Introduction to RTK

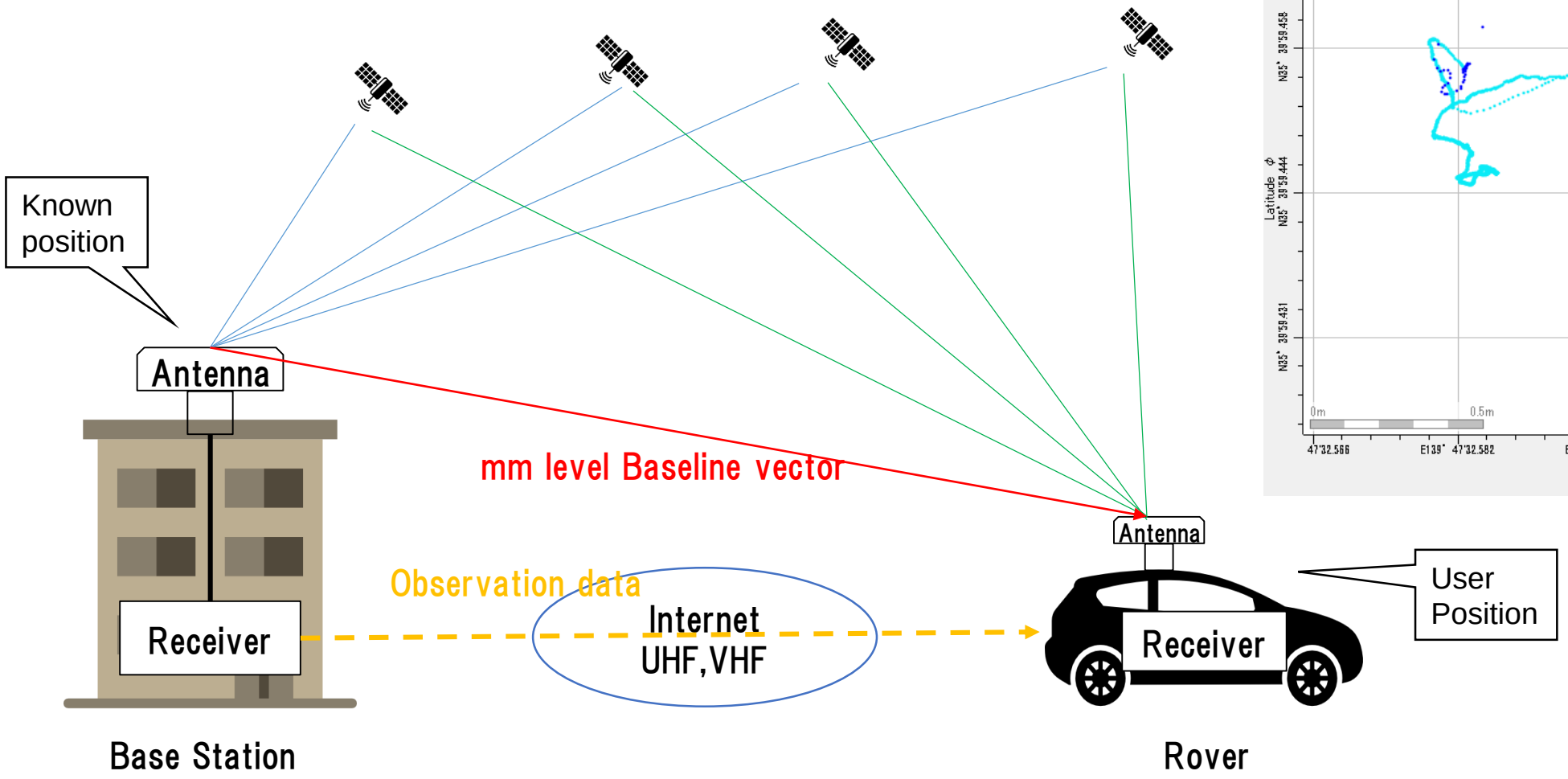
Training on GNSS, 8 JAN 2020
11:00-12:00

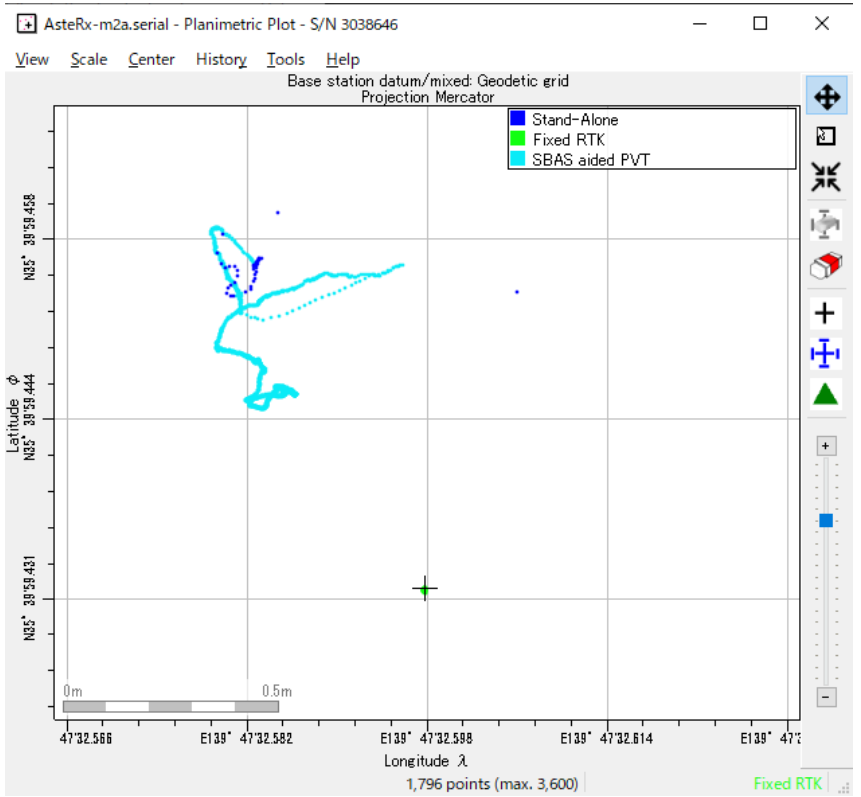
Tokyo University of Marine Science and Technology

Contents

1. What is RTK

RTK is high accuracy positioning method using “Base Station”.

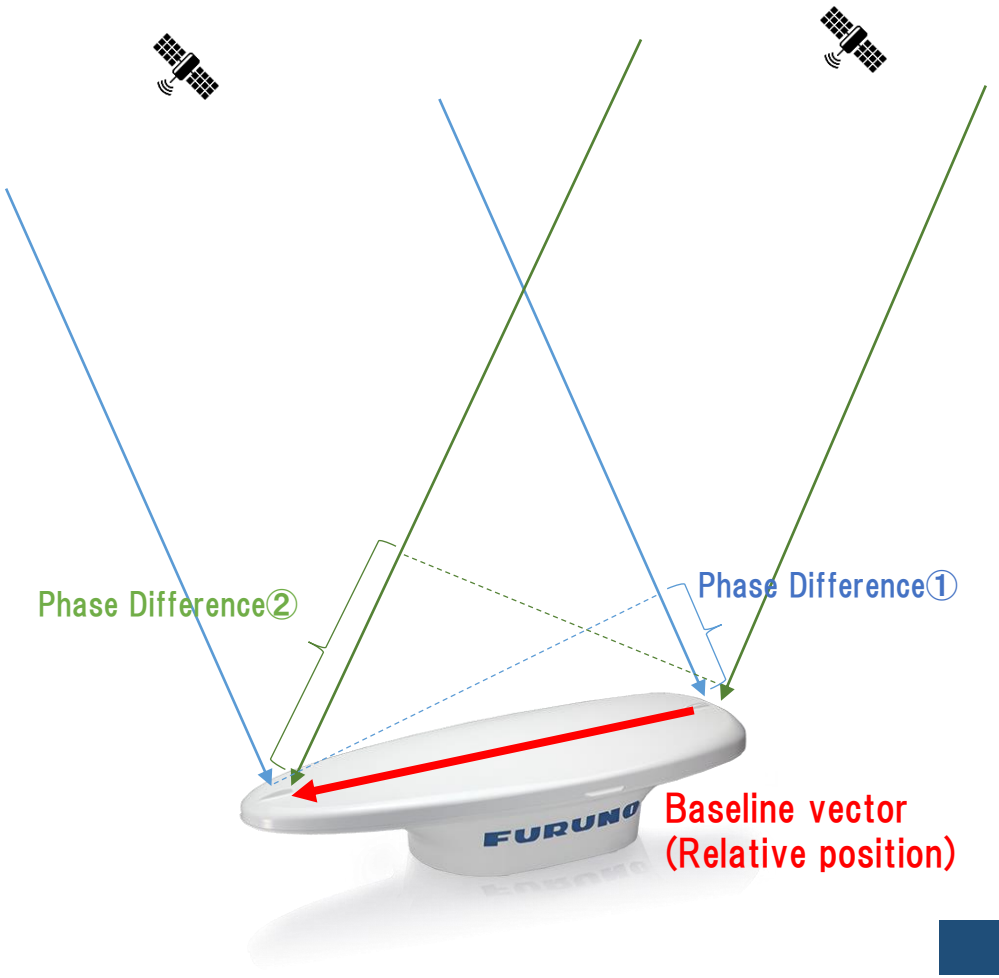


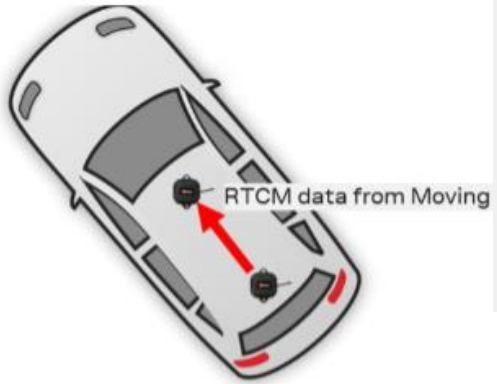


1. What is RTK

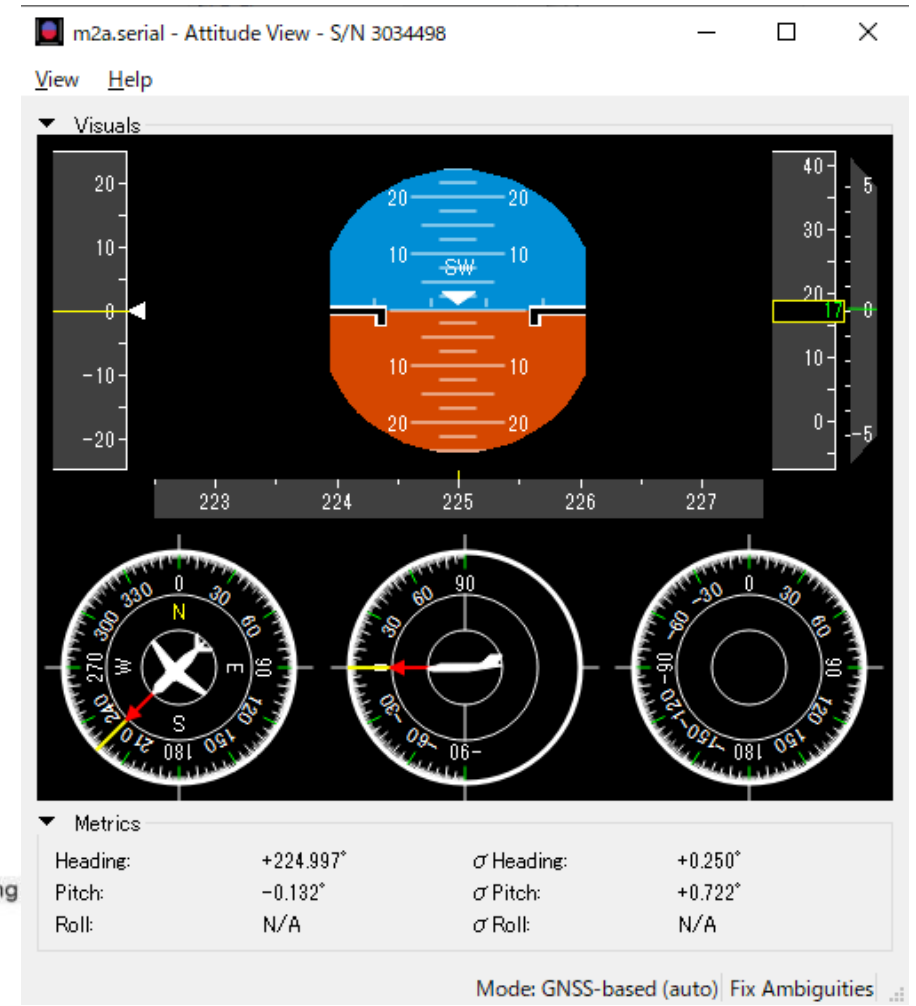
If “Base station” is not fixed → Moving-base RTK

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



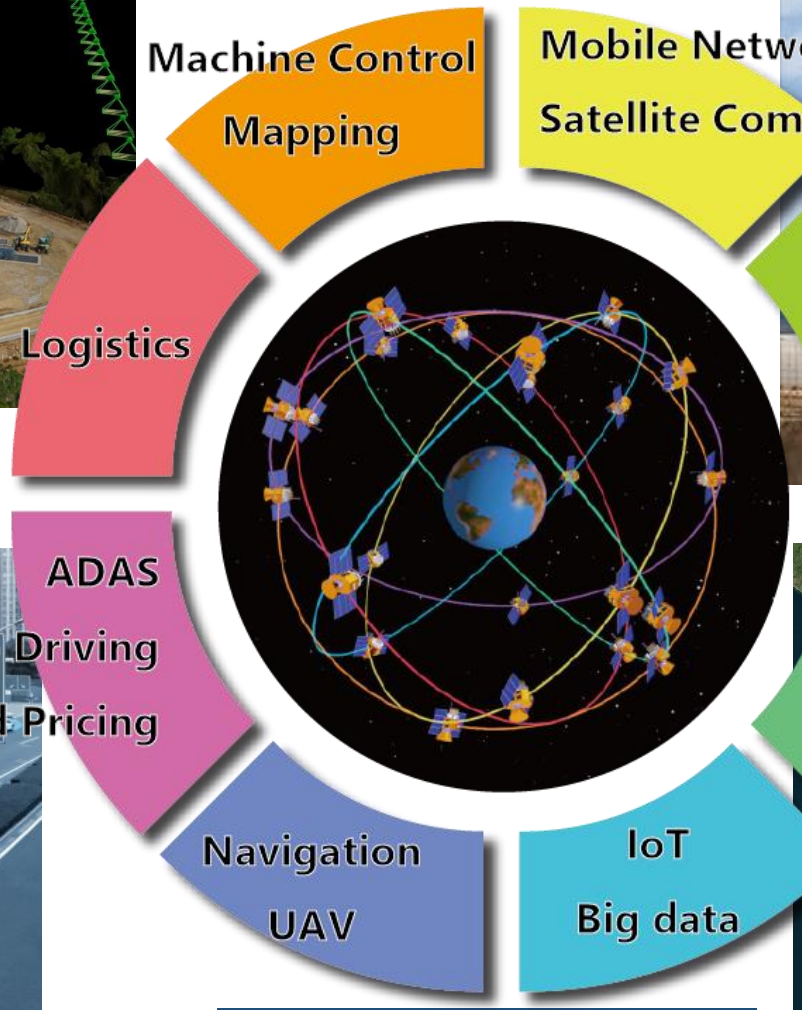


Moving baseline setup for precise heading



2. RTK applications

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



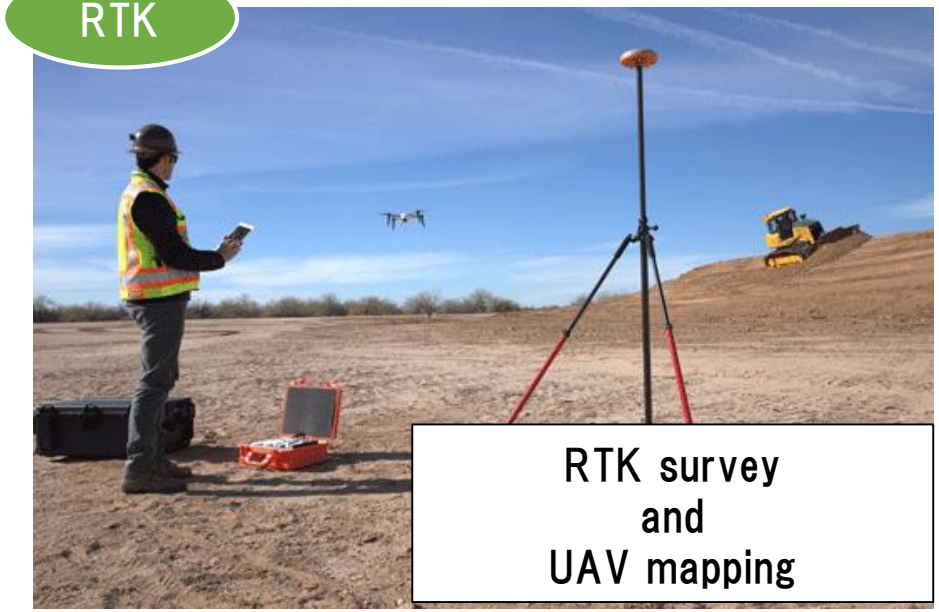
TUMSAT GNSS Lab

2. RTK applications

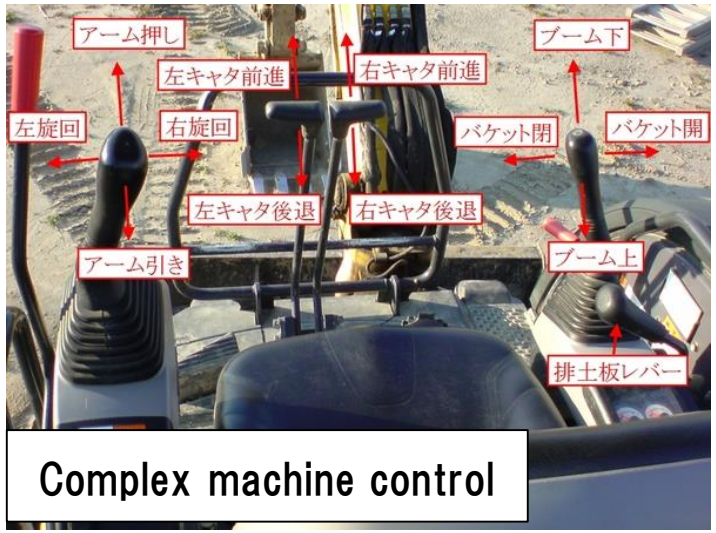
◆Construction

Traditional optical survey

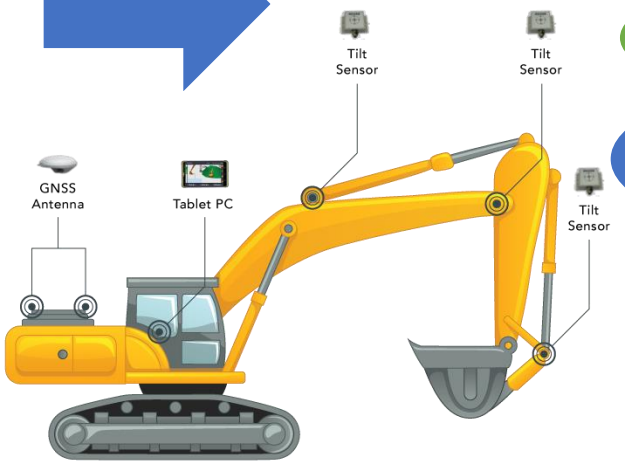
RTK



RTK survey
and
UAV mapping

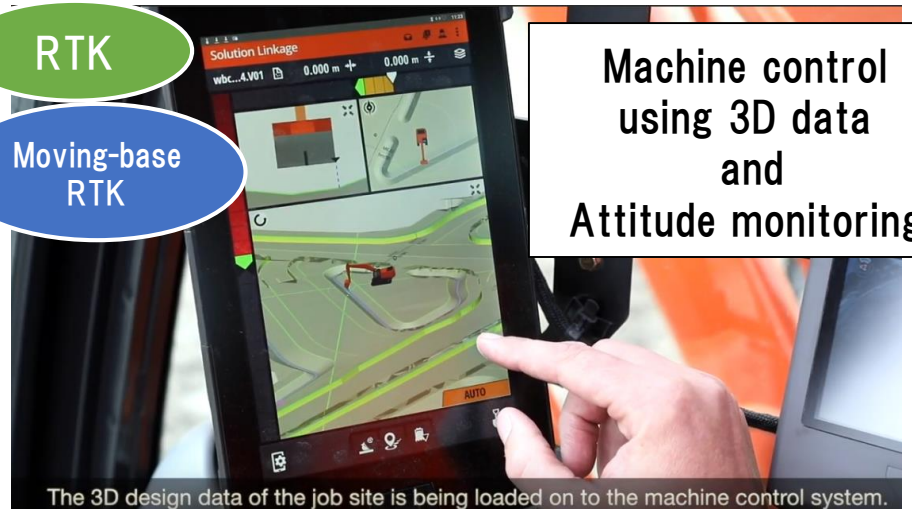


Complex machine control



RTK

Moving-base RTK



Machine control
using 3D data
and
Attitude monitoring

2. RTK applications

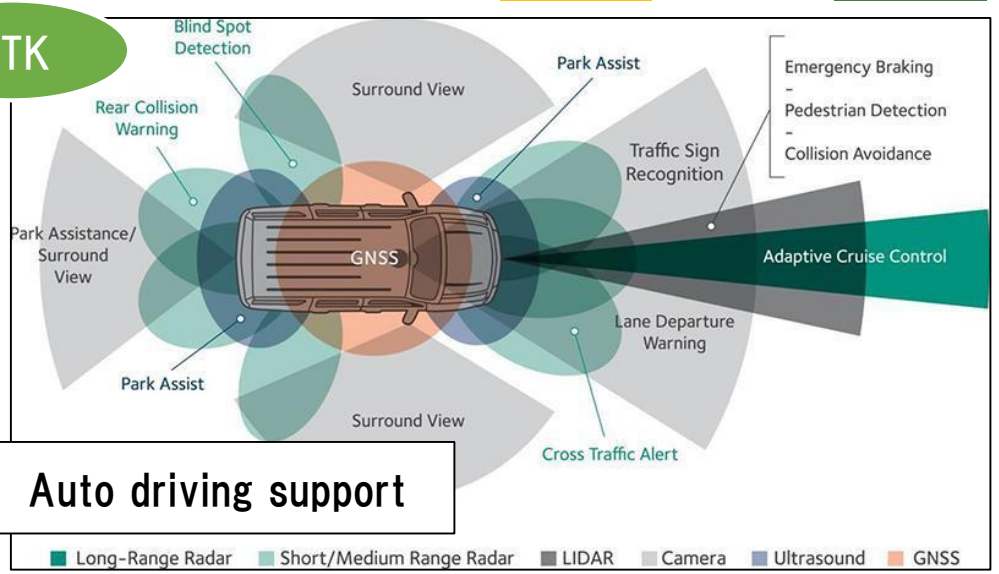
◆ITS (Intelligent Transportation System)

Car navigation

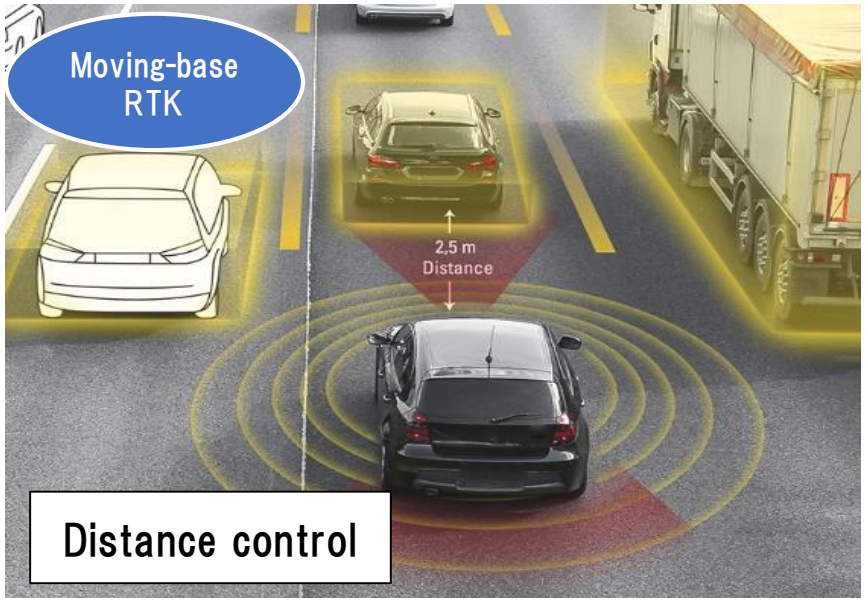
+

Road pricing by lane

RTK



Auto driving support

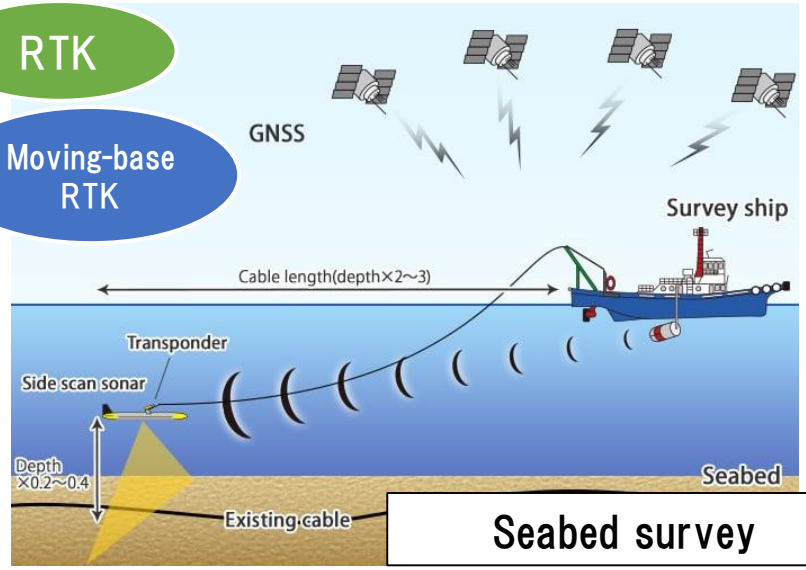


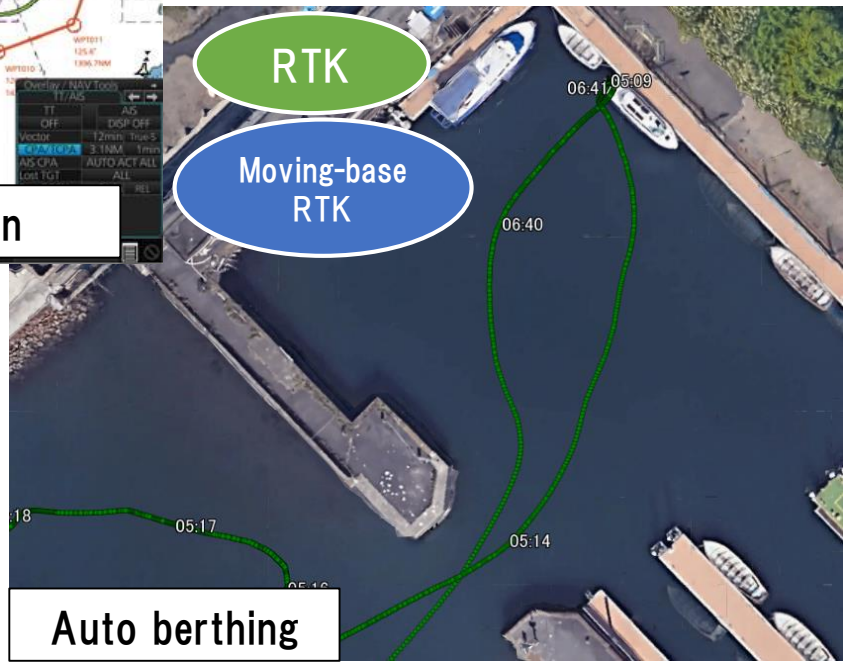
Distance control

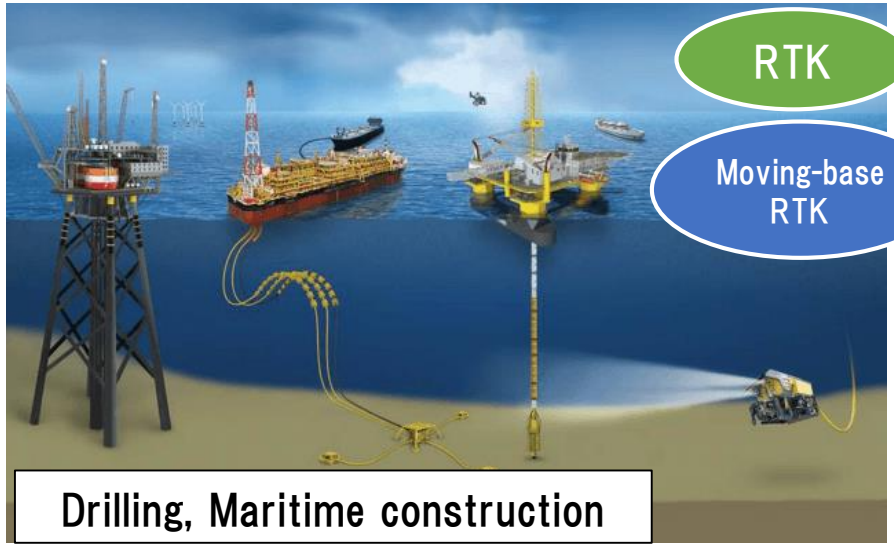
2. RTK applications

◆Maritime

+

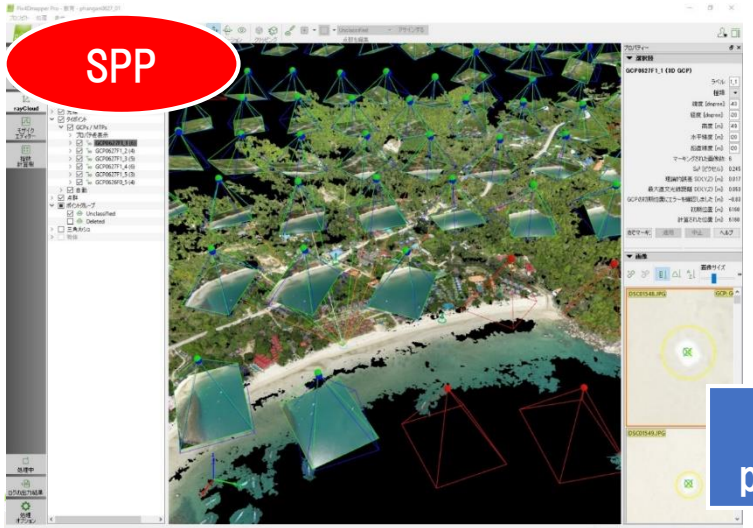






2. RTK applications

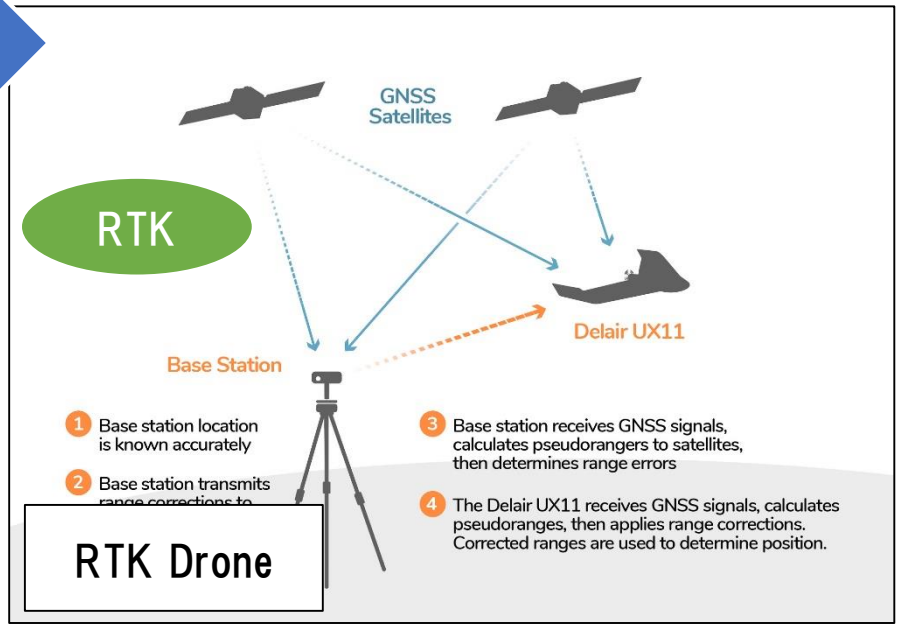
◆UAV



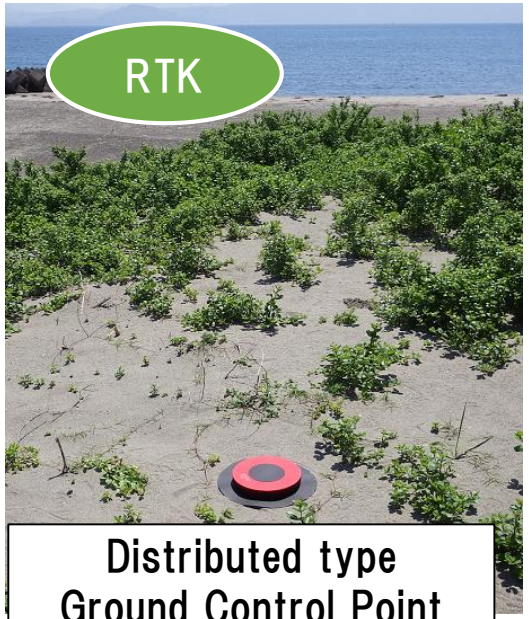
Mapping

More precise map

Attitude Monitoring



RTK Drone

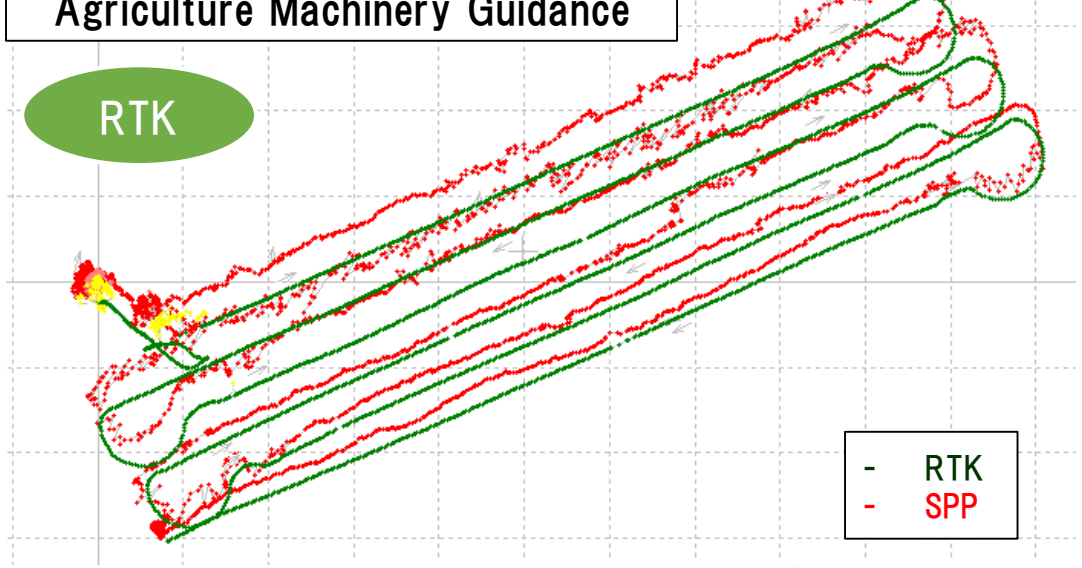


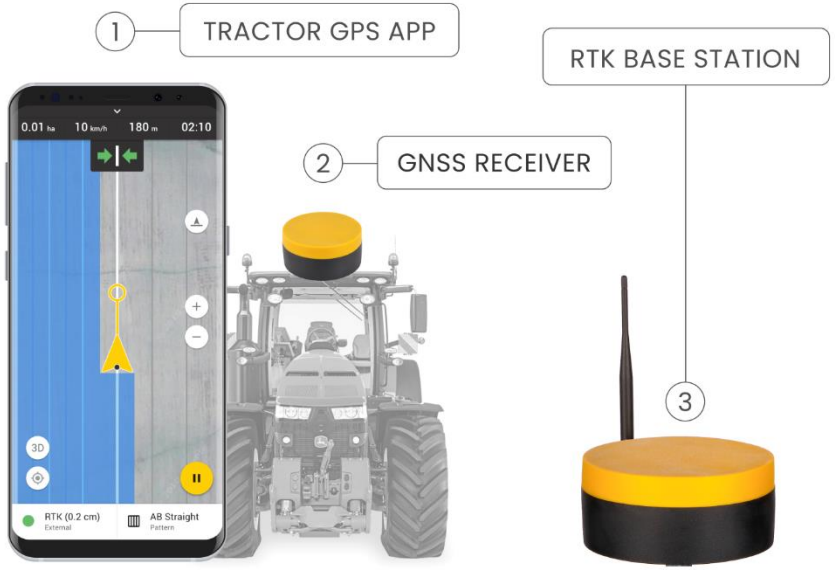
Distributed type Ground Control Point

2. RTK applications

◆Agriculture

Shift to young generation
Effective working



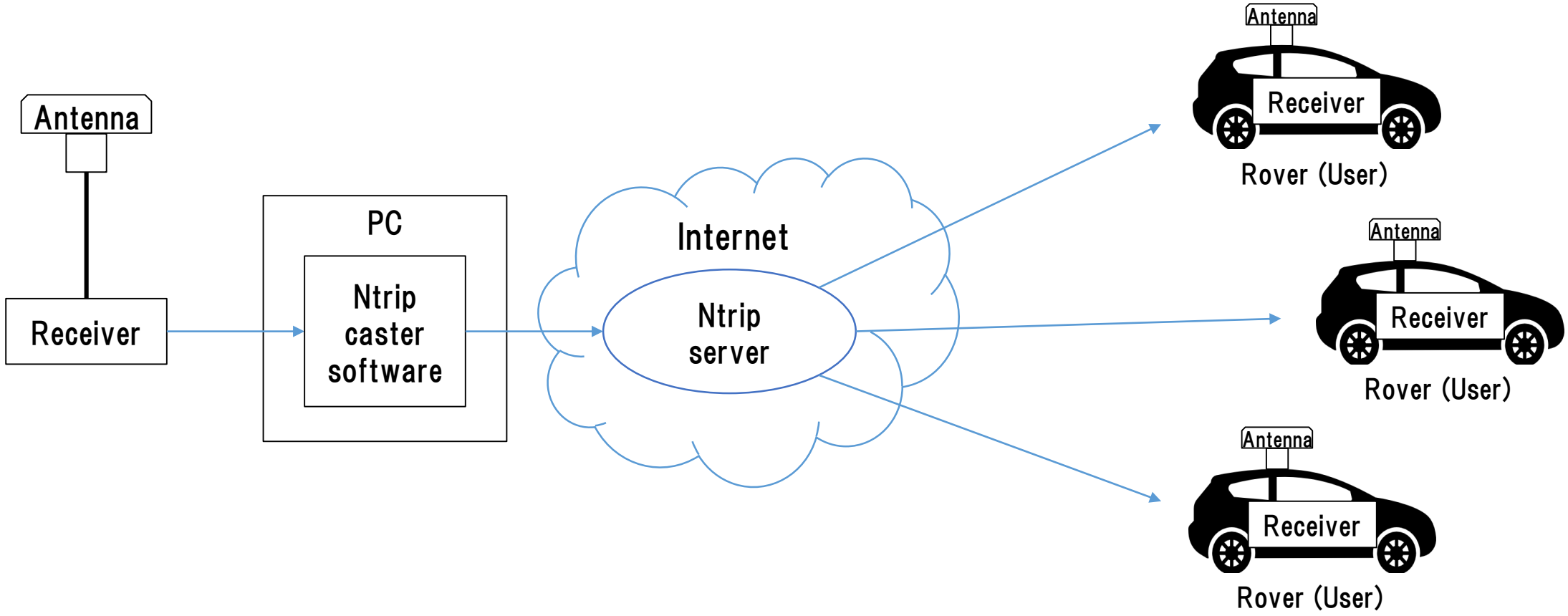


3. How to build RTK environment

◆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.

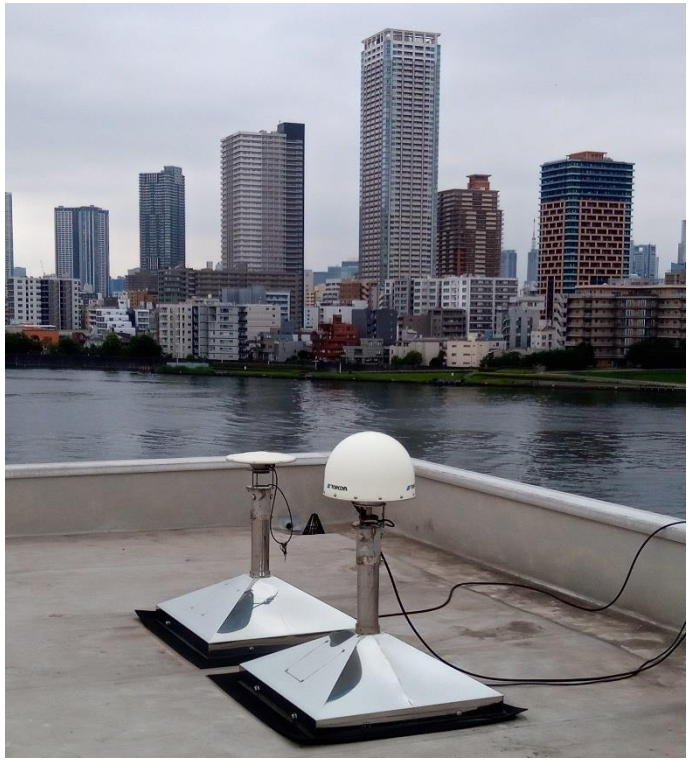


3. How to build RTK environment

◆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

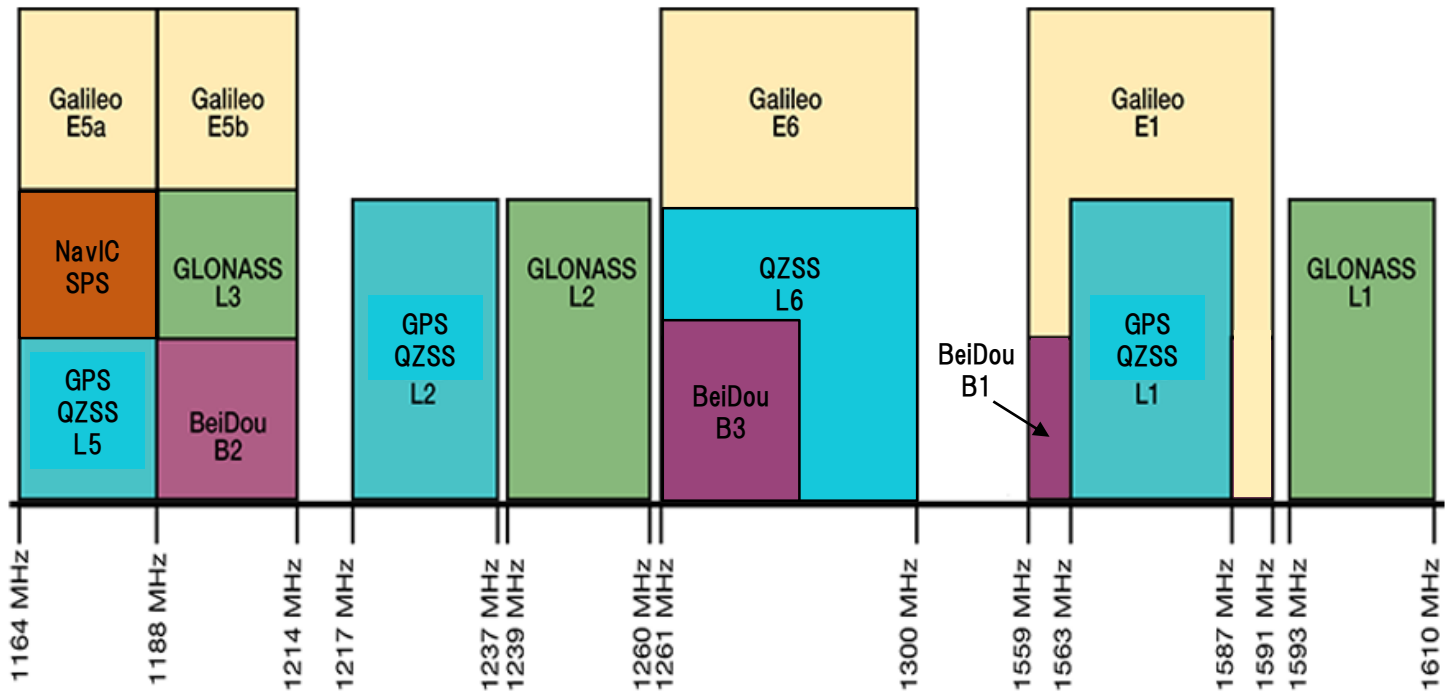
Good performance but High cost

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

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, **the main msg** 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, **the other main msg** X

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

septentrio

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

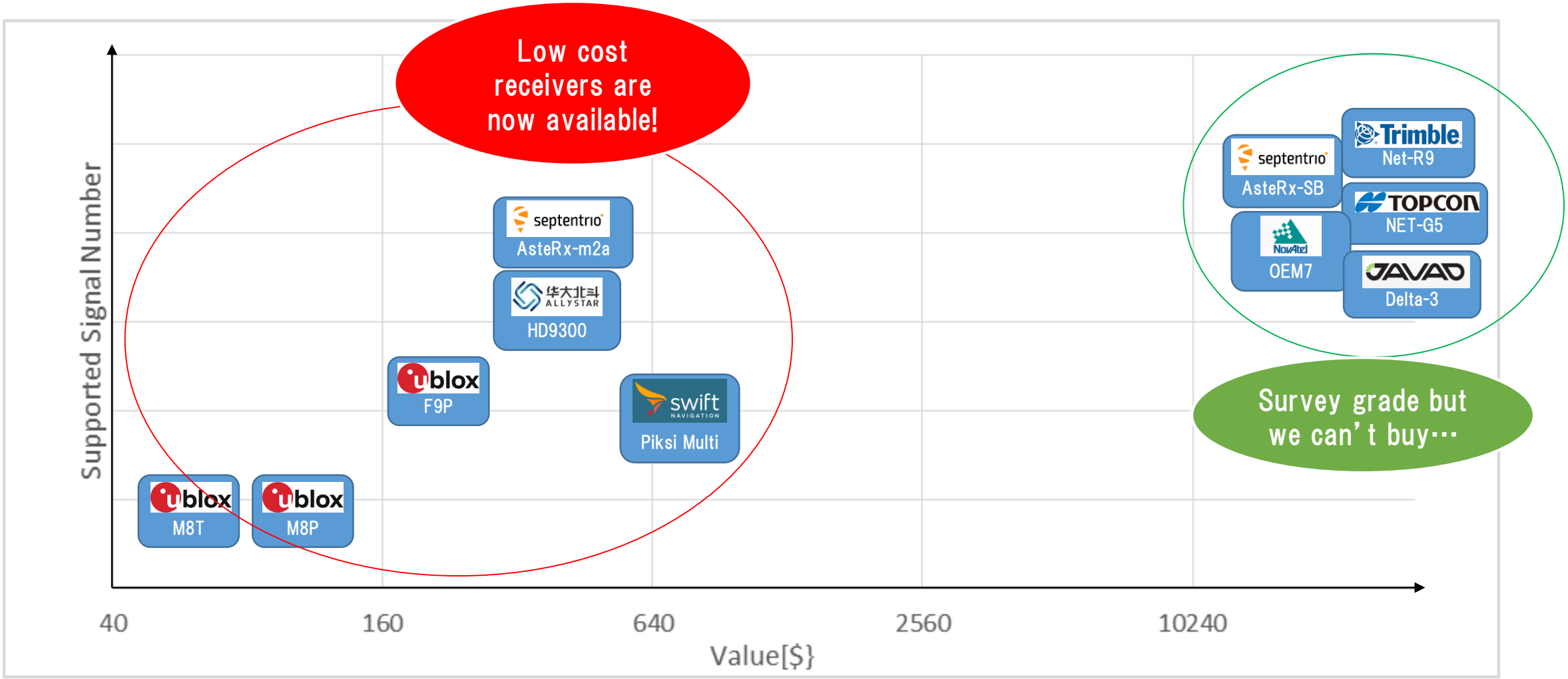
RTCM is a binary data protocol for communication of GNSS correction information. The ZED-F9P high precision receiver supports RTCM as specified by RTCM 10403.3, Differential GNSS (Global Navigation Satellite Systems) Services – Version 3 (October 7, 2016).

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

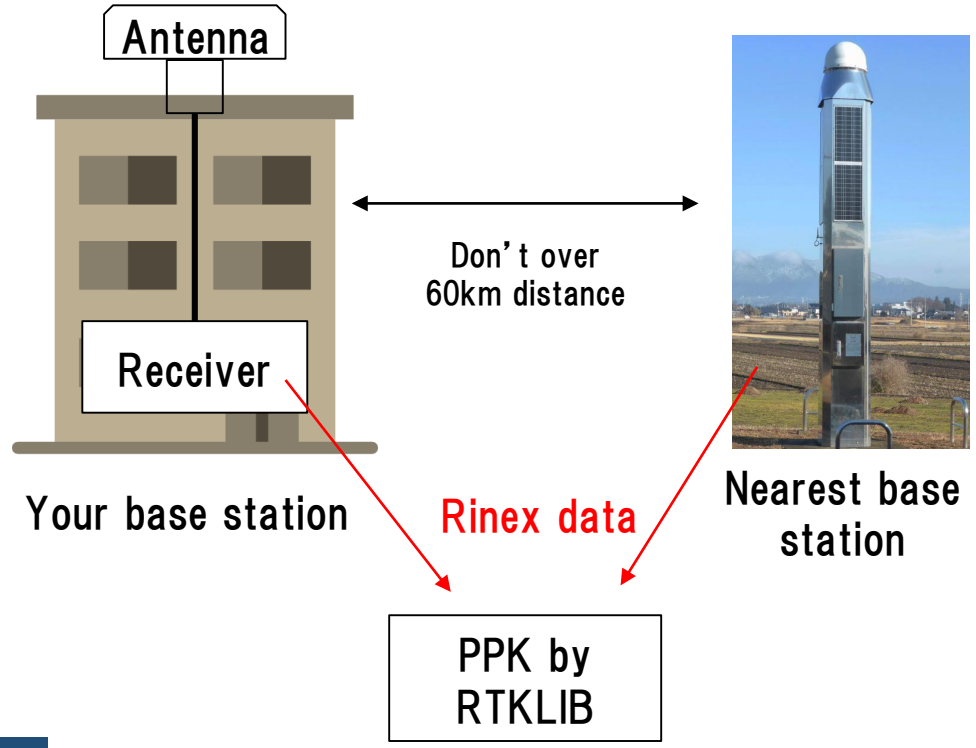
If there is another RTK base station near your base, you can calculate by PPK (Post-Process Kinematic).

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.

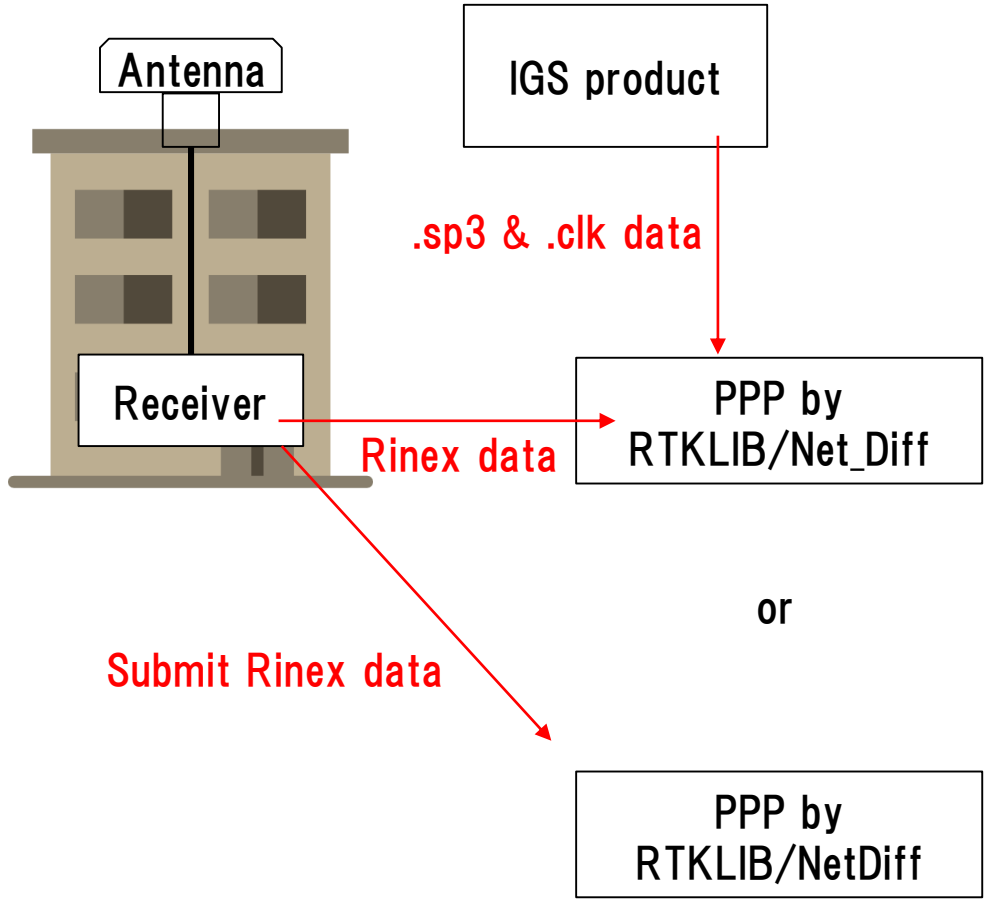
・PPP

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)
- Trimble RTX (https://www.trimblertx.com/UploadForm.aspx)
- CSRS-PPP (https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php)
- MADOCA-PPP

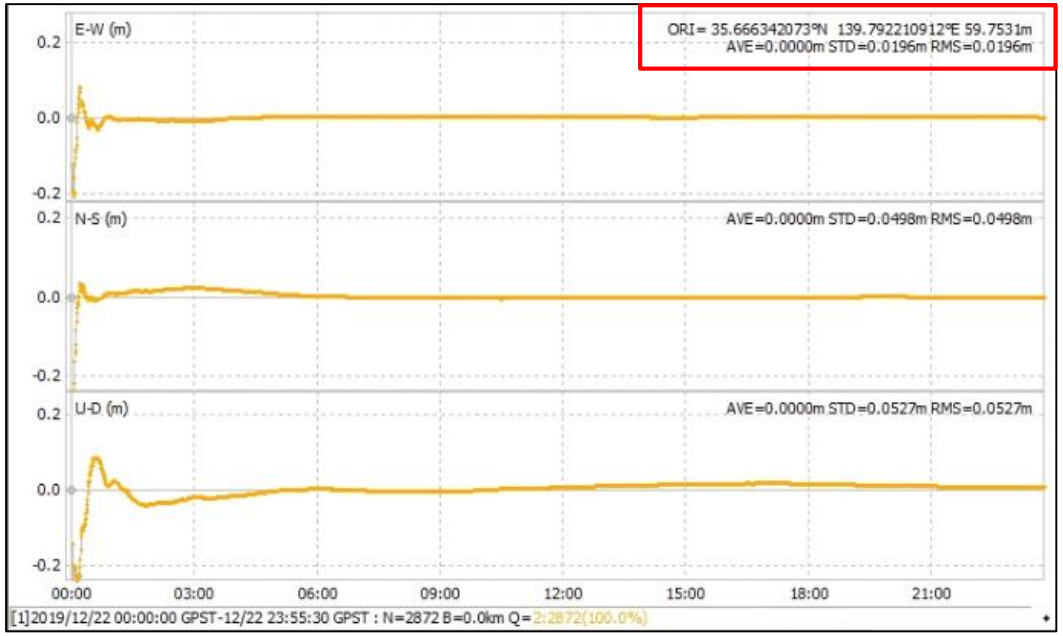
IGS product : (http://mgex.igs.org/IGS_MGEX_Products.php)



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:	5301K561652019110300000D.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):	5301K561652019110300000D.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:	MORVEL56
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		
Coordinate	Value	σ
X	-3961904.891 m	0.006 m
Y	3348992.800 m	0.006 m
Z	3698212.544 m	0.006 m
Latitude	35° 39' 58.83700" N	0.003 m
Longitude	139° 47' 31.95195" E	0.004 m
El. Height	59.679 m	0.009 m

ITRF2014 at Epoch 2019.84		
Coordinate	Value	σ
X	-3961905.083 m	0.006 m
Y	3348992.726 m	0.006 m
Z	3698212.405 m	0.006 m
Latitude	35° 39' 58.83146" N	0.003 m
Longitude	139° 47' 31.95911" E	0.004 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

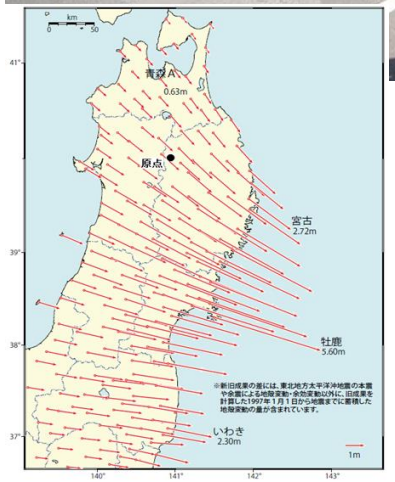
Trimble RTX service

Use this position as your base station position.

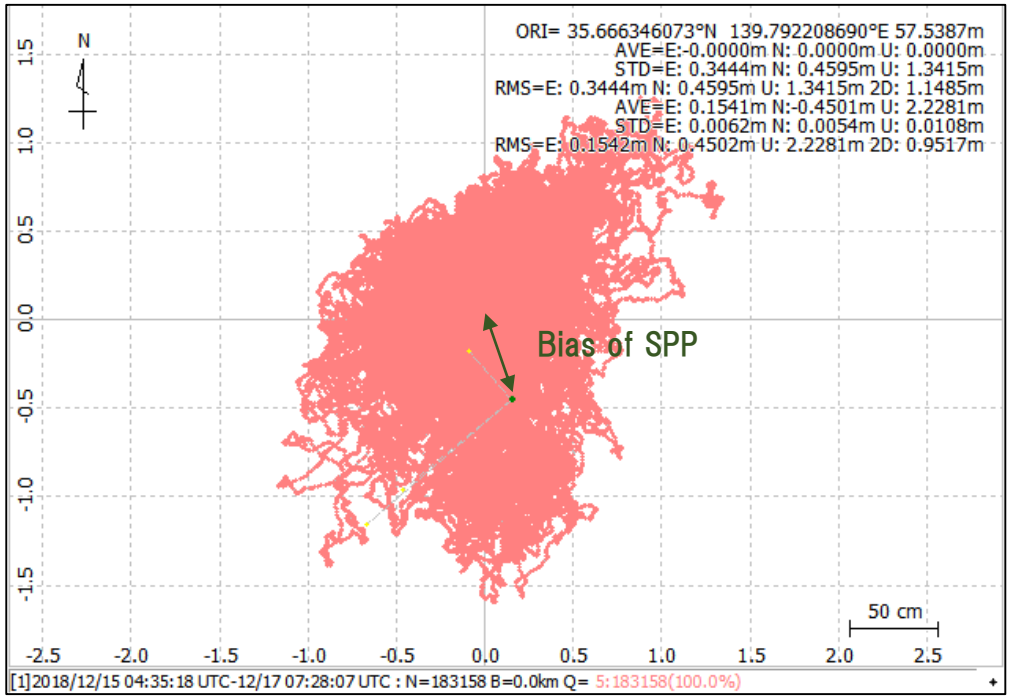
3. How to build RTK environment

◆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).

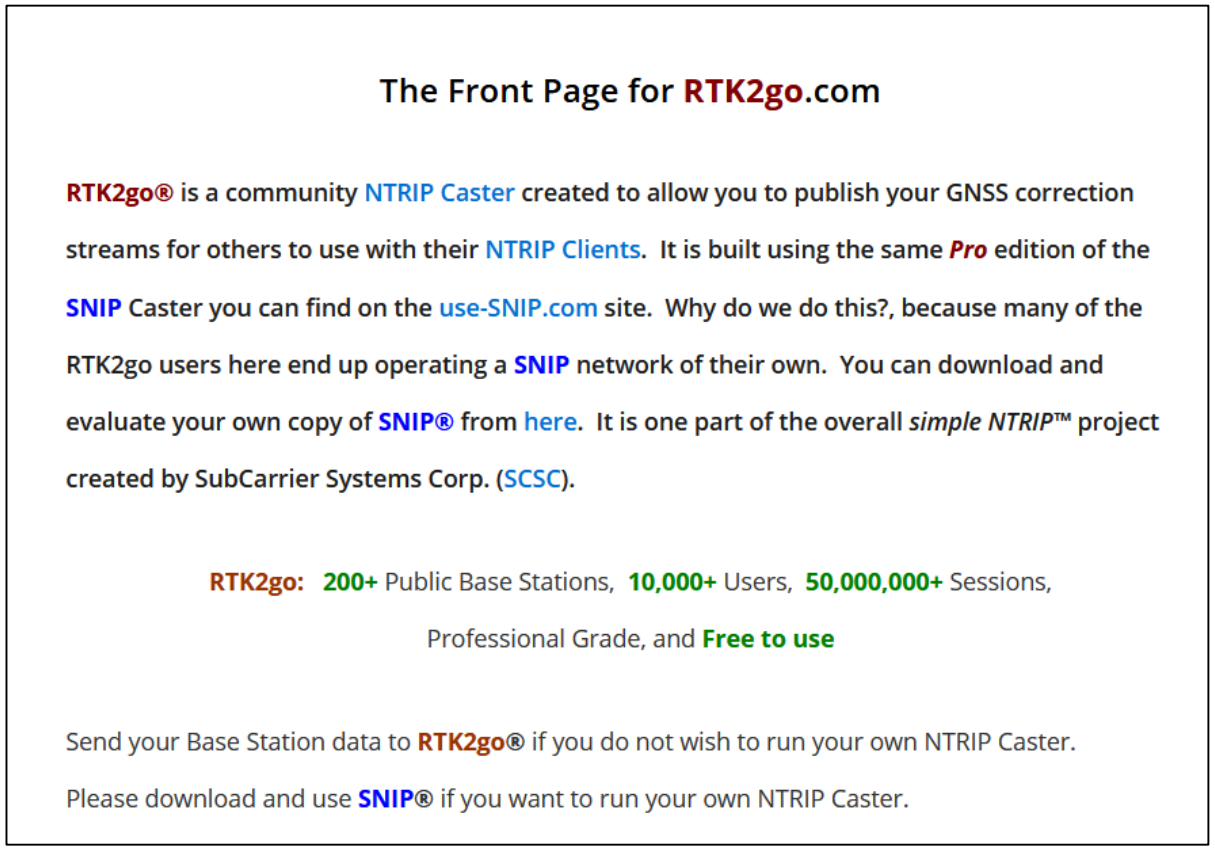


3. How to build RTK environment

◆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/

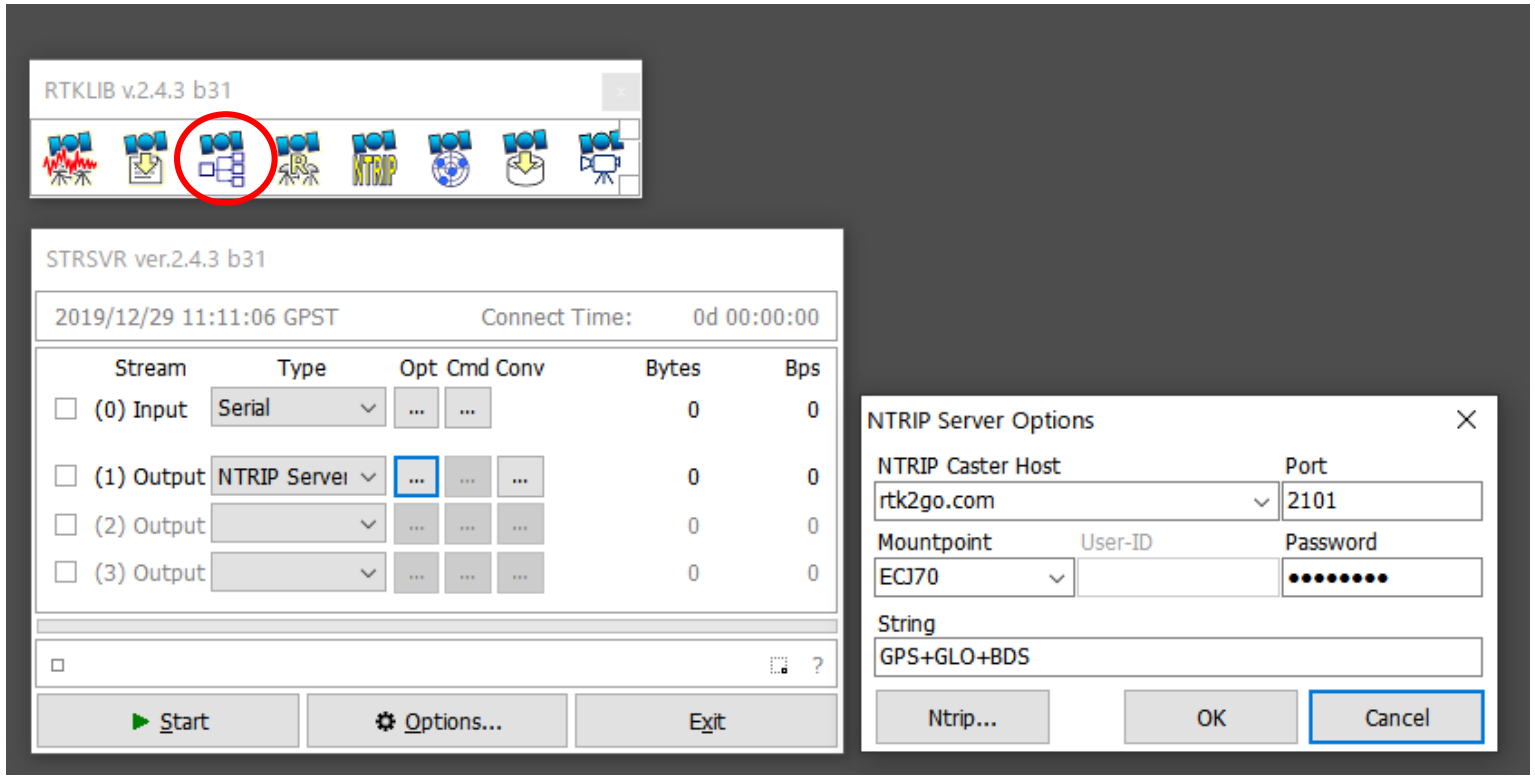
Other server

- BKG
  https://igs.bkg.bund.de/ntrip/download

3. How to build RTK environment

◆Push out data to Ntrip server

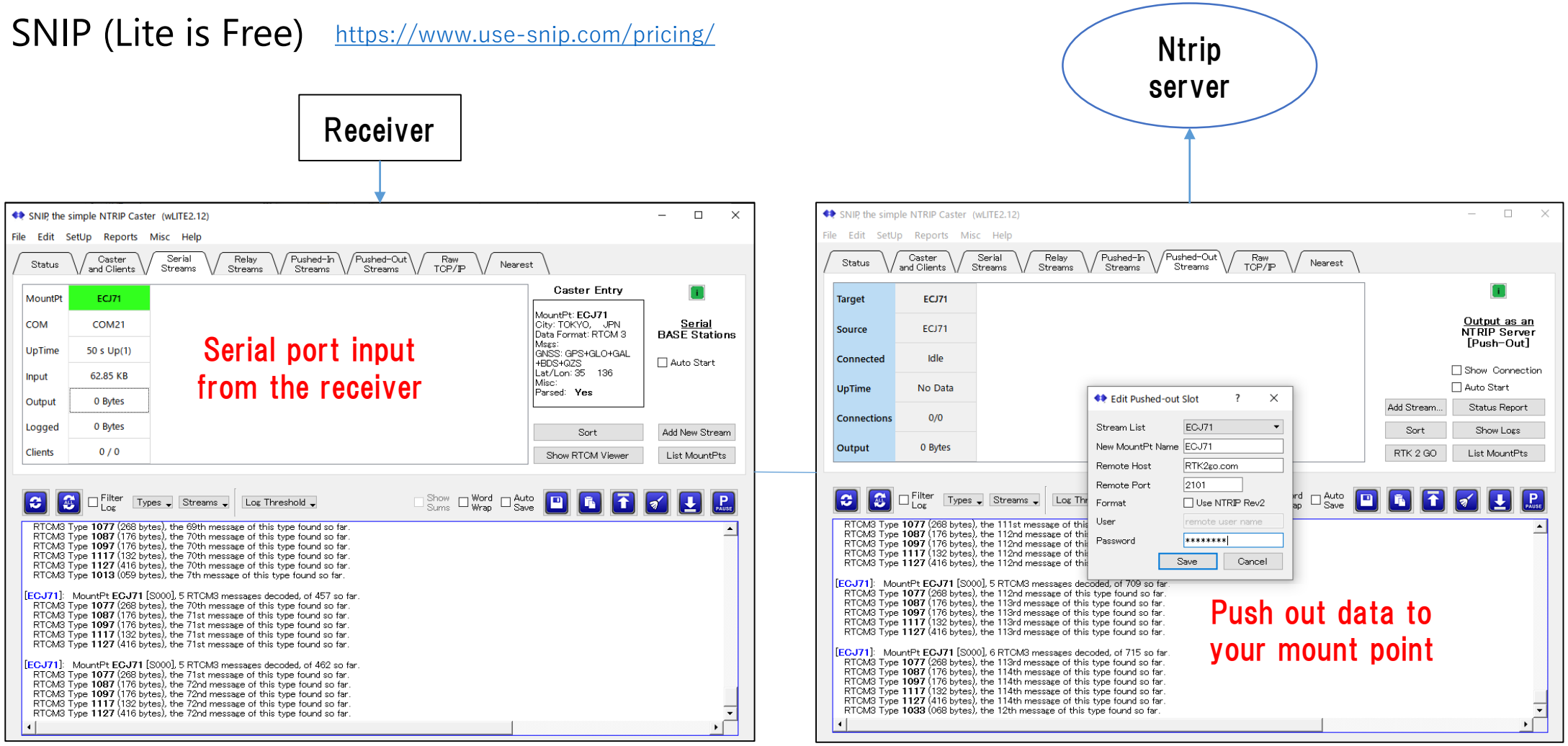
- RTKLIB STRSVR (Free)



3. How to build RTK environment

◆Push out data to Ntrip server

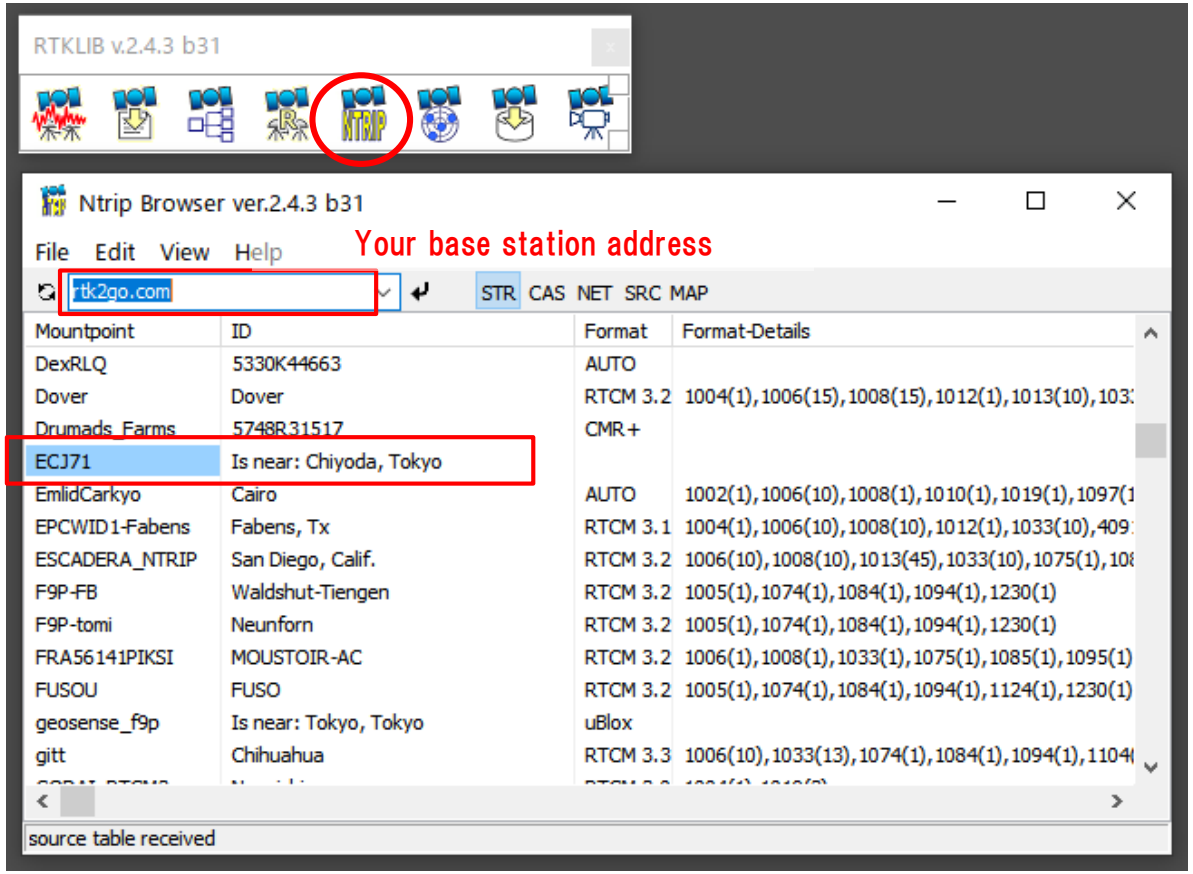
- SNIP (Lite is Free) https://www.use-snip.com/pricing/



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

High performance

Portable and low cost

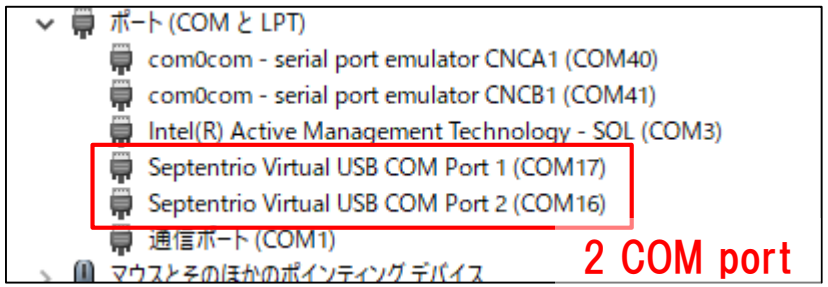
4. RTK configuration on rover

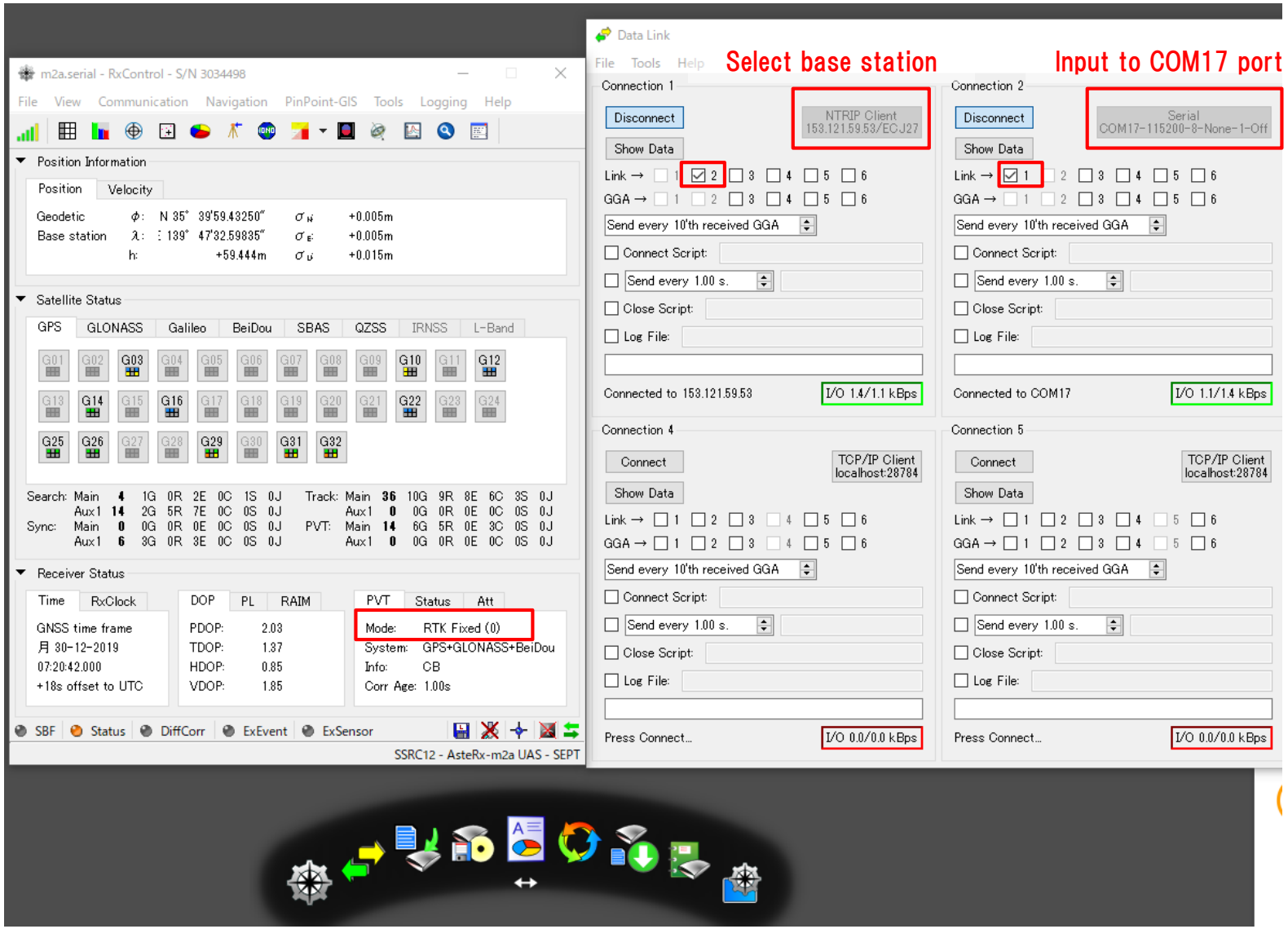
◆RTK (Septentrio with PC)

Use Ntrip client function of “Data Link” in “RxTools”

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

Downloand link
https://www.septentrio.com/en/support/software/rxtools



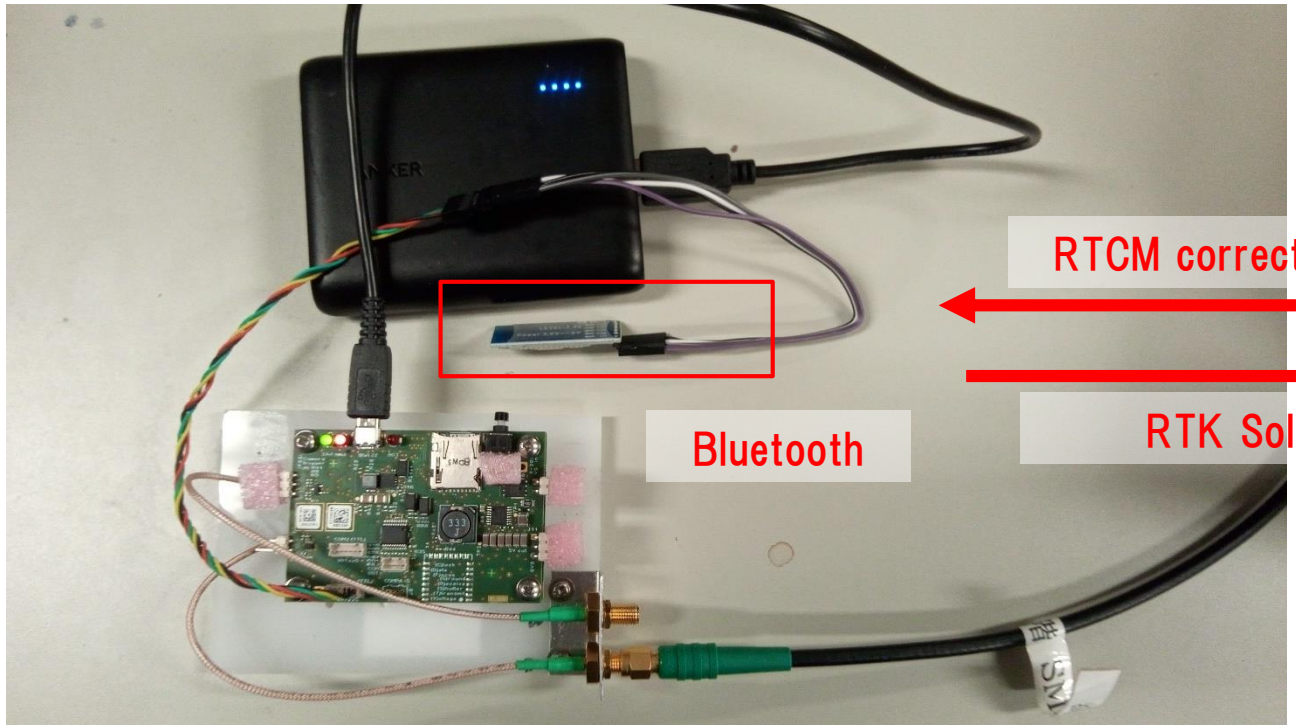


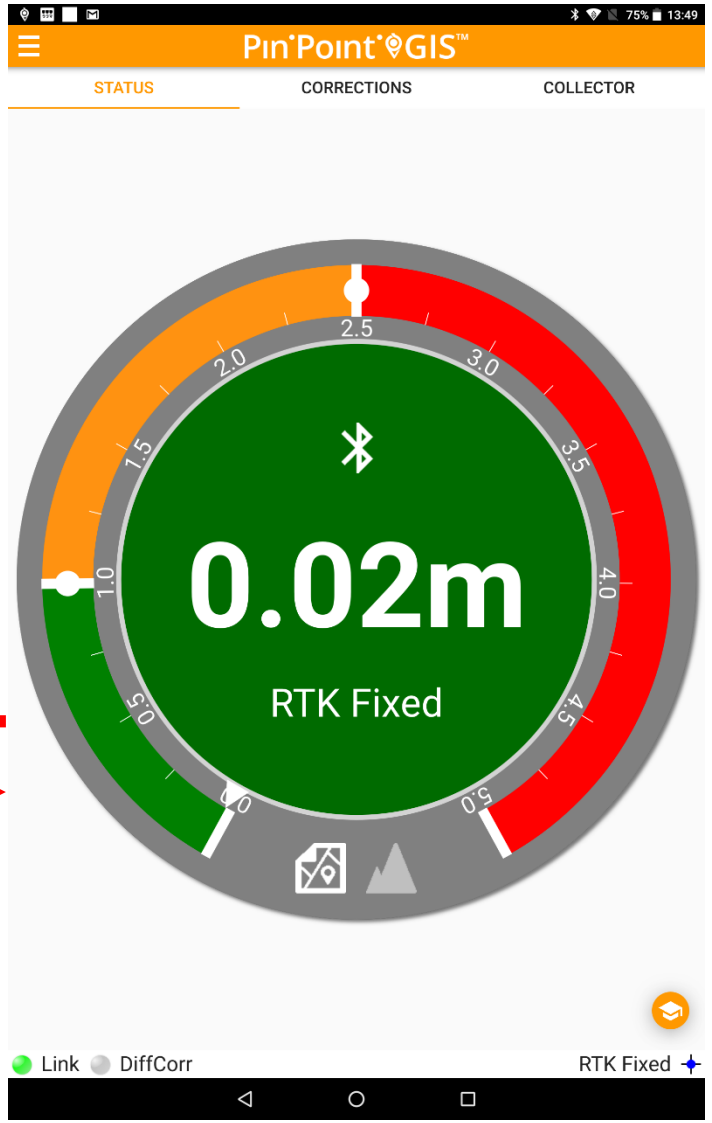
4. RTK configuration on rover

◆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)

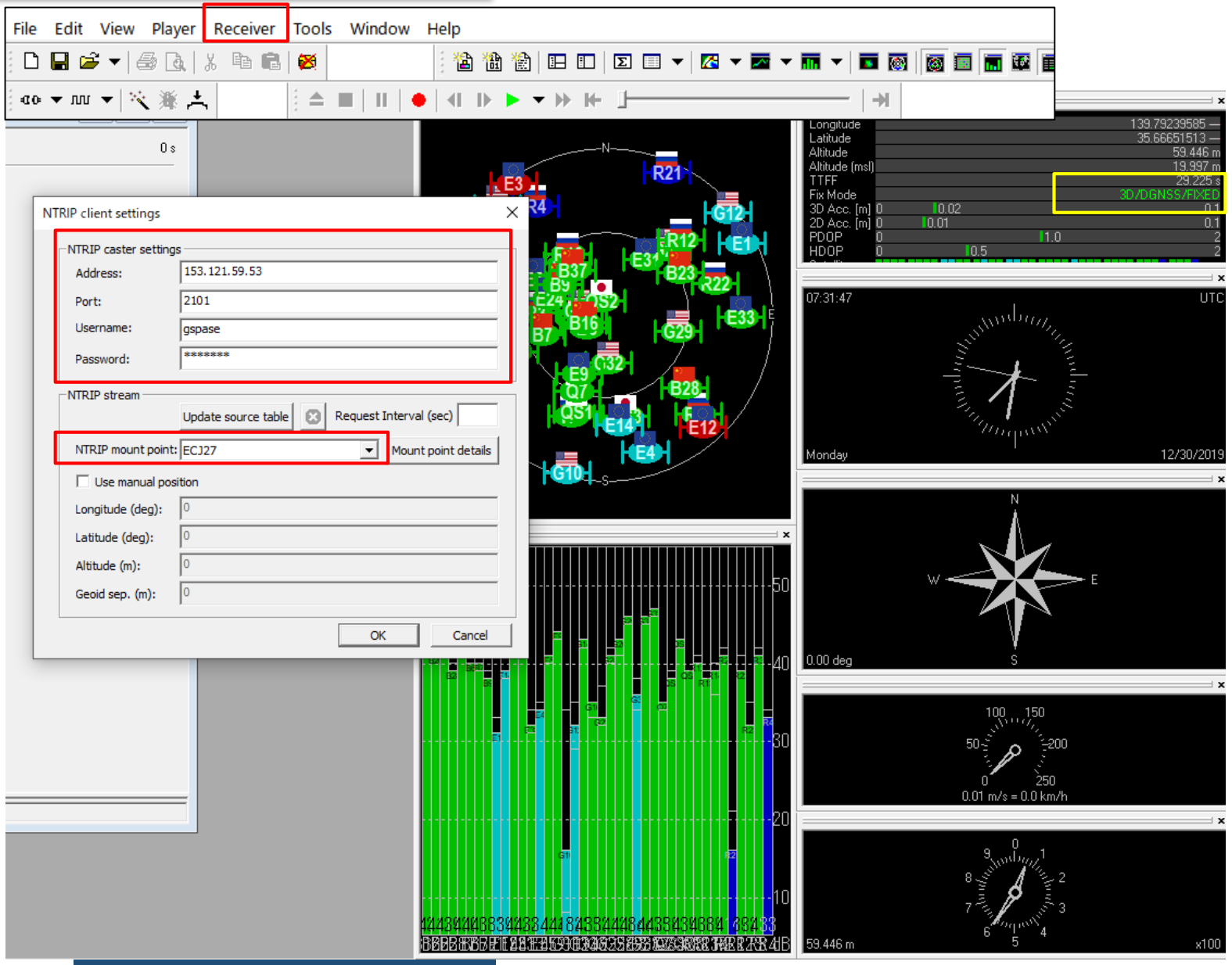
Use Ntrip client setting in u-center.

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

NTRIP client setting

Receiver>NTRIP Client

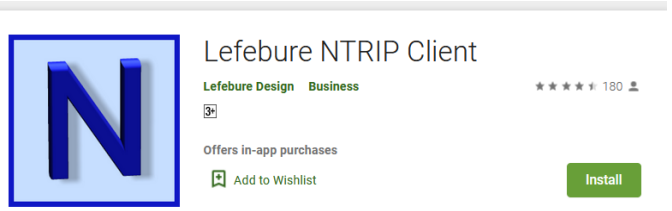
Select mount point and click “OK”.



4. RTK configuration on rover

◆RTK (ublox with smartphone)

Android app of Ntrip client.



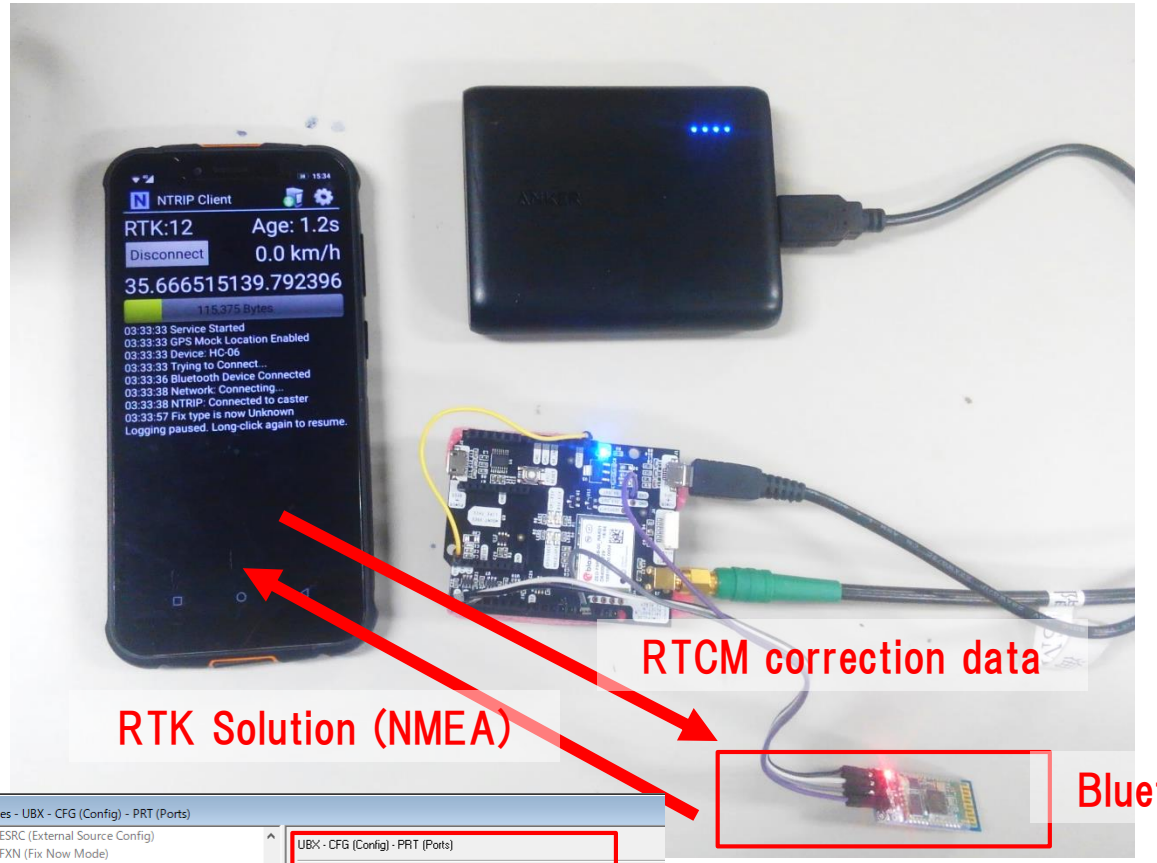
https://play.google.com/store/apps/details?id=com.lefebure.ntripclient&hl=en

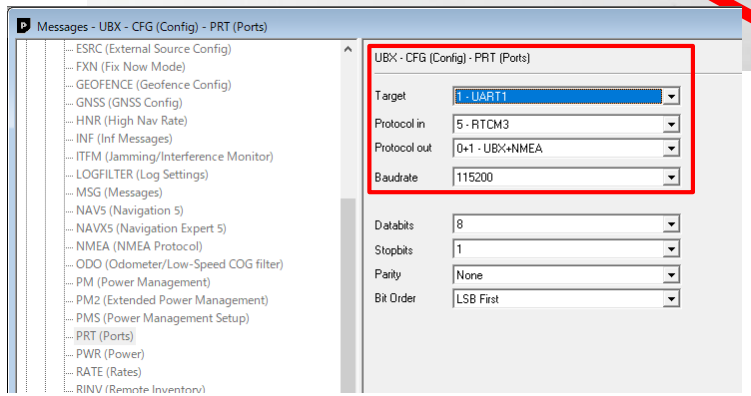
You need to setup ublox's UART port that connect with Bluetooth module

・Input : RTCM

・Output : NMEA

・Baud rate : Same with Bluetooth module.





4. RTK configuration on rover

◆RTK (RTKNAVI)

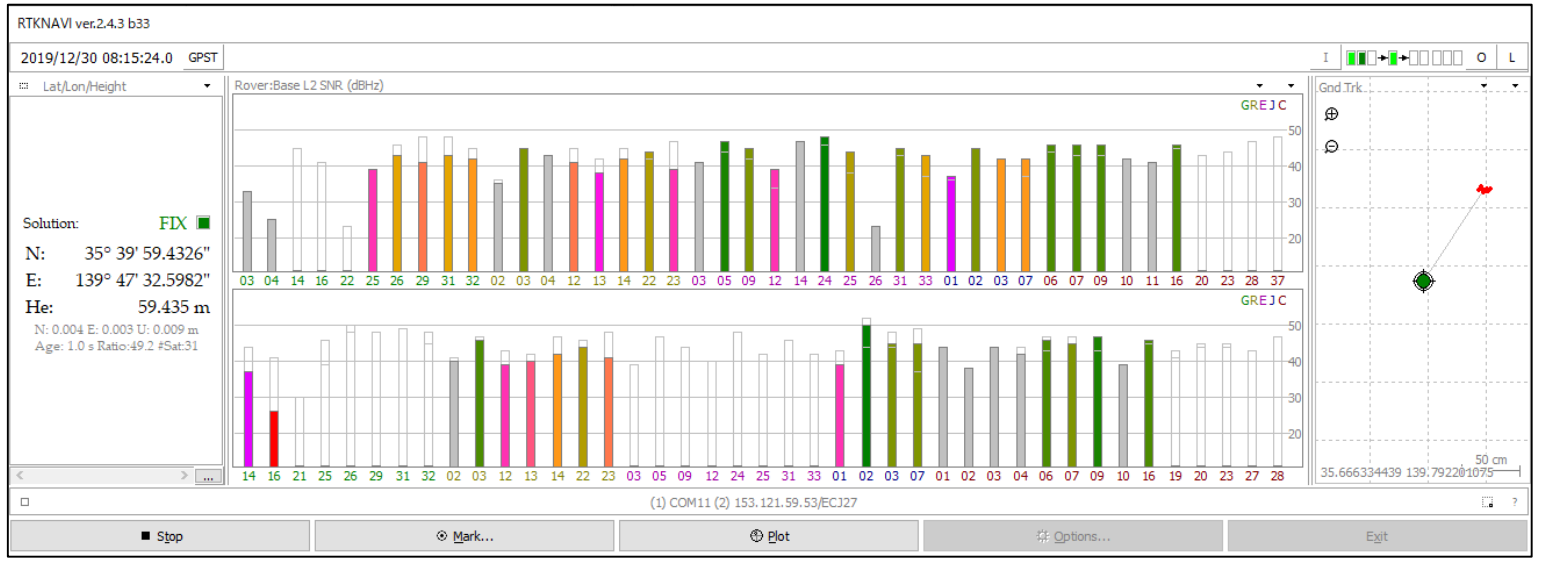
Real time RTK engine that supports many receivers.

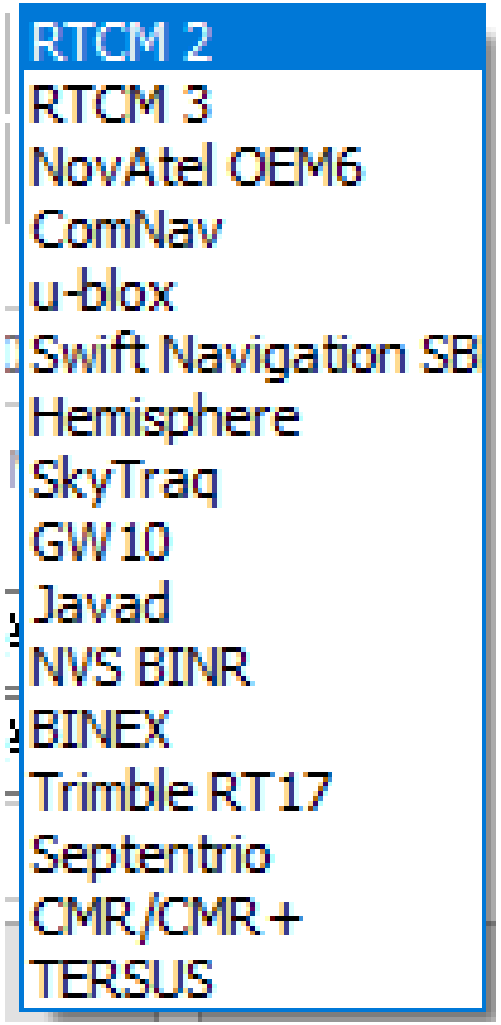
To use RTKNAVI, first you should set receiver to output “raw data”.

“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.





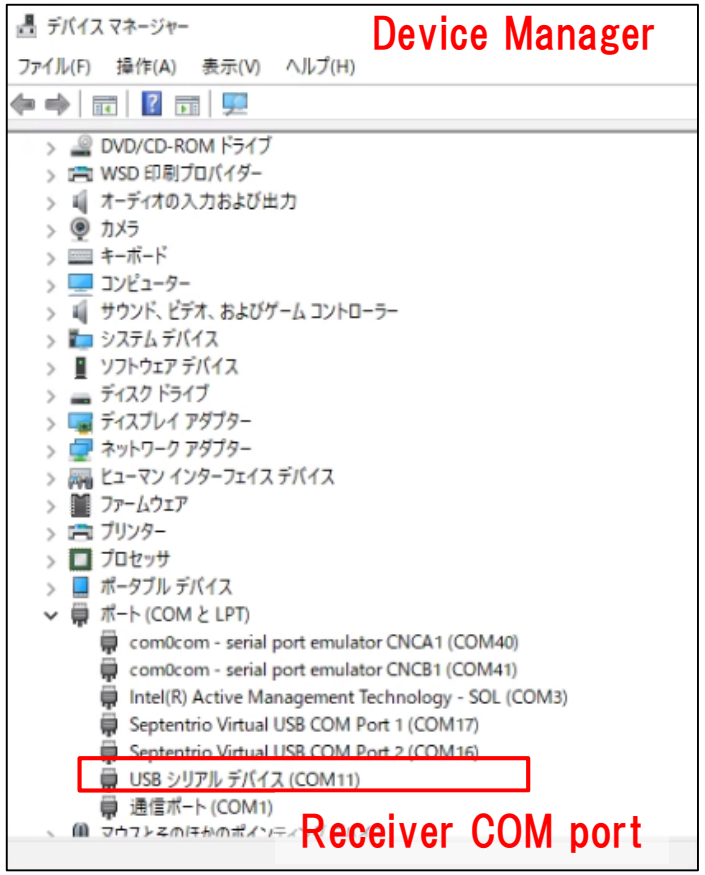
Supported “raw data” formats

4. RTK configuration on rover

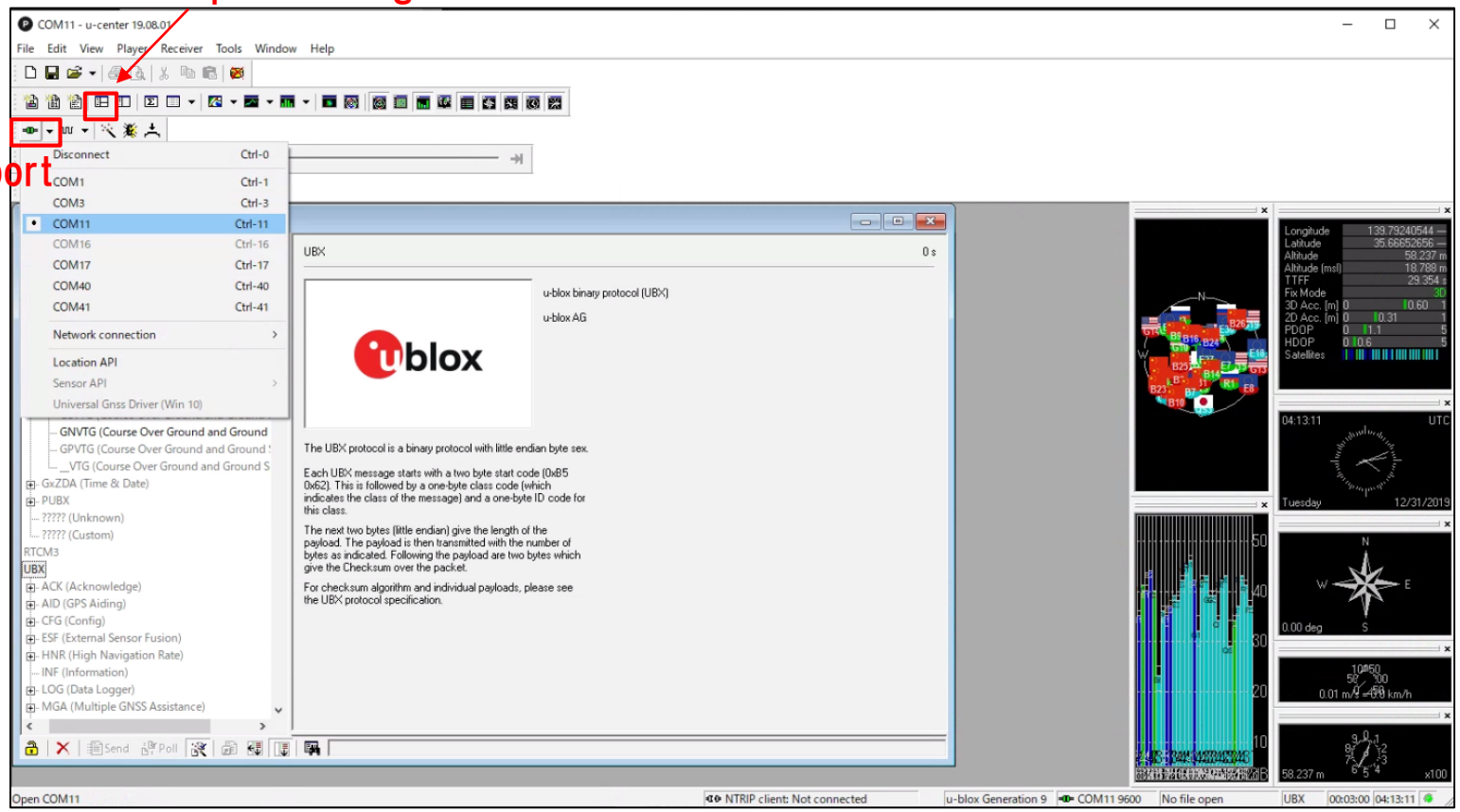
◆RTK (RTKNAVI)

Receiver configuration on u-center.

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



Select port

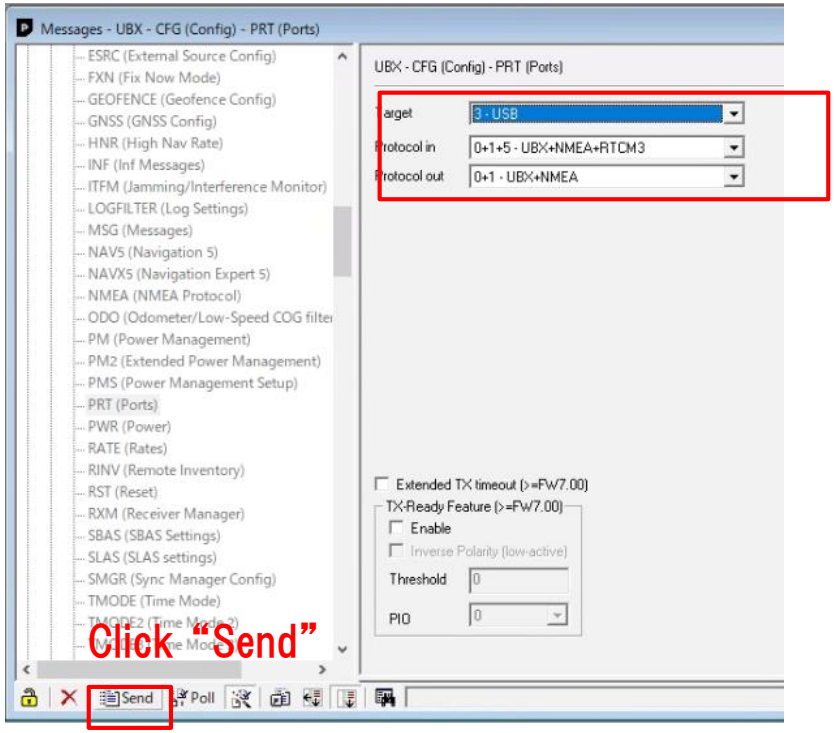


4. RTK configuration on rover

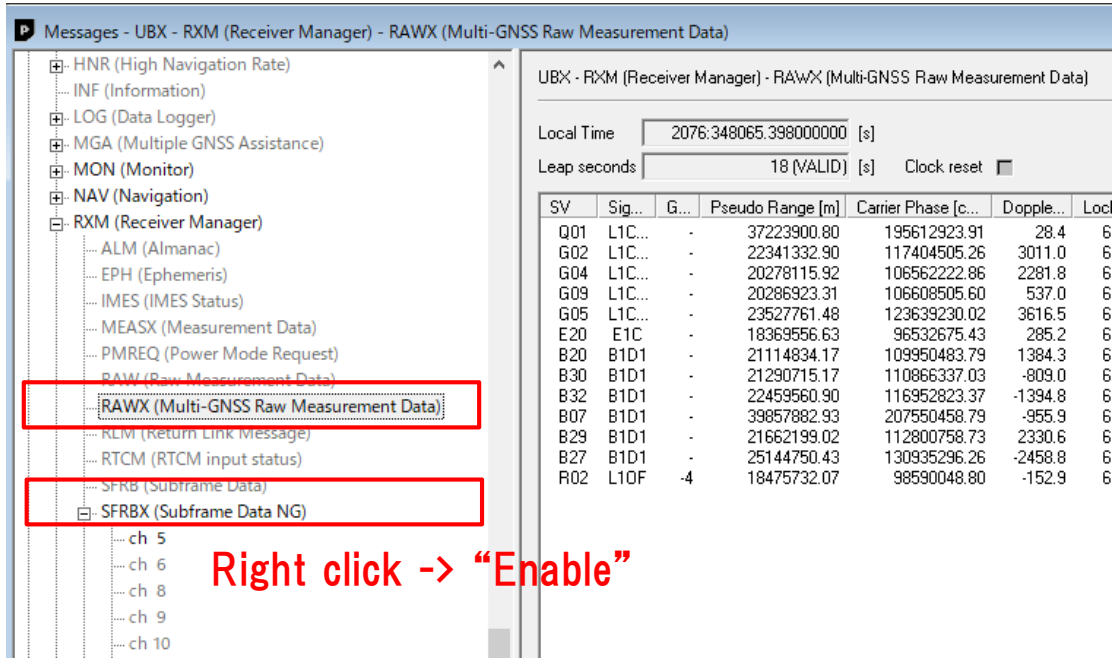
◆RTK (RTKNAVI)

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)



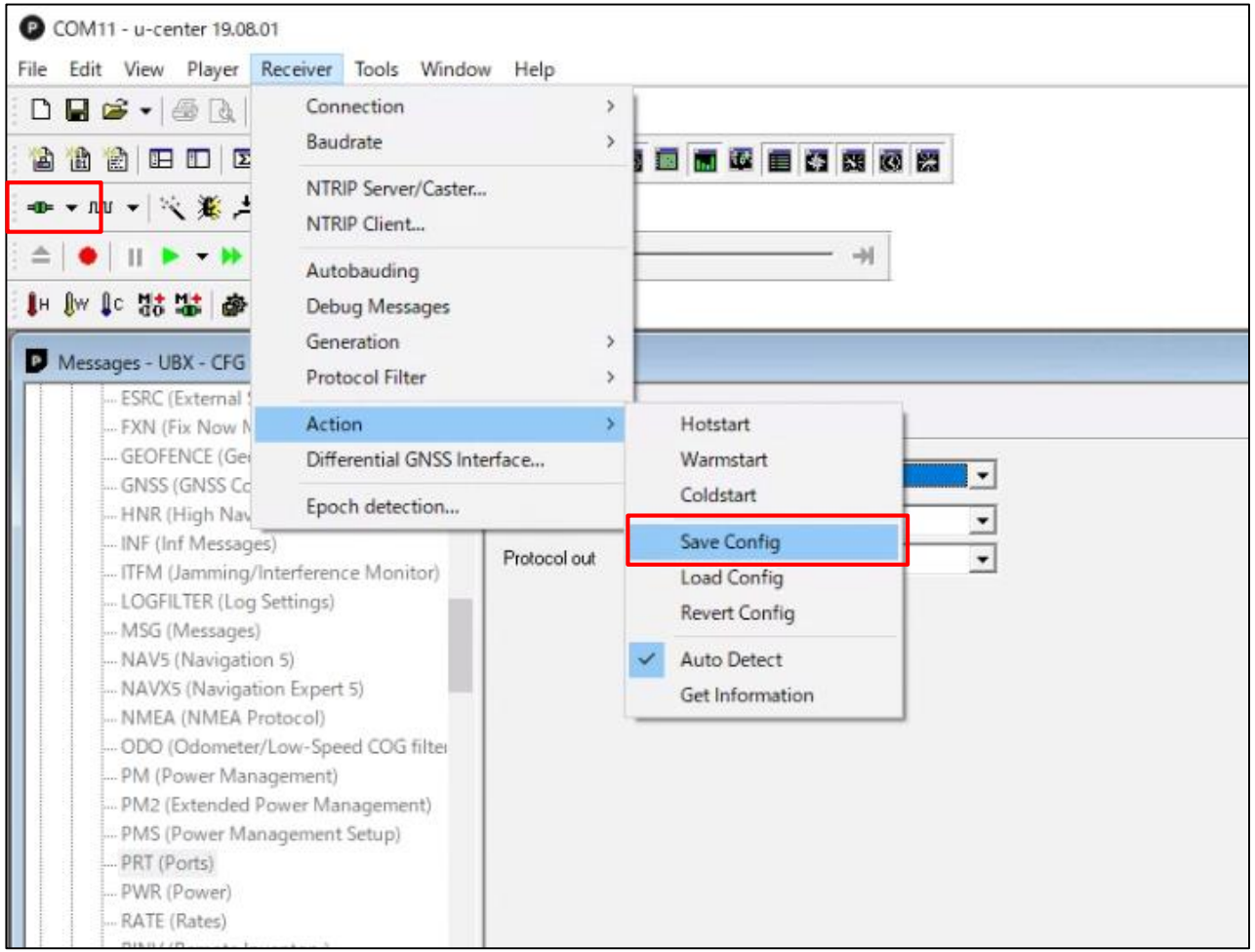
Enable output of RAWX & SFRBX (UBX-RXM)

4. RTK configuration on rover

◆RTK (RTKNAVI)

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

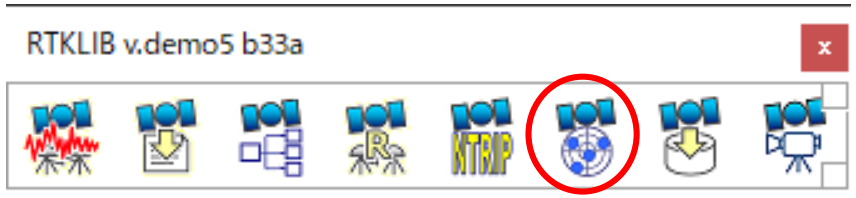
“Disconnect”

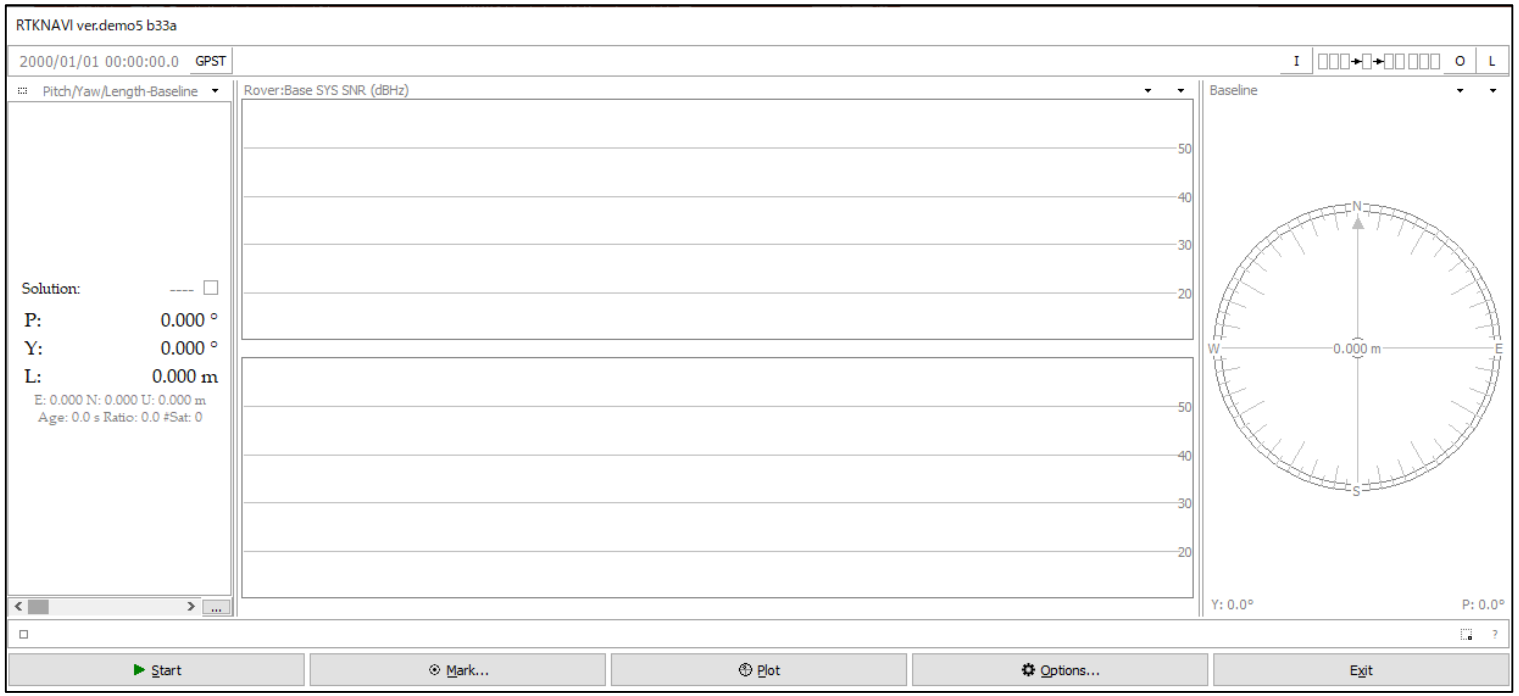


4. RTK configuration on rover

◆RTK (RTKNAVI)

Open RTKNAVI.

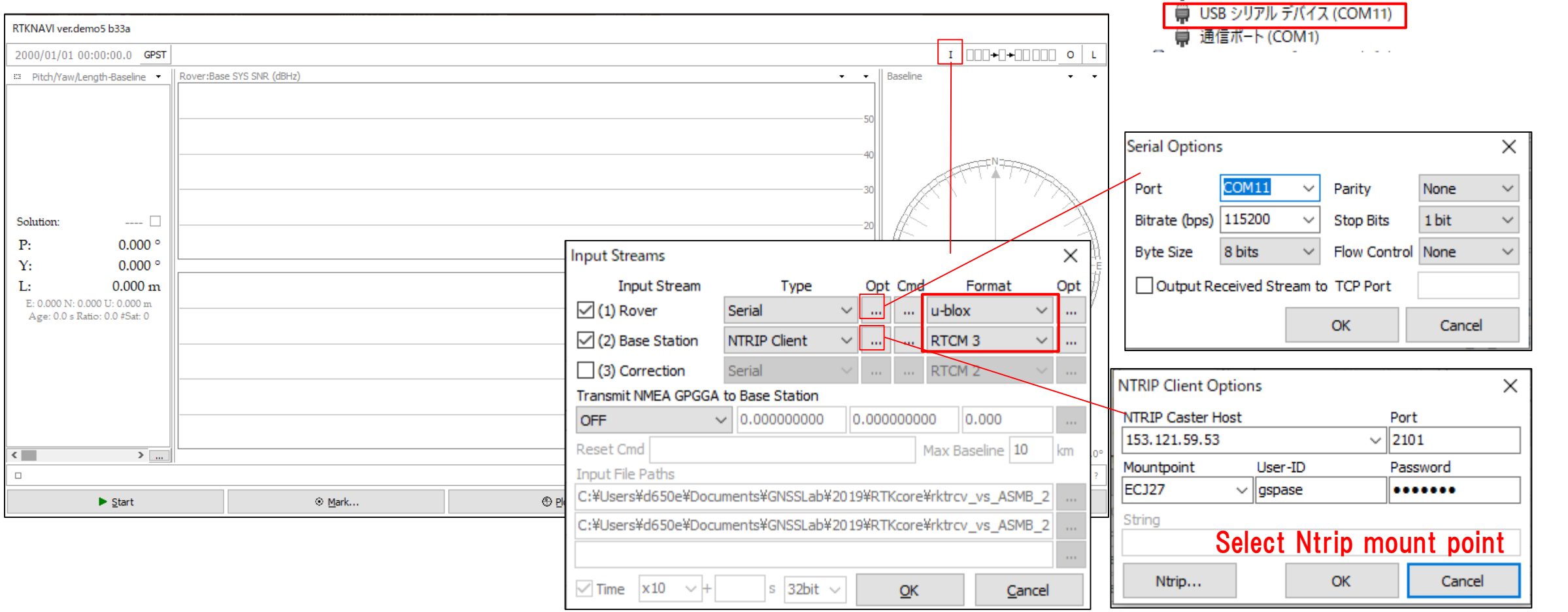




4. RTK configuration on rover

◆RTK (RTKNAVI)

Set input stream.

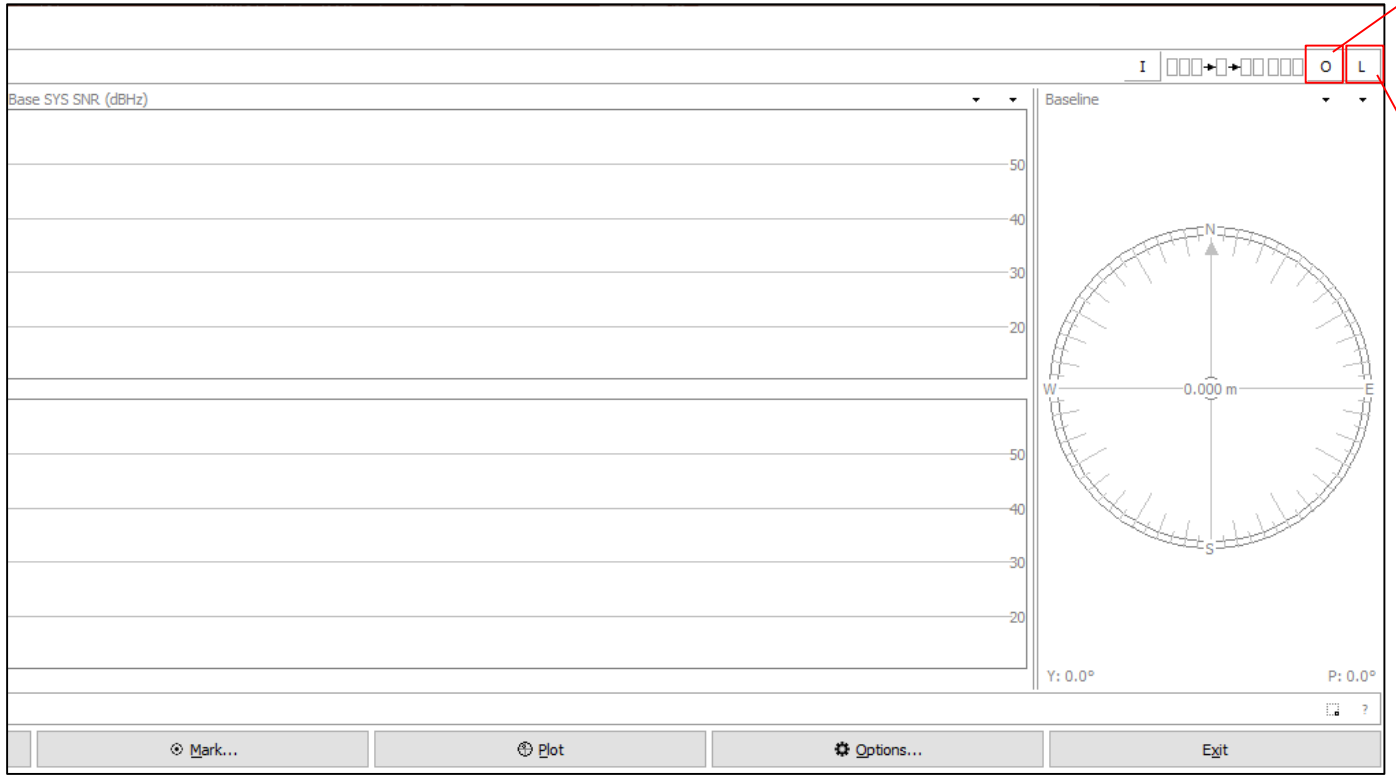


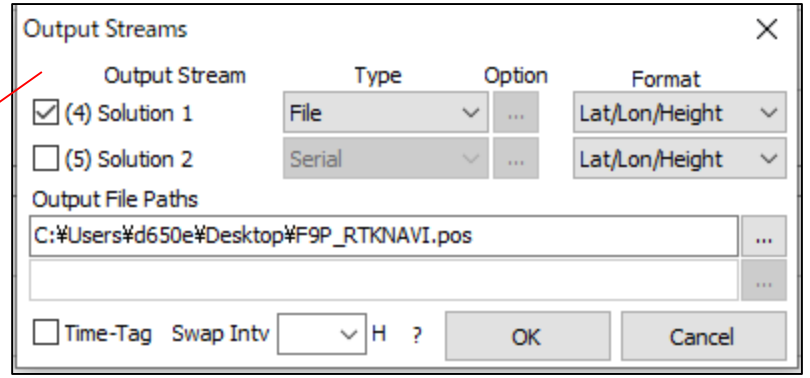
4. RTK configuration on rover

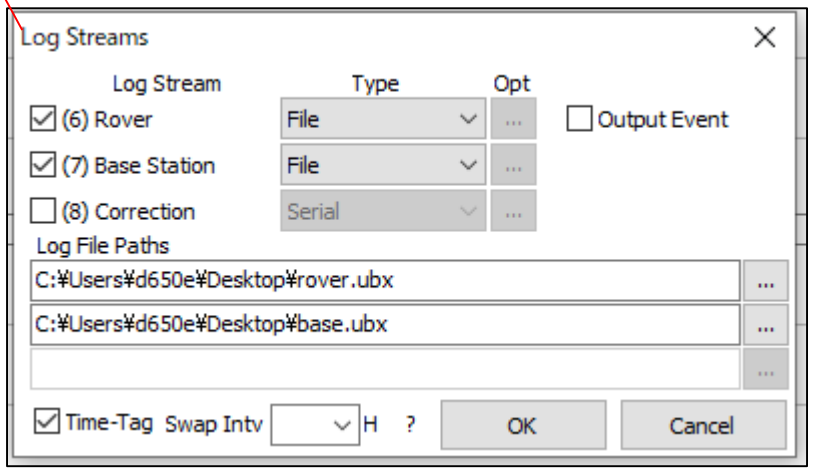
◆RTK (RTKNAVI)

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



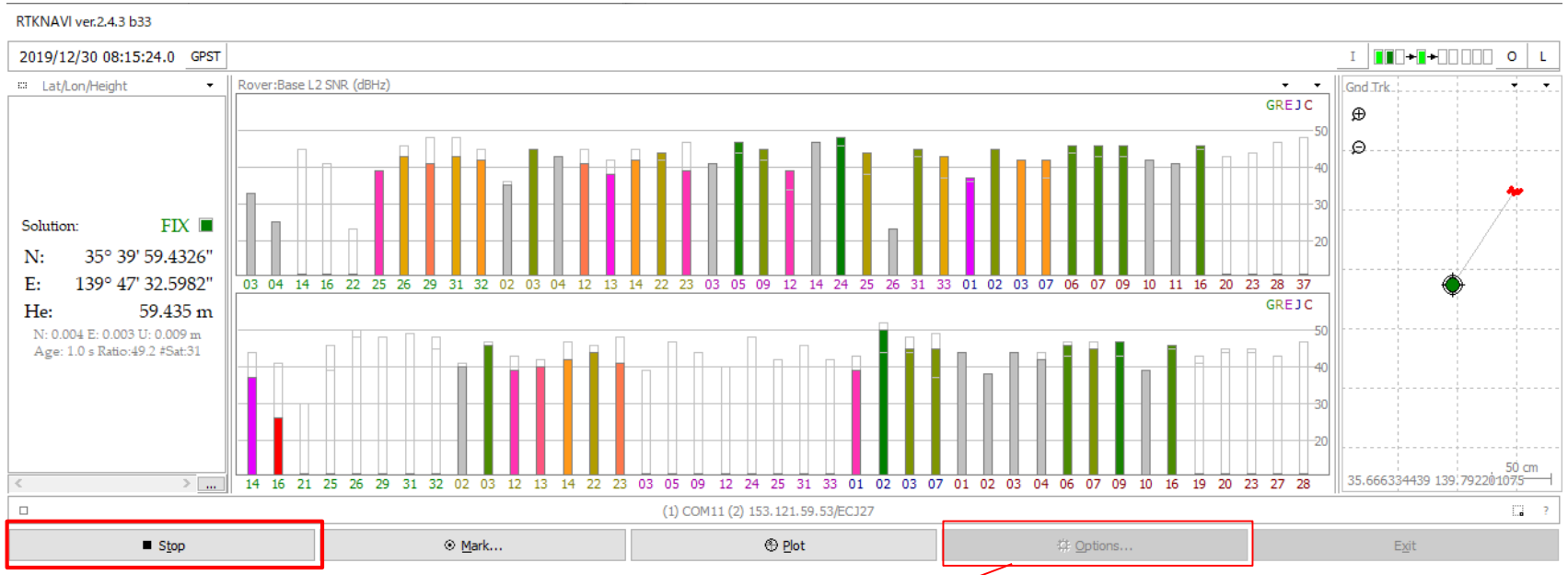


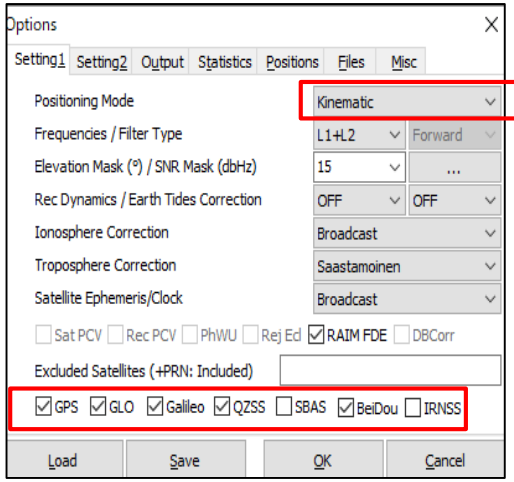


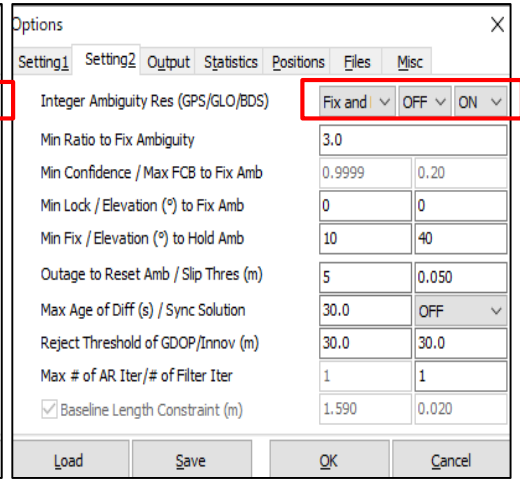
4. RTK configuration on rover

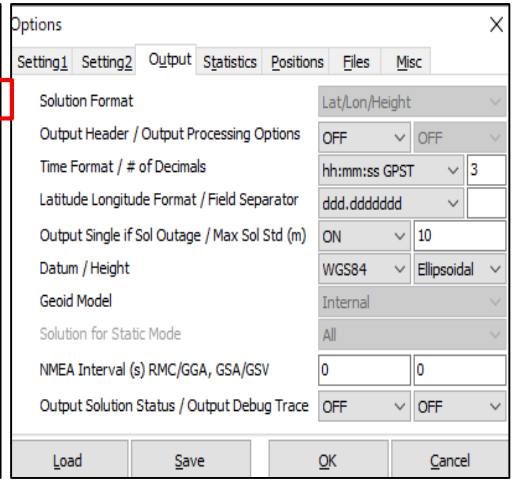
◆RTK (RTKNAVI)

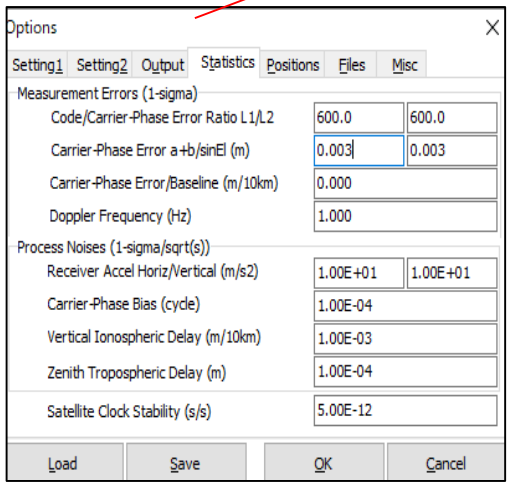
Set option to calculate RTK.
After option setting, click
“Start” and then RTK starts.

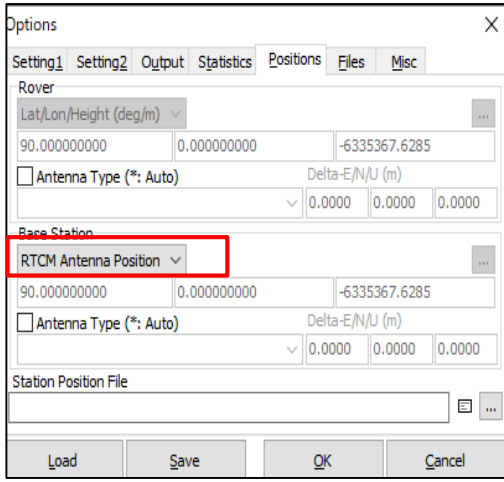








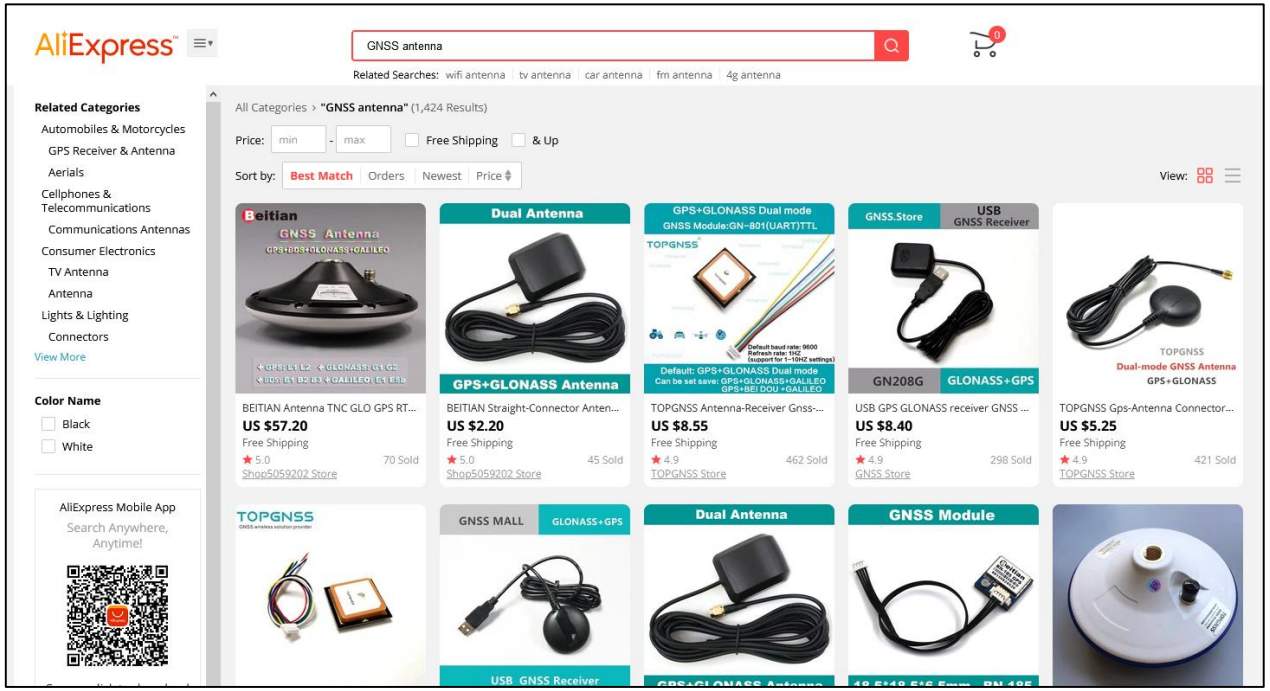




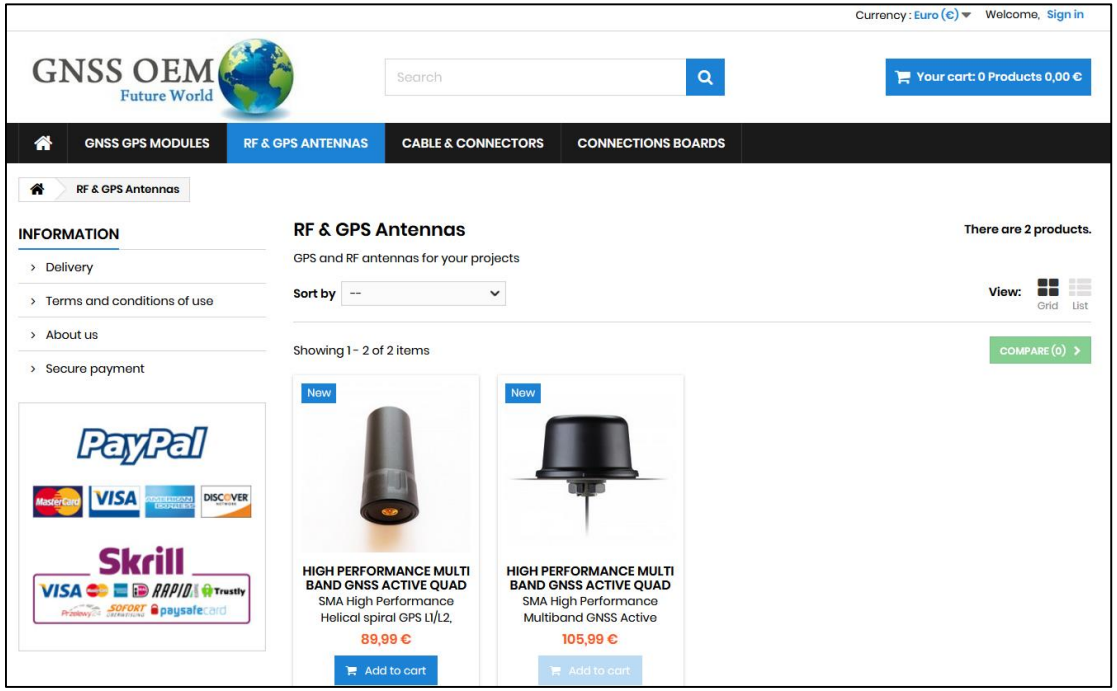
5. Where can I buy GNSS devices?

I show some shop that you can buy GNSS devices.

◆Antenna



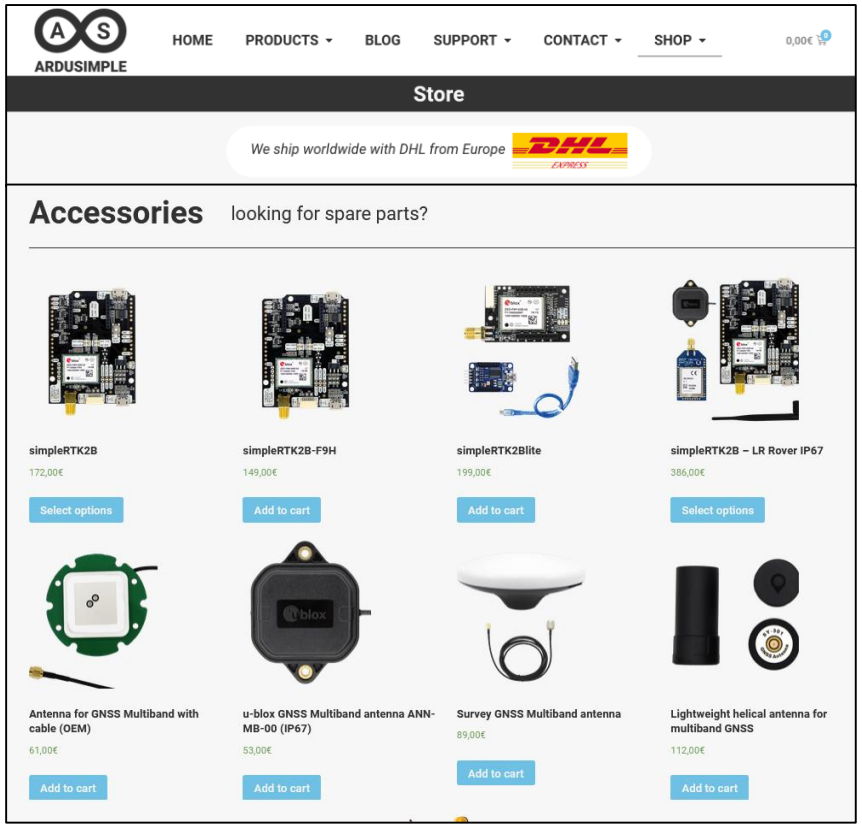
AliExpress



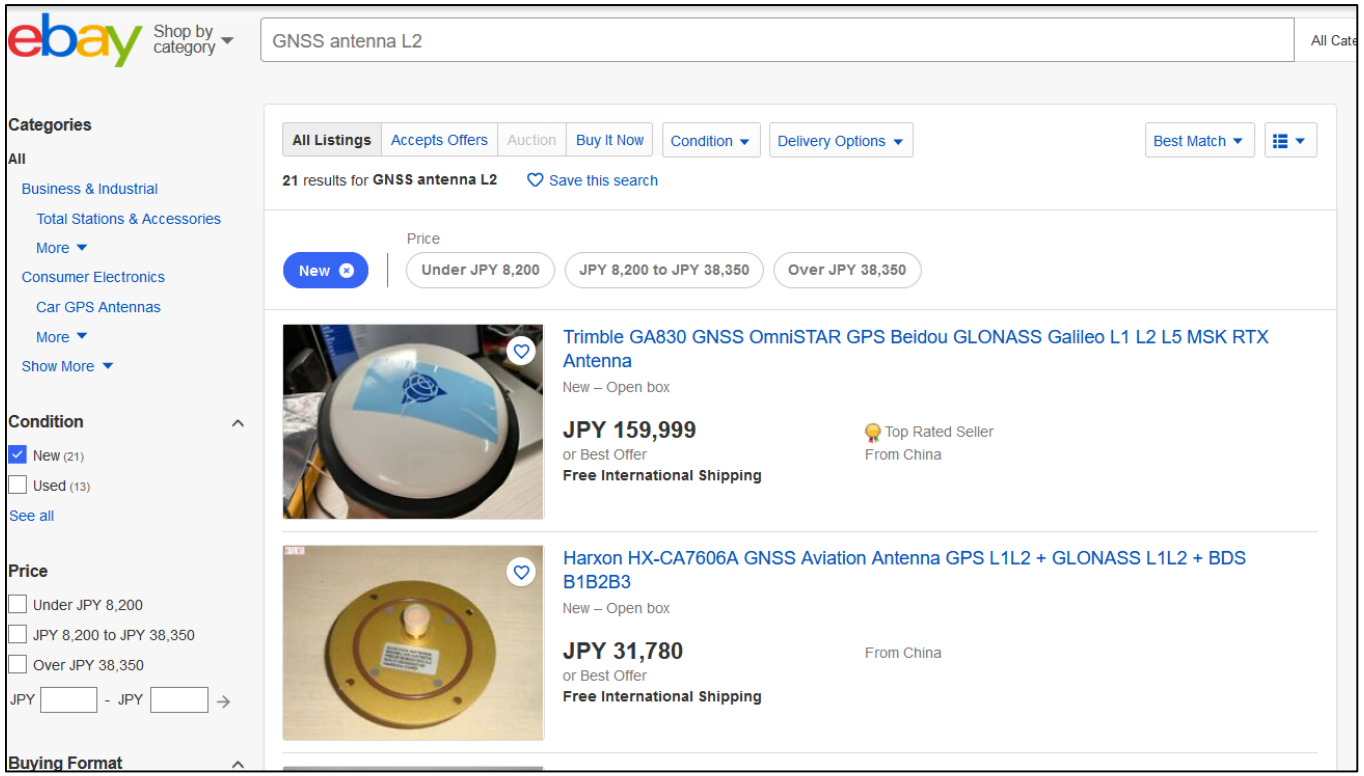
Eltehs GNSS OEM Store

5. Where can I buy GNSS devices?

◆Antenna



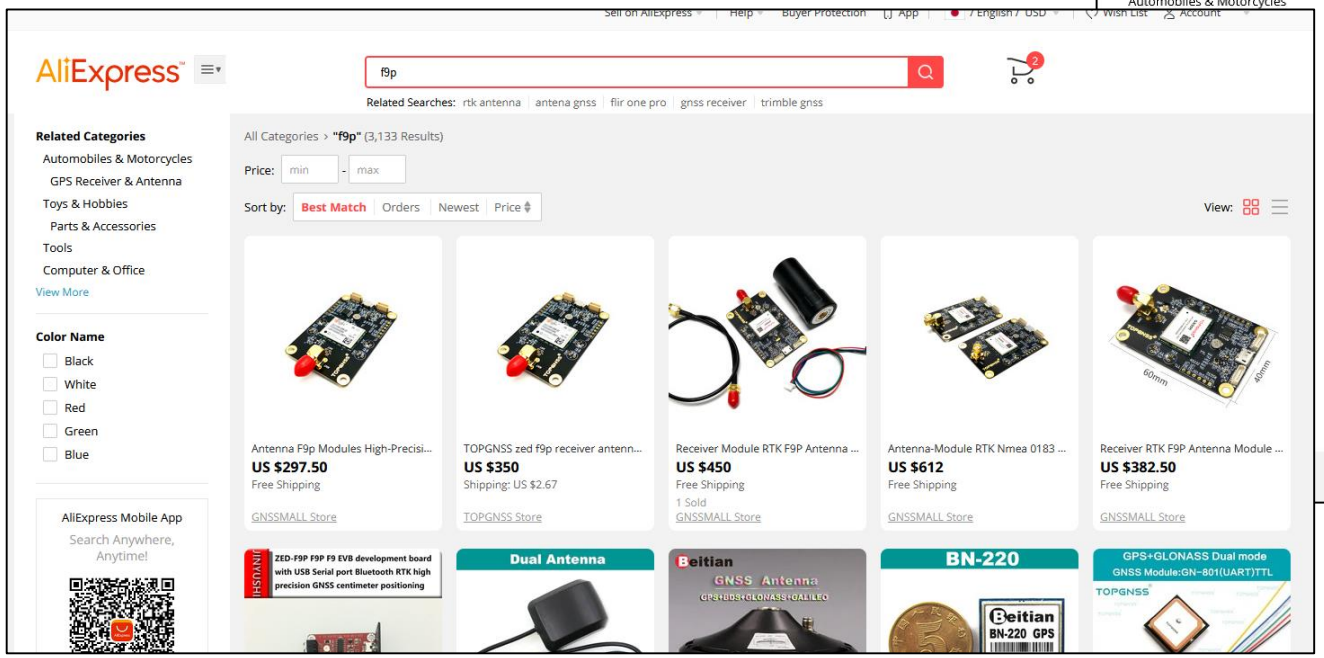
Ardusimple

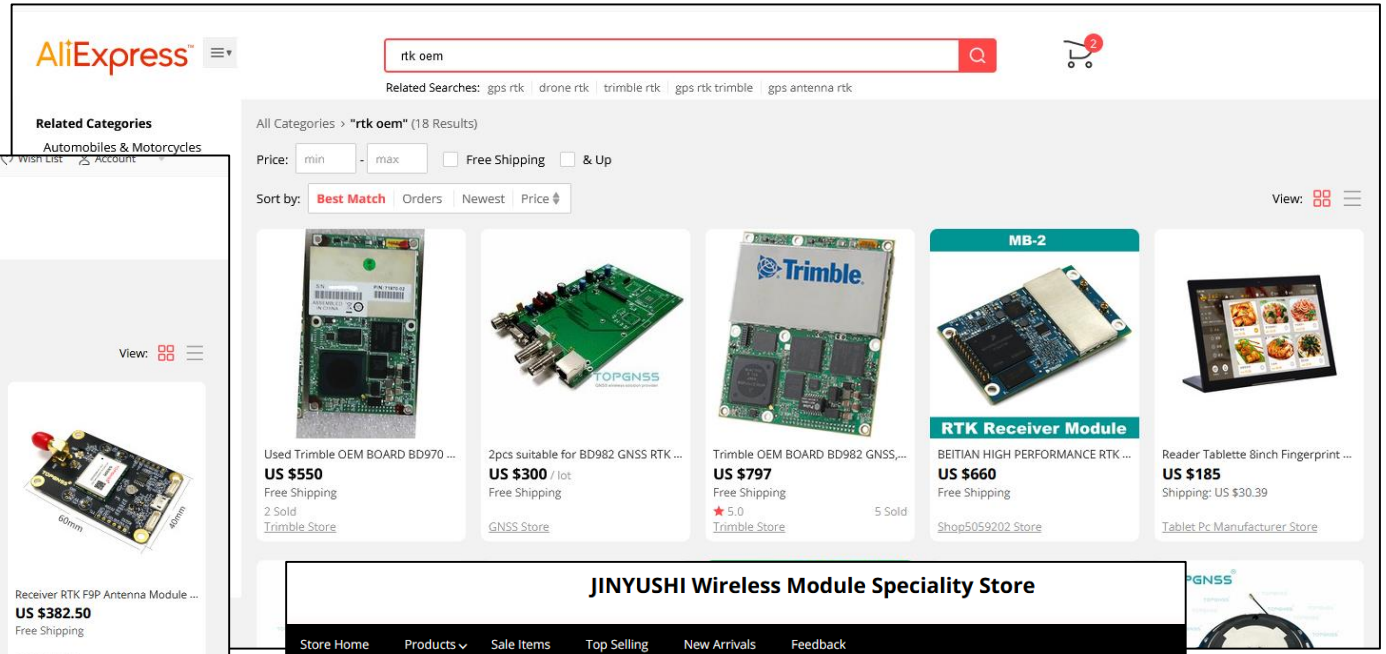


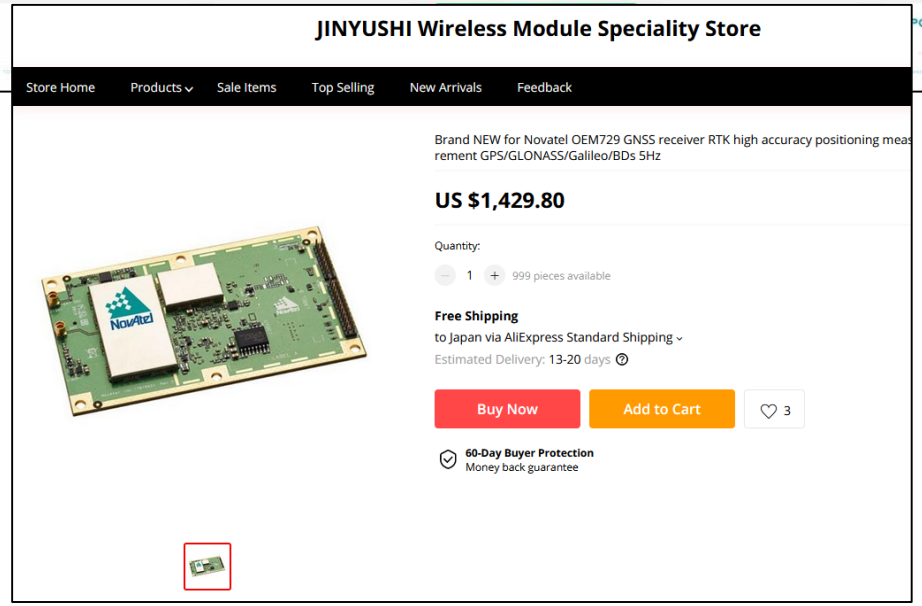
ebay

5. Where can I buy GNSS devices?

◆Receiver



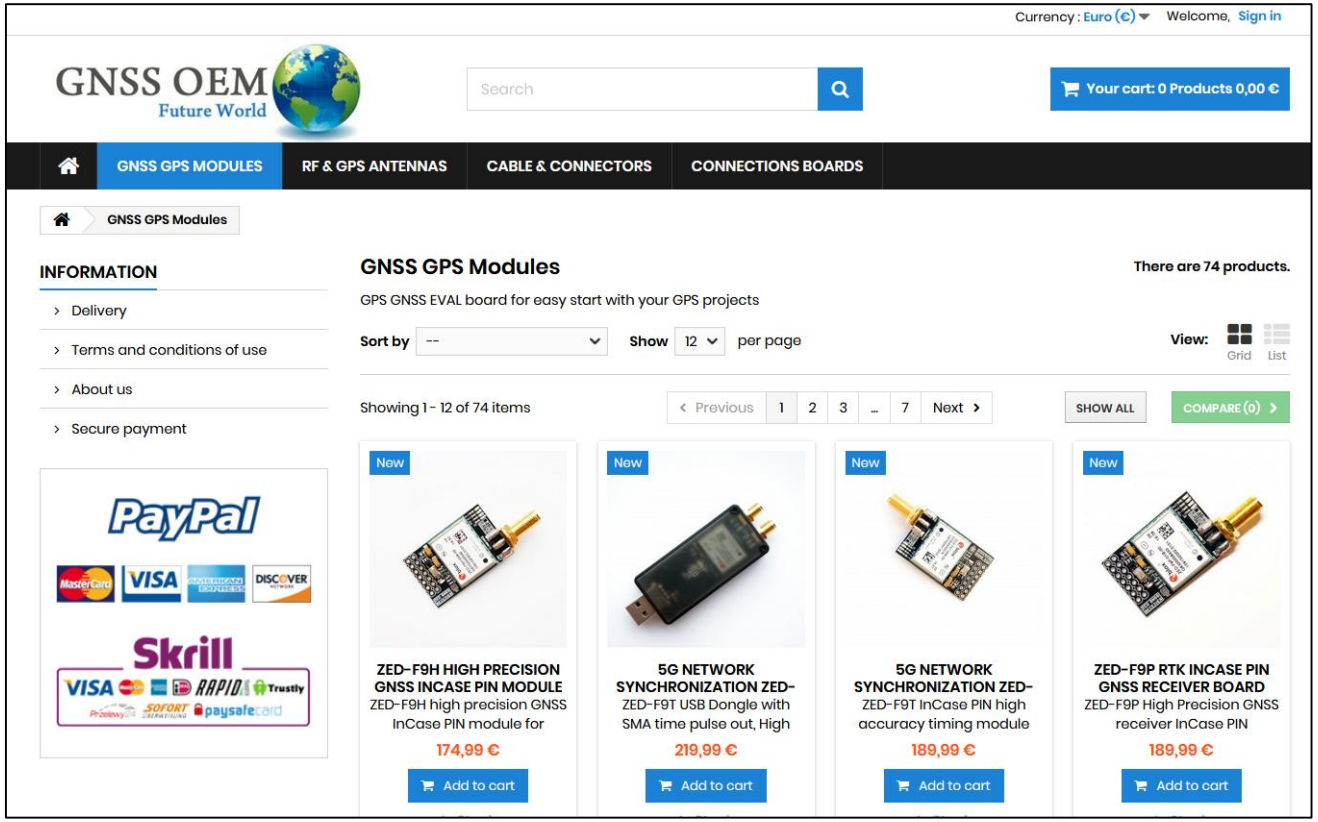




AliExpress(ublox, Trimble, Novatel)

5. Where can I buy GNSS devices?

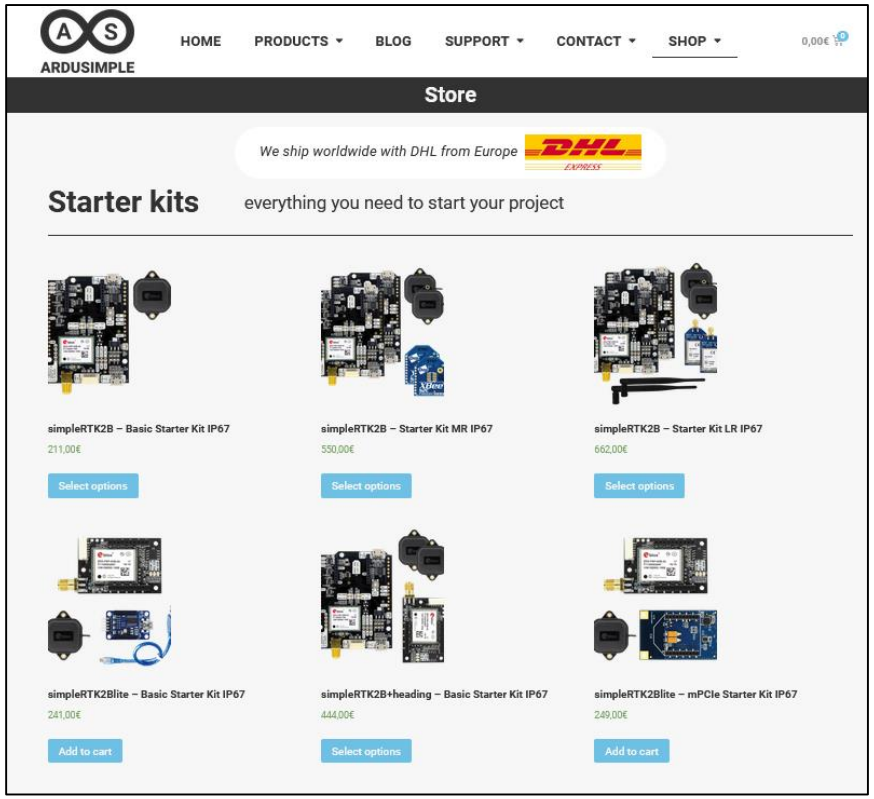
◆Receiver



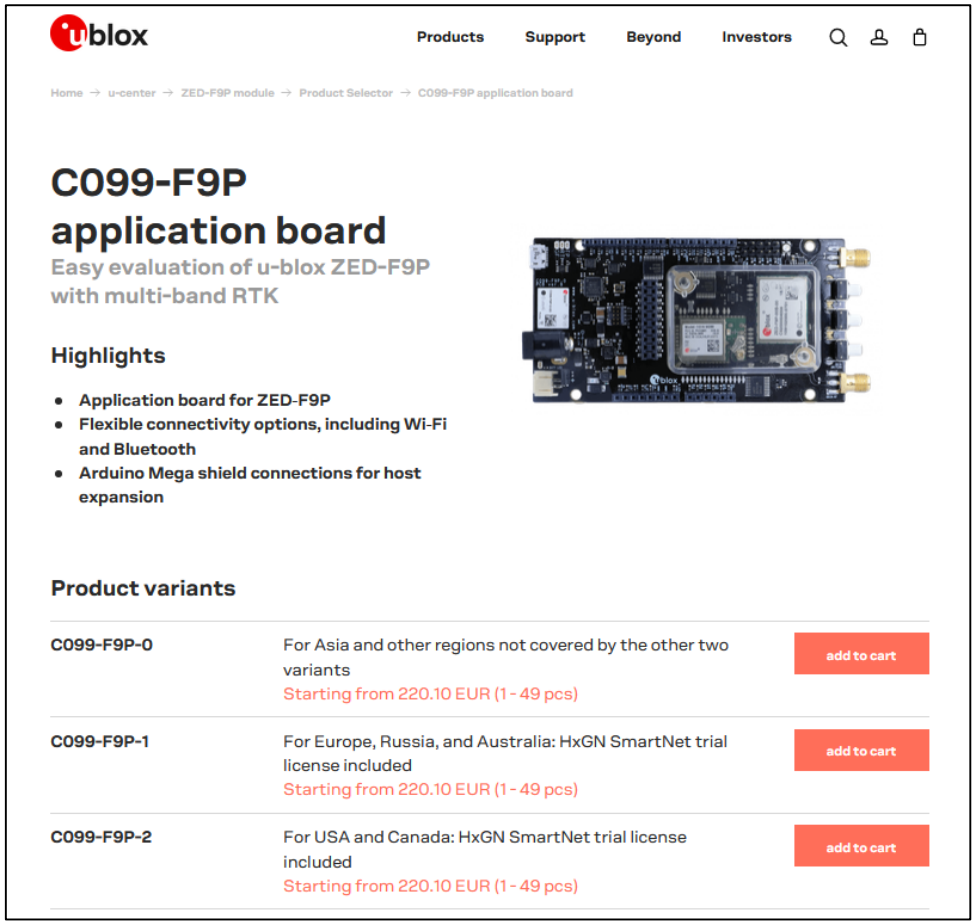
Eltehs GNSS OEM Store (ublox)

5. Where can I buy GNSS devices?

◆Receiver



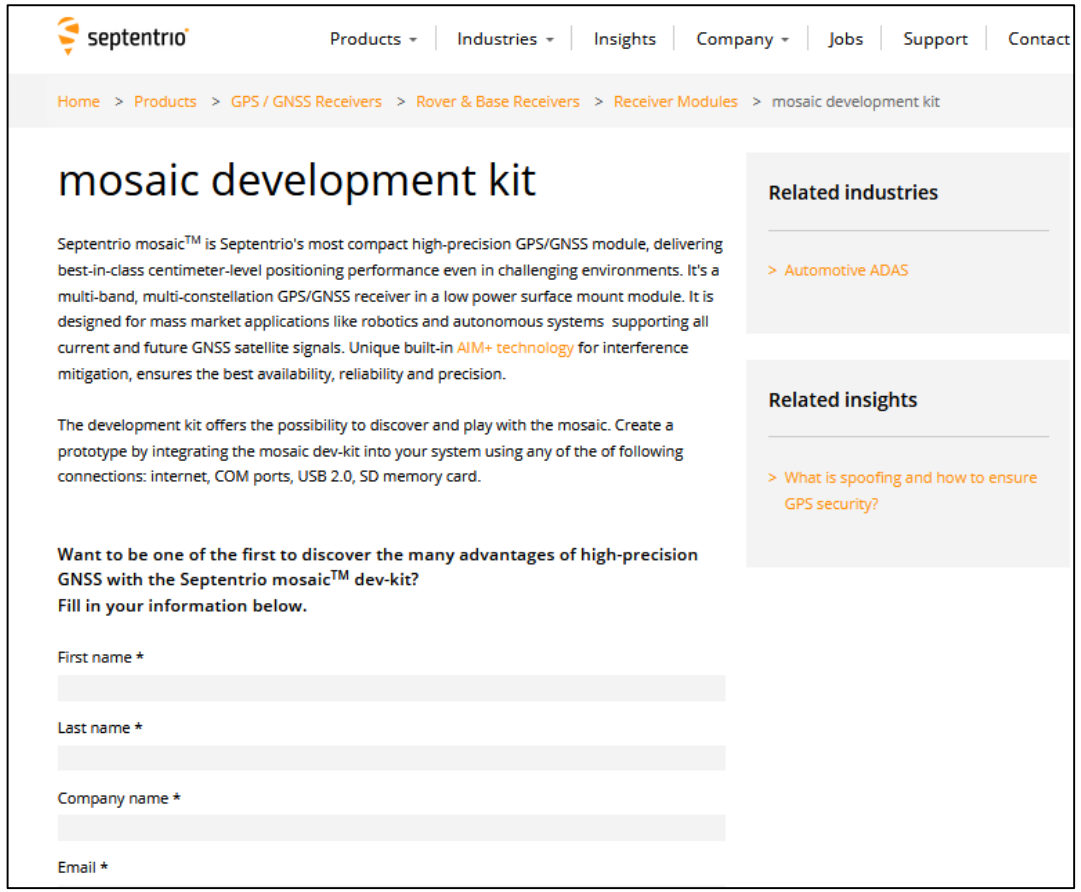
Ardusimple (ublox)



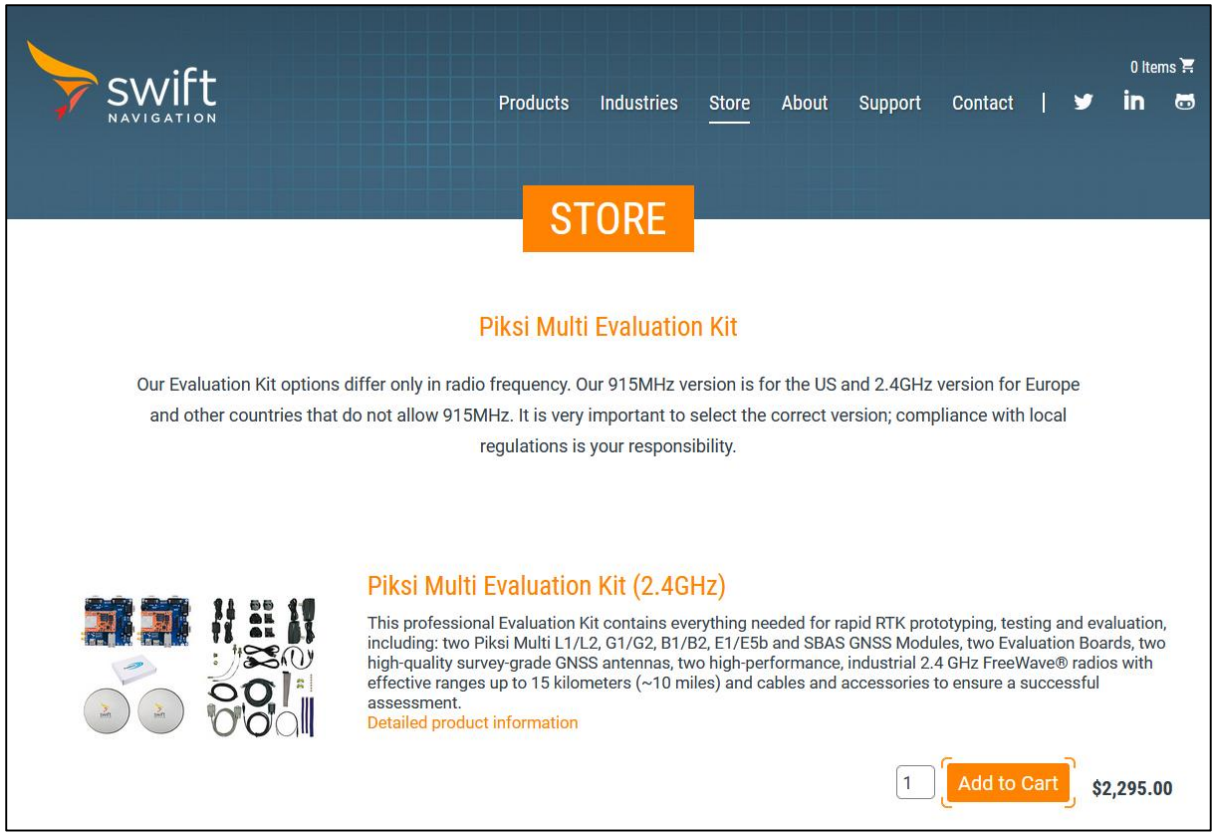
ublox direct shop

5. Where can I buy GNSS devices?

◆Receiver



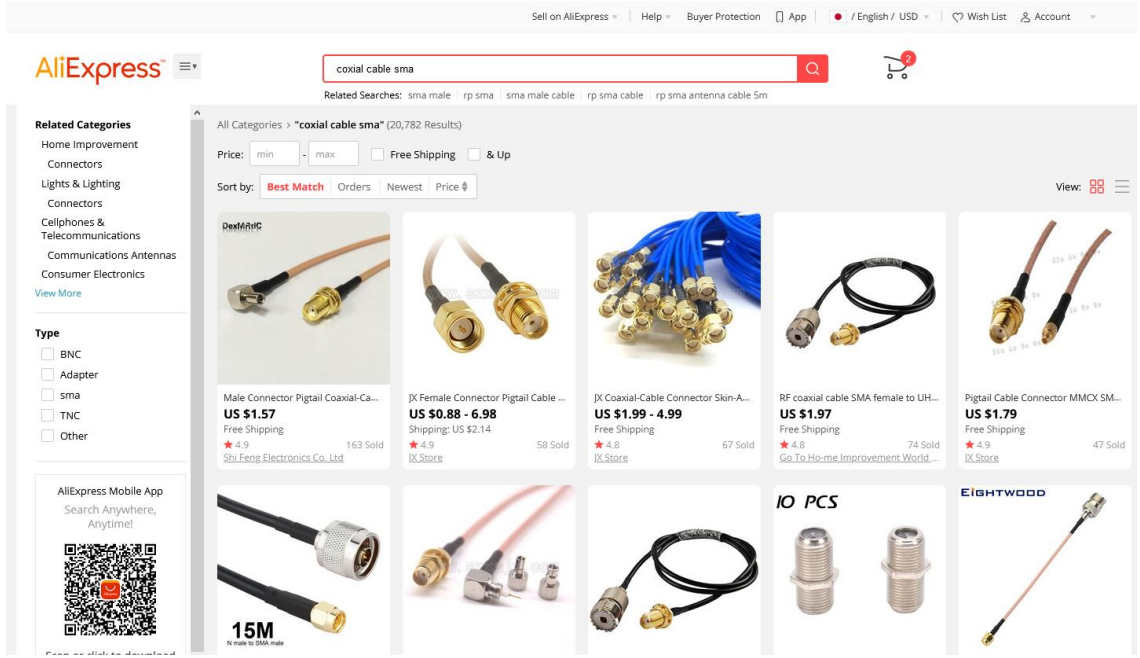
Septentrio direct shop

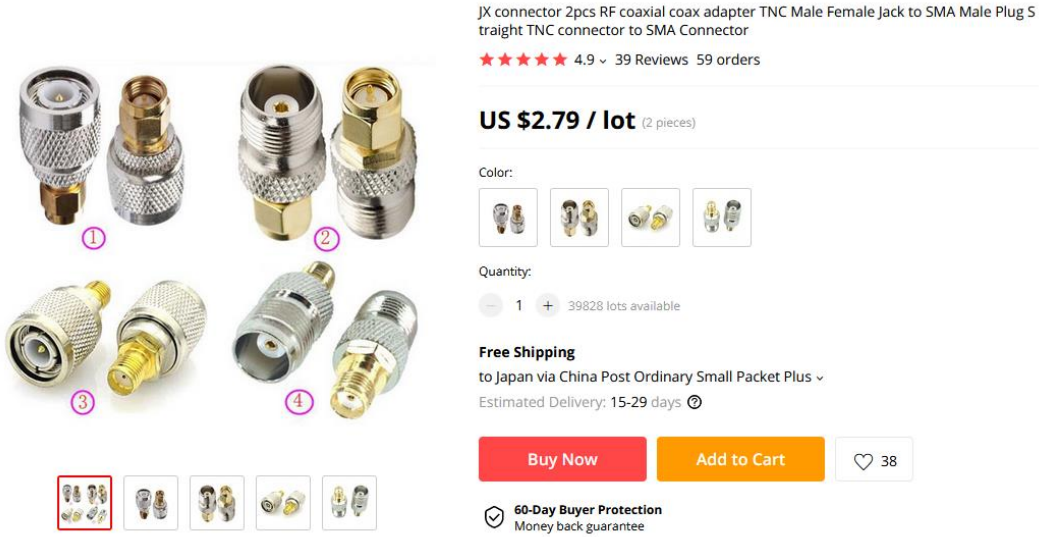


swift direct shop

5. Where can I buy GNSS devices?

◆Cable & connector



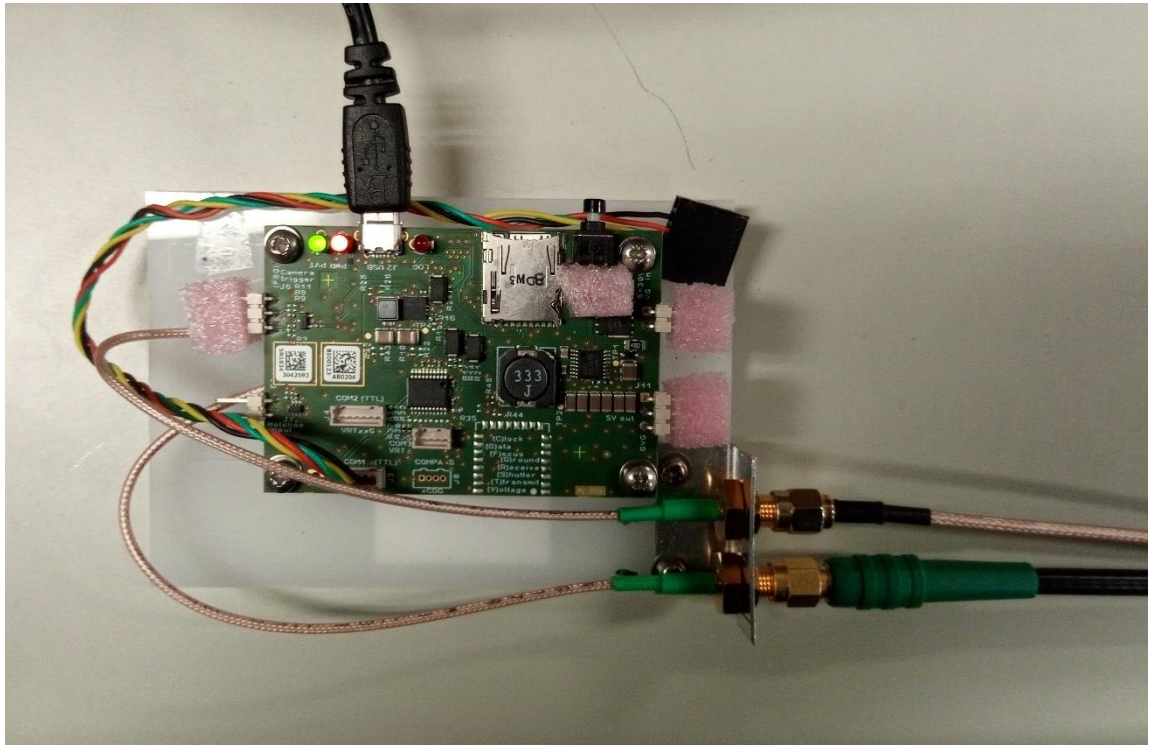


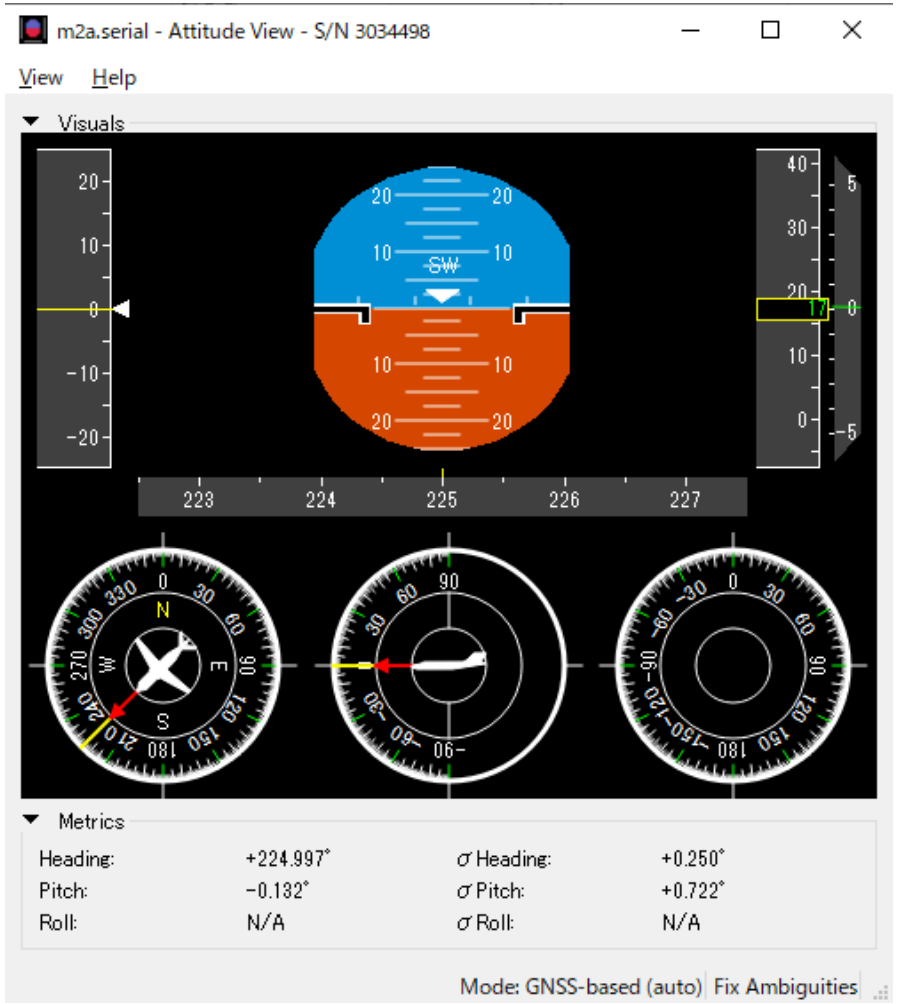
SMA or TNC type connector are major in GNSS.

6. Moving-base RTK

◆Moving-base RTK (AsteRx-m2a)

Just connect 2 antenna to the receiver.



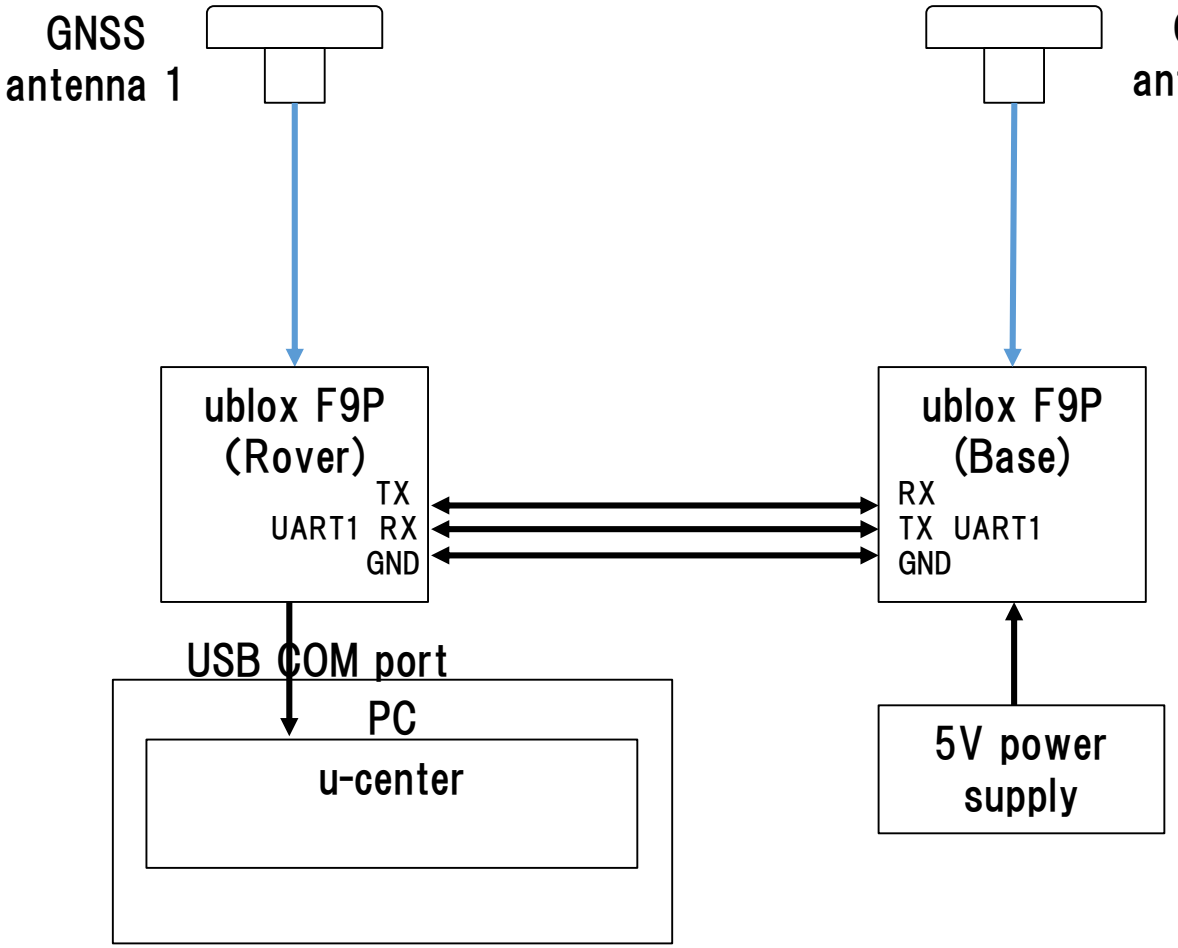


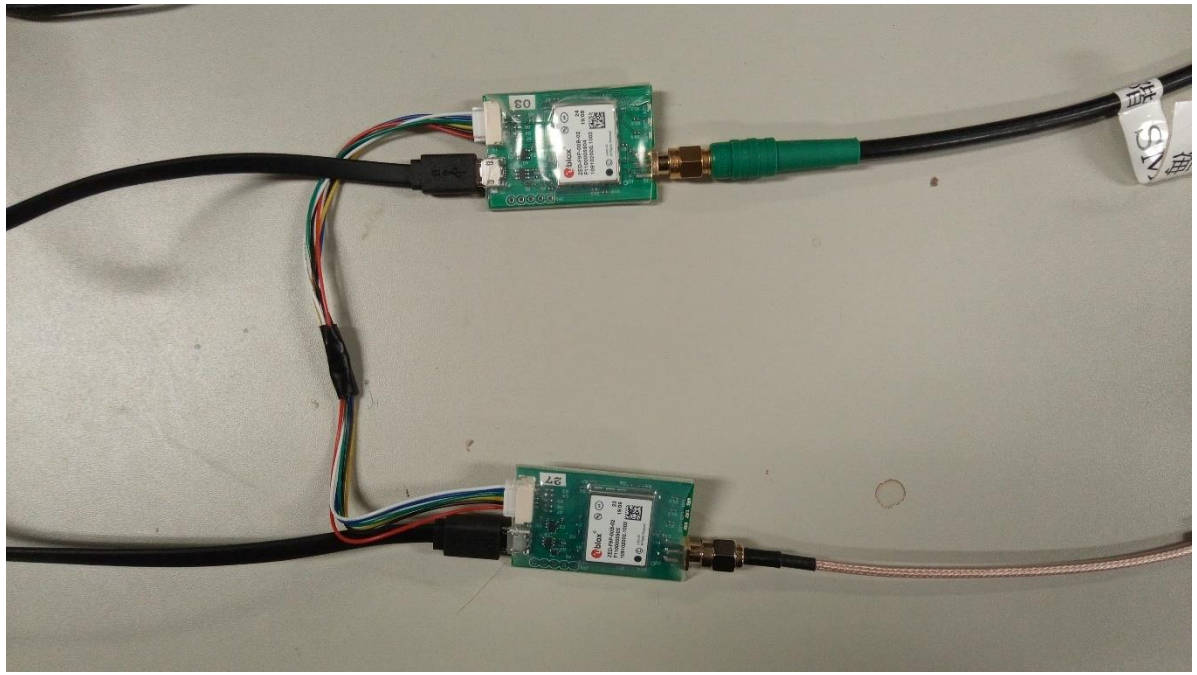
ASCII output by nmea “HDT” message.

```
$GPGGA,071402.00,3539.9910977,N,13947.5434857,E,2,28,0.6,17.3133,M,39.3
$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.

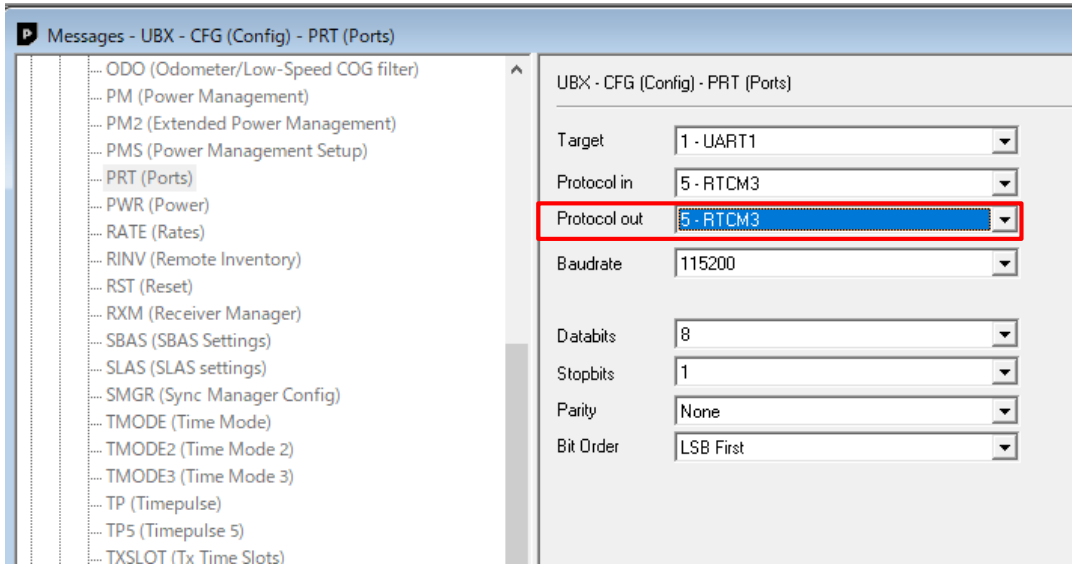


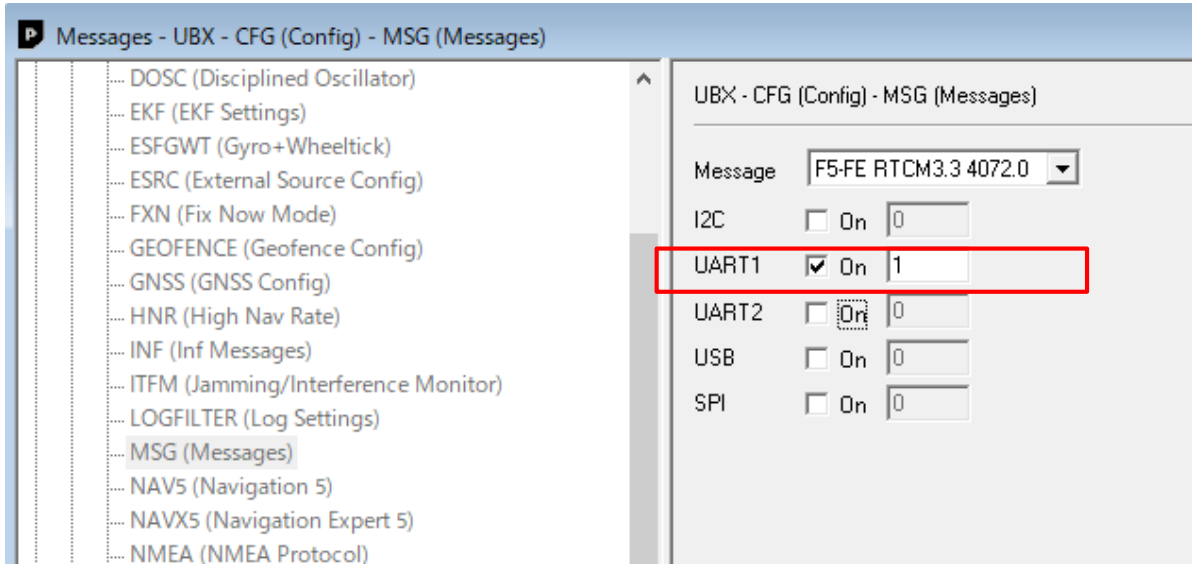


6. Moving-base RTK

◆Moving-base RTK (F9P)

Base configuration.





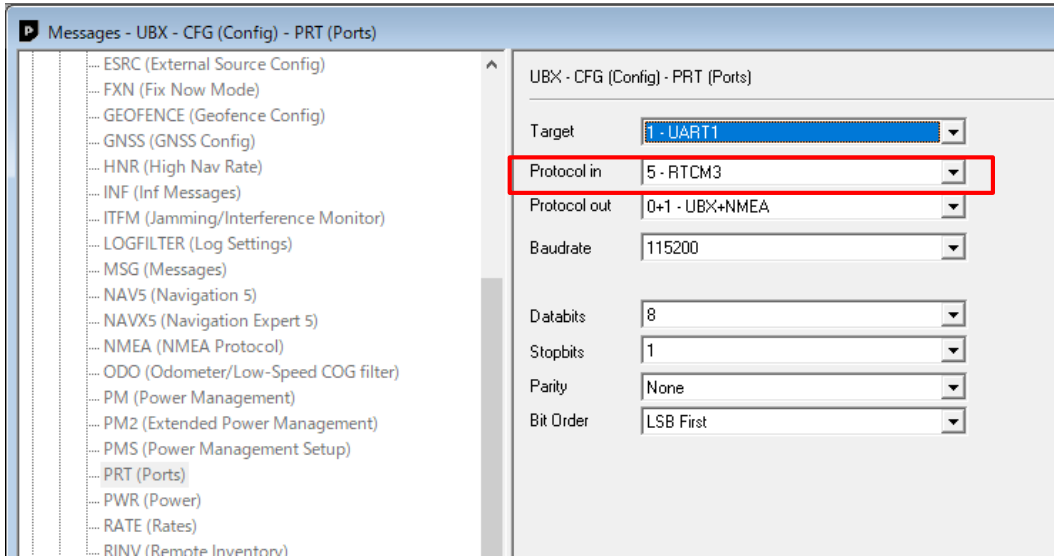
Set protocol out of used UART to RTCM. Baudrate should be over 115200. (UBX-CFG-PRT)

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)

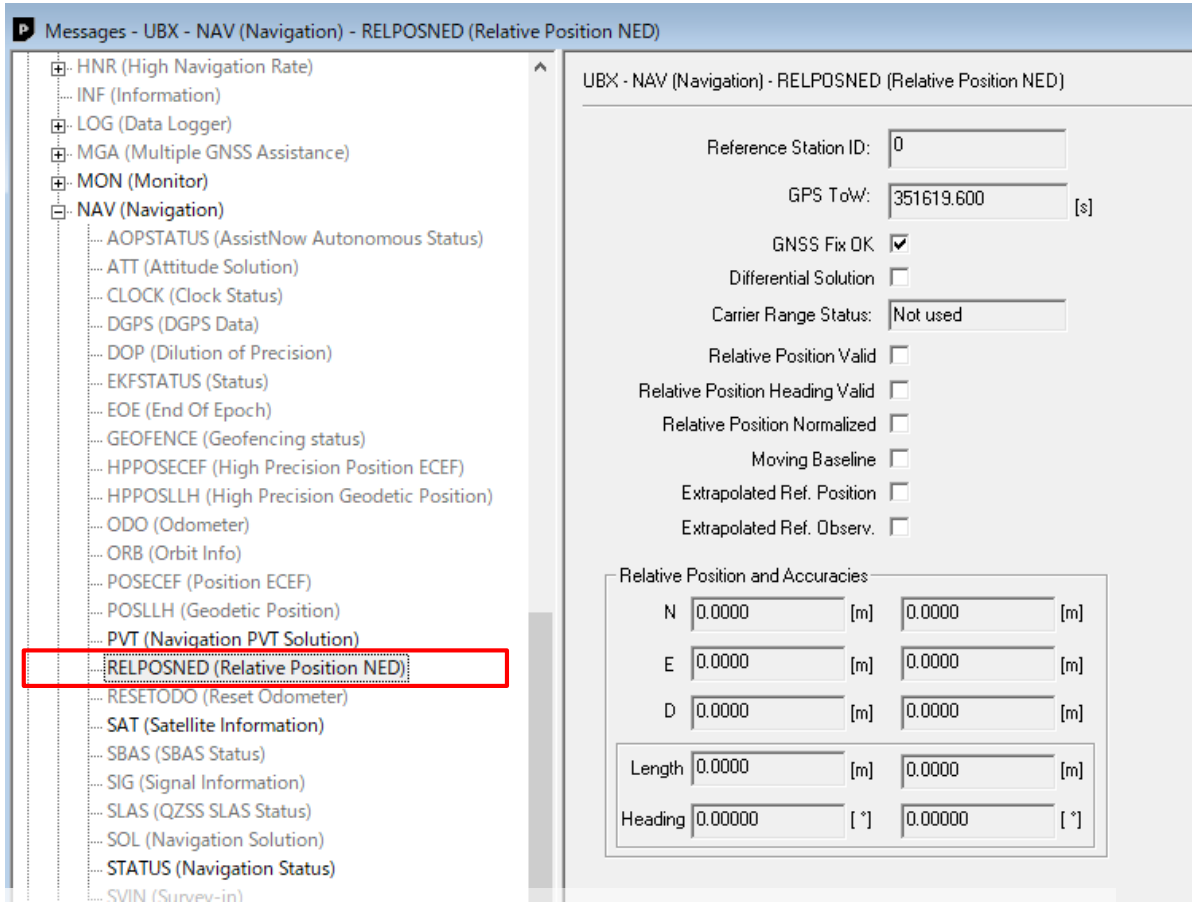
6. Moving-base RTK

◆Moving-base RTK (F9P)

Rover configuration.



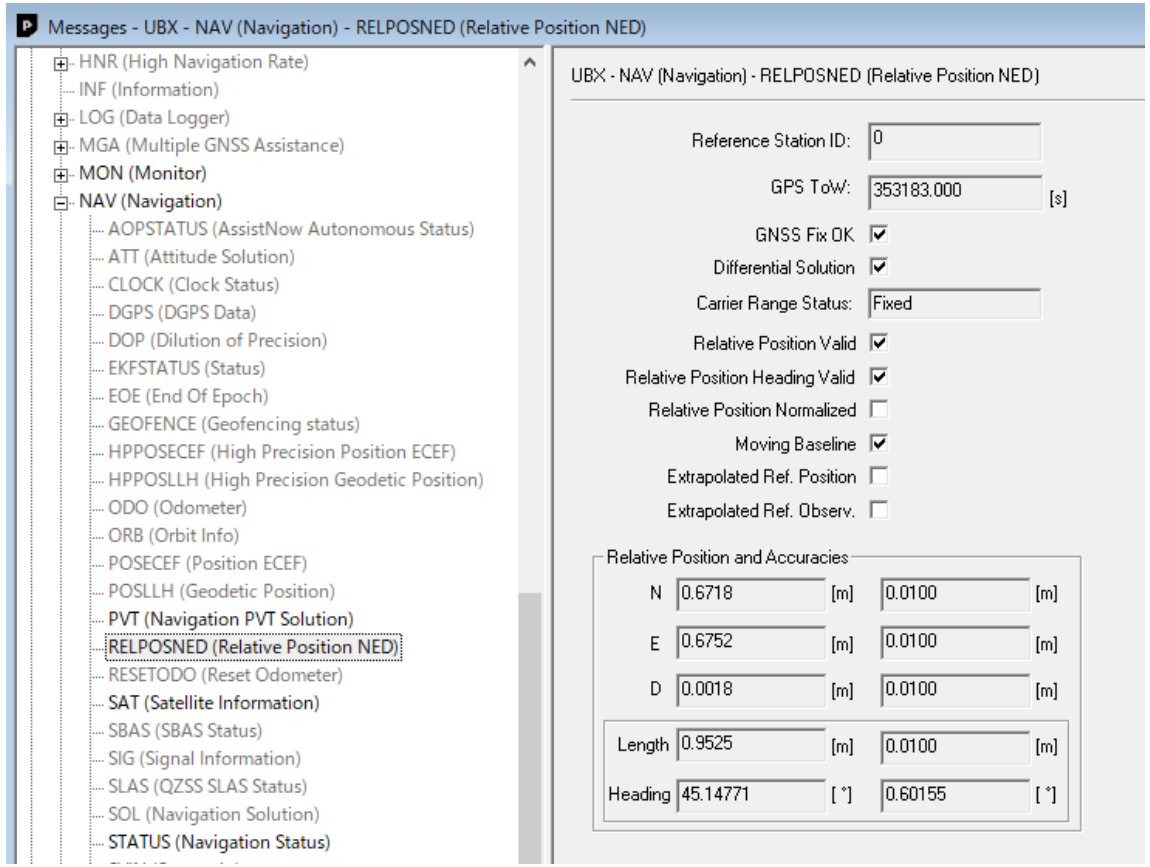
Set protocol in of used UART to RTCM. Baudrate should be over 115200. (UBX-CFG-PRT)

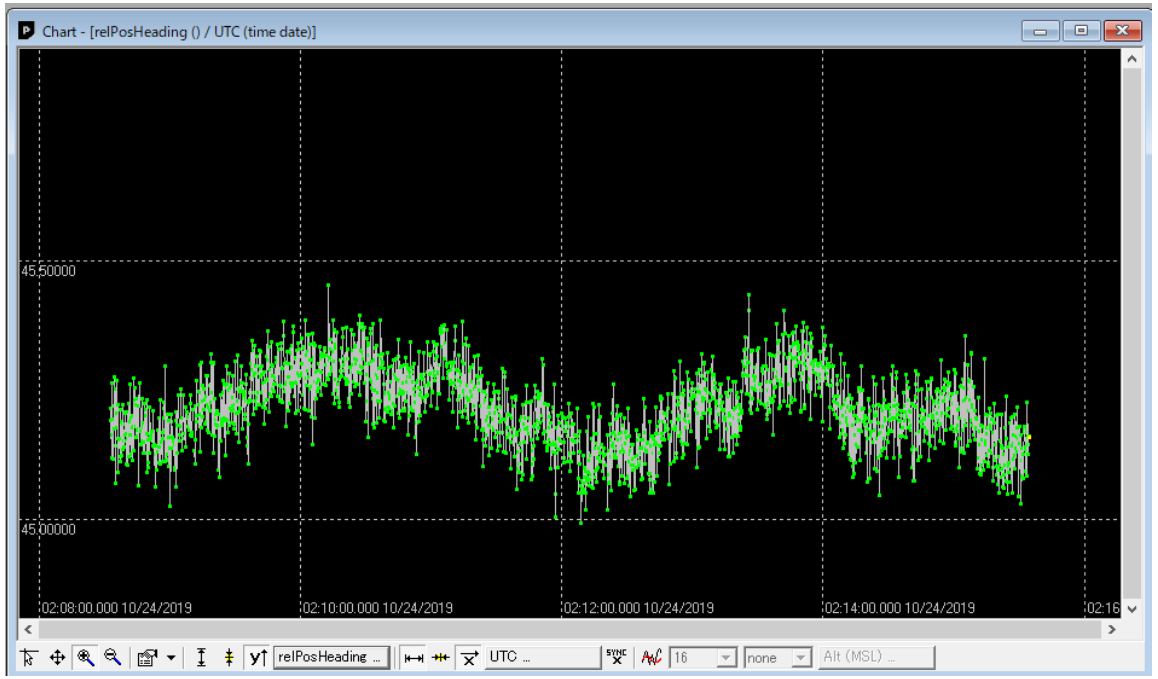


Enable RELPOSNED (UBX-NAV)

6. Moving-base RTK

◆Moving-base RTK (F9P)



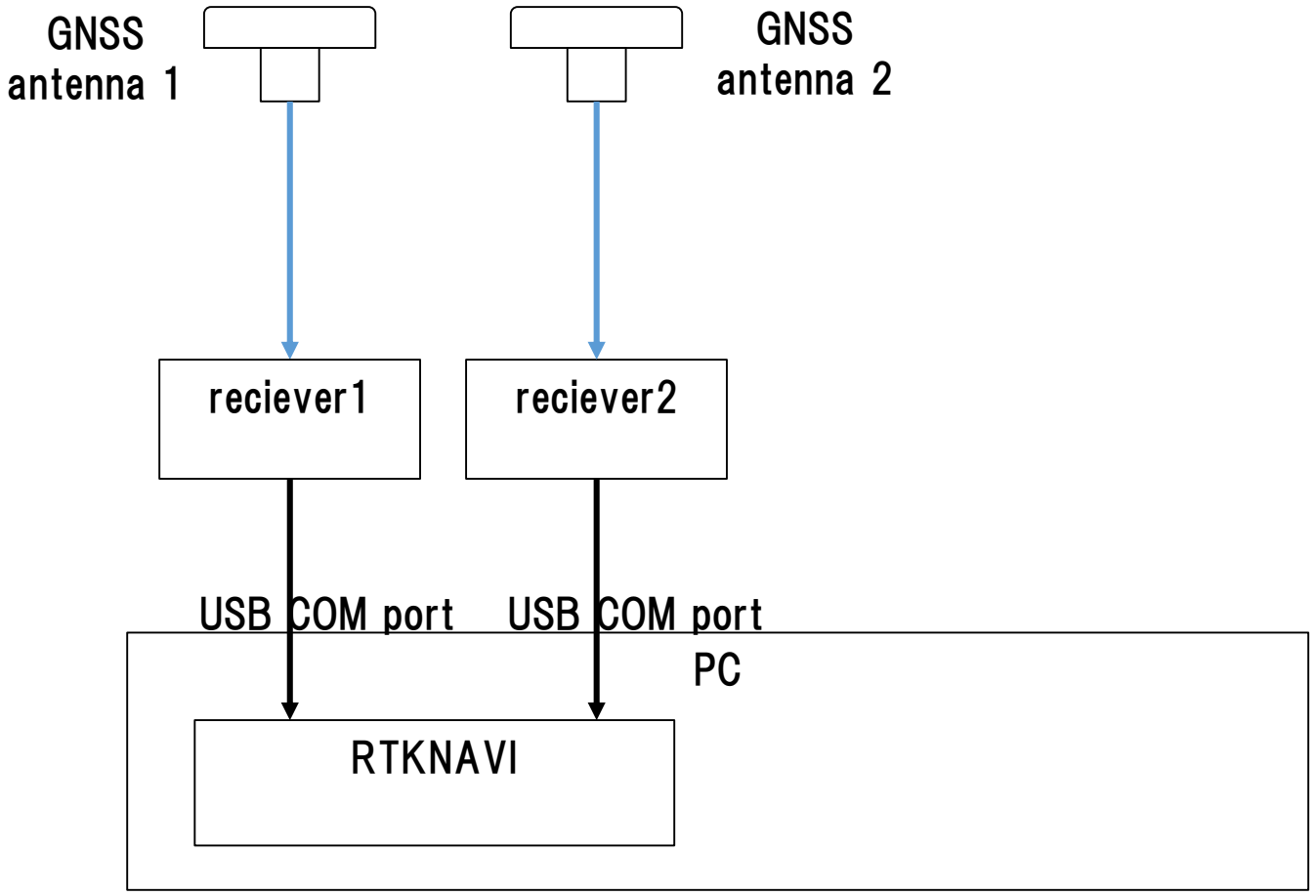


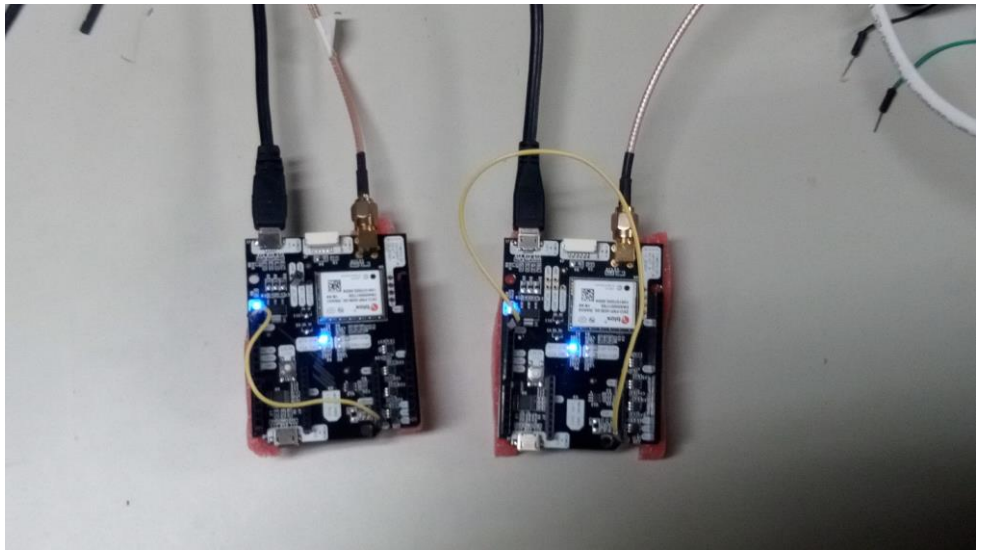
Solution is shown in UBX-NAV-RELPOSNED message
There is no ASCII output and UBX format decode is necessary for application use.

6. Moving-base RTK

◆Moving-base RTK (RTKNAVI)

Hardware Configuration

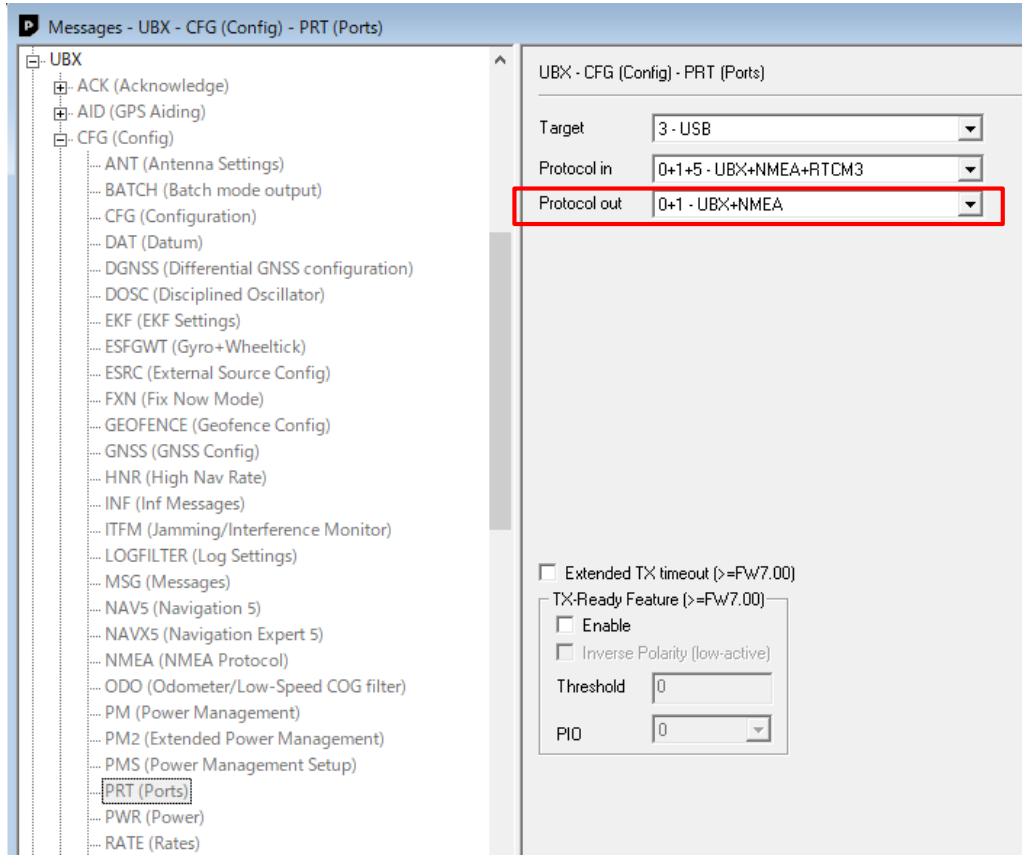




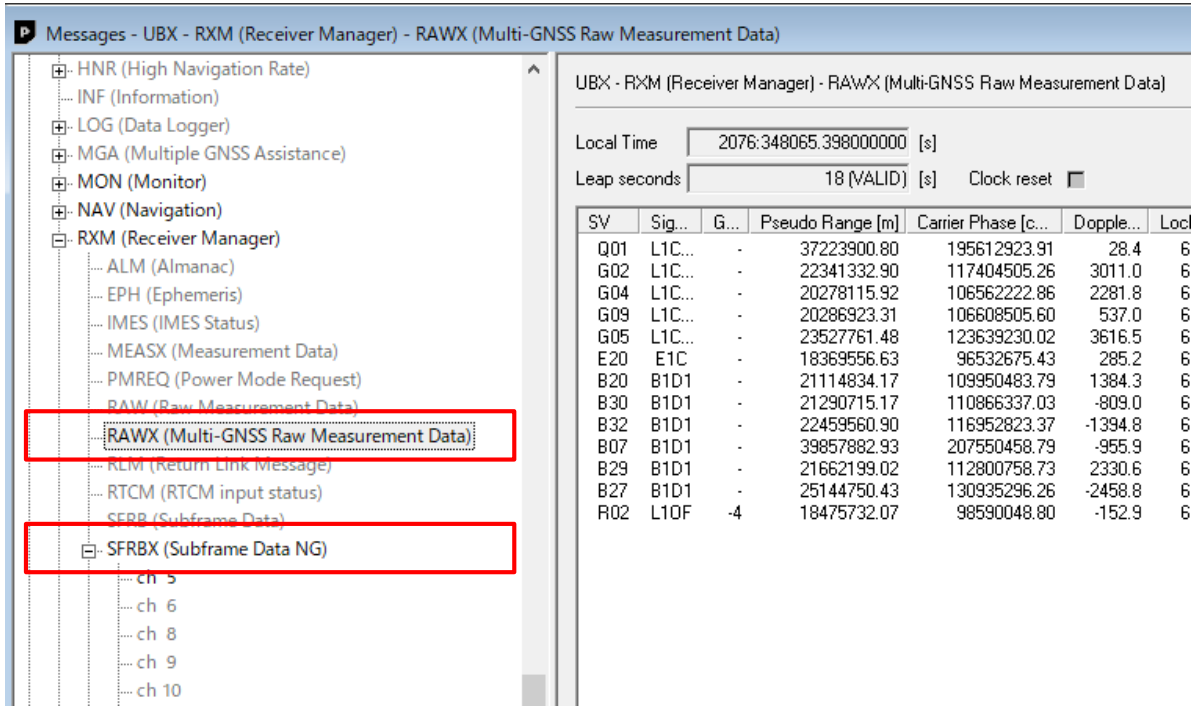
6. Moving-base RTK

◆Moving-base RTK (RTKNAVI)

Receiver configuration (both receiver).



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

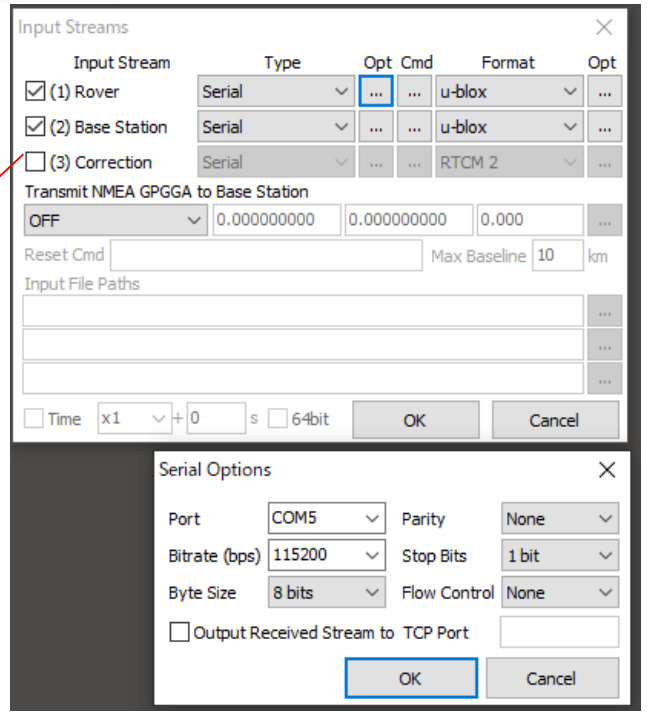


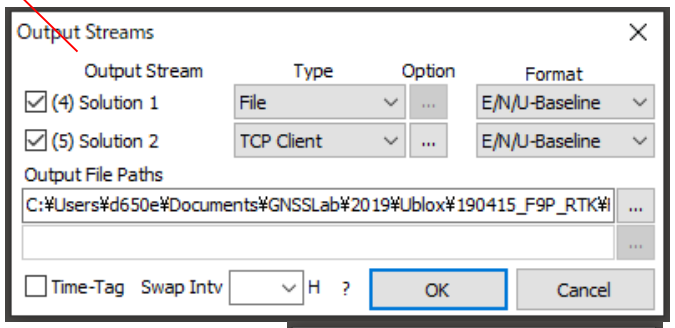
Enable output of RAWX & SFRBX (UBX-RXM)

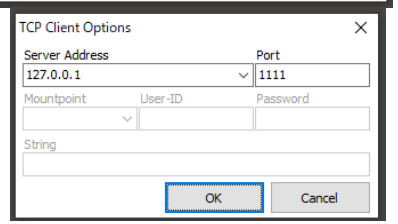
6. Moving-base RTK

◆Moving-base RTK (RTKNAVI)

RTKNAVI set up.







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

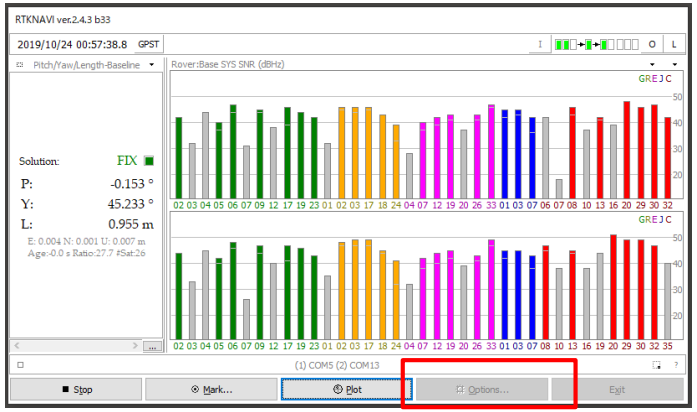
Select COM port number.

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

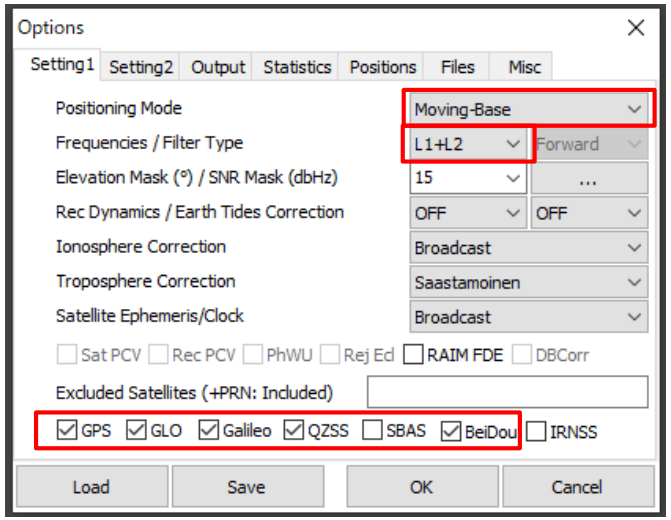
6. Moving-base RTK

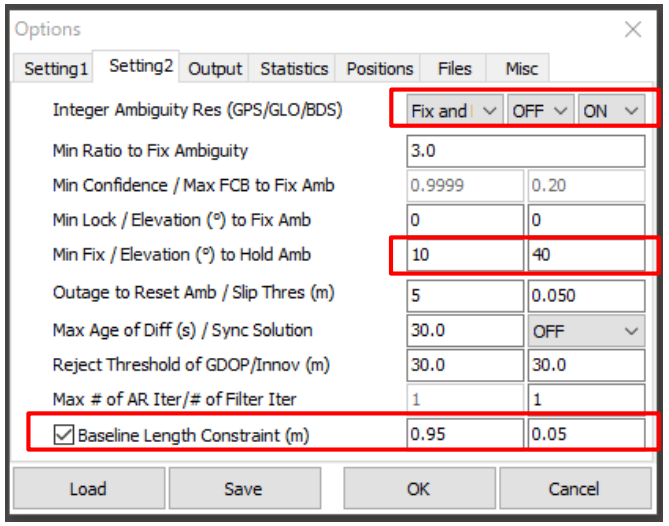
◆Moving-base RTK (RTKNAVI)

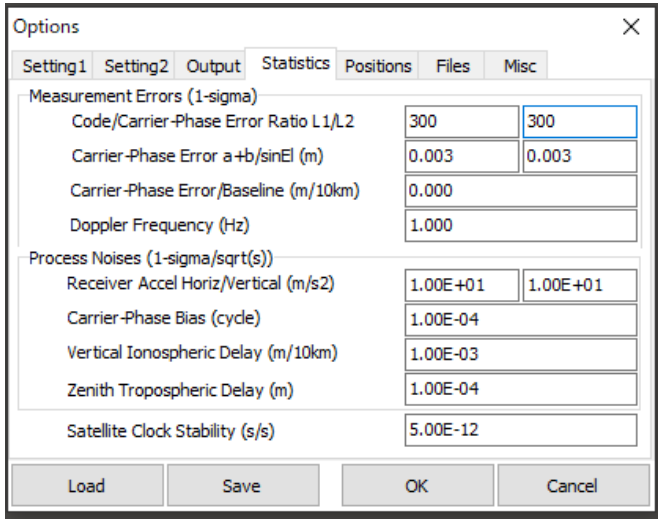
Option configuration



- "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.



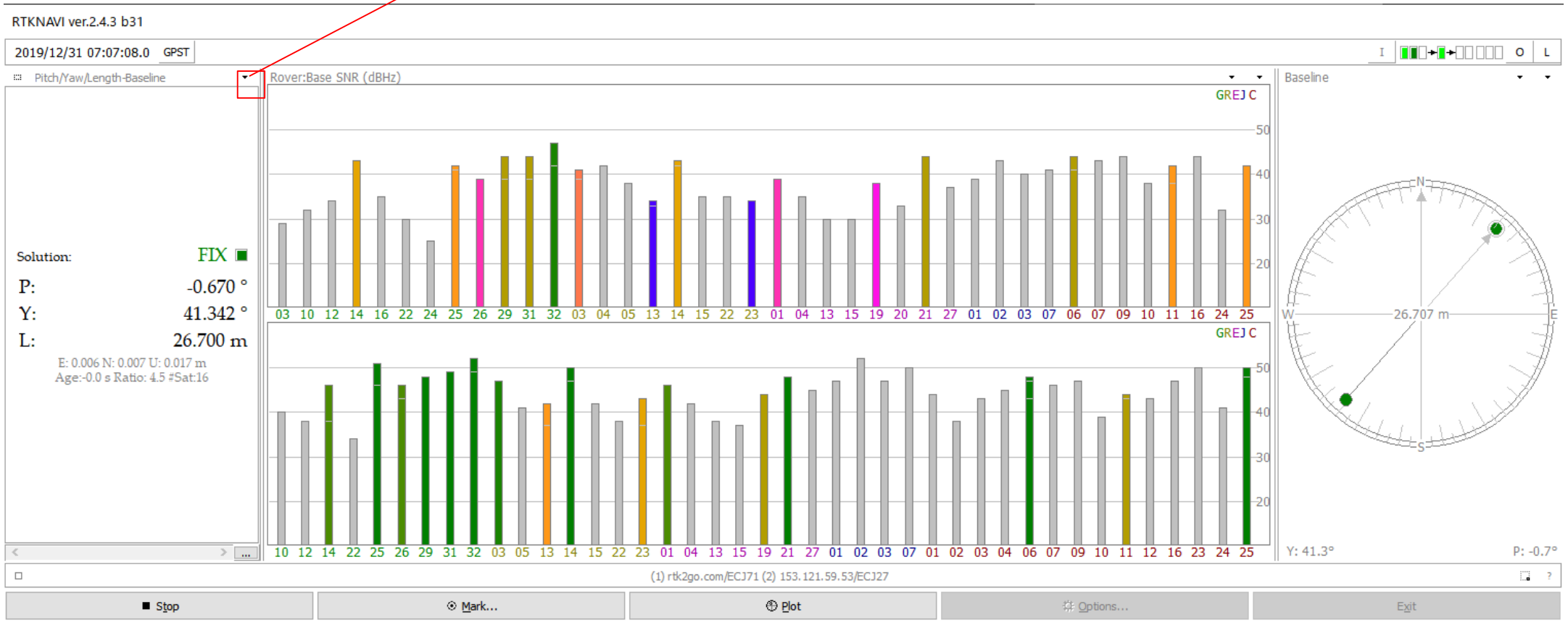




6. Moving-base RTK

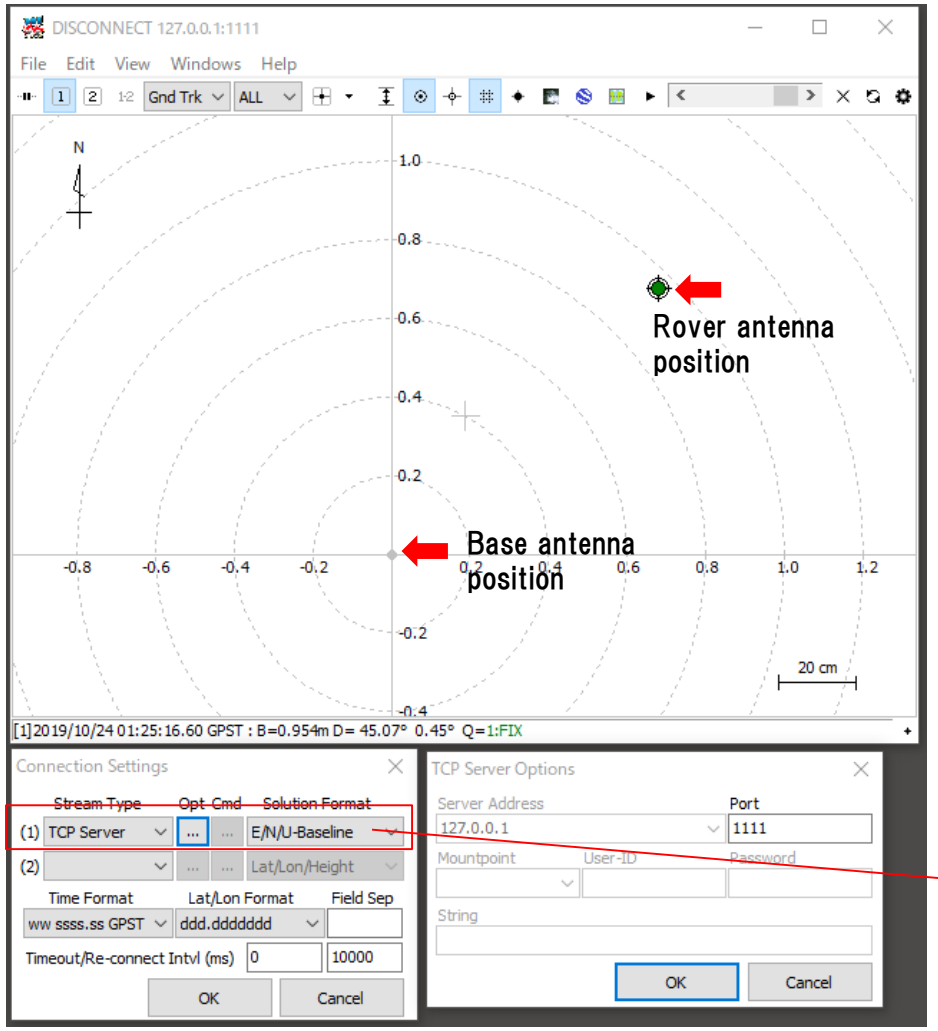
◆Moving-base RTK (RTKNAVI)

Change shown format type by this button.
ENU or PYL

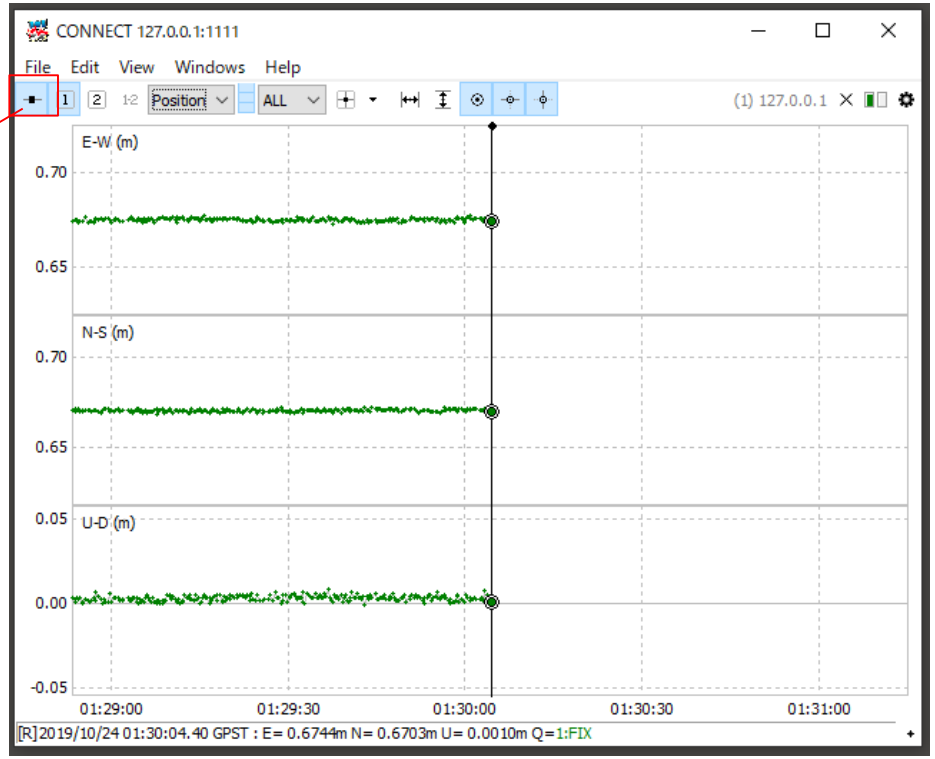


6. Moving-base RTK

◆RTKNAVI　PLOT configuration



Click “Connect button” after input setting.



Open another RTKPLOT.
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
- https://home.csis.u-tokyo.ac.jp/~dinesh/