

Leica T-Scan User Manual



Version 1.0
English

- when it has to be **right**

Leica
Geosystems

Introduction

Purchase

Congratulations on the purchase of a Leica T-Scan 5.



This manual contains important safety directions as well as instructions for setting up the product and operating it. Refer to "1 Safety Directions" for further information. Read carefully through the User Manual before you switch on the product.



To ensure safety when using the system, please also observe the directions and instructions contained in the User Manual and Safety Handbook issued by:

- Machine manufacturer
- Robot manufacturer
- Sensor manufacturer

Product identification

The type and serial number of your product are indicated on the type plate. Always refer to this information when you need to contact your agency or Leica Geosystems authorised service workshop.

Trademarks

Product names are trademarks or registered trademarks and are property of their respective owners.

Validity of this manual

This manual applies to the Leica T-Scan used as accessory to the Leica Geosystems Absolute Tracker.

Available documentation

Name	Description/Format		
Leica T-Scan User Manual	All instructions required in order to operate the product to a basic level are contained in the User Manual. Provides an overview of the product together with technical data and safety directions.	-	✓

Name	Description/Format		
Absolute Tracker User Manual	All instructions required in order to operate the product to a basic level are contained in the Absolute Tracker User Manual. Provides an overview of the product together with technical data and safety directions.	✓	✓
Leica Automation User Manual	All instructions required in order to operate the system in Automation applications are contained in the Automation User Manual. Provides an overview of Automation products together with technical data and safety directions.	✓	✓
emScon Reference Manual	Overall comprehensive technical guide to the product functions of emScon.	-	✓
emScon Programmers Manual	Describes the usage and commands of the Tracker Programming Interface (TPI).	-	✓

Refer to the following resources for Absolute Tracker and T-Products documentation/software:

- <http://www.leica-geosystems.com/metrology/>

Feedback

Your feedback is important as we strive to improve the quality of our documentation. We request you to make specific comments as to where you envisage scope for improvement.

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1 Safety Directions

1.1 General Introduction

Description

The following directions enable the person responsible for the product, and the person who actually uses the equipment, to anticipate and avoid operational hazards.

The person responsible for the product must ensure that all users understand these directions and adhere to them.

About Warning Messages

Warning messages are an essential part of the safety concept of the instrument. They appear wherever hazards or hazardous situations can occur.

Warning messages...

- make the user alert about direct and indirect hazards concerning the use of the product.
- contain general rules of behaviour.

For the users' safety, all safety instructions and safety messages shall be strictly observed and followed! Therefore, the manual must always be available to all persons performing any tasks described herein.

DANGER, WARNING, CAUTION and **NOTICE** are standardized signal words for identifying levels of hazards and risks related to personal injury and property damage. For your safety it is important to read and fully understand the table below with the different signal words and their definitions! Supplementary safety information symbols may be placed within a warning message as well as supplementary text.

Type	Description
 DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
 WARNING	Indicates a potentially hazardous situation or an unintended use which, if not avoided, could result in death or serious injury.
 CAUTION	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in appreciable material, financial and environmental damage.
	Important paragraphs which must be adhered to in practice as they enable the product to be used in a technically correct and efficient manner.

1.2

Definition of Use

Intended use

- Usage as accessory to the Leica Absolute Tracker.
 - Digitising of surfaces and character lines.
 - Carrying out 6DOF measurements as a component of the Leica Geosystems Absolute Tracker in various industrial applications.
 - Transmission of coordinates from the Absolute Tracker to the T-Scan for inspection and build measurements.
 - Transmission of measurement data to the Absolute Tracker.
-

Reasonably foreseeable misuse

- Use of the product without instruction.
 - Use outside of the intended use and limits.
 - Disabling safety systems.
 - Removal of hazard notices.
 - Opening the product using tools, for example screwdriver, unless this is permitted for certain functions.
 - Modification or conversion of the product.
 - Use after misappropriation.
 - Use of products with recognisable damages or defects.
 - Use with accessories from other manufacturers without the prior explicit approval of Leica Geosystems.
 - Inadequate safeguards at the working site.
 - Deliberate dazzling of third parties.
 - Controlling of machines, moving objects or similar monitoring application without additional control- and safety installations.
-



WARNING

Unauthorised modification of automatic machines and robots by mounting or installing the product may alter the function and safety of the machine.

Precautions:

Follow the instructions of the machine/robot manufacturer. If no appropriate instruction is available, ask machine/robot manufacturer for instructions before mounting or installing the product.

1.3

Limits of Use

Environment

Suitable for use in an atmosphere appropriate for permanent human habitation: not suitable for use in aggressive or explosive environments.



DANGER

Local safety authorities and safety experts must be contacted before working in hazardous areas, or close to electrical installations or similar situations by the person in charge of the product.

Environment

Suitable for use in dry environments only and not under adverse conditions.



1.4

Responsibilities

Manufacturer of the product

Leica Geosystems AG, CH-9435 Heerbrugg, hereinafter referred to as Leica Geosystems, is responsible for supplying the product, including the user manual and original accessories, in a safe condition.

Person responsible for the product

The person responsible for the product has the following duties:

- To understand the safety instructions on the product and the instructions in the user manual.
- To ensure that it is used in accordance with the instructions.
- To be familiar with local regulations relating to safety and accident prevention.
- To inform Leica Geosystems immediately if the product and the application becomes unsafe.

1.5

Hazards of Use

1.5.1

General



WARNING

This product may be installed on automatic machines and robots only by an appropriately trained and qualified specialist.



CAUTION

Watch out for erroneous measurement results if the product has been dropped or has been misused, modified, stored for long periods or transported.

Precautions:

Periodically carry out test measurements and perform the field adjustments indicated in the user manual, particularly after the product has been subjected to abnormal use and before and after important measurements.



CAUTION

When being dropped, the product can cause personal injury and/or mechanical damage.

Precautions:

Ensure to have a firm grip on the product before operating it.



CAUTION

If the accessories used with the product are not properly secured and the product is subjected to mechanical shock, for example blows or falling, the product may be damaged or people can sustain injury.

Precautions:

When setting-up the product, make sure that the accessories are correctly adapted, fitted, secured, and locked in position.

Avoid subjecting the product to mechanical stress.



WARNING

Inadequate securing of the working site can lead to dangerous situations, for example in traffic, on building sites, and at industrial installations.

Precautions:

Always ensure that the working site is adequately secured. Adhere to the regulations governing safety and accident prevention and road traffic.



WARNING

Cables deployed on the ground can be a hazard to pedestrians or vehicular traffic.

Precautions:

Ensure the power cable, LAN cable or any other cables do not lie in the path of pedestrian/vehicular traffic. Use appropriate cable cover and/or warning signs.

**CAUTION**

Powering up the product with no or partial cabling may cause damage to it.

Precautions:

Before connecting the product to the power supply, ensure that the installation and cabling of the entire system is completed.

**WARNING**

If the product is improperly disposed of, the following can happen:

- If polymer parts are burnt, poisonous gases are produced which may impair health.
- If batteries are damaged or are heated strongly, they can explode and cause poisoning, burning, corrosion or environmental contamination.
- By disposing of the product irresponsibly you may enable unauthorised persons to use it in contravention of the regulations, exposing themselves and third parties to the risk of severe injury and rendering the environment liable to contamination.

Precautions:

The product must not be disposed with household waste.

Dispose of the product appropriately in accordance with the national regulations in force in your country.

Always prevent access to the product by unauthorised personnel.

Product-specific treatment and waste management information can be downloaded from the Leica Geosystems home page at <http://www.leica-geosystems.com/treatment> or received from your Leica Geosystems dealer.

**WARNING**

Only Leica Geosystems authorised service workshops are entitled to repair these products.

1.5.2**For the T-Scan Controller/T-Scan Rack**

**WARNING**

If you open the product, either of the following actions may cause you to receive an electric shock.

- Touching live components
- Using the product after incorrect attempts were made to carry out repairs

Precautions:

Do not open the product. Only Leica Geosystems authorised service workshops are entitled to repair these products.

**CAUTION**

Using the wrong types of fuses may cause damage to the product.

Precautions:

If defect, the fuse of the product shall only be replaced by the same type of fuse. Unplug the power supply cord before replacing the fuse.

Refer to the relevant label of the product for information about the correct type of fuse.

**CAUTION**

Connecting the product to an ungrounded socket may cause damage to the system.

Precautions:

The product is set up according to Safety Class I and may only be connected to a grounded socket. Connect the product only to a suitable power supply.

**WARNING**

If unit is not connected to ground, death or serious injury can occur.

Precautions:

To avoid electric shock power cable and power outlet must be grounded.



 **WARNING**

The product is not designed for use under wet and severe conditions. If unit becomes wet it may cause you to receive an electric shock.

Precautions:

Use the product only in dry environments, for example in buildings or vehicles. Protect the product against humidity. If the product becomes humid, it must not be used!



1.6 Laser Classification

General

The following chapters provide instructions and training information about laser safety according to international standard IEC 60825-1 (2007-03) and technical report IEC TR 60825-14 (2004-02). The information enables the person responsible for the product and the person who actually uses the equipment, to anticipate and avoid operational hazards.

-  According to IEC TR 60825-14 (2004-02), products classified as laser class 1, class 2 and class 3R do not require:
 - laser safety officer involvement,
 - protective clothes and eyewear,
 - special warning signs in the laser working areaif used and operated as defined in this User Manual due to the low eye hazard level.
-  National laws and local regulations could impose more stringent instructions for the safe use of lasers than IEC 60825-1 (2007-03) and IEC TR 60825-14 (2004-02).

Status LEDs and Infrared LEDs

The T-Scan sensor contains the following types of LEDs:

Type of LED	Laser class	Classification
Status LEDs: produce a visible LED beam	Exempt Group	IEC 62471-1 (2006-07)
Infrared LEDs: produce an invisible LED beam	Exempt Group	IEC 62471-1 (2006-07)

A product classified as exempt group does not pose any hazard provided that the product is used and maintained in accordance with this user manual.

Scanning module

The scanning module built into the product produces a visible red laser beam which emerges from the scanning window.

The laser product described in this section is classified as laser class 2M in accordance with:

- IEC 60825-1 (2007-03): "Safety of laser products"
- EN 60825-1 (2007-10): "Safety of laser products"

These products are safe for momentary exposures but can be hazardous for deliberate staring into the beam, especially when viewing it through telescopic optics. The beam may cause dazzle, flash-blindness and after-images, particularly under low ambient light conditions.

Description	Value
Wavelength	660 nm
Maximum radiant power	12 mW
Pulse duration	continuous wave
Pulse repetition frequency	continuous wave
Beam divergence	0.784 rad x 0.003 rad

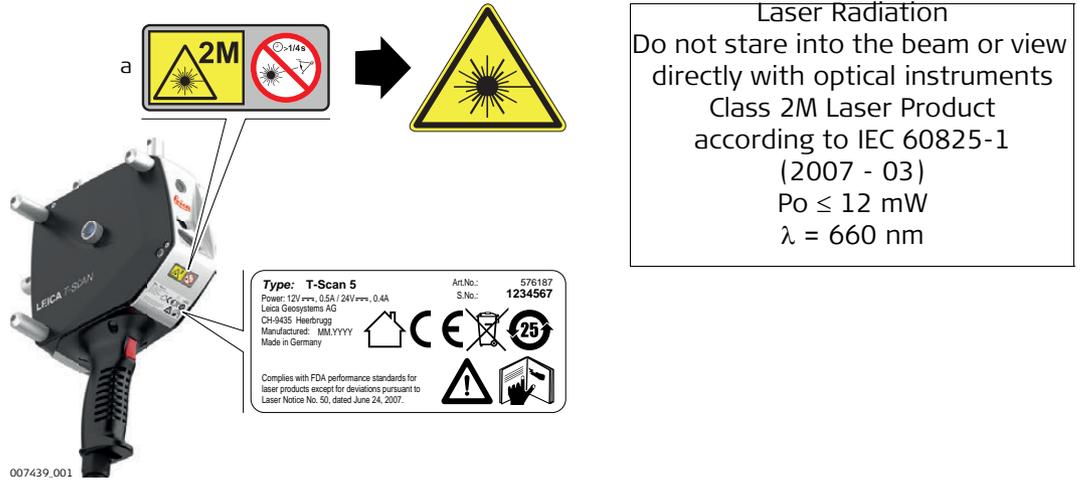
CAUTION

From a safety perspective, class 2M laser products are not inherently safe for the eyes.

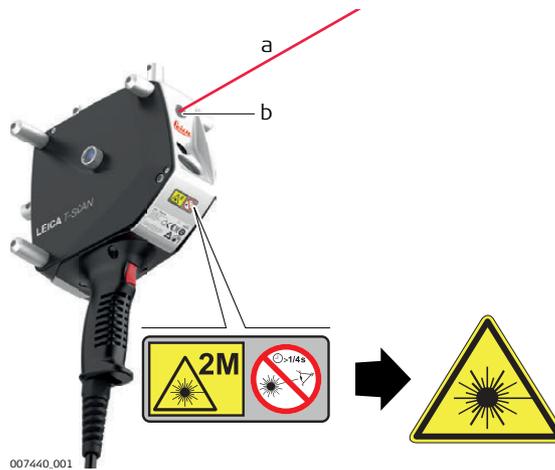
Precautions:

- 1) Avoid staring into the beam or viewing it directly with telescopic optics.
- 2) Avoid pointing the beam at other people or at animals.
- 3) Avoid pointing the beam at mirror-like (specular) surfaces.

Labelling



a) Laser class 2M



a) Laser beam
b) Exit for laser beam

Description

The term Electromagnetic Compatibility is taken to mean the capability of the product to function smoothly in an environment where electromagnetic radiation and electrostatic discharges are present, and without causing electromagnetic disturbances to other equipment.

**WARNING**

Electromagnetic radiation can cause disturbances in other equipment.

Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that other equipment may be disturbed.

**CAUTION**

There is a risk that disturbances may be caused in other equipment if the product is used with accessories from other manufacturers, for example field computers, personal computers or other electronic equipment, non-standard cables or external batteries.

Precautions:

Use only the equipment and accessories recommended by Leica Geosystems. When combined with the product, they meet the strict requirements stipulated by the guidelines and standards. When using computers or other electronic equipment, pay attention to the information about electromagnetic compatibility provided by the manufacturer.

**CAUTION**

Disturbances caused by electromagnetic radiation can result in erroneous measurements.

Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that the product may be disturbed by intense electromagnetic radiation, for example, near radio transmitters, two-way radios or diesel generators.

Precautions:

Check the plausibility of results obtained under these conditions.

**CAUTION**

If the product is operated with connecting cables attached at only one of their two ends, for example external supply cables, interface cables, the permitted level of electromagnetic radiation may be exceeded and the correct functioning of other products may be impaired.

Precautions:

While the product is in use, connecting cables, for example product to external battery, product to computer, must be connected at both ends.

**WARNING**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

**WARNING**

Changes or modifications not expressly approved by Leica Geosystems for compliance could void the user's authority to operate the equipment.

Labelling

007506_001

Type: T-Scan Controller		Art.No.: 819828
Power: 85-265V ~, 0.3A max., 47-63Hz		
Leica Geosystems AG	CH-9435 Heerbrugg	S.No.: 1234567
Manufactured: 05.2014	Made in Switzerland	
This device complies with part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.		

2 Description of the System

2.1 System Components

Introduction

The Leica T-Scan system consists of:

- T-Scan Sensor
- T-Scan Controller
- T-Scan Inspect Software

The terms "Absolute Tracker" and "Laser Tracker" are used as synonyms for the Leica Geosystems Absolute Tracker. The term "T-Scan" is used as a synonym for the Leica T-Scan 5.

2.2 System Concept

General

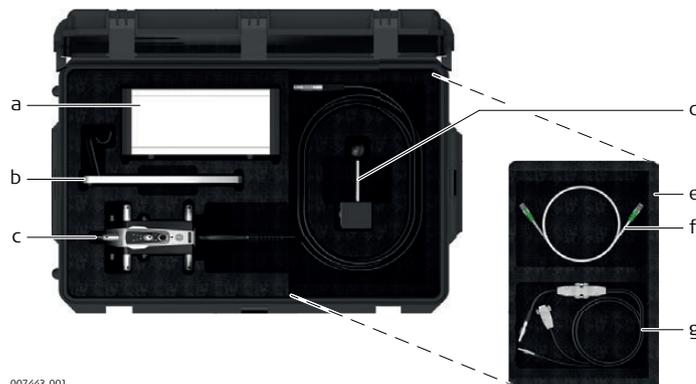


007442_001

Component	Description
T-Scan sensor	Used to measure clouds of points. The T-Scan sensor can be operated as a handheld scanner or can be mounted onto a robot or machine.
T-Scan controller	Controls scan frequencies. Records and synchronises measurement data.

2.3 Container Contents

Container for T-Scan System Components



007443_001

- a) T-Scan Controller
- b) Horizontal Scanner Holder
- c) T-Scan Sensor
- d) Calibration Sphere
- e) Removable Inlay
- f) LAN cable
- g) Trigger/Probe Cable

2.4
2.4.1

T-Scan Components
T-Scan Sensor

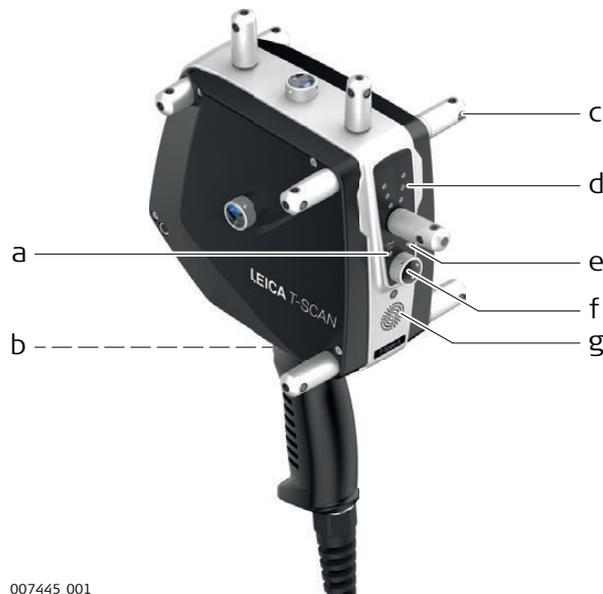
Front view



007444_001

- a) Aperture for Laser Beam (Scan Line)
- b) Aperture for Pilot Beam
- c) Aperture for Receiver Optics
- d) Trigger Button

Back view



007445_001

- a) Status LED for Laser Tracker
- b) Trigger Button (front side)
- c) Marker LED
- d) Stand-Off Indicator LED
- e) Status-LED for T-Scan Controller
- f) Reflector
- g) Speaker

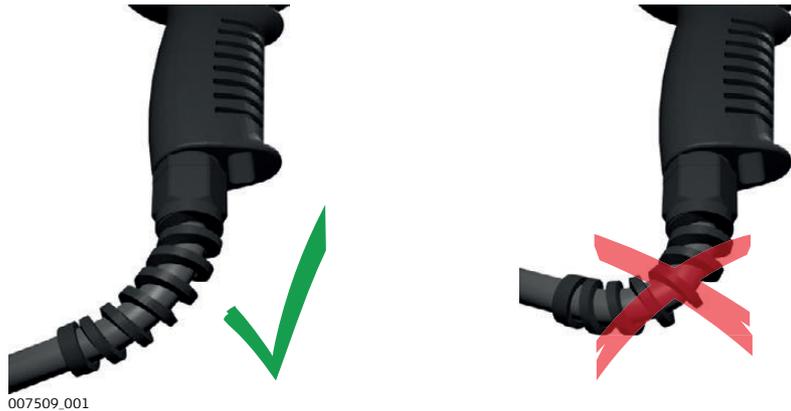


CAUTION

Putting too much strain on the cable when bending it for a prolonged time may cause damage to the cable.

Precautions:

Ensure that the bending radius is not less than 8 cm when bending the cable for a prolonged time.



007509_001

T-Scan Indicators

Acoustical status information

To inform about the current measurement status of the sensor, the T-Scan can give an acoustical status information. For example, the following status information is indicated by different acoustic signals:

- Laser Tracker beam locked on and ready to measure
- Measurement completed
- 6DOF not available
- Laser beam broken

The volume of the acoustic signal can be adjusted in the emScan software. Refer to the emScan Reference Manual for detailed information on the T-Scan configuration.

Optical status information

The T-Scan can also give an optical information to inform about the status of the sensor and the communication to other system components:

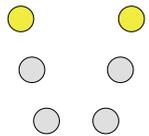
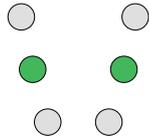
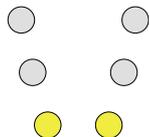


007446_001

- a) Stand-Off Indicator LED
- b) Status LED for Laser Tracker
- c) Status LED for T-Scan Controller

Stand-Off Indicator LED

The Stand-Off Indicator LED shows the following status cases:

LED Status	Status information
Off	Laser Tracker beam is not locked on or T-Scan sensor is outside of working range
	Maximum working distance, Stand-Off is at far end of working range
	Mid working distance
	Minimum working distance, Stand-Off is at close end of working range

Status LED for Laser Tracker

The Status LED for the Laser Tracker shows...

- the communication status between T-Scan sensor and Laser Tracker.
- the measurement status of the T-Scan System.

Colour	Pattern	Status information
LED OFF	-	No communication between T-Scan and Laser Tracker
Green	Static	Communication to Laser Tracker is established T-Scan system is ready to measure
Red	Static	Laser Tracker beam not locked onto T-Scan T-Scan system is not ready to measure
Yellow	Static	Communication to Laser Tracker is established T-Scan measurement is in process

Status LED for T-Scan Controller

The Status LED for the T-Scan Controller shows...

- the status of the T-Scan Controller (ON/OFF).
- the communication status between controller and T-Scan sensor.

Colour	Pattern	Status information
LED OFF	-	T-Scan Controller is OFF No communication between controller and sensor
Red	Blinking	Power on
Yellow	Blinking	Booting
Green	Blinking	Successfully booted Communication between T-Scan Controller and sensor is okay.
Green	Static	PC Software has connected to T-Scan Controller

2.4.2

T-Scan Holder

Horizontal Scanner Holder

Use the horizontal scanner holder (a) as a safe storage place for the T-Scan sensor.



007450.001

a



b

2.4.3

T-Scan Controller

Control unit for T-Scan sensor

The T-Scan controller is the control unit for the T-Scan sensor. This device controls the scan frequencies, records the measurement data and synchronises the scan data with the 6DOF measurements of the Absolute Tracker.

Front view



007452_001

Back view



007452_001

- a) Connector for Scanner Cable
- b) Power Switch
- c) Power Socket with fuse
- d) Connector for Trigger/Probe Cable
- e) Connector for Trigger Cable
- f) LAN Connection to Application Computer
- g) LAN Connection to Laser Tracker Controller

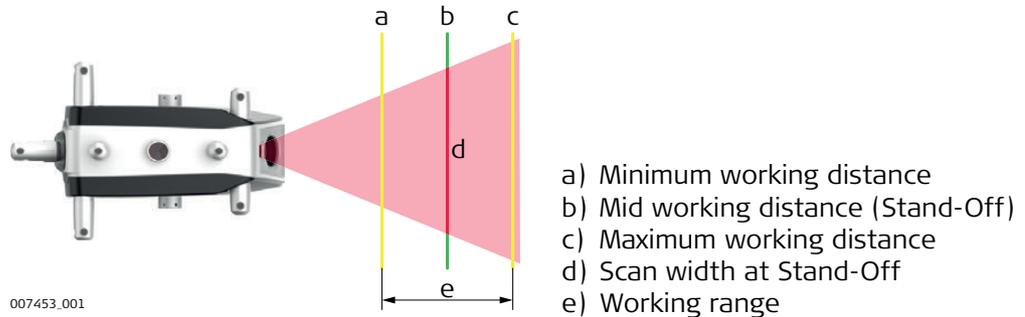
2.5

General Operating Principle

Measurement depth and Scan Width

The T-Scan Sensor is a triangulation scanner using an optically amplified laser line observed by a 2D imaging sensor.

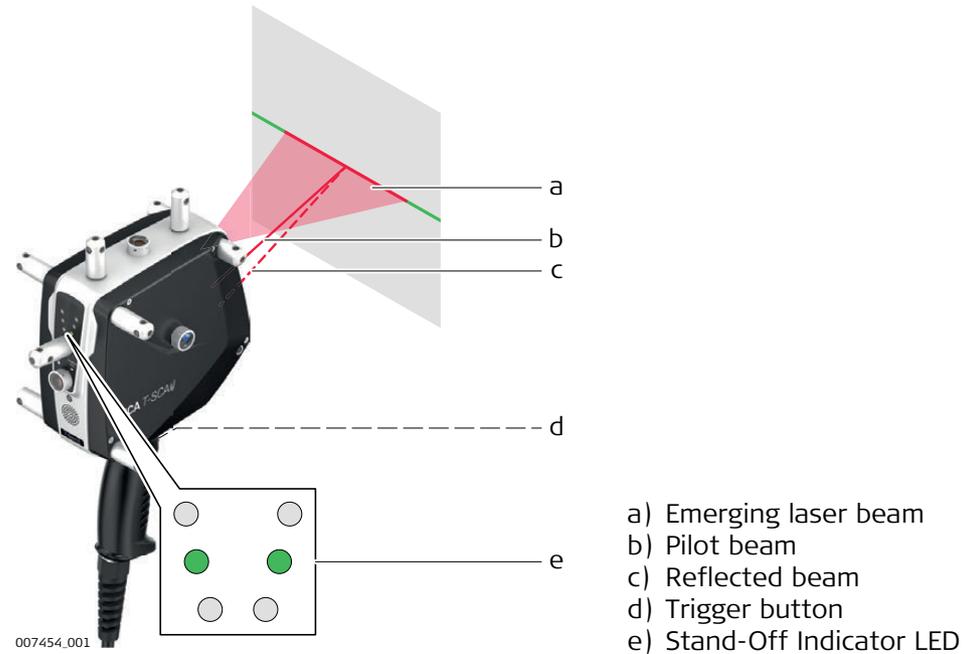
The T-Scan Sensor has a working range (measurement depth) of approximately ± 50 mm. The mid working distance is the distance from the housing to the centre of the working range. This distance is also called Stand-Off and amounts approximately 150 mm. The usable scan width at Stand-Off is approximately 100 mm.



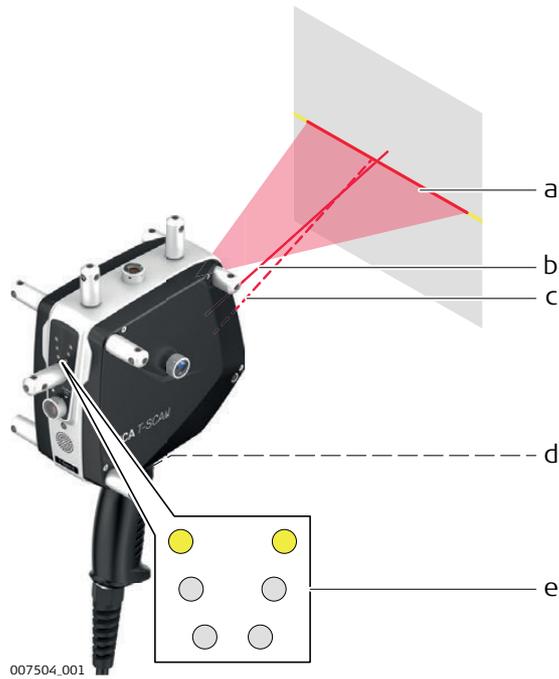
Positioning of the T-Scan sensor

In order to facilitate the positioning of the T-Scan sensor, the sensor emits a pilot beam. The pilot beam intersects the laser beam at the centre of the working range. If the pilot beam is underneath the scan line, the distance between sensor and measuring object is too small. If the pilot beam is above the scan line, the distance is too large.

Optimal distance:

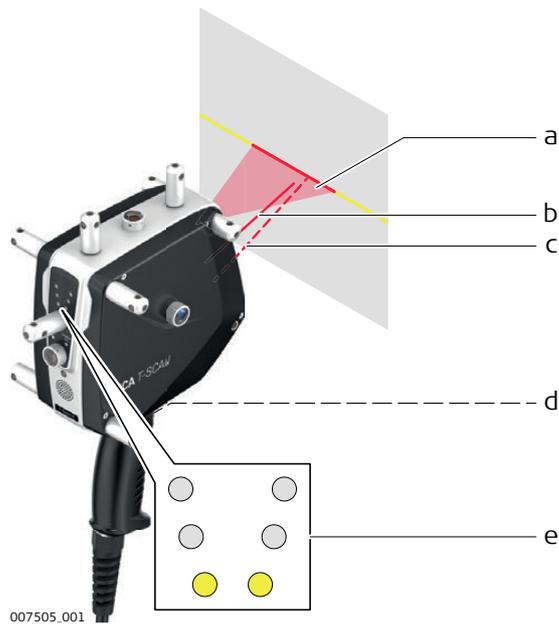


Distance too large:



- a) Emerging laser beam
- b) Pilot beam (above the scan line)
- c) Reflected beam
- d) Trigger button
- e) Stand-Off Indicator LED

Distance too small:



- a) Emerging laser beam
- b) Pilot beam
(underneath the scan line)
- c) Reflected beam
- d) Trigger button
- e) Stand-Off Indicator LED

The LEDs on the back side of the sensor also function as positioning aid:

- The Stand-Off indicator LED indicates the distance between sensor and measuring object.
- The Status LEDs indicate the status of the T-Scan Controller (ON/OFF) and the measurement status of the T-Scan and the Laser Tracker.

The data acquisition can be started with the Trigger button on the handle of the sensor.

The Laser Tracker 6DOF System

The T-Scan can be operated as a handheld scanner or can be mounted onto a robot or machine to measure clouds of points. The T-Scan works with the Leica Absolute Tracker 6DOF system. The measurement range of the T-Scan depends on the Laser Tracker model that is used.

The Absolute Tracker Controller synchronises all relevant system components to a common time base.

On the centre of each face of the T-Scan, a reflector is located. Together with the Marker LEDs, the reflectors represent the measurement targets of the system. In order to describe the position and orientation of the T-Scan in relation to the Absolute Tracker system, six measurement parameters are needed:

- Three position parameters (Hz, V, D)
- Three orientation parameters (ω , φ , κ)

These parameters are determined by measurements with the Laser Tracker (position) and the Measurement Camera (orientation).

Laser Tracker parameter for 3D position

- Horizontal angle - Hz
- Vertical angle - V
- Distance - D

Measurement Camera - Parameter for orientation

- Rotation around the X-axis – Omega ω
- Rotation around the Y-axis – Phi φ
- Rotation around the Z-axis – Kappa κ

Reflectors

The reflectors are at the centre of each face of the T-Scan. The reflectors are glass prisms which reflect the AIFM laser beam of the Laser Tracker to support the initial distance measurement of the Absolute Distance Meter (ADM) and the tracking measurement of the Interferometer (IFM). These measurements provide the 3D information.

Infrared Marker LEDs

There are several Marker LEDs on each face of the T-Scan which have a three-dimensional distribution. These LEDs operate infrared.

Each Marker LED has a unique ID, which identifies the LED and its position on the device.

The Marker LEDs are flashing in accordance with the synchronisation frequency. The Absolute Tracker Controller provides a real-time feedback loop to monitor the illumination and the identification of the Marker LEDs.

The real time control optimises the illumination of the Marker LEDs for the measurement. It also reduces the load on the Marker LEDs and improves their performance and lifetime.

Device	Number of infrared Marker LEDs
T-Scan	7

Measurement Mode

The measurement mode of the T-Scan provides identical illumination values for all Marker LEDs to reach the best image accuracy, independent from the orientation of the T-Scan.

In general, a minimum of five Marker LEDs must be in the view of the Measurement Camera on each image. Best results are achieved when the visible Marker LEDs are spread over a large 3D space. To guarantee the best accuracy, the LEDs are divided into groups where in minimum one marker of each group has to be visible. If this geometrical condition is not fulfilled, the T-Scan warns the user by an acoustic and visual signal. The system does not take a measurement to avoid a reduction of accuracy.

Description

The following accessories for the T-Scan systems are available:

- Measurement Cart
- Vertical Scanner Holder
- Reflectors
- T-Probe

 Refer to the relevant user manuals for a detailed description of the accessories and their usage (e.g. Measurement Cart User Manual, Absolute Tracker User Manual, T-Probe User Manual).

This list of accessories is not exhaustive, various other products are available for different measurement tasks.

 Refer to the brochure “Leica Metrology Accessories Catalog” for detailed information on additional accessories.



The use of accessories from third-party manufacturers without prior approval of Leica Geosystems is not permitted. Unauthorised modifications to the system make the warranty null and void.

4 Operation

4.1 Setup

General

The first installation of the product should be done by authorised Leica Geosystems personnel. Installation by unauthorised personnel may cause damage and will make the warranty null and void.

4.2 Measurement Strategy

Warm-up Time for T-Scan Sensor

The inside temperature of the T-Scan sensor increases during operation, due to the warming of electronic components inside. This warming is taken into account for the sensor calibration.

 For measurements that require utmost accuracy, allow a warm-up time of 30 minutes for the T-Scan sensor before starting the measurement.

Working with the Laser Tracker

Observe the following guidelines for the Laser Tracker:

- Set up the Laser Tracker in a way that the 6DOF position of the T-Scan sensor can be captured from all required measurement positions.
- Ensure that the T-Scan sensor is operated within the working range of the Laser Tracker system.
- Ensure that the visual contact between the Tracking Head and the reflectors/LEDs on the T-Scan sensor is given.
- When orientating the T-Scan sensor, be careful of the tilt between the prism surface of the locked-on side of the T-Scan and the measurement beam of the Laser Tracker. The maximum tilt between prism surface and beam is $\pm 45^\circ$.

 Do not expose the Laser Tracker system to vibrations or other disturbing influences that may affect the accuracy of the system. Pay attention to the ambient temperature and possible airflow.

Triangulation

To obtain the non-contact measurement data, the T-Scan sensor uses the principle of laser triangulation:

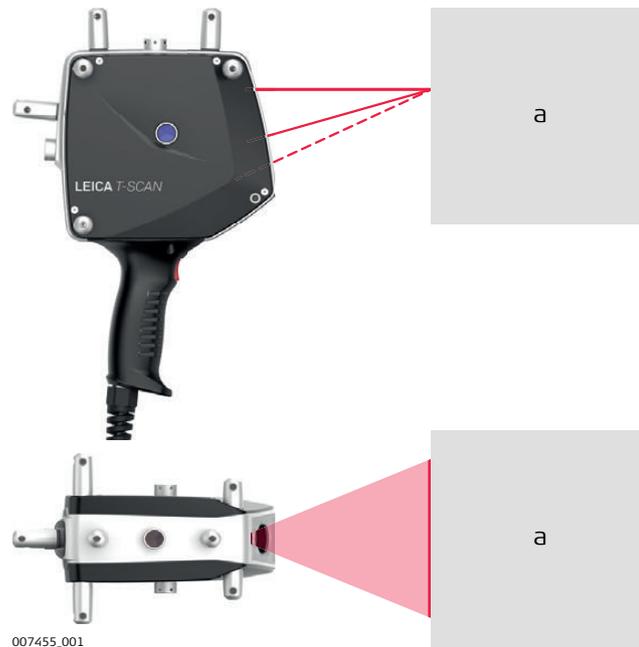
The laser source directs its laser beam to the measuring object. A part of the diffuse reflected light hits the receiving optical lens in a certain angle. This angle is called triangulation angle and is used to determine the distance.

Necessary surface characteristics

To achieve optimal measurement results, the measuring object should have a bright, diffusely reflecting surface, where the emerging laser light does not penetrate. Objects with surfaces that do not diffusely reflect the laser light are less suitable. Objects with surfaces that absorb the laser light completely are not suitable at all.

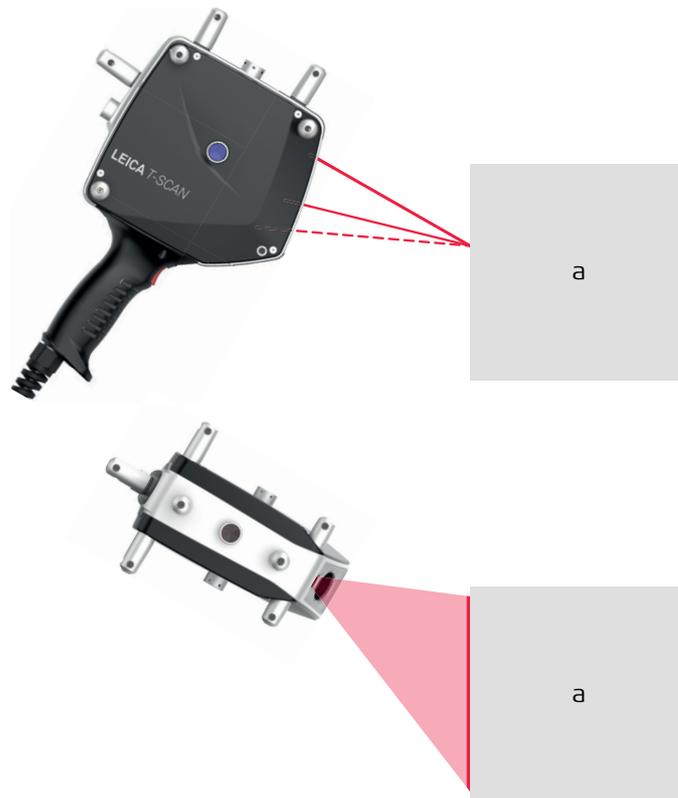
Optimal Orientation of the T-Scan Sensor

Orientate the T-Scan sensor in a way that the emerging laser beam perpendicularly impinges on the surface of the measuring object (a). This ensures that the laser beam is reflected in an optimal way for the best accuracy. This advice also applies for the laterally deflected laser beam (scan line).



Unfavourable Orientations of the T-Scan Sensor

If the T-Scan sensor is used in an unfavourable orientation, some parts of the scan line could exceed the working range of the sensor. In this case, the measurement data may not be captured completely. Example for unfavourable orientations of the T-Scan sensor:



Obstruction of the Laser Beam

Certain shapes of the measuring object, for example edges, can cause an interruption of the reflected laser beam. Before and after such an obstruction, the measurement accuracy might be reduced because only a part of the reflected light reaches the receiver optics.

To avoid the effect of obstruction, rotate the T-Scan sensor in the appropriate direction.



Total Reflection of the Laser Beam

Under certain circumstances, the surface of the measuring object (a) can totally reflect the laser beam. This total reflection occurs when the angle of reflection is the same as the angle of incidence. In that case, too much light is returned to the receiver optics. The measuring lens is irradiated and can no longer correctly detect the position or the measurement distance.

Schematic illustration of a total reflection:



To avoid total reflection during measurement, ensure that the T-Scan sensor is optimally orientated toward the measuring object.

Discontinuous Change of Reflection Characteristics

The T-Scan sensor is able to measure surfaces with varying reflection characteristics; the intensity of the light is regulated automatically.

At a contrast change within a single scan line, the target point of the receiving optical lens appears to be shifted, due to the varying degree of reflection of bright and dark surfaces or at object edges. This effect may lead to deviations in the measurement data.

Surface Digitising step-by-step

Digitising is the numerical recording of surface coordinates of 3D-lines (character lines) or freeform surfaces in a variable point grid. The result of digitising with the T-Scan is a set of 3D coordinates of the points on the scan lines.

The complete recording of any freeform surface area is called Surface Digitising. For digitising an object, any number of single measurements is possible.

Step	Description
1.	To start data recording, hold down the trigger button on the handle of the T-Scan sensor. As long as the trigger button is held down, the data is recorded.
	Ensure that the Stand-Off is at the centre of the working range. Move the T-Scan sensor perpendicularly to the scan direction.
	To scan large areas, take several measurements of smaller patches. Move the T-Scan sensor in a way that is similar to painting with a brush. To avoid gaps in the measurement data, ensure that there is a sufficient overlap of data between two scan rows.
2.	To stop data recording, release the trigger button.

Use the settings of the Application Software or the T-Scan Collect Software to control the density of the recorded data.

Refer to the "T-Scan Collect Reference Manual" for details on the settings and functionality of the software.

T-Scan Coordinate System

The centre of the reflector on each face of the T-Scan housing represents the origin of the local (sensor) coordinate system.



4.3

Accuracy

4.3.1

Accuracy of Coordinates

Coordinates of the T-Scan

The accuracy of the T-Scan coordinates depends on the determination of

- the reflector's position on the T-Scan
- the reflector's position in relation to the Absolute Tracker

The adjustment (compensation) of the Marker LEDs and of the reflector on the T-Scan determines the accuracy of the determination of the reflector's position.

Some of the parameters, which affect the accuracy, are:

- Marker LEDs and their local coordinates
 - Local coordinates of the reflector
 - Height of the reflector and its index of refraction
 - X- and Y-rotation in local coordinates
 - Local X-, Y- and Z-coordinates of the T-Scan
-

Coordinates of the Marker LEDs

The infrared Marker LEDs are placed on the T-Scan with an optimal three-dimensional distribution. Based on a specific adjustment (compensation) procedure, the position of the Marker LEDs and the reflector in a common local coordinate system (X, Y and Z) can be determined.

 Local coordinates refer to the coordinate system of the T-Scan.

Coordinates of the reflector

The position of the reflector on the T-Scan is determined by the relative position of the Marker LEDs. The accuracy of the reflector's position depends on the following parameters:

- Height of the reflector
- Refraction index of the glass prism
- Tilt angle of the reflector front to the X/Y-plane of the T-Scan coordinate system

The automated adjustment procedure uses these parameters to avoid systematic measurement errors.

4.3.2

Maximum Permissible Error (MPE)

Description

Accuracy specifications in the technical data of this manual are stated by means of the Maximum Permissible Error (MPE). The Automotive Society of Mechanical Engineers (ASME) defines Maximum Permissible Error (MPE) as the "extreme values of an error permitted by specification, regulations, etc. ... for a given instrument". The ASME B89.4.19-2006 standard further expands this definition by specifying that if during testing a corresponding measurement fails to meet the MPE requirements, then the failed measurement is allowed to be re-measured 5 times, with the magnitude of the largest error replacing the failed position value. If the new value fails to satisfy the MPE requirement, then the test is allowed to be done a second time (but not more than twice) with a failed result leading to a failed inspection test. Typical measurement results of the Absolute Tracker are half of the relevant MPE values.

4.3.3

Measurement Uncertainty

Specification of uncertainty with T-Scan

The following specification of uncertainty is achieved with the Leica T-Scan under stable environmental conditions.

 Refer to "7 Technical Data" for detailed specifications of the product.

Spatial length U_L

The measurement uncertainty of the spatial length " U_L " is defined as the deviation of a measured length from its nominal value. This deviation is specified as a function of the shortest distance between the Laser Tracker and the measured length. The length can be up to 6 m and is positioned perpendicularly to the laser beam. At the end of the reference length are two fix-mounted spheres (sphere radius between 15 mm and 20 mm). The sphere centres represent the nominal distance. The measured distance between the sphere centres is calculated by using the scan data of all four T-Scan sides.

Measurement uncertainty of a spatial length (2σ)	
$U_L < 8.5 \text{ m (27.9 ft)}$	$\pm 60 \text{ }\mu\text{m (0.0024 in)}$
$U_L > 8.5 \text{ m (27.9 ft)}$	$\pm 26 \text{ }\mu\text{m} + 4 \text{ }\mu\text{m/m (}\pm 0.0010 \text{ in} + 0.00005 \text{ in/ft)}$

Sphere Radius U_R

The measurement uncertainty of the sphere radius " U_R " is defined as the deviation of a measured sphere radius from its nominal value.

Measurement uncertainty of a sphere radius (2σ)	
$U_R < 8.5 \text{ m (27.9 ft)}$	$\pm 50 \text{ }\mu\text{m (0.002 in)}$
$U_R > 8.5 \text{ m (27.9 ft)}$	$\pm 16 \text{ }\mu\text{m} + 4 \text{ }\mu\text{m/m (}\pm 0.0006 \text{ in} + 0.00005 \text{ in/ft)}$

Sphere Surface U_S

The measurement uncertainty of the sphere surface " U_S " is defined as the total value of deviation of a sphere surface from the best-fit sphere. This value is calculated from all measured points. The measurement uncertainties are specified as a function of the distance between the Laser Tracker and the sphere. The specification assumes a reference sphere with a radius between 10 mm and 50 mm. The sphere radius and the sphere surface are calculated by using the data of all four T-Scan sides.

Measurement uncertainty of a sphere surface (2σ)	
U_S	$\pm 85 \text{ }\mu\text{m} + 1.5 \text{ }\mu\text{m/m (0.0033 in} + 0.00002 \text{ in/ft)}$

Plane Surface U_P

The measurement uncertainty of plane surface " U_P " is defined as the total value of deviation of a plane surface from the best-fit surface. This value is calculated from all measured points. The plane surface is calculated by using the data of all four T-Scan sides.

Measurement uncertainty of a plane surface (2σ)	
U_P	$\pm 80 \text{ }\mu\text{m} + 3 \text{ }\mu\text{m/m (0.0031 in} + 0.00004 \text{ in/ft)}$

Description

Leica Geosystems products are manufactured, assembled and adjusted to the best possible quality. Quick temperature changes, frequent movements of the product, shock or stress can cause deviations and decrease the measurement accuracy. It is therefore recommended to check and adjust (compensate) the product from time to time. This can be done onsite by running through specific field check or compensation measurements. If field checks do not provide satisfying results repeatedly, a full compensation of the product is recommended.

The following product parameters can be checked and adjusted electronically to an instrument specific parameter file:

- The infrared Marker LEDs and their local coordinates

 Refer to "6DOF Field Check" in the emScon Reference Manual for details on the Field Check process.

Measurement precision

To achieve precise measurement results in the daily work, it is important to check and adjust (compensate) the product from time to time. During the manufacturing process the product parameters are carefully determined.

As mentioned above, these values can change and it is highly recommended to check or adjust the product in the following situations:

- Before the first use of the product
- Before taking high precision measurements
- After long transportations
- After long working periods
- After long storage periods
- After mechanical shock of the product, for example drop
- In a high or low temperature environment



Before starting to work the product has to become acclimatised the ambient temperature, especially if the product has been stored under different temperature conditions. Ensure sufficient acclimatisation to the environment before taking precision measurements.

Scanner Alignment Calibration

To achieve the best possible scanning accuracy, it is recommended to perform an alignment calibration of the T-Scan in the following situations:

- Before taking a measurement.
- After a temperature change.

Use the provided calibration sphere for the scanner alignment calibration.

 Refer to the T-Scan Collect Reference Manual for details on the alignment calibration process.

6 Care and Transport

6.1 Transport

General	The equipment is sensitive to shock, vibration, temperature, humidity and air pressure.
Transport onsite	When transporting the product onsite, always make sure that you carry the product in its original transport container.
Transport in a road vehicle	Never carry the product loose in a road vehicle, as it can be affected by shock and vibration. Always carry the product in its transport container, original packaging or equivalent and secure it.
Shipping	When transporting the product by rail, air or sea, always use the complete original Leica Geosystems packaging, transport container and cardboard box, or its equivalent, to protect against shock and vibration.
Field adjustment	Periodically carry out test measurements and perform the field adjustments indicated in the emScon Reference Manual, particularly after the product has been dropped, stored for long periods or transported.

6.2 Storage

Product	Respect the temperature limits when storing the equipment, particularly in summer if the equipment is inside a vehicle. Refer to "Technical Data" for information about temperature limits.
Field adjustment	After long periods of storage a field check or an adjustment (compensation) of the product should be performed.

6.3

Cleaning and Drying

Cleaning the housing

Use the cleaning tissues of the Measurement Camera cleaning kit to clean the housing of the T-Scan.

6.3.1

Cleaning Optical Parts

General

Optical elements, like the reflector, are sensitive to dirt, moisture and mechanical damage, which may influence the following factors:

- General functionality (loss of tracking)
- System accuracy (angular and distance accuracy)
- Intensity of laser beam (cover glass)

The cleaning intervals depend on the local conditions of use.

The following optical parts must be cleaned regularly:

- Reflector
- Infrared LEDs

NOTICE

Cleaning of all optical parts requires great care. Improper cleaning can destroy optical surfaces which may lead to a malfunction.

Precautions:

Only use appropriate cleaning material and follow the cleaning procedure described in this User Manual.

Cleaning liquid

Use Isopropanol as cleaning liquid to soak tissues or cleaning swabs.

-  Keep the content of the liquid container clean. Do not dip the swabs into the liquid container, pour the liquid onto the swab or tissue.
-  Do not use common liquid cleaners or cleaning tissues for eyeglasses. They can damage or leave a residue on the optical surfaces.

Cleaning the reflector

To clean the reflector use the following procedure:

Step	Description
1.	Use hand blower to clear out dirt.
2.	Use the hairbrush to loosen and remove remaining dirt.
3.	Repeat procedure with the hand blower and brush until the residues of dirt have been removed.
4.	Use the cotton swabs or cleaning tissues soaked in cleaning liquid to remove any remaining dirt.

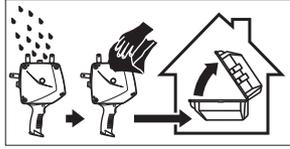
Infrared LEDs

To clean the infrared LEDs use the following procedure:

Step	Description
1.	Use hand blower to clear out dirt.
2.	Use the hairbrush to loosen and remove remaining dirt.
3.	Repeat procedure with the hand blower and brush until the residues of dirt have been removed.
4.	Use toothpicks only to remove dirt, which cannot be removed otherwise.  Use toothpicks with care. They can damage the optical surface.
5.	Use cleaning swabs soaked in cleaning liquid to remove any remaining dirt.

Damp products

Dry the product, the transport container, the foam inserts and the accessories at a temperature not greater than 40°C /104°F and clean them. Do not repack until everything is completely dry. Always close the transport container when using in the field.

**Cables and plugs**

Keep plugs clean and dry. Blow away any dirt lodged in the plugs of the connecting cables.

Wet connectors must be dry before attaching the dust cap.

6.4**Maintenance****Service**

The product is a high-precision measuring instrument and to be handled with care. Maintenance of the equipment must be carried out by a Leica Geosystems authorised Service Centre.

Service Intervals

The periodicity of service intervals is dependent on the conditions of use. We recommend a service contract or participation in the 5-year-warranty program of Leica Geosystems which covers preventative inspection, re-certification and an extension of the factory warranty. Please contact your local Leica Geosystems representative for details.

Repairs

In case of visible damage, system failure or errors, contact your local Leica Geosystems representative.

Physical dimensions



T-Scan Sensor	Dimensions
Size	ca. 210 x 380 x 138 mm
Weight (without cable)	ca. 1.1 kg



T-Scan Controller	Dimensions
Size	ca. 316 x 235 x 142 mm
Weight	6 kg

Electrical power

AC/DC Adapter for T-Scan Controller	Value
Input voltage	85 - 265 VAC
Output voltage	24 VDC
Frequency	47 - 63 Hz
Power	100 W
Max. input AC current	1.3 A (100 VAC) / 0.65 A (200 VAC)
Max. input AC current (over current protection)	5 A

Environmental specifications**Temperature**

Type	Operating temperature	Storage temperature
T-Scan	+0°C to +40°C (+32°F to +104°F)	-25°C to +70°C (+77°F to +158°F)

Humidity

Type	Protection
All instruments	Max. 95% (non condensing) - To avoid the effects of condensation, periodically dry out the instrument.

Elevation

Elevation	Range	
	[m]	[ft]
Operation	-700 to 2000	-2300 to 6600
Storage	-700 to 21000	-2300 to 70000

Protection against water, dust and sand

Type	Protection
T-Scan	IP40 (IEC 60529)

Scan Field

Device	Range
Stand-Off (mid working distance)	150 mm
Working range (measuring depth)	± 50 mm
Scan width (at Stand-Off)	ca. 100 mm

Scan Performance

Measurement Camera	Value
Sampling rate of distance measurement	max. 210 kHz
Line frequency	160 Hz (at 100% scan width) max. 330 Hz (at 40% scan width)
Minimum point density	0.075 mm at 150 mm distance

Range

Measurement range	Range
T-Scan	1.5 - 25 m (depending on type of Laser Tracker)

Rotation angles	Range
Roll (rotation around X-axis)	$\pm 360^\circ$
Pitch (rotation around Y-axis)	$\pm 46^\circ$
Yaw (rotation around Z-axis)	$\pm 46^\circ$

Conformity to national regulations

- FCC Part 15 (applicable in US)
- Hereby, Leica Geosystems AG, declares that the product is in compliance with the essential requirements and other relevant provisions of the applicable European Directives. The declaration of conformity may be consulted at <http://www.leica-geosystems.com/ce>.



Software Licence Agreement

This product contains software that is preinstalled on the product, or that is supplied to you on a data carrier medium, or that can be downloaded by you online according to prior authorisation from Leica Geosystems. Such software is protected by copyright and other laws and its use is defined and regulated by the Leica Geosystems Software Licence Agreement, which covers aspects such as, but not limited to, Scope of the Licence, Warranty, Intellectual Property Rights, Limitation of Liability, Exclusion of other Assurances, Governing Law and Place of Jurisdiction. Please make sure, that at any time you fully comply with the terms and conditions of the Leica Geosystems Software Licence Agreement.

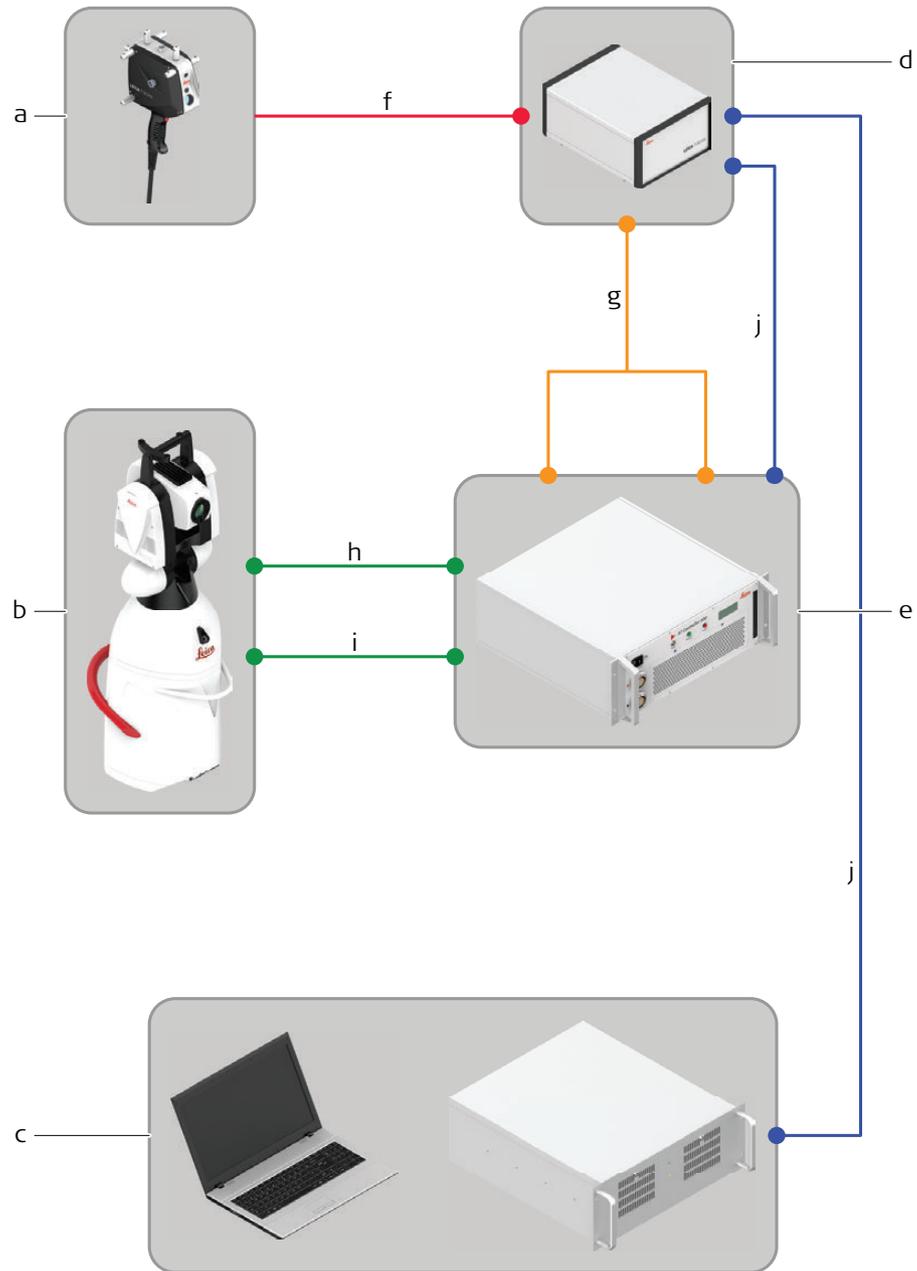
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Appendix A Cabling

Cabling of T-Scan system components

The following illustration shows the correct cabling to connect the T-Scan system components.



007463_001

- a) T-Scan 5
- b) AT901 Laser Tracker
- c) Application computer
- d) T-Scan controller
- e) AT Controller 900
- f) Scanner cable (connector type: LEMO)
- g) Trigger/Probe Y-cable (connector type: 6 pin LEMO/16 pin LEMO/Sub-D HD 15 pin)
- h) Sensor cable (connector type: LEMO/LEM0)
- i) Motor cable (connector type: LEMO/LEM0)
- j) LAN cable CAT6 (connector type: RJ45/RJ45)

Appendix B Abbreviations

Abbreviations

The following abbreviations may be found in this manual:

Term	Description
3D	three-dimensional
6DOF	6 degrees of freedom
ADM	Absolute Distance Meter
AIFM	Absolute Interferometer
EMC	Electromagnetic Compatibility
EN	Standard of the European Committee for Standardization
IEC	International Electrotechnical Commission
IFM	Interferometer
LED	Light Emitting Diode
TPI	Tracker Programming Interface

Appendix C Regional Contact Addresses

Regional contact addresses

<p>China Hexagon Metrology (Qingdao) Co., Ltd. 188 Zhuzhou Road 266101 Qingdao China P.R. China Phone +86 532 8870 2188 Fax +86 532 8870 3060</p>	<p>France Hexagon Metrology SAS Service Client Leica Immeuble Le Viking 32, Avenue La Baltique 91978 Courtaboeuf Cédex France Phone +33 01 69 29 12 00 Fax +33 01 69 29 00 32</p>
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<p>Italy Hexagon Metrology SpA Via Bizzozzero, 118 20132 Cormano (MI) Phone +39 02 6154 111 Fax +39 02 6150 473</p>	<p>Spain Hexagon Metrology S.A. Parc Tecnològic del Vallès C/ Sabaters, 5 ES-08290 Cerdanyola del Vallès (Barcelona) Phone +34 93 594 69 20 Fax +34 93 594 69 21</p>
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<p>USA Hexagon Metrology Precision Center 9424 E 37th Street North Suite 220 Wichita, KS 67226 Toll free +1 866 756 6763 Phone +1 316 634 0856 Fax +1 316 634 0878</p>	<p>USA Hexagon Metrology Precision Center 2473 Belvo Road Miamisburg, OH 45342 Phone +1 937 353 1206 Fax +1 937 247 0426</p>

Refer to "Sales & Support Contacts" on www.leica-geosystems.com/metrology for a complete list of regional contacts.

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