System 1200 Newsletter – No. 52

RTK Networks – An Introduction

RTK Networks - The Future

Ten years ago, RTK surveys typically involved two GPS receivers (a base and a rover), a lot of batteries and 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, and, a radio or a mobile phone. Only a few batteries are required, no cables, and it all fits on the pole. And 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.

RTK Networks will be the topic for this and the next two Newsletters. An outline of each Newsletter is given below.

Newsletter 52 – An Introduction: Introduces RTK Networks, briefly describing how they work in comparison to Single Reference RTK, and highlights the economic advantages of using Network RTK.

Newsletter 53 – Different Methods: Describes the different methods of Network RTK available on the market (FKP, MAX, Virtual Reference Station etc), and the advantages and disadvantages of each. Includes the issues of traceability and the use of proprietary vs. standardized methods.

Newsletter 54 – A Case Study: Describes and discusses some case studies where different Network RTK methods are being used. Includes the issues of accuracy, repeatability and reliability.

RTK Networks – An Introduction

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, such as, Germany, Spain, Hong Kong and parts of America and Australia, just to name a few.

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 the **SmartNet UK** (http://smartnet.leica-geosystems.co.uk) (Fig. 1).

A user subscribes to a Network RTK Service to receive RTK corrections with their rover (instead of setting up their own reference/base station).

These RTK corrections can be generated by more than one method - Master-Auxiliary corrections (MAX), Individualized MAX (i-MAX), Virtual Reference Station and Flächen-Korrektur-Parameter (FKP) – more information on these methods in the next Newsletter. *Note: System1200 supports all these methods.*

Figure 1: SmartNET UK, network overview

But before going too deep it is useful to give an overview of what exactly Network RTK is.

The easiest way to explain this is by comparing Single Reference Station RTK and Network RTK.

Single Reference 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 it might be temporarily set up in the field. In both cases the principle is the same.

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) (Fig. 2).

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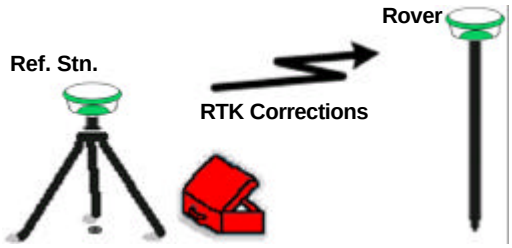

Figure 2: Principle of single baseline RTK

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

1. Both the reference and rover are observing a common set of satellites.
2. The reference 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 SmartRTK on the System1200.

Recent advances in RTK algorithms - especially with SmartRTK - allows the rover to successfully and repeatedly work at distances of up to 50km from the RTK reference station.

ADVANTAGES

The advantages of Single Reference RTK are:

- 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

The disadvantage of the Single Reference RTK approach is:

- The cost to purchase the reference station.
- The time needed to setup the reference station.
- As the distance increases between the reference and the 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.

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*, which is the backbone of *the Network RTK* principle.

THE PRINCIPLE

The principle of Network RTK begins with 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 (Fig. 3).

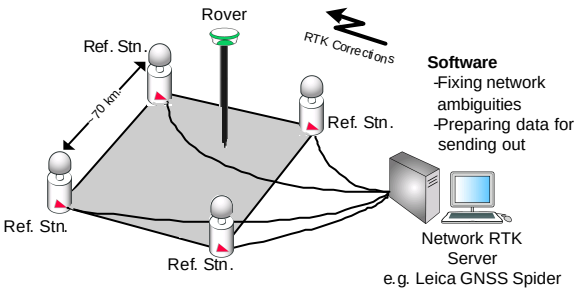

Figure 3: Principle of Network RTK

The rover connects to the Network RTK server via a one-way or two-way communication link (e.g. radio modem, GSM or Internet). 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 very much dependant on the Network RTK method being used.

Previously we mentioned MAX, FKP and Virtual Reference Station as examples of Network RTK

methods available in the market - each of these methods minimizes (or models) the errors in different ways. Depending on the method, this modelling is either carried out on the Network RTK server or at the rover. Therefore, the relationship between the RTK Network and the rover is different for each method – which can lead to significant differences in performance, accuracy, reliability and traceability for the rover. This topic will be covered in more detail in the next two Newsletters.

Advantages of Network RTK

The advantages of Network RTK are:

- No need to set up a base station
- The accuracies of the computed rover positions are more homogeneous.
- The accuracy is maintained over larger distances between the reference stations and the rover.
- 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").

Disadvantages of Network RTK

The disadvantage of Network RTK is:

- The cost to subscribe to an RTK Network and receive Network RTK corrections

Now we have an overview of how Network RTK works – the main question is: Is it economically worth subscribing to an RTK Network and receiving Network RTK corrections?

Network RTK – Is It Worth It?

Lets consider a surveyor in the UK as a typical example.

Leica UK offer an unlimited annual subscription to *SmartNet UK* for around £2,000. This means that anywhere, anytime within the UK, the Surveyor can receive RTK corrections for their rover – with no need to ever setup their own base station.

£2,000 is not a small sum of money. But assume the Surveyor completes an average of 2-3 jobs per week for 40 weeks of the year using Network RTK – this is a total of around 100 jobs per year.

The cost per job to receive Network RTK correction is therefore £20 per job. (There are also some costs of dialling into the RTK Network, but with special subscriptions from mobile phone companies this cost is minimal and may anyway be incurred if the surveyor uses a mobile phone connection to their own RTK base station).

So the question for the UK surveyor to answer is, can I save £20 per job by not using a base station? Consider the following.

Firstly, the surveyor saves time by not needing to do the following:

- Researching a known point to setup the base station over.
- Arranging a power-supply (e.g. batteries) for the base station.
- Travelling to the base station location (which may not always be conveniently located next to the site where he is working).
- Setting up the base-station.
- Securing the base station (i.e. do not need to worry about it being stolen or knocked over).
- Packing up the base station at the end of the job.

Secondly, the surveyor saves money by not needing to purchase:

- A base station.
- Base station accessories (radios, batteries, tripod, etc.).
- Labour for the time spent doing the tasks listed earlier (which may also include to pay someone to simply sit by the base station to ensure it is not stolen)
- Maintenance for the base station and accessories.

And thirdly, other advantages include:

- The removal of some potential error sources (e.g. not needing to plumb a base station and measure its height).
- Less equipment to move/transport.

The list probably goes on. So lets look at an example of how using an RTK Network might benefit a surveyor.

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EXAMPLE – USING NETWORK RTK

In this example there are two UK surveyors, Surveyor A and Surveyor B. Both surveyors have the same two jobs to complete, Job 1 and Job 2. Each job takes 30 minutes to walk around all the required points. The jobs are spaced 35 km apart.

SURVEYOR A

Surveyor A is using a Leica GPS1200 Rover and a GSM mobile phone to receive RTK corrections from *SmartNet UK*.

Surveyor A takes the following steps to complete Job 1 (Fig. 4):

1. Drive to Job.
2. Setup the rover.
3. Connect to *SmartNet UK* to receive RTK corrections.
4. Walk around and measure points.
5. Disconnect from *SmartNet UK.*
6. Pack up rover.

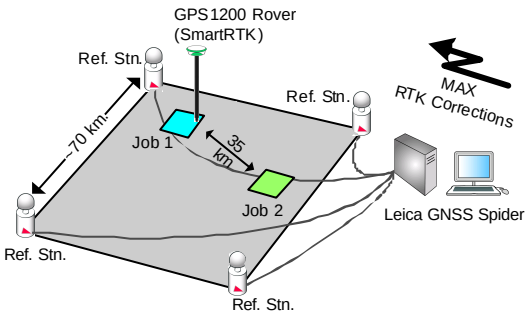

Figure 4: Surveyor A completing Job 1

Surveyor A then repeats steps 1 – 6 for Job 2 (Fig. 5) with the final step of driving back to the office.

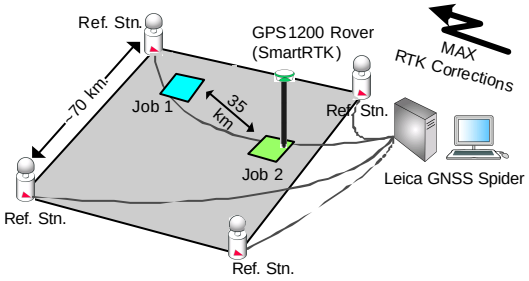

Figure 5: Surveyor A completing Job 2

SURVEYOR B

Surveyor B is using a base station and rover pair with GSM mobile phones for the communication link.

Surveyor B takes the following steps to complete Job 1 (Fig. 6):

1. Drive to Job.
2. Setup base station in a suitable location, which may or may not be adjacent to the working area.
3. Measure height of base station.
4. Start the base station broadcasting RTK corrections.
5. Go to the start of the job.
6. Setup the rover.
7. Connect rover to the base station to receiver RTK corrections.
8. Walk around and measure points.
9. Pack up rover.
10. Return to the base station.
11. Re-measure height of base station (to check that it has not moved).
12. Pack up base station.

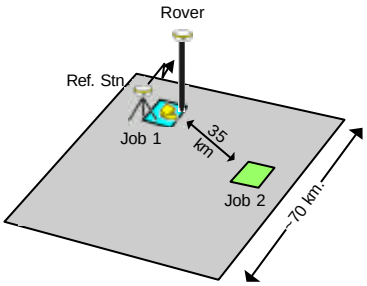

Figure 6: Surveyor B completing Job 1

Surveyor B then repeats steps 1 – 12 for Job 2 (Fig. 7) with the final step of driving back to the office.

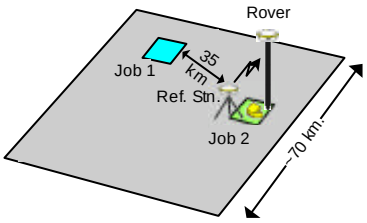

Figure 7: Surveyor B completing Job 2

Surveyor B could also choose to leave the base station setup at Job 1 and carry on to Job 2 (Fig. 8).

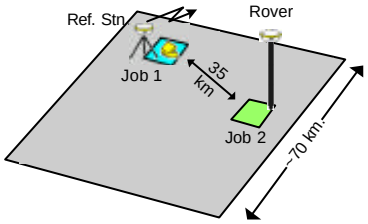

Figure 8: Surveyor B completing Job 2, with base station setup at Job 1

In this case, by increasing the distance between the rover and the reference to 35 km, there would be an associated decrease in accuracy of the rovers computed position. Therefore, Surveyor B would be sacrificing accuracy in favour of saving time on the setting up of the base station.

Surveyor B would also have the additional step of collecting the base station before returning to work.

SUMMARY

By not needing to setup a base station, Surveyor A had a lot less work to do in the field than Surveyor B. In addition, Surveyor A avoided potential risks such as:

- The base station battery going flat.
- The base station radio battery going flat.
- The base station being moved (e.g. cattle, wind, traffic… or thieves!).

Surveyor B could have setup and packed up their base station twice, or simply left the base station at the first setup – sacrificing accuracy for convenience

In contrast, by using *SmartNet UK*, Surveyor A could achieve consistent accuracy for both jobs. No sacrifices were made.

REMEMBER

- By not needing to setup your own base station, it is possible save time and money, both in the field and in the office.
- RTK Networks are constantly being established in an increasing number of countries – to find out if an RTK Network is in your area, then please contact your local Leica sales representative
- More information on RTK Networks can be found on:

  http://www.leica-geosystems.com/corporate/en/products/gps_systems/lgs_4229.htm

- The next Newsletter will describe in detail the different methods of Network RTK, including MAX, i-MAX, FKP and Virtual Reference Station.

Please contact your local Leica representative if there are specific topics you would like covered in these newsletters.

We welcome all suggestions for TPS1200, GPS1200, specific applications or LGO. We look forward to receive your ideas.