Low-Cost High-Accuracy GNSS Receiver

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High Accuracy Receivers are Expensive

• High-Accuracy Survey Grade Receivers are multi-frequency and multi-system receivers
  • L1/L2/L5, G1/G2, B1/B2/B3 etc
  • GPS, GLONASS, BGALILEO, BeiDou, QZSS etc
  • Price varies from $5,000 to $30,000 or more.

• However, Low Cost Receivers are also capable of
  • Multi-System: GPS, GLONASS, GALILEO, BeiDou, QZSS, SBAS etc
  • Currently only in L1-Band Frequency
  • Low Cost: $300
  • Very soon: Multi Frequency, L1/L5
    • Broadcom already announced production of L1/L5 GNSS chip
How accurate is GPS Position?

- SPP (Single Point Position): 50 cm grid
- DGPS (Differential GPS): 50 cm grid
- RTK (Real Time Kinematic): 5 cm grid
# Errors in GPS Observation (L1C/A Signal)

<table>
<thead>
<tr>
<th>Error Sources</th>
<th>One-Sigma Error, m</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>DGPS</td>
</tr>
<tr>
<td>Satellite Orbit</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Satellite Clock</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Ionosphere Error</td>
<td>4.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Troposphere Error</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Multipath</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Receiver Circuits</td>
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<td>0.5</td>
</tr>
</tbody>
</table>

- If we can remove common errors, position accuracy can be increased.
- Common errors are: Satellite Orbit Errors, Clock Errors and Atmospheric Errors (within few km)

Table Source: http://www.edu-observatory.org/gps/gps_accuracy.html#Multipath
Principle of Differential Correction

Base-Station
Antenna is installed at a known-position

Send Correction Data to Rover
For Real-Time Position

For RTK, both rover and base receivers need to use the same satellites

Rover
User in the Field
(Either fixed or moving)
Principle of QZSS MADOCA / CLAS Service

Correction Data:
- Satellite Orbit Error of GPS and Other Satellites
- Satellite Clock Error of GPS and Other Satellites
Low-Cost High Accuracy System

Low-Cost RTK System

GNSS Antenna

GNSS Receiver
U-blox Neo-M8T

GNSS Rover Unit
(User in the Field)

Raspberry Pi 3B

USB Cable

WiFi

BT

Raspberry Pi 3B

Tablet

RasPi APP for RTK

SW Maps for GIS

Data Input

GNSS Antenna

GNSS Base-Station

NTRIP Caster

Internet

WiFi

BT

NTRIP Caster

GNSS Base-Station

Internet

GNSS Base-Station

GNSS Antenna
RtkPi APP for Low-Cost RTK System
Board Computer for Low-Cost RTK System

Raspberry Pi 3B for Realtime and Postprocessing RTK

Raspberry Pi Zero w/ WiFi & BT for Post-processing RTK
Accuracy from Low-Cost RTK System

Rover-Station:
Receiver: u-blox M8T
Antenna: Zephyr 2
Computer: RaspberryPi 3B+
Distance between Base and Rover: about 12Km

Base-Station:
Receiver: Trimble NetR9
Antenna: Zephyr 2
Data from Low-Cost RTK System
Data from Low-Cost RTK System
Simple to Use, Low-Cost System

Simple to Use, No Commands, Just One Time Setting
Connect Antenna, Receiver and Battery Pack
Device Starts Logging GNSS Raw Data required for RTK Post-Processing
SW Maps APP to integrate GPS Data into GIS