Network RTK adding reliability to precision agriculture

By Volker Janssen

Precision agriculture has become a widespread technique for improving agricultural practices and productivity in recent years. Real Time Kinematic or RTK technology has provided the positioning framework for GPS guidance applications such as Controlled Traffic Farming and Variable Rate Applications. Permanent GPS base stations, called Continuously Operating Reference Stations (CORS), are being established across Australia and are taking RTK to the next level by considering multiple base stations at once, this is referred to as Network RTK.

In the mid-1990s the concept of RTK was developed, allowing users to access centimetre-level accurate positioning in real time. RTK involves a single GPS base station on a point with known coordinates and a static or moving user receiver (rover), e.g. mounted on a tractor. The so-called baseline vector between base station and rover is then calculated instantaneously to determine the user's position relative to the base station. Without this relative positioning technique, the expected user accuracy (or repeatability) would be at the few metre-level.

Complex signal interpretation and mathematical procedures are used to account for errors which change depending on the distance of the rover from the base station. Atmospheric errors affect the GPS signal as it travels about 20,000km from the satellite to the receiver. Orbit errors are caused by the satellite deviating from its predicted path due to effects such as solar winds. The positioning accuracy diminishes as the rover gets further away from the base station because the conditions experienced at each site become increasingly different.

Figure 1: Single-base RTK scenario (Pacific Crest)

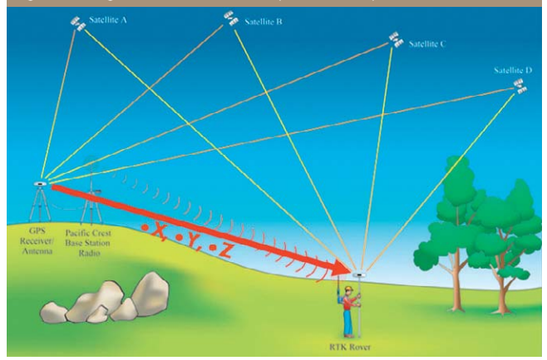
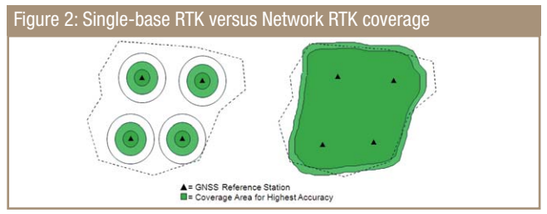


Figure 2: Single-base RTK versus Network RTK coverage



Traditionally, RTK is made possible using a UHF/VHF radio link to transmit base station data to a rover for real-time processing (Figure 1). More recently, wireless telecommunication networks and even satellite communications have been used as an alternative.

One significant drawback of single-base RTK is that the achievable repeatability decreases with growing distance from the base station. The maximum distance between base and rover receiver for 2cm-level horizontal positioning is generally limited to about 20km, although acceptable results can be achieved over 50km under certain conditions. As previously mentioned, this range limitation is caused by the distance-dependent errors. In addition, if a UHF/VHF radio link is used, the achievable range is influenced to a great extent by the existence or non-existence of radio signal interference in the area and the prevailing terrain. Wattage of the base station radio, height of the transmitting radio antenna and line-of-sight to the rover all play a part as well. If the correction data are transmitted via the internet, there are no line-of-sight issues but sufficient mobile phone coverage is critical.

Network RTK is achieved by extending RTK positioning from a single base to using multiple reference stations. The advantage of Network RTK is that the distance-dependent errors can be modelled more reliably and consistently across the entire network. The correction data provided to a user is optimised based on the (changing) location of the rover within the network. This allows greater inter-station distances between the reference stations (up to 70-100km), while providing repeatability at the same level as or better than single-base RTK.

The coverage area of high-quality and consistent real-time positioning can therefore be increased substantially with Network RTK (Figure 2). This means, for instance, that Network RTK could make use of four reference stations in a region as opposed to RTK based on a single reference station per farm.

The Network RTK solution is generally based on between three and six of the closest CORS with respect to the user. The two main Network RTK methods are the Virtual Reference Station (VRS) approach and the Master-Auxiliary Concept (MAC). From the user's point of view, both methods achieve the same level of accuracy and repeatability. In the instance that a reference station goes offline, the user can continue working because the network solutions are still available, making use of the remaining sites. This would not be possible with traditional, single-base RTK.

CORS networks such as GPSnet in Victoria (http://gnss.vicpos.com.au/), CORSnet-NSW in New South Wales (http://www.corsnet.com.au/) and SmartNet Aus (http://smartnetaus.com/) provide both single-base RTK and Network RTK services to users. CORS network corrections are generally sent over the internet, although products are available on the market to re-broadcast over a farm using a radio link, e.g. via an RTK bridge. For precision farmers, CORS networks provide a valuable alternative to operating their own single-base RTK base station without tying farmers to a particular brand of GPS equipment.

CORS are permanent, stable, reliable and accurate reference stations (Figure 3). Typical differences to standard base stations are that they observe all Global Navigation Satellite System (GNSS) signals, not just GPS, and contain additional hardware such as backup communication links and uninterruptable power supply units with backup batteries. They are also professionally installed in secure locations and largely maintained remotely. GNSS experts determine the location of the sites and ensure consistent positioning and guidance solutions across Australia.

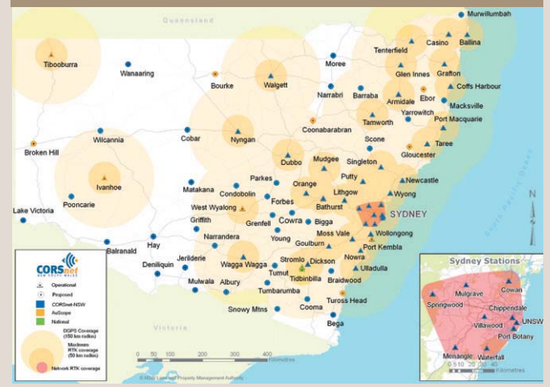
Through the use of RTK, precision agriculture has enabled improved agricultural practices and productivity. Network RTK has the potential to reduce the cost of embracing this new technology, while at the same time improving reliability and consistency of guidance applications. Many agricultural machinery suppliers are now selling and retro-fitting equipment to make it compatible with Network RTK and CORS networks. The potential for these solutions is immense within the agricultural sector and for many other positioning and guidance applications across Australia.

Find out more:

Dr Volker Janssen, Survey Infrastructure and Geodesy, NSW Land and Property Management Authority, Volker.Janssen@lpma.nsw.gov.au

Figure 3: Examples of CORSnet-NSW sites

Figure 4: Current coverage of CORSnet-NSW (September 2010)



CORSnet-NSW developments

CORSnet-NSW is a network of permanently installed Continuously Operating Reference Stations (CORS) operated by the NSW Land and Property Management Authority (LPMA). The network allows nearby equipment and machinery to accurately determine coordinates for satellite-based positioning and guidance applications.

CORSnet-NSW provides state-of-the-art positioning infrastructure across NSW. Users benefit from access to 2cm RTK and Network RTK services, a sub-metre DGPS service and an archived data service for post processing.

As of September 2010, the network consists of 46 sites across the state (Figure 4). Strategically positioned, these stations are currently providing NSW spatial data users with high-accuracy coverage in key metropolitan, coastal and regional areas. CORSnet-NSW will be expanded to at least 70 stations by 2012. The network integrates 10 AuScope sites that are being built as part of the National Collaborative Research Infrastructure Strategy, aimed at applications such as monitoring movements of the Earth's crust and sea level change. With the ongoing installation of additional reference stations, the coverage area for all services will increase substantially over the next two years.

Some of the many benefits of CORSnet-NSW are that it:

- achieves positioning accuracies to within 2cm in real time
- provides greater coverage and a reliable service to more people
- supports precise positioning applications
- enables LPMA to significantly improve the state's essential positioning infrastructure
- fosters scientific research and industrial innovation in the spatial sector
- avoids duplicated CORS network development throughout the state, and
- compliments the national AuScope network.

– Volker Janssen

Find out more:

www.corsnet.com.au, (02) 8258 7545, CORSnetCustomerSupport@lpma.nsw.gov.au