REPORTER 41

The Magazine of Leica Geosystems

Leica
MADE TO MEASURE

A gripping start!

The new year of 1999 burst forth with a fanfare. The launching of the EURO has unleashed a wave of expectation and euphoria, but has also generated an undercurrent of unease. The world looks at the last year of the stormy twentieth century with a certain suspicion and wonders what the next millennium will bring.

For Leica Geosystems, the years 1998/1999 will certainly not go into history as the prelude to a finale. On the contrary, they herald a new awakening. Over the last weeks and months, many of you have come to know our new ranges of total stations, the TPS1100 and the TPS300 series. We expected them to be successful, but the sheer volume of orders has taken us by surprise, to the extent that some of our customers have had to practise patience. These attractive new survey instruments exhibit impressive features; their new technologies are fascinating (particularly the facility of reflectorless measuring); and the favourable price / performance ratio has convinced customers everywhere.

The new GPS500 series has also met with great acclaim. Its great plus points are the compact design, the state-of-the-art technology, the ease in use and the outstanding performance. Just a few weeks after the market launch, the demand was already enormous. This speaks volumes for the success of the venture.

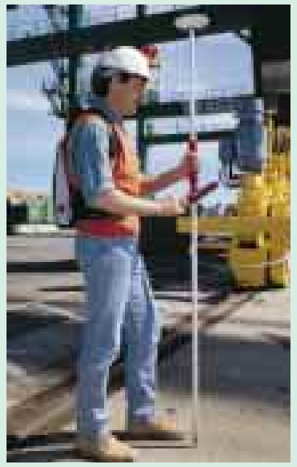
The best thing is for you to judge for yourself. Our personnel will certainly be contacting you soon and they are already looking forward to every one of your telephoned enquiries. They will be glad to demonstrate to you the economic benefits that you can expect if you work on a regular basis with these new survey instruments from Leica Geosystems. Put us to the test, and compare us with others – we have nothing to fear !

Once again in this issue of the Reporter you will find accounts of the interesting projects which are occupying our customers in the most varied fields of activity and in very different countries. I never cease to derive pleasure from the fact that Leica Geosystems is playing an active role in highly-impressive projects, and for this am very grateful to you, our customer. We are proud to be helping you to meet the challenges posed in the last year of the present millennium – and we are already prepared and well equipped to cope with what the next millennium has to throw at us. What is more, we will press on with our unremitting efforts to become better and better.

Sincerely

Hans Hess
President & CEO
Leica Geosystems

In this issue



Please tell us what you like about the REPORTER, and if you feel there is anything missing. You could win one of three Leica cameras!

READER POLL

Dear Reader

The REPORTER is celebrating 30 years of publication: an appropriate opportunity for a brief retrospective. Since the first issue appeared in 1969, the work of surveying professionals has grown broader and more demanding. Over the years, the technologies and equipment for meeting these challenges – in particular GPS, DPS and GIS – have led to fundamental changes to working practice.

The central section of this issue is devoted to a concise review of three decades of the REPORTER. Right after that, we focus on another jubilee: it is exactly 150 years since the highest mountain on earth was first surveyed. To mark the event, we are publishing a report by the expert who led two of this decade's major Himalayan research expeditions and the team responsible for re-surveying the world's highest mountains, using Leica equipment.

In this issue we are also appealing to you, our readers. There is a short questionnaire at the magazine centre-fold. We would like to hear your opinions about the REPORTER customer magazine: what you like and find interesting, and also what you feel could be improved, given more coverage, or added to the editorial mix. It's easy to respond by fax (+41 71 727 4689), via Internet (www.leica-geosystems.com) or by mail.

I look forward to your comments and suggestions.

Waltraud Strobl
Brand & Image Planning Manager

IMPRINT

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Assembly Alignment of NASA´s X-38 CRV Crew Return Vehicle

The Leica LT500 Laser Tracker is a space-age industrial measurement system being used for inspection, analysis and component alignment in a variety of NASA projects. NASA purchased the Laser Tracker primarily for the X-38 flying body spacecraft, a project destined to set milestones in cost-effective manufacturing and assembly, high precision and on-schedule delivery.

NASA engineers at the Johnson Space Center in Houston, Texas are currently designing and flight-testing the prototype X-38, a vehicle which could become the first new spacecraft to travel from orbit in the past two decades. Developed at a fraction of the cost of former space vehicles, the X-38's most immediate application is a vital one: It will serve as a model for the emergency crew return vehicle (CRV), or lifeboat, for the International Space Station (ISS). The lifeboat is designed to hold seven astronauts, and with the touch of a button will bring the crew home within two hours of initiating the return-to-Earth sequence. The X-38 may also serve as the model for the Crew Transport Vehicle (CTV), a space van meant to carry astronauts only, not cargo.

Part of the prototype X-38, a spacecraft model for the emergency crew return vehicle (CRV), the lifeboat for the International Space Station.

The mandate for the X-38 is to develop an economic spaceship. Because it will be a re-entry vehicle, the spacecraft requires precision assembly of thousands of tiles and parts. In the past, NASA engineers used typical manufacturing alignment techniques, such as levels, plump bobs and micrometers. It was labor intensive. Then NASA acquired a Leica LT500 Laser Tracker in January 1997.

Reduction of man hours by 70% compared to conventional means

"The first thing we noticed was the time savings", said Frank Jenson, an engineering technician with NASA's Manufacturing, Material and Process Technology Division. "Man-hours spent for the inspection and analysis of large manufactured parts were reduced dramatically. I would estimate we save 70 percent of our time over conventional verification techniques. A typical ring frame, which used to require about two weeks for an inspection, now takes two-and-a-half to three days".

Inspection of parts and comparison against CAD

Steve Peterschmidt, Mechanical Engineer for Rothe Joint Venture on the X-38 project, is responsible for analyzing the 3D coordinate data collected by the LT500 and comparing it against their original CAD models. "We have to measure a bilateral profile tolerance of 0.010 inches (0.25 mm) over compound curvatures on parts up to 120-inches (3 m) long. In standard dimensional inspection, we do not get the resolution we need; nor do we have the time to use a normal coordinate measuring machine. With the Laser Tracker, we have the inspection completed within a few hours", he said.

The X-38 engineers use the LT500 to measure the components manufactured within the enterprise and by outside suppliers. The X-38 project has the distinction of being the first in-house-manufactured project at NASA, rather than a contracted project. The Laser Tracker is also used to align thousands of parts on the large vehicles.

"There is a tolerance stack-up as you assemble the parts", Peterschmidt said. "If you assemble thirty parts together, you might multiply your deviations by thirty. The Laser Tracker allows us to place each part within the vehicle coordinate system, so it is attached to the assembly according to a single reference datum. We are trying to stay within an overall tolerance of 0.050 inches (1.2 mm), and so far, the accuracy is around 0.020 inches (0.5 mm). I believe we can stay within 0.020 inches to 0.030 inches (0.5-0.8 mm) for the entire project". The LT500 has an accuracy of 0.001 inches (0.025 mm).

The tightest tolerances NASA has ever maintained

These are the tightest tolerances NASA has ever maintained for a spacecraft. Considering the X-38 is NASA's first in-house design through manufacturing project, this is quite an impressive feat.

Another advantage of the Leica Laser Tracker is its portability. The LT500 sensor head weighs approximately 69 pounds, and can be easily moved around the part to be measured. The whole process takes about ten to fifteen minutes for repositioning and a few seconds for data collection. "We move it all over the building", said Brian Anderson, the X-38 Design and Production Manager, "and this is a large facility. We don't have to bring the parts to the laser tracker, we move the laser tracker to the parts".

Portability facilitates short term jobs at different places

The Laser Tracker has such a reputation around the Johnson Space Center that engineers on many other projects want to utilize it. The X-38 team has been happy to oblige their fellow engineers. Nearby is Johnson Space Center's main machining facility, with just about every type of manufacturing tool available. There has been no difficulty transporting the LT500 to this building and because the machine is simple to use and quickly does its job, there has been no loss of time on the X-38 project.

Jenson even packs the LT500 in its original shipping box, loads it on a government pick-up truck, and drives five miles to the Ellington Airfield. The Laser Tracker is then used to measure engine intake port on the astronauts' T-38 trainer aircraft. Jenson can make the drive, take six detailed measurements with more than 6,000 data points each, and be back in time for lunch. Four other projects at Ellington have utilized the laser tracker in the first five months of 1998.

Lasers are notorious for calibration problems if repetitively moved. It is a common belief that the more precise the laser device becomes, the less it can be moved about. However, the LT500 is the sturdiest laser tracker in existence, built to be very portable. Jenson never needs more than fifteen minutes to check the laser tracker's calibration after the appropriate warm-up. In eighteen months of heavy daily use, the Leica Laser Tracker has never been out of calibration, staying within the parameters of 0.0015 degrees of accuracy.

Stability of the calibration: a precondition for maximum efficiency

"That's the whole idea of using a measurement device like this", Jenson said. "It has to be portable. We will even ship it to Dryden in California where they do the atmospheric testing on the X-38. We have to be able to put it through government shipping and still economize our time at each of the facilities".

The target date for the X-38 project is to have a working CRV attached to the International Space Station in 2003. Until then, the space station will use a Soyuz spacecraft similar to Mir's emergency return vehicle. However, the Soyuz is cramped, and expensive. The X-38 will comfortably accommodate seven astronauts who may be injured or incapacitated and bring them automatically to safety without need of a pilot.

Use of the Leica LT500 on the X-38 project has resulted in a significant saving in time and effort, The X-38 project is on schedule to provide one of the most vital components of the International Space Station: a fast ticket home and perhaps an affordable ticket outbound. It is a project worthy of the planet's sharpest engineering experts – minds that are much too busy to be slowed down by conventional measuring methods. The Leica Laser Tracker LT500 delivers sharp, fast, accurate measurements at lightning speed.

(NASA's policy is not to endorse any product, service or company. Leica Geosystems is very appreciative for the candid remarks by X-38 project engineers, and their statements reflect solely on the technology presented by the LT500, in their individual experience).

The reflector is moved along the inside wall for inspection.

The Leica LT500 Laser Tracker at Johnson Space Center Houston

The Laser Tracker has been lifted up to get a wider working area.

New Era for Leica in India

Leica instruments have been in use on the Indian sub-continent for decades. Now, customers and users can expect support from a powerful new marketing and business partner: Elcome Technologies Private Limited, with headquarters in New Delhi. The company benefits from technical and applications backup by Leica Geosystems India, New Delhi.

Modern workshop facilities at Elcome Technologies Private Limited in New Delhi

Leica Geosystems' main priorities are to provide optimum solutions, and high-quality customer service. These aims are fully met by Elcome Technologies, as witnessed by the numerous guests who attended the official celebrations marking the launch of this cooperative venture. The events included a tour of the workshops and the inauguration of a show room, and were attended by representatives from major customers including NHO, Survey of India, Bharat Electronics, Nuclear Science Center, RITES, DGLL, National Physical Laboratory, University of Delhi, and Jaiprakash Industries. An unusual highlight was India's first permanent GPS base station providing a working reference to the Leica GPS users in and around the Indian capital as well as using the station for calibrating their own systems. The service department boasts high-precision equipment, including a T4 collimator of astronomical accuracy.

Hans Hess, President of Leica Geosystems, celebrates the new Indian partnership with K.S. Grewal, Board Chairman of the Elcome Group.

BasicLevel – The new starter´s level from Leica Geosystems

Leica Geosystems is adding to its range of automatic levels a new model which will not strain anyone's budget. This builder's level, sturdy and reliable, is the right tool for all small to medium building sites.

The BasicLevel has a stable line of sight and an extremely robust compensator, ensuring precise measurements. The accuracy of the BasicLevel is 3mm for 1 km double-run levelling. It is water- and dirt resistant owing to its sealed design and the precise matching of all of its components. Pointing is made easy by a bilateral endless drive and an optical sight. The 20x erect telescope image enables even the novice to read off values easily from the scale. The accessories for the instrument also come up fully to expectations. The BasicLevel from Leica Geosystems has an exceptionally good price-performance ratio, difficult to match in this class of level. If you are looking for a robust and reliable builder's level at an affordable price, then the Leica BasicLevel is your best bet.

The new Leica BasicLevel – the tough and reliable builder's level that everyone can afford.

No change for LH Systems

In REPORTER issue 38, page 15 we published news of plans by LH Systems LLC, a joint enterprise established by Leica Geosystems AG (Heerbrugg, Switzerland) and GDE Systems, Inc. (San Diego, California, USA), to acquire a third partner in the form of the photogrammetry division of the Carl Zeiss Group.

Merger and business plans were drawn up between February and September 1998, followed by a submission for approval by the Cartel Commission of the European Community. The plans were subjected to intense scrutiny, which would have continued into early 1999. It was clear to top management at LH Systems and the Carl Zeiss photogrammetry division that an investigative phase of this duration would place a severe damper on market development, as well as customer and employee relations. For this reason, and in the interests of customer contact and workforce security, both parties agreed to withdraw the application and call off merger negotiations.

GPS Joint Development Agreement between Leica and IBM

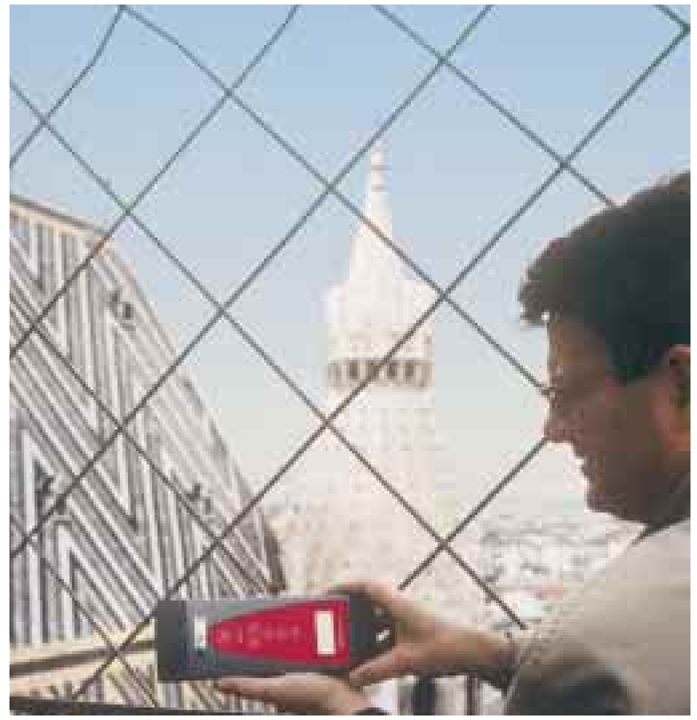
A major success for Leica GPS technology: Joe Petrosky (IBM) and Neil Vancans (Leica Geosystems) have already brought out the first SiGe-based GPS chip, and look forward to continued partnership success.

In September 1998 Leica Geosystems announced that an agreement has been reached with IBM to jointly develop new GPS products for use in single frequency applications. This agreement is historic for two reasons. First, IBM is entering the world of GPS with the intent of becoming a major player. This means that Leica Geosystems technology will be in the hands of millions of consumers as well as giving Leica Geosystems enormous advantage in its traditional markets. Second, this is the first time a GPS receiver has been built in silicon germanium. It is a particularly good medium for high speed applications, with lower manufacturing costs than GaAs.

These jointly developed products with integrated GPS functions will be complete engines, chipsets and derivatives, for markets not previously accessed, such as portable computing, cell phones, in-vehicle navigation, timing, and many more.
GPS product manager for IBM´s Microelectronics Division, Joe Petrosky said, "The goal of the joint development project is to produce the world´s smallest, most competitively priced and fully integrated and tested GPS solution to support multiple products and applications."

An enthusiastic Neil Vancans, President of Leica Geosystems GPS Business Unit of Torrance said, "IBM critically researched the GPS community before finally deciding to work with Leica Geosystems. We´ve been working with IBM for over a year and both sides have enjoyed a stimulating relationship. This business relationship represents an ideal match of Leica Geosystems' patented GPS receiver design and IBM's world-class IC technology. There are numerous benefits in the offing for both parties, as well as their customers."

Below: A double celebration – Rost's 110th corporate anniversary, and a 50-year marketing partnership with Leica in Austria. Rost General Managers Dr. Michaela Schlögl and Dr. Michael Hiermanseder in discussion with Hans Hess (centre), President of Leica Geosystems, in Vienna.



DISTO basic measures St. Stephen's Cathedral

Yet another culturally and historically important application for the Leica DISTO lasermeter, this time in Vienna: the site office at St. Stephen's Cathedral has purchased a DISTO™ basic lasermeter for taking interior and exterior measurements of the structure. The cathedral, visible from a large surrounding area, is a Viennese landmark with a history going back to 1147.

The cathedral building, with architectural treasures from several epochs dating back numerous centuries, is an ongoing constructional challenge for the head craftsman and his team at the site office. Renovation work continues virtually around the clock – and not just while parts of the structure are shrouded in scaffolding, as is the case at present!

The visible red laser spot emitted by the DISTO lasermeter can be aimed at any target: a projecting wall, the tip of a spire, or an arch. Targets that are physically inaccessible, or only accessible with great difficulty, are no problem for the DISTO: the laser goes straight across obstructions like fences, or distant heights. Once the beam is on-target, a press of the measure key is all that is needed to produce a display reading in just seconds – with millimetre accuracy!
After the Viennese state opera-house, the palace and zoological gardens at Schönbrunn, and the ancient church of the Jesuits, state-of-the-art Leica measurement know-how is helping to monitor and renovate yet another landmark in Austria's metropolis on the Danube.

Leica Geosystems' Austrian marketing partner is R & A Rost. While not quite as ancient as Vienna's architectural landmark, the company nonetheless celebrated its 110 year jubilee, along with a 50 year business relationship with Leica, at the end of 1998. Such a long-standing past has a certain rarity in international business life, and speaks for a solid foundation, healthy dynamism, and first-class customer relations.

Total station eliminates control string

Automated total stations and GPS are revolutionising the work of surveying professionals and their clients, not least in highway construction. The technique is being used in France to build roads faster and more accurately, as evidenced by the trade periodical "Matériels et Chantiers" in a recent report from a construction site along the RN 109 motorway. In recent years, Leica Geosystems has combined technologies from total stations and GPS with special software, giving rise to DPS (Driving Positioning Systems) for automatic machine control. They have proved their worth on construction sites all over the world.

The Leica total station automatically tracks the construction machine with attached reflecting prism. Station points are approximately 750m apart.

Below: The reflecting prism atop a 3.5m high mast is clearly visible here.

"This equipment allows a surveyor to mark out three kilometres of highway construction site every week – that's twice as much as before, when you also had to work in two-man teams", explains Christian Fabreguettes, surveyor for the Jean Lefèbvre Méditeranée construction company. "In addition, all the data is stored electronically, which eliminates the effort and errors associated with manual recording. One can be more flexible, because the project can be adapted on the fly at any time. For example, one can quickly add a shaft without having to do a lot of recalculations. There are so many advantages, it really makes everyone's work easier!"

Closed-loop automation

The target prism is attached directly to the construction machine and automatically stays within the total station's field of view. The total station sends information via a radio link to a PC in the machine, which also holds all the project data. The PC uses the total station measurement data to track the construction machine's position continually in real time, and compares it with the project data. It derives a continuous stream of control parameters, which are sent to the construction machine's automatic control system.

High productivity, safety and quality

"This allows us to overcome the physical limitations of control strings, like movement and logistical bottlenecks, damage, and occasional inaccuracies – we are seeing real improvements in productivity, safety and quality!", says Christian Fabreguettes. He remembers, "on a traditional highway construction site, staking out and securing the control strings used to require a team of two surveyors and eight assistants".

An 8.1 metre wide Vögele road-laying machine was used in the Route Nationale RN 109 project. A Leica TCA-series total station tracked the machine's position in real time. The same machine was previously deployed in early 1998 on the RN 106 between Nîmes and Alès, where it laid a nine-centimetre thick road surface over a 20-kilometre stretch. The machine has a 3.5m mast carrying the prism, an integrated PC with a ruggedised screen, radio equipment for communicating with the surveying station, automatic hydraulic regulators, and an inclinometer attached to the machine operator's console.

On-site procedures are considerably simpler as a result: having surveyed the terrain, the surveyor stores the project on a diskette which is then loaded into the road-laying machine PC. Then, the surveyor simply has to measure successive reference points (approximately every 350 m) on which to position the total station as it tracks the machine's advance. This gives an approximate range of 750m per station. The machine lays around 300m of road per hour, so station switching is required roughly every $2\frac{1}{2}$ hours. At the start of operations, the surveyor measures the exact position and height of the prism, and activates the PC – total station radio link for transmitting the measurement data. Hydraulically operated regulators on the construction machine receive updated information four times every second. The machine operator need only concentrate on steering, while keeping an eye on the display showing the current machine position in x, y and z axes, longitudinal profile gradient, the surface thickness to lay, speed, material consumption, and other auxiliary statistics (e.g. operational and stop times, defects, etc.). The foreman need only intervene to make spot-checks, for example to verify the surface thickness and plane inclination. The surveyor is always one station ahead with a second total station, monitoring the road surface that has been laid.

… and less stress

Christian Fabreguettes again: "We now work with considerably smaller road-laying teams. However, this method increases the burden of responsibility on the surveyor because without control strings there is absolutely no visual orientation point. To avoid mistakes, the surveyor must work extremely carefully, both while surveying the terrain and planning the project, and when transferring the data. The automated process can be interrupted at any time should something go wrong, and we can control things manually. The nearby surveyor checking the surface height can also intervene at short notice, to stop everything grinding to a halt." The French surveying engineer values the speed of production, the precise results, and the improved working conditions brought about by this technique. Christian Fabreguettes has experienced many large construction sites – "and this is the first one without stress!", he says.

The computer on board the road-laying machine receives positional data from the total station by radio, and relays appropriate parameters directly to the hydraulic control system.

Surveyor Christian Fabreguettes checks the road surface thickness. The Jean Lefèbvre construction company deploys several systems (hardware and software) from the French company D&P Systems.

Leica MC1000 – a compact GPS receiver ideal for machine control

In addition to automated total stations, Leica Geosystems offers alternative solutions for machine control based on the Global Positioning System (GPS). The MC1000 is the most accurate and responsive GPS receiver anywhere in the world, capable of calculating independent positional data ten times per second, with just 0.03 seconds latency – all with millimetre precision. The machine operator and control system are sent a continuous flow of information concerning the current position of the shovel or drill shaft, tool and machine – right where it's needed, in real time! Like Leica's automated total station solutions, the MC1000 is already deployed in diverse projects ranging from large dockside cranes, bulldozer shovels on construction sites, to precision planting machines used by seedling growers.

3000 pages of REPORTER stories in 30 years

The year: 1969. In the USA, NASA was preparing to land the first three men on the moon. Meanwhile in Switzerland, at the former Wild company in Heerbrugg, a small editorial team was working on a considerably smaller project: the first edition of a customer magazine. In the second issue of the REPORTER, Dr. Georg Strasser, the editor at the time, was already able to report on the moonwalking exploits of Neil Armstrong and Edwin Aldrin. The homegrown contribution was not inconsiderable: Wild BC-4 astronomical cameras were used to create the satellite triangulation network and record flight trajectories. Optical landing aids also came from Switzerland – from Kern Aarau – as did the wide-angle lens used for the spectacular photographs of the moon's surface. The engineers who built the LEM landing craft used Wild T2 theodolites and autocollimating eyepieces for optical component alignment and measurements during construction. Such was the state-of-the-art in 1969.

Exactly three decades and forty reporter issues later: another story about NASA space vehicle manufacture, this time using optoelectronic alignment instruments. The Leica LT500's laser beam has superseded "ordinary" light, an automatic laser tracker and reflector have taken the place of the observer's eye and the notepad. State-of-the-art in 1999. Global pioneering projects of this kind are perfect examples of the technological developments that occupy the thoughts and working lives of the professional community, and Leica's customers. The Reporter's coverage has filled a total of 3000 pages in German, English, French and Spanish, plus some in Japanese and Portuguese. Leafing through three decades of surveying history, it becomes clear that it is not so much the tasks that have changed or perhaps grown, but rather the techniques, equipment and combinations now used by the surveying professionals who perform them.

Thirty years ago, armed with a Wild T3 theodolite, a DI10 infra-red Distomat (range with nine prisms: 900m in those days!) and a Wild GAK north-seeking compass, the German geologist Schneider worked his way through Nepal to create a 1:25,000 map of the Mt. Everest region. Swissairphoto overflew the same area during the mid 'eighties, using a Wild RC10 aerial camera to record material that would later be analysed using photogrammetry equipment from Heerbrugg to create the impressive jubilee map for the National Geographic Society. In 1992, the first man with GPS equipment (Leica GPS 200 system) stood on the mountain's peak.

The Wild-Magnavox WM101, introduced in 1986, marked the launch of GPS technology for surveying applications. Since then, the Global Positioning System has made steady inroads into the working lives of REPORTER readers, and gained corresponding prominence in REPORTER articles. In addition to its use in surveying and mapping, GPS equipment is deployed in many larger construction engineering projects. GPS technology, total stations for reflectorless measuring, and automatic tracking, are all making a powerful impact as the industry enters the next millennium. It barely needs mentioning that none of these developments in surveying instrument technology have been influenced more heavily than by the very same company that publishes the REPORTER.

With your help, the magazine editorial team will continue to report the latest news from Leica Geosystems and follow developments from a user perspective – in a similar style to our recent coverage of building work at Hong Kong's new airport, the Stade de France, the Öresund mainland link and the reconstruction of the Potsdamer Platz in Berlin.

The first issue contained the following appeal: "With this periodical, we aim to create an even closer tie between ourselves and the many thousands of people who use our instruments. Of course, we do not aim merely to publicise our own views. On the contrary, we urge you to make contributions of general interest that will enrich the content of the REPORTER". We have nothing further to add to that original statement – with one exception. Please send us the questionnaire by fax, mail or via the Internet, telling us what you find especially interesting about the REPORTER, what you enjoy and would like to see more of – but also what you think is not so good and where you feel there is room for improvement. We thank you in advance for your comments and observations!

The REPORTER editorial team

Welcome to www.leica-geosystems.com

Leica Geosystems has been present on the Internet since 1996. Three years ago, the company recognised the medium's potential for communicating with customers and the industry at large. The Leica Geosystems site enjoyed highly favourable reviews by web experts right from the start, and it has been undergoing continuous improvement and expansion ever since. It's certainly worth taking a look: there is plenty to discover here!

Web-publisher Boris Krkljes maintains the Leica Geosystems web site: "Up to ten thousand visitors come to our site every month. We also receive four hundred customer requests – and the figures are going up and up!" Miren Kauer-Zubiaur started the project and is responsible for the Internet presence. Together, the pair pulled off a remarkable coup at the last FIG congress: just minutes after being interviewed and photographed at the stand, visitors could see themselves on-screen on the worldwide web!

Miren Kauer and Boris Krkljes are always developing new ideas to ensure that the Leica Geosystems web site remains attractive and up-to-date.

Many REPORTER readers, especially in research organisations, multinational corporations and workgroups, use the Internet as a business tool, as well as for GIS applications.

How can I access the Leica web site?

Not everyone has an Internet connection already, but demand is growing all the time. Miren Kauer: "Get an electrician, telecommunications or computer expert to connect your computer to the telephone network via a modem. If you don't already have the required software as part of your regular office package, he will install the necessary access program or browser as well (e.g. MS Internet Explorer, Netscape Navigator). Now choose an Internet service provider, if possible one that offers Internet access at local-rate call charges. That's really all you need to begin surfing the Worldwide Web". Now type *www.leica-geosystems.com* on the search bar, and within a few seconds you should see the Leica Geosystems home page with the table of contents overview: Instruments and Systems, Applications and Projects, News and Events, Worldwide Organisation, and Leica Geosystems in your region. Many pages allow you to choose between English, German or French at the click of a button – unless you jump to a Leica Geosystems country home page in the national language (e.g. Dutch, Finnish, Swedish or Spanish).

Measurement on the Internet: an opportunity offered by the Leica Geosystems web site as part of the DISTO application demonstration.

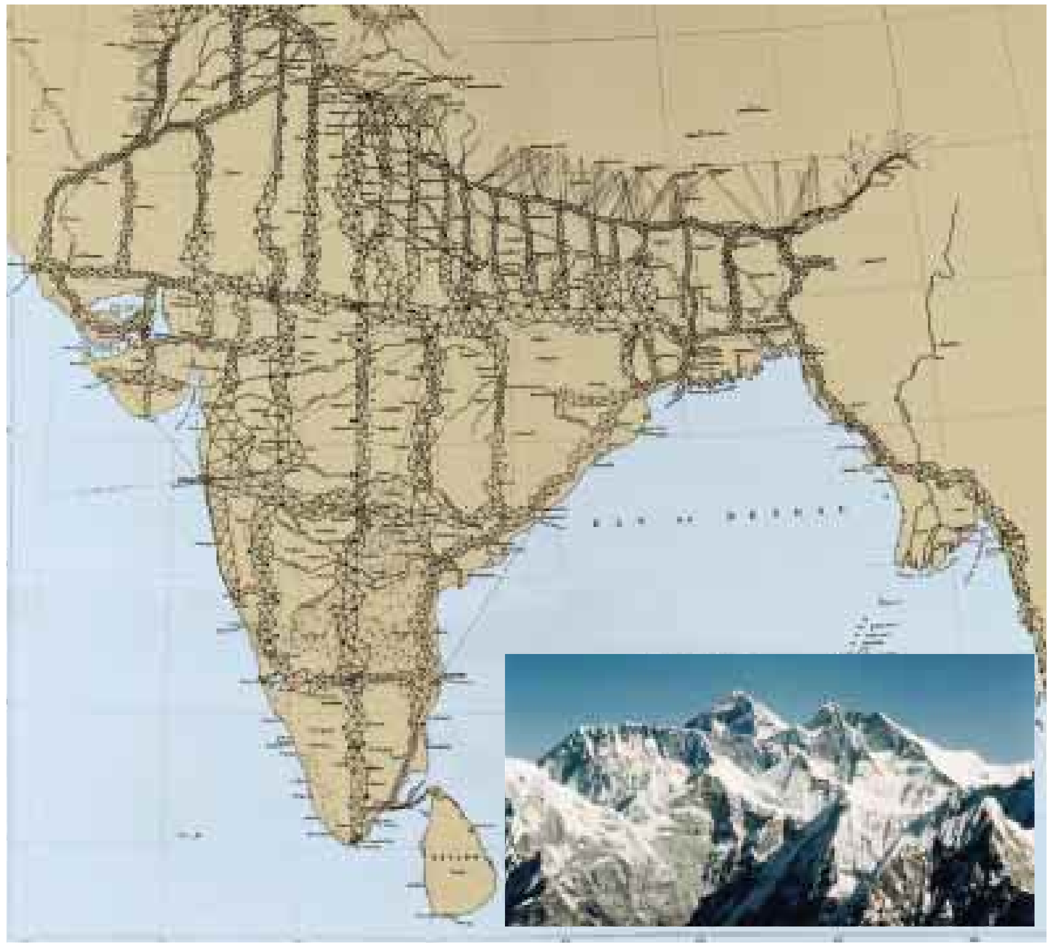
1200 pages available

At present, the in-house Leica Geosystems server offers a total of 1200 pages filled with information, software and application examples. Boris Krkljes ensures that the pages are always up-to-date, for example with the latest product announcements and Y2K compatibility notes.

Customer-friendly and interactive

If you want to know something about a Leica product or a special application, or if you want to quickly find out the address of the nearest Leica Geosystems support and service facility, just click on the appropriate buttons. You can use the integrated e-mail facility to contact Leica Geosystems directly, if you want to ask questions or request documentation, product videos and other services. You can even download interactive product demonstrations that allow you to test typical product applications on-line. The next step is already reality for customers in the USA: they can already order various products directly from the Leica Geosystems web site. And there's something else too: should someone fail to return your copy of the REPORTER, you can find it here in electronic form. You can even respond to the reader poll contained in this issue directly on the Leica Geosystems web site – no pen and paper required!

150 years of measuring the Himalayas



In the 19th century, the Survey of India worked its way through the sub-continent as far as the Himalayan peaks. The photograph shows Mt. Everest, known locally as Quomolangma, from the south-west, flanked by Nuptse (left) and Lhotse and Lhotse Shar (right).
Map courtesy: Royal Geographical Society, London.

Measurement campaigns carried out in this decade using Leica equipment confirm Mt. Everest and K2 as the highest and second-highest mountains on earth.

It was exactly 150 years ago that James Nicolson measured the highest mountain in the world, then known as Peak "B", later Peak XV and then Mt. Everest. Subsequent analysis of the data by the British India Survey determined its height as 29,002 feet (8840m) above sea level. This measurement was carried out in the years 1847-49 by vertical triangulation from six points at a distance of more than 150 km, without taking into account the deflection of the vertical produced by the Himalayan chain, the discrepancy between geoid and ellipsoid, and roughly estimating the refraction of the atmosphere.

About ten years later the topographers of the Survey of India discovered another group of very high mountains in the western part of the Himalayas. The highest of them turned out to be the one indicated as K2: 8611 metres.

Bradford Washburn's excellent 1988 National Geographic map of the Mt. Everest region, produced in Switzerland using Leica photogrammetry equipment to analyse images made by Leica aerial photography systems, shows the peak of Mt. Everest with the decades-old official height of 8848m.

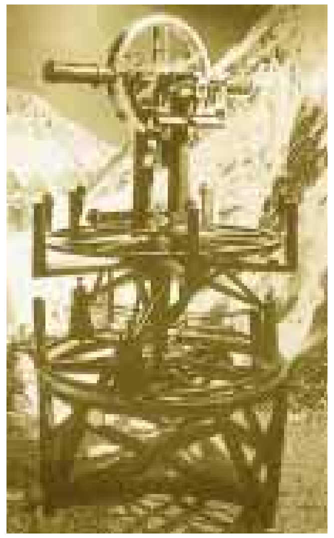
In 1987 the rumor that K2 might have been higher than Everest led to the creation of the EV-K2-CNR Committee by Professor Ardito Desio, the leader of the Italian mountaineering expedition who first climbed K2. The purpose was to remeasure both mountains and find out the truth.

The recent development of very accurate electronic distance meters and of satellite positioning systems has brought about a great increase in the accuracy of the measurements of the elevations and of the coordinates of the summits in the WGS84 system.

The 1992 remeasuring campaign of Mt. Everest

To verify the height of Mt. Everest with the most modern techniques, the Chinese National Bureau of Surveying and Mapping (NBSM) in Beijing offered to carry out the measurement from the Tibetan side, while the Italian National Research Council (CNR) agreed to organise the climbing expedition to carry the instruments necessary for the survey to the top of the mountain, with Italian topographers performing the measurement from the Nepali side.

The climbing expedition was arranged for September 1992. Since it was the first time that a GPS system would work at –40°C, a measurement from the ground was also arranged with distance meters and theodolites. A set of reflecting prisms was needed at the top of the mountain for the distance meters and as a target for the theodolites. The Leica ME5000 distance meter, the



One of the large triangulation theodolites used in the 19th century for the first measurement of Mt. Everest from a distance of more than 150km. Photo: Courtesy National Museum of Photography, Film & Television/SSPL.

most precise instrument available on the market (0.2mm+0.2ppm) was used together with a Leica T3000 precision theodolite to match it. It was also decided to bring along a Leica DI3000 distance meter, slightly less accurate, but easier to use.

At a distance of 10-12 km three prisms were sufficient for a good measurement with both instruments. However two prism sets were needed, one facing the Nepali side and the other facing the Rongbuk Monastery in Tibet, where the Chinese surveyors led by Professor Jun-Yong Chen planned to make the measurement with distance meters and a Wild T2 theodolite. The horizontal angle was calculated on the map at 76° while both sets were tilted at 12° in the vertical plane. Leica Geosystems, Switzerland, built the tripod on which the prisms were set, meeting very strict specifications. The total weight had to be less than 10 kg and it had to be divisible into two parts. The structure was built of aluminium, except for the lowest part which was an ice piton made of stainless steel. Another piton was made to hold the GPS antenna.

The data recorded during the Mt. Everest campaign

Two climbers, Benoit Chamoux and Oswald Santin, reached the summit on the 29th of September 1992 at 10.30, read the temperature (-15°C) and activated the Leica GPS 200 system, which had already been positioned close to the the peak the previous day, and had spent the night at -30°C on the roof of the world. At the same time, four other Leica GPS 200 sets were

After the initial measurements of the Himalayan peaks carried out by the British India Survey in the middle of the XIX century other measurements followed for Mt. Everest (1904, 1954, 1975, 1992), Kanchenjunga and Dhawlagiri. Another team followed in 1998. This article is the first in the REPORTER to describe the major international Mt. Everest measurement campaign of 1992, and the remeasuring of K2 in 1996. On this 150th anniversary, the comprehensive results achieved by the original surveyors under George Everest and Andrew Waugh still remain impressive. However, a completely different situation surrounds K2, the second-highest mountain on earth: it was only in 1986, some 120 years later, that George Wallerstein rekindled interest in the height of K2. His claim that K2 might be even higher than Mt. Everest triggered fascination among his peers, and a storm of sensationalism in the international press.
Subsequent remeasurement by Alessandro Caporali and Ardito Desio already disproved the claim. Reports by the research expedition described here under professor Giorgio Poretti, scientific leader of the major Mt. Everest and K2 remeasurements, again revealed that the assumption was no longer tenable. K2 remains in the shadow of Mt. Everest.

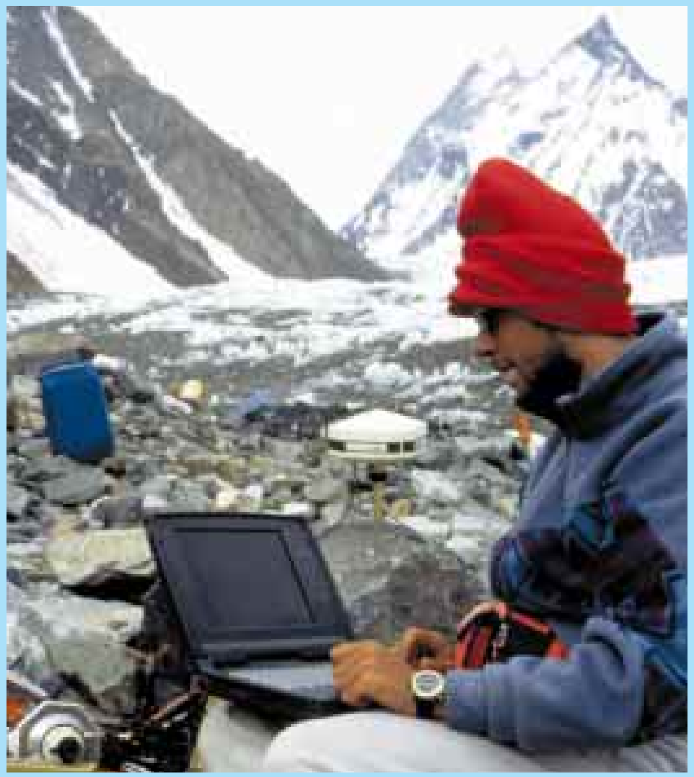
-Stf-

How high is K2 really?

When Alessandro Caporali and Ardito Desio remeasured K2 in 1986 a global positioning system (WM 101) and laser distance meters for the measurement of the base lines were employed for the first time. Leica TC2000 total stations were aimed at the snow covering of the summit of the mountains. The measurement of Caporali was performed from Concordia at a distance of about 15 km. The ellipsoidal height GPS turned out to be 8579 metres. The geoid-ellipsoid separation deduced from the global geoid was of -37 metres and therefore the geoidal height of K2 turned out to be 8616 metres.
In 1996, a research expedition led by the author set out to verify this height using a combination of modern equipment, and concepts tried out during the remeasurement of Mt. Everest. The base network for the measurement of K2 was formed by a triangle with two points (C and E) located on bedrock and one (G) on the glacier's moraine. To define the movements of the Godwin Austen Glacier, a special measuring project was carried out. The point G was linked to a point located at the "K2 Motel" in Skardu at a distance of about 98 km. This point was later linked to a fundamental trigonometric point (TR) of the triangulation network of Pakistan located on the rock above the Fort of Skardu. The Geological Survey of Pakistan provided the coordinates of the trigonometric point from which the ellipsoidal height of the point at the K2 Motel was computed at 2222.583 metres. A 30 hour GPS session linked the K2 Motel to the G point at K2 Base Camp establishing an elevation of 4934.338 metres for it. The average height difference between the Base Camp network and the summit was 3656.920 metres, giving for the summit the ellipsoidal height of 8591.258 metres at snow level.
Taking into account the depth of the snow of 2.22 metres and the ellipsoid-geoid separation 25.23 m derived from the NASA/DMA 1996 Global Geoid the elevation of the rock top of Mount K2 was computed as 8614.27 ±0.6 m a.s.l.

Results for K2 from 1996 measuring campaign

	(in meters)
Skardu K2 Motel	2222.583 ±0.3m
Base Camp-G point	2711.755
G point-summit	3656.920
K2 ellipsoidal height	8591.258 (at snow level)
Ellipsoid-geoid separation	25.23
Depth of snow	-2.22
Geoidal height	**8614.27 ±0.6m a.s.l.**



The K2 measurement campaign of 1996 established the second-highest mountain on earth as having a height of 8614 metres above mean sea level.
Mountaineer Mario Panzeri measuring the depth of snow on the peak of Mount K2.

The author performing measurements with the Leica ME5000 Mekometer.

started: two in the valley of the Khumbu in Nepal and two at the end of the Rongbuk glacier in Tibet. They then assembled the tripod and oriented the prisms. When we saw that the red spot of the laser beam reflected from the summit, we realised that our measurement had a chance of success after all. The climbers remained on the summit for two hours, until we were sure that our two stations on the Nepali side and the Chinese on the northern slopes had received a good signal with the distance meters.
This surveying campaign integrated all the most modern techniques of our decade:

a) Distance and angle measurements
The summit was observed from three points in Nepal and three in Tibet. Within each group of points all possible angles and distances were measured, yielding two trigonometric networks with one common target – the top of Everest. The geodetic network on the Nepali side was measured as a base triangle (KNL) from the corners of which the top of Everest (E) has been aimed at by the Italian team. On the Tibetan side the Chinese surveyors observed the summit from the three points R, III7 and W1. Both geodetic networks had one common target point: the top of Everest.

b) GPS measurements
The GPS Leica System 200 installed on the summit recorded every 2 seconds for 54 minutes. On the Nepali side the GPS installed at the Kala Pattar and at the point G near the Pyramid recorded at the same 2-second time interval. On the Tibetan side the recordings were performed every 15 seconds. All surveying data (triangulation/distance measurement and GPS) have been separately processed in China and in Italy. The results were presented at a meeting at the beginning of April 1993, taking into consideration also the results of the following measurements and technologies:

c) Meteorological data
For an accurate determination of the index and coefficient of refraction affecting the measurements of the theodolites and of the distance meters a special sensor was built capable of measuring the temperature and pressure of the air at the summit and sending this information to a receiver and recorder in the valley. During the measurements performed towards the summit the vertical temperature gradient was provided by sounding balloons launched from two positions. Temperature, humidity and pressure were recorded every 15 seconds.

d) Deviations of the vertical
Prof. Alessandro Caporali (Padua University) measured the deflections at four points between Lukla and Everest Base Camp. The astronomical coordinates were determined with a Leica T1600 theodolite connected to a Time Digitizing Unit made by the ETH (Zurich, Switzerland) and the geodetic coordinates with a GPS receiver (Caporali 1992).

e) Doris station
There is a station of the DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) system to which the G point has been linked by surveying.

The beacon at the peak of Mt. Everest was targeted from six sites in Tibet (left) and Nepal (right).

f) Depth of snow
On the 30th September 1992 two more climbers reached the summit. Their task was to determine the depth of the snow. This was accomplished by piercing the snow cap in several places near the tripod and referring the measurement to the main pole of the tripod where a millimetre scale had been drawn. The depth of the snow was determined as 2.55 metres.

g) Photogrammetry
Great importance has been given to the comparison between ground and GPS data by careful determination of the relative position between the prisms and the GPS antenna with a centimetre accuracy. Therefore not only a tape measure, a level and a compass were included in the GPS container and the alpinists were trained to use them, but also the photogrammetric method was applied. Two of the pictures taken by the mountaineers on the summit allowed the 3-dimensional reconstruction of the summit of the mountain. All data resulted in the elevation of the summit of Mt. Everest above the WGS84 ellipsoid to be 8823.51 metres with reference to the snow surface. The depth of the snow has been measured as 2.55 m and should be subtracted to achieve the value of the elevation at the actual rock top.

The Mt.Everest elevation

From the Chinese side a levelling network was brought from the Yellow Sea to the R and III7 points. In 1974 the geoid undulations were also computed with gravity observations performed up to 7900 metres (J. Y. Chen and D. S. Gum, 1980). The amount of the separation between ellipsoid and geoid was computed to be 25.14 metres. The value of the elevation of Mt. Everest referred to the Chinese High Datum has been obtained by averaging GPS and terrestrial data.

For the first time in history a GPS receiver has been operating on the summit of Mt. Everest giving a new determination of the summit coordinates of the summit and the value of its elevation above the WGS84 ellipsoid. This survey of the century, performed simultaneously from the Tibetan and Nepalese sides by Chinese, Italian, Nepalese and French researchers and mountaineers was also the first to determine the height of Mt. Everest geodetically using laser distance meters and theodolites in tandem.

Giorgio Poretti
University of Trieste

Right: Peak target and Leica GPS on Mt. Everest.

Results for Mt. Everest from GPS and terrestrial data in 1992 measuring campaign

	(in meters):
Everest ellipsoidal height	8823.51 (at snow level)
Ellipsoid-Geoid separation	25.14
Depth of snow	-2.55
Geoidal Height	**8846.10 ± 0.35 m a.s.l.**

Leica T3000 theodolite and DI3000 distance meter in action in the Khumbu glacier valley (Nepal).

Discussing measurement results in Trieste: the author (left), Prof. Dr. Jun-Yong Chen (right).

New Leica GPS System 500

The GPS System 500 from Leica Geosystems sets new standards for GPS measurements. Never before has a GPS measurement system taken customers' needs and wishes so thoroughly into account. A single unit fits the bill for all GPS applications. Extremely modest weight, size and current consumption coupled with compact, robust construction result in the utmost convenience for field use. An easily understood, straightforward user interface for the field system and the office software (SKI-pro) ensure rapid, reliable results. ClearTrak™, the latest development in receiver technology, gives the shortest possible measurement times together with maximum dependability, even under difficult conditions.

System 500 GPS receiver

An open, straightforward system architecture plus compliance with industry standards ensure compatibility with other measuring instruments, as well as facilitating upgrades and easing integration for specialised applications such as photogrammetry or hydrography. These benefits, coupled with an attractive price, make GPS measurements even more productive and economical!

Leica GPS System 500 – modular design for every application

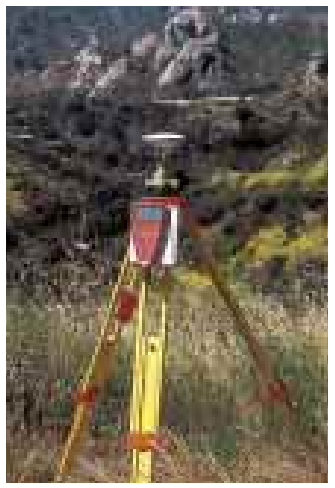
There is a choice of three small, lightweight, high-performance receivers: the SR510 single-frequency model, the SR520 dual-frequency model, and the SR530 dual-frequency receiver for real time applications. All the models are freely interchangeable. The SR510 is an entry-level receiver offering a low-cost introduction to GPS measuring. Later, as tasks grow more complex, it is always possible to upgrade to the SR520 or the top-of-the-range SR530. Flexibility and modularity make the receivers suitable for any application: post-processing and real-time, as a rover in unipole vertical pole or back-pack variants, or for static fixed-point measurement using a tripod. The system can also be used for kinematic measurements from a land, water or air vehicle.

Even when fully laden with a comprehensive set of accessories, everything including the tripod and two-piece (2x1m) vertical pole fits into a convenient container for transportation. The new SKI-Pro GPS software has been developed according to the latest Windows guidelines. It is quick to learn, easily used, and includes many attractive options. SKI-Pro addresses both real-time and post-processing requirements.

High-performance ClearTrack™ technology

All System 500 receivers have Leica's new, patented ClearTrack™ chip for rapid satellite acquisition and excellent tracking, even to low elevations and in poor conditions. With new multipath-mitigation and anti-jamming techniques, pure code measurements can be achieved in the 30cm range. For 1–2cm accuracy using code and phase measurement, the technology provides the shortest possible initialisation times and even better reliability. Phase ambiguities are resolved with more than 99.9% certainty in just 30 seconds. 12 channels on one or two frequencies come as standard. The receiver output rate is 5Hz (five complete measurements per second) with maintained accuracy (1–2cm) and 0.05 seconds data latency. This short latency is especially noticeable when taking real-time measurements.

Rapid-Static-Surveying with the System 500



With or without the terminal

A simple switch suffices to operate the sensor with predefined parameters, thus dispensing with the terminal. Three LED's indicate tracking, recording and battery status. This is ideal for applications that do not require input, such as static measurements or operation as a real-time reference station. The TR500 terminal, with its large, clear display and full alphanumeric keyboard is recommended for configuration, as well as for kinematic operation and detail recording (input of point numbers, codes, attributes, etc.) To minimise and simplify the operational effort involved, the extremely powerful and versatile SR530 can be switched between two modes using the TR500 terminal: standard mode for routine tasks, and an advanced mode for custom requirements.

The real-time rover: Unipole®-variant or minipack

The actual work of real-time GPS measurement is performed at the mobile rover station. The System 500 provides various options for configuring the rover station: a unipole variant or a backpack.
The unipole variant fits the entire equipment including receiver, terminal and antenna into a 3.8kg vertical pole, without any cables to get in the way. The backpack version consists of a handheld, lightweight (1.6kg) pole with a GPS antenna and a terminal, plus the backpack with GPS receiver and power supply (3.9kg). The equipment is light and comfortable to wear, even for prolonged periods. Aluminium or carbon fibre poles are available.

On-board and optional programs

Freely-definable ASCII output format makes it possible to transfer results to other hardware and software platforms. A suite of measurement-oriented programs (COGO) – such as area calculations and many more – are standard.

The SR530 with real-time option provides special applications (RoadPlus, Quickslope, DTM). And the SR530 has ample spare power and capacity for future additional programs.

Compatibility with Leica TPS Total Stations, DISTO™ and GPS System 200/300

Accessories such as forced centering, camcorder batteries and chargers can be used for GPS as well as TPS measurements. Like the TPS1000/1100 series Total Stations, the GPS System 500 uses PCMCIA SRAM or flash-RAM cards for data storage. GPS and TPS use the same code lists for attribute assignment. Coordinates determined using GPS may be instantly transferred to the total station or reflectorless total station in the field. For measuring inaccessible points (COGO functions), a DISTO™ may be directly connected to an interface on the GPS receiver, allowing digital transmission of distance information. The GPS System 500 is compatible with its GPS 200/300 predecessors for post-processing as well as real-time measurement. For example, a System 300 acting as the reference station provides extended facilities for a System 500 rover.

SKI-Pro Professional Office Software

The new SKI-Pro software prepares the GPS surveys in the field and evaluates the data in the office. This brand-new software runs on 32-bit Windows™ 95, 98 and NT platforms providing complete office support, data and project management, and full data processing. With a full Windows-style operating system, SKI-Pro is extremely easy to learn and use. Components include planning, import, project management, coordinate systems, least-squares adjustment, transformations, viewing and editing, reporting, code and attribute management, export to ASCII, export to GIS/CAD systems. SKI-Pro processes all types of GPS data taken in all measuring modes and combines real-time with post processed results. SKI-Pro complements the new GPS receiver and completes System 500.

Real-time kinematic with SR530

A Small Step, A Giant Leap… Introducing the System 500 from Leica Geosystems, the New World Standard in GPS surveying. With it, your job just became a whole lot easier. From it's small size and light weight to it's new modular design, the System 500 has been engineered for outstanding performance, faster than ever, and at a price you can afford. Whatever the application, or location, whether you need it on a pole or a backpack, in a car a boat or a spaceship, it's your best GPS solution. No more barriers, just limitless operation with plug-in batteries and PCMCIA smart cards. It's a small step for mankind, but a giant leap forward for surveying. Contact us at +41 71 727 31 61 (Europe) or call your local representative.

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MADE TO MEASURE