

# Introduction to RTK

Training on GNSS, 8 JAN 2020

11:00–12:00

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# Contents

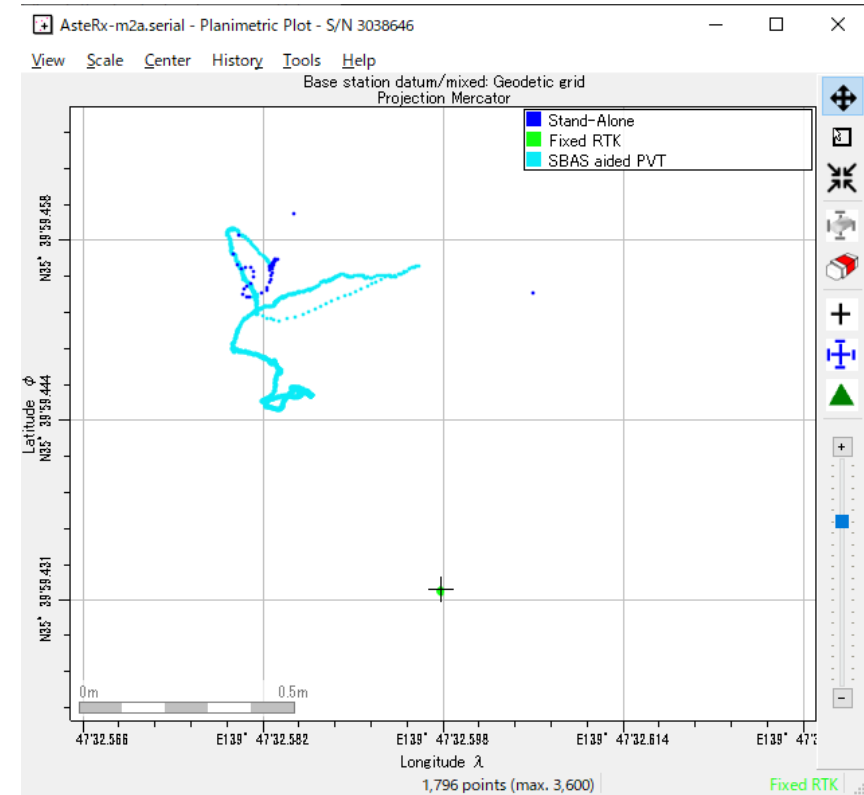
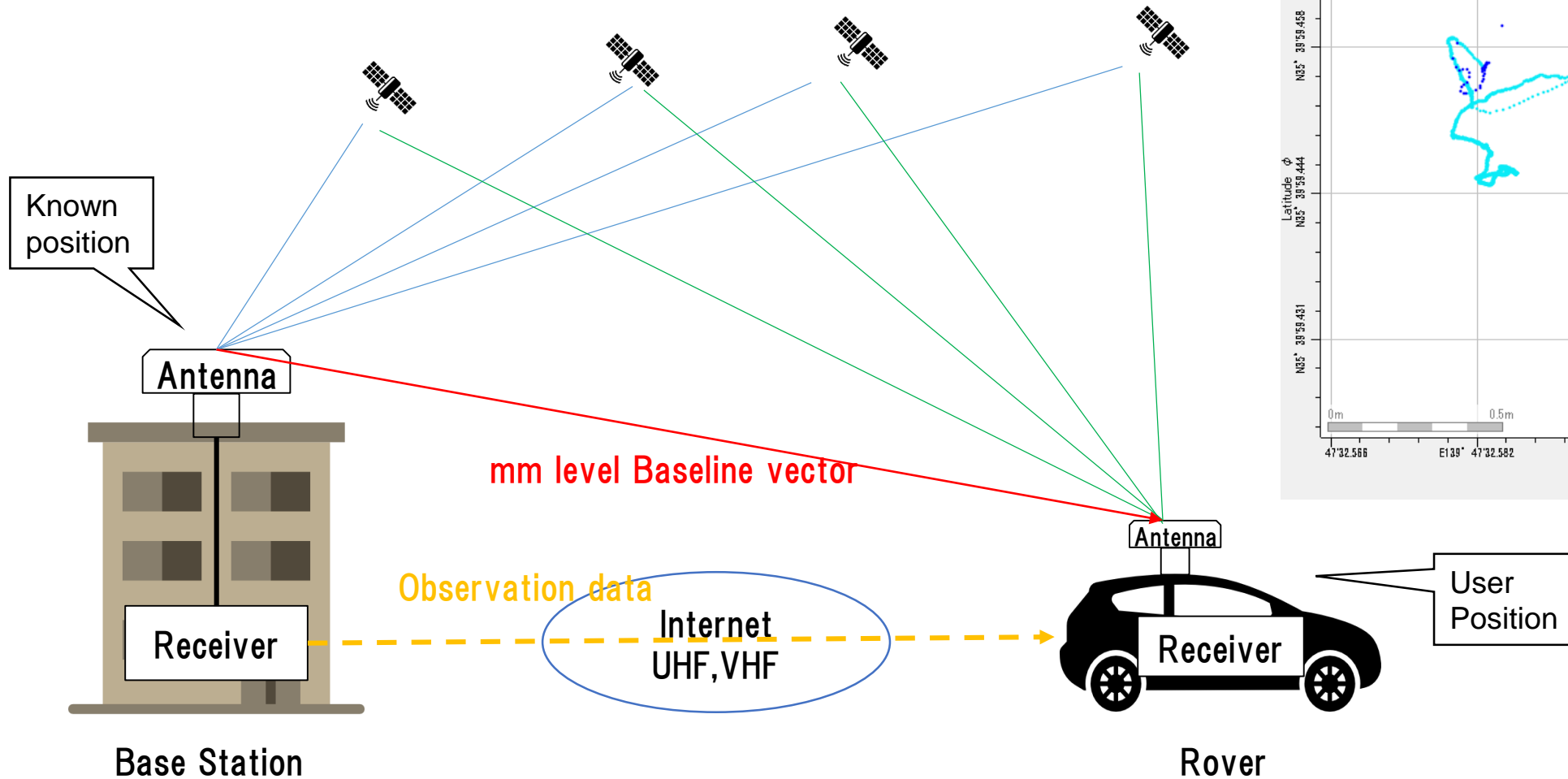
1. What is RTK
2. RTK applications
3. How to build RTK environment
4. RTK configuration on rover
5. Where can I buy GNSS devices?
6. Moving-base RTK
7. Useful web sites

Download link of this presentation

<https://1drv.ms/u/s!AidzfXwz4kDK5TGapdiZGWkcFYQD?e=G5zzbv>

# 1. What is RTK

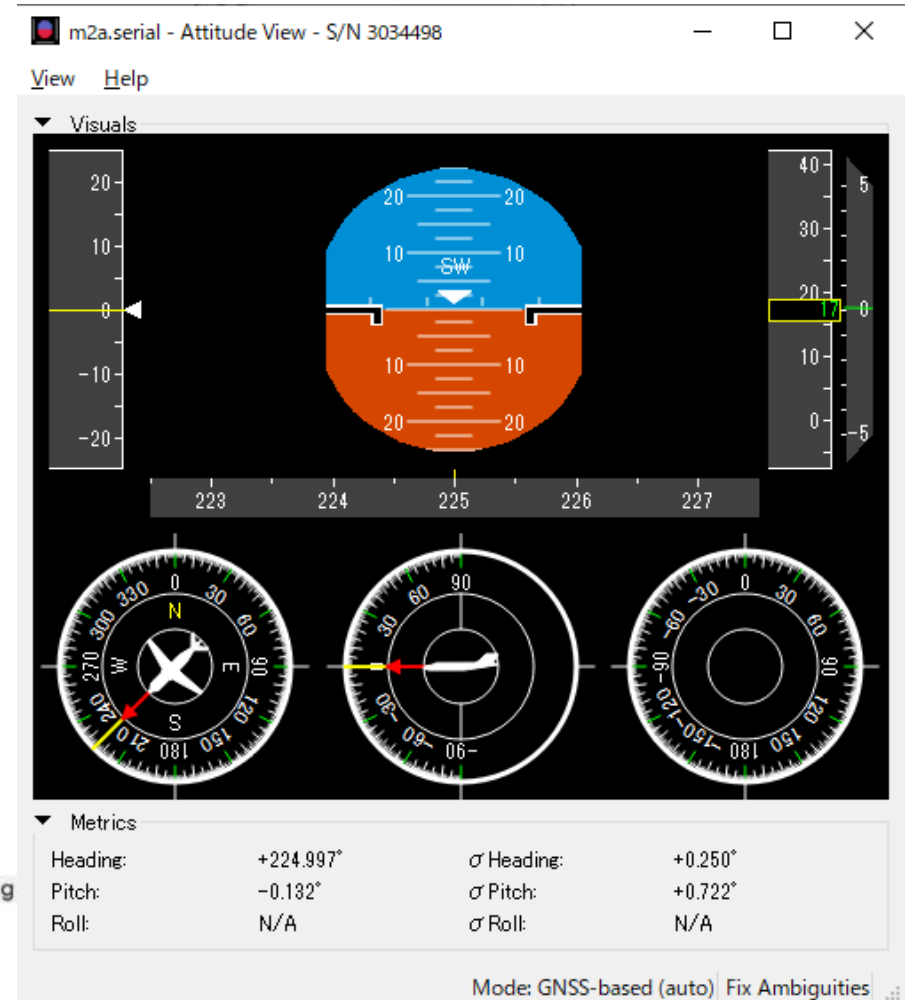
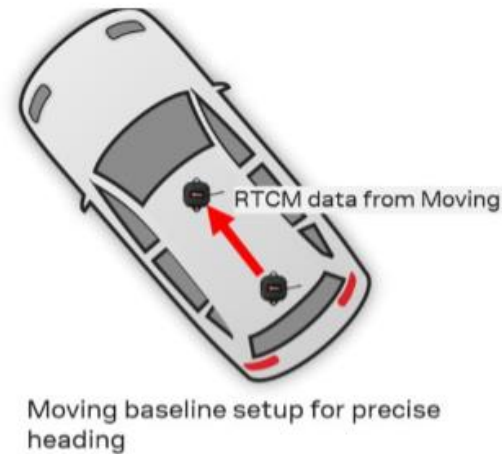
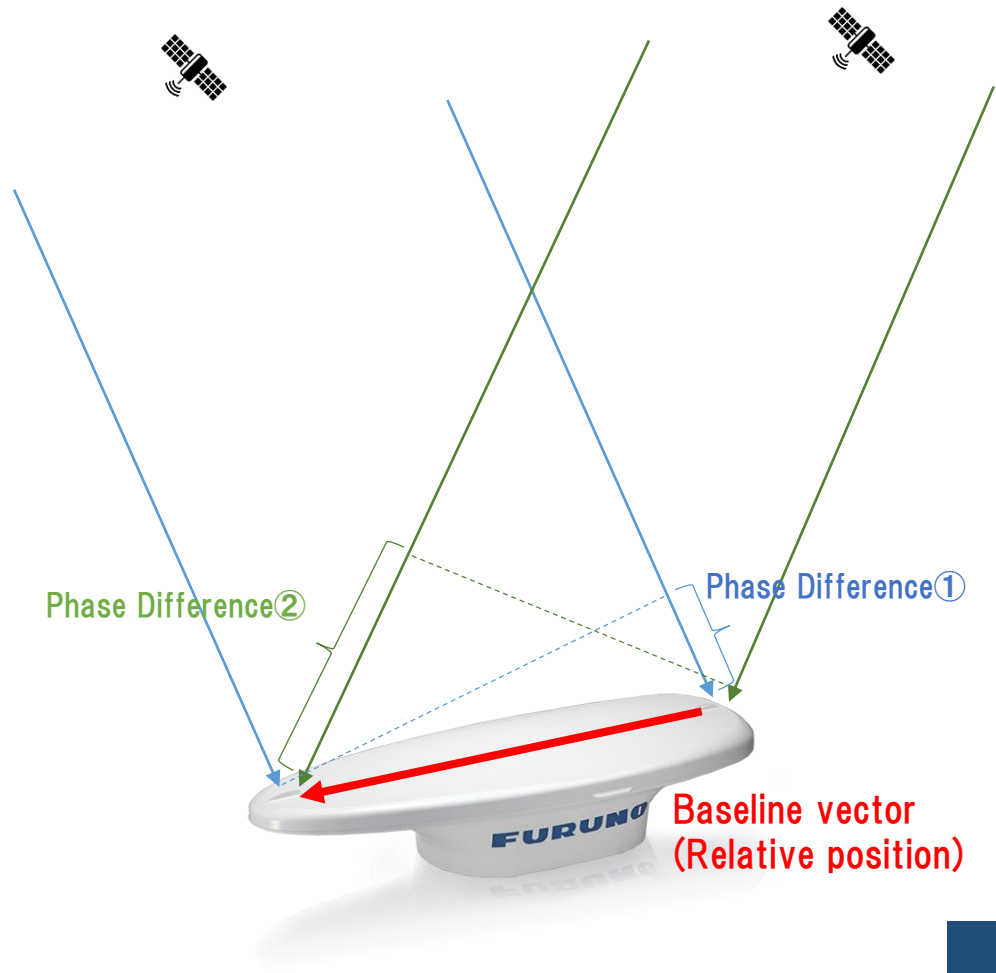
RTK is high accuracy positioning method using "Base Station".



# 1. What is RTK

If "Base station" is not fixed → Moving-base RTK

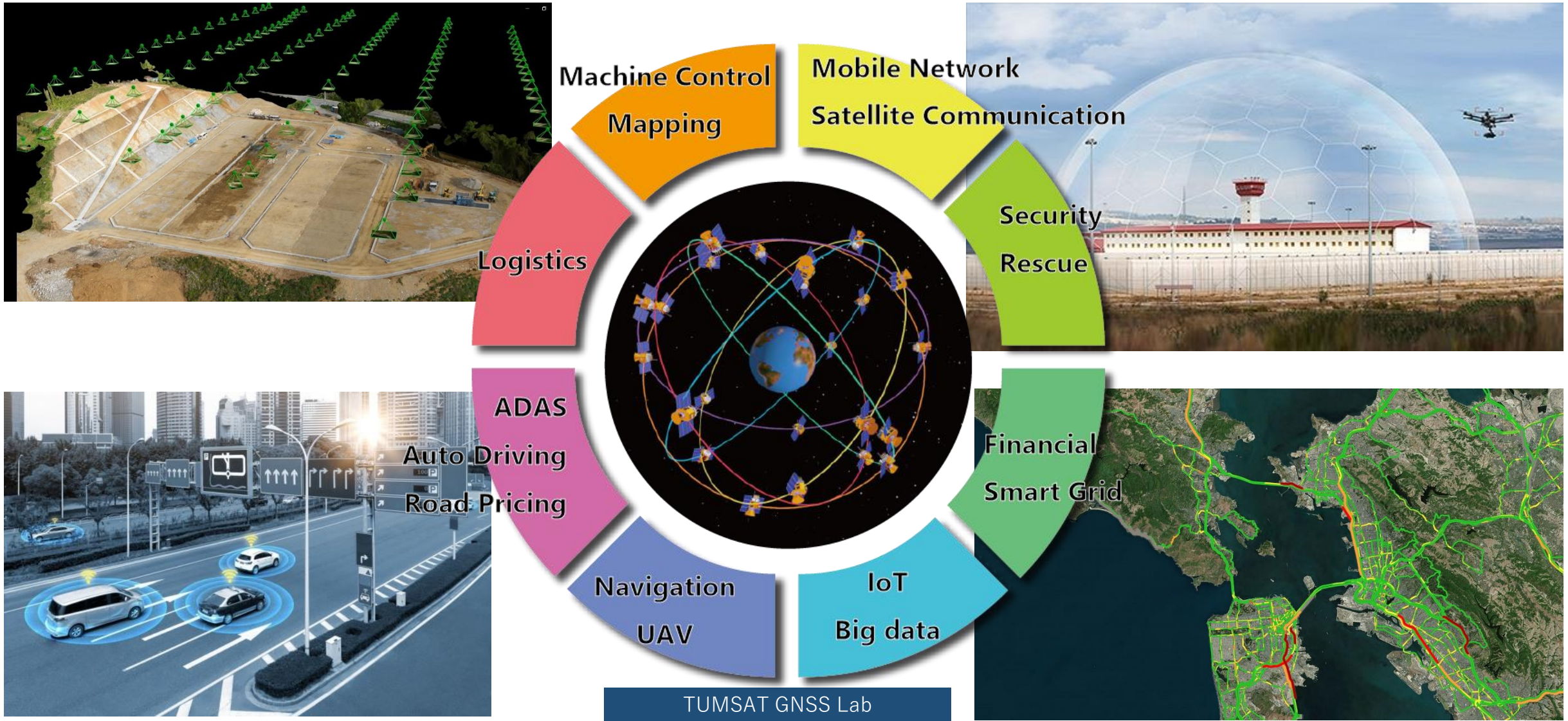
You can get precise relative position, angle between 2 antenna.





# 2. RTK applications

RTK can expand GNSS use field over traditional PNT (Positioning, Navigation, Timing).





# 2. RTK applications

## ◆ Construction

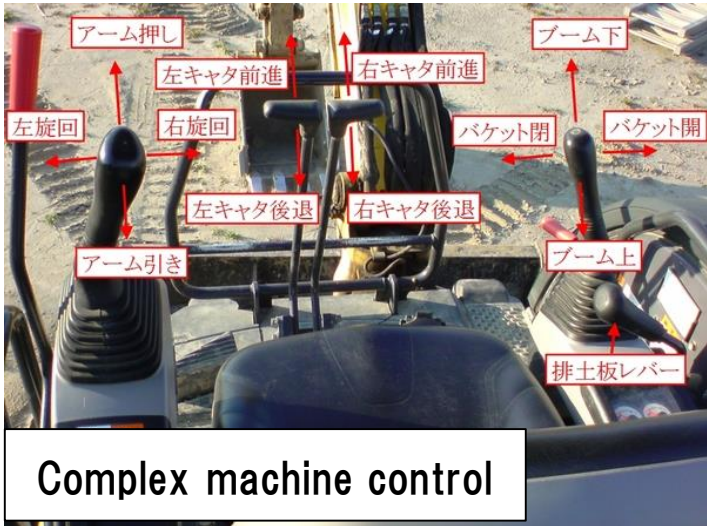


Traditional optical survey

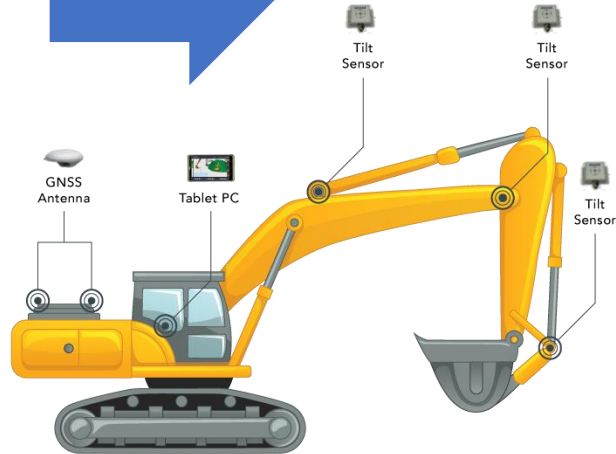
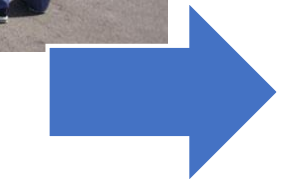


RTK

RTK survey and UAV mapping



Complex machine control



TUMSAT GNSS Lab



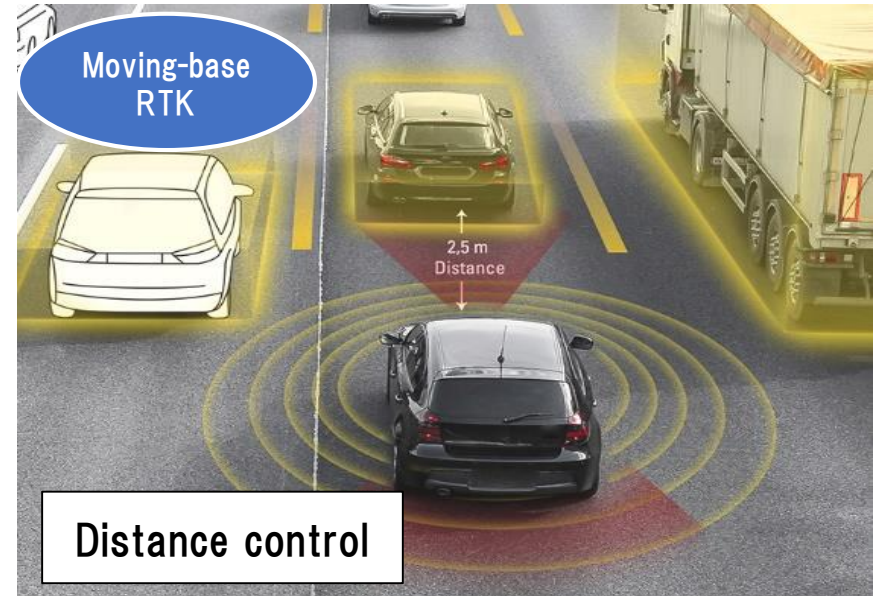
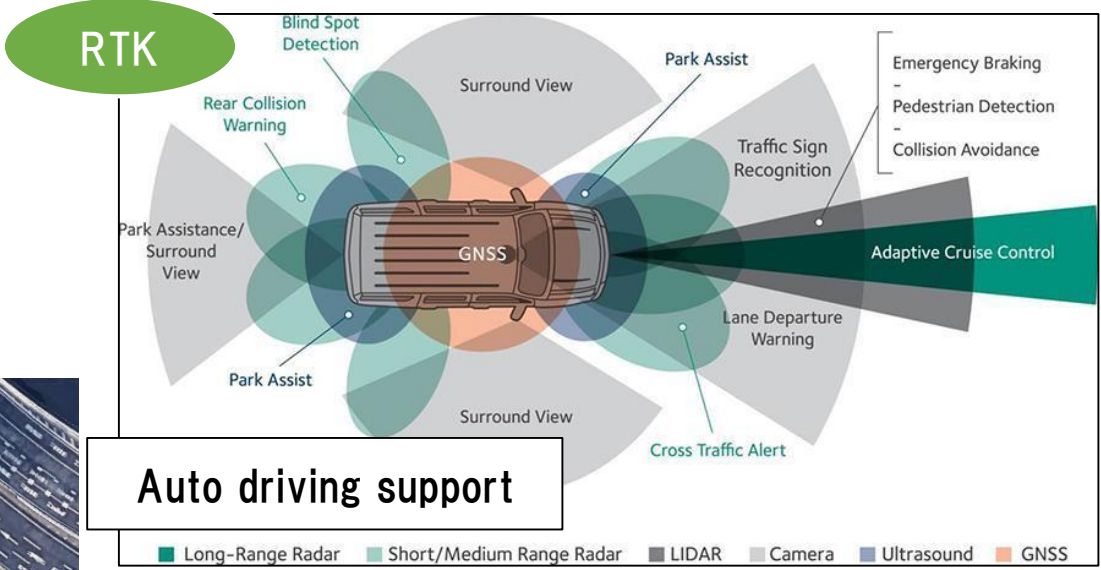
Machine control using 3D data and Attitude monitoring

The 3D design data of the job site is being loaded on to the machine control system.



# 2. RTK applications

## ◆ ITS (Intelligent Transportation System)





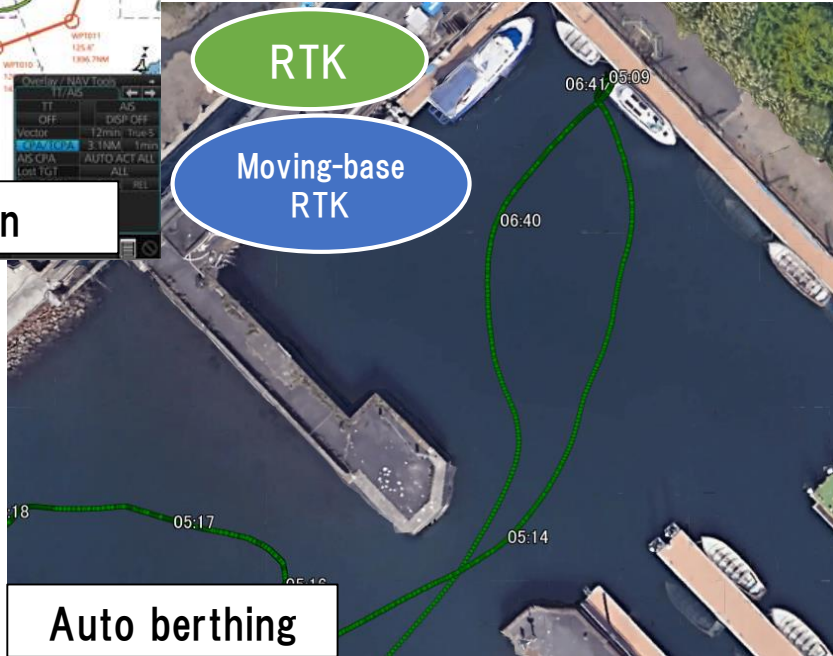
# 2. RTK applications



## ◆ Maritime

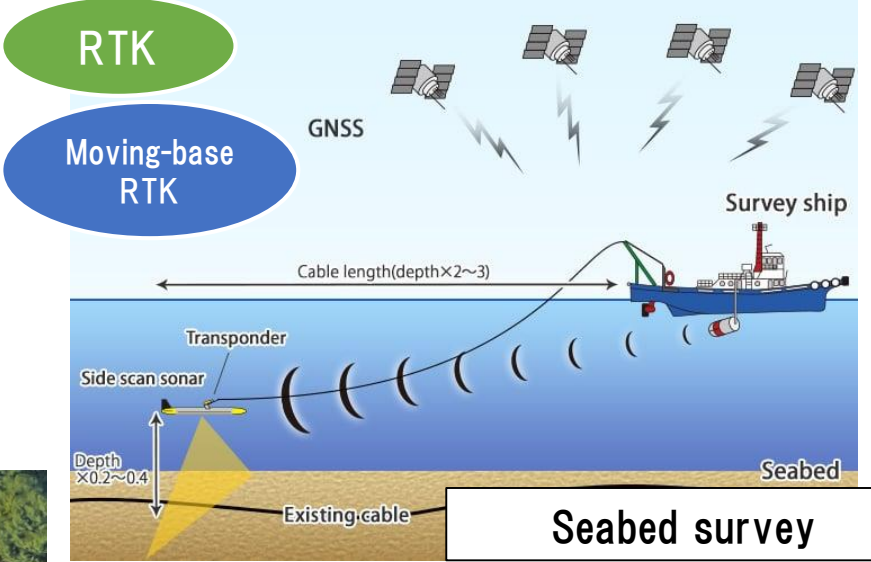


Ship navigation



Auto berthing

+

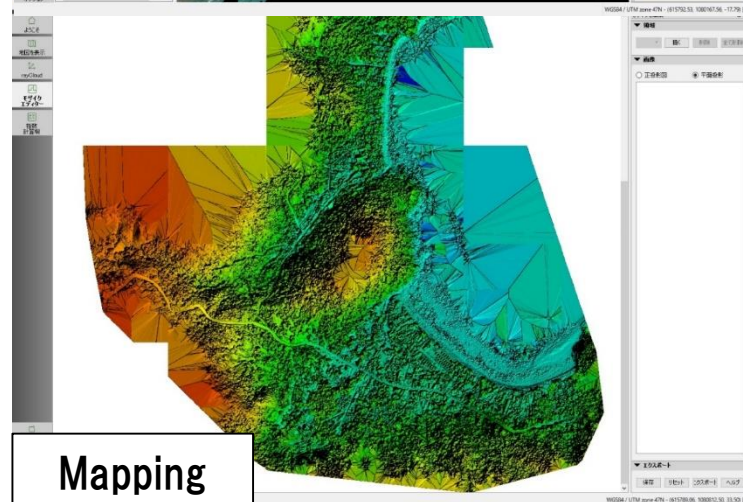
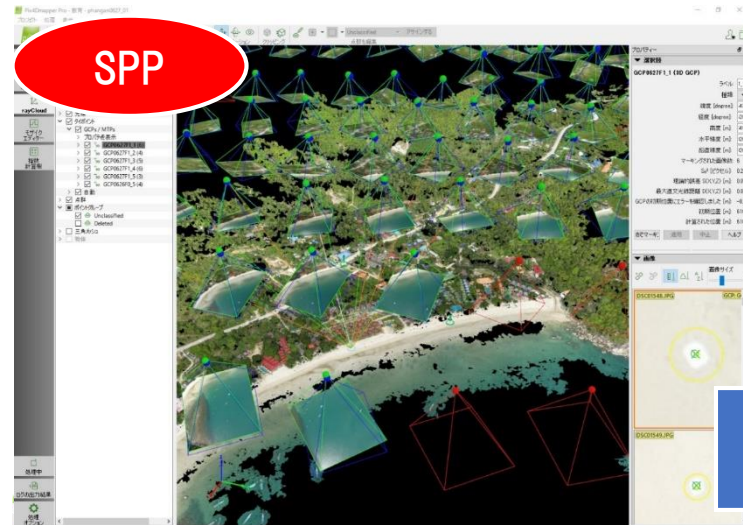




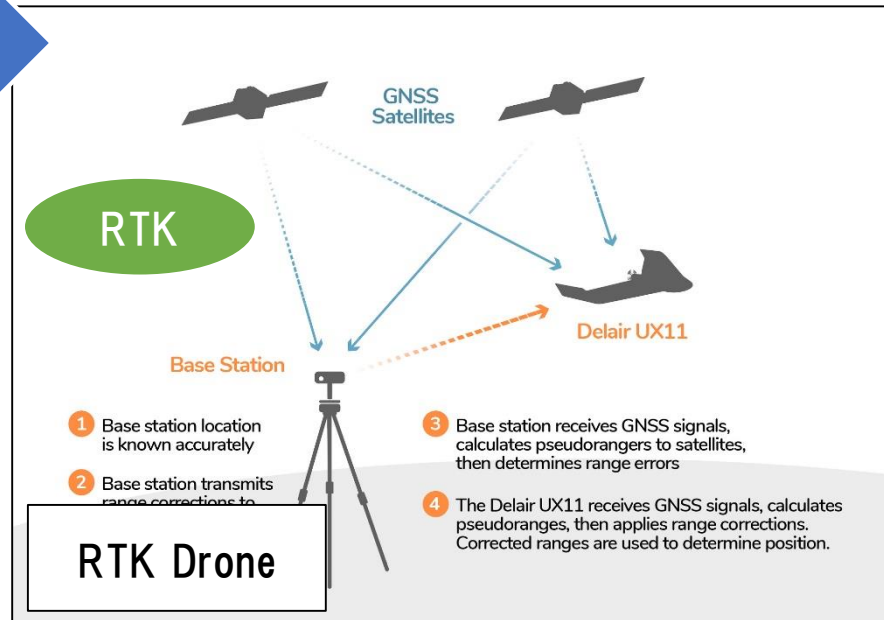
# 2. RTK applications



## ◆ UAV



More precise map



# 2. RTK applications

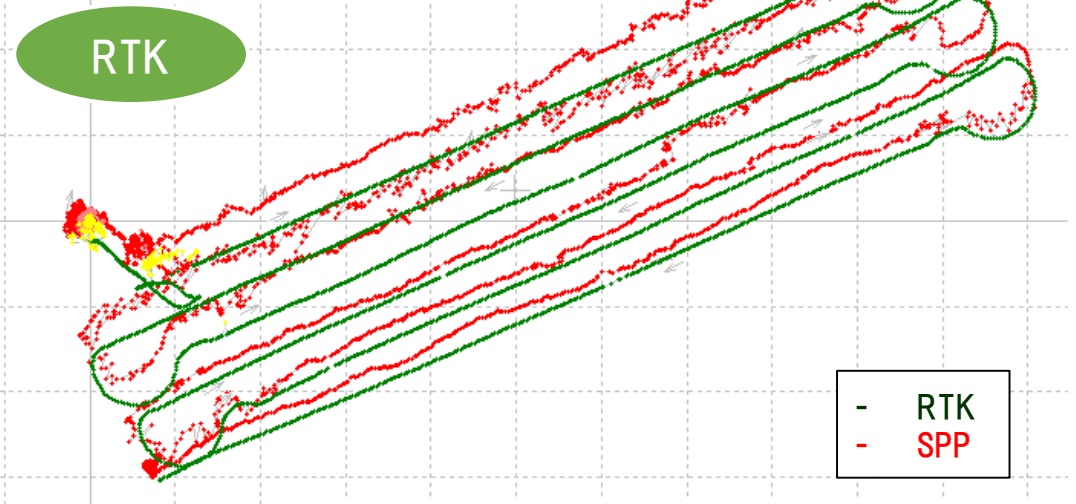


## ◆ Agriculture

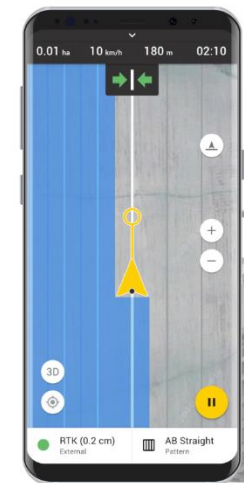


Shift to young generation  
Effective working

### Agriculture Machinery Guidance



1 TRACTOR GPS APP



2 GNSS RECEIVER



RTK BASE STATION



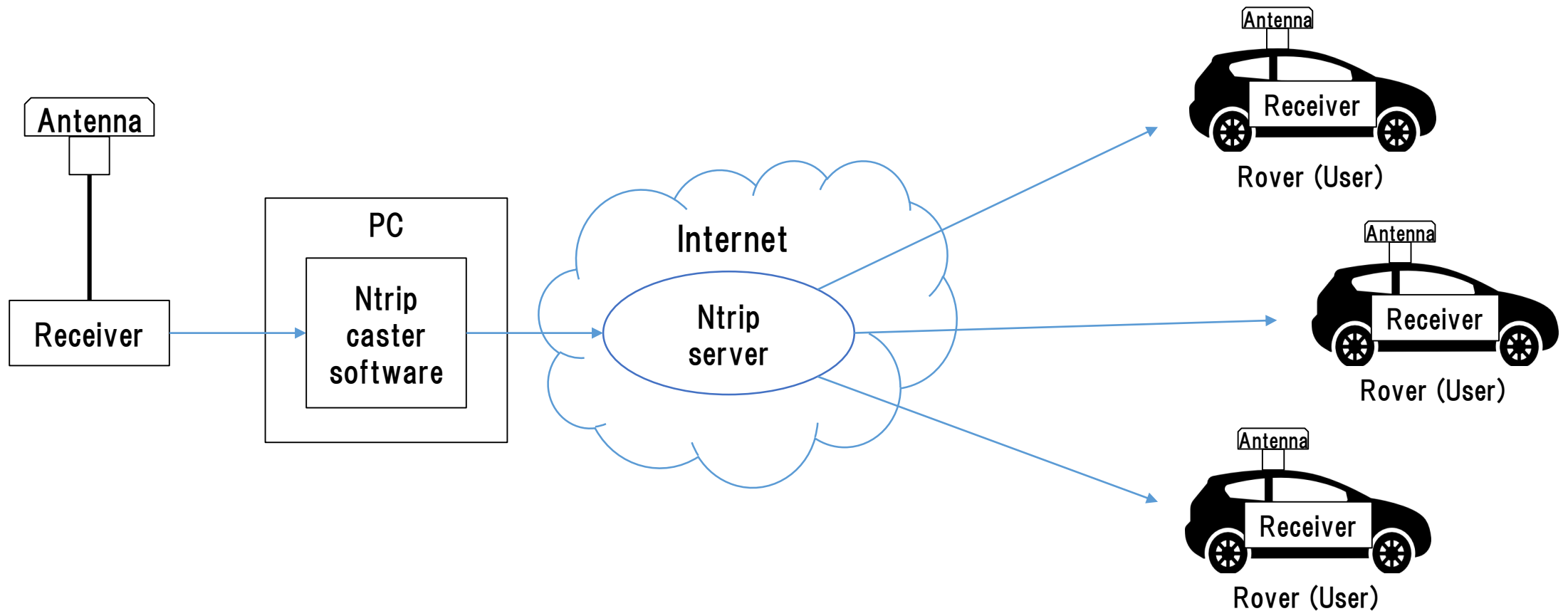
3

# 3. How to build RTK environment

## ◆ Base station overview

I explain the most common broadcast way using "Ntrip server".

However you can also use VHF/UHF radio, Bluetooth, LAN or cable communication to broadcast base station data.





# 3. How to build RTK environment

## ◆ Base station antenna

Install antenna in open sky & static environment.



Japanese government base station



Our University base station



Temporary base station

# 3. How to build RTK environment

## ◆ Base station antenna

There is many kind of antenna in the market. Choose which can receive GNSS signal you want to use.

- Antenna Type



Choke ring



Patch antenna  
with ground plane



Helical



Patch antenna  
without ground plane



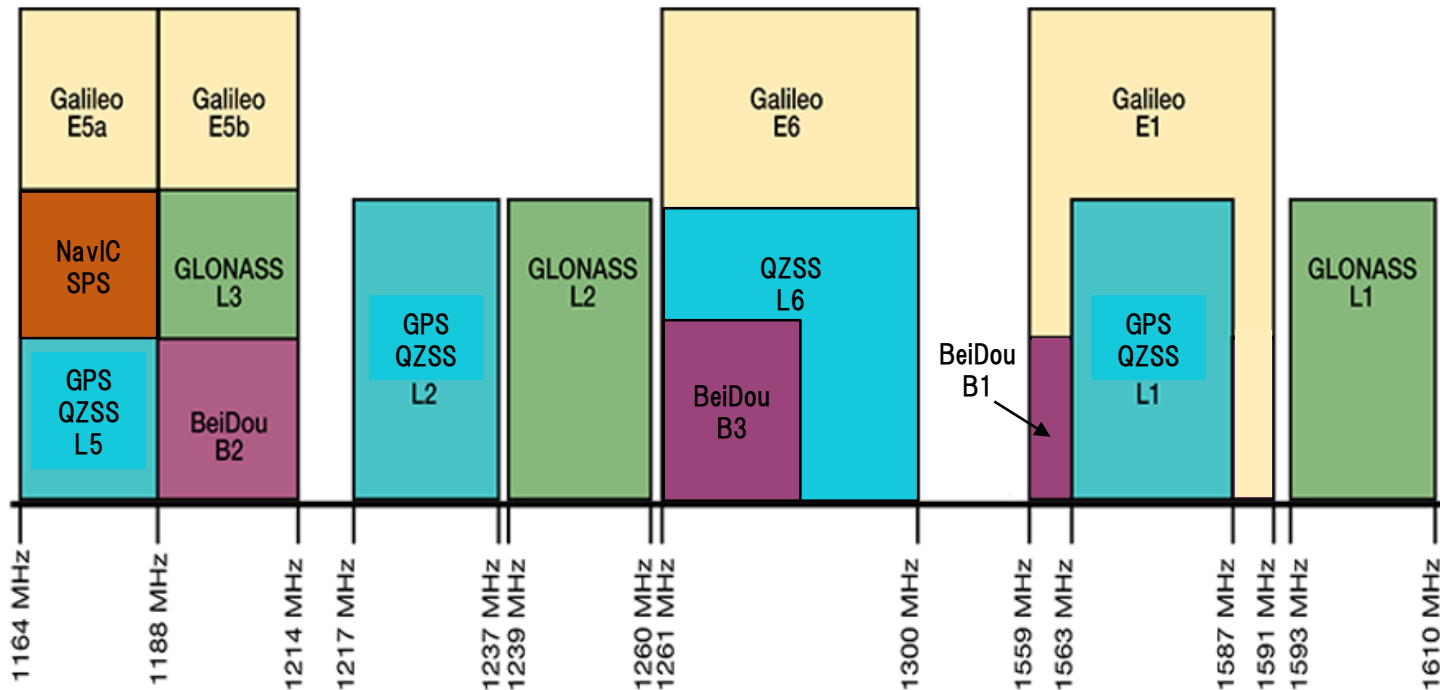
Good performance but High cost

# 3. How to build RTK environment

## ◆ Base station antenna

There is many kind of antenna in the market. Choose which can receive GNSS signal you want to use.

- Frequency



### BENEFITS

- + Choke ring antenna functionality without the size and weight
- + Reduces equipment costs and need for future redesign
- + High quality measurements and stable phase center for precision applications

### FEATURES

Check datasheet

- + L1, L2, L3, L5, B1, B2, E1 and E5a/b
- + GPS+GLONASS+BeiDou+Galileo signal reception
- + Excellent multipath rejection
- + Highly stable phase center
- + RoHS compliant

If you require more information about our antennas, visit [www.novatel.com/antennas](http://www.novatel.com/antennas)



# 3. How to build RTK environment

## ◆ Base station receiver selection

The receiver should support raw data output.

- RTCM3

Standard format for RTK. Select base station position and observation message is must.

- Receiver manufacturer format

Binary message.

Input support is depend on the rover receiver.

### RTCM Rev3 Common Message Types

Most common message used for >90% of all RTK applications

1004	Extended L1&L2 GPS RTK Observables for GPS RTK Use, <b>the main msg</b> X
1005	Stationary RTK Reference Station ARP X
1006	Stationary RTK Reference Station ARP plus the Antenna Height X
1007	Antenna Descriptor (msg 1008 (X) is also commonly used) X
1012	Extended L1&L2 GLONASS RTK Observables, <b>the other main msg</b> X

<https://www.use-snip.com/kb/knowledge-base/an-rtcm-message-cheat-sheet/>



CHAPTER 4. CONFIGURING THE ASTERX SB AS A ROVER

### Configure input of differential corrections

The format of the differential corrections output by the Base station should be compatible with what is accepted by the Rover. In the **Corrections Input** window of the **Corrections** menu, you can configure the AsteRx SB to only accept differential corrections of a particular format. The default 'auto' setting will accept correction data format **RTCMv2, RTCMv3 or CMR+**.

### 3.1.5.1 RTCM corrections

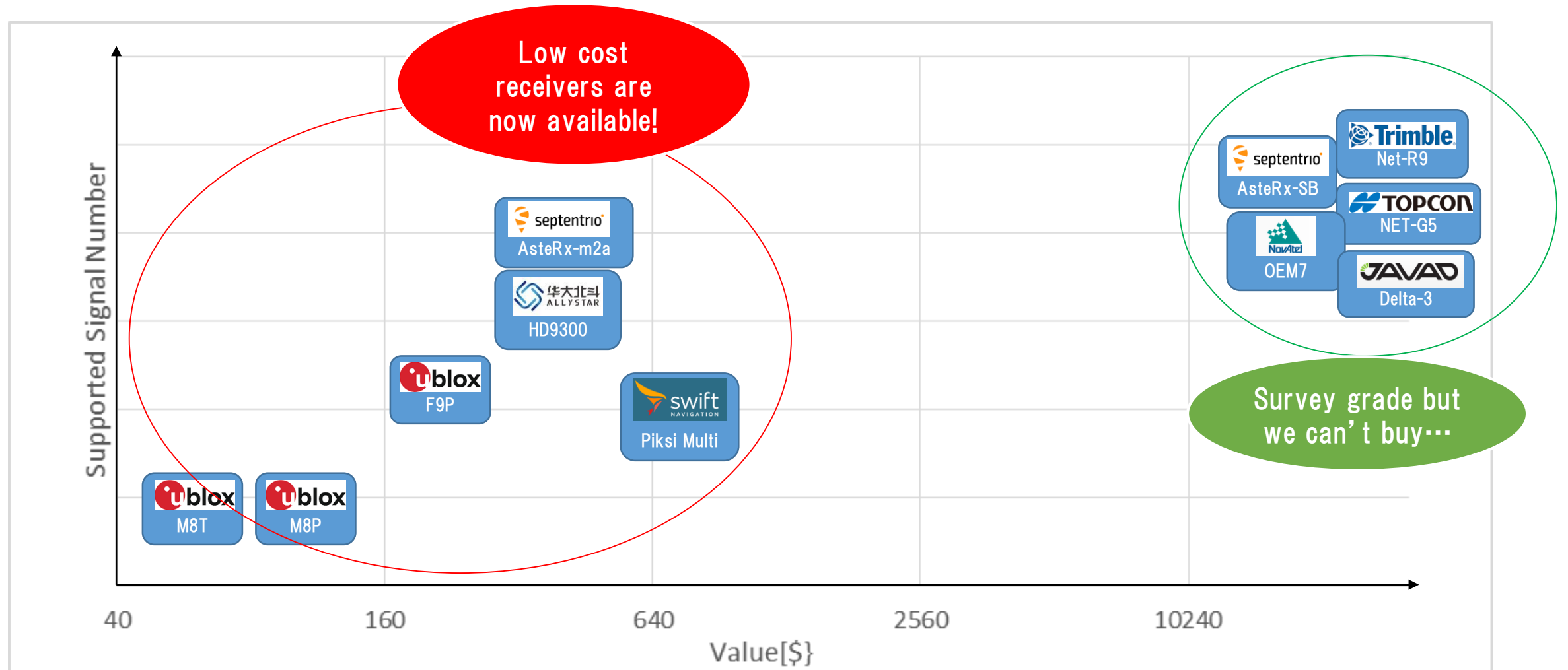
RTCM is a binary data protocol for communication of GNSS correction information. The ZED-F9P high precision receiver supports RTCM as specified by RTCM 10403.3, Differential GNSS (Global Navigation Satellite Systems) Services - Version 3 (October 7, 2016).

The RTCM specification is currently at version 3.3 and RTCM version 2 messages are not supported by this standard. Users can download the standard from the RTCM website [here](#).

To modify the RTCM input/output settings, see the configuration section in the u-blox ZED-F9P Interface Description [2].

# 3. How to build RTK environment

## ◆ Base station receiver selection



## 3. How to build RTK environment

### ◆ Base station receiver setting

Change receiver configuration to output RTCM message from USB port.

Here I will show example using u-blox F9P and Septentrio AtseRx-m2a



### 3. How to build RTK environment

#### ◆ Base station antenna position

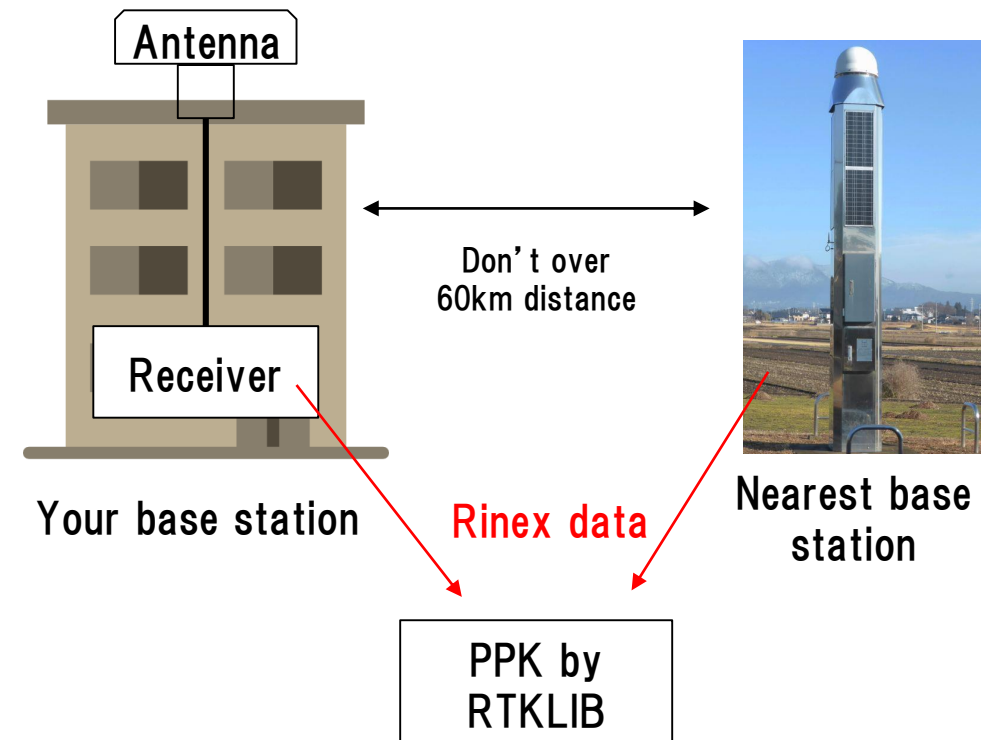
You need to know your base station antenna position with cm level accuracy.

· RTK

If there is another RTK base station near your base, you can calculate by PPK (Post-Process Kinematic).

Free RTK base stations.

- IGS station <http://www.igs.org/network>  
datalink : <ftp://cddis.gsfc.nasa.gov/gnss/data/daily>
- Local CORS <https://www.chcthailand.com/cors-picture>



# 3. How to build RTK environment

## ◆ Base station antenna position

You need to know your base station antenna position with cm level accuracy.

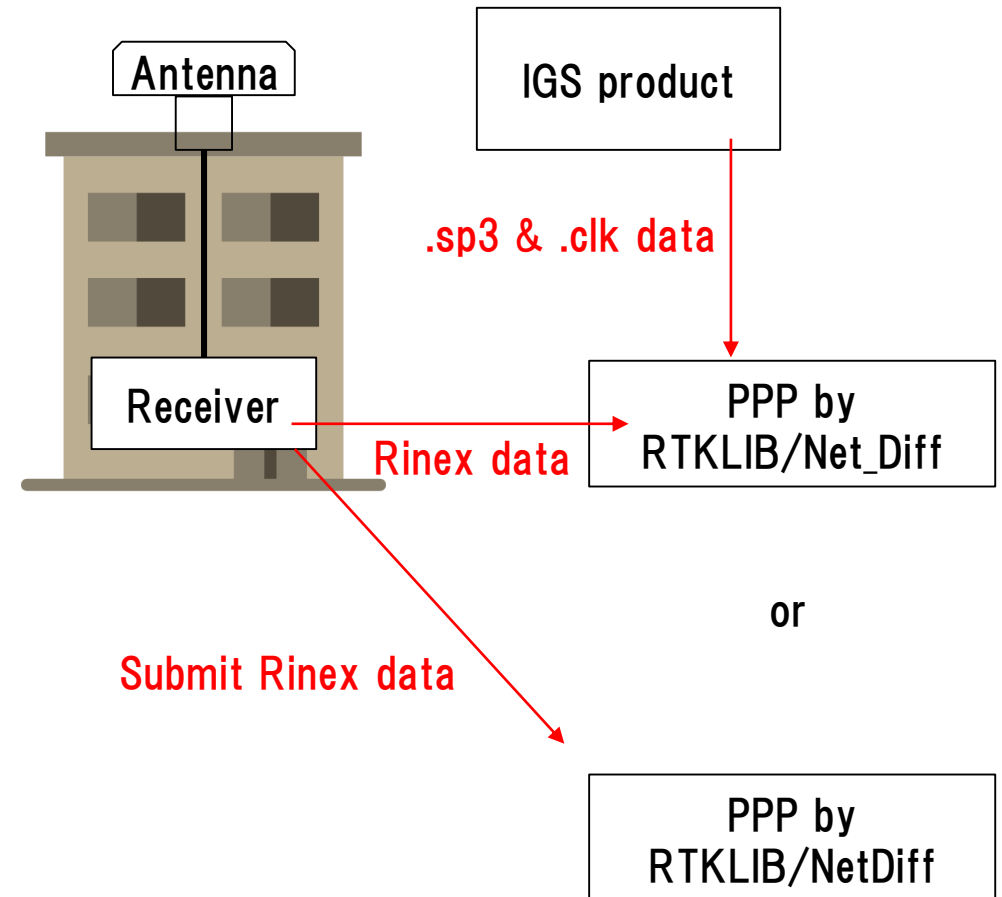
· PPP

If there is no another RTK base station, calculate by PPP.

Free PPP service

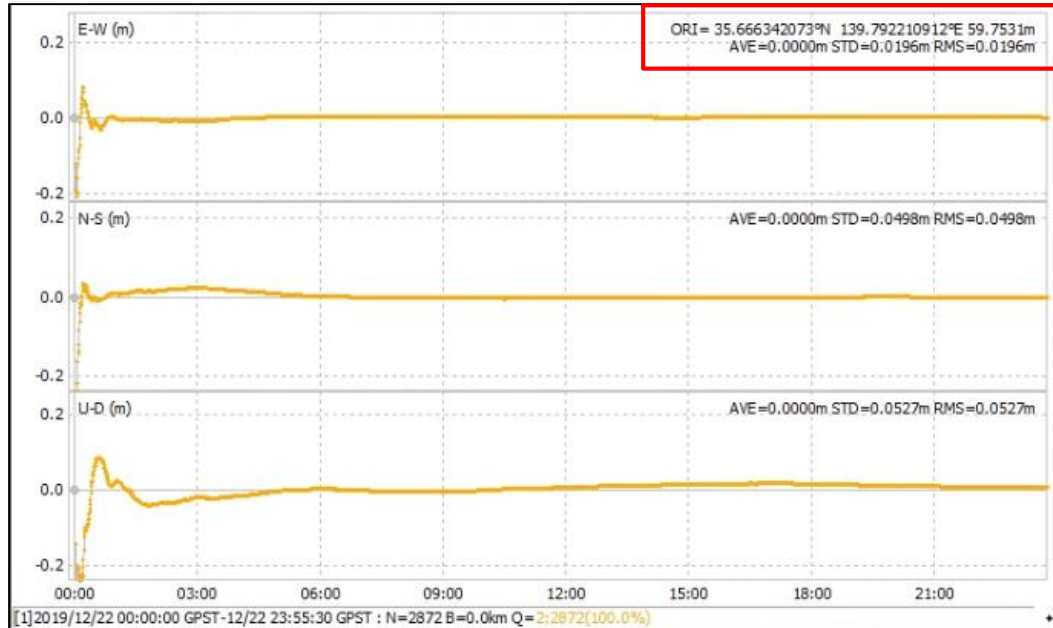
- RTKLIB with IGS product (<http://www.rtklib.com/>)
- Net\_Diff with IGS product ([https://github.com/YizeZhang/Net\\_Diff](https://github.com/YizeZhang/Net_Diff))
- Trimble RTX (<https://www.trimblertx.com/UploadForm.aspx>)
- CSRS-PPP (<https://webapp.geod.nrcan.gc.ca/geod/tools-ouils/ppp.php>)
- MADOCA-PPP

IGS product : ([http://mgex.igs.org/IGS\\_MGEX\\_Products.php](http://mgex.igs.org/IGS_MGEX_Products.php))



# 3. How to build RTK environment

- ◆ Base station antenna position
- Sample of PPP solution



Net\_Diff + MGEX product

**Trimble**

**Post-Processing Service Based on RTX Technology**  
TrimbleRTX.com

Contributor: t161064@edu.kaiyodai.ac.jp  
 Reference Name: 5301K5616520191103000D.T02  
 Upload Date: 11/05/2019 09:32:44 UTC

Report Time Frame:  
 Start Time: 11/03/2019 00:00:00 UTC  
 End Time: 11/03/2019 23:59:59 UTC  
 Observation File Type(s): T02  
 Observation File(s): 5301K5616520191103000D.T02

Antenna:  
 Name: TRM55971.00 NONE  
 Height: 0.000 m  
 Reference: Bottom of antenna mount

Receiver Name: TRIMBLE NETR9  
 Coordinate Systems: ITRF2014  
 Tectonic Plate: Okhotsk (Auto-detected)  
 Tectonic Plate Model: MORVELS6  
 Processing Interval: 10 s

**Statistics**

# Total Obs	# Usable Obs	# Used Obs	Percent
81815	8181	8172	99

**Used Satellites**

# Total Satellites:	82
GPS:	G01 G02 G03 G05 G06 G07 G08 G09 G10 G11 G12 G13 G14 G15 G16 G17 G19 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 G32
GLONASS:	R01 R02 R03 R05 R07 R08 R09 R11 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24
QZSS:	J01 J02 J03
Galileo:	E01 E02 E03 E04 E05 E07 E08 E09 E12 E13 E15 E19 E21 E24 E26 E27 E30 E31 E33 E36
BeiDou:	C06 C07 C08 C09 C10 C11 C12 C13 C14

**Processing Results**

ITRF2014 at Epoch 2010.0			ITRF2014 at Epoch 2019.84		
Coordinate	Value	$\sigma$	Coordinate	Value	$\sigma$
X	-3961904.891 m	0.006 m	X	-3961905.083 m	0.006 m
Y	3348992.800 m	0.006 m	Y	3348992.726 m	0.006 m
Z	3698212.544 m	0.006 m	Z	3698212.405 m	0.006 m
Latitude	35° 39' 58.83700" N	0.003 m	Latitude	35° 39' 58.83146" N	0.003 m
Longitude	139° 47' 31.95195" E	0.004 m	Longitude	139° 47' 31.95911" E	0.004 m
El. Height	59.679 m	0.009 m	El. Height	59.679 m	0.009 m

**Report Information**

Trimble RTX Solution ID: 22163547  
 Solution Type: Static  
 Software Version: 6.1.4.17185  
 Creation Date: 11/05/2019 09:38:09 UTC

Trimble RTX service

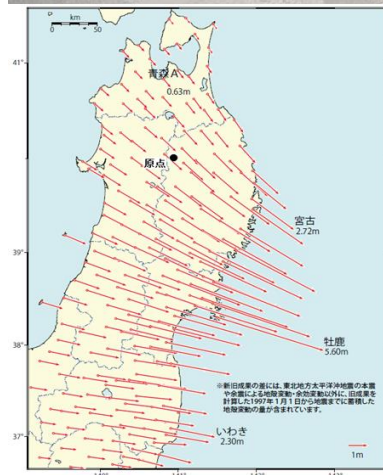
Use this position as your base station position.



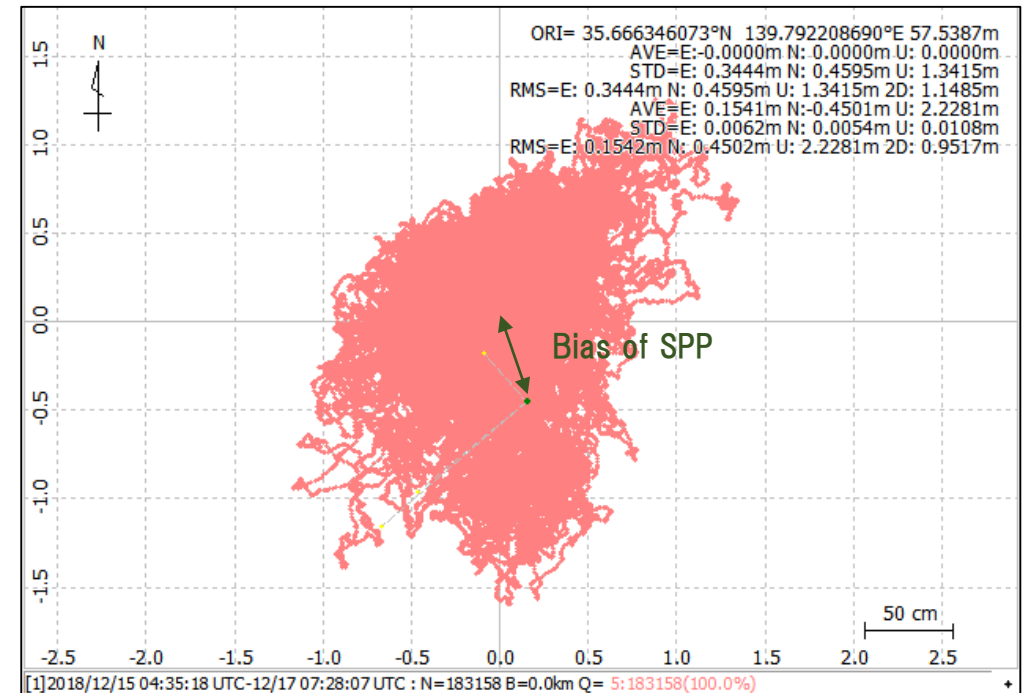
# 3. How to build RTK environment

## ◆ Base station antenna position

Unless there is a special reason, I don't recommend to use optical survey position or SPP average position for the base station position.



Local survey coordinate has a gap with GNSS coordinate (ITRF).



# 3. How to build RTK environment

## ◆ Get Ntrip server

- RTK2GO

Free Ntrip server. You can create your mount point and broadcast data.

### The Front Page for **RTK2go.com**

**RTK2go®** is a community **NTRIP Caster** created to allow you to publish your GNSS correction streams for others to use with their **NTRIP Clients**. It is built using the same **Pro** edition of the **SNIP Caster** you can find on the **use-SNIP.com** site. Why do we do this?, because many of the RTK2go users here end up operating a **SNIP** network of their own. You can download and evaluate your own copy of **SNIP®** from **here**. It is one part of the overall *simple NTRIP™* project created by SubCarrier Systems Corp. (**SCSC**).

**RTK2go:** **200+** Public Base Stations, **10,000+** Users, **50,000,000+** Sessions,  
Professional Grade, and **Free to use**

Send your Base Station data to **RTK2go®** if you do not wish to run your own NTRIP Caster.

Please download and use **SNIP®** if you want to run your own NTRIP Caster.

<http://www.rtk2go.com/>

## Other server

- BKG

<https://igs.bkg.bund.de/ntrip/download>

# 3. How to build RTK environment

- ◆ Push out data to Ntrip server
- RTKLIB STRSVR (Free)

The screenshot shows the RTKLIB v2.4.3 b31 interface. The main window is titled 'STRSVR ver.2.4.3 b31' and displays the following information:

2019/12/29 11:11:06 GPST      Connect Time: 0d 00:00:00

Stream	Type	Opt	Cmd	Conv	Bytes	Bps
<input type="checkbox"/> (0) Input	Serial	...	...	...	0	0
<input type="checkbox"/> (1) Output	NTRIP Server	...	...	...	0	0
<input type="checkbox"/> (2) Output	...	...	...	...	0	0
<input type="checkbox"/> (3) Output	...	...	...	...	0	0

At the bottom of the main window are buttons for 'Start', 'Options...', and 'Exit'. A red circle highlights the 'NTRIP' icon in the top toolbar.

An 'NTRIP Server Options' dialog box is open, showing the following fields:

- NTRIP Caster Host: rtk2go.com
- Port: 2101
- Mountpoint: ECJ70
- User-ID: (empty)
- Password: (masked with dots)
- String: GPS+GLO+BDS

Buttons for 'Ntrip...', 'OK', and 'Cancel' are visible at the bottom of the dialog.



# 3. How to build RTK environment

## ◆ Push out data to Ntrip server

- SNIP (Lite is Free) <https://www.use-snip.com/pricing/>

Receiver

Ntrip server

The screenshot shows the SNIP software interface with the 'Caster and Clients' tab selected. The 'MountPt' is set to 'ECJ71'. The 'COM' is 'COM21'. The 'UpTime' is '50 s Up(1)'. The 'Input' is '62.85 KB'. The 'Output' is '0 Bytes'. The 'Logged' is '0 Bytes'. The 'Clients' are '0 / 0'. The 'Caster Entry' section shows 'MountPt: ECJ71', 'City: TOKYO, JPN', 'Data Format: RTCM 3', 'Mss: GNS: GPS+GLO+GAL, HDOP+QZS', 'Lat/Lon: 35 136', and 'Misc: Parsed: Yes'. The 'Serial BASE Stations' section has an 'Auto Start' checkbox. The 'Log' window at the bottom shows RTCM3 messages being received from the receiver.

**Serial port input from the receiver**

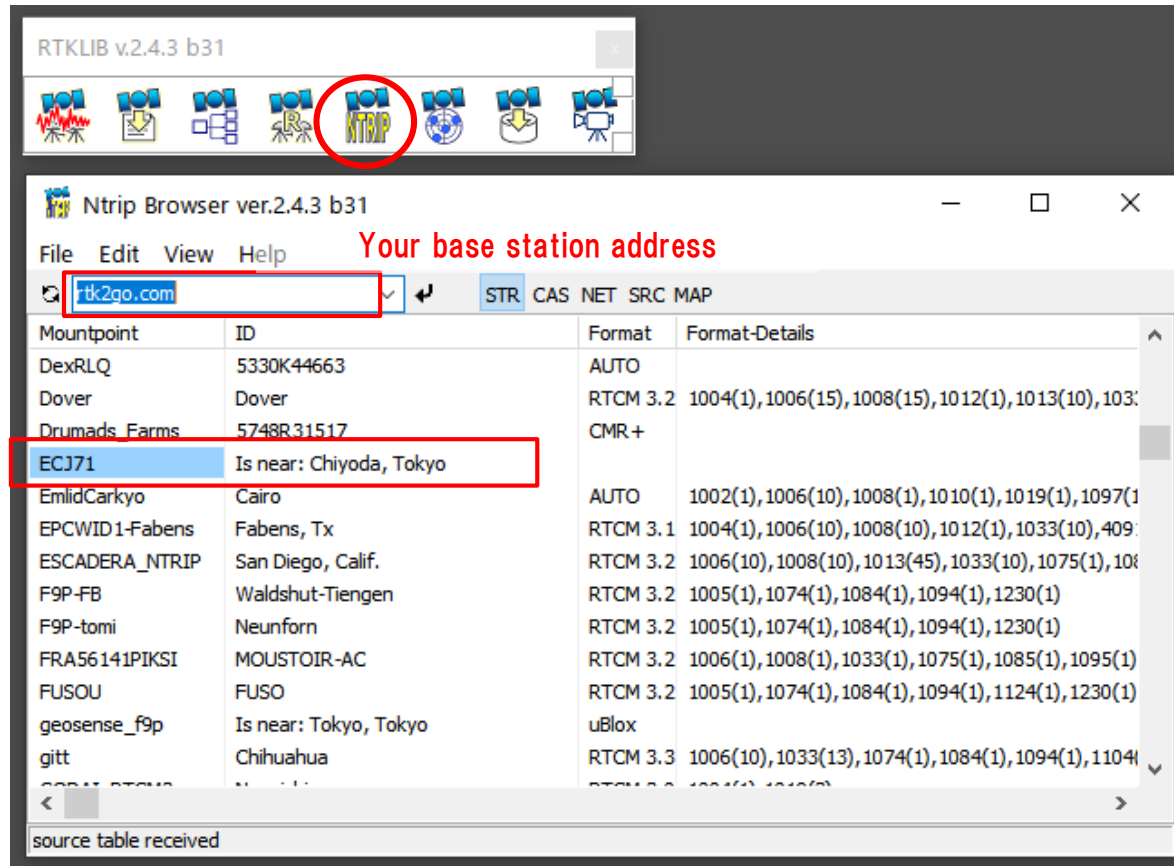
The screenshot shows the SNIP software interface with the 'Pushed-Out Streams' tab selected. The 'Target' is 'ECJ71'. The 'Source' is 'ECJ71'. The 'Connected' status is 'Idle'. The 'UpTime' is 'No Data'. The 'Connections' are '0/0'. The 'Output' is '0 Bytes'. The 'Output as an NTRIP Server [Push-Out]' section has 'Show Connection' and 'Auto Start' checkboxes. The 'Add Stream...' button is highlighted. The 'Edit Pushed-out Slot' dialog box is open, showing 'Stream List' as 'ECJ71', 'New MountPt Name' as 'ECJ71', 'Remote Host' as 'RTK2go.com', 'Remote Port' as '2101', 'Format' as 'Use NTRIP Rev2', and 'User' as 'remote user name'. The 'Password' field is masked with asterisks. The 'Log' window at the bottom shows RTCM3 messages being pushed out to the Ntrip server.

**Push out data to your mount point**

# 3. How to build RTK environment

## ◆ Push out data to Ntrip server

You can check your Mount Point from "NTRIP Browser" in RTKLIB.



## 4. RTK configuration on rover

### ◆ Rover antenna

Same manufacturer antenna with base station is recommended.

However, there is not much degradation between antennas from other manufacturers.



Choke ring



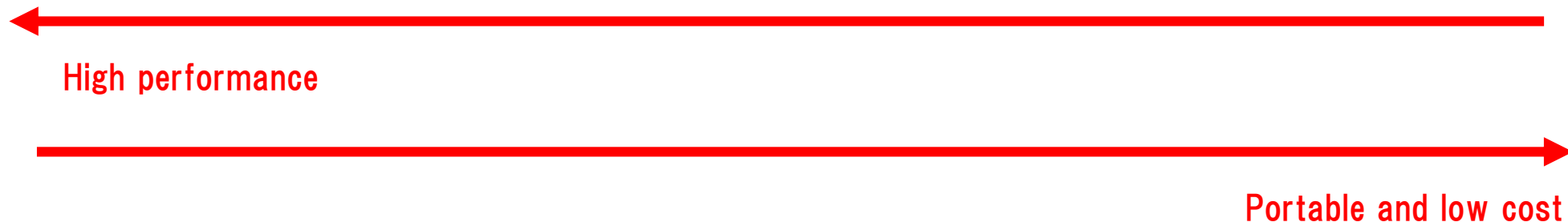
Patch antenna  
with ground plane



Helical



Patch antenna  
without ground plane





# 4. RTK configuration on rover

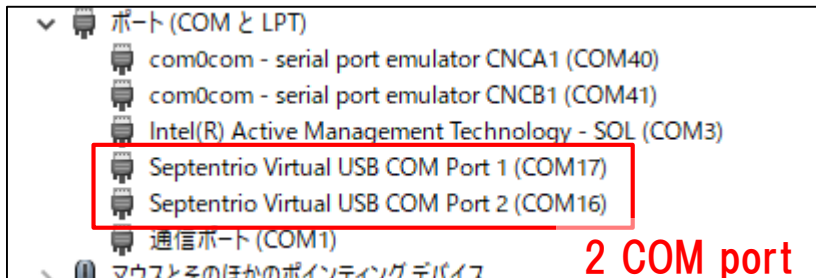
## ◆ RTK (Septentrio with PC)

Use Ntrip client function of "Data Link" in "RxTools"

<https://www.septentrio.com/en/products/software/rxtools>

Download link

<https://www.septentrio.com/en/support/software/rxtools>



m2a.serial - RxControl - S/N 3034498

File View Communication Navigation PinPoint-GIS Tools Logging Help

Position Information

Position Velocity

Geodetic  $\phi$ : N 35° 39'59.43250"  $\sigma_H$  +0.005m

Base station  $\lambda$ : E 139° 47'32.59885"  $\sigma_E$  +0.005m

h: +59.444m  $\sigma_U$  +0.015m

Satellite Status

GPS GLONASS Galileo BeiDou SBAS QZSS IRNSS L-Band

Search: Main 4 1G 0R 2E 0C 1S 0J Track: Main 36 10G 9R 8E 6C 3S 0J

Aux1 14 2G 5R 7E 0C 0S 0J Aux1 0 0G 0R 0E 0C 0S 0J

Sync: Main 0 0G 0R 0E 0C 0S 0J PVT: Main 14 6G 5R 0E 3C 0S 0J

Aux1 6 3G 0R 3E 0C 0S 0J Aux1 0 0G 0R 0E 0C 0S 0J

Receiver Status

Time	RxClock	DOP	PL	RAIM	PVT	Status	Att
GNSS time frame		PDOP: 2.03			Mode: RTK Fixed (0)		
月 30-12-2019		TDOP: 1.37			System: GPS+GLONASS+BeiDou		
07:20:42.000		HDOP: 0.85			Info: CB		
+18s offset to UTC		VDOP: 1.85			Corr Age: 1.00s		

Data Link

File Tools Help

Select base station

Input to COM17 port

Connection 1

Disconnect

Show Data

NTRIP Client 153.121.59.53/ECJ27

Link →  1  2  3  4  5  6

GGA →  1  2  3  4  5  6

Send every 10'th received GGA

Connect Script:

Send every 1.00 s.

Close Script:

Log File:

Connected to 153.121.59.53 I/O 1.4/1.1 kBps

Connection 2

Disconnect

Show Data

Serial COM17-115200-8-None-1-Off

Link →  1  2  3  4  5  6

GGA →  1  2  3  4  5  6

Send every 10'th received GGA

Connect Script:

Send every 1.00 s.

Close Script:

Log File:

Connected to COM17 I/O 1.1/1.4 kBps

Connection 4

Connect

Show Data

TCP/IP Client localhost:28784

Link →  1  2  3  4  5  6

GGA →  1  2  3  4  5  6

Send every 10'th received GGA

Connect Script:

Send every 1.00 s.

Close Script:

Log File:

Press Connect... I/O 0.0/0.0 kBps

Connection 5

Connect

Show Data

TCP/IP Client localhost:28784

Link →  1  2  3  4  5  6

GGA →  1  2  3  4  5  6

Send every 10'th received GGA

Connect Script:

Send every 1.00 s.

Close Script:

Log File:

Press Connect... I/O 0.0/0.0 kBps

SSRC12 - AsteRx-m2a UAS - SEPT

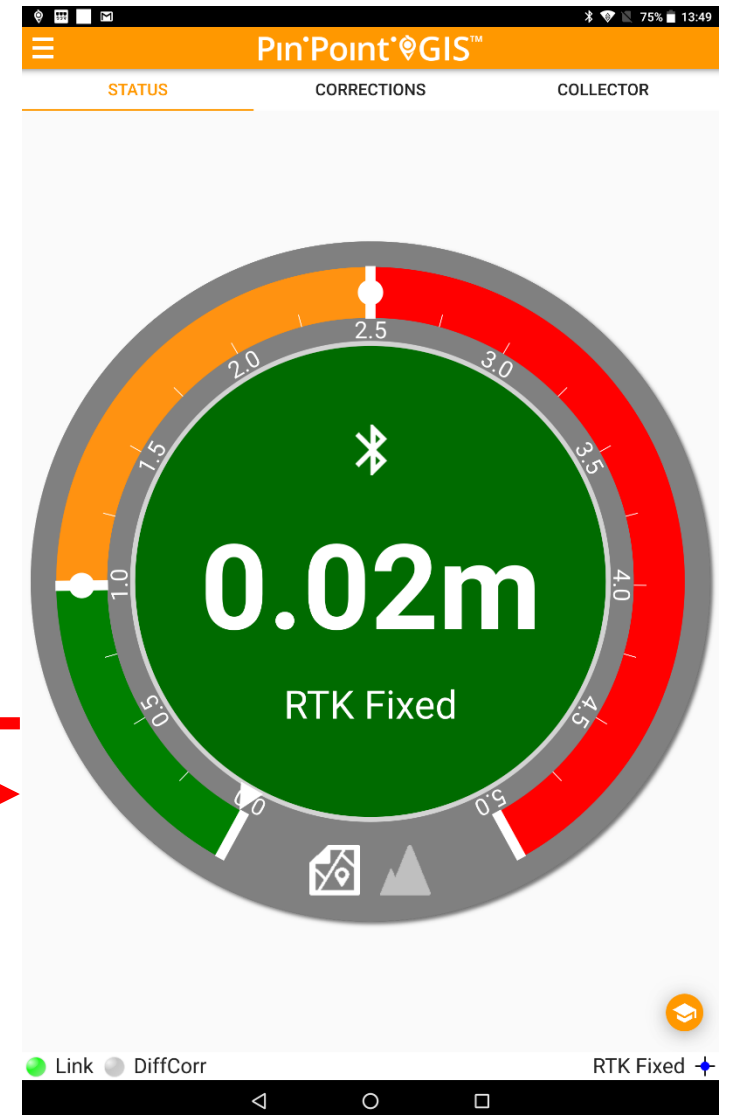
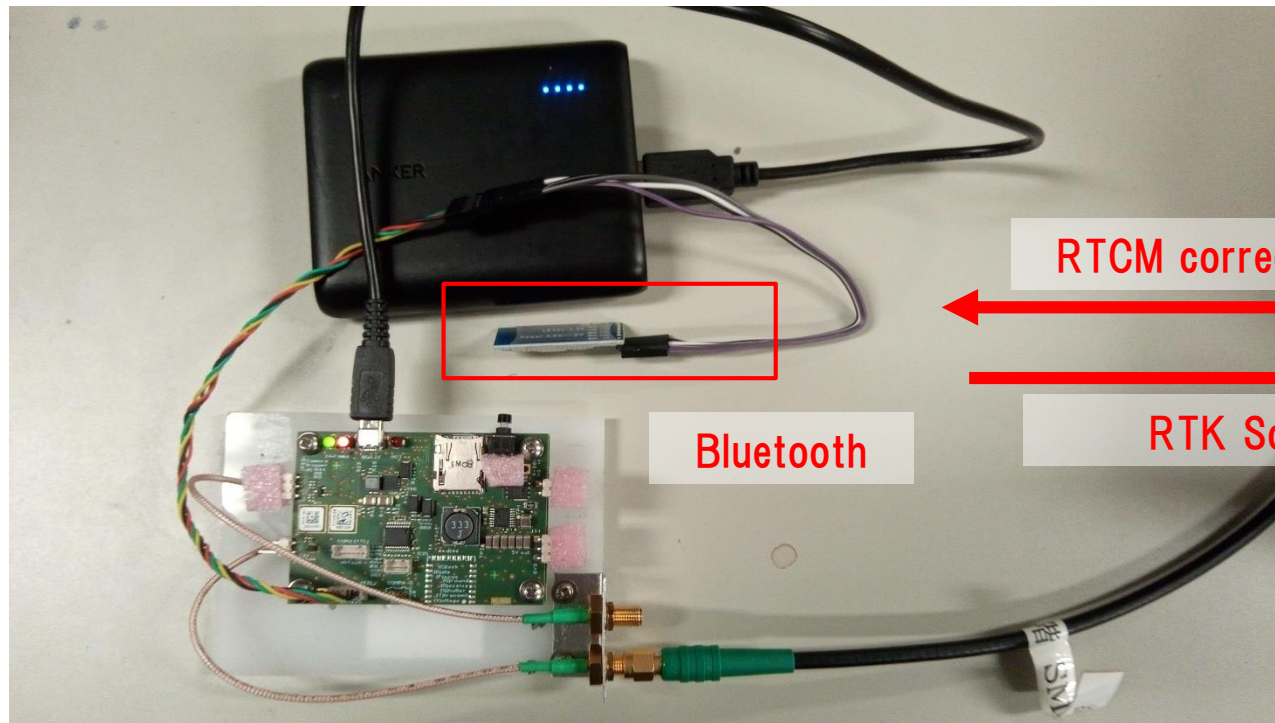
# 4. RTK configuration on rover

## ◆ RTK (Septentrio with smartphone)

Android app that supports septentrio receiver.



<https://play.google.com/store/apps/details?id=com.septentrio.pinpointgis&hl=en>



# 4. RTK configuration on rover

## ◆ RTK (ublox with PC)

Use Ntrip client setting in u-center.

<https://www.u-blox.com/en/product/u-center>

NTRIP client setting

Receiver > NTRIP Client

Select mount point and click "OK".

The screenshot shows the u-center software interface with the 'Receiver' menu highlighted. An 'NTRIP client settings' dialog box is open, with the following fields highlighted in red:

- NTRIP caster settings:
  - Address: 153.121.59.53
  - Port: 2101
  - Username: gspase
  - Password: \*\*\*\*\*
- NTRIP stream:
  - Update source table: [X]
  - Request Interval (sec): [ ]
  - NTRIP mount point: ECJ27 (selected in a dropdown menu)
- Use manual position:
- Longitude (deg): 0
- Latitude (deg): 0
- Altitude (m): 0
- Geoid sep. (m): 0

Buttons: OK, Cancel

The background interface includes a satellite constellation diagram, a data table with the following values:

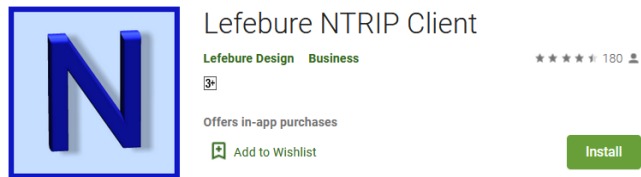
Longitude	139.79239585
Latitude	35.66651513
Altitude	59.446 m
Altitude (msl)	19.997 m
TTF	29.225 s
Fix Mode	3D/DGNSS/FIXED
3D Acc. [m]	0.02
2D Acc. [m]	0.01
PDOP	1.0
HDOP	0.5

Other displays include a compass, a speedometer (0.01 m/s = 0.0 km/h), and a heading indicator (59.446 m).

# 4. RTK configuration on rover

## ◆ RTK (ublox with smartphone)

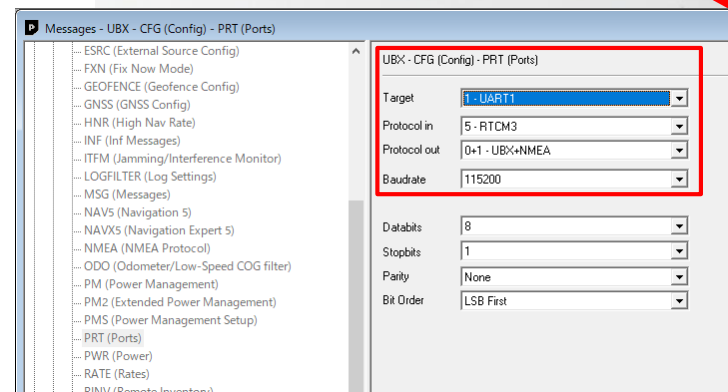
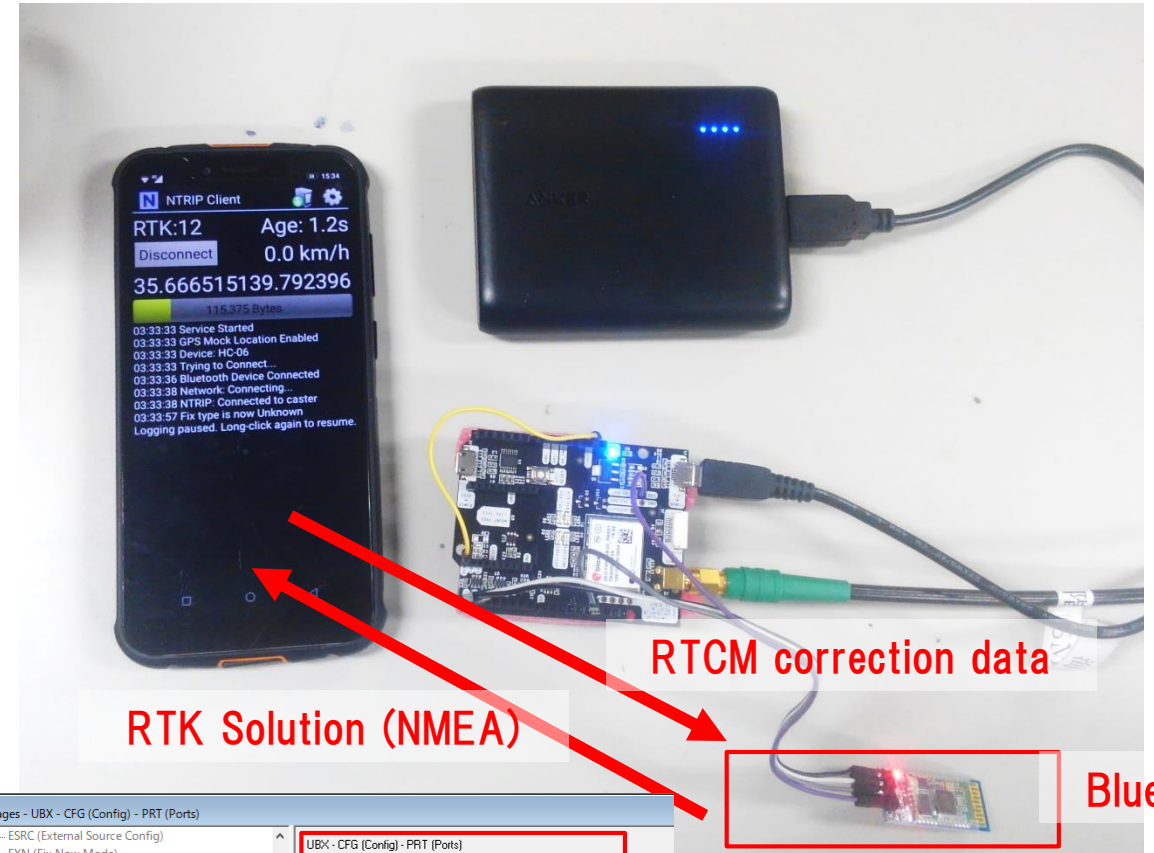
Android app of Ntrip client.



<https://play.google.com/store/apps/details?id=com.lefebure.ntripclient&hl=en>

You need to setup ublox's UART port that connect with Bluetooth module

- Input : RTCM
- Output : NMEA
- Baud rate : Same with Bluetooth module.





# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Real time RTK engine that supports many receivers.

To use RTKNAVI, first you should set receiver to output “raw data”.

“raw data” means binary observation message include RTCM.

RTKNAVI decodes this “raw data” and calculate RTK solution.

Here, I show the example using u-blox receiver.



- RTCM 2
- RTCM 3
- NovAtel OEM6
- ComNav
- u-blox
- Swift Navigation SB
- Hemisphere
- SkyTraq
- GW10
- Javad
- NVS BINR
- BINEX
- Trimble RT17
- Septentrio
- CMR/CMR +
- TERSUS

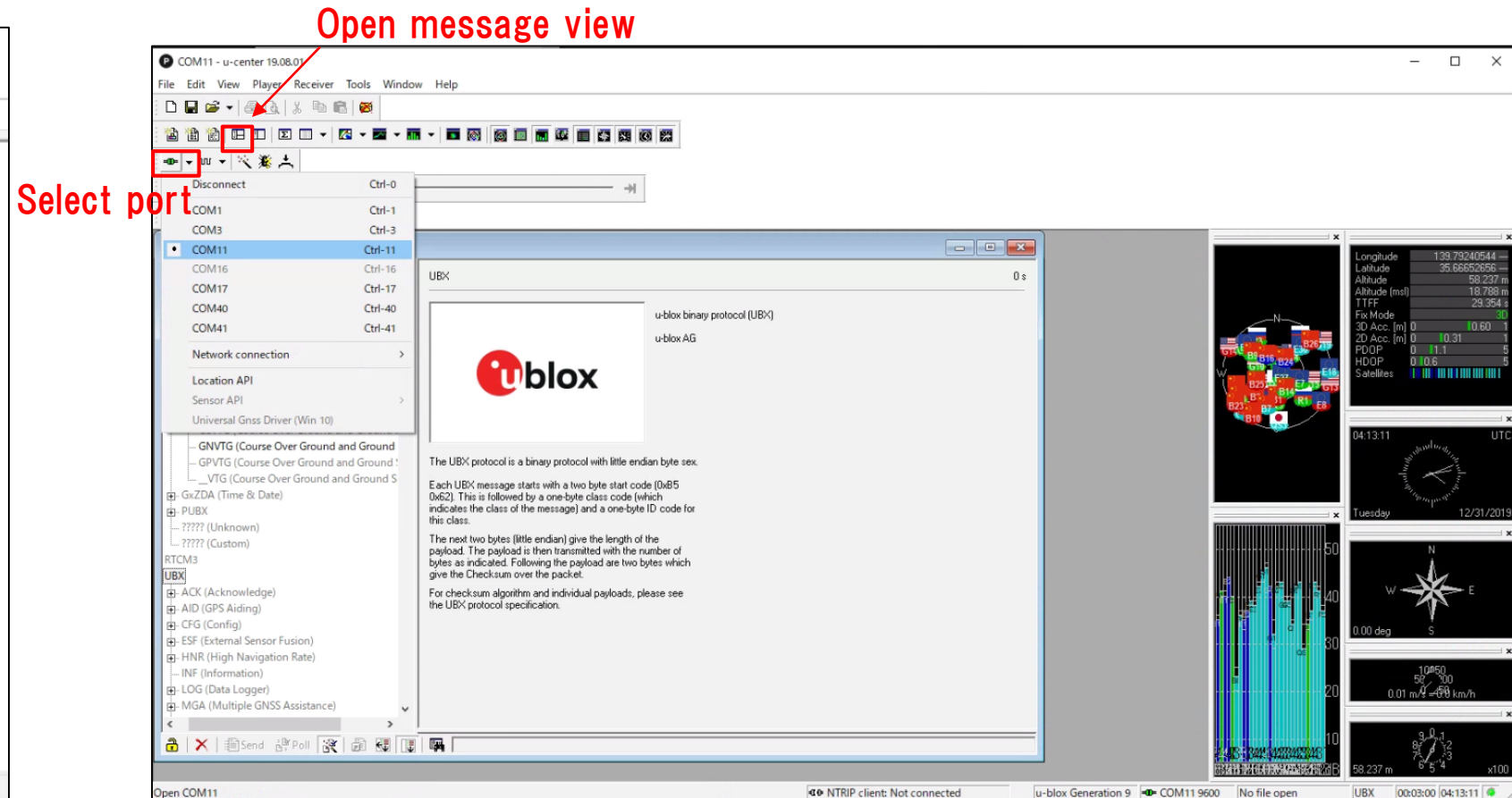
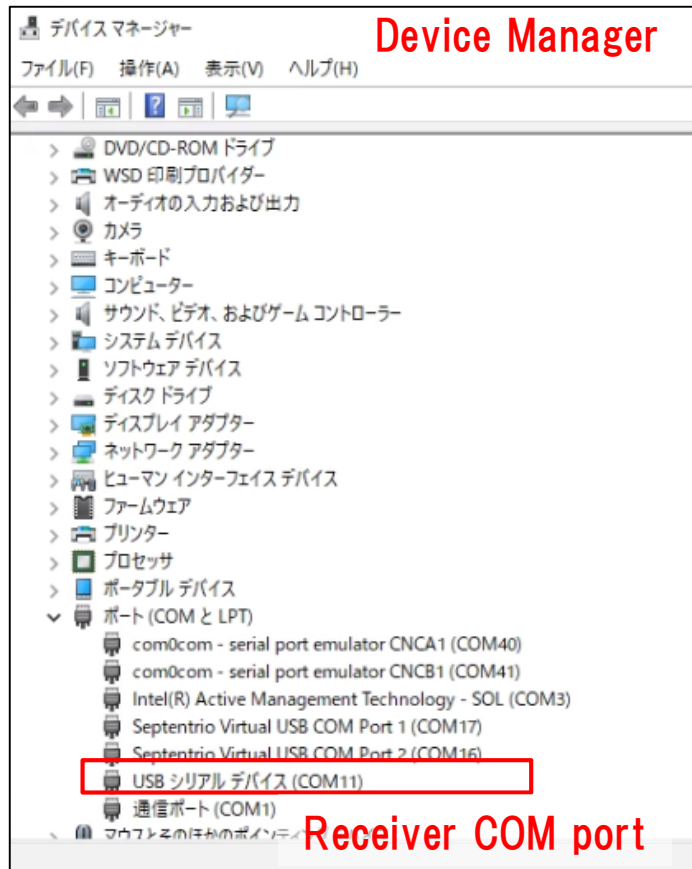
Supported “raw data” formats

# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Receiver configuration on u-center.

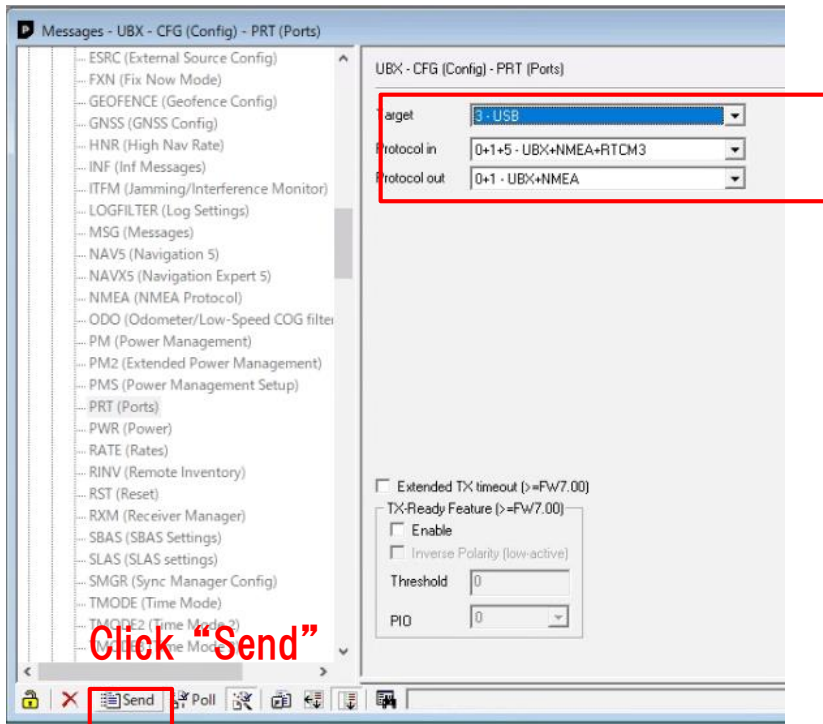
First, select COM port of the receiver and connect. Then open "message view".



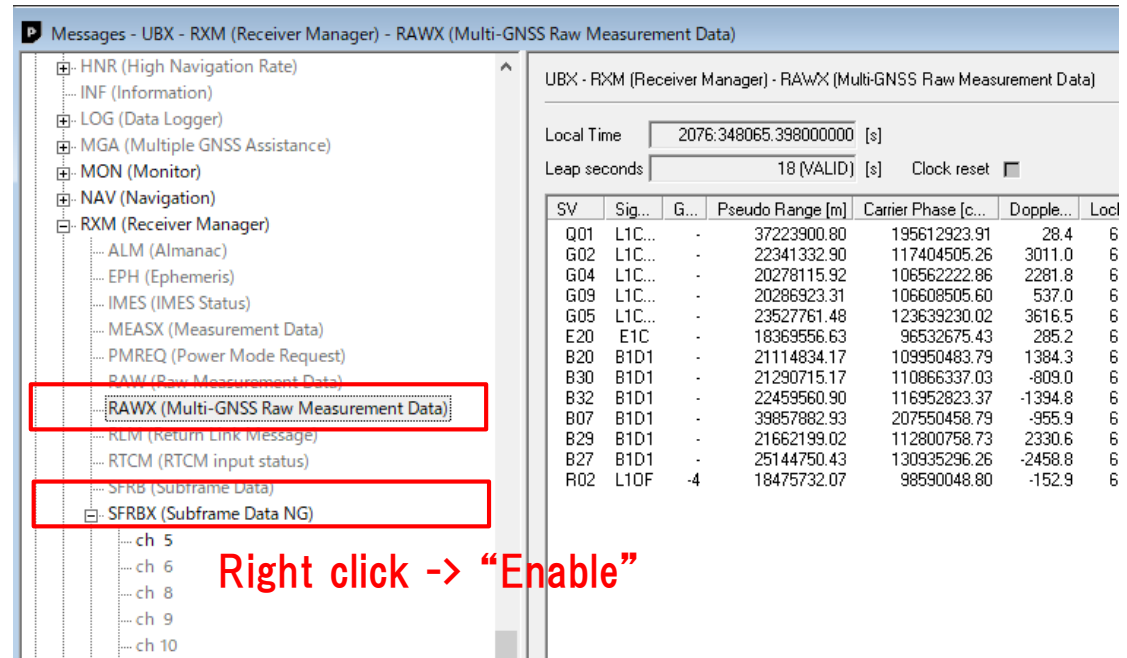
# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Receiver configuration on u-center. Open message view from View>Message View. You need to click “send” after change configuration.



Setting to output UBX format (UBX-CFG-PRT)



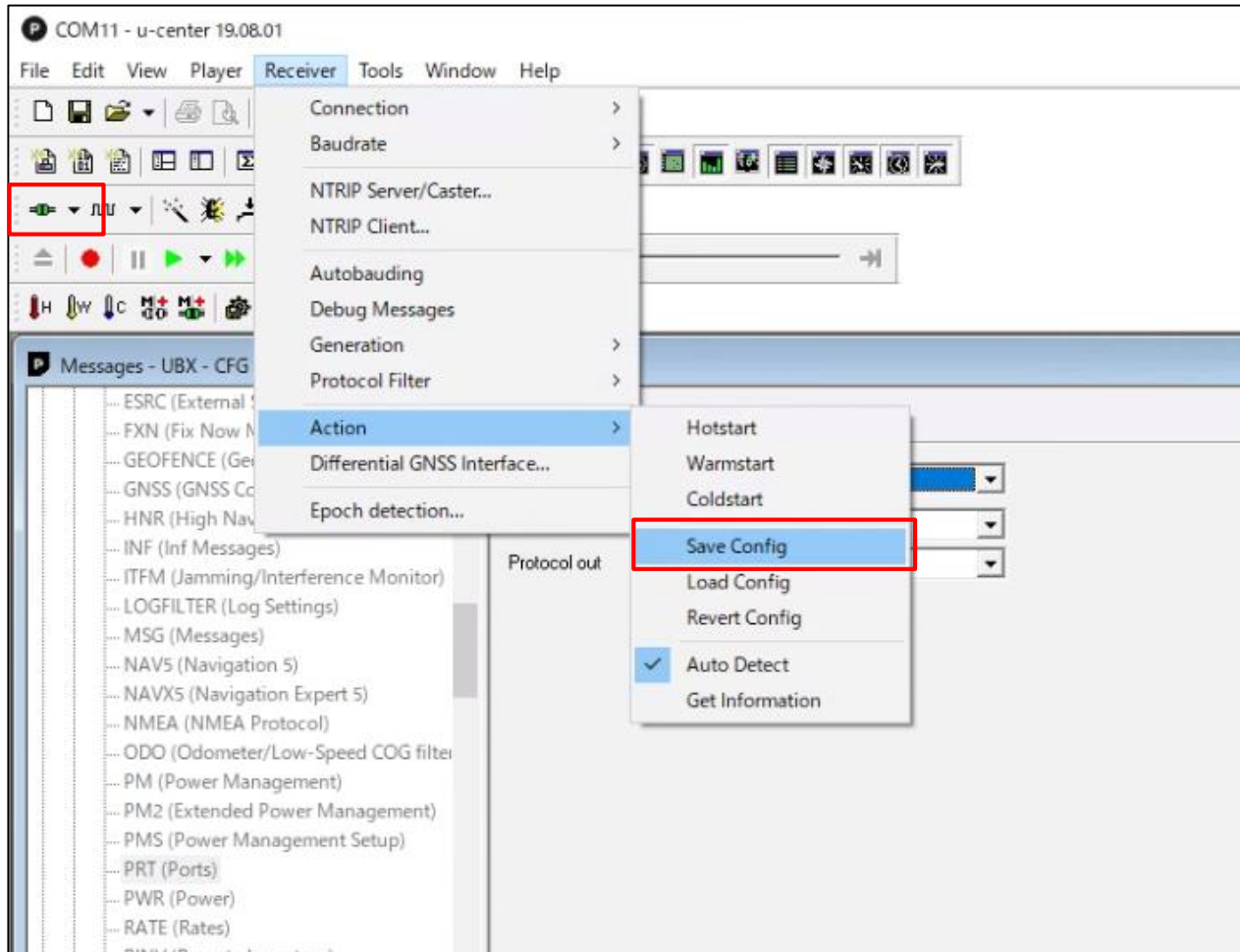
Enable output of RAWX & SFRBX (UBX-RXM )

# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

After receiver configuration was completed, save it and disconnect receiver.

“Disconnect”





# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

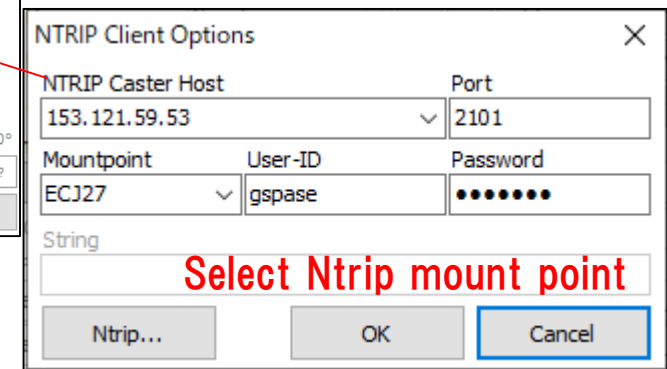
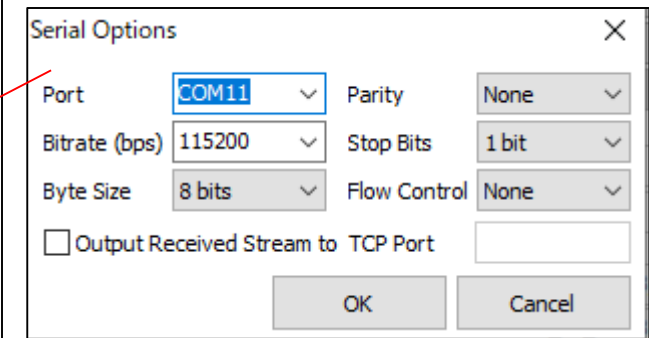
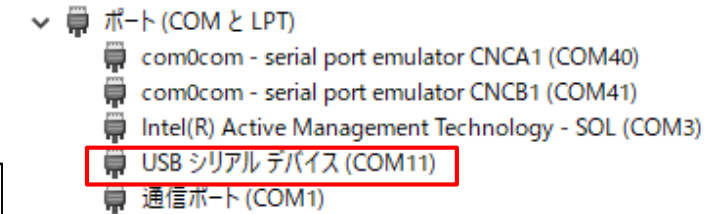
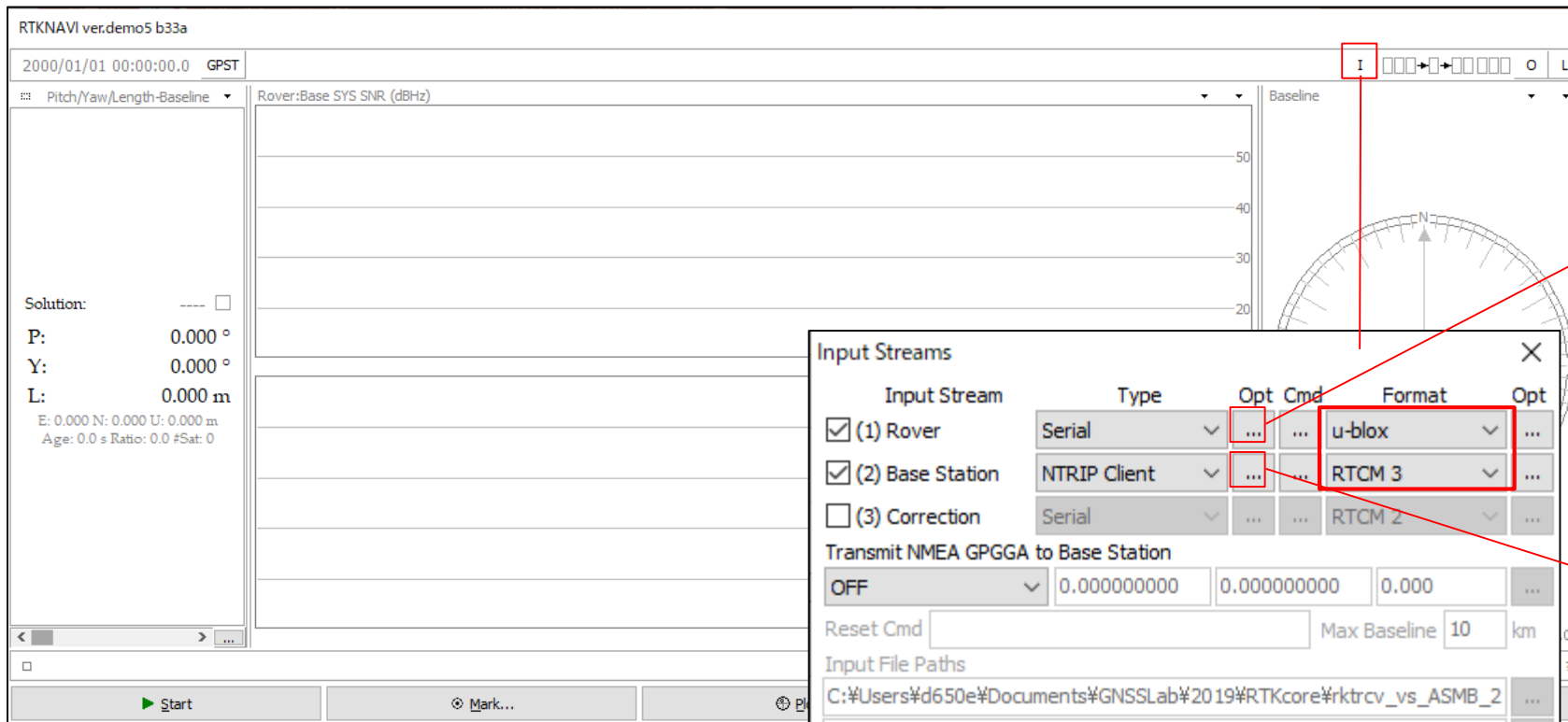
Open RTKNAVI.

The image shows a Windows taskbar with several icons. The icon representing RTKNAVI (a globe with a blue circle) is circled in red. Below the taskbar is the RTKNAVI application window. The window title is "RTKNAVI ver.demo5 b33a". The main interface includes a status bar at the top showing "2000/01/01 00:00:00.0 GPST" and a toolbar with icons for "I", "O", and "L". The main area is divided into three sections: a left sidebar with "Solution:" information (P: 0.000°, Y: 0.000°, L: 0.000 m, E: 0.000 N: 0.000 U: 0.000 m, Age: 0.0 s Ratio: 0.0 #Sat: 0), a central "Rover:Base SYS SNR (dBHz)" table with empty rows, and a right "Baseline" plot showing a circular scale with "0.000 m" at the center and axes labeled N, S, E, W. The plot also shows "Y: 0.0°" and "P: 0.0°". At the bottom, there is a toolbar with buttons for "Start", "Mark...", "Plot", "Options...", and "Exit".

# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Set input stream.

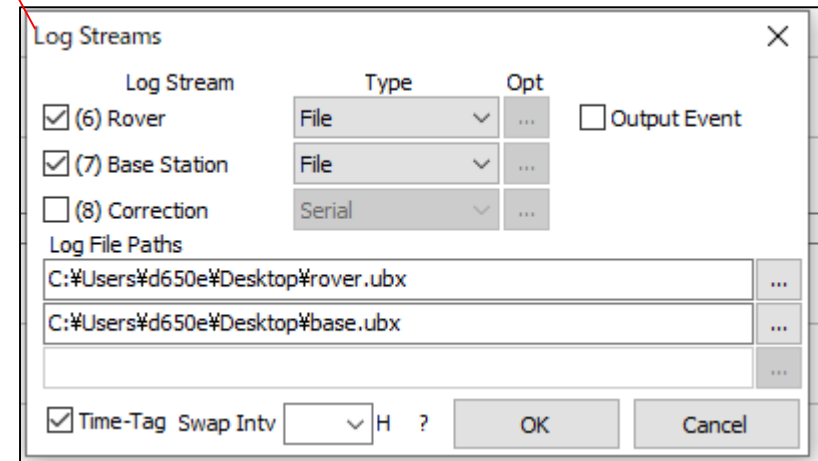
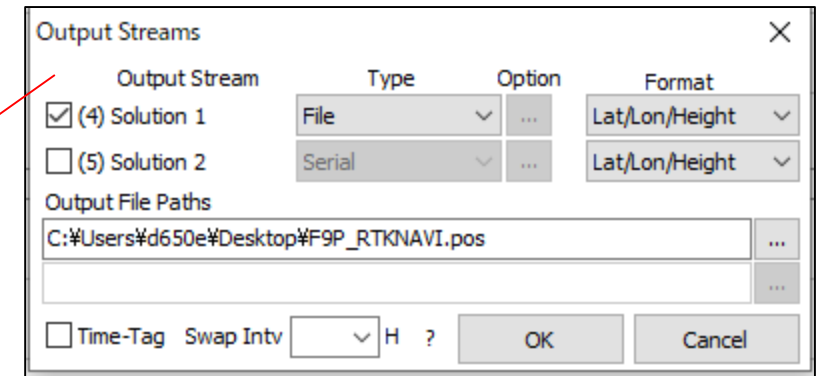
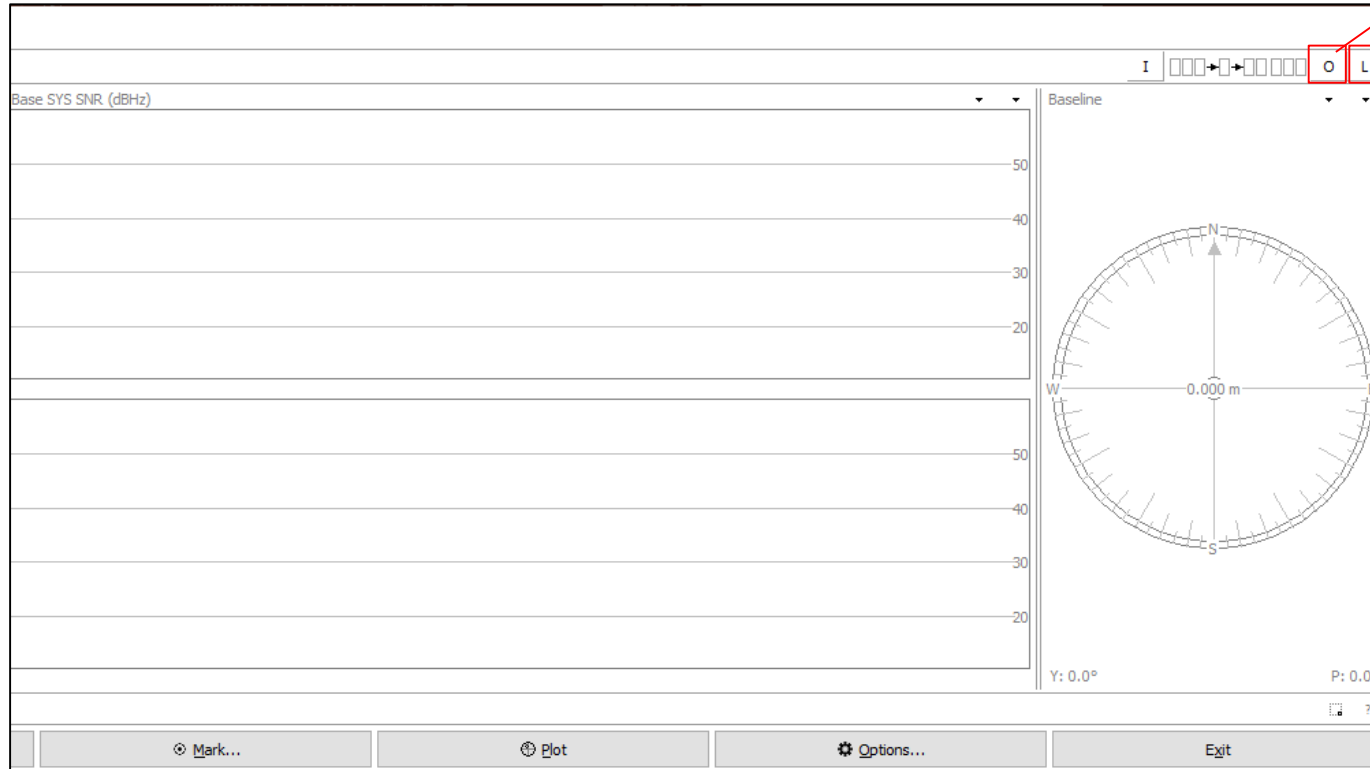


# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Set output stream & log stream.

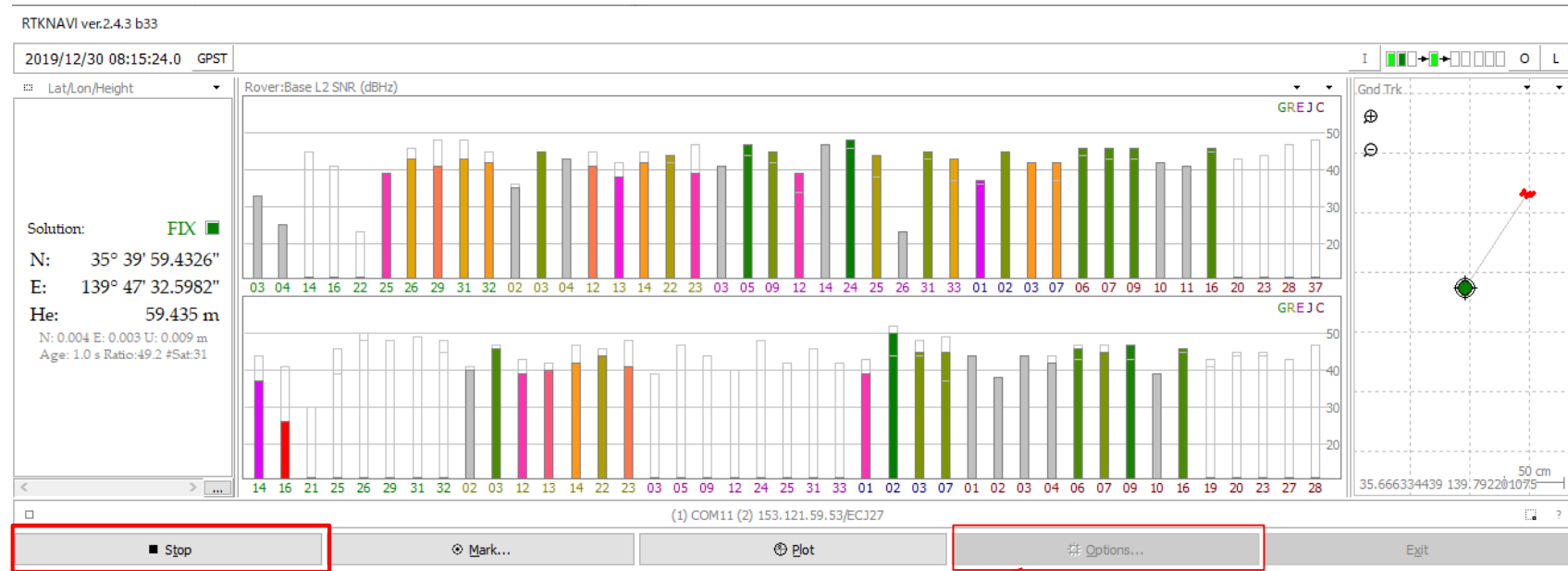
Here the RTK position will be written to the file.  
Also you can choose other option (TCP, Serial) according to your use case



# 4. RTK configuration on rover

## ◆ RTK (RTKNAVI)

Set option to calculate RTK.  
After option setting, click  
"Start" and then RTK starts.



The screenshot shows the 'Options' dialog box, 'Setting1' tab. The 'Positioning Mode' is set to 'Kinematic'. The 'Frequencies / Filter Type' is 'L1+L2' and 'Forward'. The 'Elevation Mask (°) / SNR Mask (dbHz)' is '15'. The 'Rec Dynamics / Earth Tides Correction' is 'OFF'. The 'Ionosphere Correction' is 'Broadcast'. The 'Troposphere Correction' is 'Saastamoinen'. The 'Satellite Ephemeris/Clock' is 'Broadcast'. The 'Excluded Satellites (+PRN: Included)' field is empty. The 'GPS', 'GLO', 'Galileo', 'QZSS', 'SBAS', 'BeiDou', and 'IRNSS' checkboxes are all checked. The 'Load', 'Save', 'OK', and 'Cancel' buttons are at the bottom.

The screenshot shows the 'Options' dialog box, 'Setting2' tab. The 'Integer Ambiguity Res (GPS/GLO/BDS)' is 'Fix and'. The 'Min Ratio to Fix Ambiguity' is '3.0'. The 'Min Confidence / Max FCB to Fix Amb' is '0.9999' and '0.20'. The 'Min Lock / Elevation (°) to Fix Amb' is '0' and '0'. The 'Min Fix / Elevation (°) to Hold Amb' is '10' and '40'. The 'Outage to Reset Amb / Slip Thres (m)' is '5' and '0.050'. The 'Max Age of Diff (s) / Sync Solution' is '30.0' and 'OFF'. The 'Reject Threshold of GDOP/Innov (m)' is '30.0' and '30.0'. The 'Max # of AR Iter / # of Filter Iter' is '1' and '1'. The 'Baseline Length Constraint (m)' is '1.590' and '0.020'. The 'Load', 'Save', 'OK', and 'Cancel' buttons are at the bottom.

The screenshot shows the 'Options' dialog box, 'Output' tab. The 'Solution Format' is 'Lat/Lon/Height'. The 'Output Header / Output Processing Options' is 'OFF' and 'OFF'. The 'Time Format / # of Decimals' is 'hh:mm:ss GPST' and '3'. The 'Latitude Longitude Format / Field Separator' is 'ddd.dddddd'. The 'Output Single if Sol Outage / Max Sol Std (m)' is 'ON' and '10'. The 'Datum / Height' is 'WGS84' and 'Ellipsoidal'. The 'Geoid Model' is 'Internal'. The 'Solution for Static Mode' is 'All'. The 'NMEA Interval (s) RMC/GGA, GSA/GSV' is '0' and '0'. The 'Output Solution Status / Output Debug Trace' is 'OFF' and 'OFF'. The 'Load', 'Save', 'OK', and 'Cancel' buttons are at the bottom.

The screenshot shows the 'Options' dialog box, 'Statistics' tab. The 'Measurement Errors (1-sigma)' are: Code/Carrier-Phase Error Ratio L1/L2: 600.0 / 600.0; Carrier-Phase Error a+b/sinEl (m): 0.003 / 0.003; Carrier-Phase Error/Baseline (m/10km): 0.000; Doppler Frequency (Hz): 1.000. The 'Process Noises (1-sigma/sqrt(s))' are: Receiver Accel Horiz/Vertical (m/s2): 1.00E+01 / 1.00E+01; Carrier-Phase Bias (cycle): 1.00E-04; Vertical Ionospheric Delay (m/10km): 1.00E-03; Zenith Tropospheric Delay (m): 1.00E-04; Satellite Clock Stability (s/s): 5.00E-12. The 'Load', 'Save', 'OK', and 'Cancel' buttons are at the bottom.

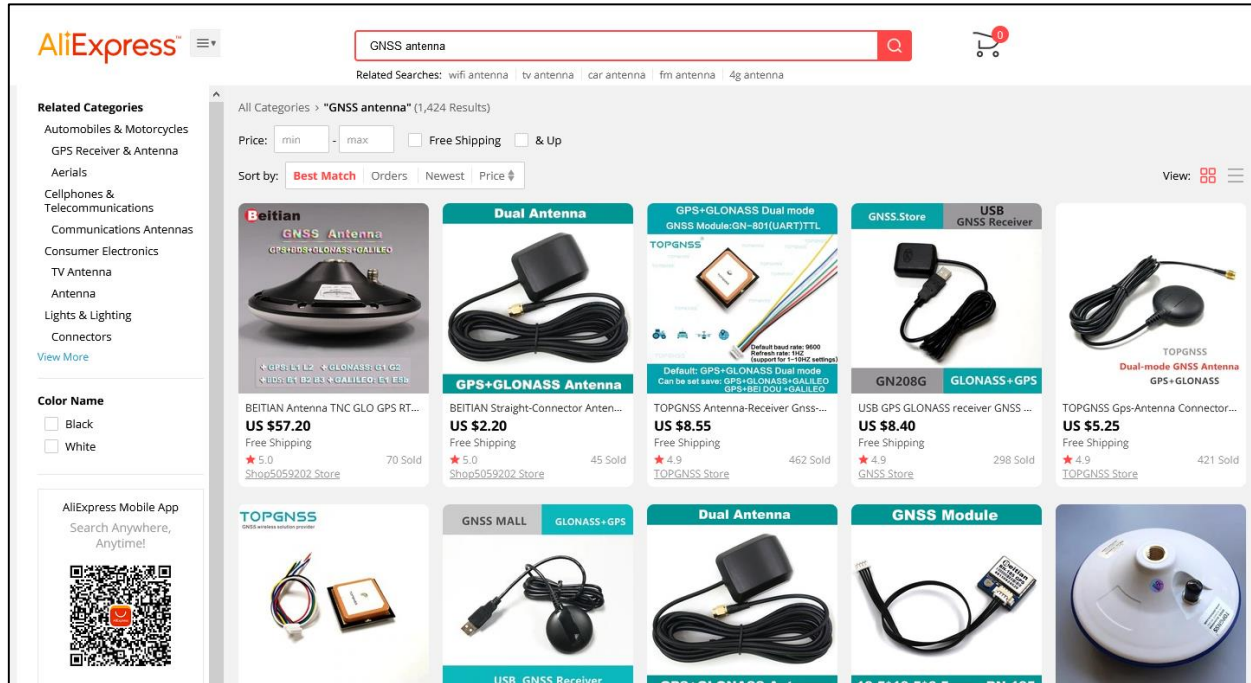
The screenshot shows the 'Options' dialog box, 'Positions' tab. The 'Rover' position is 'Lat/Lon/Height (deg/m)'. The 'Base Station' position is 'Lat/Lon/Height (deg/m)'. The 'RTCM Antenna Position' dropdown is highlighted with a red box. The 'Antenna Type (\*: Auto)' is 'Auto'. The 'Station Position File' is empty. The 'Load', 'Save', 'OK', and 'Cancel' buttons are at the bottom.



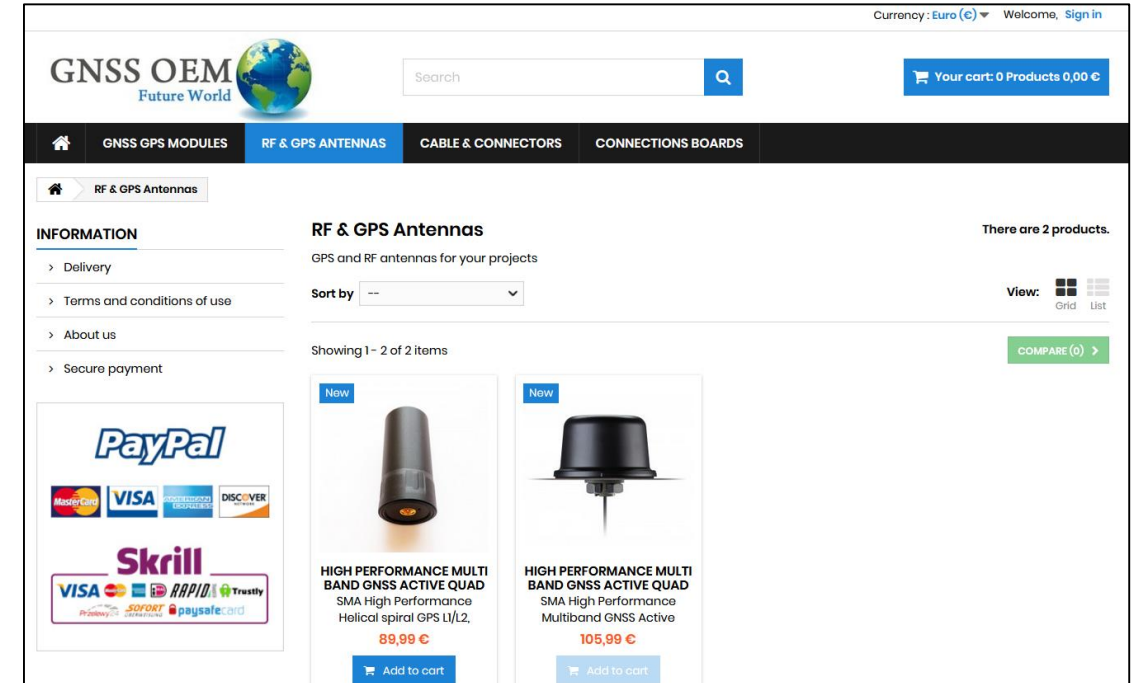
# 5. Where can I buy GNSS devices?

I show some shop that you can buy GNSS devices.

## ◆ Antenna



AliExpress



Eltehs GNSS OEM Store

# 5. Where can I buy GNSS devices?

## ◆ Antenna

The screenshot shows the ArduSimple website's 'Store' section. The navigation bar includes 'HOME', 'PRODUCTS', 'BLOG', 'SUPPORT', 'CONTACT', and 'SHOP'. A DHL logo indicates worldwide shipping from Europe. The main heading is 'Accessories looking for spare parts?'. Below this, there are eight product listings arranged in two rows of four. Each listing includes a product image, a name, a price, and an 'Add to cart' button. The products are: simpleRTK2B (172,00€), simpleRTK2B-F9H (149,00€), simpleRTK2Blite (199,00€), simpleRTK2B – LR Rover IP67 (386,00€), Antenna for GNSS Multiband with cable (OEM) (61,00€), u-blox GNSS Multiband antenna ANN-MB-00 (IP67) (53,00€), Survey GNSS Multiband antenna (89,00€), and Lightweight helical antenna for multiband GNSS (112,00€).

Ardusimple

The screenshot shows an eBay search results page for 'GNSS antenna L2'. The search bar at the top contains the text 'GNSS antenna L2'. The page displays 21 results. The first two results are highlighted. The first result is for a 'Trimble GA830 GNSS OmniSTAR GPS Beidou GLONASS Galileo L1 L2 L5 MSK RTX Antenna' priced at JPY 159,999. The second result is for a 'Harxon HX-CA7606A GNSS Aviation Antenna GPS L1L2 + GLONASS L1L2 + BDS B1B2B3' priced at JPY 31,780. The page also shows filters for categories, condition, and price.

ebay

# 5. Where can I buy GNSS devices?

## ◆ Receiver

AliExpress search results for "f9p" (3,133 Results). The page shows a search bar with "f9p" and related searches: rtk antenna, antenna gnss, fir one pro, gnss receiver, trimble gnss. The results are sorted by "Best Match".

Product Name	Price	Shipping	Store
Antenna F9p Modules High-Precisi...	US \$297.50	Free Shipping	GNSSMALL Store
TOPGNSS zed f9p receiver antenn...	US \$350	Shipping: US \$2.67	TOPGNSS Store
Receiver Module RTK F9P Antenna ...	US \$450	Free Shipping	GNSSMALL Store
Antenna-Module RTK Nmea 0183 ...	US \$612	Free Shipping	GNSSMALL Store
Receiver RTK F9P Antenna Module ...	US \$382.50	Free Shipping	GNSSMALL Store

AliExpress search results for "rtk oem" (18 Results). The page shows a search bar with "rtk oem" and related searches: gps rtk, drone rtk, trimble rtk, gps rtk trimble, gps antenna rtk. The results are sorted by "Best Match".

Product Name	Price	Shipping	Store
Used Trimble OEM BOARD BD970 ...	US \$550	Free Shipping	Trimble Store
2pcs suitable for BD982 GNSS RTK ...	US \$300 /lot	Free Shipping	GNSS Store
Trimble OEM BOARD BD982 GNSS...	US \$797	Free Shipping	Trimble Store
BEITIAN HIGH PERFORMANCE RTK ...	US \$660	Free Shipping	Shop5059202 Store
Reader Tablette 8inch Fingerprint ...	US \$185	Shipping: US \$30.39	Tablet Pc Manufacturer Store

JINYUSHI Wireless Module Speciality Store

Brand NEW for Novatel OEM729 GNSS receiver RTK high accuracy positioning measurement GPS/GLONASS/Galileo/BDS 5Hz

**US \$1,429.80**

Quantity: 1 (999 pieces available)

**Free Shipping**  
to Japan via AliExpress Standard Shipping -  
Estimated Delivery: 13-20 days

**Buy Now** **Add to Cart** **3**

60-Day Buyer Protection  
Money back guarantee

AliExpress(ublox, Trimble, Novatel)

# 5. Where can I buy GNSS devices?

## ◆ Receiver

The screenshot displays the Eltehs GNSS OEM Store website. At the top, the logo reads "GNSS OEM Future World" with a globe icon. A search bar and a cart icon showing "Your cart: 0 Products 0,00 €" are visible. The navigation menu includes "GNSS GPS MODULES", "RF & GPS ANTENNAS", "CABLE & CONNECTORS", and "CONNECTIONS BOARDS". The main content area is titled "GNSS GPS Modules" and indicates "There are 74 products." It features a sidebar with "INFORMATION" links (Delivery, Terms and conditions of use, About us, Secure payment) and a payment methods section with logos for PayPal, MasterCard, VISA, DISCOVER, Skrill, VISA, SOFORT, RAPID, Trustly, and paysafecard. The product grid shows four items:

- ZED-F9H HIGH PRECISION GNSS INCASE PIN MODULE**: ZED-F9H high precision GNSS InCase PIN module for **174,99 €**. [Add to cart](#)
- 5G NETWORK SYNCHRONIZATION ZED-ZED-F9T USB Dongle**: 5G NETWORK SYNCHRONIZATION ZED-ZED-F9T USB Dongle with SMA time pulse out, High **219,99 €**. [Add to cart](#)
- 5G NETWORK SYNCHRONIZATION ZED-ZED-F9T InCase PIN**: 5G NETWORK SYNCHRONIZATION ZED-ZED-F9T InCase PIN high accuracy timing module **189,99 €**. [Add to cart](#)
- ZED-F9P RTK INCASE PIN GNSS RECEIVER BOARD**: ZED-F9P High Precision GNSS receiver InCase PIN **189,99 €**. [Add to cart](#)

Eltehs GNSS OEM Store (ublox)



# 5. Where can I buy GNSS devices?

## ◆ Receiver

The screenshot shows the ArduSimple website's 'Store' section. At the top, there is a navigation bar with 'HOME', 'PRODUCTS', 'BLOG', 'SUPPORT', 'CONTACT', and 'SHOP'. A DHL logo is prominently displayed with the text 'We ship worldwide with DHL from Europe'. Below this, a 'Starter kits' section is titled 'everything you need to start your project'. Six different starter kit options are listed in a grid, each with an image, a title, a price, and a 'Select options' button. The kits include: simpleRTK2B - Basic Starter Kit IP67 (211,00€), simpleRTK2B - Starter Kit MR IP67 (530,00€), simpleRTK2B - Starter Kit LR IP67 (662,00€), simpleRTK2B-lite - Basic Starter Kit IP67 (241,00€), simpleRTK2B+heading - Basic Starter Kit IP67 (444,00€), and simpleRTK2B-lite - mPCIe Starter Kit IP67 (249,00€).

Ardusimple (ublox)

The screenshot shows the ublox direct shop website. The navigation bar includes 'Products', 'Support', 'Beyond', and 'Investors'. The breadcrumb trail reads: Home → u-center → ZED-F9P module → Product Selector → C099-F9P application board. The main heading is 'C099-F9P application board' with the subtitle 'Easy evaluation of u-blox ZED-F9P with multi-band RTK'. A product image of the application board is shown on the right. Below the heading, a 'Highlights' section lists: Application board for ZED-F9P, Flexible connectivity options, including Wi-Fi and Bluetooth, and Arduino Mega shield connections for host expansion. A 'Product variants' table is located at the bottom.

Product Variant	Description	Action
C099-F9P-0	For Asia and other regions not covered by the other two variants Starting from 220.10 EUR (1 - 49 pcs)	add to cart
C099-F9P-1	For Europe, Russia, and Australia: HxGN SmartNet trial license included Starting from 220.10 EUR (1 - 49 pcs)	add to cart
C099-F9P-2	For USA and Canada: HxGN SmartNet trial license included Starting from 220.10 EUR (1 - 49 pcs)	add to cart

ublox direct shop

# 5. Where can I buy GNSS devices?

## ◆ Receiver

septentrio Products Industries Insights Company Jobs Support Contact

Home > Products > GPS / GNSS Receivers > Rover & Base Receivers > Receiver Modules > mosaic development kit

### mosaic development kit

Septentrio mosaic™ is Septentrio's most compact high-precision GPS/GNSS module, delivering best-in-class centimeter-level positioning performance even in challenging environments. It's a multi-band, multi-constellation GPS/GNSS receiver in a low power surface mount module. It is designed for mass market applications like robotics and autonomous systems supporting all current and future GNSS satellite signals. Unique built-in AIM+ technology for interference mitigation, ensures the best availability, reliability and precision.

The development kit offers the possibility to discover and play with the mosaic. Create a prototype by integrating the mosaic dev-kit into your system using any of the of following connections: internet, COM ports, USB 2.0, SD memory card.

Want to be one of the first to discover the many advantages of high-precision GNSS with the Septentrio mosaic™ dev-kit?  
Fill in your information below.

First name \*

Last name \*

Company name \*

Email \*

**Related industries**

- > Automotive ADAS

**Related insights**

- > What is spoofing and how to ensure GPS security?

Septentrio direct shop

swift NAVIGATION 0 Items

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## STORE

### Piksi Multi Evaluation Kit

Our Evaluation Kit options differ only in radio frequency. Our 915MHz version is for the US and 2.4GHz version for Europe and other countries that do not allow 915MHz. It is very important to select the correct version; compliance with local regulations is your responsibility.

#### Piksi Multi Evaluation Kit (2.4GHz)

This professional Evaluation Kit contains everything needed for rapid RTK prototyping, testing and evaluation, including: two Piksi Multi L1/L2, G1/G2, B1/B2, E1/E5b and SBAS GNSS Modules, two Evaluation Boards, two high-quality survey-grade GNSS antennas, two high-performance, industrial 2.4 GHz FreeWave® radios with effective ranges up to 15 kilometers (~10 miles) and cables and accessories to ensure a successful assessment.

[Detailed product information](#)

1  \$2,295.00

swift direct shop

# 5. Where can I buy GNSS devices?

## ◆ Cable & connector

The screenshot shows an AliExpress search results page for 'coaxial cable sma'. The search bar contains 'coaxial cable sma' and shows related searches: 'sma male', 'rp sma', 'sma male cable', 'rp sma cable', and 'rp sma antenna cable 5m'. The page displays a grid of product listings with details such as price, shipping, and seller information.

Product Name	Price	Shipping	Seller Rating	Sold
Male Connector Pigtail Coaxial-Ca...	US \$1.57	Free Shipping	★ 4.9	163 Sold
JX Female Connector Pigtail Cable ...	US \$0.88 - 6.98	Shipping: US \$2.14	★ 4.9	58 Sold
JX Coaxial-Cable Connector Skin-A...	US \$1.99 - 4.99	Free Shipping	★ 4.8	67 Sold
RF coaxial cable SMA female to UH...	US \$1.97	Free Shipping	★ 4.8	74 Sold
Pigtail Cable Connector MMCX SM...	US \$1.79	Free Shipping	★ 4.9	47 Sold



JX connector 2pcs RF coaxial coax adapter TNC Male Female Jack to SMA Male Plug S  
traight TNC connector to SMA Connector  
★★★★★ 4.9 - 39 Reviews 59 orders

**US \$2.79 / lot** (2 pieces)

Color:



Quantity:

1 + 39828 lots available

**Free Shipping**

to Japan via China Post Ordinary Small Packet Plus

Estimated Delivery: 15-29 days

[Buy Now](#) [Add to Cart](#) [38](#)

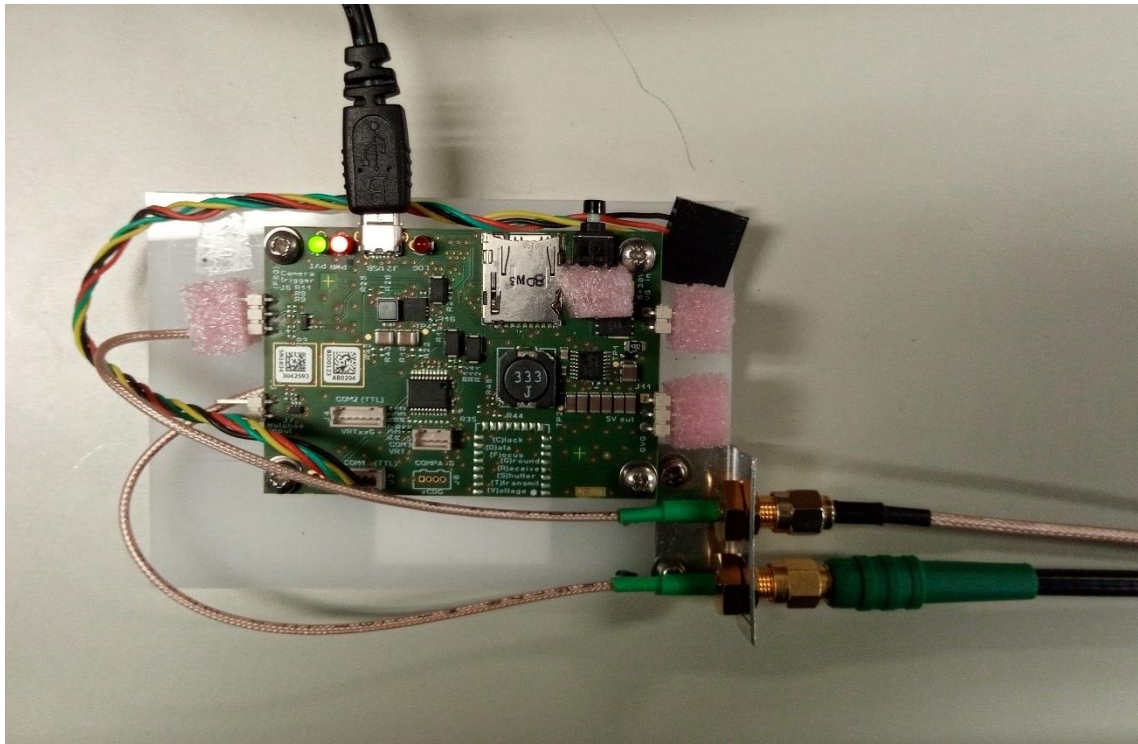
**60-Day Buyer Protection**  
Money back guarantee

SMA or TNC type connector are major in GNSS.

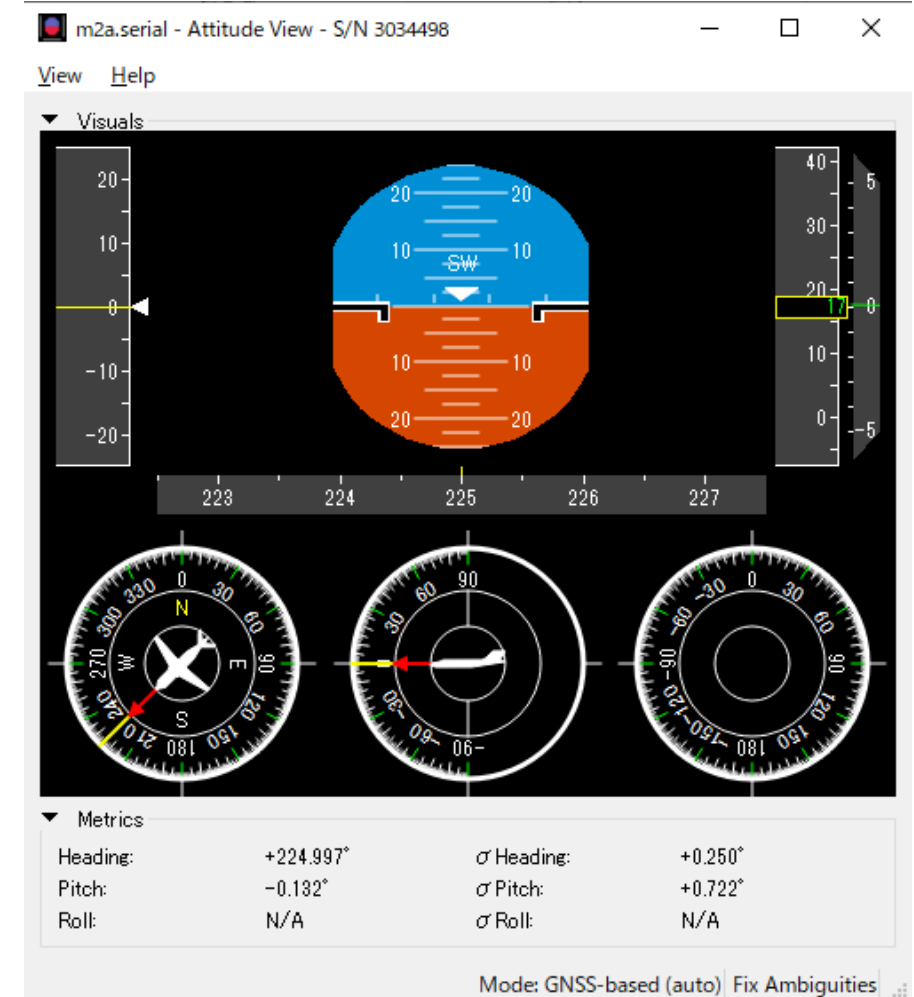
# 6. Moving-base RTK

## ◆ Moving-base RTK (AsteRx-m2a)

Just connect 2 antenna to the receiver.



ASCII output by nmea "HDT" message.

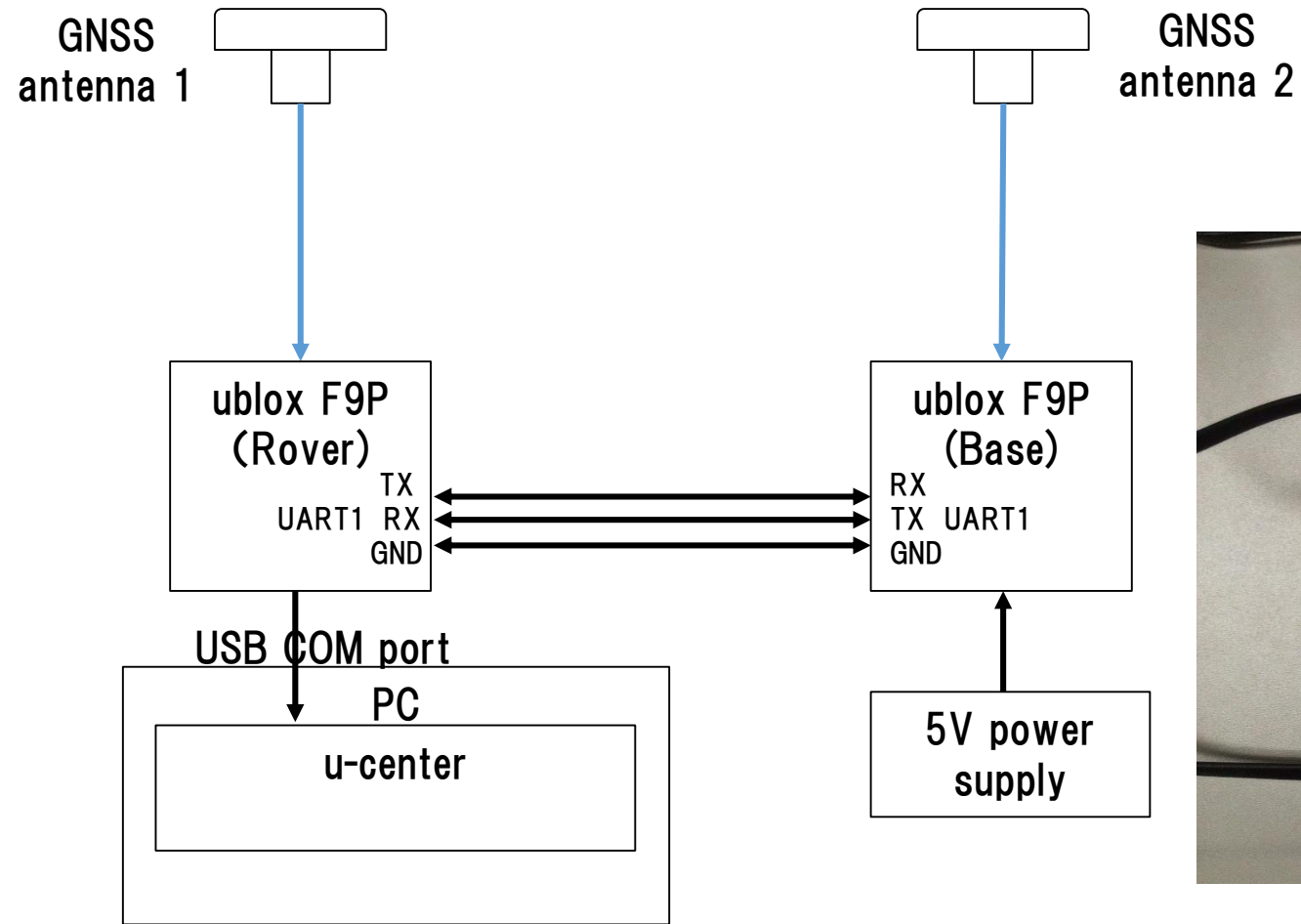


```
$GPGGA,071402.00,3539.9910977,N,13947.5434857,E,2,28,0.6,17.3133,M,39.1  
$GPVTG,,T,,M,0.00,N,0.01,K,D*27  
$GPHDT,225.230,T*31
```



# 6. Moving-base RTK

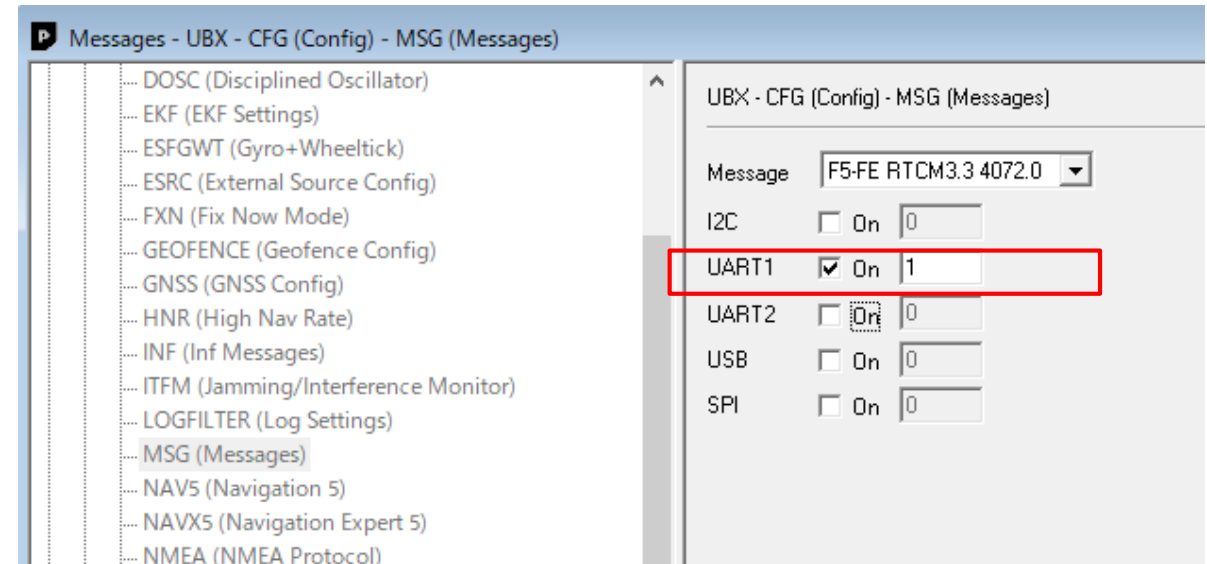
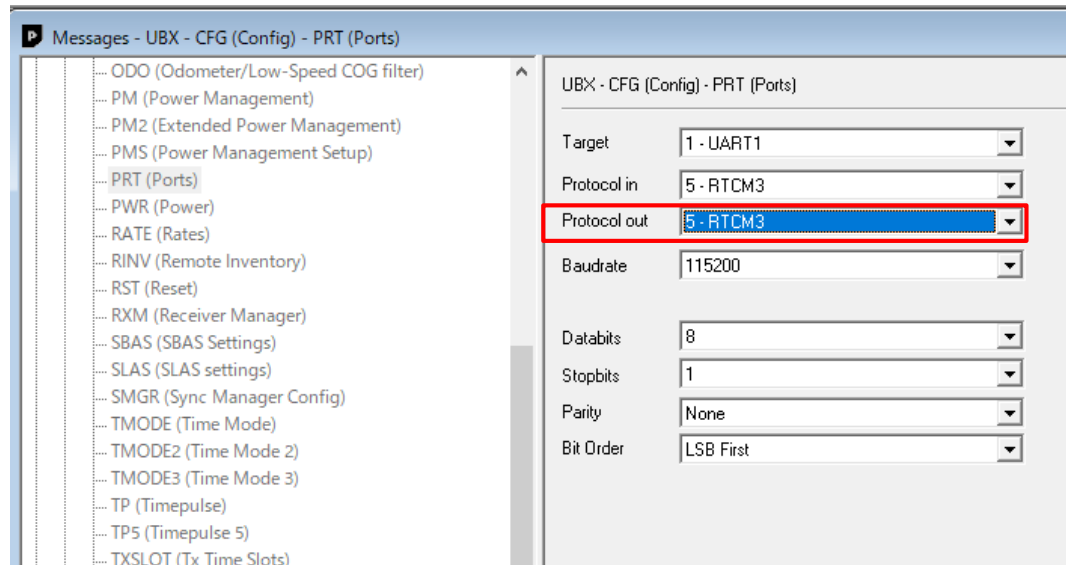
- ◆ Moving-base RTK (F9P)  
Hardware configuration.





# 6. Moving-base RTK

## ◆ Moving-base RTK (F9P) Base configuration.



At UBX-CFG-MSG enable following message to output from used UART.

RTCM3.3 1077 (GPS)

RTCM3.3 1087 (GLONASS)

RTCM3.3 1097 (Galileo)

RTCM3.3 1127 (BeiDou)

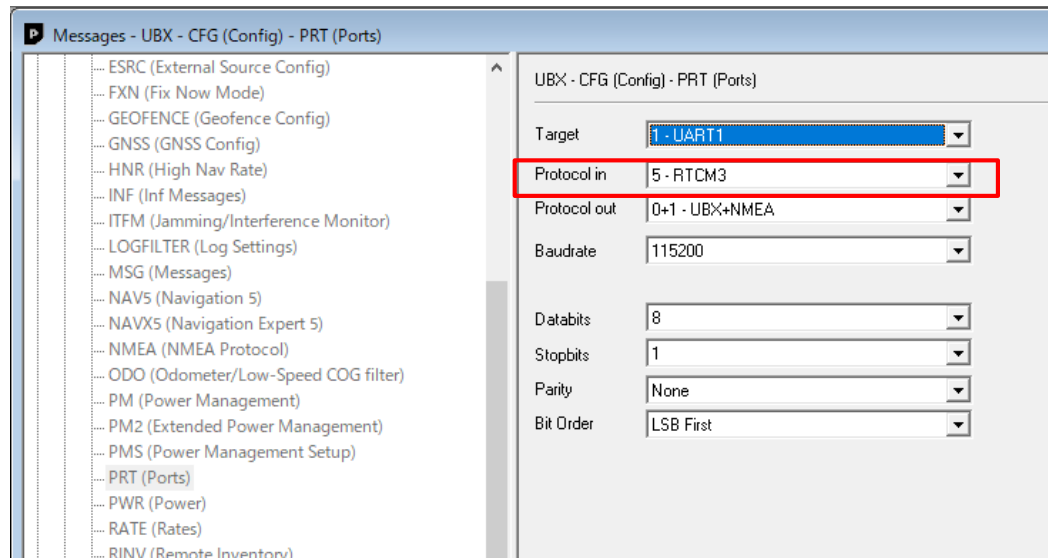
RTCM3.3 4072.0 (For Moving-Base special message)

RTCM3.3 4072.1 (For Moving-Base special message)

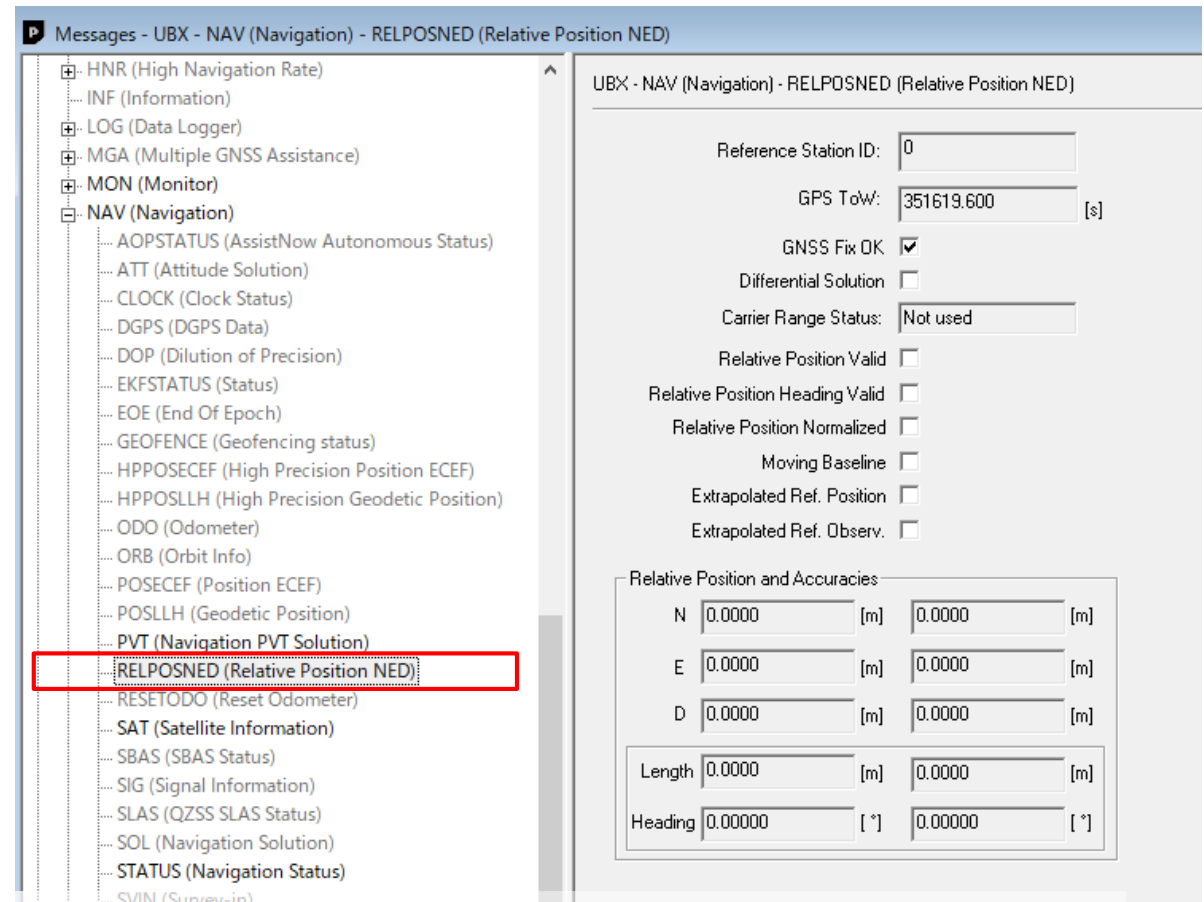
Set protocol out of used UART to RTCM. Baudrate should be over 115200. (UBX-CFG-PRT)

# 6. Moving-base RTK

## ◆ Moving-base RTK (F9P) Rover configuration.



Set protocol in of used UART to RTCM. Baudrate should be over 115200. (UBX-CFG-PRT)



Enable RELPOSNED (UBX-NAV)

# 6. Moving-base RTK

## ◆ Moving-base RTK (F9P)

Messages - UBX - NAV (Navigation) - RELPOSNED (Relative Position NED)

- HNR (High Navigation Rate)
- INF (Information)
- LOG (Data Logger)
- MGA (Multiple GNSS Assistance)
- MON (Monitor)
- NAV (Navigation)
  - AOPSTATUS (AssistNow Autonomous Status)
  - ATT (Attitude Solution)
  - CLOCK (Clock Status)
  - DGPS (DGPS Data)
  - DOP (Dilution of Precision)
  - EKFSTATUS (Status)
  - EOE (End Of Epoch)
  - GEOFENCE (Geofencing status)
  - HPPOSECEF (High Precision Position ECEF)
  - HPPOSLLH (High Precision Geodetic Position)
  - ODO (Odometer)
  - ORB (Orbit Info)
  - POSECEF (Position ECEF)
  - POSLLH (Geodetic Position)
  - PVT (Navigation PVT Solution)
  - RELPOSNED (Relative Position NED)**
  - RESETODO (Reset Odometer)
  - SAT (Satellite Information)
  - SBAS (SBAS Status)
  - SIG (Signal Information)
  - SLAS (QZSS SLAS Status)
  - SOL (Navigation Solution)
  - STATUS (Navigation Status)

UBX - NAV (Navigation) - RELPOSNED (Relative Position NED)

Reference Station ID: 0

GPS ToW: 353183.000 [s]

GNSS Fix OK

Differential Solution

Carrier Range Status: Fixed

Relative Position Valid

Relative Position Heading Valid

Relative Position Normalized

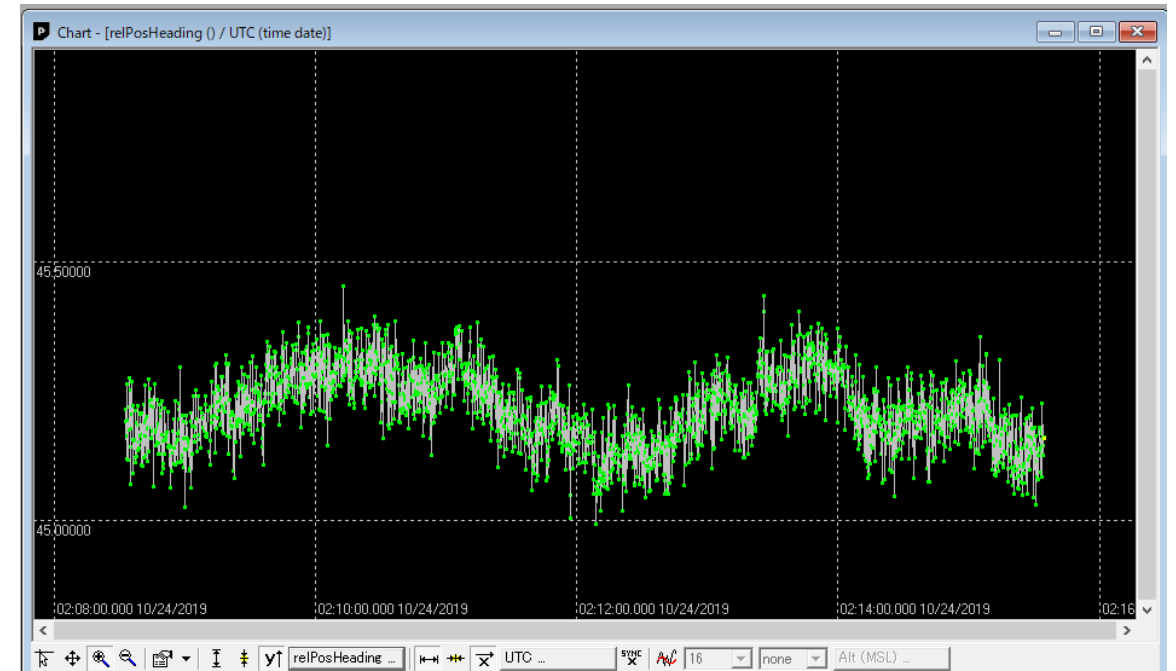
Moving Baseline

Extrapolated Ref. Position

Extrapolated Ref. Observ.

Relative Position and Accuracies

N	0.6718 [m]	0.0100 [m]
E	0.6752 [m]	0.0100 [m]
D	0.0018 [m]	0.0100 [m]
Length	0.9525 [m]	0.0100 [m]
Heading	45.14771 [°]	0.60155 [°]

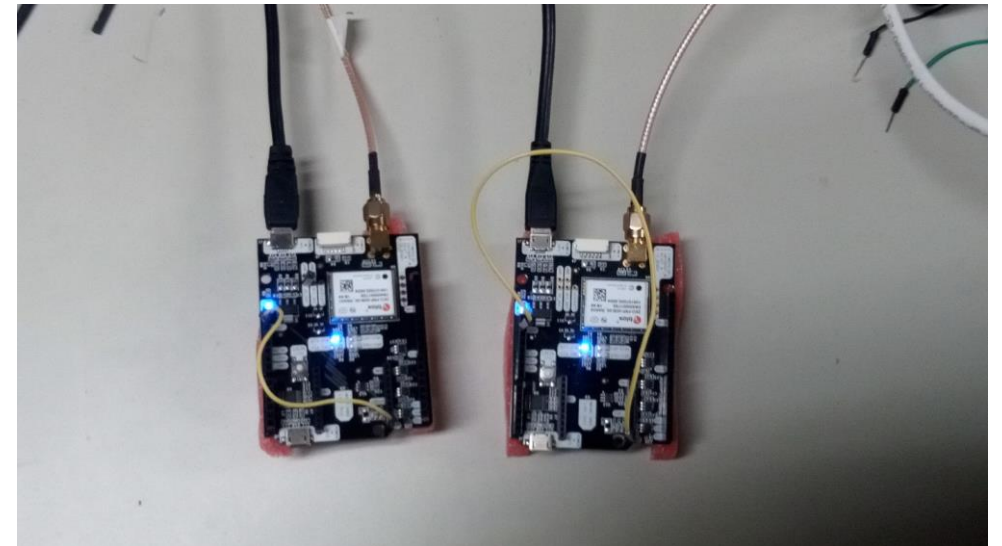
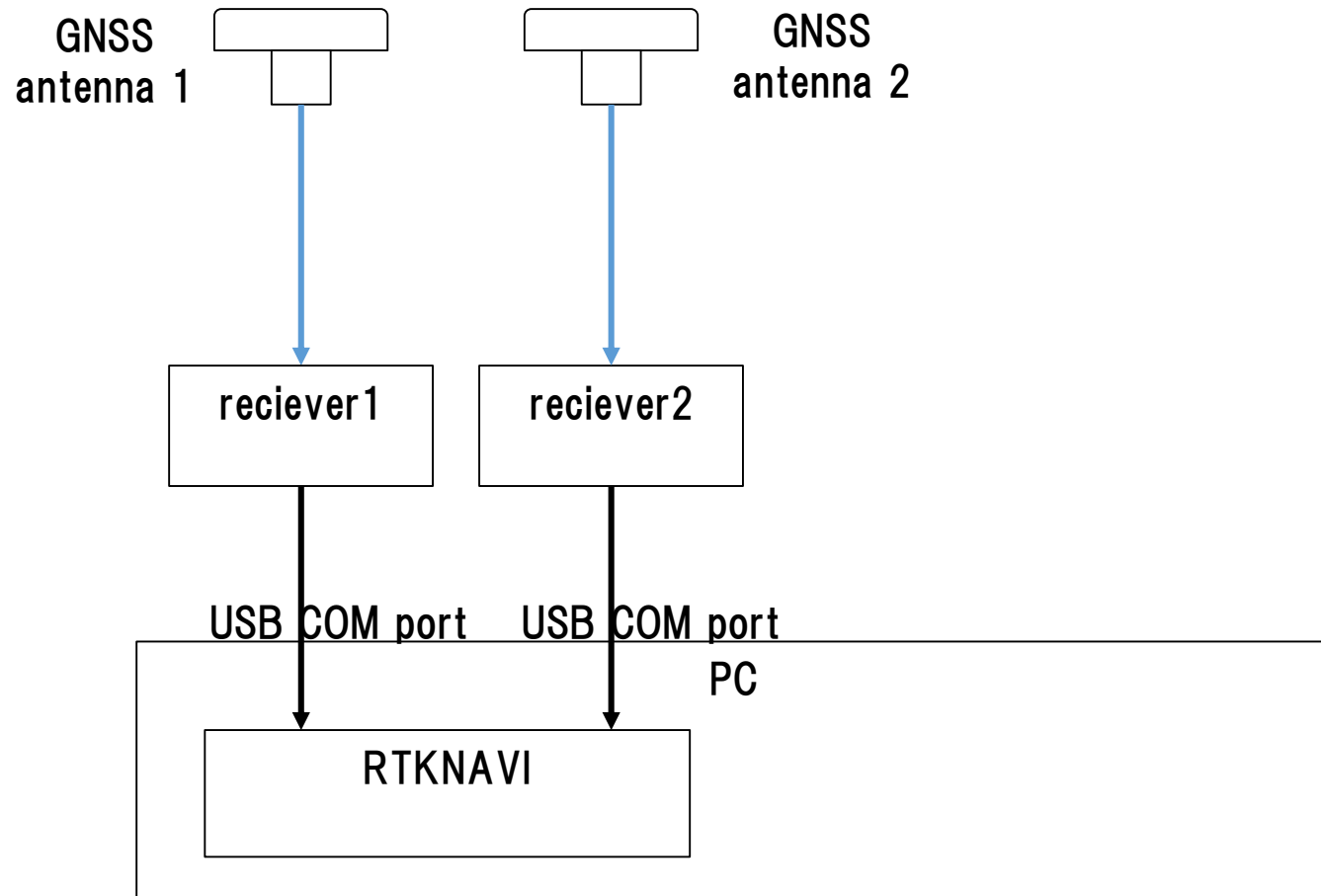


Solution is shown in UBX-NAV-RELPOSNED message  
There is no ASCII output and UBX format decode is necessary for application use.

# 6. Moving-base RTK

## ◆ Moving-base RTK (RTKNAVI)

### Hardware Configuration



# 6. Moving-base RTK

- ◆ Moving-base RTK (RTKNAVI)  
Receiver configuration (both receiver).

Messages - UBX - CFG (Config) - PRT (Ports)

UBX - CFG (Config) - PRT (Ports)

Target: 3 - USB

Protocol in: 0+1+5 - UBX+NMEA+RTCM3

Protocol out: 0+1 - UBX+NMEA

Extended TX timeout (>=FW7.00):

TX-Ready Feature (>=FW7.00):  Enable  Inverse Polarity (low-active)

Threshold: 0

PID: 0

Setting to output UBX format (UBX-CFG-PRT)

Messages - UBX - RXM (Receiver Manager) - RAWX (Multi-GNSS Raw Measurement Data)

UBX - RXM (Receiver Manager) - RAWX (Multi-GNSS Raw Measurement Data)

Local Time: 2076:348065.398000000 [s]

Leap seconds: 18 [VALID] [s] Clock reset

SV	Sig...	G...	Pseudo Range [m]	Carrier Phase [c...	Dopple...	Loc
Q01	L1C...	-	37223900.80	195612923.91	28.4	6
G02	L1C...	-	22341332.90	117404505.26	3011.0	6
G04	L1C...	-	20278115.92	106562222.86	2281.8	6
G09	L1C...	-	20286923.31	106608505.60	537.0	6
G05	L1C...	-	23527761.48	123639230.02	3616.5	6
E20	E1C	-	18369556.63	96532675.43	285.2	6
B20	B1D1	-	21114834.17	109950483.79	1384.3	6
B30	B1D1	-	21290715.17	110866337.03	-809.0	6
B32	B1D1	-	22459560.90	116952823.37	-1394.8	6
B07	B1D1	-	39857882.93	207550458.79	-955.9	6
B29	B1D1	-	21662199.02	112800758.73	2330.6	6
B27	B1D1	-	25144750.43	130935296.26	-2458.8	6
R02	L10F	-4	18475732.07	98590048.80	-152.9	6

RAWX (Multi-GNSS Raw Measurement Data)

SFRBX (Subframe Data NG)

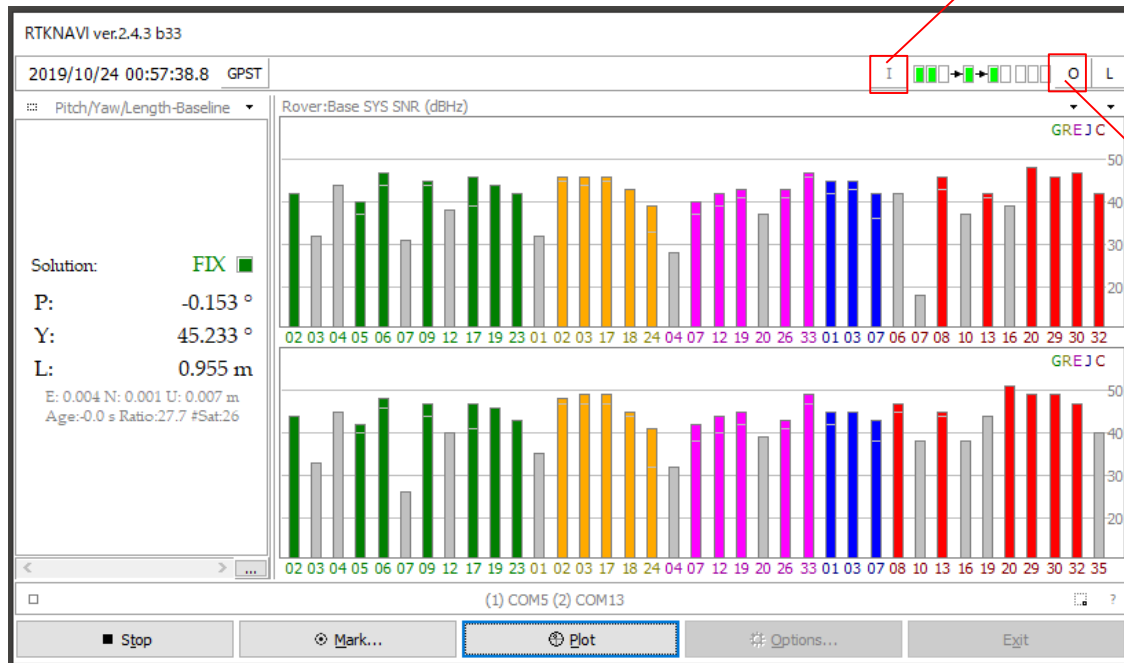
- ch 5
- ch 6
- ch 8
- ch 9
- ch 10

Enable output of RAWX & SFRBX (UBX-RXM )



# 6. Moving-base RTK

- ◆ Moving-base RTK (RTKNAVI)  
RTKNAVI set up.



The 'Input Streams' dialog box is shown with the following settings:

Input Stream	Type	Opt	Cmd	Format	Opt
<input checked="" type="checkbox"/> (1) Rover	Serial	...	...	u-blox	...
<input checked="" type="checkbox"/> (2) Base Station	Serial	...	...	u-blox	...
<input type="checkbox"/> (3) Correction	Serial	...	...	RTCM 2	...

Transmit NMEA GPGGA to Base Station: OFF

Reset Cmd: [ ] Max Baseline: 10 km

Input File Paths: [ ] [ ] [ ]

Time: x1 + 0 s 64bit

Buttons: OK, Cancel

Select "Serial" in both rover and base and format is "u-blox".

Select COM port number.

The 'Output Streams' dialog box is shown with the following settings:

Output Stream	Type	Option	Format
<input checked="" type="checkbox"/> (4) Solution 1	File	...	E/N/U-Baseline
<input checked="" type="checkbox"/> (5) Solution 2	TCP Client	...	E/N/U-Baseline

Output File Paths: C:\Users\d650e\Documents\GNSSLab\2019\Ublox\190415\_F9P\_RTK\ [ ] [ ]

Time-Tag Swap Intv: [ ] H ?

Buttons: OK, Cancel

Select output format to "E/N/U-Baseline". If you want to show in RTKPLOT, set one output stream to TCP.

The 'TCP Client Options' dialog box is shown with the following settings:

Server Address: 127.0.0.1 Port: 1111

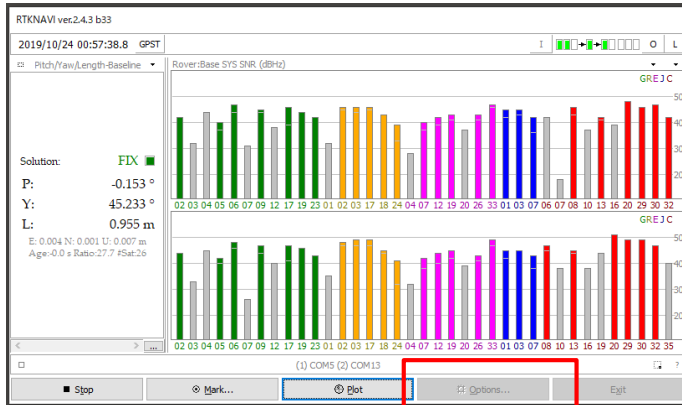
Mountpoint: [ ] User-ID: [ ] Password: [ ]

String: [ ]

Buttons: OK, Cancel

# 6. Moving-base RTK

## ◆ Moving-base RTK (RTKNAVI) Option configuration



- “Fix and Hold” is recommended in “Integer Ambiguity Res” setting.
- If 2 antenna relative length is not changed, set “Baseline Length Constraint” is better. (Input value is length between 2 antenna [m]/length error level[m])
- Without highlighted in red are default values.

Positioning Mode	Moving-Base
Frequencies / Filter Type	L1+L2
Elevation Mask (°) / SNR Mask (dbHz)	15
Rec Dynamics / Earth Tides Correction	OFF
Ionosphere Correction	Broadcast
Troposphere Correction	Saastamoinen
Satellite Ephemeris/Clock	Broadcast
Excluded Satellites (+PRN; Included)	<input checked="" type="checkbox"/> GPS <input checked="" type="checkbox"/> GLO <input checked="" type="checkbox"/> Galileo <input checked="" type="checkbox"/> QZSS <input type="checkbox"/> SBAS <input checked="" type="checkbox"/> BeiDou <input type="checkbox"/> IRNSS

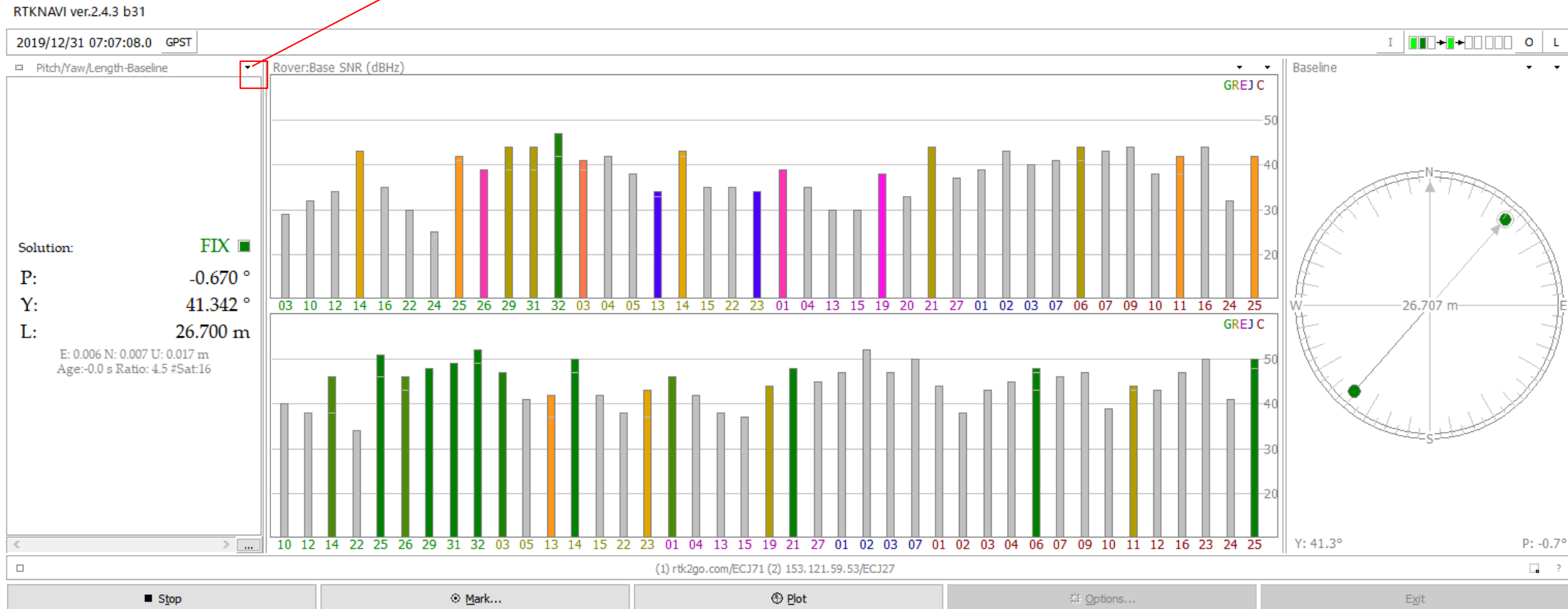
Integer Ambiguity Res (GPS/GLO/BDS)	Fix and	OFF	ON
Min Ratio to Fix Ambiguity	3.0		
Min Confidence / Max FCB to Fix Amb	0.9999	0.20	
Min Lock / Elevation (°) to Fix Amb	0	0	
Min Fix / Elevation (°) to Hold Amb	10	40	
Outage to Reset Amb / Slip Thres (m)	5	0.050	
Max Age of Diff (s) / Sync Solution	30.0	OFF	
Reject Threshold of GDOP/Innov (m)	30.0	30.0	
Max # of AR Iter/# of Filter Iter	1	1	
<input checked="" type="checkbox"/> Baseline Length Constraint (m)	0.95	0.05	

Code/Carrier-Phase Error Ratio L1/L2	300	300
Carrier-Phase Error a+b/sinE1 (m)	0.003	0.003
Carrier-Phase Error/Baseline (m/10km)	0.000	
Doppler Frequency (Hz)	1.000	
Receiver Accel Horiz/Vertical (m/s2)	1.00E+01	1.00E+01
Carrier-Phase Bias (cycle)	1.00E-04	
Vertical Ionospheric Delay (m/10km)	1.00E-03	
Zenith Tropospheric Delay (m)	1.00E-04	
Satellite Clock Stability (s/s)	5.00E-12	

# 6. Moving-base RTK

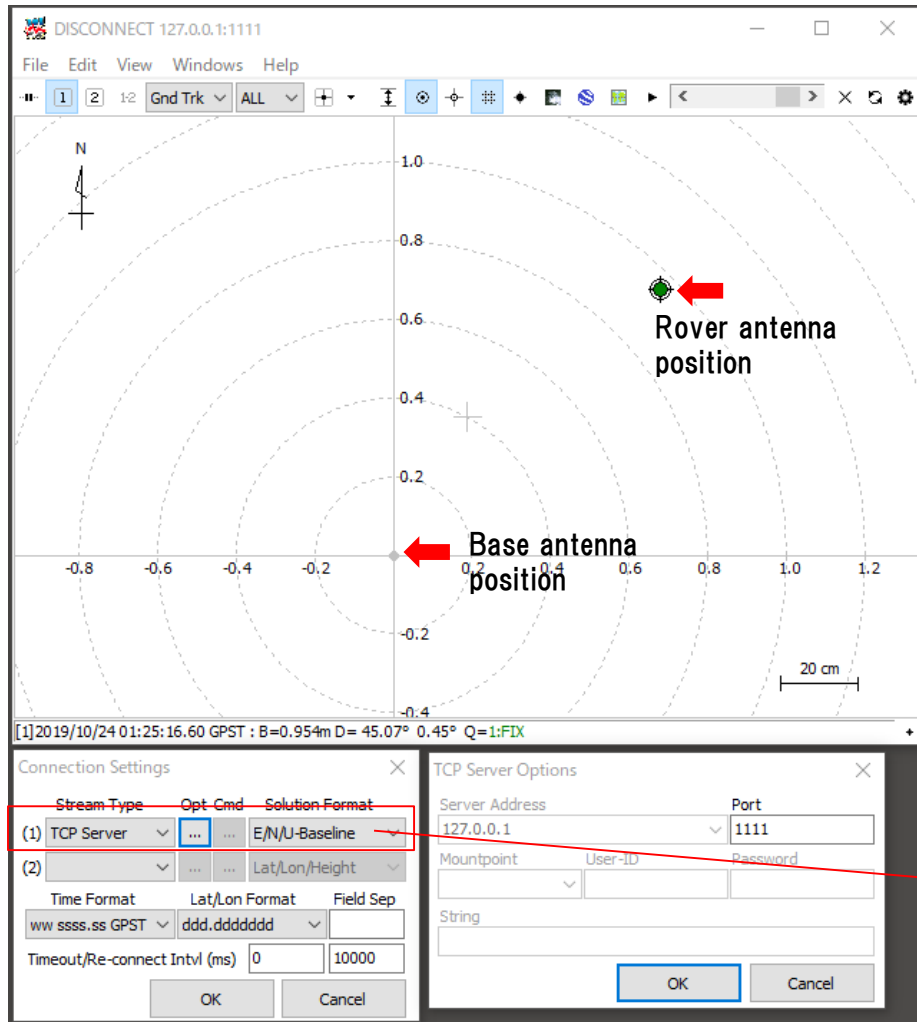
## ◆ Moving-base RTK (RTKNAVI)

Change shown format type by this button.  
ENU or PYL

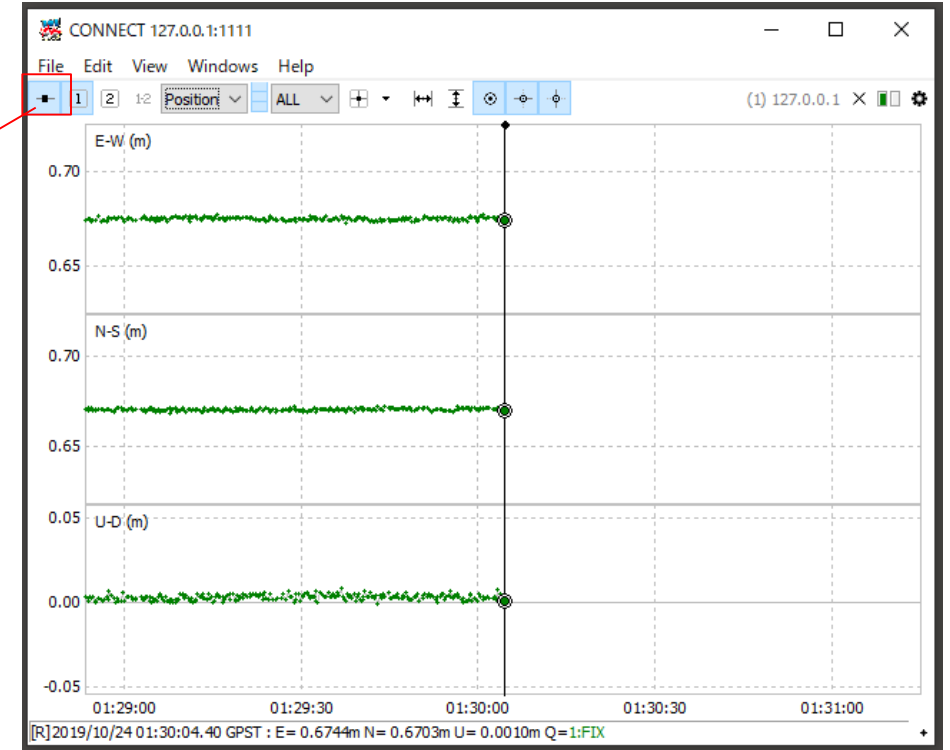


# 6. Moving-base RTK

## ◆ RTKNAVI PLOT configuration



Click "Connect button" after input setting.



Open another RTKPLT.  
Select TCP server from File>Connection Setting and select port which defined in RTKNAVI output stream.

## 7. Useful web sites

- ◆ Useful web sites for your RTK experiment
- <https://www.ardusimple.com/blog/>
- <http://rtkexplorer.com/how-to/posts-getting-started/>
- [http://www.denshi.e.kaiyodai.ac.jp/gnss\\_tutor/base\\_station.html](http://www.denshi.e.kaiyodai.ac.jp/gnss_tutor/base_station.html)
- <https://home.csis.u-tokyo.ac.jp/~dinesh/>