Report on

FEASIBILITY OF USING GPS TO CONDUCT BOUNDARY / TOPOGRAPHIC SURVEY

Survey Technician Certification Board
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This report details the conditions that would make the use of the Global Positioning System (GPS) and other technology favorable in conducting a Boundary Survey and a Topographic Survey on a typical 30 acre parcel of land in accordance with the Minimum Technical Standards of Surveying and Mapping in the state of Florida as set out in chapter 61G17-6 of the Florida Administrative Code.

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FEASIBILITY OF USING GPS TO CONDUCT BOUNDARY / TOPOGRAPHIC SURVEY

I. INTRODUCTION

Advancements in technology and amendments to the rules that govern the profession of Surveying and Mapping have opened the door to possibilities of producing a larger array of services to an expanding clientele. Also, the products that are the mainstay of the profession can be made more accurate, precise, and economical even with today's demanding constraints on time and personnel.

Through the use of GPS, a modern surveyor is capable of more quality and yield in a single day than a small army could accomplish in a months time only a few years ago. As the size of the geographic area to be covered expands and the amount of obstacles to overcome increases the advantages of GPS become more pronounced and the precision of the measurements increases exponentially over conventional methods.

Additional benefits are realized when the advantage of referencing work to a common datum is accomplished which without GPS would not have been economically feasible. The proliferation of Geographic Information Systems has driven a demand for data to exist in a format compatible across multiple disciplines.

II. GLOBAL POSITIONING SYSTEM (GPS) TECHNOLOGIES

A minimal technical background on GPS technologies is necessary to make informed decisions concerning its potential benefits and uses.

Definition of GPS

Global Positioning System is a space based radio position, navigation, and time transfer system developed by the U.S. Department of Defense. The system is intended to provide highly accurate position and velocity information and precise time, on a continual basis, to an unlimited number of properly equipped subscribers. The system is unaffected by weather and provides a worldwide common grid reference system. The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to the user. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into a three-dimensional position, velocity, and time [GPS npag].

Components [GPS Survey Equipment npag]

- **Receiver:** The receivers used for network surveys should record the full wavelength carrier phase and signal strength of both the L1 and L2 frequencies, and track at least eight satellites simultaneously on parallel channels. Dual frequency instruments are required for all baselines longer than 10 kilometers.
- **Antenna:** The antennas should have stable phase centers and choke rings or large (> 16 cm) ground planes to minimize multipath interference, and a common orientation indicator (e.g., an arrow) to point north during observations.
- **Tripod:** The tripods used must facilitate precise offset measurements between the mark datum point and the Antenna Reference Point (ARP). Fixed height tripods are preferable, due to the decreased potential for antenna centering and height measurement errors.
- **Tribrach:** The tribrachs used shall be of suitable quality and condition for high-accuracy surveys.
- **Meteorological Equipment:** Meteorological equipment includes a psychrometer (wet-bulb and dry-bulb thermometers) to measure temperatures and a barometer or altimeter to measure atmospheric pressure. Relative humidity can either be measured with a hygrometer or computed (the preferred method) from psychrometer and barometer readings.
- **Personnel:** All field personnel should be trained in the avoidance of systematic errors and blunders during field operations. Office personnel should be familiar with geodetic concepts and least-squares adjustments.

Procedures [GPS Survey Observations npag]

User Densification Network (UDN) surveys allow regional densification of the High Accuracy Reference Network (HARN). UDN surveys are conducted in accordance with the following specifications:

Station Requirements

- **UDN Stations:** The survey shall include UDN stations established at 25 km spacing or less.
- **HARN Stations:** The survey shall include at least 2 HARN stations.

Observation Requirements

These guidelines for UDN surveys are summarized in Table below:

Network Design Guidelines for UDN Surveys	
Minimum Number of Stations	At least 2 HARN stations
Maximum Station Spacing	< 25 km between UDN stations
Required Baselines	To adjacent stations
Observations per Baseline	2 each, 30 minute observations
Sidereal Time Offset Between Repeated Observations	No time offset required
Fixed-height Tripods Required?	No fixed-height tripods required
Acquire Meteorological Data?	At representative stations in the middle of each observation
Data Acquisition Parameters	30 second epochs, 15 degree elevation masks
Data Processing Parameters	30 second epochs, 15 degree elevation masks, precise or rapid ephemerides

III. BENEFITS TO USE OF GPS TECHNOLOGIES

Relative Positioning

- **Coordinate System:** The coordinate system used for all stages of surveying and construction can coincide with a well-established datum used over a large geographic area by many entities such as the Florida State Plane Coordinate System.
- **HARN:** Positions established in relation to HARN stations benefit from intensive enhancement of local control networks by federal and state authorities.
- **Bluebooking:** Monumentation established in accordance with the Federal Geodetic Control Subcommittee (FGCS) guidelines is eligible for inclusion in the National Spatial Reference System (NSRS). The data will be checked for quality assurance, archived and distributed through a central database, and updated with any future regional adjustments.

Compatibility

Data in a common datum can be used in a large number of applications including:

- **Overlay:** Orthorectified aerial photography adjusted to common datum is readily available. Data can be overlaid onto aerial photography and can be used for visual analysis or mapping applications.
- **Automated Machine Control:** Site work for construction of residential or commercial development can be automated with the use of computer files containing design information in a referenced datum.

- **Interagency Coordination:** Use of a common datum can streamline sharing information between entities such as consultants for engineering and environmental management, government agencies, and contractors.
- **Navigation:** Movement of equipment and personnel on a job site can be aided by the use of inexpensive consumer grade GPS receivers.
- **GIS:** A vast array of information is available through many local governments and is referenced to a common coordinate system. Much of the topographic data necessary for initial review of a proposed development can be obtained using economical mapping grade GPS and provided to necessary authorities in an electronic format compatible within a GIS.

Performance

- **Precision:** Typical GPS equipment has an attainable quality of 3mm + 0.5ppm in horizontal measurement and typical infrared Electronic Distance Measuring (EDM) equipment has an attainable quality of 2mm + 2ppm. Therefore, as distances increase the precision of GPS measurements surpasses EDM measurements quickly. Conventional methods of surveying may also rely on angular measurements that will degrade as distance increases [GPS 1200 5, TPS 4].
- **Accuracy:** The accuracy of a survey depends not only on precise measurements but on the ability to gather a substantial number of measurements to existing monumentation. A few additional measurements may resolve a problem that would require an additional visit to the jobsite. The ability of GPS to acquire measurements

despite obstacles and inclement weather increases the likelihood of attaining additional measurements.

- **Speed:** The ability of GPS to acquire measurements despite obstacles and inclement weather also dramatically increases the speed at which measurements can be obtained. Without the need to clear a line of sight or the inability to acquire measurements due to rain, fog, or strong heat shimmer the duration of an average project can easily be reduced using GPS.
- **Economics:** Although the initial investment to purchase GPS equipment exceeds that of conventional survey equipment the difference can be recouped quickly by gains in productivity. Without intricate moving parts, as contained within a conventional survey instrument, maintenance costs and lost productivity due to failures remains low and reductions in personnel injuries from line clearing activities can reduce insurance costs. Additionally, planning for each day's activities using GPS includes fewer unknown variables about the speed at which the survey can progress, allowing for less scheduling difficulties.
- **Geodetic:** Referencing a survey to geodetic control monumentation is advantageous but is often a time consuming process. GPS aids in the recovery of published marks by navigation to within centimeters of the location without the need to rely on obsolete or inaccurate to-reach descriptions. The process of acquiring measurements to geodetic monumentation that can be several kilometers from the jobsite is aided by the aforementioned topics.

IV. OTHER TECHNOLOGIES

A brief discussion of other available technologies that can be used in the acquisition of topographic information is necessary to evaluate the appropriateness of their use on a typical 30-acre parcel.

Photogrammetry

- **Definition:** Photogrammetry is a measurement technology in which the three-dimensional coordinates of points on an object are determined by measurements made in two or more photographic images taken from different positions [Photogrammetry npag].
- **Overview:** Photogrammetry can obtain equivalent accuracy as conventional surveying on features visible from the air. The time required to obtain the data in the field is greatly reduced but some control and ground truth measurements still must be performed. Also, topographic features obscured by standing water and vegetation must be located with other means.

Airborne Light Detection and Ranging Systems (LIDAR)

- **Definition:** LIDAR is defined as an airborne laser system, flown aboard rotary or fixed-wing aircraft, that is used to acquire x, y, and z coordinates of terrain and terrain features that are both manmade and naturally occurring. LIDAR systems consist of an airborne Global Positioning System (GPS) with attendant GPS base station(s), Inertial Measuring Unit (IMU), and light-emitting scanning laser [Airborne npag].

- **Overview:** LIDAR is more tolerant of weather conditions that affect other photogrammetric methods such as rain, fog, and cloud cover. LIDAR can obtain equivalent accuracy as photogrammetry and can also penetrate vegetation and shallow water.

Application to 30-Acre Parcel

A typical 30-acre parcel of land in Florida is relatively flat, contains dense vegetation and some standing water. Due to the fact all three of these factors negatively affect photogrammetric methods and the issue of contracting with a company capable of providing these services, conventional ground survey methods will not significantly increase the cost of acquiring the topographic information.

V. CONCLUSION

GPS technologies have the advantages of easily relating the coordinate system of a project to a common datum that is well established and rigorously adjusted by federal authorities. Through the process of *Bluebooking* project control monumentation can be submitted for inclusion in the NSRS where the data will be checked, maintained, and distributed for future use by others.

By easing the process of referencing a common datum GPS allows the data collected to be used for a variety of applications such as; overlay onto aerial photography, basemaps for automated machine control, standardized distribution to other agencies, navigation, and direct input into GIS databases.

Performance and economic efficiencies are realized on all size projects by the use of GPS. As the size of the geographic area increases the benefits increase proportionally as the quality and speed of the work with GPS exceeds that of conventional surveying. A typical 30-acre parcel in Florida requires a variety of tools to survey effectively and of all that are available for use on the ground and in the air; GPS outperforms conventional methods at a lower cost than aerial methods.

Unlike photogrammetry and LIDAR, training existing personnel to operate GPS equipment is realistic and avoids costs involved with outsourcing data collection and processing that can be substantial. Safety is improved when the use of GPS removes the need for line clearing activities and reduced risks of liability for errors will certainly increase profits.

According to the US Department of Transportation, Federal Highway Administration, “Over the past 5 years, studies across the United States have shown that GPS technology increases the productivity of conventional survey crews, reduces data collection time, improves survey accuracy, and allows crews to work under a broad range of weather conditions. Moreover, less expertise is required to operate a GPS surveying unit than is needed to operate conventional surveying technologies” [Global npag].

“The Utah Department of Transportation found that one person operating GPS equipment is generally twice as fast as a conventional survey crew, and a GPS system with two units is potentially four times faster than crews using conventional surveying technologies. Other advantages of GPS technology include the ability to use the technology across long distances with minimal setups. After a GPS system is placed, roving can be performed within a radius of 10 kilometers (6 miles) of the stationary base unit. Using conventional technologies, the base unit would have to be moved every 183 meters (600 feet). In one study, GPS equipment recorded 5,511 topographic points in 30 person-hours, while a similar project using conventional technologies covered only 1,500 topographic points in 120 person-hours”[Global npag].

INFORMATION SOURCES

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APPENDIX

A: Leica Geosystems GPS 1200 Technical Data pp. 3-5.

B: Leica Geosystems TPS 1200 Technical Data pp. 3-4.

Leica GPS1200 Series

Technical Data

- when it has to be **right**

Leica Geosystems

GPS1200 Technical Data

For reference station products please refer to the technical data for GRX1200 series receivers (739 355)

Summary Description

	GX1230/ATX1230	GX1220	GX1210
Receiver type	Dual-frequency, geodetic, real-time RTK receiver	Dual-frequency, geodetic receiver	Single-frequency, survey receiver
Summary of measuring, modes and applications	Static, rapid static, kinematic On the fly L1 + L2, code, phase Real-time RTK standard Post processing DGPS/RTCM standard Survey, geodetic and real-time RTK applications	Static, rapid static, kinematic On the fly L1 + L2, code, phase Post processing DGPS/RTCM optional Survey and geodetic applications	Static, kinematic L1, code, phase DGPS/RTCM optional Survey and GIS applications

System Components

Receiver

	GX1230/ATX1230	GX1220	GX1210
Receiver technology	SmartTrack - patented. Discrete elliptical filters. Fast acquisition. Strong signal. Low noise. Excellent tracking, even to low satellites and in adverse conditions. Interference resistant. Multipath mitigation.		
No. of channels	12 L1 + 12 L2	12 L1 + 12 L2	12 L1
L1 measurements	Carrier phase full wave length C/A narrow code	Carrier phase full wave length C/A narrow code	Carrier phase full wave length C/A narrow code
L2 measurements	Carrier phase full wave length with AS off or on P2 code / P-code aided under AS Equal performance with AS off or on	Carrier phase full wave length with AS off or on P2 code / P-code aided under AS Equal performance with AS off or on	No
Independent measurements	Fully independent L1 and L2 code and phase measurements	Fully independent L1 and L2 code and phase measurements	Fully independent L1 code and phase measurements
Time to first phase measurement after switching ON	Typically 30 secs	Typically 30 secs	Typically 30 secs
LED status indicators	3: for power, tracking, memory	3: for power, tracking, memory	3: for power, tracking, memory
Ports	4 RS232 port 1 Power only port 1 TNC port for antenna 1 PPS, 2 Event port optional	4 RS232 port 1 Power only port 1 TNC port for antenna 1 PPS, 2 Event port optional	4 RS232 port 1 Power only port 1 TNC port for antenna 1 PPS, 2 Event port optional

Supply voltage Power consumption	Nominal 12V DC range 10.5-28V DC 3.8W typically, 320mA	Nominal 12V DC range 10.5-28V DC 3.8W typically, 320mA	Nominal 12V DC range 10.5-28V DC 3.8W typically, 320mA
Dimensions (all receivers):	The dimensions are given for the housing without the sockets		
length x width x thickness	0.212m x 0.166m x 0.079m	0.212m x 0.166m x 0.079m	0.212m x 0.166m x 0.079m
Weight, receiver only	1.2kg	1.2kg	1.2kg

GPS Antennas

	GX1230	GX1220	GX1210
Standard survey antenna	AX1202, L1/L2 SmartTrack	AX1202, L1/L2 SmartTrack	AX1201, L1/L2 SmartTrack
Groundplane	Built-in groundplane	Built-in groundplane	Built-in groundplane
Dimensions (diameter x height)	170mm x 62mm	170mm x 62mm	170mm x 62mm
Weight	0.44kg	0.44kg	0.44kg
Choke-ring antenna	AT504 choke-ring, L1/L2 microstrip.	AT504 choke-ring, L1/L2 microstrip.	No
Design	Dorne Margolin, JPL design.	Dorne Margolin,JPL design.	
Protection radome	optional	optional	
Dimensions:diameter x ht	380mm x 140mm (antenna)	380mm x 140mm (antenna)	
Weight	4.3kg (antenna)	4.3kg (antenna)	

SmartAntenna

	ATX1230
Groundplane	Built-in groundplane
Dimensions (diameter x height)	186mmX89mm
Weight	1,12kg

Controller

	GX1230/ATX1230	GX1220	GX1210
Type	RX1210, RX1210T (with touch screen), RX1250 (with touch screen)		
Display	¼ VGA, monochrome, graphics capable, illumination		
Character Set	Maximum 256 characters , extended ASCII characters set		
Touch screen (RX1210T only)	Toughened film on glass		
Keyboard	Full alphanumeric (62 keys), 12 function keys, 6 user-definable keys, illumination		
Controller Weights	RX1210 0.48kg RX1250 0.75kg		
Total Weights of System	SmartRover 2.79kg (all on the pole) GX1200 Rover 4.15kg (all on the pole) GX1200 Rover 2.35kg (weight of pole for Minipack setup)		

Measurement Precision and Position Accuracies

	GX1230/ATX1230	GX1220	GX1210

Important Note

Measurement precision and accuracy in position and accuracy in height are dependent upon various factors including number of satellites, geometry, observation time, ephemeris accuracy, ionospheric conditions, multipath etc. Figures quoted assume normal to favourable conditions. Times can also not be quoted exactly. Times required are dependent upon various factors including number of satellites, geometry, ionospheric conditions, multipath etc.
The following accuracies, given as root mean square, are based on measurements processed using LGO and on real-time measurements.

Code and Phase Measurement Precision (irrespective whether AS off/on)

	GX1230/ATX1230	GX1220	GX1210
Carrier phase on L1	0.2mm rms	0.2mm rms	0.2mm rms
Carrier phase on L2	0.2mm rms	0.2mm rms	
Code (pseudorange) on L1	2cm rms	2cm rms	2cm rms
Code (pseudorange) on L2	2cm rms	2cm rms	

Accuracy (rms) with post processing

	GX1230/ATX1230	GX1220	GX1210
	With LEICA Geo Office L1/L2 processing software	With LEICA Geo Office L1/L2 processing software	With LEICA Geo Office L1 processing software
Static (phase), long lines, long observations, choke ring antenna	Horizontal: 3mm + 0.5ppm Vertical: 6mm + 0.5ppm	Horizontal: 3mm + 0.5ppm Vertical: 6mm + 0.5ppm	Not applicable
Static and rapid static (phase) with standard antenna)	Horizontal: 5mm + 0.5ppm Vertical: 10mm + 0.5ppm	Horizontal: 5mm + 0.5ppm Vertical: 10mm + 0.5ppm	Horizontal: 10mm + 1ppm Vertical: 20mm + 2ppm
Kinematic (phase), in moving mode after initialization	Horizontal: 10mm + 1ppm Vertical: 20mm + 1ppm	Horizontal: 10mm + 1ppm Vertical: 20mm + 1ppm	Horizontal: 20mm + 2ppm
Code only	Typically 25cm	Typically 25cm	Typically 30cm

Accuracy (rms) with real-time/RTK

	GX1230/ATX1230	GX1220	GX1210
RTK capability	Yes, standard	No	No
Rapid static (phase), Static mode after initialization	Horizontal: 5mm + 0.5ppm Vertical: 10mm + 0.5ppm		
Kinematic (phase), moving mode after initialization	Horizontal: 10mm + 1ppm Vertical: 20mm + 1ppm		
Code only	Typically 25cm		

Accuracy (rms) with DGPS/RTCM

	GX1230/ATX1230	GX1220	GX1210
	DGPS/RTCM standard	DGPS/RTCM optional	DGPS/RTCM optional
DGPS/RTCM	Typically 25cm (rms)	Typically 25cm (rms)	Typically 30cm (rms)

Accuracy (rms) in single receiver navigation mode

	GX1230/ATX1230	GX1220	GX1210
Navigation accuracy	5–10m rms for each coordinate	5–10m rms for each coordinate	5–10m rms for each coordinate
Degradation effect	Degradation possible due to SA	Degradation possible due to SA	Degradation possible due to SA

On-the-Fly (OTF) initialisation

	GX1230/ATX1230	GX1220	GX1210
OTF Capability	Real time and post processing	Post processing only	No OTF
Reliability of OTF initialisation	Better than 99.99%	Better than 99.99%	Not applicable
Time for OTF initialisation	Typically 8secs, with 5 or more satellites on L1 and L2	Typically 8secs, with 5 or more satellites on L1 and L2	Not applicable
OTF Range*	Typically up to 30km in normal conditions	Typically up to 30km in normal conditions	Not applicable
*Assuming reliable data-link is available in RTK case	Up to 40km in favorable conditions.	Up to 40km in favorable conditions.	

Position update and latency

	GX1230/ATX1230	GX1220	GX1210
	RTK and DGPS standard	DGPS optional	DGPS optional
Position update rate	Selectable: 0.05 sec (20Hz) to 60 secs	Selectable: 0.05 sec (20Hz) to 60 secs	Selectable: 0.05 sec (20Hz) to 60 secs
Position latency	0.03 sec or less	0.03 sec or less	0.03 sec or less

Real-time RTK and DGPS/RTCM Data Formats

	GX1230/ATX1230	GX1220	GX1210
	Real-time RTK standard DGPS/RTCM standard	DGPS/RTCM optional	DGPS/RTCM optional
RTK Data Formats for data transmission and reception	Leica proprietary format. CMR, CMR+		
RTCM Format for data transmission and reception	RTCM Versions 2.x supporting messages 1,2,3,9,18,19,20,21,22,23,24 And RTCM Version 3	RTCM Versions 2.x supporting messages 1,2,3,9,18,19,20,21,22,23,24 And RTCM Version 3	RTCM Versions 2.x supporting messages 1,2,3,9 And RTCM Version 3
Simultaneous transmissions	2 real time output interfaces via independent ports, providing identical or different RTK/RTCM formats		

Data recording

Recording rate	Selectable from 0.05 to 300 s
Standard medium	CompactFlash cards: 32MB, 256 MB
Optional medium	Internal memory for receiver: 32MB, 256 MB
Data capacity:	32 MB is sufficient for about ▪ 550h L1 + L2 data logging at 15s rate ▪ 2200h L1 + L2 data logging at 60s rate ▪ 45’000 real-time points with codes

Power supply for GX1200 receivers

Internal battery	GEB221 rechargeable Li-Ion battery 3.8Ah/7.2V, 2 batteries fit into receiver
Operation time	2 GEB221 power GX1200 receiver plus antenna plus RX1200 Controller for about 15h
Weight, GEB221 battery	0.2kg
External battery, optional	GEB171 7Ah/12V NiMh battery
Operation time	1 GEB171 powers GX1200 receivers plus antenna plus RX1200 Controller for about 30h

Power supply for SmartRovers

Internal battery	GEB211 rechargeable Li-Ion battery 1.9Ah/7.2V, 1 battery fits into ATX1230 and 1 battery fits into RX1250
Operation time	1 GEB211 powers ATX1230 for about 5h 1 GEB211 powers RX1250 for about 11h
Weight, GEB211 battery	0.11kg

Operation of GX1200 receivers with and without controller

Manual operation with RX1210 Controller	Standard method. Receiver control, operation, data input, survey-data acquisition, information display via controller
Automatic operation without Controller	Automatic on switching on. Modes and parameters for receiver operation, measuring, recording, transmission etc preset using controller
LED	3 LED's indicate power, tracking, memory
Manual operation with RX1220 Controller	As an alternative the total station remote control unit RX1220 can be used for manual operation of the sensor in exactly the same way as the RX1210

Operation of SmartRovers with and without controller

An RX1250 Controller is always required to operate an ATX1230

Navigation mode

Navigation	Full navigation information in position and stakeout displays Position, course, speed, bearing and distance to waypoint

Environmental specifications

Receivers	Valid for GX1210, GX1220, GX1230, ATX1230
Temperature, operating	-40°C to +65°C* Compliance with ISO9022-10-08, ISO9022-11-special and MIL-STD-810F Method 502.4-II, MIL-STD-810F Method 501.4-II *Bluetooth: -30°C to +60°
Temperature, storage	-40°C to +80°C Compliance with ISO9022-10-08, ISO9022-11-special and MIL-STD-810F Method 502.4-I, MIL-STD-810F Method 501.4-I
Humidity	Up to 100%* Compliance with ISO9022-13-06, ISO9022-12-04 and MIL-STD-810F Method 507.4-I * The effects of condensation are to be effectively counteracted by periodically drying out the product
Protection against Water, Sand and Dust	IP67 Protection against blowing rain Waterproof to temporary submersion into water (maximum depth of 1m) Dust-tight, protection against blowing dust Compliance with IP67 according IEC60529 and MIL-STD-810F Method 506.4-I, MIL-STD-810F Method 510.4-I, MIL-STD-810F Method 512.4-I
Drops	Withstands 1m drop onto hard surfaces
Vibration	Withstands vibrations during operation on large civil construction machines Compliance with ISO9022-36-08 and MIL-STD-810F Method 514.5-Cat24
Functional Shock	No loss of lock to satellite signal when used on a pole set-up and submitted to pole bumps up to 150mm

GPS Antennas	Valid for AX1201, AX1202
Temperature, operating	-40°C to +70°C Compliance with ISO9022-10-08, ISO9022-11-05 and MIL-STD-810F Method 502.4-II, MIL-STD-810F Method 501.4-II
Temperature, storage	-55°C to +85°C Compliance with ISO9022-10-09, ISO9022-11-06 and MIL-STD-810F Method 502.4-I, MIL-STD-810F Method 501.4-I
Humidity	Up to 100%* Compliance with ISO9022-13-06, ISO9022-12-04 and MIL-STD-810F Method 507.4-I * The effects of condensation are to be effectively counteracted by periodically drying out the product
Protection against Water, Sand and Dust	IP66, IP67 Protection against water jets Protection against blowing rain Waterproof to temporary submersion into water (maximum depth of 1m) Dust-tight, protection against blowing dust Compliance with IP66 and IP67 according IEC60529 and MIL-STD-810F Method 506.4-I, MIL-STD-810F Method 510.4-I, MIL-STD-810F Method 512.4-I
Drops Vibration	Withstands 1.5m drop onto hard surfaces Withstands vibrations during operation on large civil construction machines Compliance with ISO9022-36-08 and MIL-STD-810F Method 514.5-Cat24
Functional Shock	No loss of lock to satellite signal when used on a pole set-up and submitted to pole bumps up to 150mm
Topple over pole	Survives topple over from a 2m survey pole onto hard wood on a concrete floor

Controller	Valid for RX1210, RX1210T and RX1250 controllers
Temperature, operating	-30°C to +65°C Compliance with ISO9022-10-06, ISO9022-11-special and MIL-STD-810F Method 502.4-II, MIL-STD-810F Method 501.4-II
Temperature, storage	-40°C to +80°C Compliance with ISO9022-10-08, ISO9022-11-special and MIL-STD-810F Method 502.4-I, MIL-STD-810F Method 501.4-I
Humidity	Up to 100%* Compliance with ISO9022-13-06, ISO9022-12-04 and MIL-STD-810F Method 507.4-I * The effects of condensation are to be effectively counteracted by periodically drying out the product
Protection against Water, Sand and Dust	IP67 Protection against blowing rain Waterproof to temporary submersion into water (maximum depth of 1m) Dust-tight, protection against blowing dust Compliance with IP67 according IEC60529 and MIL-STD-810F Method 506.4-I, MIL-STD-810F Method 510.4-I, MIL-STD-810F Method 512.4-I
Drops Vibration	Withstands 1.5m drop onto hard surfaces Withstands vibrations during operation on large civil construction machines Compliance with ISO9022-36-08 and MIL-STD-810F Method 514.5-Cat24

Communication Module	Valid for all Leica GFU based communication modules
Humidity	Up to 100%* Compliance with ISO9022-13-06, ISO9022-12-04 * The effects of condensation are to be effectively counteracted by periodically drying out the product
Protection against Water, Sand and Dust	IP67 Protection against blowing rain Waterproof to temporary submersion into water (maximum depth of 1m) Dust-tight, protection against blowing dust Compliance with IP67 according IEC60529 and MIL-STD-810F Method 506.4-I, MIL-STD-810F Method 510.4-I, MIL-STD-810F Method 512.4-I
Drops	Withstands 1.5m drop onto hard surfaces
Vibration	Withstands vibrations during operation on large civil construction machines Compliance with ISO9022-36-08

NMEA output

NMEA sentences	NMEA Data output format, internationally standardized format for data and position output, For real-time/RTK, DGPS, navigation positions, NMEA 0183 V2.20 and Leica proprietary

OWI interface

Leica proprietary Outside World Interface, enables full remote control of GPS receivers by PC, PDA

Protocol Versions	Binary or ASCII

Data links

Support of various Radio modems and GSM/TDMA cellular mobile phones for RTK, DGPS or remote control operation modes

No. of simultaneous data links	Up to two data links can be attached simultaneously using Leica GFU housing, plus two generic data links, to be used with different sensor interfaces. Or up to four generic data links can be attached simultaneously.
Radio modem	Any suitable radio modem with RS232 interface and operating in transparent mode
Recommended radio modems	Satelline 3AS integrated into Leica GFU housing Pacific Crest PDL receive-only integrated into Leica GFU housing
GSM phone modem	Any suitable model
Recommended GSM phone	Siemens MC45 mobile phone integrated into Leica GFU housing, 900, 1800, 1900 MHz.
Recommended TDMA phone	Sony-Ericson DM25 mobile phone integrated into Leica GFU housing
Landline phone modem	Any suitable model

Coordinate systems

	Management of ellipsoids, projections, geoid models, transformation parameters
Ellipsoids	All common ellipsoids User-definable ellipsoids
Map projections User definable and country specific	Mercator Transverse Mercator UTM Oblique Mercator Lambert (1 and 2 standard parallels) Soldner Cassini Polar Stereographic Double Stereographic RSO (rectified skewed orthomorphic projection) Other country-specific projections
Geoid model	Upload geoid model from LGO
Transformation in receiver	Classical 7 -parameter 3-D Helmert One step and two step (direct WGS84 to grid)

Onboard Software

User Interface	
Graphics:	Graphical representation of points, lines and areas Application result plots
Icons:	Icons indicating the current status of measure modes, settings, battery etc.
Status information:	Current position, satellite status, logging status, real-time status, battery and memory status
Function keys:	Direct function keys for quick and easy operation.
User menu:	User menu for quick access of the most important functions and settings
Configuration	
Configuration sets:	Ability to store and transfer all instrument and application configuration settings for different operators, survey tasks etc.
Displays masks:	User definable measuring display
User menu:	User definable menu for quick access to specific functions
Hot keys:	User configurable hot keys for quick access to specific functions
Coding	
Free Coding:	Recording codes with optional attributes in between of measurements Manual code entry or selection from a user defined codelist
Thematical Coding:	Coding points, lines and areas with optional attributes when measuring Manual code entry or selection from a user defined codelist
Quick Coding:	Recording a measurement with a point code or free code by entering a alphanumeric or a numeric quick codefrom user defined codelist
Data Management	
Jobs:	User definable jobs containing measurements, points, lines, areas and codes Directly transferable to LEICA Geo Office software
Points, lines, areas:	Creating, viewing, editing, and deleting points, lines and areas and codes
Functions:	Sorting and filtering of points, lines and areas Averaging of multiple points within user defined averaging limits
Data Import & Export	
Data import:	Character delimited ASCII files with point id, easting, northing, height and point code GSI8 and GSI16 files with point id, easting, northing, height and point code
Data export:	User defined ASCII files with measurements, points, lines, codes

Standard application programs	
Survey:	Measuring points, lines and areas with codes and offsets. ▪ Auto Points: High -speed surveying for mass data acquisition by automatically logging points at a given time interval, minimum distance difference or minimum height difference. ▪ Hidden Point: The coordinates of inaccessible points can be calculated by - measuring distances and/or azimuth to the inaccessible point using a hidden point measurement device such as the LEICA Disto or any other suitable laser range finder or by using a conventional tape - manually occupying auxiliary points - computing bearings from previously occupied points
Determine Coordinate System:	GPS coordinates are measured relative to the global geocentric datum known on WGS 1984. A transformation is required to convert the WGS 1984 coordinates to local coordinates. Three different transformation methods are available: ▪ Onestep ▪ Twostep ▪ Classic 3 D (Helmert transformation)
Stakeout:	3D Staking of points using various stakeout methods: ▪ Orthogonal: Displaying distances forwards / backwards, left / right from or to the station and cut / fill. ▪ Polar: Displaying direction, distance and cut / fill. ▪ Coordinate differences: Displaying coordinate differences and cut /fill.
COGO:	Computation of coordinates of points using various coordinate geometrical methods: ▪ Inverse: Compute bearing and distance between 2 points. ▪ Traverse: Compute coordinates of points using bearing and distance from origin point. ▪ Intersections: Compute coordinates of points using intersections created from other points. ▪ Line Calculations: Compute coordinates of points based on distance and offsets along lines ▪ Shift, Rotate and Scale: Compute coordinates of group of points based on a shift, rotate and scale from their existing coordinates. The shift, rotate and scale values can be manually entered or computed ▪ Area Division: Divide areas into smaller areas using a variety of methods.
Optional application programs	
Reference Line:	Defining lines and arcs, which can be stored and used for other tasks, using various methods: ▪ Measuring to a line / arc where the coordinates of a target point are calculated from its position relative to the defined reference line / arc. ▪ Staking to a line / arc where a target point is known and instructions to locate the point are given relative to the reference line / arc. ▪ Grid staking to a line / arc where a grid can be staked relative to a reference line / arc.
Reference Plane:	Stake-out or measure points relative to a reference plane ▪ Defining a plane by either measuring or selecting points. ▪ Calculate the perpendicular distance and height difference from a measure point to the plane.
DTM Stakeout:	▪ Staking out a Digital Terrain Model. ▪ Comparing actual and design height and displaying height differences.
Cross Section Survey:	Survey cross sections (such as highway profiles, river profiles, beach profiles) using code templates. The appropriate code for the next point on the profile is always correctly suggested. ▪ Also shows distance from last cross section ▪ Free, point, line or area codes can be used

RoadRunner:	Stake-out and as-built check of roads and any type of alignment related design (e.g. rail, pipeline, cable, earthworks) ▪ Handles any combination of geometric elements in the horizontal alignment, from simple straights to different types of partial spirals. ▪ Vertical alignment supports straights, arcs and parabolas. ▪ Covers all working tasks including stake-out/check of lines, grades/slopes (e.g. road surface, cut & fill), DTMs and many more. ▪ Visualization of cross-sections and planar view of design. ▪ Graphical selection of tasks to stake-out/check. ▪ Smart project management of design data. ▪ Support of multiple road layers (construction phases). ▪ Enhanced station equation capabilities. ▪ Comprehensive, user definable log files and cut sheets. ▪ Seamless data flow from all major design packages via PC conversion tool.
RoadRunner Lite:	▪ Same as RoadRunner, but with some functionalities remmoved

LEICA Geo Office Software

Description

Easy, fast and comprehensive, automated suite of programs for TPS, GPS and Level data. View and manage TPS, GPS and Level data in an integrated way. Process independently or combine data – including post processing and support of real-time GPS measurements.
Manages all data in an integrated manner. Project management, data transfer, import/export, processing, viewing data, editing data, adjustment, coordinate systems, transformations, codelists, reporting etc.
Consistent operating concepts for handling GPS, TPS and level data, based on Windows standards. An embedded help system includes tutorials with additional information.
Runs on Windows™ 98, 2000 and XP platforms.

User Interface

Intuitive graphical interface with standard Windows™ operating procedures. Customizable built-in configuration options allow users to set up the software exactly to suit their specific needs and preferences.

Standard components

Data and Project Management:	Fast, powerful database manages automatically all points and measurements within projects according to well-defined rules to ensure data integrity is always maintained. Projects, coordinate systems, antennas, report templates and codelists all have their own management. Numerous transformations, ellipsoids and projections, as well as user-defined geoid models and country specific coordinate systems which are based on a grid of correction values are supported. Six different transformation types are supported, giving the flexibility to select the approach which suits the project needs best. Antenna management system for offsets and correction values. Codelist management for code groups / code / attributes.
Import & Export:	Import data from compact-flash cards, directly from receivers, total stations and digital levels, or from reference stations and other sources via the Internet. Import of real-time (RTK), DGPS coordinates.
ASCII Import & Export	Import coordinate lists as user-defined ASCII files using the import wizard. Export results in any format to any software using the ASCII export function. Transfer point, line, area, coordinate, code and attribute data to GIS, CAD and mapping systems.
View & Edit:	The various graphical displays form the basis for visualizing data and giving an instant overview of the data contained within a project. Point, line and area information may be viewed in View/Edit together with coding and attribute information. Editing functionality is embedded allowing to query and clean up the data before processing or exporting it further.
Codelist Manager:	Generation of codelists with code groups, codes, and attributes. Management of codelists.

Reporting:	HTML-based reporting provides the basis for generating modern, professional reports. Measurement logs in field book format, reports on averaged coordinates, various processing log files and other information can be prepared and output. Configure reports to contain the information that are required and define templates to determine the presentation style.
Tools:	Powerful Tools like Codelist Manager, Data Exchange Manager, Format Manager and Software Upload are common tools for GPS receivers, total stations and also for digital levels.

GPS Options

L1 data processing:	Graphical interface for baseline selection, processing commands etc. Automatic or manual selection of baselines and definition of processing sequence. Single baseline or multi-baseline batch processing. Wide range of processing parameters. Automatic screening, cycle-slip fixing, outlier detection etc. Automated processing or user-controlled processing.
L1 / L2 data processing:	Graphical interface for baseline selection, processing commands etc. Automatic or manual selection of baselines and definition of processing sequence. Single baseline or multi-baseline batch processing. Wide range of processing parameters. Automatic screening, cycle-slip fixing, outlier detection etc. Automated processing or user-controlled processing.
RINEX Import:	Import of data in RINEX format.

Level Options

Level data processing:	View the data collected from the Leica digital level in the Geo Office level booking sheet. Select the preferred processing settings and process the level lines. Processing runs quickly and automatically. Use Results Manager to inspect and analyze the leveling results and generate a report. Finally, store the results and/or export them as required.
Design & Adjustment 1D:	Powerful MOVE3 Kernel with rigorous algorithms for 1D adjustment. Furthermore, network design and analysis is supported.

General Options

Datum & Map	LEICA Geo Office supports numerous transformations, ellipsoids and projections, as well as user-defined geoid models and country specific coordinate systems, which are based on a grid of correction values. The optional Datum/Map component supports the determination of transformation parameters. Six different transformation types are supported, giving the flexibility to select the approach which suits the project needs best.
Design & Adjustment 3D:	Combine all measurements in a least-squares network adjustment to obtain the best possible set of consistent coordinates and check that the measurements fit with the known coordinates. Use adjustment to help identify blunders and outliers based upon the extensive statistical testing. Using the powerful MOVE3 Kernel, the algorithms are rigorous and the user can choose between whether a 3D, 2D or 1D adjustment is computed. Furthermore, the component supports network design – allowing to design and analyze a network before actually going into the field.
GIS / CAD Export:	Permits export to GIS/CAD systems such as AutoCAD (DXF / DWG), MicroStation

System requirements

Minimum PC configuration:	Pentium 150 MHz processor 32MB RAM 100MB free hard disk space Microsoft® Windows™ 98 Microsoft® Internet Explorer 4.0
Recommended PC configuration:	Pentium® 300 MHz processor or higher 256 MB RAM or more 300 MB or more free space on hard disk Microsoft® Windows™ 2000 or XP Microsoft® Internet Explorer 5.5 or higher

Leica System 1200 – working together

TPS, GPS and SmartStation.
Use TPS and GPS together or separately according to the work you do.
Use whichever is the most suitable for the job in hand.
Change easily from one to the other and use them in the same way.
Enjoy all the freedom, flexibility and power of System 1200.

When it has to be right.

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Leica Geosystems AG
Switzerland
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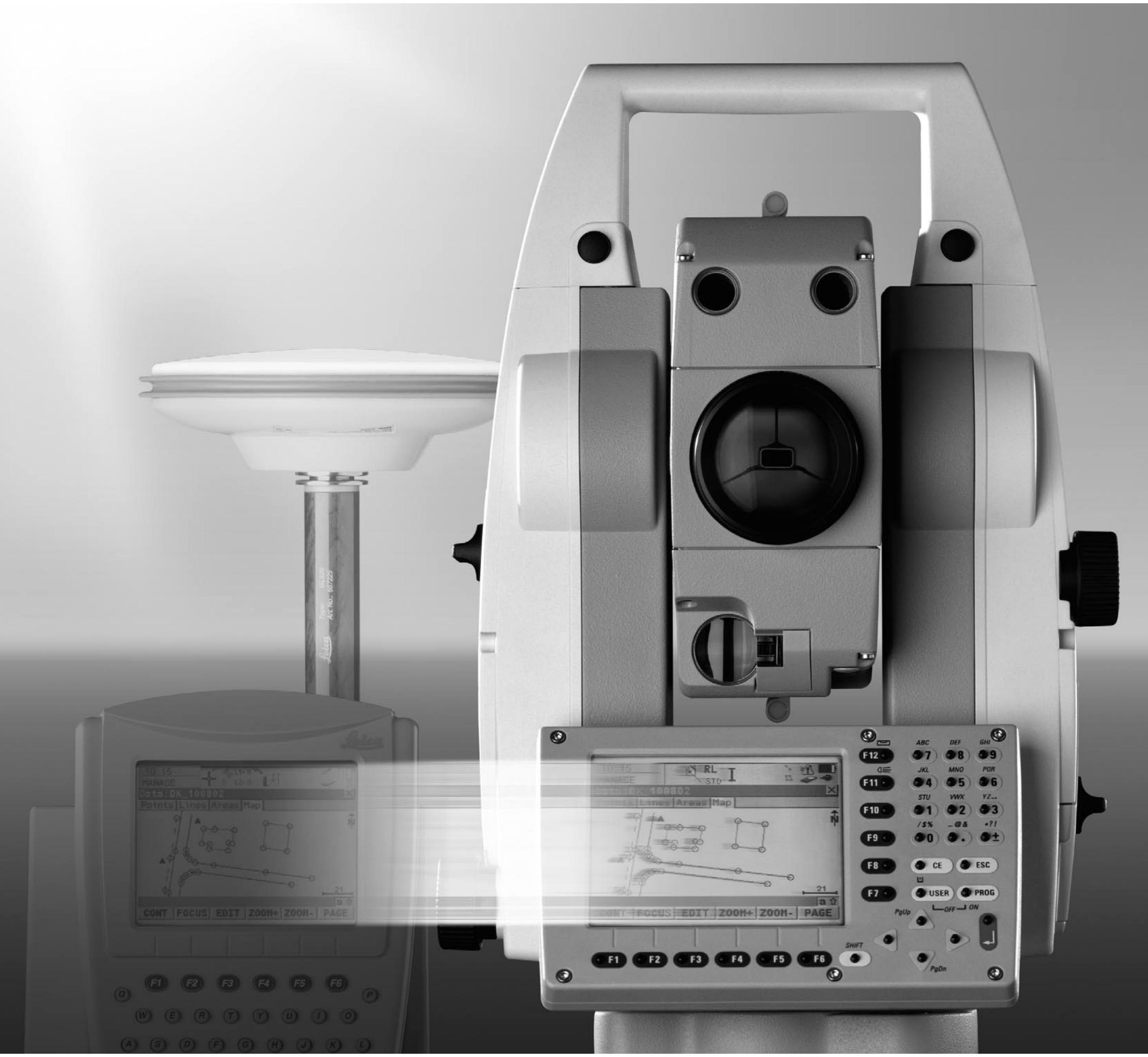
Leica Geosystems

Leica TPS1200 Series

Technical Data



- when it has to be **right**

Leica Geosystems

TPS1200 Technical Data

Models and Options

	TC	TCR	TCRM	TCA	TCP	TCRA	TCRP
Angle measurement	●	●	●	●	●	●	●
Distance measurement (IR)	●	●	●	●	●	●	●
PinPoint reflectorless distance measurement (RL)		●	●			●	●
Long range distance measurement (LO)		●	●			●	●
Motorized			●	●	●	●	●
Automatic Target Recognition (ATR)				●	●	●	●
PowerSearch (PS)					●		●
Guide Light (EGL)	○	○	○	●	●	●	●
Remote Control Unit (RX1220)	○	○	○	○	○	○	○
Laser Guide GUS74				○		○	
SmartStation (ATX1230)	○	○	○	○	○	○	○

● Standard ○ Optional

Angle measurement

Description

The highly accurate and reliable angle measurement system consists of a static line-coded glass circle, which is read by a linear CCD array. A special algorithm determines the exact position of the code lines on the array and determines the precise measurement instantly. As the code on the glass circle is absolute and continuous, no initialization of the instrument is required prior to measurements.

A dual axis compensator constantly monitors both axes of the vertical axis tilt. The compensator consists of an illuminated line pattern on a prism, which is reflected twice by a liquid mirror forming the reference horizon. The reflected image of the line pattern is read by a linear CCD array and then used to mathematically determine both tilt components. These components are then used to immediately correct all angle measurements.

	Type 1201	Type 1202	Type 1203	Type 1205
Accuracy (standard deviation ISO 17123-3)				
Hz, V:	1“ (0.3 mgon)	2“ (0.6 mgon)	3“ (1 mgon)	5“ (1.5 mgon)
Display least count:	0.1“ (0.1 mgon)	0.1“ (0.1 mgon)	0.1“ (0.5 mgon)	0.1“ (0.5 mgon)
Method	absolute, continuous, diametrical			
Compensator				
Working range:	4’ (0.07 gon)			
Setting accuracy:	0.5“ (0.2 mgon)	0.5“ (0.2 mgon)	1.0” (0.3 gon)	1.5” (0.5 mgon)
Method:	centralized dual axis compensator			

Distance measurement (IR)

Description

The IR EDM transmits an invisible laser beam to specular targets such as prisms or reflector tapes. The reflected light is detected by a sensitive photo receiver and converted into an electrical signal. After digitizing and accumulating the signal, the distance is determined by means of modern phase measurement techniques. A modulation frequency of 100 MHz is the time base for the high distance accuracy. The coaxiality and the divergence angle of the laser beam together with the automatic target recognition (ATR), allow dynamic tracking of targets quickly and accurately in 3 dimensions.

	A	B	C
Range			
Standard prism (GPR1):	1800 m (6000 ft)	3000 m (10000 ft)	3500 m (12000 ft)
3 standard prisms (GPR1):	2300 m (7500 ft)	4500 m (14700 ft)	5400 m (17700 ft)
360° prism (GRZ4):	800 m (2600 ft)	1500 m (5000 ft)	2000 m (7000 ft)
360° mini prism (GRZ101):	450 m (1500 ft)	800 m (2600 ft)	1000 m (3300 ft)
Mini prism (GMP101):	800 m (2600 ft)	1200 m (4000 ft)	2000 m (7000 ft)
Reflector tape (60 mm x 60mm):	150 m (500 ft)	250 m (800 ft)	250 m (800 ft)
Shortest measuring distance:	1.5 m		

Atmospheric conditions:
A: Strong haze, visibility 5 km; or strong sunlight, severe heat shimmer
B: Light haze, visibility about 20 km; or moderate sunlight, slight heat shimmer
C: Overcast, no haze, visibility about 40 km; no heat shimmer

Accuracy (standard deviation ISO 17123-4) / Measure time

Standard mode	2 mm + 2 ppm / typ. 1.5 s
Fast mode:	5 mm + 2 ppm / typ. 0.8 s
Tracking mode:	5 mm + 2 ppm / typ. < 0.15 s
Averaging mode:	2 mm + 2 ppm
Display resolution:	0.1 mm

Method

Principle:	Phase measurement
Type:	Coaxial, infrared laser
Carrier wave:	780 nm
Measuring system:	Special frequency system basis 100 MHz ≅ 1.5 m

PinPoint reflectorless distance measurement (RL)

Description

The reflectorless EDM PinPoint R100 transmits an accurately collimated visible red laser beam to the target. The distance is measured by an optimally deigned phase measurement technique that allows measuring to low reflective targets even at distances greater than 100 m. The coaxiality of the measurement beam and its extremely small “diffraction limited” spot size allow the highest degree of pointing and measurement accuracy.

The reflectorless EDM PinPoint R300 measures to targets up to 768 m. To measure to targets at such long distances with high measurement accuracy, a new measurement technology was developed. The main component of the EDM is a system analyzer, which uses modulation frequencies of the transmitted signal between 100 MHz and 300 MHz. The system analyzer properties are defined for each individual measurement for both the EDM beam and the target qualities. As a result of the system analysis, the parameters for every individual measurement are now known. The distance is calculated using modern signal processing based on the principle of maximum-likelihood. Besides the drastically increased sensitivity which leads to a sensational increase in reflectorless measurement range, the new EDM system provides many other advantages such as a very high measurement quality and reliability even when measuring in rain, fog, dust or snow. In addition the measurement system helps to prevent errors, by detecting if there are multiple targets within the measurement beam.

	D	E	F
Range PinPoint R100			
Kodak Gray Card, 90% reflective:	140 m (460 ft)	170 m (560 ft)	> 170 m (> 560 ft)
Kodak Gray Card, 18% reflective:	70 m (230 ft)	100 m (330 ft)	> 100 m (> 330 ft)
Range PinPoint R300			
Kodak Gray Card, 90% reflective:	300 m (990 ft)	500 m (1640 ft)	> 500 m (> 1640 ft)
Kodak Gray Card, 18% reflective:	200 m (660 ft)	300 m (990 ft)	> 300 m (> 990 ft)
Range of measurement:	1.5 m to 760 m		
Display unambiguous:	up to 760 m		

Atmospheric conditions:
- D: Object in strong sunlight, severe heat shimmer
- E: Object in shade, or sky overcast
- F: Underground, night and twilight

Accuracy (standard deviation ISO 17123-4) / Measure time

0 m - 500 m:	3 mm + 2 ppm / typ. 3-6 s, max. 12 s
> 500 m:	5 mm + 2 ppm / typ. 3-6 s, max. 12 s
Atmospheric conditions:	Object in shade, sky overcast
Display resolution:	0.1 mm

Laser dot size

At 20 m:	7 mm x 14 mm
At 100 m:	12 mm x 40 mm
At 200 m:	25 mm x 80 mm

Method

Type:	Coaxial, visible red laser
Carrier wave:	670 nm
Measuring system PinPoint R100:	Special frequency system basis 100 MHz ≅ 1.5 m
Measuring system PinPoint R300:	System analyzer basis 100 MHz - 150 MHz

Long Range distance measurement (LO)

Description

The highly collimated red laser beam of the PinPoint R100 can also be used to measure to prism targets at distances between 1000 m and 12000 m or reflector tape at extended ranges. The visibility of the laser beam simplifies the search of far distant reflectors, because the reflected light is even visible at distances more than 5000 m. The distance is measured by the same phase measurement technique as for the infrared beam.

The accurately collimated red laser beam of the PinPoint R300 is similar to that of the PinPoint R100, the ambiguity range is also 12000 m. The main module of the long range EDM is again a system analyzer (similar to the system analyzer used for reflectorless measurements) but with a reduced frequency set between 100 MHz and 150 MHz. The distance is calculated by an estimation method using modern signal processing incorporating the advantages such as high measurement quality and reliability when measuring in rain or snow positive and the detection of multiple targets within the measurement beam.

	A	B	C
Range			
Standard prism (GPR1):	2200 m (7300 ft)	7500 m (24600 ft)	> 10000 m (> 32800 ft)
Reflector tape (60 mm x 60mm):	600 m (2000 ft)	1000 m (3300 ft)	> 1300 m (> 4300 ft)
Range of measurement to prism:	1000 m to 12000 m		
Display unambiguous:	up to 12000 m		

Atmospheric conditions:
- A: Strong haze, visibility 5 km; or strong sunlight, severe heat shimmer
- B: Light haze, visibility about 20 km; or moderate sunlight, slight heat shimmer
- C: Overcast, no haze, visibility about 40 km; no heat shimmer

Accuracy (standard deviation ISO 17123-4) / Measure time

Entire measurement range: :	5 mm + 2 ppm / typ. 2.5 s, max. 12 s
Display resolution:	0.1 mm

Method

Principle:	Phase measurement
Type:	Coaxial, visible red laser
Carrier wave:	670 nm

Motorized

Maximum speed

Rotating speed:	45° / s

Automatic Target Recognition (ATR)

Description

The ATR sensor transmits an invisible laser beam, which is reflected by any standard prism (no active prisms emitting special signals are required) and is received by an internal high-resolution CCD camera. The intensity and the “spot” characteristics of the reflected light are calculated in respect to the CCD camera center. The offset components from this reference are computed in both the vertical and horizontal planes. These offsets are then used to control the motors of the telescope axes, which react immediately to position the instrument’s crosshairs onto the prism. To minimize measurement time the crosshairs are only positioned within a 5 mgon tolerance (EDM mode IR-Fine) of the actual prism center. The remaining offsets are then mathematically applied to the Hz and V angles.

	ATR mode	LOCK mode
Range		
Standard prism (GPR1):	1000 m (3300 ft)	800 m (2600 ft)
360° prism (GRZ4):	600 m (2000 ft)	500 m (1600 ft)
360° mini prism (GRZ101):	350 m (1150 ft)	300 m (1000 ft)
Mini prism (GMP101):	500 m (1600 ft)	400 m (1300 ft)
Reflector tape (60 mm x 60mm):	55 m (175ft)	-
Shortest measuring distance:	1.5 m	5 m

Accuracy / Measure time

Positioning accuracy (GPR1):	< 2 mm
Measure time (GPR1):	3-4 s

Maximum speed (LOCK mode)

Tangential (standard mode):	5 m / s at 20 m, 25 m / s at 100 m
Radial (tracking mode):	5 m / s

Searching

Search time in field of view:	Typ. 3 s
Field of view:	1° 30’ (1.66 gon)
Definable search windows:	Yes

Method

Principle:	Digital image processing
Type:	infrared laser

PowerSearch (PS)

Description

This fast and reliable prism search uses a sender / receiver couple to detect prisms by means of digital signal processing algorithms. An invisible, vertical laser fan sized 40 gon in height and 0.025 gon in width is sent out while the instrument rotates around its standing axis. Once this fan comes across a prism, the reflected signal is evaluated on the fly to verify the target. If the specified signal patterns are matched, the horizontal position of the prism is determined and the rotation is stopped. Now an ATR search limited to the vertical line of the fan is launched, which precisely positions to the prism center. With this technique any standard prism (no active prisms emitting special signals are required) can be used.

Range

Standard prism (GPR1):	200 m (650 ft)
360° prism (GRZ4):	200 m (650 ft) (perfectly aligned to the instrument)
Mini prism (GMP101):	100 m (330 ft)
Shortest measuring distance:	1.5 m

Searching

Search time:	Typ. < 10 s
Default search area:	Hz: 400 gon V: 40 gon
Definable search windows:	Yes

Method

Principle:	Digital signal processing
Type:	infrared laser

Guide Light (EGL)

Range

Working range:	5 m - 150 m

Accuracy

Positioning accuracy:	5 cm at 100 m

General data

Telescope

Magnification:	30 x
Free objective aperture:	40 mm
Field of view:	1°30’ (1.66 gon) / 2.7 m at 100 m
Focusing range:	1.7 m to infinity

Keyboard and Display

Display:	¼ VGA (320*240 pixels), graphic LCD, illumination, touch screen (optional)
Keyboard:	34 keys (12 function keys, 12 alphanumeric keys), illumination
Angle display:	360° ' “, 360° decimal, 400 gon, 6400 mil, V%
Distance display:	meter, int. ft, int. ft/inch, US ft, US ft/inch
Position:	face I standard / face II optional

Data storage

Internal memory:	32 MB (optional)
Memory card:	CompactFlash cards (32 MB and 256 MB)
Number of data records:	1750 / MB
Interface:	RS232, Bluetooth™ (optional)

Laser plummet

Centering accuracy:	1.5 mm at 1.5 m (deviation from plumb line)
Laser dot diameter:	2.5 mm at 1.5 m

Endless drives

Number of drives:	1 horizontal / 1 vertical

Circular level

Sensitivity:	6' / 2 mm

Internal Battery (GEB221)

Type:	Lithium-Ion
Voltage:	7.4 V
Capacity:	3.8 Ah
Operating time:	Typ. 6 - 8 h

Dimensions

Tilting axis height:	196 mm above tribrach
Height:	345 mm
Width:	226 mm
Length:	203 mm

Weights

Total station:	4.8 - 5.5 kg (depending on type and options)
Battery (GEB221):	0.2 kg
Tribrach (GDF121):	0.8 kg

Environmental specifications

Working temperature range:	-20°C to +50°C
Storage temperature range:	-40°C to +70°C
Dust / water (IEC 60529):	IP54
Humidity:	95%, non-condensing

Onboard Software

User Interface

Graphics:	Graphical representation of points, lines and areas Application result plots
Icons:	Icons indicating the current status of measure modes, settings, battery etc.
Quick settings menu:	Quick settings menu for toggling reflectorless EDM, ATR, LOCK, EDM Tracking etc. on and off
Function keys:	Direct function keys for quick and easy operation.
User menu:	User menu for quick access of the most important functions and settings

Configuration

Configuration sets:	Ability to store and transfer all instrument and application configuration settings for different operators, survey tasks etc.
Displays masks:	User definable measurement display
User menu:	User definable menu for quick access to specific functions
Hot keys:	User configurable hot keys for quick access to specific functions

Coding

Free Coding:	Recording codes with optional attributes in between of measurements Manual code entry or selection from a user defined codelist
Thematical Coding:	Coding points, lines and areas with optional attributes when measuring Manual code entry or selection from a user defined codelist
Quick Coding:	Recording a measurement with a point, line, area or free code by entering an alphanumerical or a numerical quick code from a user defined codelist. Line and area quick codes automatically create line and area objects.

Data Management

Jobs:	User definable jobs containing measurements, points, lines, areas and codes Directly transferable to LEICA Geo Office software
Points, lines, areas:	Creating, viewing, editing, and deleting points, lines and areas and codes
Functions:	Sorting and filtering of points, lines and areas Averaging of multiple points within user defined averaging limits

Data Import & Export

Data import:	Character delimited ASCII files with point id, easting, northing, height and point code GSI8 and GSI16 files with point id, easting, northing, height and point code
Data export:	User defined ASCII files with measurements, points, lines, codes

Standard application programs

Survey:

Measuring points, lines and areas with codes and offsets.

- Auto Points:
  Tracking 3D movements of the target by automatically logging points at a given time interval, minimum distance difference or minimum height difference.
- Remote Points:
  Determining the 3D coordinates of inaccessible points by measuring the distance to a base point directly underneath or above the target and then measuring the angles to the inaccessible point.

Setup:

Setting up and orienting the instrument using various set-up methods. For all setup methods that require a known setup point the coordinates can be measured by GPS whenever a SmartAntenna is connected.

- Set Azimuth:
  Setting up the instrument on a known point and orienting to a backsight with known or unknown coordinates. Once the coordinates of the backsight are known all measurements are automatically updated.
- Known Backsight Point:
  Setting up the instrument on a known point and orienting to a known backsight point.
- Orientation and Height Transfer:
  Setting up the instrument on a known point and setting the orientation by measuring angles or angles and distances to known targets points.
- Resection:
  Setting up the instrument on an unknown point and set the orientation and calculate the station coordinates by measuring angles or angles and distances to up to 10 known targets points.

Stakeout:

3D Staking of points using various stakeout methods:

- Orthogonal:
  Displaying distances forwards / backwards, left / right from or to the station and cut / fill.
- Polar:
  Displaying direction, distance and cut / fill.
- Coordinate differences:
  Displaying coordinate differences and cut /fill.

COGO:

Performing various coordinate geometry calculations:

- Inverse: Calculating the direction, the distance and the coordinate differences between two known points.
- Traverse: Calculating position coordinates given either azimuth and distance or angle and distance from a known point.
- Intersection: Calculating intersections given any combination of bearings and distances between two known points or two lines between four known points.
- Line Calculations
- Arc Calculations

Determine Coordinate System:

GPS coordinates are measured relative to the global geocentric datum known on WGS 1984. A transformation is required to convert the WGS 1984 coordinates to local coordinates. Three different transformation methods are available:

- Onestep
- Twostep
- Classic 3D (Helmert transformation)

GPS Survey

Measuring points with GPS if a SmartAntenna is connected, optional entry of codes.

Optional application programs

Reference Line:	Defining lines and arcs, which can be stored and used for other tasks, using various methods: ▪ Measuring to a line / arc where the coordinates of a target point are calculated from its position relative to the defined reference line / arc. ▪ Staking to a line / arc where a target point is known and instructions to locate the point are given relative to the reference line / arc. ▪ Gridstaking to a line / arc where a grid can be staked relative to a reference line / arc.
DTM Stakeout:	▪ Staking out a Digital Terrain Model. ▪ Comparing actual and design height and displaying height differences.
RoadRunner:	Stake-out and as-built check of roads and any type of alignment related design (e.g. rail, pipeline, cable, earthworks) ▪ Handles any combination of geometric elements in the horizontal alignment, from simple straights to different types of partial spirals. ▪ Vertical alignment supports straights, arcs and parabolas. ▪ Covers all working tasks including stake-out/check of lines, grades/slopes (e.g. road surface, cut & fill), DTMs and many more. ▪ Visualization of cross-sections and planar view of design. ▪ Graphical selection of tasks to stake-out/check. ▪ Smart project management of design data. ▪ Support of multiple road layers (construction phases). ▪ Enhanced station equation capabilities. ▪ Comprehensive, user definable log files and cut sheets. ▪ Seamless data flow from all major design packages via PC conversion tool.
Sets of Angles:	Measuring directions and distances to targets in one or two faces in various measurement routines. ▪ Calculating the average directions and distances of all sets. ▪ Calculating the standard deviations for single directions / distance and average directions / distances. Monitoring option to repeat measurements at given time intervals.
Traverse:	Measuring a traverse with unlimited number of legs: ▪ Measuring sets to angles to backsight and multiple foresights. ▪ Measuring topographic points from any station. ▪ Using known points during traverse to validate quality of traverse. ▪ Calculating traverse closure results for field checking.
Reference Plane	Stake-out or measure points relative to a reference plane: ▪ Defining a plane by either measuring or selecting points. ▪ Calculate the perpendicular distance and height difference from a measured point to the plane. ▪ Scanning of points on a defined plane.

Remote Control Unit (RX1220)

Description

The RX1220 uses the latest in spread spectrum 2.4 GHz radio technology to permitting total remote control of the TPS1200 total station while at the prism pole. This market proven remote controlling philosophy has created an easy to learn and simple to use communication concept which mirrors the user interface of the TPS1200 on the RX1220 while at the same time adding the flexibility of a full QWERTY alpha keypad.
This concept ensures that no valuable measurement data is relayed over the radio link totally eliminating the risk of data loss. The encrypted protocol and frequency band hopping technology used in the data transmission greatly reduce the cases of interference from any other 2.4 GHz transmitters. In addition, a number of user selectable 'link numbers' can be configured easily in cases where more than one RX1220 is being used in the same area.
The RX1220 also enables the transmission of measurement data to a remote location for processing in real time. Such features result in a system, which offers total remote data flexibility.
Further more, the RX1220 is completely interchangeable with both the TPS1200 and the GPS1200 giving the user an efficient and economic solution to all sensor control needs.

Communication:

Communication:	via integrated radio modem

Control unit

Display:	¼ VGA (320*240 pixels), graphic LCD, touch screen, illumination
Keyboard:	62 keys (12 function keys, 40 alphanumeric keys), illumination
Interface:	RS232

Internal Battery (GEB211)

Type:	Lithium-Ion
Voltage:	7.4 V
Capacity:	1.9 Ah
Operating time:	Typ. 10 h

Weights

RX1220:	0.6 kg
Battery (GEB211):	0.1 kg
Reflector pole adapter:	0.25 kg

Environmental specifications

Working temperature range:	-30°C to +65°C
Storage temperature range:	-40°C to +80°C
Dust / water (IEC 60529):	IP67
Waterproof (MIL-STD-810F):	temporary submersion to 1m

SmartStation (ATX1230)

Description

SmartStation is a TPS1200 with ATX1230 12 L1+12 L2 SmartAntenna. All GPS and TPS operations are controlled from the TPS keyboard, all data are in the same database, all information is shown on the TPS screen. RTK GPS fixes the position to centimeter accuracy, then the setup routine is completed using the total station. SmartAntenna can also be used independently on a pole with a GTX1230 and RX1210 controller.

Important Note

Measurement precision and accuracy in position and accuracy in height are dependent upon various factors including number of satellites, geometry, observation time, ephemeris accuracy, ionospheric conditions, multipath etc. Figures quoted assume normal to favourable conditions. Times can also not be quoted exactly. Times required are dependent upon various factors including number of satellites, geometry, ionospheric conditions, multipath etc.The following accuracies, given as root mean square, are based on real-time measurements.

Accuracy

Position accuracy:	Horizontal: 10mm + 1ppm Vertical: 20mm + 1ppm When used within reference station networks the position accuracy is in accordance with the accuracy specifications provided by the reference station network.

Initialisation :

Method:	Real time (RTK)
Reliability of initialisation:	Better than 99.99%
Time for initialisation:	Typically 8 sec, with 5 or more satellites on L1 and L2
Range:	Up to 50 km, assuming reliable data-link is available

RTK Data Formats

RTK Data Formats for data reception:	Leica proprietary format, CMR, CMR+, RTCM V2.1/2.2/2.3/3.0

ATX1230 SmartAntenna

Receiver technology	SmartTrack - patented. Discrete elliptical filters. Fast acquisition. Strong signal. Low noise. Excellent tracking, even to low satellites and in adverse conditions. Interference resistant. Multipath mitigation.
No. of channels	12 L1 + 12 L2
Groundplane	Built-in groundplane
Dimensions (diameter x height)	186mm x 89mm
Weight	1.12kg

LEICA Geo Office Software

Description

Easy, fast and comprehensive, automated suite of programs for TPS, GPS and Level data. View and manage TPS, GPS and Level data in an integrated way. Process independently or combine data – including post processing and support of real-time GPS measurements.
Manages all data in an integrated manner. Project management, data transfer, import/export, processing, viewing data, editing data, adjustment, coordinate systems, transformations, codelists, reporting etc.
Consistent operating concepts for handling GPS, TPS and level data, based on Windows standards. An embedded help system includes tutorials with additional information.
Runs on Windows™ 98, 2000 and XP platforms.

User Interface

Intuitive graphical interface with standard Windows™ operating procedures. Customizable built-in configuration options allow users to set up the software exactly to suit their specific needs and preferences.

Standard components

Data and Project Management:	Fast, powerful database manages automatically all points and measurements within projects according to well-defined rules to ensure data integrity is always maintained. Projects, coordinate systems, antennas, report templates and codelists all have their own management. Numerous transformations, ellipsoids and projections, as well as user-defined geoid models and country specific coordinate systems which are based on a grid of correction values are supported. Six different transformation types are supported, giving the flexibility to select the approach which suits the project needs best. Antenna management system for offsets and correction values. Codelist management for code groups / code / attributes.
Import & Export:	Import data from compact-flash cards, directly from receivers, total stations and digital levels, or from reference stations and other sources via the Internet. Import of real-time (RTK), DGPS coordinates.
ASCII Import & Export	Import coordinate lists as user-defined ASCII files using the import wizard. Export results in any format to any software using the ASCII export function. Transfer point, line, area, coordinate, code and attribute data to GIS, CAD and mapping systems.
View & Edit:	The various graphical displays form the basis for visualizing data and giving an instant overview of the data contained within a project. Point, line and area information may be viewed in View/Edit together with coding and attribute information. Editing functionality is embedded allowing to query and clean up the data before processing or exporting it further.
Codelist Manager:	Generation of codelists with code groups, codes, and attributes. Management of codelists.
Reporting:	HTML-based reporting provides the basis for generating modern, professional reports. Measurement logs in field book format, reports on averaged coordinates, various processing log files and other information can be prepared and output. Configure reports to contain the information that are required and define templates to determine the presentation style.
Tools:	Powerful Tools like Codelist Manager, Data Exchange Manager, Format Manager and Software Upload are common tools for GPS receivers, total stations and also for digital levels.

GPS Options

L1 data processing:	Graphical interface for baseline selection, processing commands etc. Automatic or manual selection of baselines and definition of processing sequence. Single baseline or multi-baseline batch processing. Wide range of processing parameters. Automatic screening, cycle-slip fixing, outlier detection etc. Automated processing or user-controlled processing.

L1 / L2 data processing:	Graphical interface for baseline selection, processing commands etc. Automatic or manual selection of baselines and definition of processing sequence. Single baseline or multi-baseline batch processing. Wide range of processing parameters. Automatic screening, cycle-slip fixing, outlier detection etc. Automated processing or user-controlled processing.
RINEX Import:	Import of data in RINEX format.

Level Options

Level data processing:	View the data collected from the Leica digital level in the Geo Office level booking sheet. Select the preferred processing settings and process the level lines. Processing runs quickly and automatically. Use Results Manager to inspect and analyze the leveling results and generate a report. Finally, store the results and/or export them as required.
Design & Adjustment 1D:	Powerful MOVE3 Kernel with rigorous algorithms for 1D adjustment. Furthermore, network design and analysis is supported.

General Options

Datum & Map	LEICA Geo Office supports numerous transformations, ellipsoids and projections, as well as user-defined geoid models and country specific coordinate systems, which are based on a grid of correction values. The optional Datum/Map component supports the determination of transformation parameters. Six different transformation types are supported, giving the flexibility to select the approach which suits the project needs best.
Design & Adjustment 3D:	Combine all measurements in a least-squares network adjustment to obtain the best possible set of consistent coordinates and check that the measurements fit with the known coordinates. Use adjustment to help identify blunders and outliers based upon the extensive statistical testing. Using the powerful MOVE3 Kernel, the algorithms are rigorous and the user can choose between whether a 3D, 2D or 1D adjustment is computed. Furthermore, the component supports network design – allowing to design and analyze a network before actually going into the field.
GIS / CAD Export:	Permits export to GIS/CAD systems such as AutoCAD (DXF / DWG), MicroStation

System requirements

Minimum PC configuration:	Pentium 150 MHz processor 32MB RAM 100MB free hard disk space Microsoft® Windows™ 98 Microsoft® Internet Explorer 4.0
Recommended PC configuration:	Pentium® 300 MHz processor or higher 256 MB RAM or more 300 MB or more free space on hard disk Microsoft® Windows™ 2000 or XP Microsoft® Internet Explorer 5.5 or higher

Leica System 1200 – working together

TPS, GPS and SmartStation.
Use TPS and GPS together or separately according to the work you do.
Use whichever is the most suitable for the job in hand.
Change easily from one to the other and use them in the same way.
Enjoy all the freedom, flexibility and power of System 1200.

When it has to be right.

738601en – I.05 – RVA

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

Guide Light (EGL):
LED 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 (PinPoint R100 / R300):
Laser class 3R in accordance with IEC 60825-1 resp. EN 60825-1

Leica Geosystems AG
Switzerland

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- when it has to be **right**

Leica Geosystems