IAV Hassan II

CRASTE-LF

Comparative analysis of GNSS Real Time Kinematic methods for navigation

Mourad BOUZIANI

School of Geomatic Sciences, IAV Hassan II, Rabat, Morocco.

Coordinator of the Master - GNSS, IAV & CRASTE-LF, Affiliated to the United Nations.

Email : m.bouziani@iav.ac.ma

United Nations/Nepal Workshop on the Applications of GNSS

12 – 16 december 2016, Kathmandu, Nepal

Contents

Introduction

Some Applications

Road management

Infrastructure Monitoring

Mobile mapping systems

Real Time Land Delimitation

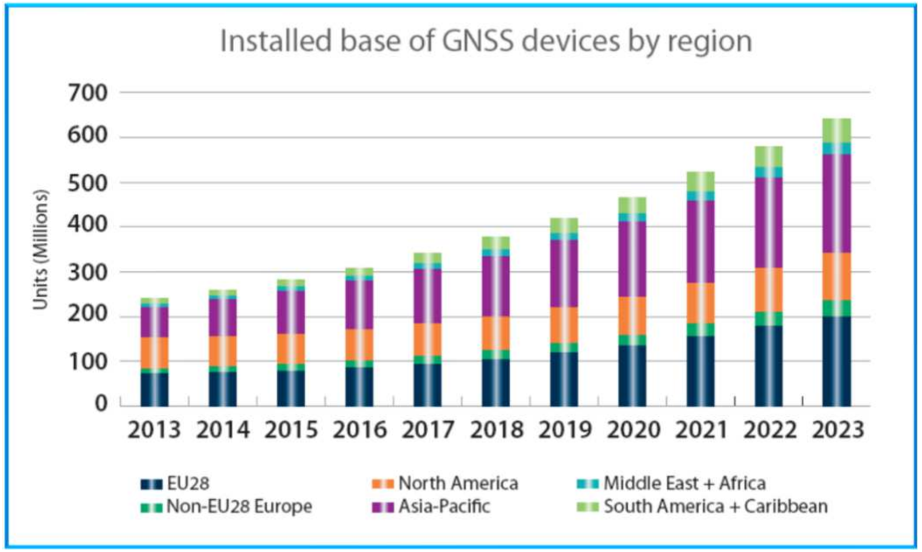
Introduction

Road sector

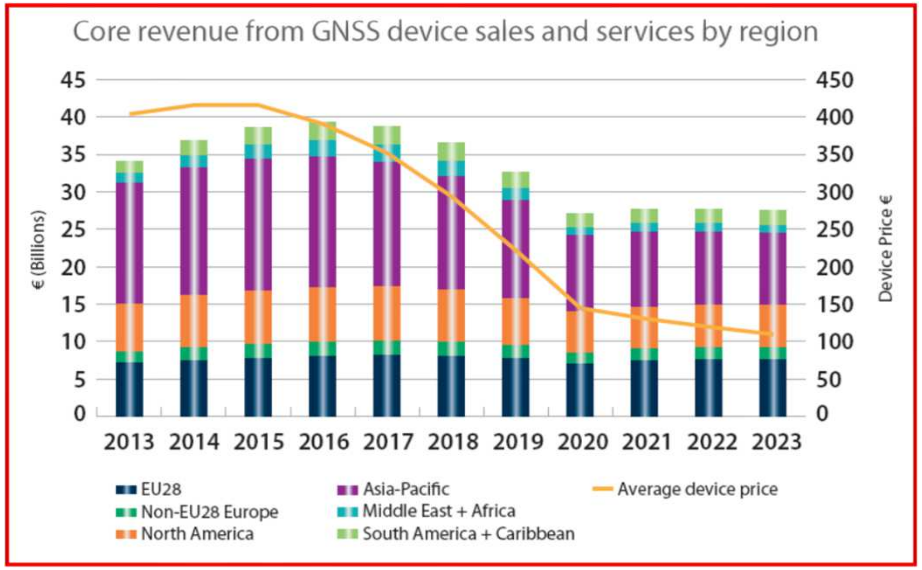
- **Smart mobility applications**:
  - Navigation.
  - Fleet management.
  - Satellite road traffic monitoring services.
- **Safety-critical applications:**
  - GNSS positioning with information from other sensors and communication technologies.
  - Dangerous goods tracking.
- **Liability applications:**
  - 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)



Source : GSA (2015)

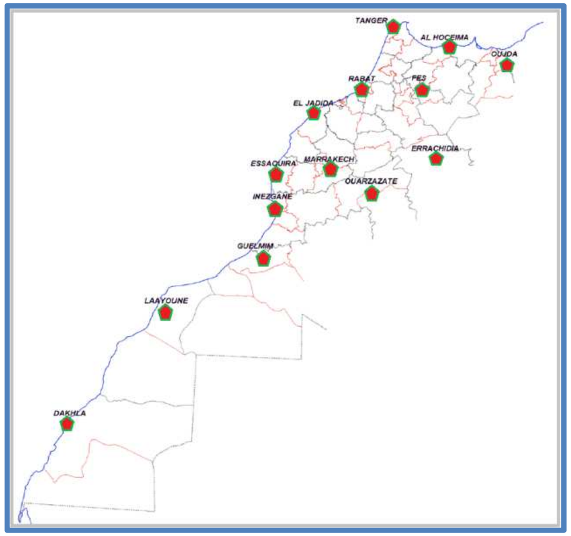
Introduction

National Strategy & Accomplishment

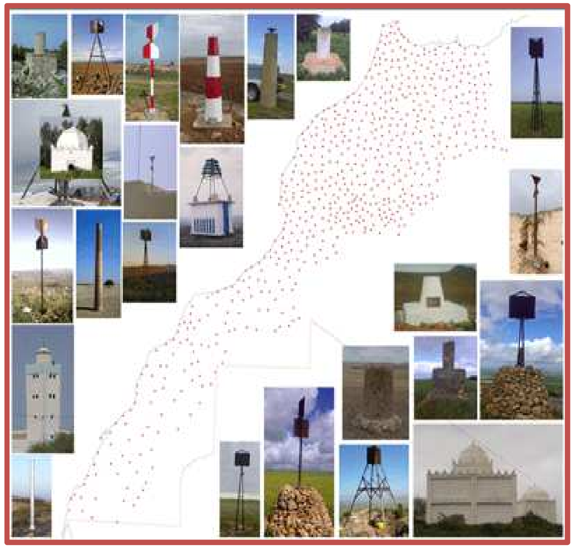
GNSS permanent stations

Many agencies are deploying Permanent stations :

- Research & applications in Geodesy, Surveying and Mapping, construction : ANCFCC.
- Applications and geodynamic research, monitoring of African and Eurasian tectonic plates, Space Weather : CNRST, UNAVCO, Universities.
- Meteorology, Water Vapor estimation : DMN.



ANCFCC PRS Network. Source : http://www.ancfcc.gov.ma/



ANCFCC Geodetic Network. Source : http://www.ancfcc.gov.ma/

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

IGS INTERNATIONAL GNSS SERVICE

Network Products Working Groups Resources About Search

Real-time Service

Network User Access Products Monitoring Contributors Information

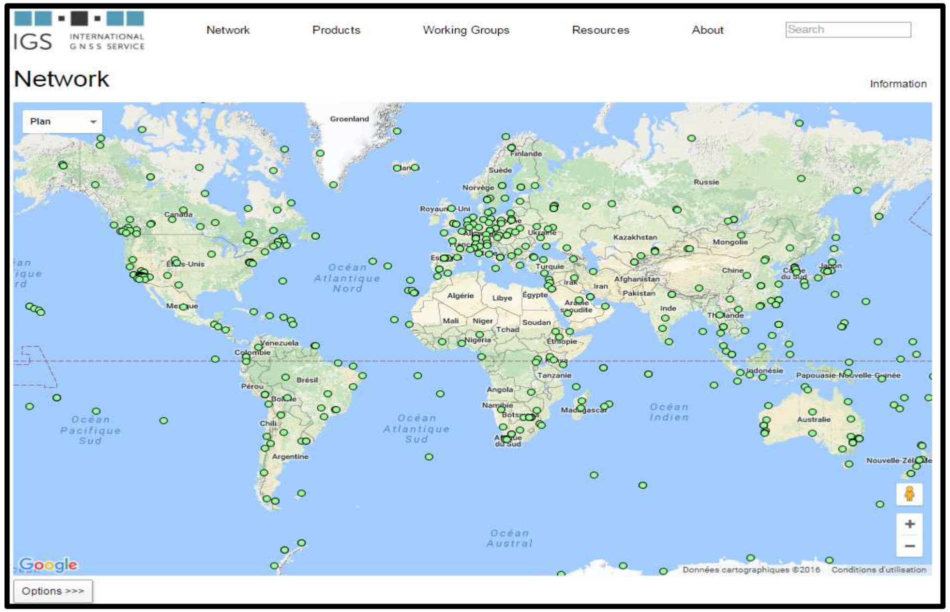
The International GNSS Service (IGS) has ensured the availability of open access, high-quality GNSS data products since 1994. These products enable access to the definitive global reference frame for scientific, educational, and commercial applications – a tremendous benefit to the public.

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.

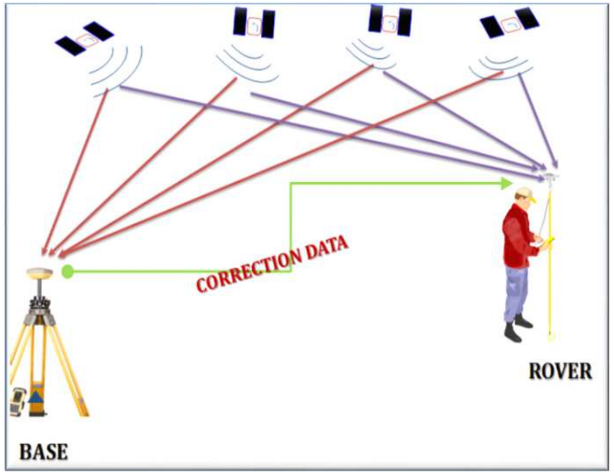
This service is made possible through partnerships with Natural Resources Canada (NRCan), the German Federal Agency for Cartography and Geodesy (BKG), and the European Space Agency's Space Operations Centre in Darmstadt, Germany (ESA/ESOC). Support is provided by 160 station operators, multiple data 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.



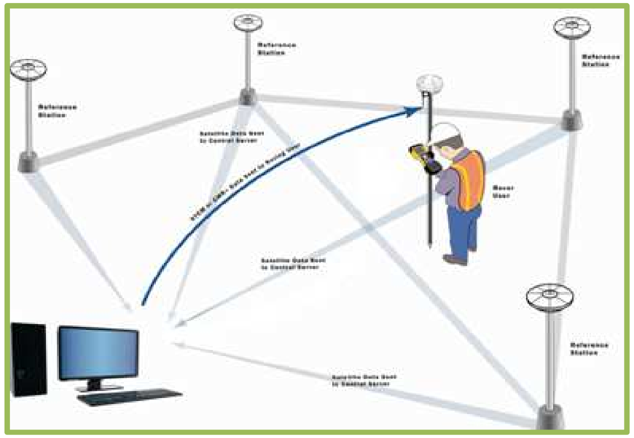
Error sources:
- Satellite clock error
- Satellite orbit error
- Ionosphere error
- Troposphere error
- Multipath
- Antenna PCV
- Receiver clock error
- Receiver Bias

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.

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).

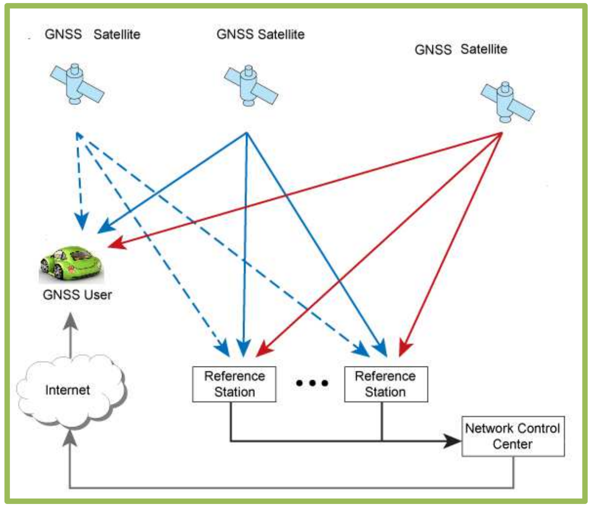


Advantages :

- 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.



- Precise positioning at a single station when precise satellite orbits and clocks are provided.

- Absolute positioning based on a sparse network.

- Homogeneous positioning accuracy on a global scale.

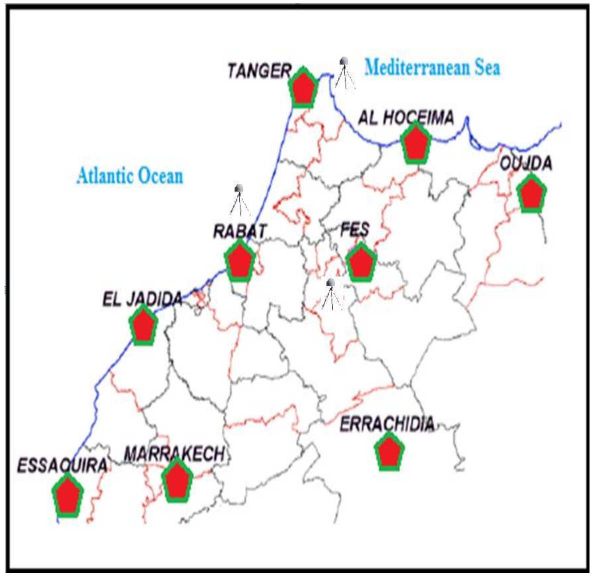
IAV Hassan II

CRASTE-LF

Experimentation : Site & Hardware & Software

(Bani & ElKourk, 2016)

EXPERIMENTATION SITE : IAV H2 CAMPUS



NETWORK _REFERENCE STATIONS

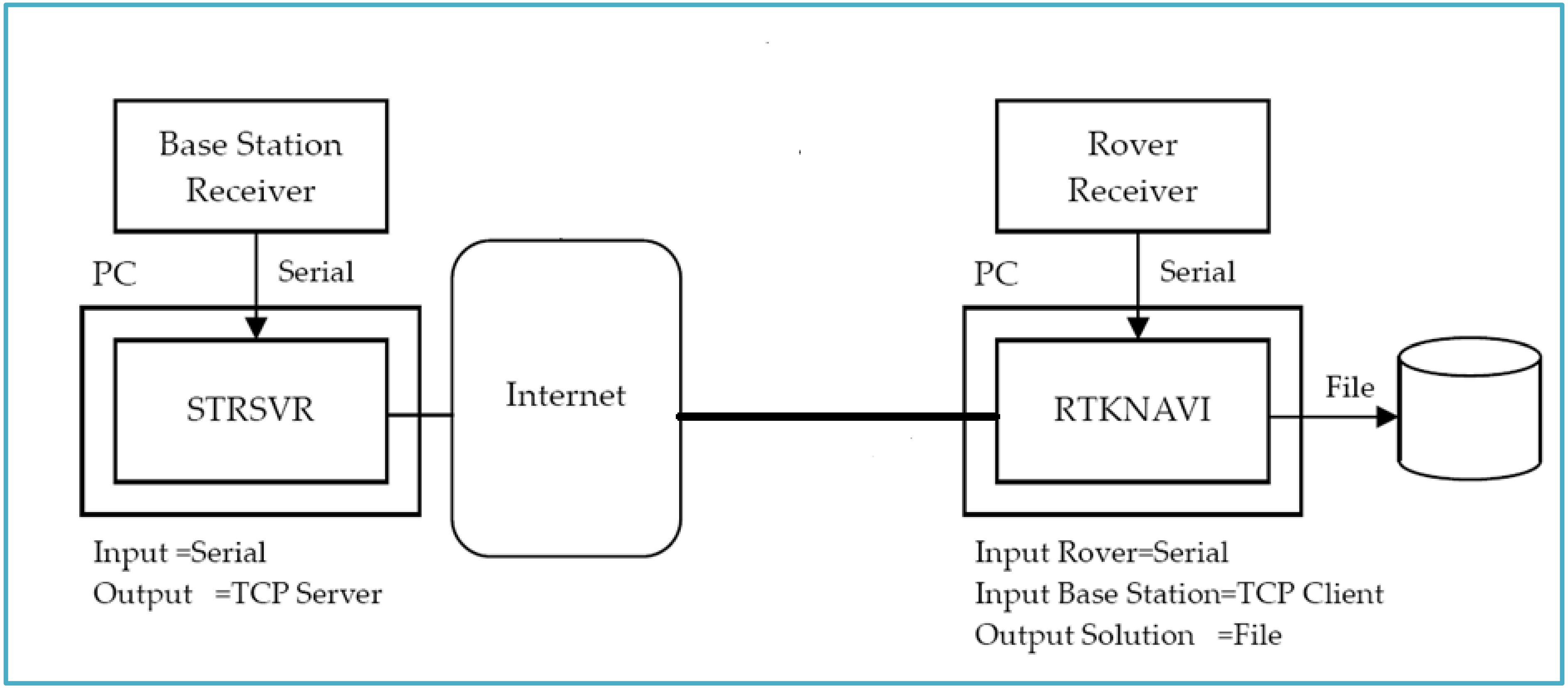
BASE

ROVERS

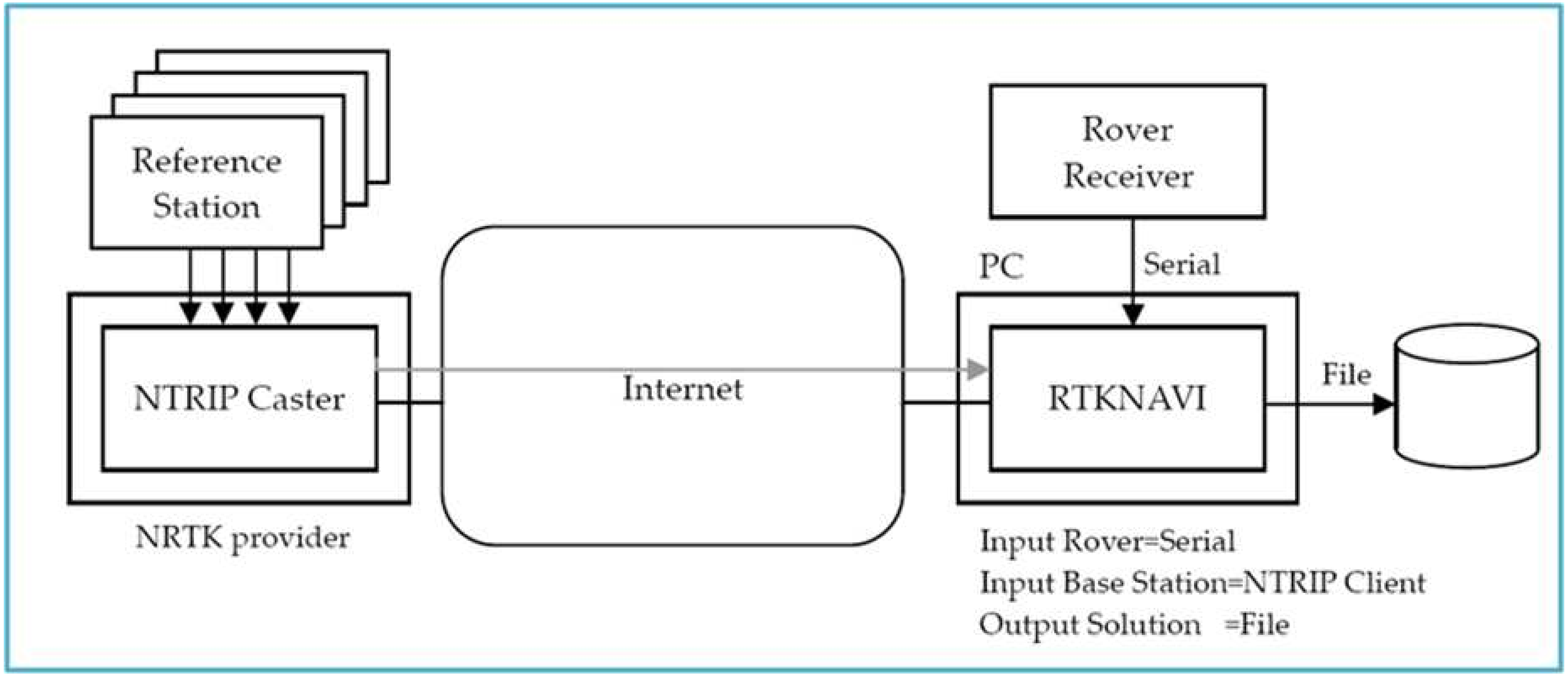
SOFTWARE

United Nations/Nepal Workshop on the Applications of GNSS, 12 – 16 december 2016, Kathmandu, Nepal

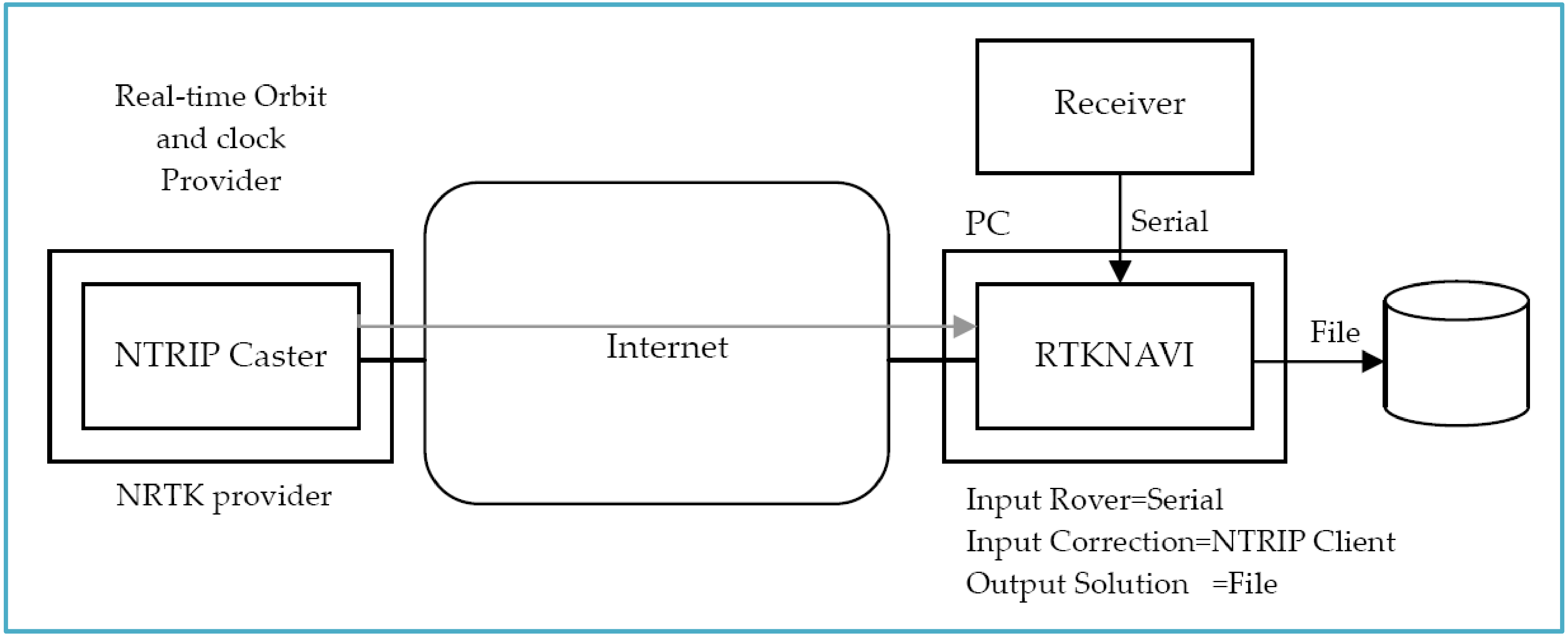
One-Base RTK


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

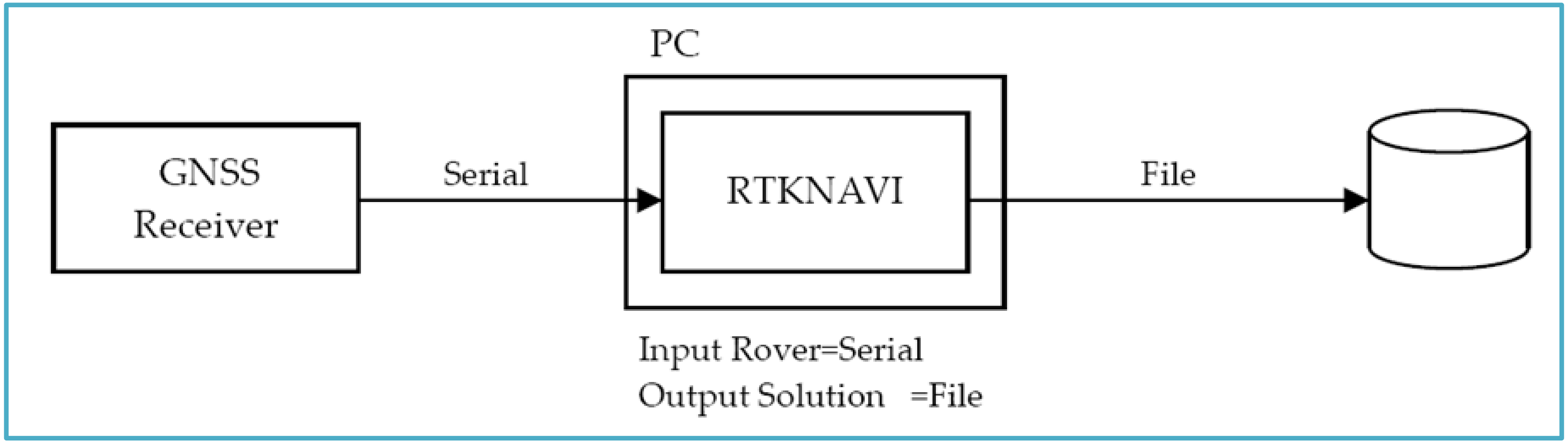
Network-RTK


Reference Station
NTRIP Caster
NRTK provider
Internet
Rover Receiver
PC
Serial
RTKNAVI
File
Input Rover=Serial
Input Base Station=NTRIP Client
Output Solution =File

RTK-PPP

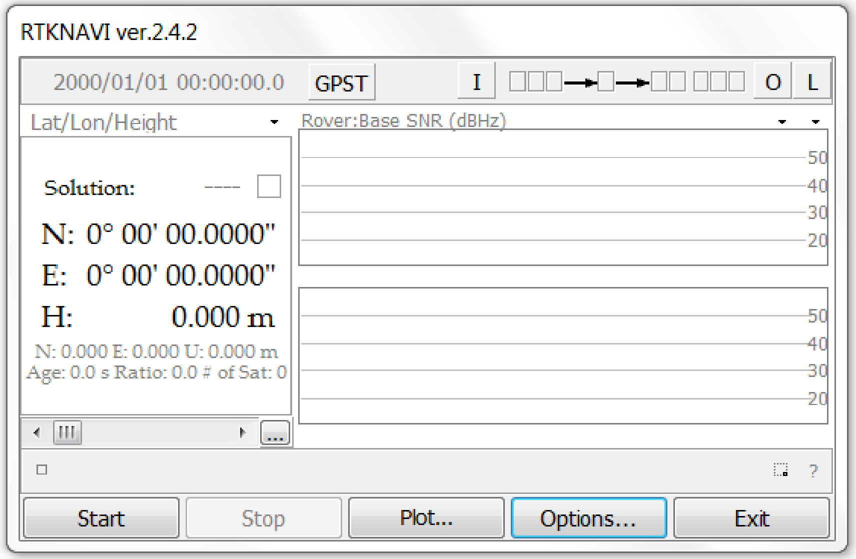

Real-time Orbit
and clock
Provider
Receiver
PC
Serial
NTRIP Caster
Internet
RTKNAVI
File
NRTK provider
Input Rover=Serial
Input Correction=NTRIP Client
Output Solution =File

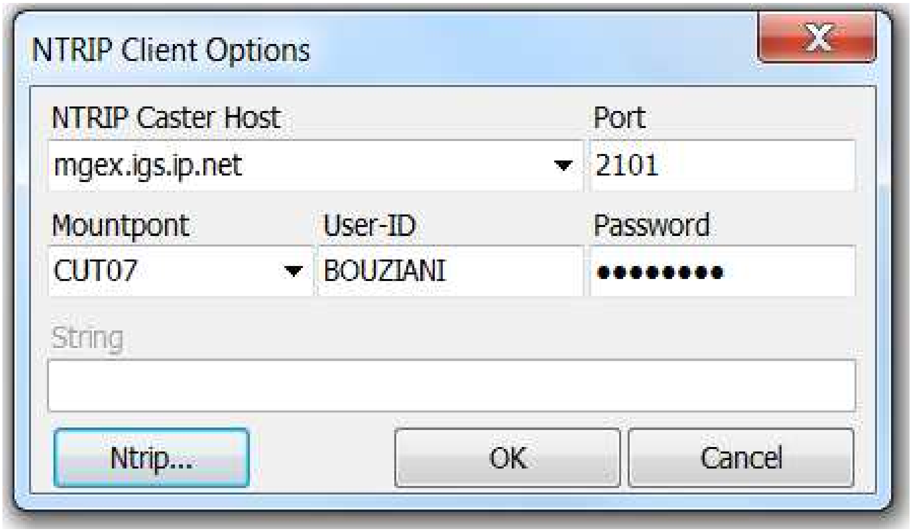
Standard Point Positioning (SPP)

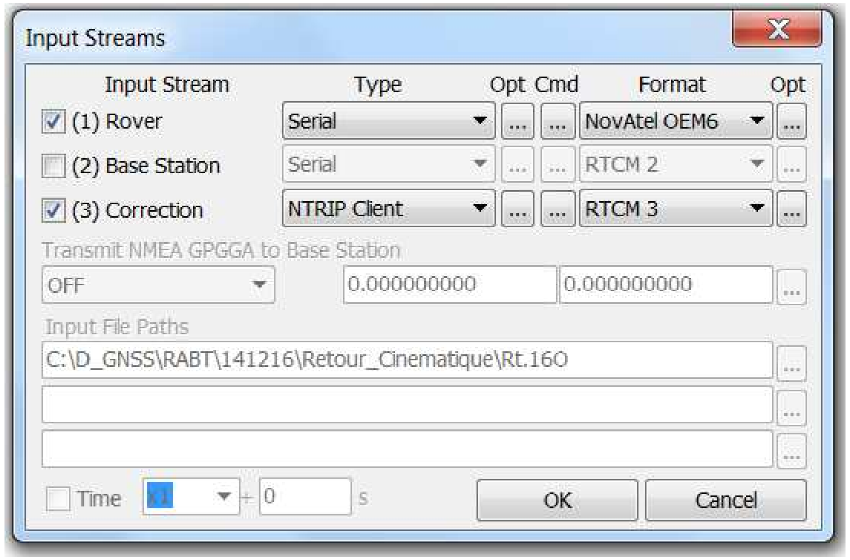


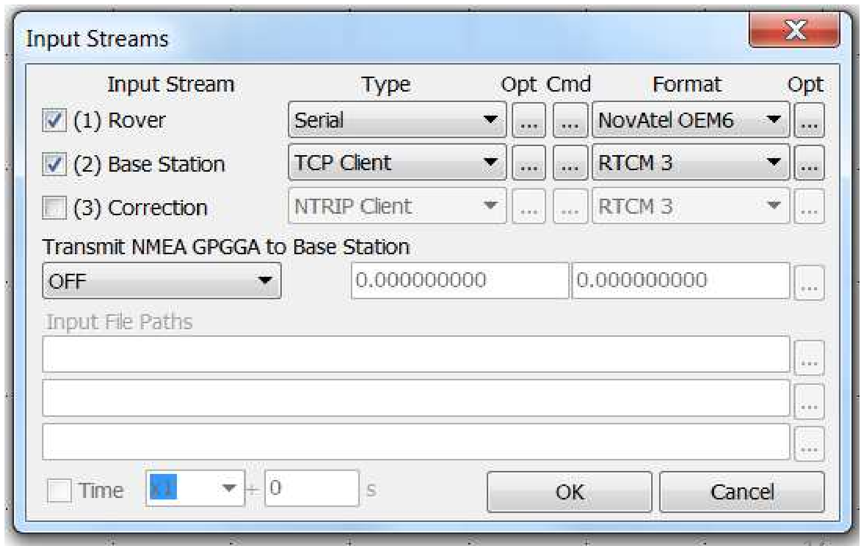
RTKLIB Configuration :

Example : RTK-PPP & One-Base-RTK



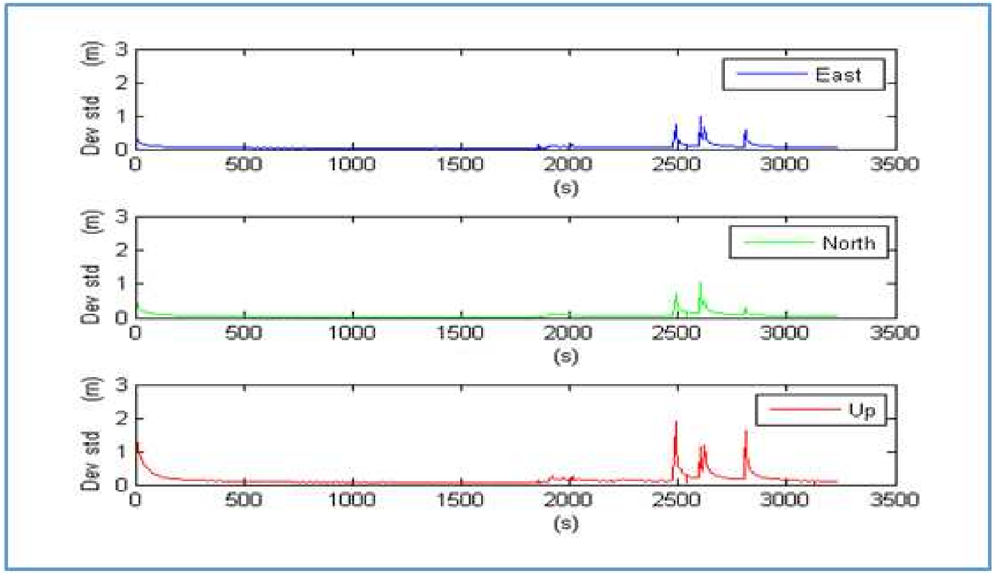




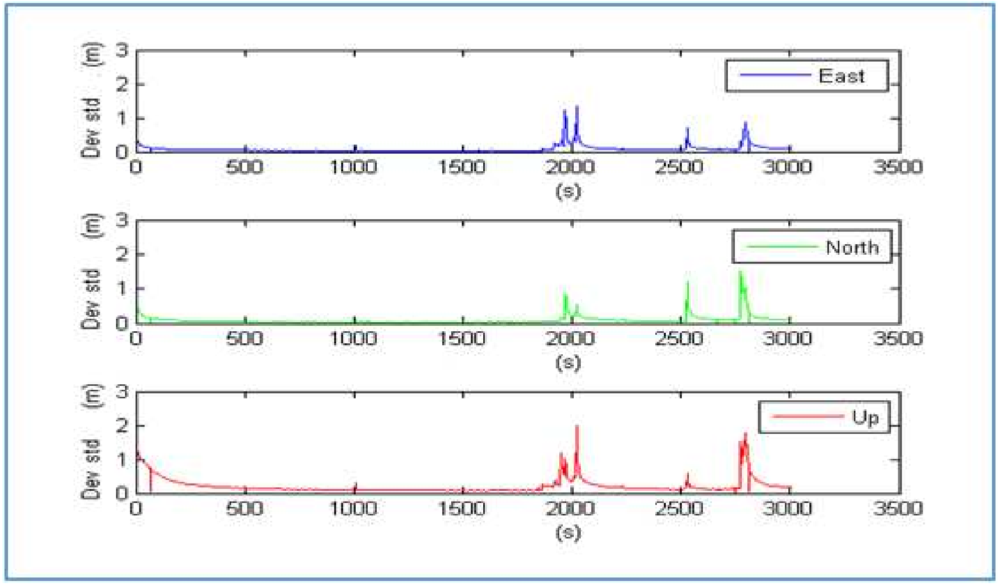


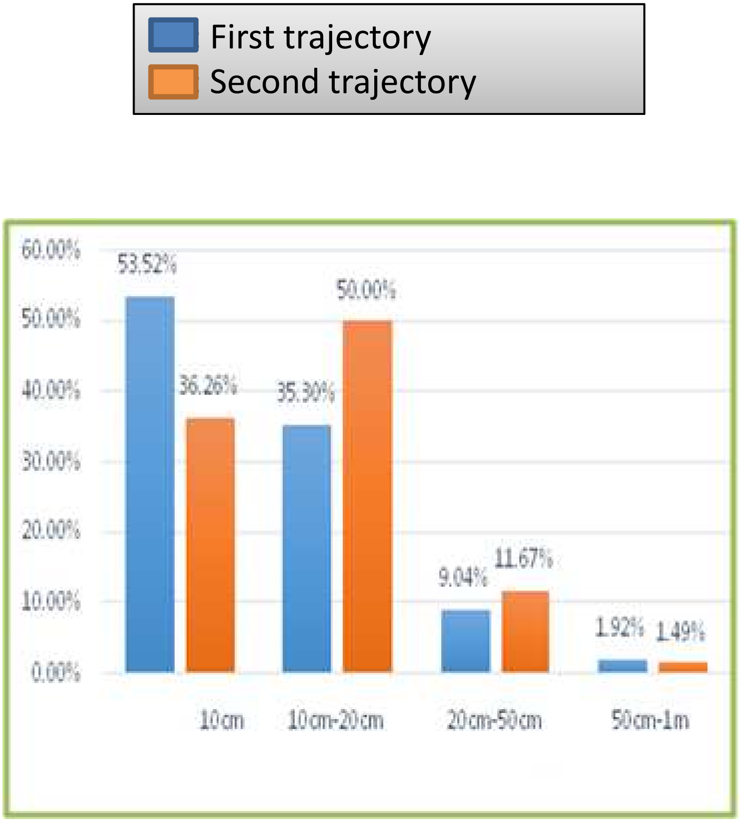
Results : One Base-RTK

(1)



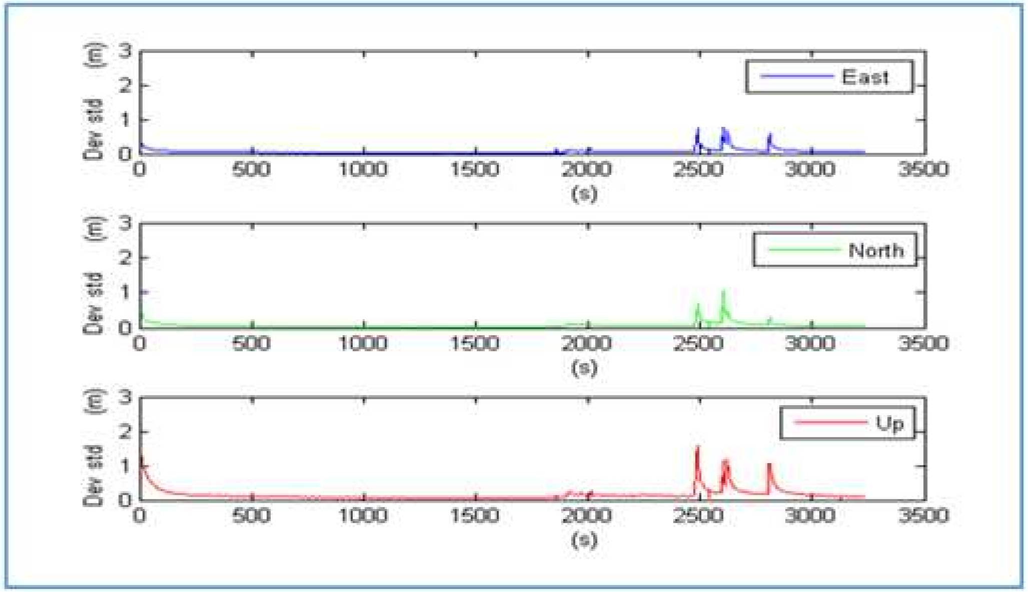
(2)



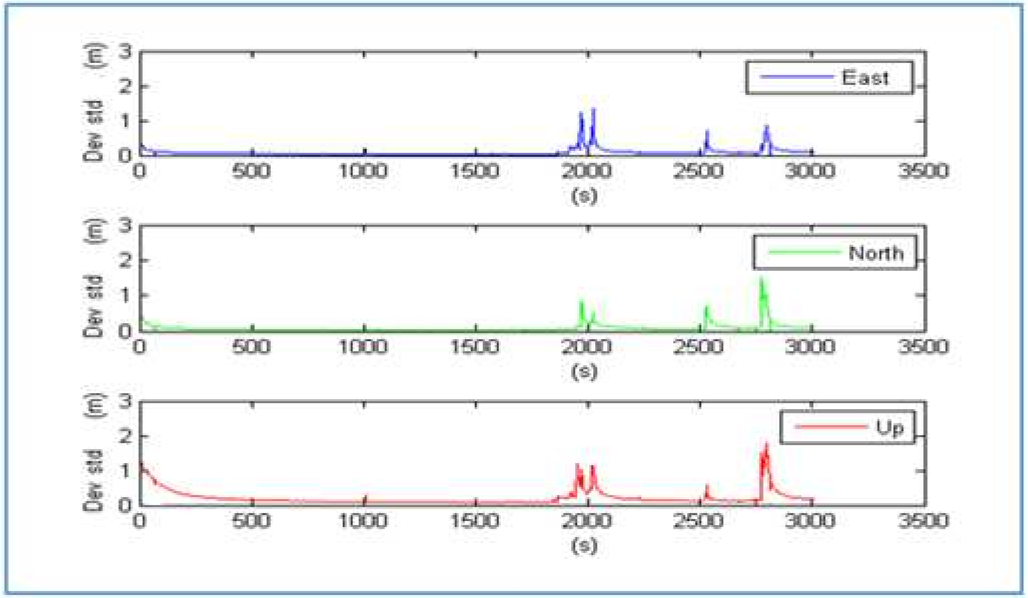


Results : N-RTK

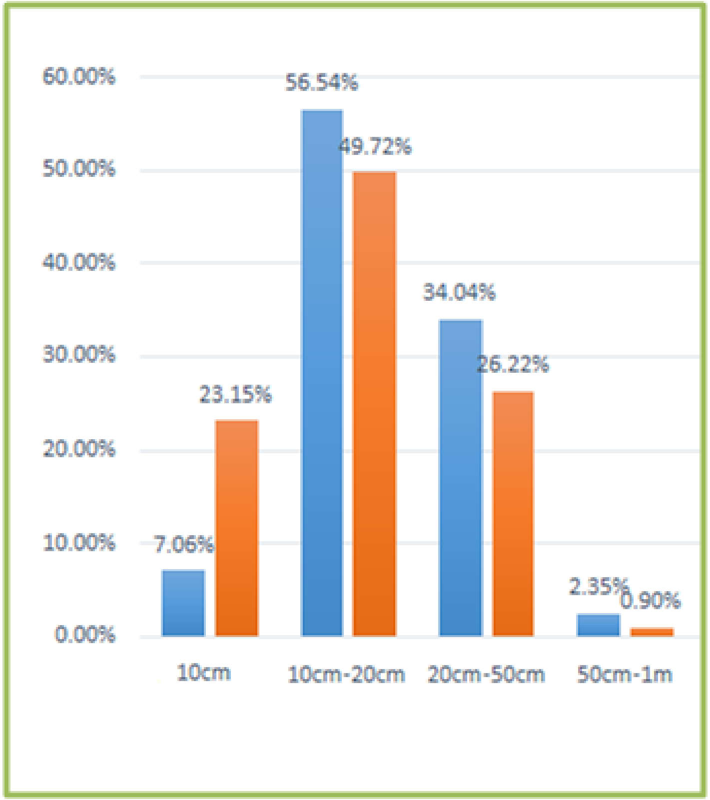
(1)



(2)



First trajectory
Second trajectory

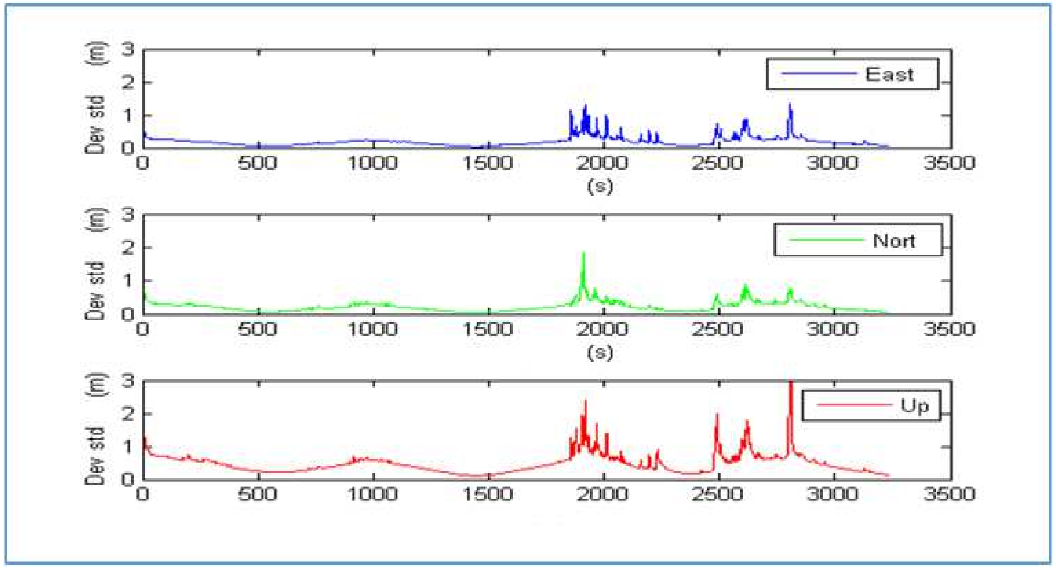


IAV Hassan II

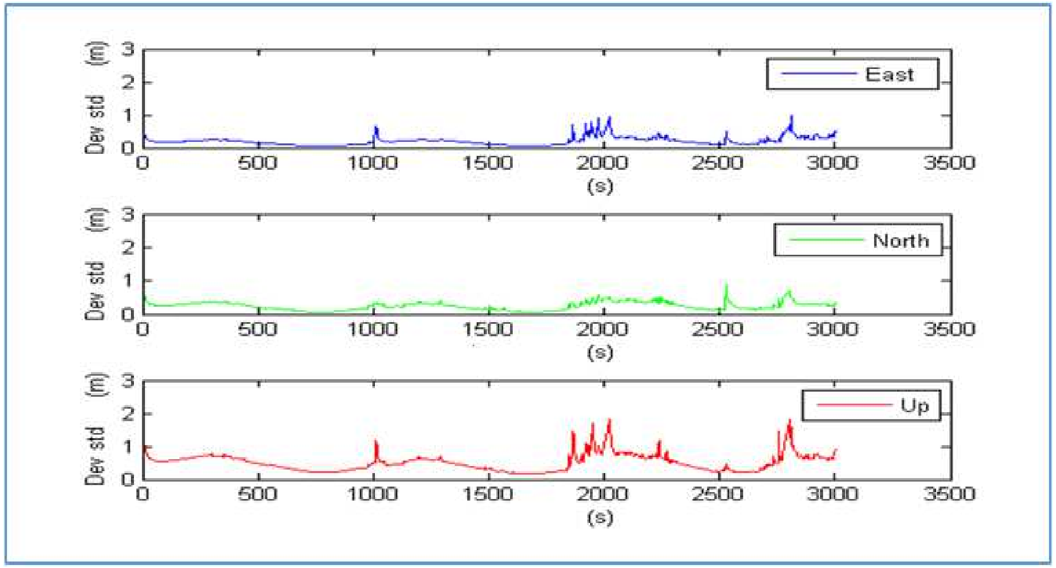
CRASTE-LF

Results : PPP-RTK

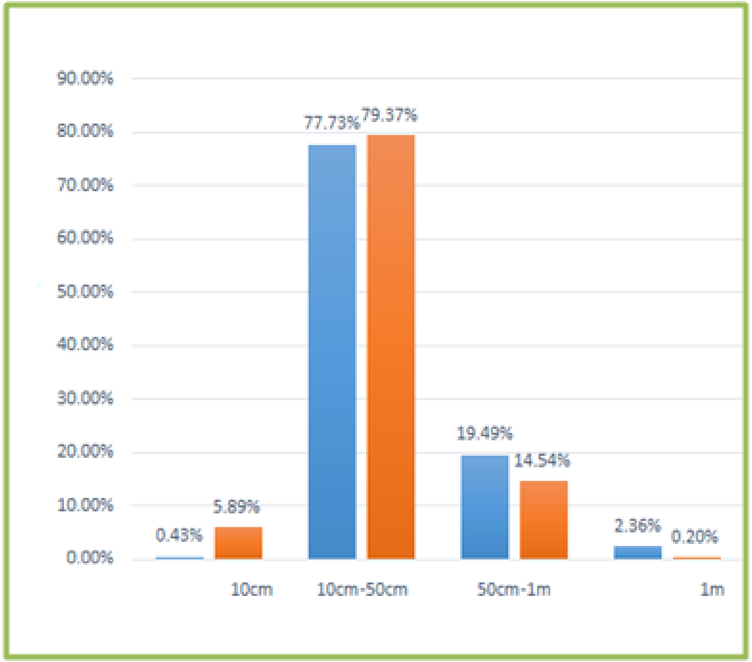
(1)



(2)



First trajectory
Second trajectory



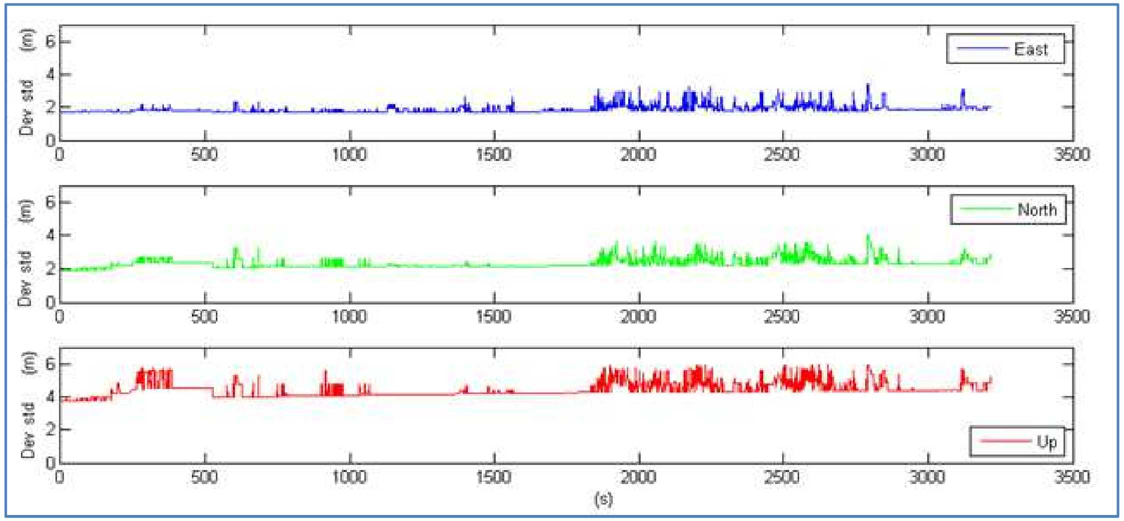
IAV Hassan II

CRASTE-LF

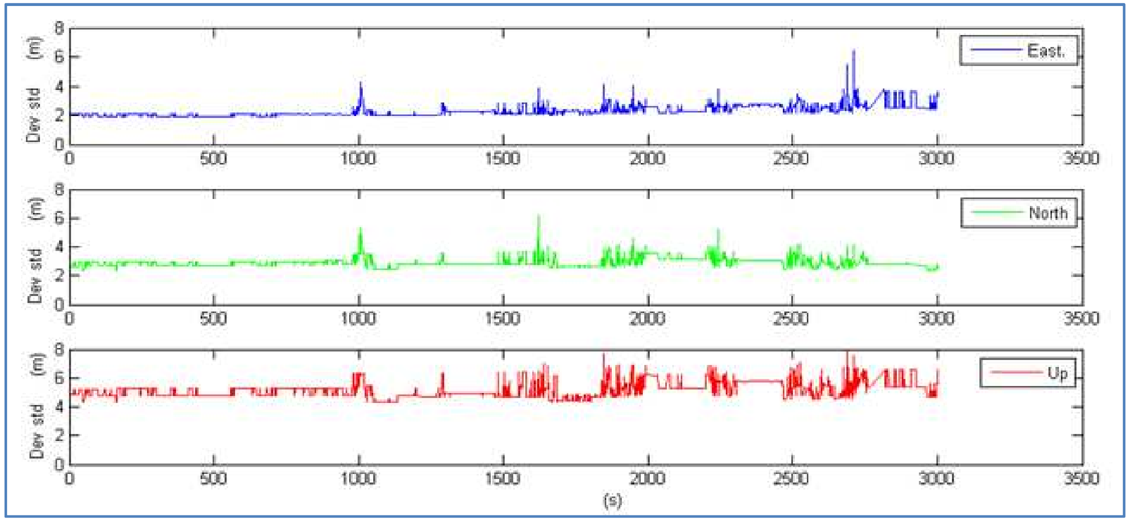
Results : SPP

First trajectory
Second trajectory

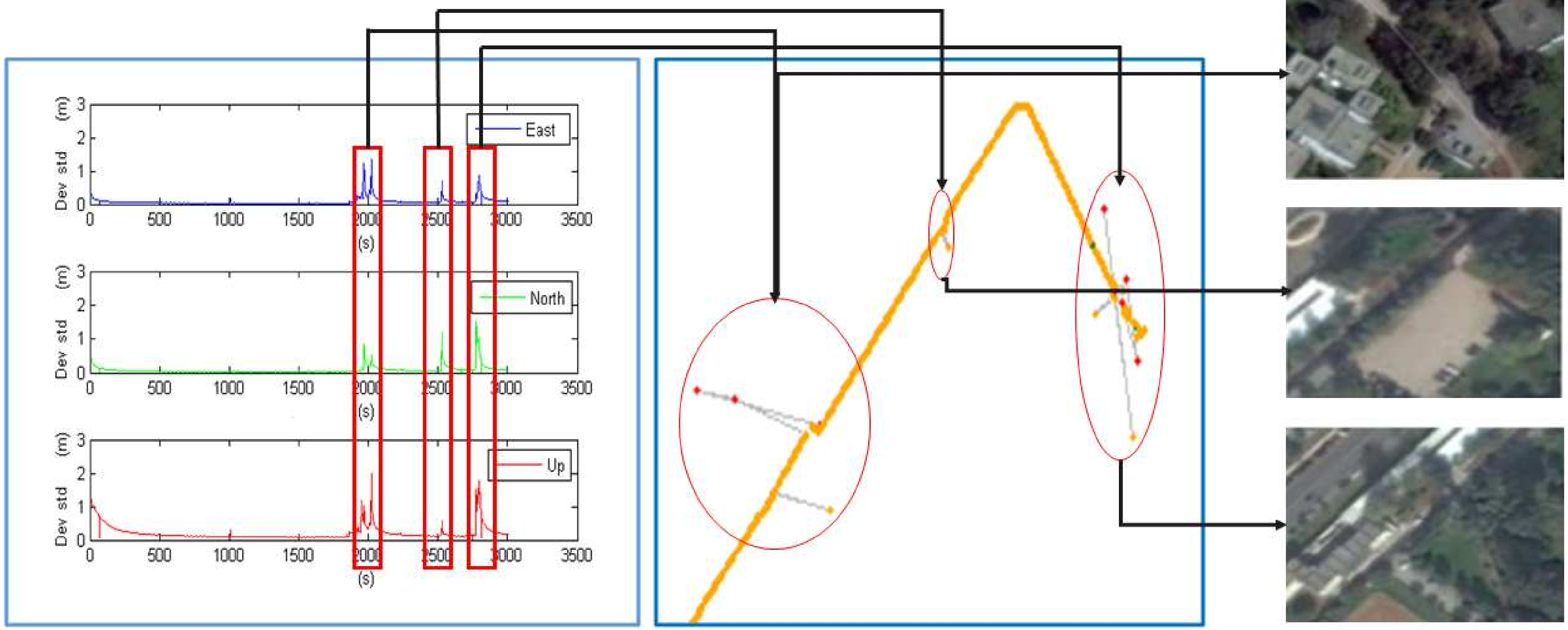
(1)



(2)



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

Comparative analysis of GNSS Real Time Kinematic methods for navigation

Mourad BOUZIANI

School of Geomatic Sciences, IAV Hassan II, Rabat, Morocco.

Coordinator of the Master - GNSS, IAV & CRASTE-LF, Affiliated to the United Nations.

Email : m.bouziani@iav.ac.ma

United Nations/Nepal Workshop on the Applications of GNSS

12 – 16 december 2016, Kathmandu, Nepal