

Leica Nova MS50

White paper



September 2013

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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.



Figure 1 Leica Nova MS50 MultiStation

The Leica Nova MS50 allows the user to decide on-site which measurement technology to use to fulfil his measurement tasks. The results are available directly in the field, for example the volume of a stockpile derived from point clouds which have been scanned with the Leica Nova MS50.

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

angular accuracy (according to ISO-17123-3)	1" Hz and V
distance measurement accuracy onto GPR1 prism ¹ (according to ISO-17123-4)	1 mm + 1.5 ppm
distance measurement accuracy onto any surface ² (according to ISO-17123-4)	2 mm + 2 ppm
distance measurement range ¹ onto prism	1.5 m up to 10,000 m
distance measurement range onto any surface ²	1.5 m up to 2,000 m

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 2,000m and distances up to at least 10,000m 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 fulfils IP65 standard and the MIL standard blowing rain test³.

The mechanical design of the MultiStation has been developed for highest protection against environmental conditions. The Leica Nova MS50 fulfils 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.

³ MIL-STD-810G, Method 506.5-1

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

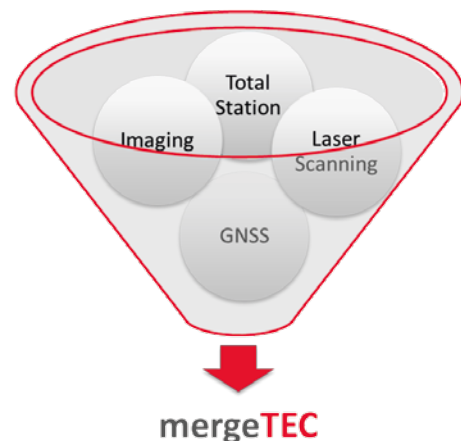


Figure 2 mergeTEC, merging technologies and data

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".

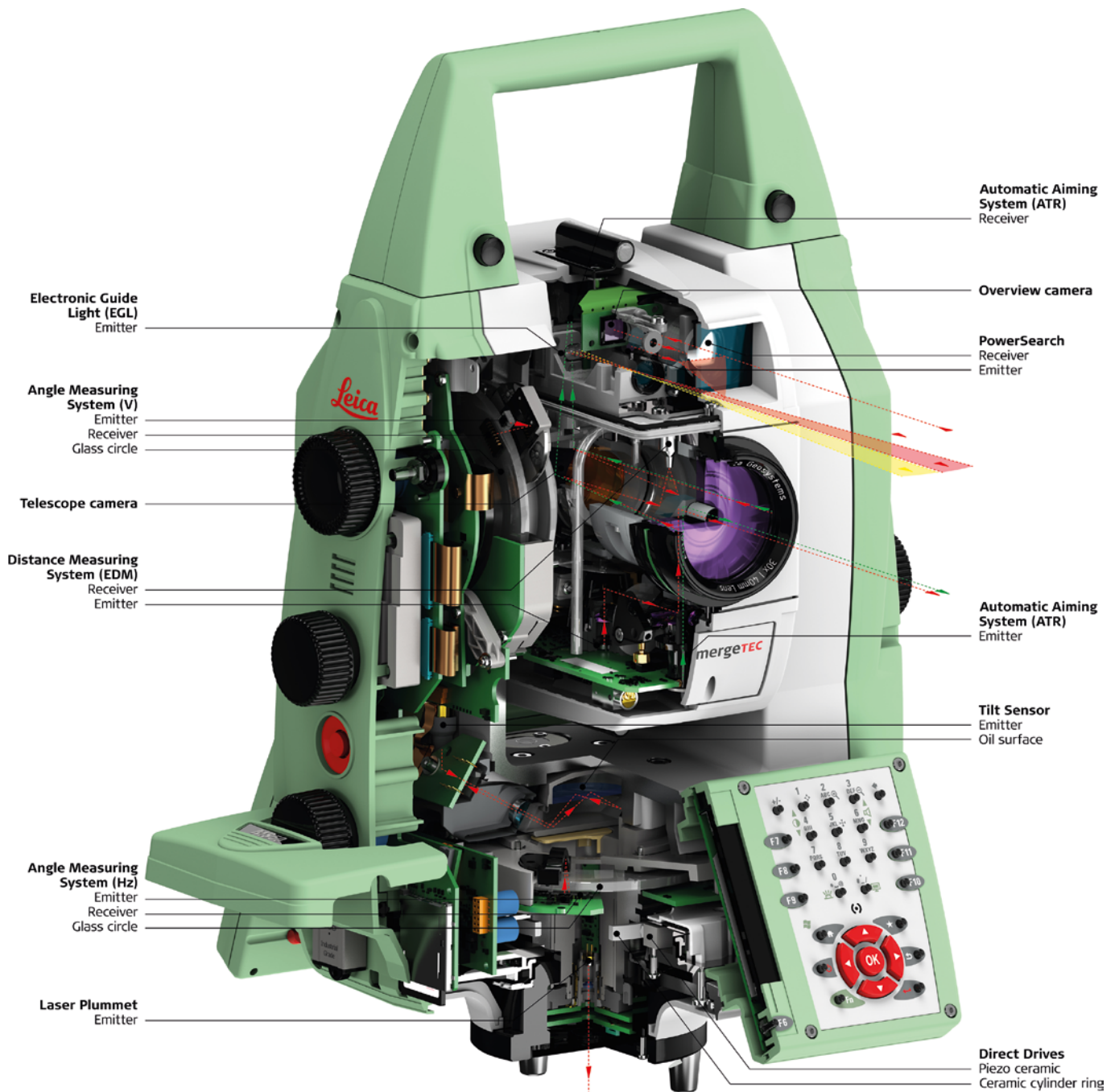


Figure 3 Cross-section of the Leica Nova MS50 MultiStation

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.



Figure 4 Leica Nova MS50 as SmartStation setup

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 2 Technical data of overview and telescope camera

	Overview Camera	Telescope Camera
sensor	5Mpixel CMOS	5Mpixel CMOS
field of view (hz, v)	15.5° x 11.7° 19.4° diagonal	1.3° x 1.0° 1.5° diagonal
magnification / zoom	8x zoom	30x optical magnification 8x zoom
live view update rate	20Hz	20Hz
focus	fix focus 2 m to infinity	focusing range: 1.7 m to infinity autofocus
sensor pixel – angle relationship	one sensor pixel corresponds to 67 cc	one sensor pixel corresponds to 5 cc
display resolution	VGA	VGA

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

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.

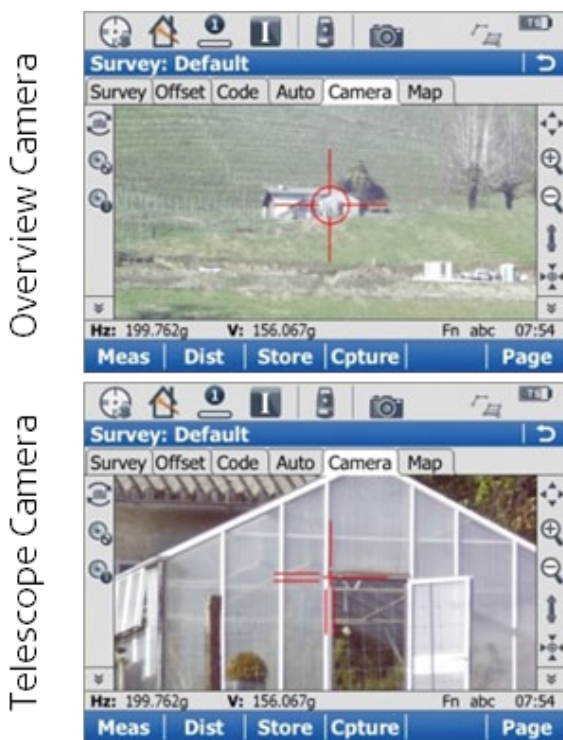


Figure 5 Scenery displayed once with live video stream of overview camera and once with live video stream of telescope camera

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.

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.

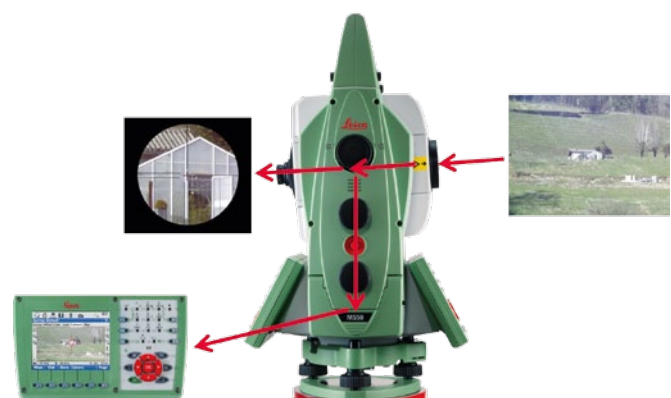


Figure 6 Live video stream and optical path through the ocular delivering simultaneously focussed and sharp image

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.

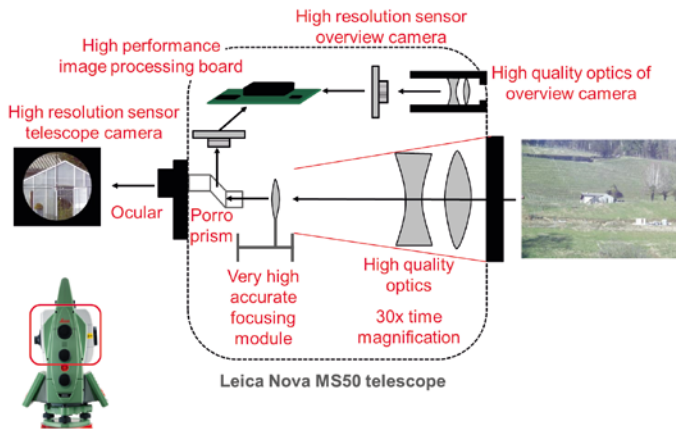


Figure 7 Schematic cross-sectional view of the telescope

The Leica Nova MS50 has been designed to use both, the visual path through the ocular and the live video stream for aiming at the target point. The possibility to use the camera and the ocular at the same time is important to ensure versatility in the measurement processes and is required for highest measurement accuracies under difficult light conditions.

3D Laser Scanning

Thanks to the new electro-optical distance measurement system based on the wave form digitizing technology, the fast and precise Piezo-motorisation, the high processor power and Leica Geosystems' scanning expertise, the Leica Nova MS50 integrates 3D laser scanning functionality into the regular measuring workflow of a total station. Detailed point clouds can be combined with topographic survey data.

EDM – Electro-Optical Distance Measurement

The Leica Nova MS50 features an electro-optical distance measurement system based on the wave form digitizing technology (WFD). WFD is a specific type of a time-of-flight measurement system which sends out a signal and detects and stores a digital signal vector. The advantages of the WFD technology are the fast distance measurements, small laser dot size, high measurement accuracy and the long ranges which are available at the same time. Compared to the phase-based EDM technology, the distance measurements with the WFD technology are approximately 50% faster onto prisms but the measure-

ment accuracy is slightly lower (see Table 3). Compared to pure time-of-flight measurement systems, the WFD technology results in better measurement performance, which shall be explained in the following.

Table 3 Comparison of the different EDM technologies

Technology	Description
WFD	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> fast measurement time large laser spot size lower measurement accuracy no measurements if signal to noise ratio is too low
phase-shift	<ul style="list-style-type: none"> 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 SNR gets improved by the square root of the measurement time. A measurement time of 9s for example has a three times better SNR than a measurement time of 1s. The selection of the measuring time therefore has an impact on the distance measurement accuracy.

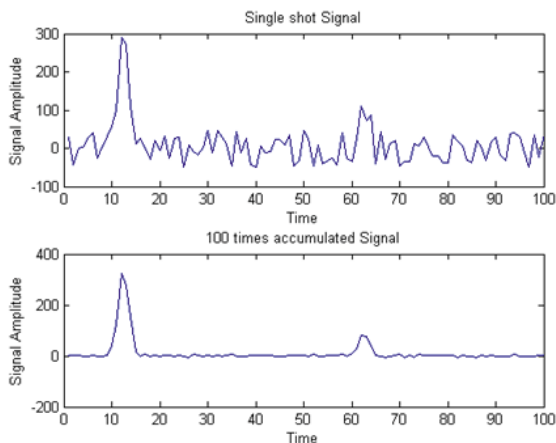


Figure 8 Start and stop pulse for a single shot and accumulated signals

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 straight forward 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).

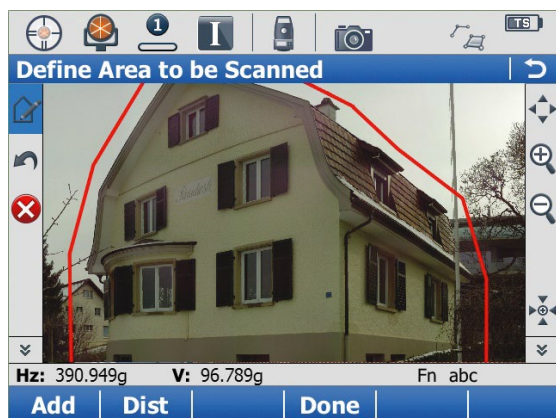


Figure 9 Live video stream with polygonal scan area definition

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 1,000m 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.

Table 4 Leica Nova MS50 3D laser scanning specifications

scanning speed	1,000 points/s up to 300m
scanning range	up to 1,000m
scanning precision (range noise)	< 1 mm @ 50m 1 σ , Kodak Grey Card Albedo 90%
onboard point cloud visualization	onboard 3D scan viewer including true colour point clouds

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.

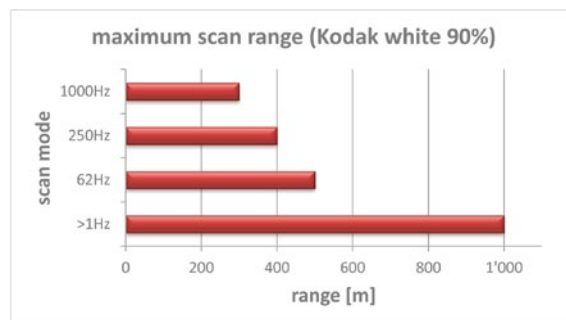


Figure 10 Maximum scan ranges for the different scanning frequencies

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).

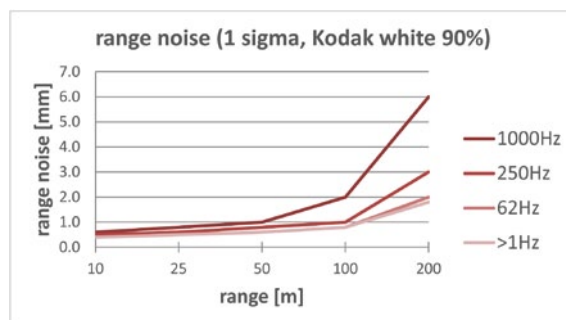


Figure 11 Range noise (1 σ) of the different scan modes in relation to the scan range

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).

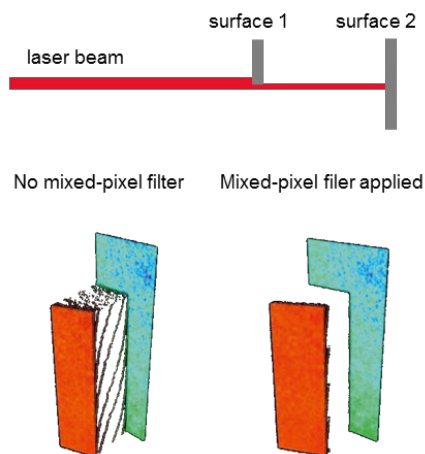
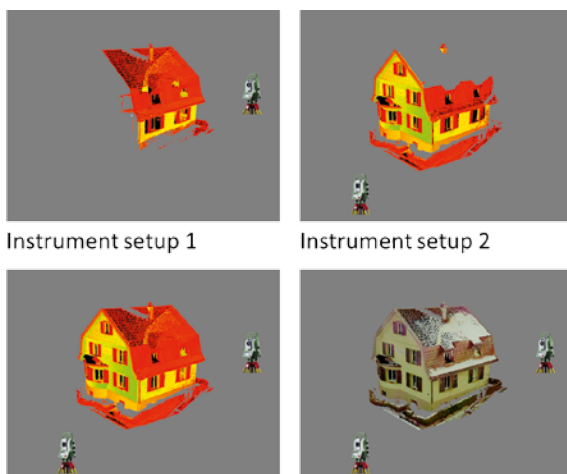


Figure 12 Mixed-pixel filter removes mixed pixels on the instrument for high data quality

Point clouds can optionally be colored with the values of the returned laser beam intensity, the true colors from the digital images or by a single color for each setup. Providing different color schemes improves the understanding of the scanned data. mergeTEC ensures that the point clouds and the image data fit together perfectly.



Auto-registered point cloud (left: intensity coloured point cloud, right: RGB coloured point cloud)

Figure 13 Auto-registration of the point clouds directly in the field

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.



Figure 14 Scan viewer for point cloud visualization on the MultiStation

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.

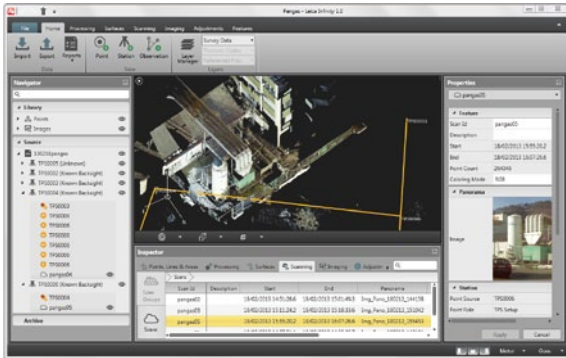


Figure 15 Leica Infinity for processing single measurements and point clouds

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.

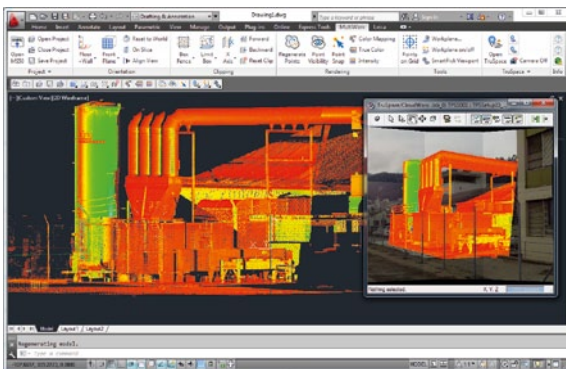


Figure 16 Leica MultiWorx plugin for AutoCAD

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.



Figure 17 Leica Cyclone – dedicated point cloud processing software

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.

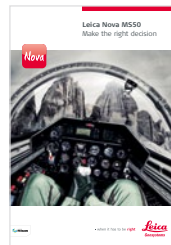


**Distance meter (Prism),
ATR and PowerSearch:**
Laser class 1 in accordance
with IEC 60825-1 resp. EN 60825-1

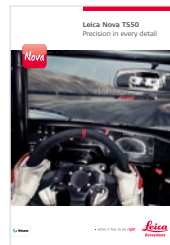
Laser plummet:
Laser class 2 in accordance
with IEC 60825-1 resp. EN 60825-1

Distance meter (Non-Prism):
Laser class 3R in accordance
with IEC 60825-1 resp. EN 60825-1

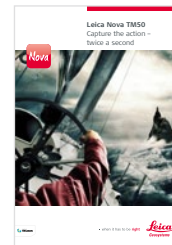
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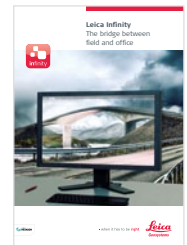
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