Comparative analysis of GNSS Real Time Kinematic methods for navigation

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Introduction
Some Applications

Road management
Infrastructure Monitoring

Mobile mapping systems
Real Time Land Delimitation
Introduction
Road sector

• **Smart mobility applications:**
  – Navigation.
  – Fleet management.
  – Satellite road traffic monitoring services.

• **Safety-critical applications:**
  – GNSS positioning with information from other sensors and communication technologies.
  – Dangerous goods tracking.

• **Liability applications:**
  – In Road User Charging based on the actual use of the roads and in managing congestion control.
  – Insurance telematics: fairness of insurance for both insurers and subscribers.

• **Regulated applications:**
  – Accelerating emergency assistance to drivers.
  – Enhanced digital tachographs leverage GNSS positioning.
Introduction

GNSS Market - Roads

Source: GSA (2015)

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Introduction
National Strategy & Accomplishment

- **GNSS permanent stations**
  Many agencies are deploying Permanent stations:
  - Research & applications in Geodesy, Surveying and Mapping, construction: ANCFCC.
  - Meteorology, Water Vapor estimation: DMN.

- **Geodetic Infrastructure**
  - Implementation of a new homogeneous geodetic reference frame using GNSS and attached to ITRF (9158 points).
  - Modernization of the geodetic infrastructure.
  - More than 30,000 new geodetic points.
  - More than 7820 New Markers determined using High precision leveling (~13,400 km).
Introduction
IGS Real-Time Service

Real-time Service

The International GNSS Service (IGS) has ensured the availability of open access, high-quality GNSS data products since 1994. These products enable access to the definitive global reference frame for scientific, educational, and commercial applications—a tremendous benefit to the public.

Through the Real-time Service (RTS), the IGS extends its capability to support applications requiring real-time access to IGS products. RTS is a GNSS orbit and clock correction service that enables precise point positioning (PPP) and related applications, such as time synchronization and disaster monitoring, at worldwide scales. RTS is based on the IGS global infrastructure of network stations, data centers and analysis centers that provide world standard high-precision GNSS data products.

The RTS is currently offered as a GPS-only beta service for the development and testing of applications. The Russian GLONASS is initially provided as an experimental product and will be included within the service when the RTS reaches its full operating capability at the end of 2015. Other GNSS constellations will be added as they become available.

This service is made possible through partnerships with Natural Resources Canada (NRCan), the German Federal Agency for Cartography and Geodesy (BKG), and the European Space Agency’s Space Operations Centre in Darmstadt, Germany (ESASOC). Support is provided by 160 station operators, multiple data centers, and 10 analysis centers around the world.

The RTS is operated by the IGS as a public service. Users are offered open and readily available access through subscription.
Experimentation: One-base RTK

- One-RTK is a differential GNSS technique which achieves performances in the range of a few centimeters.
- The technique is based on the use of carrier measurements and the transmission of corrections from the base station, whose location is well known, to the rover.
- The main errors that drive the stand-alone positioning cancel out.
- The base station covers an area of about 20 kilometers.
- A real time reliable communication channel is needed connecting base and rover.
- After the initialization time, the rover can continuously determine a precise position relative to the base station.

Spatial correlated errors can be effectively cancelled out only when the baseline length is not greater than about 20 km.
As baseline length increases iono and tropo errors decorrelate causing a decrease in accuracy, reliability and availability.

Error sources:
- Satellite clock error
- Satellite orbit error
- Ionosphere error
- Troposphere error
- Multipath
- Antenna PCV
- Receiver clock error
- Receiver Bias
Experimentation : N-RTK

- Real Time Network (RTN) surveying has been developed to extend the One-base-to-rover range limitation.
- In RTN a group of reference or base stations collect GNSS observations and send them in real-time to a central processing system.
- The central processor then combines the observations from a subset of the reference stations and computes a network solution.
- From this network solution the observation errors and their corrections are computed and broadcast to rovers.
- Several different approaches exist: the virtual reference station (VRS), master auxiliary concept (MAC), and Flächen Korrektur Parameter (FKP).

Advantages:
- Modeling GNSS errors over the entire network area
- Increased mobility and efficiency
- Quicker initialization times
- Extended surveying range
- Multiple users and Continuous operation
- Provide data and corrections in a consistent datum
- Wide exploitation for many applications: transport, engineering applications, agriculture, navigation.
Experimentation : RTK PPP

- PPP is a positioning technique that models GNSS system errors to provide a high level of position accuracy from a single receiver.

- A PPP solution depends on GNSS corrections, generated from a network of global reference stations. These corrections are calculated and then delivered to the end user via satellite or over the Internet.

- The receiver uses the corrections to obtain decimeter or centimeter level positioning with no base station required.

- A typical PPP solution requires a period of time to converge to decimeter accuracy: to resolve any local biases such as the atmospheric conditions, multipath environment and satellite geometry.

- The actual accuracy achieved and the convergence time required is dependent on the quality of the corrections and how they are applied in the receiver.

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Experimentation: Site & Hardware & Software

(Bani & ElKourk, 2016)
One-Base RTK

Base Station Receiver

PC  Serial

STRSVR

Internet

Rover Receiver

PC  Serial

RTKNAVI

File

Input = Serial
Output = TCP Server

Input Rover = Serial
Input Base Station = TCP Client
Output Solution = File
Network-RTK

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RTK-PPP

Real-time Orbit and clock Provider

NTRIP Caster

NRTK provider

Internet

Receiver

PC

Serial

RTKNAVI

Input Rover=Serial
Input Correction=NTRIP Client
Output Solution =File

File
Standard Point Positioning (SPP)
RTKLIB Configuration:
Example: RTK-PPP & One-Base-RTK

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Results: One Base-RTK

(1) First trajectory
(2) Second trajectory
Results: N-RTK

(1)

(2)

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Results: PPP-RTK

(1)

(2)

First trajectory
Second trajectory

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Results: SPP

(1) First trajectory

(2) Second trajectory
Results: Multi-path error

Trees and buildings effects
CONCLUSION

For Navigation:

• One-base-RTK: achieves the best performances in the range of a few centimeters (95%, < 30 cm). Relevant for limited area.

• N-RTK: Increased mobility (no need for temporary stations) & Extended surveying range (95%, < 50 cm).

• PPP-RTK: More time for convergence & Absolute positioning & Homogeneous positioning accuracy (95%, < 1 m). No constraint of range.

• SPP: Absolute positioning (95%, < 4 m). Low precision.

• Precision degradation in challenging conditions for all techniques.
Thank you for your attention
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