Traditional GNSS RTK compared to Network RTK Solutions

Presenter: David Twaddle
Role: National Technical Support

Bsc Mine & Engineering Surveying
Authorised Grade One Mine Surveyor
CR Kennedy

- 80 Years Operating History in Australia
- National Company
- Distributor of Leica Products for Australia

- VIVA
- NOVA
- CAPTIVATE

New Release Leica GNSS Unlimited
- Full Satellite Capability
- IP68 Rated
- Smart Track
- Smart Check
- Smart Link
- X-RTK
CR Kennedy

- Machine Control and Automation
- Full Range of CI Products
- Digital Levels and Leica / Riegl Scanners
- UAV Fix Wings and Multi-Copter Options
- New Local Product Launch in June
What are we Talking about today?

Traditional RTK Survey vs RTK Network Survey

- Look at two methods of RTK Survey
- Look at Field Procedure of Typical Situation
- Look at Errors within RTK Surveying
- What Options do we have with Network Methods?
Traditional RTK

GNSS Base and Rover

- Uses a GNSS Base placed locally
- RTK Corrections are transmitted
- Typically via UHF or Spread Spectrum Radios
Typical Field Procedure

1. Turn up on Site
2. Find a Secure Site (probably known mark) to setup Base
3. Setup Base
4. Setup Rover
5. Check communications between Base & Rover (Radio Link)
6. Measure Job
7. Go back to Base Setup
8. Check Setup has not been disturbed
9. Pack up Base
10. Pack up Rover
11. Return to Office / Continue to next job
Traditional RTK

GNSS Base and Rover

Disadvantages of this Method

- Location
  - Finding a Secure site to Setup a Base
- Missing Pieces
  - Realising something is missing (Battery, Cables, Antenna)
- Battery at Base goes Flat
- Radio Range too Short
- Radio Signal not Present at All!
- Base Position is Compromised AFTER job is measured
- Pieces missing from the base setup
- EVERYTHING goes missing from the base setup!
- Am I limiting myself / What are my Checks?
- Am I using all of the Satellites Available?

-$$$$
Issues with RTK

Error Influences:

- Satellite clock error $\delta_{\text{sat\_clock}}$
- Satellite orbit error $\delta_{\text{orbit}}$
- Ionosphere $\delta_{\text{iono}}$
- Troposphere $\delta_{\text{tropo}}$
- Multipath $\delta_{\text{mpath}}$
- Antenna PCV $\delta_{\text{PCV}}$
- Receiver clock error $\delta_{\text{rec\_clock}}$
- Receiver Bias $\delta_{\text{biases}}$
Issues with RTK

RTK Errors – Distance Dependant Errors

- The further we get away from the point we are using to determine the errors, the less those errors hold true

- Typical RTK accuracies are 10mm + 1ppm

- Typical results
  - 5km Baseline: 15mm
  - 10km Baseline: 20mm
  - 30km Baseline: 40mm
  - Vertical 1½-2 Times Greater

Satellite Availability Under Utilised

- Existing Base Station may be GPS Only
Issues with UHF RTK - Usage Density & Licensing
Issues with RTK

RTK Delivery – UHF Licensing

- With the ACMA revised 400MHz Schema, UHF licences in High Density Zones have reduced output power and bandwidth.

- By 2015, all Area Wide licences will be on one of 10 x 12.5KHz or 4 x 25.0KHz Channel spaced frequencies, Nationally.

- UHF Licence fees will only rise. ACMA have stated they want people out of the 400MHz spectrum

- Alternatives are 900MHz Spread Spectrum or 3G connections.
Network RTK

GNSS CORS Network

- Lets look at the “New” RTK Alternative
- Network RTK is utilising one or more Continuous Operating Reference Stations (CORS) to provide RTK data to the GNSS Rover.
- For my Company it is called Smartnet
Network RTK

GNSS CORS Field Procedure

Typical situation

1. Turn up on Site
2. Setup Rover
3. Connect to RTK service via Internet (eg.SIM card)
4. Measure job
5. Pack up rover
6. Return to office / next job
Network RTK

What is Currently Available?
Creating a CORS Network

- To build a successful CORS Network, firstly you need the CORS themselves.
- SmartNet Aus is a mixture of Federal, State and Privately owned infrastructure.
- New Users build the Network and Reap the Benefits
- Is not Manufacturer Specific
- RTCM Format
Network RTK

Background of a CORS Network Solution

- Survey Practices tell us we need reliability & redundancy
- Network is Built on consistent Datum / Datum's
- REG13 Values provided by GeoScience Australia
- RTCM selected as Format of Choice
Network RTK

Background of the CORS Network Solution?

– It needs a Two Way Communications System
Network RTK

Background of the CORS Network Solution?
Network RTK – My Options

- **Single Base RTK Products**
  - Individual Base
  - Nearest Base
  - Virtual Reference Station

- **Network RTK Products**
  - MAX & MAC
  - iMAX
Network RTK – My Options

•Individual Base
  ▪ User Selects a data stream from a nominated Base.
  ▪ No matter where the Rover is, it receives the RTK data from the same Base.
Network RTK – My Options

• Nearest Base
  - User connects to the server & uploads the Rover location
  - The nTrip Server will provide data from the closest Base Station
Network RTK – My Options

• **Virtual Reference Station**
  - User connects to the server & uploads the Rover location
  - The nTrip Server will create a Virtual Reference Station and provide the data to the Rover

The Virtual Reference Station solution utilises proprietary algorithms to calculate the Single Base RTK corrections
Network RTK – My Options

• MAX & MAC Solutions
  - MAX – Master Auxiliary (Solution by Leica Geosystems)
  - MAC – Master Auxiliary Concept (As adopted by RTCM)

The Difference?
Nothing. It is purely a naming convention.
Network RTK – My Options

• MAX & MAC Solutions
  - Solution is sent to the server at the upload of the Rover location
  - The rTrip server determines the RTK Master from the Master Auxillary and additional differences from the Auxillaries
  - Distance Dependant Errors are reduced
  - No re-initialisations due to new VRS
Network RTK – My Options

• iMAX Solutions
  ▪ User connects to the server & uploads the Rover location
  ▪ The nTrip Server provides corrected Single Base data from the Master Site
  ▪ Distance Dependant Errors are reduced
  ▪ No re-initialisations due to new VRS
  ▪ The iMAX solution utilises proprietary algorithms to calculate the Single Base RTK corrections
Network RTK - Reliability

- What is the Accountability of these methods?
- Well...traditional Survey Wisdom states we need to be able to directly measure and remeasure the baseline.

<table>
<thead>
<tr>
<th>Correction Type</th>
<th>Traceability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Base</td>
<td>Yes</td>
</tr>
<tr>
<td>Nearest Base</td>
<td>Yes</td>
</tr>
<tr>
<td>Virtual Reference Station</td>
<td>No</td>
</tr>
<tr>
<td>MAX &amp; MAC</td>
<td>Yes</td>
</tr>
<tr>
<td>iMAX</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Network RTK

Is it all Roses?

- We still have some Distance Dependant Errors

<table>
<thead>
<tr>
<th>Correction Type</th>
<th>Distance Error Minimised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Base</td>
<td>No</td>
</tr>
<tr>
<td>Nearest Base</td>
<td>No</td>
</tr>
<tr>
<td>Virtual Reference Station</td>
<td>Yes</td>
</tr>
<tr>
<td>MAX &amp; MAC</td>
<td>Yes</td>
</tr>
<tr>
<td>iMAX</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: VRS, the further you move from the VRS the less the errors are minimised.
Network RTK

Benefits of Network RTK

- Save on cost of Base Station for RTK – only Rover needed
- Increase RTK coverage using entire network
- Avoid radio licensing issues UHF – using Internet instead
- Consistent co-ordinate and Satellite Systems
- Flexible data formats – Manufacturer Independent
- Accountability – 24 Hours a Day with Rinex Logging
- Annual Subscription – easy to budget, no obligation to renew (National, State & Site Specific)
- National Service – don’t need license per state
- CORS owners – incentives to invest / host
Network RTK

Issues

- Coverage
Network RTK

Issues

- Internet and 3G Coverage
## RTK Summary

### Comparisons

<table>
<thead>
<tr>
<th>Correction Type</th>
<th>Traditional Base RTK</th>
<th>CORS Single Base RTK</th>
<th>CORS Network RTK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quickly Setup and Start Surveying</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reduces Start Up costs to purchase an RTK system</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Minimises Distance Dependant Errors</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Consistency in Datum (eg: Setup error)</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Traceability</td>
<td>✓</td>
<td>✓</td>
<td>✓ (excl VRS)</td>
</tr>
<tr>
<td>Can be used outside of CORS coverage areas</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>
## RTK Summary

### Comparisons

<table>
<thead>
<tr>
<th>Correction Type</th>
<th>Traditional Base RTK</th>
<th>CORS Single Base RTK</th>
<th>CORS Network RTK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doesn’t Rely on 3G Coverage</td>
<td>✓ / ✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Not affected by UHF Licencing and Narrowbanding</td>
<td>✓ / ✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Licence Fees for UHF Radios</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Subscription Fees to CORS Service Provider</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Thank You.
David Twaddle
National Technical Support
CR Kennedy & Co.
dtwaddle@crkennedy.com.au