monitoring a dam or a bridge; whether capturing an accident scene with digital imaging or scanning a building façade – you need reliable and precise data. The Leica Nova solution perfectly integrates all these capabilities in one compact solution.

Leica Nova embodies 90 years of innovative thinking to develop outstanding technologies. A solution that gives you the benefits of not only being able to take faster, smarter decisions, but also better and more informed decisions regardless of the application. Leica Nova represents our commitment to precision, reliability and flexibility. Faster, Better, Smarter, Simpler are the key words that describe the benefits of the Leica Nova; a unique solution that covers the complete process from capturing and visualising data, to deciding and delivering.

Leica Nova is the new dimension in measuring technology – make the right decision.

When it has to be right.