RTK Networks: The Wild, Wild West

Survey & Construction Newsletter, April 2009

Apr 1, 2009
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GPS World

What can you say about RTK Networks, except *wow!* They have popped up everywhere and continue on a path of rapid growth. In the last five years, I'd say it's clear that two GNSS technologies have changed the survey/construction industry more than any others; machine control and RTK networks.

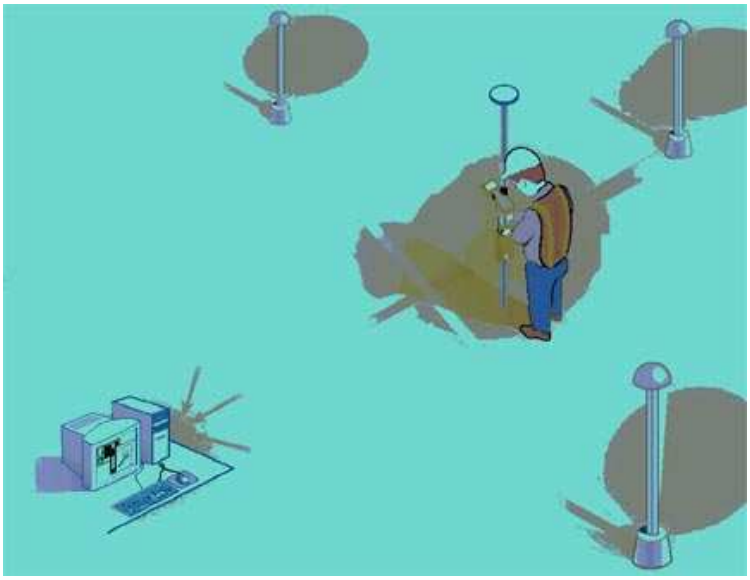
As a follow-on to our *GNSS Precise Positioning Market Report*, Rob Lorimer and I have produced another market research report entitled *GNSS Augmentation and Infrastructure.* In addition to CORS, SBAS, and other infrastructure, it includes quite a bit of information about RTK networks, growth projections, and technology trends. You can download an abstract here. RTK networks is a very complex subject. A full discussion would much more space than this newsletter can accommodate. In that light, I'm going to keep it as simple as I can make it while touching on the hot points I've heard about and experienced.

RTK Clusters vs. RTK Networks

RTK clusters are a set of strategically spaced GNSS reference stations set up and operated by an entity within a specific geographic region. They were first conceived for the survey engineering industry as a solution to the headache of operating a reference station. RTK clusters provide single-baseline RTK correctors within that region. It's worth emphasizing that it is a single-baseline solution similar to when a user operates his own reference station. By single baseline, I'm referring to the rover receiving correctors from the closest reference station in the cluster. If the user moves significantly within the cluster region, he must manually select another reference station. RTK performance in RTK clusters is the same as traditional base-rover RTK configurations, in that position accuracy is subject to degradation ("ppm error") as the user moves further from the reference station being utilized.

RTK networks are also a set of strategically spaced GNSS reference stations within a specific geographic region. The advantage of an RTK network over an RTK cluster is that the RTK network utilizes all of the reference stations, included in the network. Unlike RTK clusters, RTK networks are driven by a sophisticated suite of network software (such as VRS, SpiderNET/SmartNet, or TopNET). The network software significantly reduces "ppm error" that is introduced by the ionosphere, troposphere, and satellite orbits the further one travels from a reference station. In essence, if you are working within an RTK network coverage area, the distance from the nearest reference station becomes somewhat of a moot point, certainly much less of an issue than when discussing traditional RTK and RTK clusters.

The graphic below illustrates a simple RTK network. Data is collected by the reference stations and sent to a central processing server where it is compiled, and correctors are sent to all of the rovers that are subscribed to and logged onto the service. The number of users using the service at any one time can be several hundred or more. In an RTK cluster, the graphic would look similar to below but without the central processing server. The data link to the user wouldn't be from a central processing server but rather directly from one of the reference stations.



Source: Trimble Navigation Ltd.

The National Geodetic Survey published its latest versions of "User Guidelines For Classical Real-Time GNSS Positioning" in September 2008. It's good reading for anyone using RTK and RTK networks. Appendix A of the document discusses RTK and RTK network testing done by the Vermont Transportation Department in 2006/2007.

Another notable report that is worthwhile to read was published by The Survey Association (UK) and University of New Castle. It was conducted in 2008. It contains empirical data collected and analysis of RTK network performance. One particular point of interest in the report stated that using GLONASS observations do not improve RTK accuracy. I've always subscribed to the notion of "the more observables, the better" for RTK, because it improves productivity (field work is not shut down from lack of satellites). With respect to the accuracy, I think you have to take the above conclusion with a grain of salt. I'm not claiming GLONASS will improve accuracy, but I think we have to be careful using such a statement categorically. For example, would I rather use a five-satellite GPS-only solution up against a tree line vs. a five satellite GPS and three satellite GLONASS solution in the same location? I would choose the latter. Which would fare better with respect to accuracy? Well, satellite positioning accuracy is all about confidence and I'd have much more confidence in an eight-satellite RTK position than a five-satellite RTK position…especially when working up against a tree line.

Evolution

Before RTK networks/clusters were developed, all survey/construction RTK users had to manage their own reference stations (setup, manage, protect, etc.). Once this became accepted as mainstream technology, survey/construction managers began to understand the time investment, potential blunders, and risks associated with each crew operating their own reference station. The next logical step was for survey/construction managers to establish permanently (or semi-permanently) mounted reference stations in offices or temporary trailers with the antennas tied to the desired reference datum and a reliable power supply so one could merely "flip the switch" and be broadcasting RTK correctors within minutes. Risk of having a reference station stolen and risk of a blunder in the setup was greatly reduced.

Permanently and semi-permanently mounted reference stations managed by smaller organizations for their specific application soon morphed into departments of Transportation and other organizations setting up a number of permanently mounted reference stations in highly populated areas that covered entire cities. These were the first RTK clusters. They broadcast RTK correctors similar to the way that traditional base-rover RTK users do…mostly UHF and VHF data radios which have a limited broadcast range. Also, these systems were still subject to "ppm errors" described above. These two factors meant that the permanently mounted reference stations needed to be located a relatively close distance from each other to ensure full coverage of the areas.

Two technology developments enabled the transition from RTK clusters to RTK networks.

First of all, mobile phone networks have experienced explosive growth in the past five years. This was critical in overcoming the distance limitations of UHF/VHF radios. Using a mobile phone network, I can log onto an RTK network 1,000 miles away. Granted, the positioning would be useless (way outside of the network) but my point is that it was a huge step forward in RTK communications technology. It's true that mobile phone networks still don't provide coverage everywhere that survey/construction people want to work, but they do cover a significant portion of it and, where they don't, other communication technologies such as RTK bridges are being developed.

Second, manufacturers such as Trimble, Leica, and Topcon began developing highly sophisticated RTK network software to optimize accuracy and reliability of positioning within the network coverage area regardless (for the most part) of distance to the nearest reference station.

Who Runs the Networks an Clusters?

Worldwide there are literally hundreds (maybe more than a thousand) RTK networks/clusters. The growth rate is astounding.

Today, I would venture to state that all RTK systems setup by survey/engineering-based organizations are RTK networks. For example, departments of Transportation, survey equipment dealers, cooperatives, and even GNSS manufacturers set up and operate RTK networks.

Here are some examples of RTK networks:

Ordnance Survey (UK)

Can-Net (Canada)

ORGN (USA)

Geotop (Italy)

RTK clusters still exist. In fact, they are proliferating in the precision agriculture market. There are huge RTK clusters being run by agriculture equipment dealers and agricultural cooperatives. Cost is a major issue why RTK networks have rarely been installed for precision agriculture. RTK network systems are significantly more expensive and technically complex to install and manage than RTK clusters. Farmers are less apt to pay the higher subscription rates charged by RTK network service providers.

Here are some examples of RTK clusters:

Tri-State RTK (USA)

South Plains Precision Ag (USA)

Largely, precision agriculture and survey engineering/construction RTK systems are operated separately and independently. It seems odd that given the significant cost of the infrastructure that this wouldn't be a shared resource. In many cases, RTK clusters and RTK networks overlap themselves.

In rare cases, the RTK network owner/operator services both the survey engineering/construction and precision agriculture markets. Here is an example:

eGPS Solutions (USA)

Subscription Costs

What are the costs of subscriptions to RTK networks and RTK clusters?

The answer to this question varies widely. If the RTK network used public funding, many times there is no cost to subscribe to the network. However, the user must obtain a wireless network (mobile phone) data plan to access the network.

If the RTK network is operated by a survey equipment dealer, there is a subscription cost that varies with each service provider that can run as much as US $500 *per month* per receiver.

Subscription fees to RTK clusters are generally lower than RTK Nnetworks…on the order of US$1,500 *per year*.

Where Are We Heading?

This technology is developing and deploying rapidly and on a worldwide basis. Entire countries such as Croatia and Turkey have invested in nationwide RTK networks.

I think it's clear that RTK networks are the foundation of real-time precise positioning in the future. They will replace RTK clusters…or RTK clusters will be upgraded to RTK networks. There are just too many benefits for that not to happen.

It will be interesting to see how the subscription rates are settled, as well as the competition between public and private networks.

As I wrote in the beginning, this is a complex subject worthy of words way beyond what is written here. I only hoped to provide a broad view. For those of you who are interested, I'm conducting a webinar on the subject later this month, April 21. You can register here.

Eric