

Welcome to the world of GPS Reference Stations and Networks

This newsletter is dedicated to Leica GPS Reference Stations. It should be useful for users who already operate a GPS Reference Station and those who have yet to discover the benefits

Most GPS applications require a Reference Station

When using GPS positioning for accuracy of better than 5 m, a reference station is necessary. The reference station provides the user with the required data for differential processing of the rover data - be it in real time or post-processed - in order to achieve the desired accuracy.

Today, most people working in GPS survey or GIS data acquisition must set up their own reference station in the field each day.

More and more people and organisations are choosing to invest in their own **permanently operating GPS reference stations**. This removes the need for field crews to set up field reference station. In addition, the permanent GPS reference station provides a stable and accurate link to the existing geodetic survey network.

Many applications take advantage of GPS Reference Stations. These applications include:

Surveying, Mapping, and GIS
Land Surveying, GIS, Mapping, Construction Stakeout, Mining, Machine Guidance and Control, Civil Engineering, Marine & Hydrography

Public Utilities

Water Treatment and Distribution, Sewer and Waste Management, Telecommunications, Gas and Electric

Motion Monitoring:

Earthquake, Volcano, Landslides, and Mining

Engineering:

Dam, Bridge, Large Building Monitoring, Deformation Studies

Research:

Atmospheric Studies, Orbit Determination, Plate Motion

How is a permanent GPS Reference Station different from a "conventional" field reference station?

A conventional field reference station is usually a temporary installation on a tripod or building. It provides the reference for GPS operations in a small area over a limited time. Permanent GPS Reference Stations provide long term operation, high accuracy, and often cover larger areas.

Because a permanent GPS reference station operates continuously, it requires an **advanced, reliable and robust infrastructure**. Typically a PC is connected to the GPS receiver. Software running on the PC is used to configure and control the GPS operations and to perform some or all of the following tasks:

- Manage site parameters
- Sensor configuration
- Sensor operation control

- Monitor & display GPS sensor operation status
- Output of real-time RTK or RTCM data transmission
- Raw data logging and archiving
- Creation and archive of RINEX observation files
- Support of other external devices, like Meteo or Tilt sensors
- Perform all operations automatically, without any user interaction required

In order to provide a reliable permanent reference operation, users must pay more rigorous attention to the infrastructure than a typical field reference station.

Site monumentation must be stable and highly durable.

The **site coordinates** must be known precisely in local and global reference frames (ITRF, NAD83) with known transformations between the two.

Power supply for all equipment must be reliable and protected against failures and outages.

Depending on the location, **security protection** may be required against vandalism, theft, and electronic surge.

Access to data must well-managed. Depending on the users of the reference station data, data may be accessed simply by direct or remote control access to the PC connected to the GPS Sensor. Data access may also be expanded to include Internet or FTP data distribution.

Networks of GPS Reference Stations

In terms of traditional surveying reference systems, networks of GPS reference stations can be referred to as “**active networks**” as opposed to traditional “passive networks” using e.g. triangulation methods to establish and maintain survey control.

Organisations that are responsible for surveying tasks over larger areas often install more than one permanent station. In these cases, we recommend establishing a **network of GPS reference stations**. These stations are linked together and controlled from a single central computer. Active networks may vary from simple solutions up to complex real-time networked systems.

Modern state of the art “active networks” of GPS Reference Stations may ultimately replace (or significantly reduce) the need for the traditional survey marks and networks. This results in lower efforts and cost for the establishment, densification and maintenance of survey or spatial reference networks.

Who benefits from GPS Reference Station or Networks?

As seen from the applications listed above, many organisations can benefit from GPS reference stations or networks. Within the traditional Leica customer base there are the **surveying and engineering offices**, which may wish to install a permanent station for their own use. These are typically individual stations operated permanently or on an “as needed” basis supplying real-time or post-processed data for the firm’s operations. Depending on the area, this may be

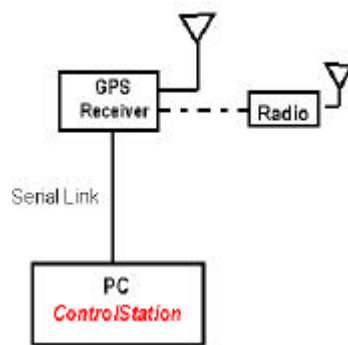
may be two, three or more individual stations.

Many local, state, and national organisations around the world are becoming increasingly interested in setting up GPS reference stations and networks.

Reference Station Examples

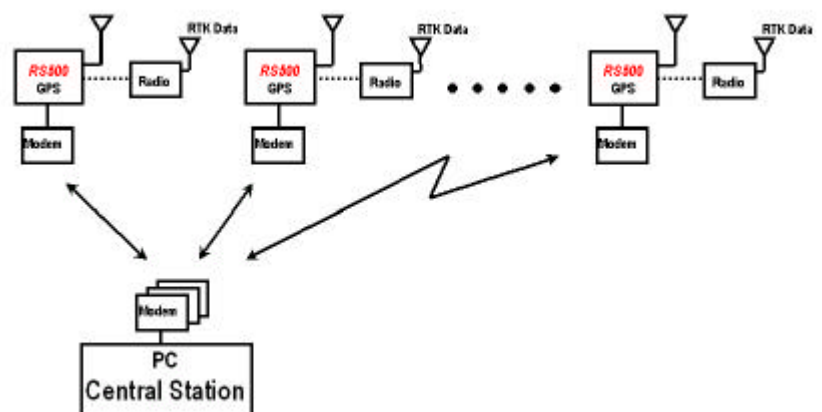
Single site system:

A single GPS sensor is set up with a PC at each GPS site location. All data is stored and managed locally onsite. A radio or cell phone may be connected to provide RTK/DGPS data. The GPS sensor is connected to the PC via direct serial connection.



[Picture 1: Single Site]

Several single sites may still be interconnected to one central location for e.g. remote control and data access. This may be done by a computer wide area network or using telephone modems to access each GPS sensor co-located PC.



[Picture 2: Multi-Site Central System]

Multi-Site Central System (semi-permanent connection)

In this configuration, GPS hardware only is installed at the reference station sites. GPS raw data is logged to the sensors’ internal memory. A radio or cell phone may be connected to provide RTK/DGPS data. PCs are not required at each site.

Receiver control and GPS raw data archiving is handled from a single control center. The control center computer is connected **semi-permanently** using a modem connection to each of the GPS sensors. It periodically downloads and archives the data from the network of GPS sensors.

This configuration provides management and data archive for multiple GPS reference stations from a single location. It is a simple, efficient, and highly cost effective method for managing a number of GPS reference stations.

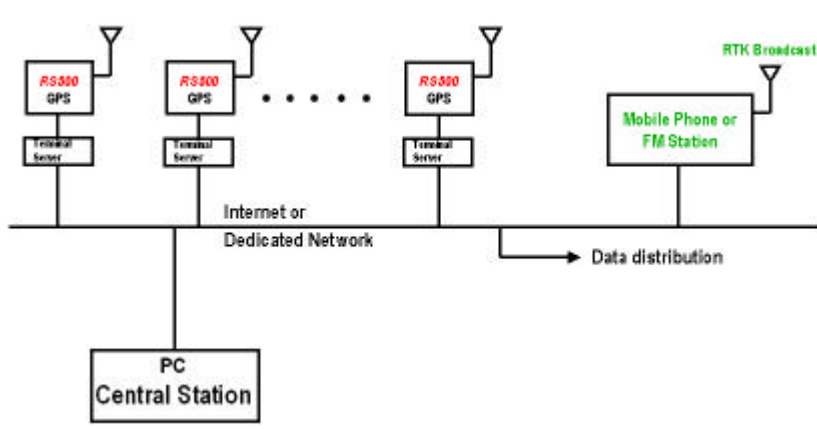
Networked System (permanent connection)

Similar to the configuration above, only GPS and communication hardware is installed at the reference station sites

The central station is **permanently connected** (see Picture 3 below) to all of the GPS sensors, receiving a continuous stream of data from all receivers. All sensor con-

trol and GPS data archiving is performed at the control center. Also, RTK/DGPS data is managed centrally and can be distributed via the network to the end user.

While the Networked System is a more complex and demanding approach, it is well-suited and cost-efficient for large-scale networks and service providers who require the control and functionality of a fully centralised system.



[Picture 3: Networked System]

The different configurations require **different levels of effort** and communication infrastructure. Different amounts of installation and maintenance efforts and cost should be expected. Any potential reference station operator must carefully define the local requirements and understand the costs and efforts involved to achieve the full benefits of their GPS Reference Stations.

Leica GPS for permanent Reference Stations

Leica Geosystems has real world experience in numerous projects for permanently operating GPS reference stations and networks. All types of GPS sensors have been used, including single and dual frequency receivers from System 200, 300 and .

A brief listing of projects includes:

- State & Governmental networks in many countries in Europe, Asia, the Americas, Africa, Australia, and Antarctica.
- Engineering Networks, including the Øresund and Hong Kong Bridge projects.

- Volcano Monitoring in Japan
- Dam Monitoring in California

Leica GPS Reference Station Sensors

While almost all Leica GPS sensors can be used for reference station applications, dual-frequency equipment is used most often. To meet the specific needs of the Reference Station market, Leica has developed the **RS500 GPS Receiver**.

The RS500 GPS Receiver is specifically designed to be operated using PC based application software. The RS500 provides all functionality required for precise, high quality GPS data acquisition, logging and RTK data transmission. Like all System 500 sensors it uses Leica's exclusive

ClearTrak technology to deliver highest quality GPS data.

Typically, all sensor operations are performed using a PC based application. The **Leica MC500** GPS Receiver has proven useful for projects that require a ruggedized sealed receiver.

Leica Reference Station Antennae

Reference stations must provide high accuracy and reliable data. Antenna locations require optimal conditions with a **clear sky view** down to low elevations .

High precision choke ring antennae are recommended to minimise multipath degradation of the satellite signals. In addition to minimising multipath, these antennae provide the best possible phase centre stability.

Leica offers two types of high precision choke ring antennae, both well suited to meet reference station requirements.

- **AT504**
The AT504 is recommended for most applications. AT504 is a JPL Design Dual Frequency choke ring antenna. It complies with International GPS Service (IGS) standards and is used whenever high accuracy and reliability standards must be met.
- **AT503**
This Dual Frequency Choke Ring Antenna is suitable for many reference station applications. It provides an excellent price/quality ratio.

For both types of choke ring antennae, **protection covers** (radomes) are used to pro-

protect the antenna from damage.

Single Site software solution

ControlStationä software is developed for single site reference station operation. It supports all functions provided with a System 500 sensor. ControlStation is suitable for a wide range of applications and many different users.

ControlStation operates under **Microsoft Windows**ä and features an interactive, easy to use graphical user interface (GUI). Once set up and in operation it runs automatically and without any user interaction. Intuitive icons provide quick access to essential operations to set up and activate raw data logging and real time data transmission. Continuously updated status displays provide the user with the full overview on all significant operation information.

ControlStation features the following operations:

- Site configuration & management
- Sensor internal data logging

- Direct PC data logging
- Internal Sensor data logging via ring buffer
- Automatic and manual download of internally logged data
- Automatic and manual conversion to standard RINEX format
- Archive of raw and RINEX data using the standard CORS/IGS data file naming convention and data structures.
- RINEX file compression
- Configuration of RTK/DGPS output in all major formats (Leica, CMR, RTCM)
- Monitoring receiver status and issuing alarms for problems in logging, communications, and sensor operation

For all details, please refer to the product brochures and literature available on the Leica Geosystems website. ControlStation includes a comprehensive online help.

All real-time data transmission devices supported by

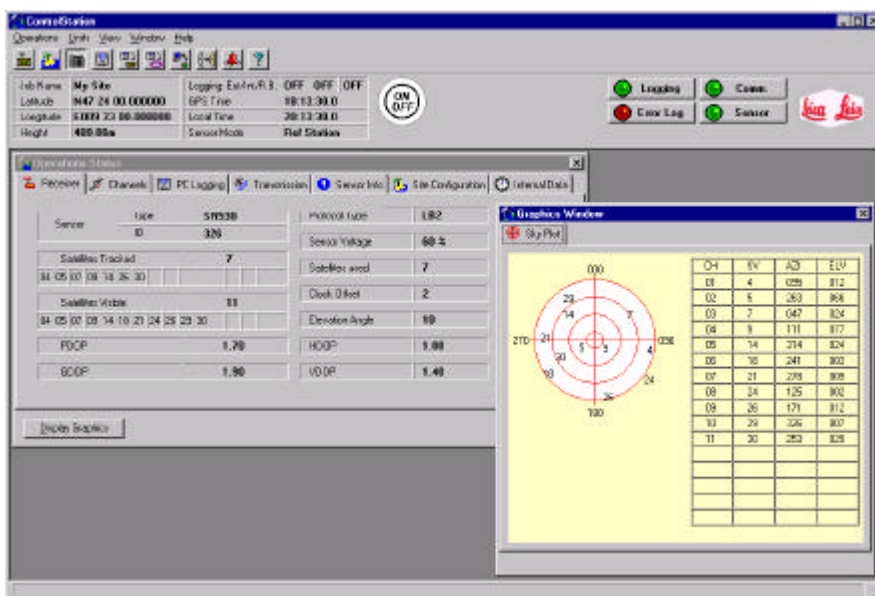
System 500 can be used for real-time data distribution. These include UHF or VHF radio modems, cellular phones, GSM, and digital PCS. The RS500 includes the ability to attach multiple devices simultaneously. So you can simultaneously transmit real time data in different formats via different commlinks.

In addition, some service providers may wish to supply **RTK via GSM or cell phone** only, but are required to service **multiple users** at one time. For this application, data broadcasting devices can be used to connect multiple analog modems or cell phones to a GPS receiver's real-time output port.

ControlStation on every System 500 CD

For Leica System 500 users who wish to evaluate ControlStation software, it is included on every System 500 SKI-Pro CD. ControlStation can be installed from this CD and can be run in **demo mode**.

ControlStation demo mode allows the user to explore the site set up and sensor configuration. All status information panels are available. Only data logging and download operations are protected.



Remember...

GPS Reference Stations and "active" Networks can be used to:

- Provide local, state or nation-wide geodetic control.
- Reduce cost and efforts needed to maintain traditional "passive" networks.
- Transmit data for multiple RTK and GIS rovers.
- Transmit DGPS for many precise navigation applications.
- Monitor movements of fault lines, volcanoes and man-made structures.
- Support non-survey applications such as weather forecasting.



News on the Leica website...

A weekly updated almanac and the Satellite Availability program can be downloaded from the Leica website.

<http://www.leica-geosystems.com/gps/almanac.htm> (English)

http://www.leica-geosystems.com/gps/almanac_de.htm (German)

http://www.leica-geosystems.com/gps/almanac_cn.htm (Chinese)