Leica SmartNet
UK & Ireland
Network RTK User Guide

SmartNet
powered by Leica Geosystems

- when it has to be right

Leica
Geosystems

Contents

Background

Ten years ago, RTK surveys typically involved two GPS receivers (a base and a rover), a lot of batteries, cables, two radios, a tripod, a pole and a backpack to carry it all. Today, you can choose between a GPS or a GNSS receiver all on the pole solution, with a radio or a mobile phone, no cables and only a few batteries. Now, with the establishment of RTK networks, you can also choose to work with an RTK rover within these networks instead of setting up your own base station.

An RTK network is a network of permanent GPS and/or GNSS receivers whose combined data is used to generate RTK corrections for a rover. These network generated RTK corrections are called network RTK. Today, RTK networks are operating in many countries over the world including; Germany, Spain, Hong Kong, America and Australia. RTK networks can vary in size, from small local networks consisting of only a few reference stations, to dozens of reference stations covering a whole country like Leica SmartNet for UK and Ireland.

Single Base Station RTK

RTK rovers traditionally receive RTK data from a single RTK reference station. The reference station may be permanently setup (e.g. on the roof of the office) or temporarily set up in the field. In both cases the principle is the same.

Figure 1. Single Base RTK

The Principle

The principle of single reference RTK begins with a single reference station that is:

1. Setup up on a known point; and
2. Sending corrections to the rover via a communication link (normally a one-way radio modem or GSM connection)

There are three important points to note in the relationship between the reference station and the rover:

1. Both the reference station and rover are observing a common set of satellites
2. The reference station sends all its position and satellite observations to the rover
3. The rover combines these reference station observations with its own observations to compute an RTK position

The position is computed using RTK algorithms, such as Leica SmartRTK on Leica System 1200.

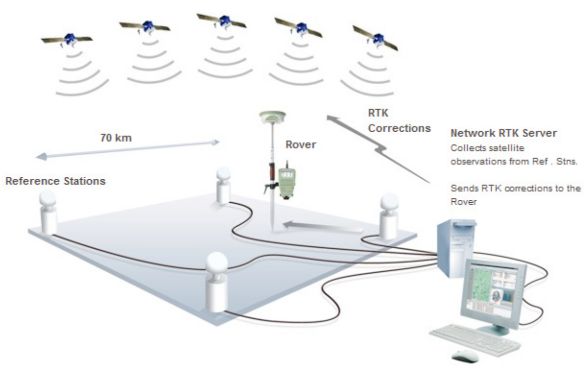
Advantages of Single Base Station RTK:

- The principle is relatively straightforward and generally well understood
- Traceability can be maintained through the reference station being setup on a known point and the rover managing all the position calculations

Disadvantages of Single Base Staion RTK:

- The cost to purchase the reference station
- The time and cost needed to travel to, setup and maintain the reference station
- Post processing of the reference station position to national grids
- As the distance increases between the reference station and rover, the accuracy of the rovers computed position decreases. This decrease in accuracy is due to distance dependant errors, mainly atmospheric errors. Essentially, as the distance between the rover and the reference station increases, the atmospheric conditions at the rover and reference station will become increasingly different. This decreases the accuracy and makes it more difficult for the rover to fix the ambiguities over long baselines.

Network RTK



Network RTK requires a recommended minimum of five reference stations (there is no maximum) with an inter-station spacing of up to 70 km. The reference stations are usually permanent installations and form the RTK network.

Figure 2. Network RTK

Leica SmartNet was introduced in December 2005 as the first commercial network RTK service for Great Britain and in July 2007 SmartNet Ireland was launched, providing a full commercial service across the whole of the UK and Ireland.

The GB network consists of 110 Ordnance Survey Leica GRX1200+ GNSS receivers and Leica AR25 antennas, known as OSNet, together with 17 Leica GRX1200+ GNSS sites for extra redundancy. Ireland is also enabled by a network of 17 GRX1200 GG and AT504 GG antennas from Ordnance Survey Ireland (OSI) and 6 GRX1200 GG and AT504 antennas from Land & Property Services LPS (formerly OSNI), covering the whole of Ireland.

Powered exclusively by Leica GNSS Spider software, SmartNet is able to deliver corrections in RTK mode and provides RINEX data for post processing. Leica GNSS Spider is also used by OSI and LPS to quality assure and compute RTK corrections for their own surveyors.

Raw data from all 150 sites above are used in the SmartNet UK and Ireland commercial service.

The Principle

The principle of network RTK involves all reference stations within the RTK network continuously streaming satellite observations to a central server running network RTK software, such as Leica GNSS Spider.

The aim of network RTK is to minimise the influence of the distance dependant errors on the rovers computed position within the bounds of the network. The network RTK server software begins this process by:

1. Fixing the ambiguities of the satellites (being observed by the reference stations) within the network; and
2. Using the data from all (or a subset of) reference stations to generate corrections that are sent out to the rover

The rover connects to the network RTK server via a one-way or two-way communication link (e.g. radio modem, GSM or Internet). In the UK and Ireland the typical connection to SmartNet is via a GPRS mobile phone or modem. Once the rover receives the RTK data it computes its position using the appropriate algorithm. Which algorithm the rover uses and how the distance dependant errors are minimised is dependant on the network RTK method being used.

Depending on the method (typically MAX, iMAX or VRS), this modeling is either carried out on the Network RTK server or at the rover.

Advantages of Network RTK:

- No need to purchase and set up a reference station
- The accuracies of the computed rover positions are more homogeneous
- The same area can be covered with fewer reference stations (i.e. compared to the number of permanent reference stations required using single reference RTK)
- Higher reliability and availability of RTK corrections (e.g. one station goes down, another station can take over)
- No need to post process and adjust reference data to national grid
- Traceability to national mapping organisations i.e. Ordnance Survey, OSI and LPS
- Higher accuracy compared to long baseline single RTK
- Higher productivity of two rovers versus one base and one rover

Disadvantages of Network RTK:

- The cost to subscribe to an RTK network and receive Network RTK corrections
- The accuracy of network RTK may not meet the same standard as single base when compared with very short single baselines of a few kilometers. i.e. a network RTK solution at 40km from the nearest station may yield a larger spread of results than a single base at only 3-4km.

What Extra Benefits do I get with the SmartNet Service?

Should communications be a problem in the field, then users can also take advantage of our SmartRINEX facility, where you can continue to record short observation data on site and then post process the data using simulated base station set ups from the SmartNet website and Leica Geo Office.

All subscribers also have additional access to the following services as soon as they subscribe.

- Full backup systems
- Immediate SMS text updates on the status of OSNet, OSI & LPS stations
- SmartNet e-news
- SmartNet newsletters
- SmartNet user workshops
- SmartNet guide sheets

- SmartNet configuration sets
- SmartNet support centre
- Free RINEX downloads from the SmartNet website
- Full network quality monitoring

What is Accuracy?

Accuracy is the measure of the difference between a particular measured coordinate and its true value, often quoted as the root mean square error (rms). If the measurement is unbiased and has normally distributed errors, then for each coordinate component roughly 68% of individual solutions will have errors smaller than the rms and 95% will have errors smaller than twice the rms.

What is the Accuracy of SmartNet?

Assuming the standard GPS RTK protocols (applicable for both single base/rover and network RTK) and best practice methods are employed for maximum precision i.e. good satellite coverage, good geometry, low multipath environments etc, SmartNet typically achieves an RTK rms accuracy of +/- 1-2 cm plan and +/- 3 cm height.

Quality Indicators & Improving Solution Robustness

Users of any GNSS equipment (including SmartNet network RTK rovers) should ensure their rover unit has the latest firmware versions and displays all available coordinate quality indicators for their rover position fix, and pay close attention to them. In most situations these indicators reflect well the actual performance of the rover.

Recommended Leica Geosystems quality control settings are as follows:

GDOP	5 or lower, 3 or lower for highest robustness
CQ Limit	30mm (CQ is an indicator of relative accuracy)
Occupation	3-5 epochs for the highest robustness
NRTK Corrections	MAX

The reference antenna on the rover configuration should also be set to ADVNULLANTENNA.

For topographic survey, the use of a 3-5 second occupations will reduce the effect of individual coordinate solution variations.

For precise work, especially control where the height component is important, the process of double window averaging should be undertaken. Users should observe an averaged window of around 3 minutes followed by another averaged window of the same length separated from the first by a suitable period e.g. 20 minutes.

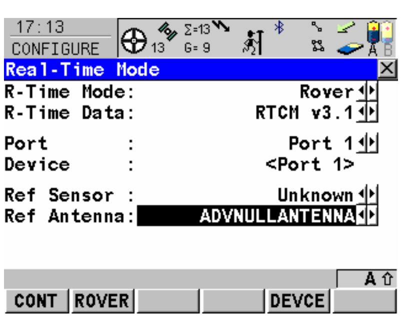


Figure 3. Setting ADVNULLANTENNA

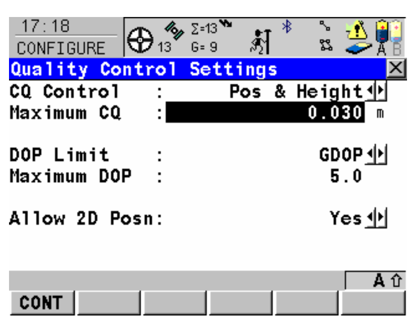


Figure 4. Setting CQ and GDOP limits

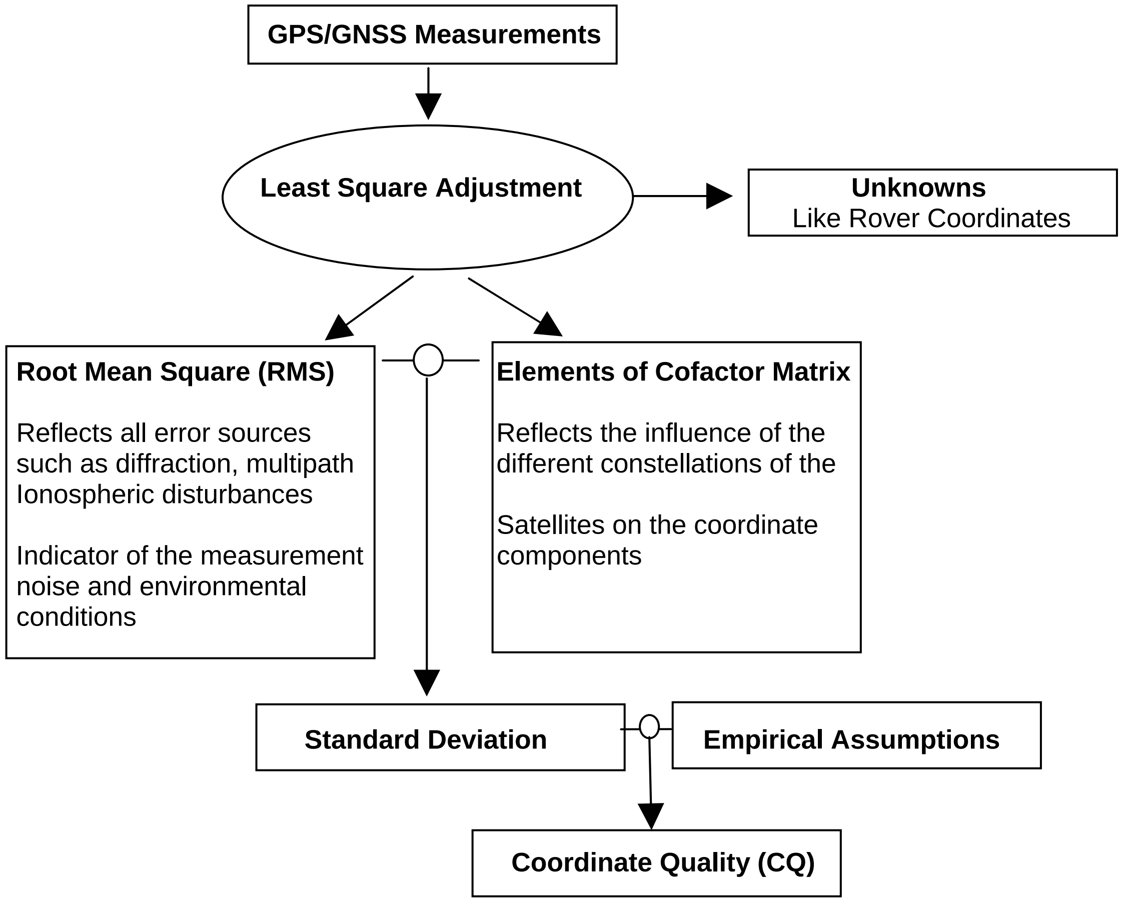
Coordinate Quality (CQ)

For the user in the field the coordinate quality is the best indicator of relative accuracy, that is how the GPS/GNSS measurements are performing relative to each other at that particular time. It should however be noted that in the most challenging environments (e.g. restricted satellite visibility, large distances or height differences to the surrounding reference stations, or high multipath) the reported coordinate quality may be over optimistic.

The **C**oordinate **Q**uality is

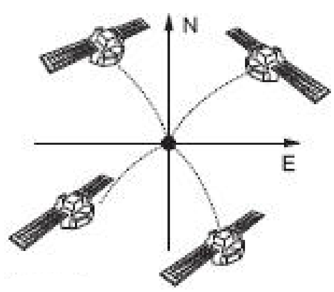
- Computed on the rover for code solutions and phase fixed solutions
- An **indicator** for the quality of the observations
- An **indicator** for the current satellite constellation
- An **indicator** for the different environmental conditions
- Derived such that there is at least a two third probability that the computed position deviates from the true position by less than the CQ
- Different from standard deviation
- Based on relative accuracy (the accuracy of a measurement between two points (i.e. the accuracy of one point measured relative to another on the rover, at that point in time)

Computation of Leica GPS1200+ CQ

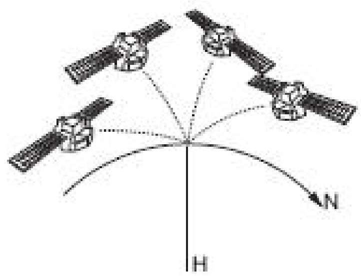


Position CQ versus Height CQ

All GPS/GNSS computed positions are almost twice as accurate in plan than in height. For the position determination, satellites can appear in all four quadrants. For the height determination, satellites can appear in two quadrants. This weakens the height position compared to the plan position.



Position determination with satellites appearing in all four quadrants.



Height determination with satellites appearing in two quadrants.

Latency

Latency is a term describing the wait time or delay time in the data transmission from the reference station network to the rover. Computation of real-time data on the rover is dependent on low latency via mobile communication providers, such as Vodafone, O2, Orange, Eircom etc.

In order to mitigate the latency issues with the mobile communication provider, Leica Geosystems signed a partnership agreement with Wireless Logic, the UK's leading specialists in SIM based communications over GPRS, 3G and HSDPA networks. This allows SmartNet customers to benefit from continuous connectivity and a dedicated private IP address from Vodafone, O2 or Orange, giving users the extra benefit of private GPRS SIM cards that do not suffer as much from outages and latency, like normal public SIM cards.

Further information on the Wireless logic sim cards please visit the SmartNet website http://smartnet.leica-geosystems.co.uk or contact your local representative.

Mobile Phone Coverage

A further consideration with the use of mobile communications technology, is the coverage from the main providers such as Vodafone, O2, Orange, Eircom etc.

GPRS (General Packet Radio Service), which is the typical communications platform for SmartNet users, does have extensive coverage across UK and Ireland with the major providers; however, depending on the provider certain areas may be weaker than others, particularly in rural areas. It is also best to seek the latest GPRS/GSM coverage maps from the providers.

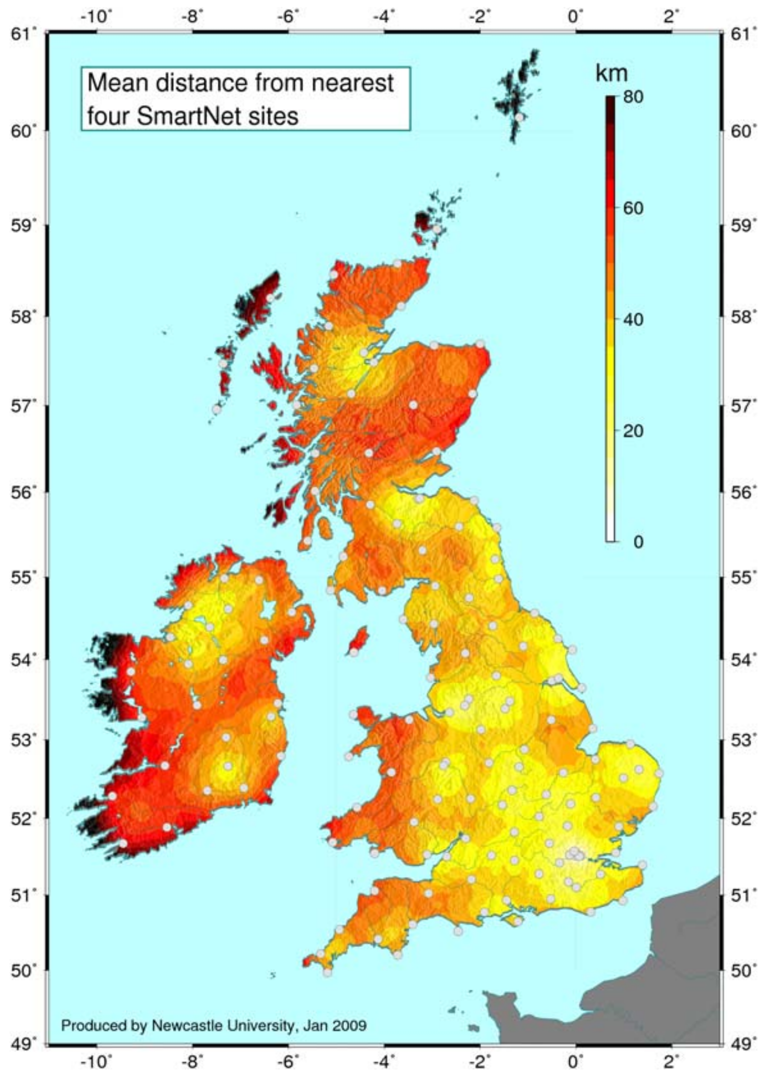


Figure 7. Mean distance from nearest four SmartNet stations.

The above figure shows the mean distance from the nearest four SmartNet sites throughout UK and Ireland. The darker red areas in the network are where more attention is required when recording single epoch (second) measurements, at large distances from the nearest reference site. For very precise work, as above, users should apply 3-5 epoch occupation times or double window separations when possible, together with appropriate GDOP and CQ limits.

More Information

For further independent information on network RTK best practice methods and results, please refer to TSA examination of commercial network RTK GPS services in Great Britain and best practice guidance www.tsa-uk.org.uk

Leica Geosystems Limited
Davy Avenue Knowlhill
Milton Keynes MK5 8LB
Phone: +44(0)1908 256500
Email: uk.sales@leica-geosystems.com
www.leica-geosystems.co.uk