Advances in GNSS-RTK for Structural Deformation Monitoring in Regions of High Ionospheric Activity

Chris Rizos, Professor & Head, School of Surveying & Spatial Information Systems UNSW
Sydney, NSW, 2052, Australia
Joël van Cranenbroeck, Business Development Manager - Geodetic Monitoring
Leica Geosystems AG, Switzerland – Heerbrugg, GSF – EMEA
Vincent Lui, Sales Manager of GNSS, BA Engineering and Taiwan Region
Leica Geosystems Ltd, Hong Kong SAR

GNSS technology is being extensively used for monitoring the movement of engineering structures such as bridges, tall buildings, dams, breakwaters, etc. Large structures increasingly have one or more GNSS receivers installed on them, and this trend is expected to continue unabated.

GNSS RTK for Monitoring Applications Challenges

However, the distance between the GNSS monitoring stations and the GNSS base station must be kept as short as possible for achieving high accuracy. There is a risk that even the GNSS base station could be located in the area subject to deformation.

But the single RTK results that are processed even if the noise is scaled down by the short distance between the GNSS base station and the GNSS monitoring receivers still contain biases from the remaining un-modelled atmospheric corrections.

Projects located in the low latitude band can be compromised with high and unpredictable ionosphere turbulences in the afternoon period of time. In that case the time series are difficult to be correctly interpreted. Is that a noise or a signal?
Distance Dependency

Master Station(s) in N-RTK MAC

GNSS N-RTK: Derived Observation Corrections

Phase and Code Corrections

Residuals are used to derive an interpolation model

Typically ~ 80 km

Practical Limit of RTK

With a GNSS Network RTK (interpolation & extrapolation) no more distance dependency. The choice of the Master Station can be any Reference station selected within the cell.
Practical trial in Hong Kong, PR China
Seawall Monitoring, CEDD Ports Work

Objectives:
- Ensure safety of seawalls in HK
- Total 120 km seawalls in HK
- Monitoring by traditional manual methods are time consuming and manpower involved with human life risk in typhoon periods.
- Real-time displacement presentation
- Multiple levels auto alert
- Fully automatic, day and night, 24/7

Center of Seawall Monitoring System Diagram

Centralized GNSS Processing Strategies
Real Time from 1Hz up to 20Hz
Leica Geosystems GNSS stations for monitoring Seawall infrastructure in Hong Kong, PR China

Hong Kong, PR China is located at 22°16’ latitude North and then in the low latitude band where in the afternoon the ionosphere is severely altering the GNSS signals. Accuracy and Ambiguities fixing are not guaranteed.

Reference Station Data from HK SatRef Network
Own by the HK Lands Dept
FIG Congress 2010
Facing the Challenges – Building the Capacity
Sydney, Australia, 11-16 April 2010

### Leica GNSS SpiderNET for Network RTK
Processing in Real Time L1 & L2 GPS data

Leica GNSS SpiderNET is processing a chain of 6 Reference Stations and is deriving the MAX corrections for the cell composed of all those stations.

The Master station is the station previously used for processing the monitoring stations in the Single RTK mode.

### Leica GNSS Spider Site Server Positioning option
Processing in Real Time L1 & L2, L1 only GPS data

Leica GNSS Spider Site Server with the Positioning option allows the operator to process any combination of baselines between the reference stations and the monitoring stations by using L1 & L2 or L1 only and by using different strategies to solved the ambiguities in real time.

The different baselines are processing using the Single RTK mode and the MAXMoM mode (MAX corrections issues of the SpiderNET Server)
The combination of GNSS Network RTK resources delivers outstanding advantages …

**Maximum (unbiased) accuracy and reliability!**

- Better control over the operations and the results by taking advantage of installed CORS infrastructure.
- Reliable time series solutions for projects located in low latitude regions where the ionospheric turbulences severely affect signal and data processing.
- The possibility to mix dual-frequency receivers (GNSS CORS) with affordable single-frequency receivers for slow deformation motion monitoring.
- No need for subsequent networked baseline adjustment.
- No need to establish simple CORS in urban areas (obstructions) for high rise building or long bridge monitoring projects.

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Although implemented for a trial in Hong Kong, the authors believe that with the return of high solar cycle activity the proposed mixed-mode solution strategy could find application in many other places than only those currently exposed to severe ionospheric disturbances (i.e. low latitude regions).
Many thanks for your attention

Chris Rizos, Joël van Cranenbroeck and Vincent Lui
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