



**Introducing SmartNet-UK, the first Leica Geosystems commercial Network RTK Correction service.**

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## SUMMARY

On 20th December 2005 at Ordnance Survey HQ, Leica Geosystems were pleased to announce that they are the first organisation to market and offer a commercial delivery of a GPS network solution across Great Britain, in partnership with the Ordnance Survey. This paper describes further the benefits of using the SmartNet correction service, with the latest RTCM 3.1 Network RTK messages. The reference station infrastructure is currently built on 96 stations, mainly from the Ordnance Survey reference station feed (OSNet), but supplemented with additional stations via Survey Association members, University's and Leica Geosystems UK. Nottingham University IESSG is also undertaking independent monitoring and integrity checking, to validate the "user experience".

The Network RTK process is based on state-of-the-art Leica GPS Spider software with the latest RTCM 3.1 Network RTK messages. These messages are based on the Master Auxiliary Concept – first published in 2001, jointly by Leica Geosystems and GEO++.

Leica GPS Spider software models and mitigates the distance-dependent biases for the entire SmartNet Network. Subsequently network correction messages can be formed and broadcast based on common integer ambiguity level for sub-networks of stations or clusters. The user will then be able to receive Network RTK corrections via mobile GSM or GPRS, for a multi-reference station solution consisting of the full correction and co-ordination information, of a dedicated master station and the correction differences of several local auxiliary stations.

Leica Geosystems UK strategy, is to also add further value to the network by introducing dual constellation GPS & Glonass receivers, as soon as possible, creating a full GNSS network ready solution for users, particularly in urban environments.

## 1.0 *Single Reference (Base Station) v Network RTK*

Real Time Kinematic surveying has been at the leading edge of surveying technology development since it's first inception in the mid 1990's. Significant developments have been made with RTK algorithms and the latest processing speeds, to bring us fast, reliable and accurate GPS solutions, for collecting and setting out spatial data. The limitation now for these solutions, is that with the single reference (base station) method, as the distance of the rover starts to exceed 30 kilometres, it becomes more difficult to rapidly resolve the carrier phase ambiguities. This is caused by the distance-dependent errors associated with the GPS measurement, such as ionospheric and tropospheric refraction and satellite orbit errors. However by using the reference station network technique, these errors can be mitigated and the GPS rover, when connected to the network control centre, can operate within the entire network (in our case anywhere within Great Britain) free of these distance-dependent constraints. This also means that with the latest technology developments from Leica Geosystems, the rover receivers have all the advantage of working with the modelled corrections of the entire network, together with a set of traceable multiple reference stations, in a subnet relevant to the user. So the whole solution of Network RTK becomes more robust, accurate and reliable than the standard RTK set up of obtaining corrections from a single reference station. Many other benefits exist with quality, productivity, availability and ultimately reduced costs when using a network solution, which are detailed later.

## 2.0 *What is SmartNet?*

SmartNet is basically a 24/7, accurate, reliable, robust, traceable and repeatable National GPS Network solution, based on a common datum, for the entire positioning community of Great Britain. Users of SmartNet can expect centimetre level Network RTK accuracies, through to sub-metre DGPS; or raw data for post processing.

SmartNet can be categorised into the following basic sub systems:

- Reference Station Infrastructure
- Control Centre
- Generation of Network Corrections
- Delivery of Corrections & Support
- Security & Backup
- Network QA/QC

## 2.1 The GPS Reference Station Infrastructure – Working Together



Institute of  
Engineering Surveying  
& Space Geodesy

The reference station infrastructure is built on a partnership with the Ordnance Survey. Known as OS Net, Ordnance Survey have their own internal RTK network, which is only available to internal staff. However, Ordnance Survey have made available the raw data from the OS Net reference station infrastructure to participating commercial partners, who are able to supply the necessary Network software, control centre, communications and expertise to deliver the service to end users in Great Britain. *Note: this is based on providing a national service and not just in small areas.* The most important part of any network is the reference station infrastructure. Ordnance Survey have put strong trust with Leica Geosystems for a number of years, to provide almost all of the receivers and antennas within their infrastructure, so there is a perfect synergy with the reference station network from Ordnance Survey and the Network processing Software from Leica Geosystems.

Leica UK also intend to add further value to this network, offering a high density, high redundancy network, by adding 'Active' Leica reference stations in combination with TSA members. Leica UK are also deploying the latest GPS & Glonass reference stations receivers with choke ring antenna's into the network to create a full GNSS network system, and will operate 14 Quality Monitoring reference sites in combination with Nottingham University's Institute of Engineering Surveying & Space Geodesy.



**Figure 1:**  
Current Ordnance Survey Network of  
90 Reference stations – June 06

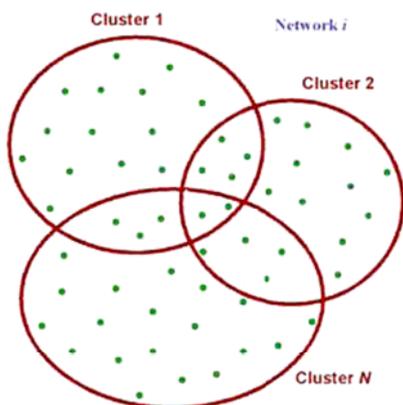
## 2.2 SmartNet Control Centre

At the SmartNet control centre, Leica GPS Spider or more specifically SpiderNET, is employed as the software to handle and disseminate all the Network RTK corrections to the entire region of Great Britain. The software Architecture is based on a secured site of network servers, streaming raw data from reference stations and computing corrections to a proxy server or web server for dissemination to users by NTRIP GPRS, access router GSM or RINEX file Web downloads. Full security systems including multiple firewalls, full network redundancy and backup servers are also supported.

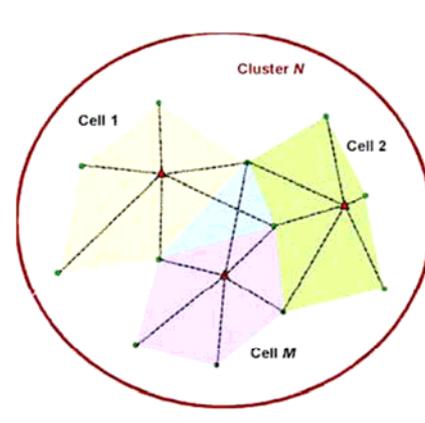
## 2.3 SpiderNet Clusters and Cells

A cluster is a sub-network of stations that are processed together to achieve a common ambiguity level. For small networks, the entire network may be contained in one cluster. For larger networks, such as SmartNet, where performance, redundancy and reliability is an issue, several clusters are used in the processing and distribution of data. Individual sites within the network may be in more than one cluster allowing overlap between clusters (see Figure 2). Each cluster in the network may or may not be on the same integer level.

A cell is a selection of sites from a cluster consisting of one master station and a number of auxiliary stations, which is used to generate master-auxiliary corrections (refer to Figure 3)



**Figure 2:**  
A reference network comprising a number of clusters



**Figure 3:**  
A cluster providing master-auxiliary corrections to several rovers, with each rover using an appropriate cell based on its location.

Since Leica GPS Spider or SpiderNET processes all data together in a single filter, every site in the cluster is reduced to the same ambiguity level. For the user this means that there is no artificial and restrictive limit of three reference stations imposed as with other approaches, therefore easily allowing the optimum number of reference stations to be used in the determination of the network corrections for the rover. Using five or six reference stations for the network corrections can improve the network geometry for the rover and help to estimate

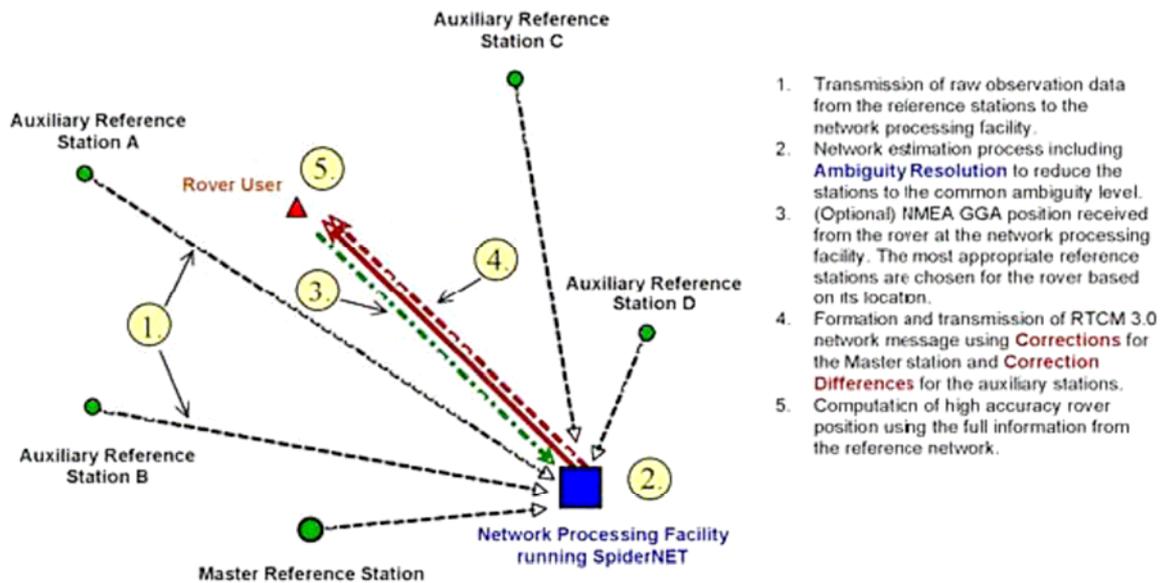
larger scale atmospheric effects. Also, by using more than three reference stations, the rover will not lose its fix if one reference station drops out of the solution as a result of unreliable communication links or other issues. The inherent flexibility of the Leica GPS Spider solution enables new modules to be added in the future, such as additional support for modernised GPS, Glonass and Galileo.

#### 2.4 *Network Auto cell creations*

SpiderNet can also decide from the rover's location, which site or cell is best suited, using 2-way communications. For users they only need to connect to the network by automatically sending their navigated position via the NMEA GGA string, which is pre-configured in the rover sensor. SpiderNet will then return the corrections to the user with the optimum cell for their location.

##### How this works

- The Rover User connects to the SmartNet service and returns their navigated position via NMEA GGA.
- SmartNet will collect all reference sites (reduced to a common ambiguity level) that are relevant for the users Geographic location.
- Reference sites are sorted for their 3D distance to the rover with the nearest site at the top.
- Typically the SpiderNET software will provide 6 stations as reference. Nearest site is given as the master station with full corrections and the next 5 sites are given as auxiliary correction differences. (please refer to section 2.5)
- Corrections are delivered to the user via Nearest, MAX or iMAX products, in either RTCM 2.x, RTCM 3.x, Leica, CMR or CMR+ formats



**Figure 4:**  
Generation of master-auxiliary corrections (MAX) for a rover

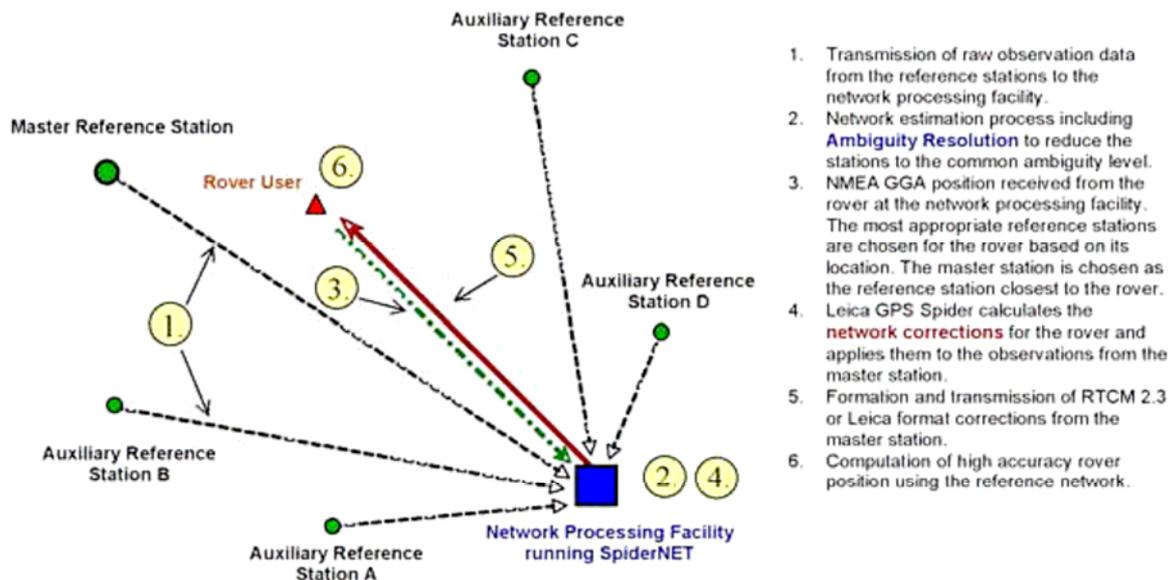
Leica Geosystems has for many years been actively researching, promoting and realising Network RTK solutions and working towards an industry standard for network RTK corrections. It is in this role that Leica Geosystems, jointly with other RTCM members, has developed and driven the Master Auxiliary Concept (MAC), the future of networked RTK and the basis of the newly approved RTCM 3.1 network RTK messages. Up until now there have been no official internationally accepted standard for network RTK corrections.

On the recent May 2006 RTCM SC104 meeting the proposed new network RTK messages for RTCM V3 have been approved and decision was taken to release them with next update of RTCM in V3.1. The formal release is expected in the coming weeks and is subject to final editorial update of the RTCM V3.1 documentation.

The RTCM V3.1 network RTK messages provide an open, unambiguous and manufacturer independent standard for network RTK corrections. The new standard, in addition to promoting increased compatibility and innovation in the industry, offers some distinct advantages to the end user over the previous non-standardised methods for generation of network corrections.

Leica GPS Spider and thus SmartNet, does not restrict users of older receiver types. In order to provide access to the entire GPS community, corrections known as individualised Master-

Auxiliary Corrections are available, known as iMAX. These iMAX corrections require two-way communications and may be transmitted in RTCM 2.3 or RTCM 3.0 formats and provides the same performance as a rover that fully supports MAX.



**Figure 5:**  
Generation of individualized master-auxiliary corrections (i-MAX) for a rover.

With SmartNet's network corrections complete information on the prevailing errors sources is made available to the rover, thereby facilitating the use of more intelligent positioning algorithms by the rover. The net result is an increased robustness of the system and increased performance in terms of time to fix, reliability of the ambiguity fix and position accuracy

Leica SmartNet is already enabled with this technology and is able to bring to its users all the benefits of this leading edge technology, today.

## 2.6 Delivery of Corrections & Support

SmartNet will authenticate and administrate each client rover, via two main mediums of mobile phone sim cards.

- Internet GPRS (General Packet Radio Service)
- GSM Cell (Global System for Mobile communication)

The user can either negotiate their own sim card tariff from providers or obtain one from the SmartNet administration, for subscribed rovers. For the GPRS access the user will be given

an IP address, a unique user ID and password, which will normally be entered under the standard NTRIP (Networked Transport of RTCM via Internet Protocol) options, on the manufactures software. For the GSM the user will only require the user ID, password and phone number to dial.

Authentication, Authorisation, Accounting and Auditing (AAAA) are fully integrated into SmartNet software. .

Full network support is provided to users subscribed to SmartNet, with guides to setting up different types of rover receivers.

## 2.7 *Security & Backup*

The whole security concept of SmartNet separates the network operation and computation from the data dissemination, thereby protecting the key infrastructure as well as sensitive user and billing information.

For maximum security the proxy server that is used to provide the data, is situated outside of the firewall. All sensitive information such as user information and billing information is stored on a database behind the firewall and NOT on the proxy server, as is the case with some competitor systems. Therefore, any hacker who manages to gain access to the proxy server (which is normally open to the internet) would not be able to access confidential information or other parts of the system.

The whole system architecture is also situated in a high security, co-location data centre in London Docklands. Full system redundancy with backup servers is located within the data centre. Should there be a problem within the network, mechanisms to fully switch to backup systems are immediately implemented.

## 2.8 *Network Quality Control*

Leica GNSS QC software is installed at the control centre to continuously monitor the data within the network and make regular audits on station multipath errors etc. Leica SpiderWeb software is also fully integrated with GNSS QC, enabling real time reports and statistics to be pushed to the web server. This will allow users the ability to view the network performance and statistics by way of real time live charts on the SmartNet web site.



Nottingham IESSG are also undertaking independent monitoring and integrity checking, to validate the “user experience”. Data from the reference sites and network RTK corrections will be available to IESSG, who will use their own processes to independently validate the data. Rover receivers will also be strategically placed within the network for quality measurement of the ‘users experience’. Future enhancements to the quality control will also

bring users the ability to view the network performance and statistics by way of real time live charts on the web.

### 3.0 *SmartNet Benefits*

#### *Quality*

- High-speed initialisation for RTK solutions
- Redundancy – multiple reference stations, not just one
- Reliability – full monitoring of network services
- Quality assurance – independent integrity monitoring by University of Nottingham.

#### *Productivity*

- Perform centimetre accuracy RTK surveys with one rover
- Eliminates daily base station set-up & potential errors
- Reduces dependency on ground control monuments
- Far exceeds range of conventional RTK systems
- Convert your existing base station into a productive rover

#### *Availability*

- “Always on” & 24/7 monitoring service
- Allows subscribers to easily work in various locations

#### *Cost*

- Halve the capital investment – no base station!
- Eliminates paying an employee to guard base station against theft

### 4.0 *Conclusion*

Numerous benefits exist within SmartNet, not just technically but also with new business opportunities for end users. SmartNet can be a very effective tool in many circumstances, enabling a further increase in GPS productivity and reliability with reduced hardware costs. SmartNet is built upon the leading Leica GPS Spider reference station software from Leica Geosystems. Leica Geosystems has been for many years actively researching, promoting and realising Network RTK solutions and working towards an industry standard for Network RTK corrections. It is in this role that Leica Geosystems jointly with other RTCM members, has developed and driven the Master Auxiliary Concept (MAC), the future of networked RTK and the basis of the newly approved RTCM 3.1 Network RTK messages. SmartNet is enabled with this technology bringing the future of Networked RTK, to the users today.

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