Data Sheet / GR-903

Centimeter-level GNSS Receiver

As a RTK Base or a RTK Rover

With USB/Bluetooth SPP,

L1/L2 Dual-band,

GPS/GLONASS/BEIDOU/Galileo/QZSS/SBAS Multi-constellation

Concurrent Tracking

RoHS
Compliant

Version 1.0

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CAUTION：

RISK OF EXPLOSION IF BATTERY IS REPLACED BY AN INCORRECT TYPE. DISPOSE OF USED BATTERIES ACCORDING TO THE INSTRUCTIONS.

Revision History

Ver.	Date	Description
1.0	Nov. 30th, 2023	First release

Contents

1 Introduction

1.1 Overview

GR-903 is an ultra-high performance, easy-to-use, cm-level high-precision GNSS receiver designed with u-blox's ZED-F9P engine and high-end antenna which simultaneously supports dual-band (L1/L2), multi-constellation (GPS/GLONASS/BEIDOU/GALILEO/QZSS/SBAS), RTK (Real Time Kinematic) technology. All satellites in view can be used to provide an RTK navigation solution when processed with correction data. If power consumption is a key factor, the receiver can be configured to have only a subset of GNSS constellations.

The RTK technology introduces the concept of a "rover" and a "base" for cm-level accuracy in clear sky environments. The base sends corrections via the RTCM protocol to the rover via a communication link, say via Ethernet, Cellular, WiFi, Bluetooth etc., enabling the rover to output its position relative to the base at cm level accuracies. GR-903 could be used for applications requiring vehicles to navigate faster and more accurately, operate more efficiently, and automatically return to base platforms. Such applications include UAV, unmanned vehicles (e.g. robotic lawn mowers), and Precision Agriculture guidance.

GR-903 could be easily setup as either a base or a rover. When being a base, it outputs RTCM 3.3 correction data continuously. When being a rover, it receives RTCM 3.3 correction data to output the center meter level position conitunously.

The system integrator could access u-blox's u-center, the complete end-to-end RTK solution, including the stationary "survey-in" functionality that is designed to reduce the setup time and increase the flexibility of the application. The Moving Baseline (MB) support allows both Base and Rover to move while computing a centimeter-level accurate position between them. Moving Baseline is ideal for UAV applications where the UAV is programmed to follow its owner or to land on a moving platform. It is also well suited to attitude sensing applications where both Base and Rover are mounted on the same moving platform and the relative position is used to derive attitude information for the vehicle or tool.

In a moving base application, and especially when the antennas are mounted on the same platform, it is recommended to use identical antennas. Furthermore it is recommended that these antennas are mounted with identical orientation to minimize effects of phase center variation.

The receiver reports position using version 2.3 or 4.x of the NMEA0183 standard referenced to the WGS-84 datum.

When operating in RTK mode, RTCM version 3 messages are required and it supports DGNSS according to RTCM 10403.3.

1.2 Main Features

Our experienced design exhibits the full performance of ZED-F9P.

- Multi-band: L1/L2
- GNSS/ Multi-satellite positioning systems support
  1. GPS/GLONASS/BEIDOU/Galileo & QZSS/SBAS
  2. SBAS includes WAAS/EGNOS/MSAS/GAGAN
- Max RTK update rate
  1. Up to 8Hz for full constellations
  2. Up to 15Hz for moving baseline dual-satellite systems, e.g. GPS/GLONASS
  3. Up to 20 Hz for single-satellite system, e.g. GPS only
- DGNSS RTCM 10403.3 version 3 messages support for RTK fix
- Easy deployment
- High sensitivity
  1. Tracking sensitivity of -167 dBm
  2. Acquisition sensitivity of -148 dBm
- Built-in L1/L2 patch antenna for above mentioned positioning satellite systems
- Built-in backup battery for faster position fix.
- USB/UART TTL/RS232 interface support
- Bluetooth SPP support.
- Power supply options: 12V/24V
- Low power consumption of 118 mA for average tracking of full visible satellites (USB, # of SVs tracked: L1: 37, L2: 27)
- Windows location sensor support
- OMA SUPL 1.0 compliant A-GNSS services
- Linux/Android support
- IP67 Waterproof
- Green LED for position fix indication; orange LED for RTK fix indication

- Pole support via quad-M3x8 screw holes for acting as an RTK base
- Magnet option
    1. Disk only: without magnet
    2. Disk + pedestal with magnet.inside
- Fully EMI shielded
- Industrial operating temperature range: -40 ~ 85℃

1.3 Receiver Specifications

Features	Specifications!
Supported GNSS Constellations	u-blox ZED-F9P GPS/SBAS/QZSS: (MHz) L1 C/A (1575.42), L2C (1227.60) GLONASS: (MHz) L1OF (1602+k*0.5625, k= -7,…,5,6), L2OF (1246+k*0.4375, k= -7,…,5,6), Galileo: (MHz) E1-B/C (1575.42), E5b (1207.140) BeiDou: (MHz) B1I (1561.098) B2I (1207.140)
Position Accuracy (RTK baseline up to 20km; 24 hours static)	Horizontal: RTK: 1 cm+1ppm CEP SBAS: 1 m CEP PVT: 1.5 m CEP Vertical: (result with 1km baseline) RTK: 1 cm+1ppm R50
Velocity Accuracy	<0.05 m/s (speed) <0.3° (heading) (50% @ 30 m/s for dynamic operation)
Time Pulse Signal	0.25Hz...10MHz3 RMS: 30ns, 99%: 60ns
Time To First Fix (TTFF) Hot start Aided start Cold start	Autonomous (All at -130dBm) 2sec (GPS+Glonass+Galileo+BeiDou) 2sec (GPS+Glonass+Galileo+BeiDou) 25sec (GPS+Glonass+Galileo+BeiDou)
Sensitivity	GPS+Glonass+Galileo+BeiDou Acquisition: -148 dBm

	Reacquisition: -160 dBm Tracking & navigation: -167 dBm
   Max. Update Rate RTK Convergence Time	a. GPS+Glonass+Galileo+BeiDou b. GPS+BeiDou c. GPS RTK: 8Hz@a, 15Hz@b, 20Hz@c PVT: 10Hz@a, 25Hz@b, 25Hz@c RAW: 20Hz@a, 25Hz@b, 25Hz@c <10s@a&b, <30s@c Depends on atmospheric conditions, baseline length, multipath conditions, satellite visibility and geometry
Moving Base RTK Performance	a. GPS+Glonass+Galileo+BeiDou b. GPS+BeiDou c. GPS Max. update rate: 8Hz@a, 10Hz@b, 10Hz@c Heading accuracy: 0.4°@a,b,c
Max. Altitude	50,000 m
Max. Velocity	500 m/s
Protocol Support Default Settings	NMEA 0183 up to v 4.11, ASCII GGA, GLL, GSA, GSV, RMC, VTG UBX: u-blox proprietary, binary RTCM 3.3: binary UART1 & 2: 38400bps, N-8-1 UART1: NMEA, UBX, RTCM 3.3 enabled Only NMEA output UART2: RTCM 3.3 enabled, No output, NMEA disabled, UBX not supported
Augmentation System Support	QZSS: Support L1S SLAS Correction data broadcasted on L1 SBAS: WAAS, EGNOS, MSAS, GAGAN DGNSS: RTCM 10403.3 ● Rover mode messages: (RTCM) 1001~1012, 1033, 1074, 1075, 1077, 1084, 1085, 1087,1094, 1095, 1097, 1124, 1125, 1127, 1230, 4072.0 ● Base mode messages: (RTCM) 1005, 1074, 1077, 1084, 1087, 1094, 1097, 1124, 1127, 1230, 4072.0, 4072.1
Dynamics	< 4g

[i]Note: Based on data from chip vendor.

1.4 Protocols

The NMEA protocol is supported via serial UART (RX/TX), RS232 or USB (DM/DP) I/O port. The default supported protocol is NMEA.

1. Serial communication channel – UART/RS232
   i. No parity, 8-data bit, 1-stop bit (N-8-1)
   ii. 38400 bps.
2. NMEA 0183 up to version 4.11, ASCII output
   i. Default RMC, VTG, GGA, GSA, GSV, GLL
3. u-blox binary protocol (UBX)
4. RTK mode supported RTCM 3.3 messages according to RTCM 10403.3
   i. Messages decoded by the rover:

1001	GPS L1 observations
1002	GPS L1 observations
1003	GPS /L2 observations
1004	GPS /L2 observations
1005	Station coordinates
1006	Station coordinates
1007	Station Antenna information
1009	GLONASS L1 observations
1010	GLONASS L1 observations
1011	GLONASS L1/L2 observations
1012	GLONASS L1/L2 observations
1033	Receiver and antenna description
1074	MSM4 GPS observations
1075	MSM5 GPS observations
1077	MSM7 GPS observations
1084	MSM4 GLONASS observations
1085	MSM5 GLONASS observations
1087	MSM7 Galileo observations
1094	MSM4 Galileo observations
1095	MSM5 Galileo observations

1097 MSM7 GLONASS observations
1124 MSM4 BEIDOU observations
1125 MSM5 BEIDOU observations
1127 MSM7 BEIDOU observations
1230 GLONASS code-phase biases
4072.0 Reference station PVT (u-blox-proprietary RTCM message)

ii. Messages generated by the base-station:

1005 Station coordinates
1074 MSM4 GPS observations
1077 MSM7 GPS observations
1084 MSM4 GLONASS observations
1087 MSM7 GLONASS observations
1094 MSM4 Galileo observations
1097 MSM7 Galileo observations
1124 MSM4 BEIDOU observations
1127 MSM7 BEIDOU observations
1230 GLONASS code-phase biases
4072.0 Reference station PVT (u-blox-proprietary RTCM message)
4072.1 Additional reference station information (u-blox-proprietary RTCM message)

1.5 BT Data

Band	2.4 GHz ISM
Data Rate	350 kbps, Bluetooth LE 1 Mbps, Bluetooth BR/EDR
Output Power	8 dBm EIRP
Sensitivity	-88 dBm

1.6 Navigation Modes

There are 3 navigation modes. One can expect cm-level accuracy only for RTK fixed mode.

- Traditional standalone fixed mode

- Fixed position without RTCM correction messages. Accuracy is in meters.
- Green LED
  - Steady ON if position is not fixed (under fixing)
  - Blinks if position has fixed.

- RTK float mode
  - When it receives an input stream of RTCM 3 messages, it enters this mode. It then tries to resolve the carrier phase ambiguity based on the received RTCM messages and the observed satellites.
    - Orange LED blinks before RTK fixed
  - If the RTCM 3 messages become unavailable, it goes back to the traditional standalone fixed mode.
    - Orange LED OFF
- RTK fixed mode
  - It enters RTK fixed mode as soon as it has resolved the carrier phase ambiguity. In this mode, relative accuracy can be expected correct to cm-level.
    - Orange LED steady ON
  - It takes less time from RTK float mode to RTK fixed mode (convergence time) if both the base and rover receive signals from numerous and common satellites. Otherwise, the convergence time would be longer depending on the base and rover's signal reception status. That is to say, if a rover receives a satellite that is not received by a base, then this satellite could not be used for RTK fix.
  - It will try to provide RTK fixed mode if sufficient ambiguities can be estimated.
    - For single constellation, 6 or more satellites with continuous phase lock above the elevation mask (default 10°) is required.
    - For GPS + BEIDOU, at least 3 BEIDOU satellites is required to form the double difference measurement because there are two BEIDOU satellite variants. That is to say, minimum of 8 satellites is required, e.g. 5 GPS + 3 BEIDOU).

- For GPS + GLONASS, at least 2 GLNASS satellites is required to form the double difference measurement. That is to say, minimum of 7 satellites is required, e.g. 5 GPS + 2 GLONASS).

- It drops back to RTK float mode if it loses carrier phase lock and sufficient ambiguities cannot be estimated. It goes back to RTK fixed mode once the minimum number of signals has been recovered.

1.7 Raw Data

GR-903 can output all the GNSS broadcast data upon reception from tracked satellites. This includes all the supported GNSS signals plus the augmentation services QZSS and SBAS. The UBX-RXM-SFRBX message is used for this information. The receiver also makes available the tracked satellite signal information, i.e. raw code phase and Doppler measurements, in a form aligned to the Radio Resource LCS Protocol (RRLP) [3]. For the UBX-RXM-SFRBX message specification, see the u-blox ZED-F9P Interface description [1].

GR-903 provides raw carrier phase data for all supported signals, along with pseudo-range, Doppler and measurement quality information. The data contained in the UBX-RXM-RAWX message follows the conventions of a multi-GNSS RINEX 3 observation file. For the UBX-RXM-RAWX message specification, see the u-blox ZED-F9P Interface description [1]. Raw measurement data are available once the receiver has established data bit synchronization and time-of-week.

1.8 Relative and Absolute Accuracy

In RTK mode, the position of the rover is relative to the location of the base position. The cm-level accuracy is also relative to the base.

If the accuracy of the base station is absolute correct, then the rover would be cm-level absolute correct, too.

1.9 Leap Second

Because of the synchronization between atomic clocks and earth rotation, there is leap second adjustments every a few years. Such kind of adjustment would be calibrated before chip release. There might be multiple leap second adjustments after chip release. The chip will adjust such kind of leap seconds automatically after it acquires the accurate clock and leap second information.

To know if a leap second has been calibrated, one can send following binary command to query (UBX-NAV-TIMEGPS).

B5 62 01 20 00 00 21 64

The chip will return binary message similar to following two.

B5 62 01 20 10 00 80 09 47 07 87 6A 06 00 22 07 0F 03 0C 00 00 00 46 50
B5 62 01 20 10 00 60 DB 56 07 AC 5F FF FF 22 07 10 07 09 00 00 00 18 45

Check the value of byte 18 which is marked in red, if the value is 07, the GPS time is correct. Otherwise (e.g. 3, 1, 0), the GPS time is still not correct.

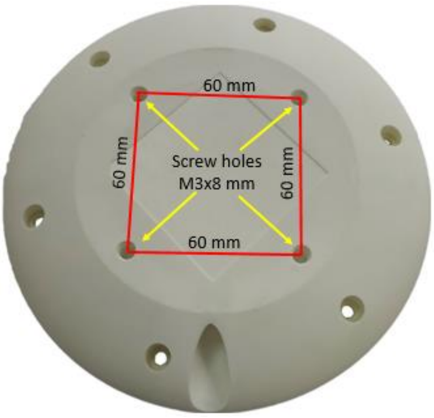
2 Hardware Interface

2.1 Dimension

- Φ116*24.6 (mm) for disk only (without pedestal)
  - Diameter: 116 mm
  - Thickness: 24.6 mm
- Φ116*56.8 (mm) for disk with pedestal
  - Diameter: 116 mm
  - Thickness: 56.8 mm

2.2 Fixing Screw Holes

At the bottom of the disk, there are four screw holes of M3x8 (mm). These four screw holes are located at corners of a rectangle with edge length of 60 mm as shown below.



One can attach a tripod, a selfie stick, or anything else via these 4 screw holes with screws of size M3x8.

For example, one option of pedestal with four magnets at the feet is available.

The pedestal was attached to the disk via the 4 screw holes as shown above.

For base setup, it’s convenient to further attach the pedestal to a tripod for stable

positioning as shown above.

Another example shown below is to attach a selfie stick to the disk via a metal plate.

2.3 I/O Connector and Pin Assignment

	GR-903U
	
Pin	USB A type Male Plug
1	VDD 5V
2	D-
3	D+
4	GND

Pin	Name	Function	I/O
1	VDD	USB 5 VDC power supply	Input
2	D-	USB D-	IO
3	D+	USB D+	IO
4	GND	USB ground	Input

2.4 Cable Length, Dimension and LEDs

The default cable length is 1.5m.

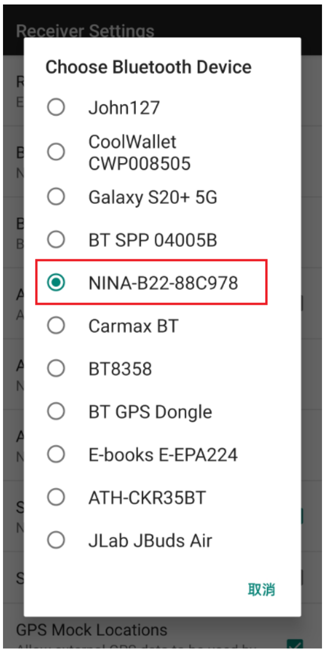
- A green LED is used to indicate the GPS position fixing status as following:
  - Green LED always ON: Position is not fixed, under fixing
  - Green LED Blinking: Position is fixed
- An orange LED is used to indicate RTK fix status
  - Orange LED OFF: no reception of RTCM correction data from base station
  - Orange LED blinking: RTCM correction data received, not yet RTK fixed
  - Orange LED ON: RTK fixed

Note.
Customization options: **cable length** (0.1~15m), **connector type** (DB9/25, RJ11/45, MicroFit, SM-4Y etc), **higher voltage input** (12/24V etc.).

2.5 Bluetooth

When scanning the Bluetooth device of GR-903,

- Its device name appears as NINA-B22-XXXXXX. Where XXXXXX is device-specific. That is to say, it is a unique name for each GR-903 so that one would not connect to a wrong device. E.g.



- There is no password associated with it.

3 Software Interface

GR-903 supports both NMEA text messages and UBX binary messages. In this section, the NMEA output messages are discussed. For UBX binary messages, please refer to [1] ZED-F9P Interface description.

3.1 NMEA Output Messages

Multi-talker IDs are used in GNSS multi-satellite positioning systems.

- Talker ID is 'GP' for GPS,SBAS-specific sentences since NMEA 2.3
- Talker ID is 'GL' for GLONASS-specific sentences since NMEA 2.3
- Talker ID is 'GA' for Galileo-specific sentences since NMEA 4.10
- Talker ID is 'GB' for BEIDOU-specific sentences since NMEA 4.10
- Talker ID is 'GQ' for QZSS-specific sentences since NMEA 4.11 ('GP' for NMEA 2.3~4.10)
- Talker ID is 'GN' is used for generic GNSS sentences

System\Sentence	GGA	GLL	GSA	GSV	RMC	VTG
GPS	GPGGA	GPGLL	GPGSA	GPGSV	GPRMC	GPVTG
GLONASS	GLGGA	GLGLL	GLGSA	GLGSV	GLRMC	GLVTG
BEIDOU	GBGGA	GBGLL	GBGSA	GBGSV	GBRMC	GBVTG
Galileo	GAGGA	GAGLL	GAGSA	GAGSV	GARMC	GAVTG
Multi-	GNGGA	GNGLL	GNGSA	Mix of above	GNRMC	GNVTG

The NMEA-0183 Output Messages are shown as below:

NMEA Record	Descriptions
GxGGA	Global positioning system fixed data: time, position, fixed type
GxGLL	Geographic position: latitude, longitude, UTC time of position fix and status
GxGSA	GPS receiver operating mode, active satellites, and DOP values
GxGSV	GNSS satellites in view: ID number, elevation, azimuth, and SNR values
GxRMC	Recommended minimum specific GNSS data: time, date, position, course, speed
GxVTG	Course over ground and ground speed

GxGNS	GNSS fix data
GxGRS	GNSS range residuals
GxGST	GNSS pseudo range error statistics
GxTXT	u-blox message

The GR-903 adopts interface protocol of National Marine Electronics Association's NMEA-0183 Version up to 4.11. GR-903 supports multiple types of NMEA sentences (GxGGA, GxGLL, GxGSA, GxGSV, GxRMC, GxVTG, GxGNS, GxGRS, GxGST, GxZDA, and GxTXT).

The default output sentences are RMC, VTG, GGA, GSA, GSV, GLL.

GPS+GLONASS+Galileo+BEIDOU message examples:

$GNRMC,025015.00,A,2446.41433,N,12100.43602,E,0.002,,091121,,,D,V*1E
$GNVTG,,T,,M,0.002,N,0.003,K,D*39
$GNGNS,025015.00,2446.41433,N,12100.43602,E,DDDD,28,0.51,122.6,16.3,,0000,V*18
$GNGGA,025015.00,2446.41433,N,12100.43602,E,2,12,0.51,122.6,M,16.3,M,,0000*42
$GNGSA,A,3,05,13,15,24,29,18,20,23,,,,,0.98,0.51,0.84,1*0C
$GNGSA,A,3,88,81,66,82,76,65,67,,,,,,0.98,0.51,0.84,2*0B
$GNGSA,A,3,03,24,15,36,05,,,,,,,,0.98,0.51,0.84,3*0B
$GNGSA,A,3,13,22,06,08,36,16,09,35,,,,,0.98,0.51,0.84,4*0C
$GPGSV,3,1,12,02,08,153,36,05,39,081,43,13,32,036,40,15,55,009,44,1*63
$GPGSV,3,2,12,18,53,309,42,20,17,106,36,23,26,316,38,24,62,173,45,1*6F
$GPGSV,3,3,12,29,19,219,37,39,22,255,33,41,39,242,41,50,60,166,41,1*6B
$GPGSV,2,1,06,05,39,081,41,15,55,009,43,18,53,309,45,23,26,316,39,6*60
$GPGSV,2,2,06,24,62,173,46,29,19,219,37,6*6D
$GPGSV,1,1,03,11,01,147,,12,01,168,,40,13,259,,0*50
$GLGSV,3,1,09,65,22,047,37,66,39,337,39,67,14,286,38,75,25,058,41,1*7E
$GLGSV,3,2,09,76,33,121,42,81,48,284,44,82,14,328,33,87,06,176,21,1*72
$GLGSV,3,3,09,88,39,204,43,1*4A
$GLGSV,3,1,09,65,22,047,38,66,39,337,45,67,14,286,42,75,25,058,45,3*71
$GLGSV,3,2,09,76,33,121,46,77,10,168,34,81,48,284,48,82,14,328,41,3*7E
$GLGSV,3,3,09,88,39,204,45,3*4E
$GAGSV,2,1,07,03,53,305,49,05,42,031,48,08,14,261,40,15,43,308,46,2*77
$GAGSV,2,2,07,24,14,082,40,25,18,136,42,36,22,162,41,2*45
$GAGSV,2,1,07,03,53,305,43,05,42,031,41,08,14,261,34,15,43,308,41,7*75

$GAGSV,2,2,07,24,14,082,36,25,18,136,34,36,22,162,39,7*4F

$GAGSV,1,1,02,02,02,180,,09,02,060,,0*72

$GBGSV,2,1,08,06,63,249,38,08,79,010,39,09,51,237,36,13,70,337,40,1*7F

$GBGSV,2,2,08,16,70,262,40,22,47,334,40,35,34,212,38,36,44,123,40,1*75

$GBGSV,2,1,06,06,63,249,46,08,79,010,48,09,51,237,46,12,,,43,3*49

$GBGSV,2,2,06,13,70,337,46,16,70,262,46,3*76

$GBGSV,2,1,07,01,51,134,,03,60,204,,04,38,118,,10,02,202,,0*77

$GBGSV,2,2,07,10,02,202,,19,38,051,,20,02,083,,0*4F

$GNGLL,2446.41433,N,12100.43602,E,025015.00,A,D*75

$GNGRS,025015.00,1,-0.3,0.0,0.0,1.2,-1.2,0.5,-0.4,0.5,,,,,1,1*79

$GNGRS,025015.00,1,,,,,,,0.0,,,,,,1,5*79

$GNGRS,025015.00,1,-0.4,,-0.9,-0.5,-1.5,-0.6,,-0.1,,,,,1,6*5F

$GNGRS,025015.00,1,-0.7,-4.0,4.1,4.4,1.3,-1.7,-5.3,,,,,,2,1*7A

$GNGRS,025015.00,1,-0.1,-1.8,2.6,2.3,-0.3,-4.1,-1.2,,,,,,2,3*59

$GNGRS,025015.00,1,-0.1,0.3,-0.2,0.4,-0.2,,,,,,,,3,2*57

$GNGRS,025015.00,1,0.8,0.3,0.5,0.7,0.8,,,,,,,,3,7*78

$GNGRS,025015.00,1,0.7,-0.4,-1.2,-1.5,0.8,-0.1,0.1,0.6,,,,,4,1*5C

$GNGRS,025015.00,1,-0.1,,-0.4,-0.3,0.0,-1.8,-1.7,,,,,,4,3*70

$GNGST,025015.00,15,0.91,0.77,43,0.34,0.34,0.91*79

$GNZDA,025015.00,09,11,2021,00,00*73

3.2 GxGGA - Global Positioning System Fix Data

- Example

  $GPGGA,065500.00,2447.65027,N,12100.78318,E,2,12,0.91,69.8,M,16.3,M,,*65

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGGA		GGA protocol header
UTC Time	065500.00		hhmmss.ss hh: hour, mm: minute, ss: second
Latitude	2447.65027		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.78318		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
Position Fix Indicator	2		0: Fix not available or invalid, 1: GPS SPS Mode, fix valid, 2: Differential GPS, SPS Mode, fix valid, 3: Not supported, 4: RTK fixed

			5: RTK float 6: Estimated/Dead Reckoning fix
Satellites Used	12		Number of satellites used in positioning calculation (0 to 12)
HDOP	0.91		Horizontal Dilution of Precision
MSL Altitude	69.8	meters	
Unit	M		Meters
Geoidal separation	16.3	meters	Geoid separation: difference between ellipsoid and mean sea level
Units	M		Meters
Age of Diff. Corr.		second	Age of differential corrections. Null when DGPS is not used
Diff. Ref. Station ID			ID of station providing differential corrections (null when DGPS is not used)
checksum	*65		
<CR><LF>			End of sentence

3.3 GxGLL - Geographic Position - Latitude / Longitude

■ Example

$GPGLL,2447.65027,N,12100.78318,E,065500.00,A,D*6E

■ Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGLL		GLL protocol header
Latitude	2447.65027		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.78318		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
UTC Time	065500.00		hhmmss.ss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid
Mode Indicator	D		A: Autonomous GNSS fix N: No position fix D: Differential GNSS fix E: Estimated/Dead reckoning fix F: RTK float R: RTK fixed
checksum	*6E		
<CR><LF>			End of sentence

3.4 GxGSA - GNSS DOP and Active Satellites

■ Example

$GNGSA,A,3,05,13,15,24,29,18,20,23,,,,,0.98,0.51,0.84,1*0C

$GNGSA,A,3,88,81,66,82,76,65,67,,,,,,0.98,0.51,0.84,2*0B

$GNGSA,A,3,03,24,15,36,05,,,,,,,,0.98,0.51,0.84,3*0B

$GNGSA,A,3,13,22,06,08,36,16,09,35,,,,,0.98,0.51,0.84,4*0C

■ Explanation

Contents	Example	Explanation
Message ID	$GNGSA	GSA protocol header
Operation Mode	A	M: Manual—forced to operate in 2D or 3D mode A: 2D Automatic—allowed to automatically switch 2D/3D
Navigation Mode	3	1: Fix not available 2: 2D (<= 4 Satellites used) 3: 3D (>= 4 Satellites used)
Satellite used in solution	05	Satellite on Channel 1
Satellite used in solution	13	Satellite on Channel 2
…		Display of quantity used (12 max) If less than 12 SVs are used for navigation, the remaining fields are left empty. If more than 12 SVs are used for navigation, only the IDs of the first 12 are output.
PDOP	0.98	Position Dilution of Precision
HDOP	0.51	Horizontal Dilution of Precision
VDOP	0.84	Vertical Dilution of Precision
System ID	1	1: GPS/SBAS, 2: GLONASS 3: Galileo, 4: BeiDou 5: QZSS
checksum	*0C	
<CR><LF>		End of sentence

3.5 GxGSV - GNSS Satellites in View

■ Example

$GPGSV,3,1,12,02,08,153,36,05,39,081,43,13,32,036,40,15,55,009,44,1*63

$GPGSV,3,2,12,18,53,309,42,20,17,106,36,23,26,316,38,24,62,173,45,1*6F

$GPGSV,3,3,12,29,19,219,37,39,22,255,33,41,39,242,41,50,60,166,41,1*6B

$GPGSV,2,1,06,05,39,081,41,15,55,009,43,18,53,309,45,23,26,316,39,6*60

$GPGSV,2,2,06,24,62,173,46,29,19,219,37,6*6D

$GPGSV,1,1,03,11,01,147,,12,01,168,,40,13,259,,0*50

■ Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGSV		GSV protocol header
Number of messages	3		Range 1 to 9
Message number	1		Range 1 to 9
Satellites in view	12		Number of satellites visible from receiver regarding both the talker ID and the signal Id.
Satellite ID number	02		Channel 2 (Range 1 to 64) The satellite ID numbers are in the range of 1 to 32 for GPS satellites, and 33 to 64 for SBAS satellites (ID=120-PRN; e.g. SV ID 33 is SBAS PRN 120, 34 is SBAS PRN 121, and so on). ID numbers 65~96 for GLONASS. ID numbers 193~197 for QZSS. ID numbers 401~437 for BEIDOU.
Elevation	08	degrees	Elevation angle of satellite as seen from receiver channel 1 (00 to 90)

Azimuth	153	degrees	Satellite azimuth as seen from receiver channel 1 (000 to 359)
SNR (C/No)	36	dBHz	Received signal level C/No from receiver channel 1 (00 to 99, null when not tracking)
…			
Satellite ID number	15		Channel 4 (Range 1 to 32) The satellite ID numbers are in the range of 1 to 32 for GPS satellites, and 33 to 64 for SBAS satellites (ID=120-PRN; e.g. SV ID 33 is SBAS PRN 120, 34 is SBAS PRN 121, and so on). ID numbers 65~96 for GLONASS. ID numbers 193~197 for QZSS. ID numbers 401~437 for BEIDOU.
Elevation	55	degrees	Elevation angle of satellite as seen from receiver channel 4 (00 to 90)
Azimuth	009	degrees	Satellite azimuth as seen from receiver channel 4 (000 to 359)
SNR (C/No)	44	dBHz	Received signal level C/No from receiver channel 4 (00 to 99, null when not tracking)
Signal Id[!]	1		1: GPS L1, SBAS L1, BeiDou B1I, QZSS L1 C/A, GLONASS L1 2: Galileo E5 bI, E5bQ 3: GLONASS L2 4: QZSS L1S 5: GPS L2 CM, QZSS L2CM 6: GPS L2 CL, QZSS L2CL 7: Galileo E1 C, E1 B 11: BeiDou B2I
checksum	*63		
<CR><LF>			End of sentence

Note. [!] Signal Id of 0 is not defined. However, it is used as the exact Signal Id is still unknown.

3.6 GxRMC - Recommended Minimum Specific GNSS Data

- Example

  $GNRMC,025015.00,A,2446.41433,N,12100.43602,E,0.002,,091121,,,D,V*1E

- Explanation

Contents	Example	Unit	Explanation
Message ID	$GNRMC		RMC protocol header
UTC Time	025015.00		hhmmss.ss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid
Latitude	2446.41433		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.43602		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
Speed over ground	0.002	knots	Receiver's speed
Course over ground		degrees	Receiver's direction of travel Moving clockwise starting at due north
Date	091121		ddmmyy dd: Day, mm: Month, yy: Year
Magnetic variation		degrees	This receiver does not support magnetic

value			declination. All "course over ground" data are geodetic WGS84 directions.
Magnetic variation E/W indication			
Mode Indicator	D		A: Autonomous GNSS fix N: No position fix D: Differential GNSS fix E: Estimated/Dead reckoning fix F: RTK float R: RTK fixed
Navigation Status	V		V (Equipment is not providing navigational status information, fixed field, only available in NMEA 4.10 and later)
checksum	*1E		
<CR><LF>			End of sentence

3.7 GxVTG - Course over Ground and Ground Speed

- Example

$GPVTG,189.32,T,,M,15.869,N,29.405,K,D*30

Explanation

Contents	Example	Unit	Explanation
Message ID	$GPVTG		VTG protocol header
Course over ground	189.32	degrees	Receiver's direction of travel Moving clockwise starting at due north (geodetic WGS84 directions)
Reference	T		True
Course over ground		degrees	Receiver's direction of travel
Reference	M		Magnetic
Speed over ground	15.869	knots	Measured horizontal speed
Unit	N		Knots
Speed over ground	29.405	km/hr	Measured horizontal speed
Unit	K		km/hr
Mode Indicator	D		A: Autonomous GNSS fix N: No position fix D: Differential GNSS fix E: Estimated/Dead reckoning fix F: RTK float R: RTK fixed
checksum	*30		
<CR><LF>			End of sentence

3.8 GxGNS – GNSS Fix Data

- Example

$GNGNS,025015.00,2446.41433,N,12100.43602,E,DDDD,28,0.51,122.6,16.3,,0000,V*18

Explanation

Contents	Example	Unit	Explanation
Message ID	$GNGNS		GNS protocol header
Time	025015.00		hhmmss.ss hh: hour, mm: minute, ss: second

Latitude	2446.41433		ddmm.mmmmm dd: degree, mm.mmmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.43602		dddmm.mmmmm dd: degree, mm.mmmmm: minute
East/West	E		E: East Longitude, W: West Longitude
Position Mode	DDDD		A: Autonomous GNSS fix N: No position fix D: Differential GNSS fix E: Estimated/Dead reckoning fix F: RTK float R: RTK fixed First character for GPS, second one for GLONASS, Third one for Galileo, Fourth one for BeiDou
Satellites Used	28		Number of satellites used in positioning calculation (0 to 99)
HDOP	0.51		Horizontal Dilution of Precision
Altitude	122.6	meters	Altitude above mean sea level
Separation	16.3	meters	Geoid separation: difference between ellipsoid and mean sea level
Differential Age	-		Age of differential corrections (null when DGPS is not used)
Differential Station	0000		ID of station providing differential corrections (null when DGPS is not used)
Navigation Status	V		V (Equipment is not providing navigational status information, fixed field, only available in NMEA 4.10 and later)
Checksum	*18		Checksum
<CR><LF>			End of sentence

3.9 GxGRS – GNSS Range Residuals

This messages relates to associated GGA and GSA messages. If less than 12 SVs are available, the remaining fields are output empty. If more than 12 SVs are used, only the residuals of the first 12 SVs are output, in order to remain consistent with the NMEA standard. **In a multi-GNSS system this message will be output multiple times, once for each GNSS.**

- Example

$GNGRS,025015.00,1,-0.3,0.0,0.0,1.2,-1.2,0.5,-0.4,0.5,,,,,1,1*79

$GNGRS,025015.00,1,,,,,,,0.0,,,,,,1,5*79

$GNGRS,025015.00,1,-0.4,,-0.9,-0.5,-1.5,-0.6,,-0.1,,,,,1,6*5F

$GNGRS,025015.00,1,-0.7,-4.0,4.1,4.4,1.3,-1.7,-5.3,,,,,,2,1*7A

$GNGRS,025015.00,1,-0.1,-1.8,2.6,2.3,-0.3,-4.1,-1.2,,,,,,2,3*59

$GNGRS,025015.00,1,-0.1,0.3,-0.2,0.4,-0.2,,,,,,,,3,2*57

$GNGRS,025015.00,1,0.8,0.3,0.5,0.7,0.8,,,,,,,,3,7*78

$GNGRS,025015.00,1,0.7,-0.4,-1.2,-1.5,0.8,-0.1,0.1,0.6,,,,,4,1*5C

$GNGRS,025015.00,1,-0.1,,-0.4,-0.3,0.0,-1.8,-1.7,,,,,,4,3*70

Explanation

Contents	Example	Unit	Explanation
Message ID	$GNGRS		GRS protocol header
Time	025015.00		hhmmss.ss hh: hour, mm: minute, ss: second
Mode	1		Computation method used: 1: Residuals were recomputed after the GGA position was computed (fixed)
Residual 1	-0.3	meters	Range residuals for SVs used in navigation. The SV order matches the order from the GSA sentence
Residual 2	0.0	meters	Same as above
Residual 3	0.0	meters	Same as above
Residual 4	1.2	meters	Same as above
Residual 5	-1.2	meters	Same as above
Residual 6	0.5	meters	Same as above
Residual 7	-0.4	meters	Same as above
Residual 8	0.5	meters	Same as above
Residual 9	-	meters	Same as above
Residual 10	-	meters	Same as above
Residual 11	-	meters	Same as above
Residual 12	-	meters	Same as above
System Id	1		1: GPS/SBAS, 2: GLONASS 3: Galileo, 4: BeiDou 5: QZSS
Signal Id	1		1: GPS L1, SBAS L1, BeiDou B1I, QZSS L1 C/A, GLONASS L1 2: Galileo E5 bI, E5bQ 3: GLONASS L2 4: QZSS L1S 5: GPS L2 CM, QZSS L2CM 6: GPS L2 CL, QZSS L2CL 7: Galileo E1 C, E1 B 11: BeiDou B2I
Checksum	*79		Checksum
<CR><LF>			End of sentence

3.10 GxGST – GNSS Pseudo Range Error Statistics

- Example

$GNGST,025029.00,15,0.92,0.78,43,0.34,0.34,0.91*7A

Explanation

Contents	Example	Unit	Explanation
Message ID	$GNGST		GST protocol header
Time	025029.00		hhmmss.ss hh: hour, mm: minute, ss: second
Range of RMS	15	meters	RMS value of the standard deviation of the ranges
Standard Deviation	0.92	meters	Standard deviation of semi-major

of Semi-Major Axis			axis (only supported in ADR 4.10 and later)
Standard Deviation of Semi-Minor Axis	0.78	meters	Standard deviation of semi-minor axis (only supported in ADR 4.10 and later)
Orientation	43	degrees	Orientation of semi-major axis (only supported in ADR 4.10 and later)
Standard deviation of latitude error	0.34	meters	Standard deviation of latitude error
Standard deviation of longitude error	0.34	meters	Standard deviation of longitude error
Standard deviation of altitude error	0.91	meters	Standard deviation of altitude error
Checksum	*7A		Checksum
<CR><LF>			End of sentence

3.11 GxTXT – Text Transmission

- Example

  $GPTXT,01,01,02,u-blox ag - www.u-blox.com*50

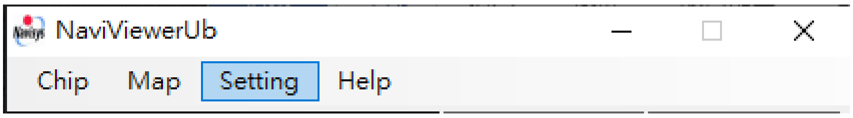
Explanation

Contents	Example	Unit	Explanation
Message ID	$GPTXT		TXT protocol header
Number of messages	01		Total number of messages in this transmission, 01..99
Message number	01		Message number in this transmission, range 01..xx
Message type	02		Text identifier, u-blox GPS receivers specify the type of the message with this number. 00: Error 01: Warning 02: Notice 07: User
Text	u-blox ag - www.u-blox.com		Any ASCII text
Checksum	*50		Checksum
<CR><LF>			End of sentence

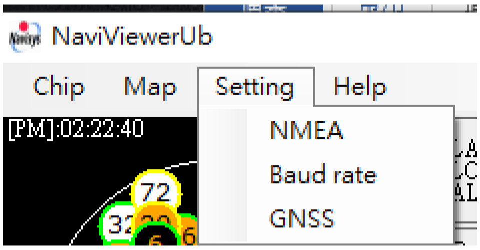
3.12 GNSS Configuration

- Higher update rate usually results in better performance. If power consumption is not a major concern, 10Hz is suggested for all satellite systems.
- If power consumption is a major concern, one may want to reduce the used satellite systems or update rate.
- Higher update and more used satellite systems will output more data. That is to say, higher baud rate would be required to communicate with GR-903.

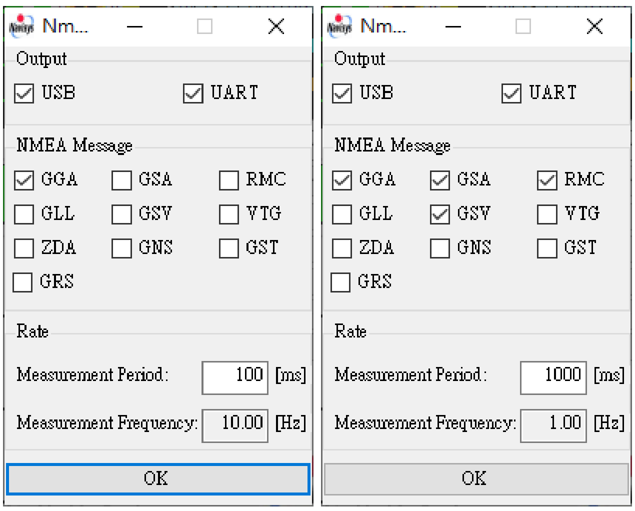
- If the focus is only on the position itself, one can have high update, say 10Hz, to all satellite systems. However, just output only limited NMEA sentence, say GGA only. In this case, small baud rate is allowed to talk to GR-903.
- To support configuration change for above mentioned purposes, one can use u-blox's u-center tool or just download NaviViewerUb from Navisys support page to perform the configuration management.
- Configured by NaviViewerUb: Click the Setting menu bar of it,



One can see 3 sets of functions for above mentioned configuration manageement.

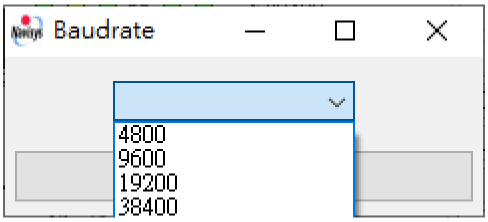


- NMEA is for a) enable/disable a NMEA sentence and/or b) change the update rate:



➔Please be noted that send OK leaving NMEA Message **blank** would cause **null outpu**t of NMEA messages. In case of update rate change, please remember to also check NMEA sentences.

- Baud rate is for changing the baud rate.



Please remember to reconnect if baud rate has been changed.

- GNSS is for enable/disable satellite systems.

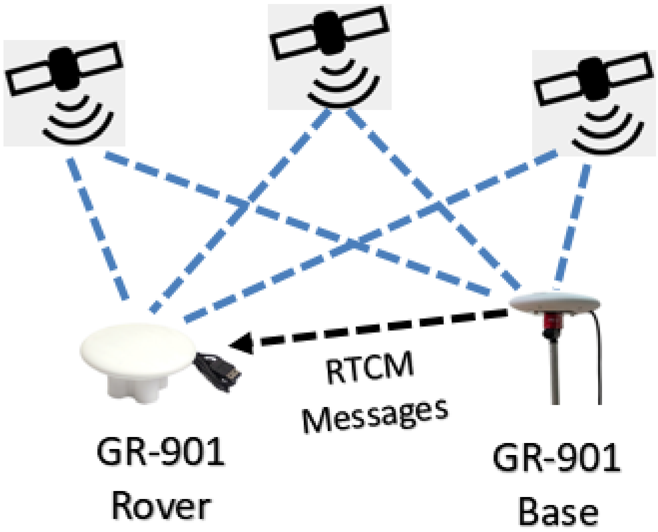
poll config will update the current setting.

OK will send the command.

4 RTK Base Setup with u-center

GR-903 could be configured as a base station using the tool u-center. u-center is available from https://www.u-blox.com/en/product/u-center.

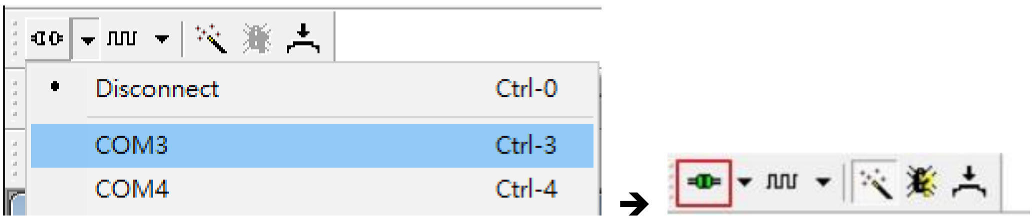
As shown in following figure, the GR-903 RTK base receives the satellite information and then sends the correction data to the GR-903 rover via RTCM messages as mentioned in section 1.4, RTK mode supported RTCM 3.3 messages according to RTCM 10403..



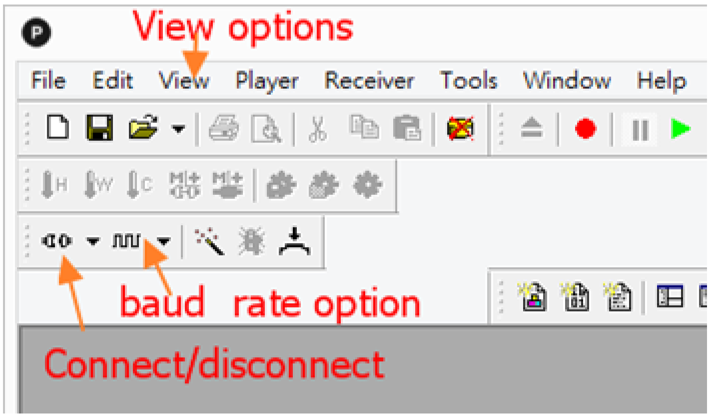
In this chapter, base setup is described while in next chapter, rover setup.

4.1 Connection

Connect GR-903 to a USB port and use its corresponding COM port to connect the u-center. Normally, u-center will detect the COM port automatically. E.g.



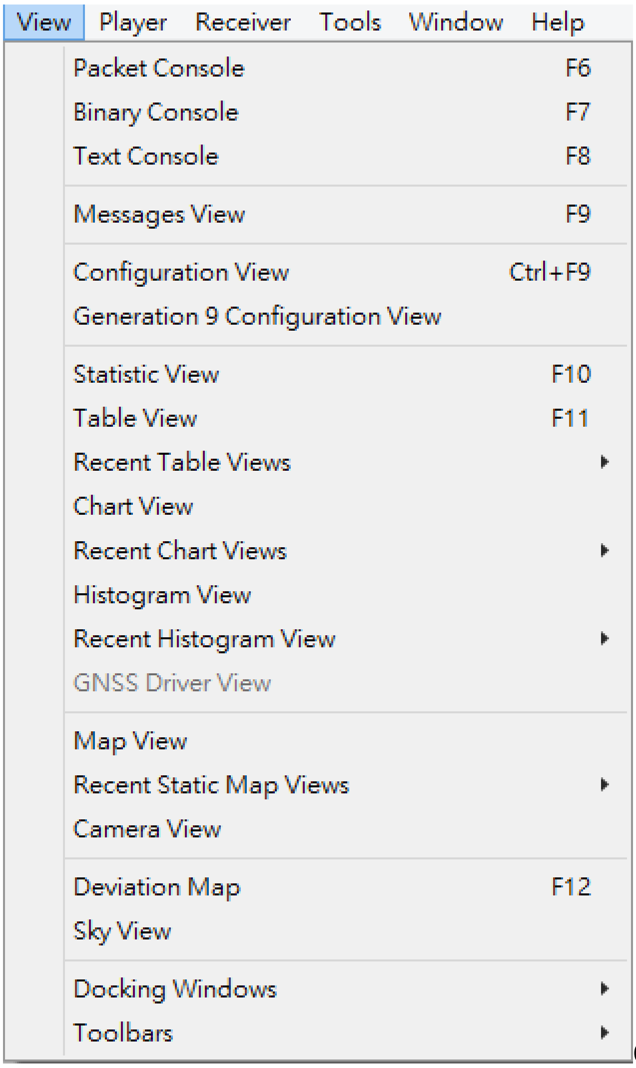
Click the connection icon and it becomes as it is connected as shown above. The default baud rate is 38400 bps.



➔In case u-center is not able to find a corresponding COM port, right USB driver is required.

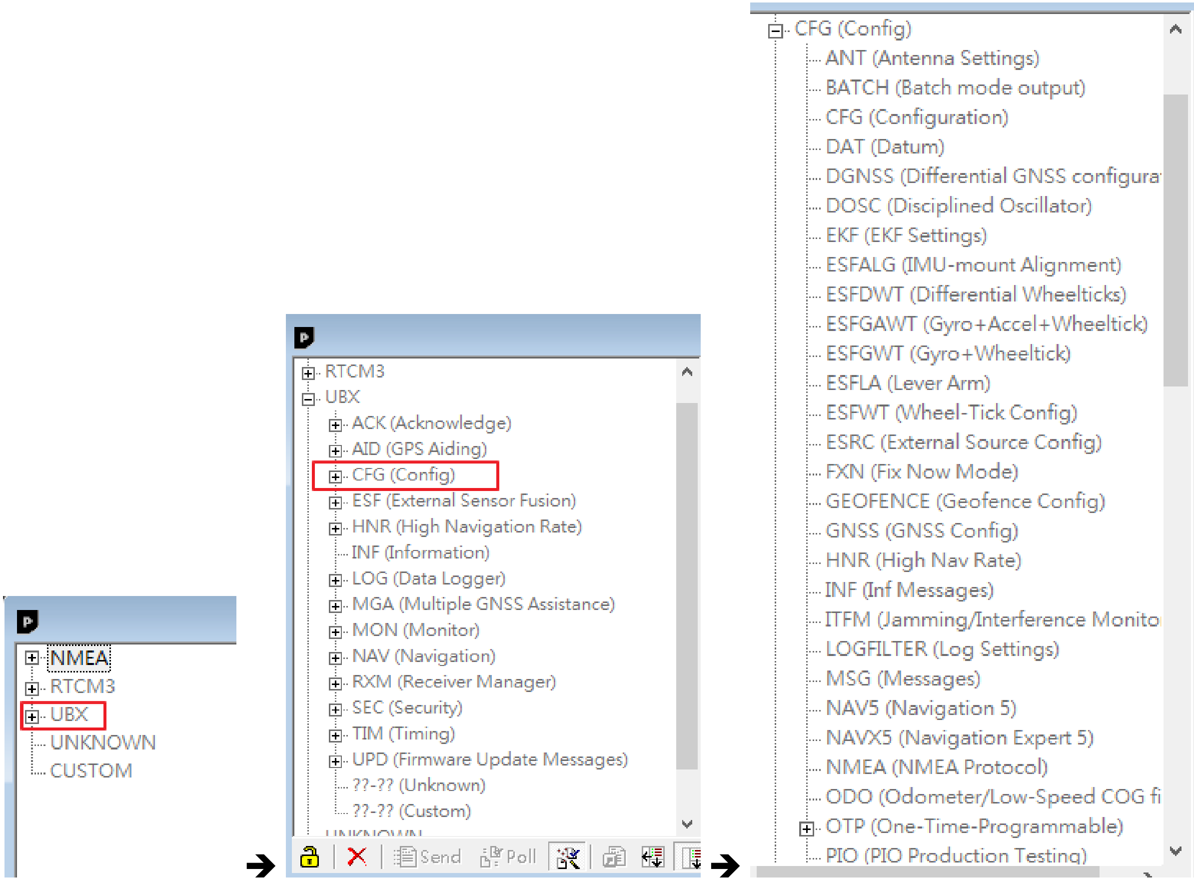
4.2 View Commands

Many RTK commands could be found under View pulldown menu. Select the "Messages View" first.

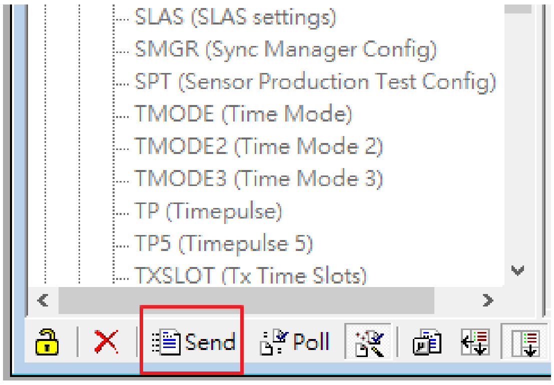


One

One would see left menu below. Collapse the UBX option and scroll to see more command options of it as shown in the middle menu below. In this documet, options chosen at different menus are separated by '-'. E.g. If you want to change the USB port setting, UBX-CFG-PRT would be chosen step by step.



Finally, after your setting is done, be sure to send the command as shown below.



4.3 Survey the Position of a Base Station

The base station would broadcast its position together with the correction data via RTCM messages. Its position could be obtained in two ways.

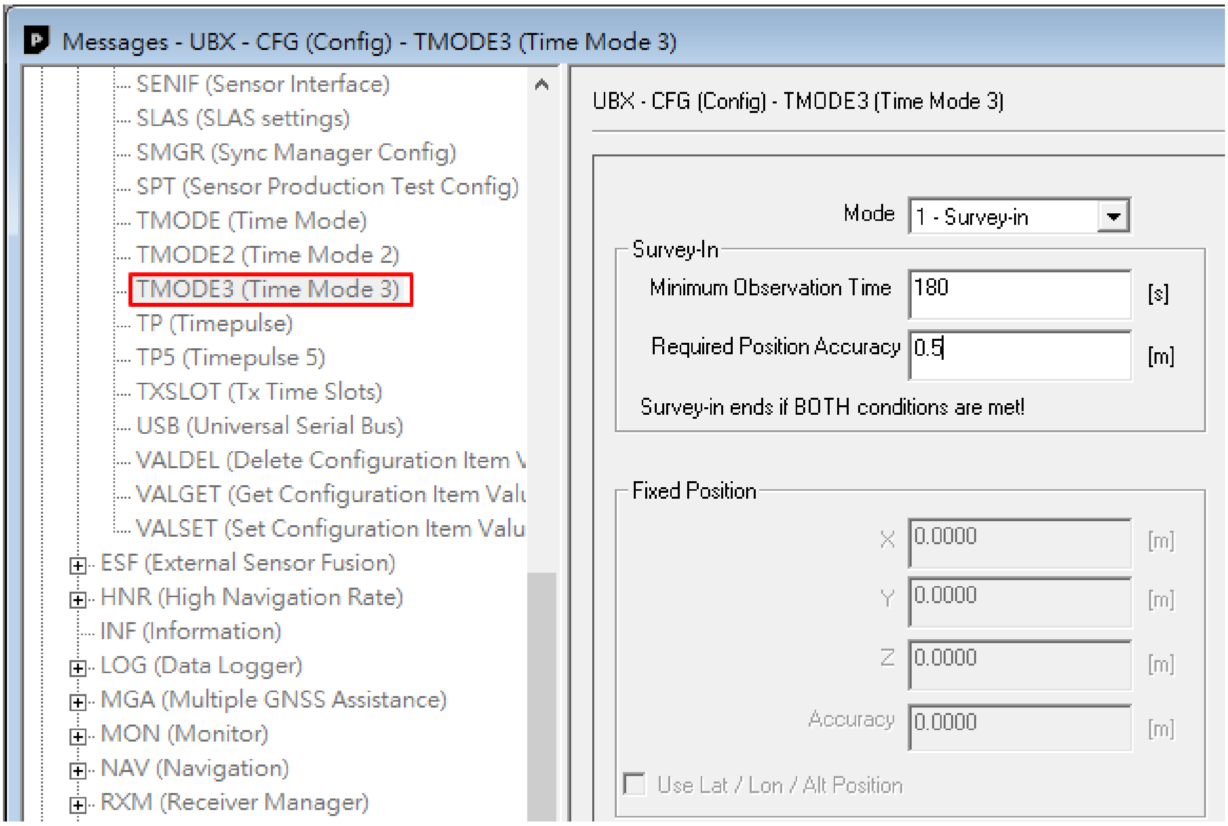
- Survey in by the base station itself

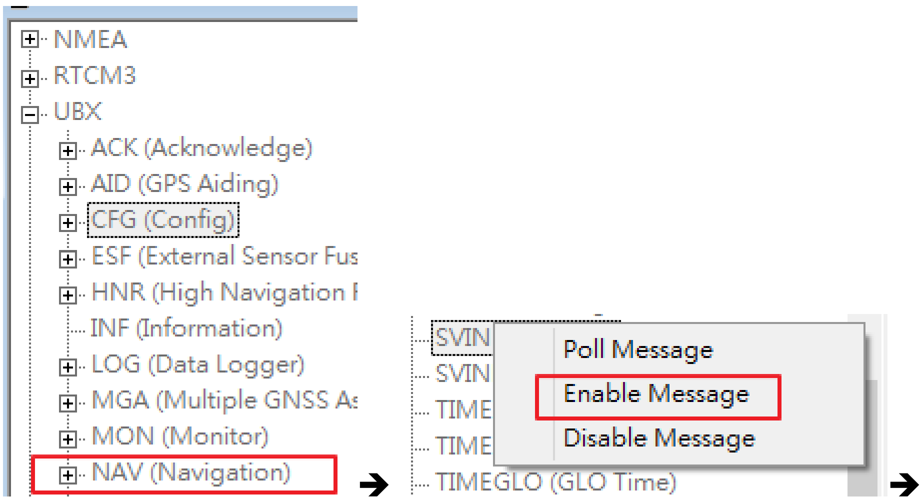
- The accuracy of base is not required to be cm-level if just relative accuracy is required by the rover. The rover's position accuracy would be **relative to** this position with cm-level precision.
- The more accurate the position is, the longer time would be required to finish the survey-in process.

- Give the known-position of the base station

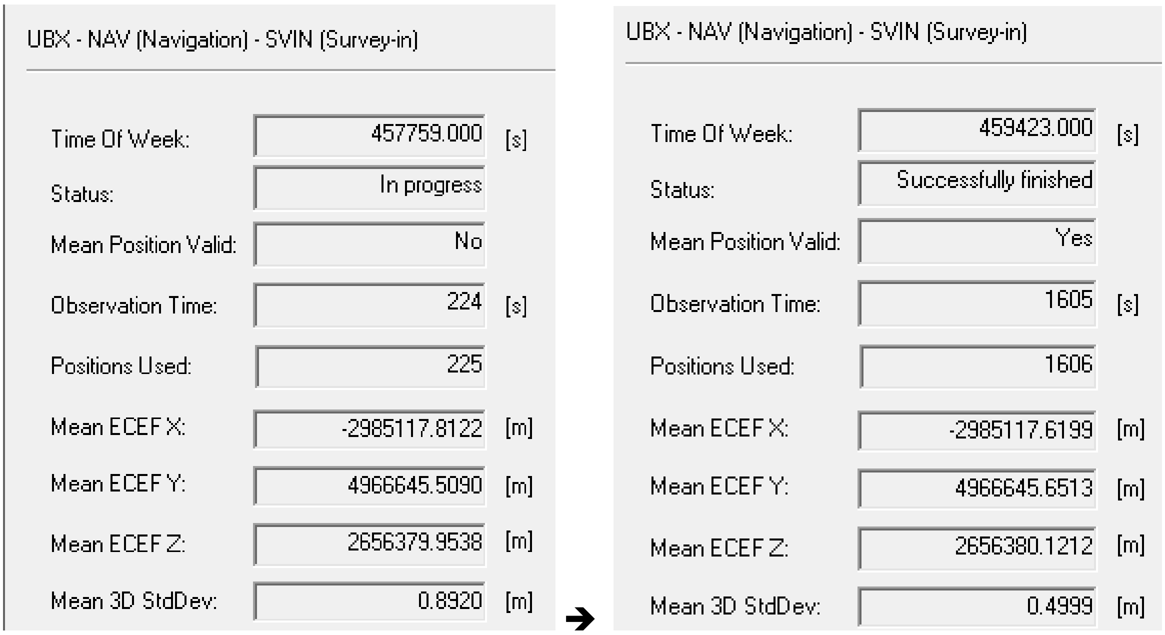
The survey in process could be achieved by

- The UBX-CFG-TMODE3 command to define the survey parameters.
- The UBX-NAV-SVIN command to enable the survey status display.



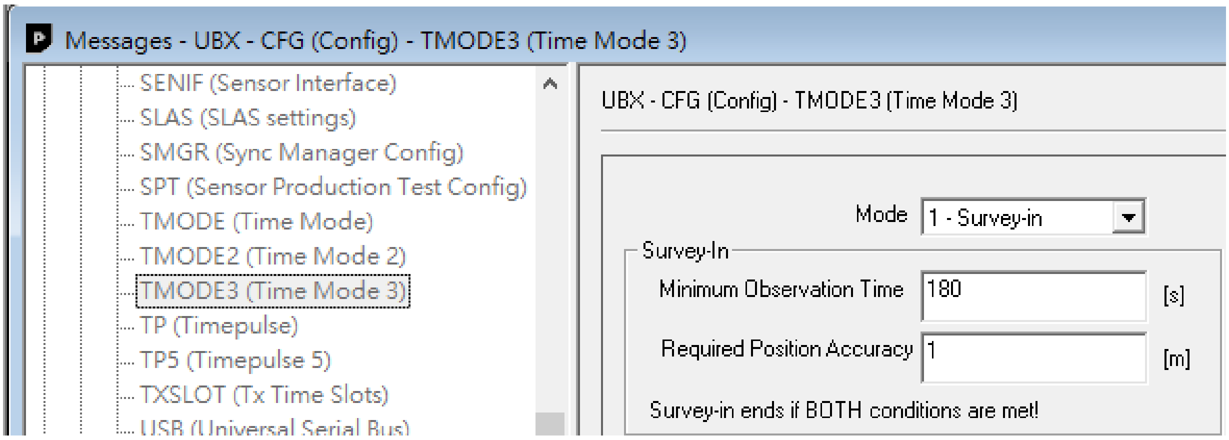


Right click on NAV (Navigation) and then select Enable Message, the SVIN window starts to show the status.

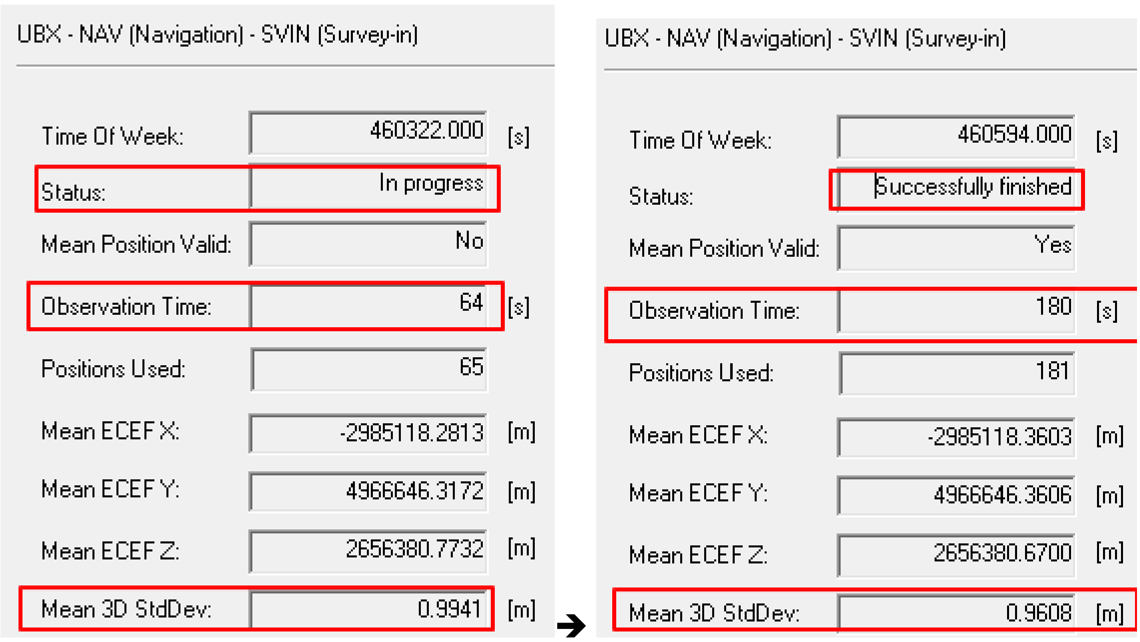


- As time elapses, the 3D StdDev becomes smaller (better). As shown above, observation time from seconds 224 to 1605.
- In this case of the UBX-CFG-TMODE3 command, the minimum observation time is 180 seconds and accuracy is 0.5m. The survey process would not stop until both conditions are met.
- In above left picture, accuracy is 0.892 (< 2)m while time is 224, the survey keeps going on. At second 1605 the condition is met and the survey stops.

- If you want to survey with different accuracy, use the UBX-CFG-TMODE3 command to redefine the accuracy and send the command to restart the survey in process. E.g. set the accuracy to 1m and survey in finished at 180th second.



The accuracy reached at second 64. However, the min observation time is 180 seconds and thus the survey in keeps on going until both time (≥180) and accuracy (≤1) criteria are met.



Please be noted that

- The GNSS signal condition determines how accurate the survey could achieve.
  - The better the signal condition, the more accurate it could achieve.
  - Surrounding electrical interference might also affect the GNSS signal reception and thus worsen the accuracy.

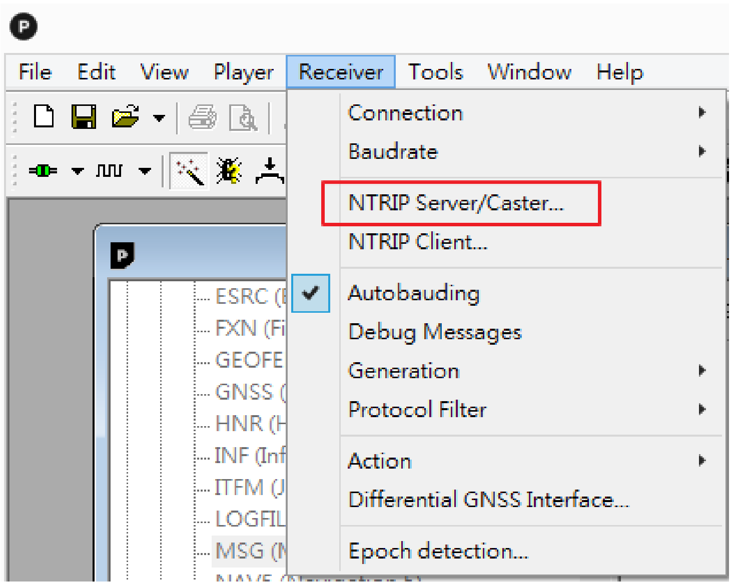
- GR-903 should be put at an open sky environment without obstructions.

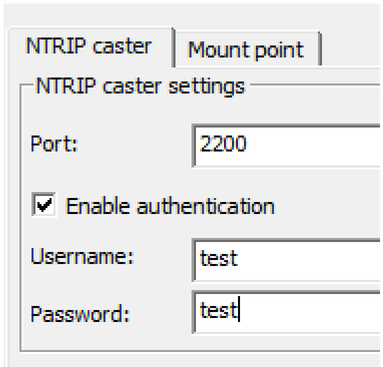
4.4 Setting the Caster

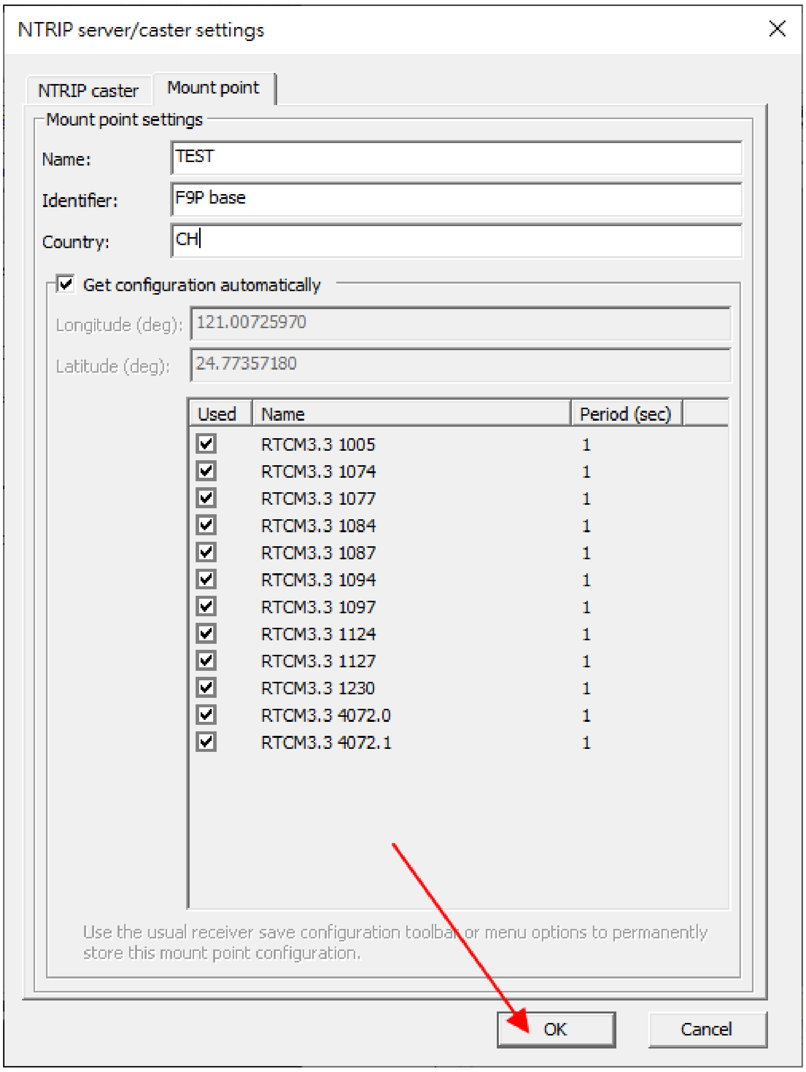
Caster is the base that would broadcast RTCM messages so that a rover can connect to it to receive these RTCM messages. Before the caster could be used, we have to define the port number, mount point, authentication options so that rover could connect to it.

Under the "Receiver" menu, choose the "NTRIP Server/Caster" option for configuration as shown below.

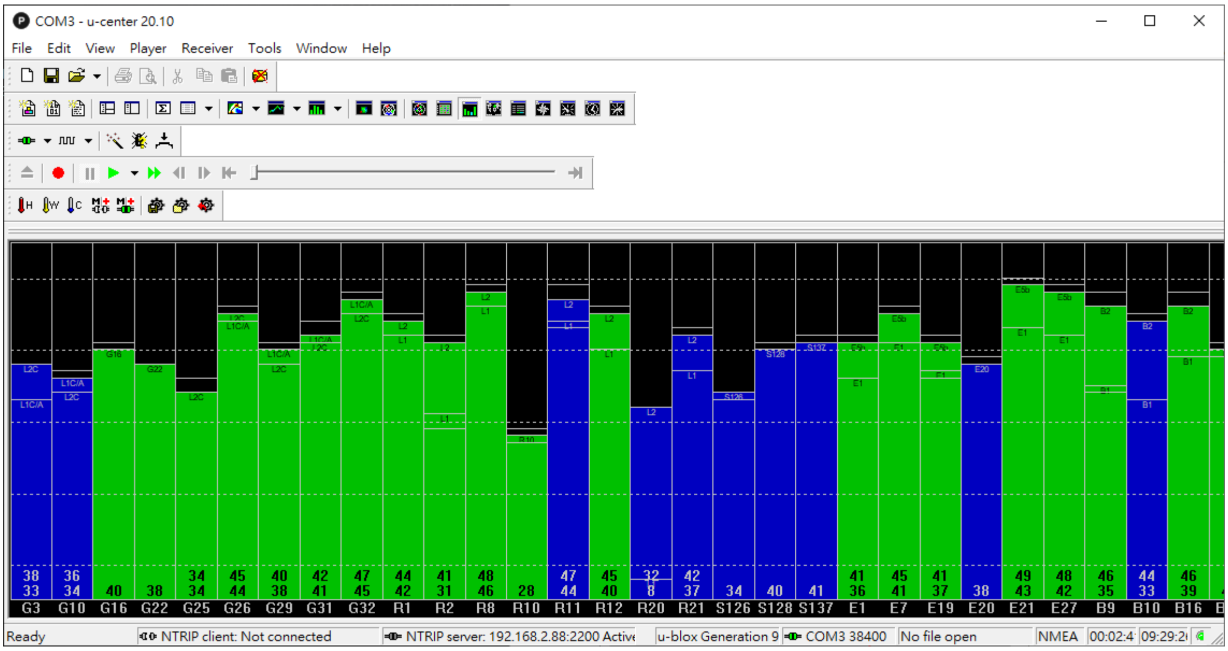
Here is just an example. You can define your own settings (port number etc.). Check option of Get configuration automatically to use longitude, latitude and RTCM message configuration of the currently connected GR-903 that will be sent out on the mount point.



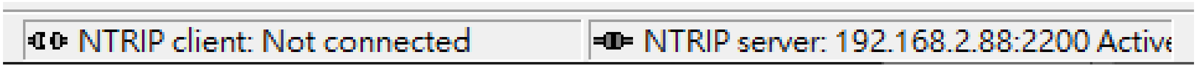




After configuration, the server is ready for broadcasting correction data.

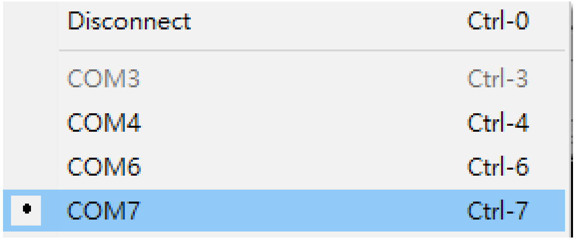


You should be able to see the NTRIP server status bar showing Active on the bottom of the u-center window as also enlarged shown below.

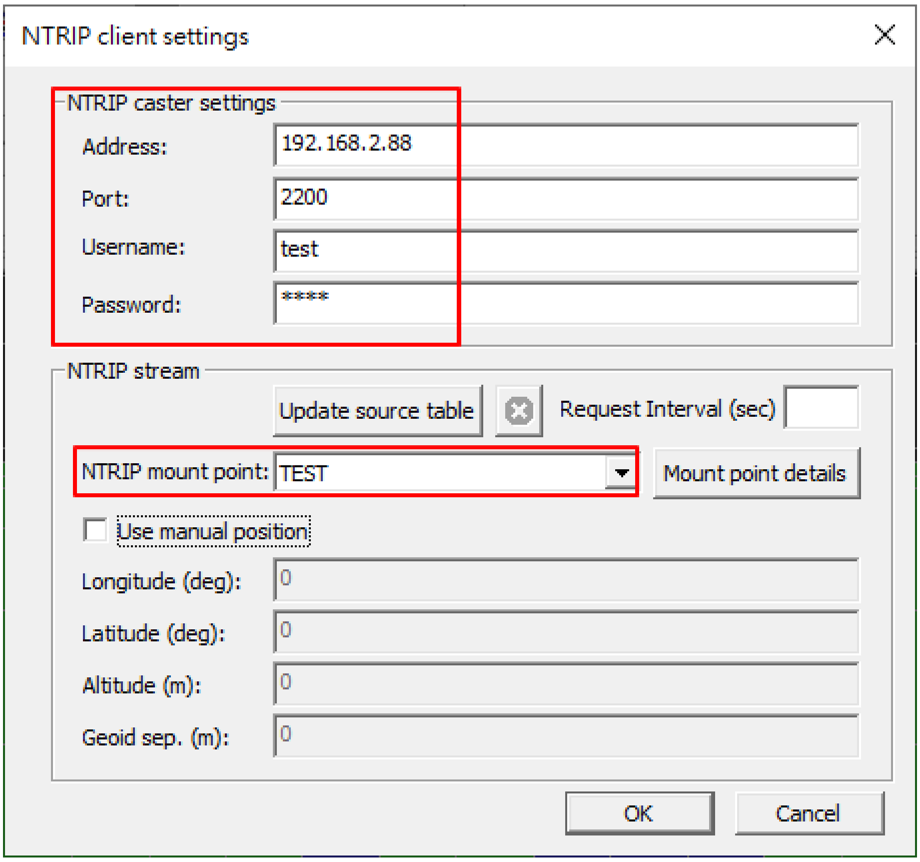


5 Connecting Rover to Caster with u-center

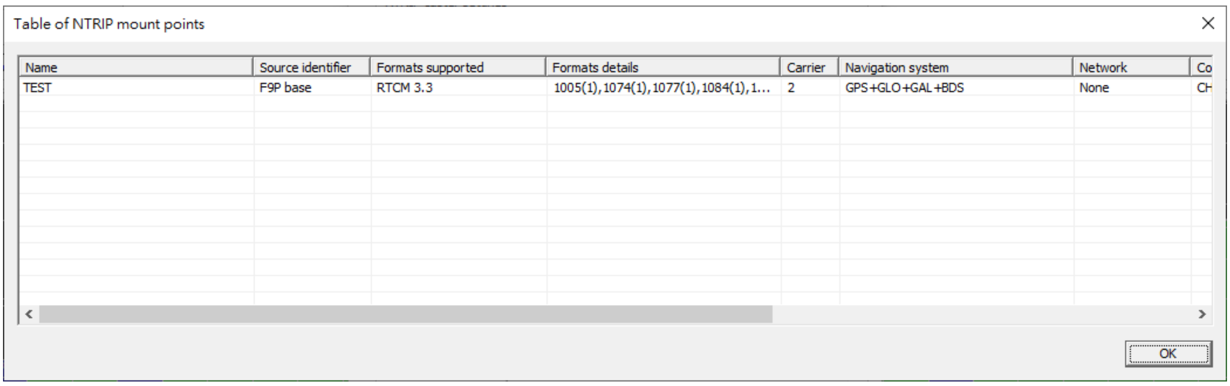
Establish the communication between u-center and GR-903 rover.



Open NTRIP client settings dialog by clicking on Receiver | NTRIP Client.

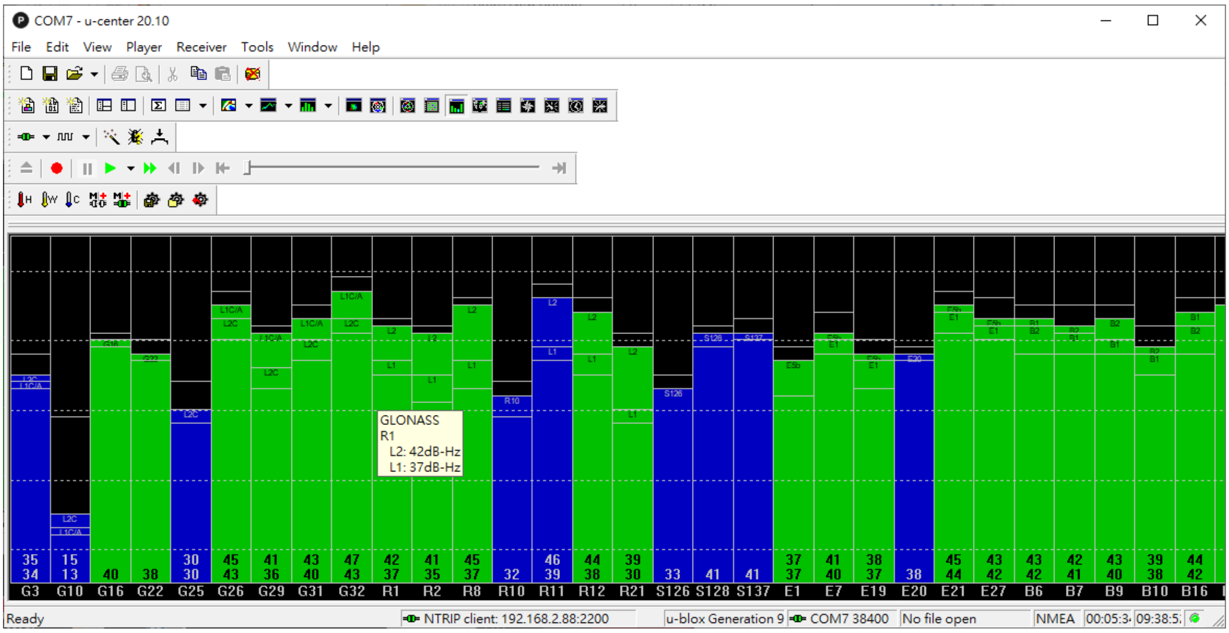


Mount Point details:

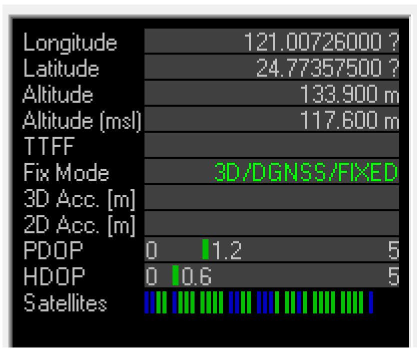


Enter the address, port number, username, and password of the NTRIP caster. If authentication is not required by the caster, then leave username/password fields empty.

Click on Update source table to get an up to date list of all available mount points from the caster. Click on Mount Point Details to know its detailed information. Click on OK to start receiving correction data. The NTRIP client becomes connected ( ) to the caster.



The fix mode will display FIXED if the GR-903 rover calculates an RTK position using correction data from the caster successfully.



Tips:

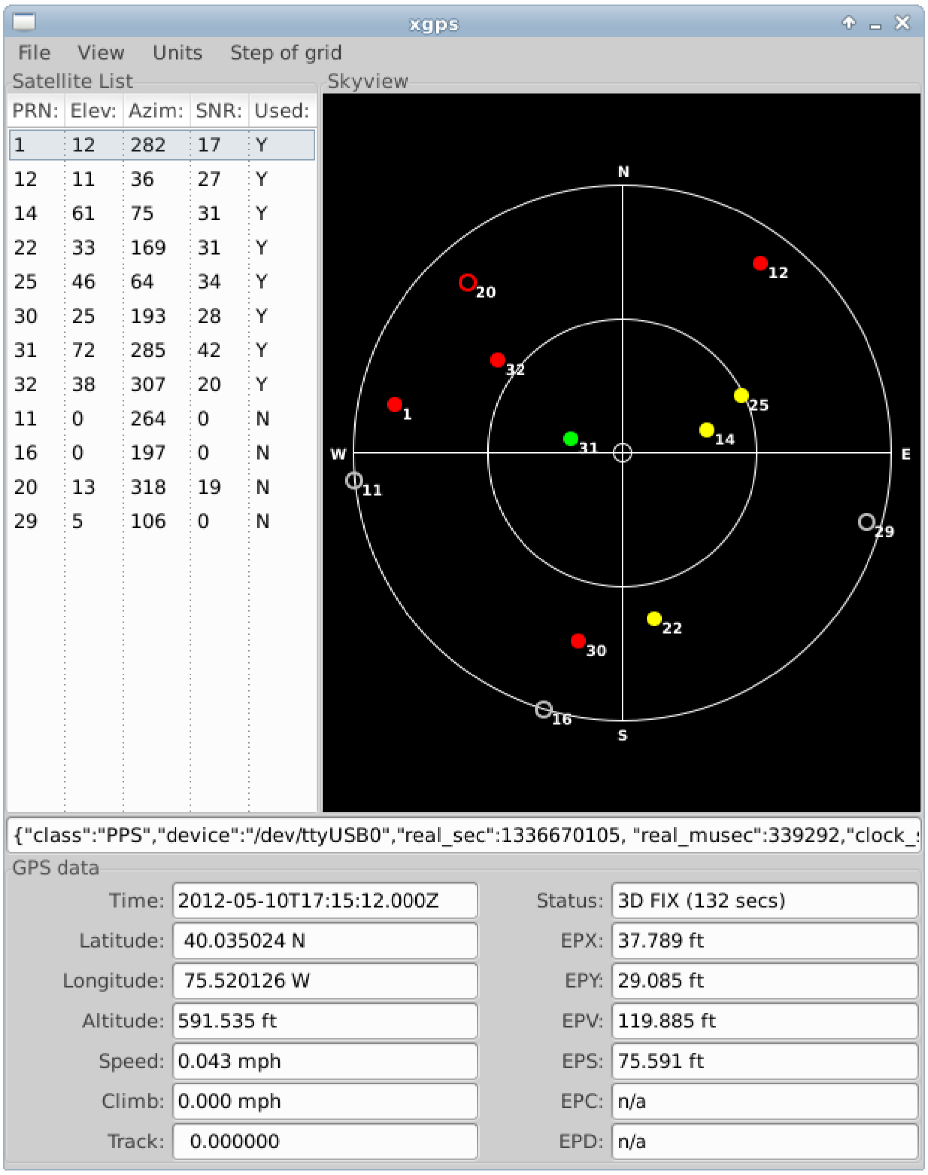
☞GR-903 rover could connect to any other casters. In this document, GR-903 is just taken as a caster example for illustration purpose.

6 Evaluation Information

6.1 Overview

Under Windows, connect the GR-903 to your PC and check its performance using the Navisys GPS viewer tool. You can download the Navisys GPS viewer tool for u-blox from our web site as shown in next section.

Under Linux or *BSD, install GPSD and ensure that the gpsd daemon is running (under Linux, a hot-plug will launch it when you plug the device into a USB port). Then run the xgps or cgps test client.

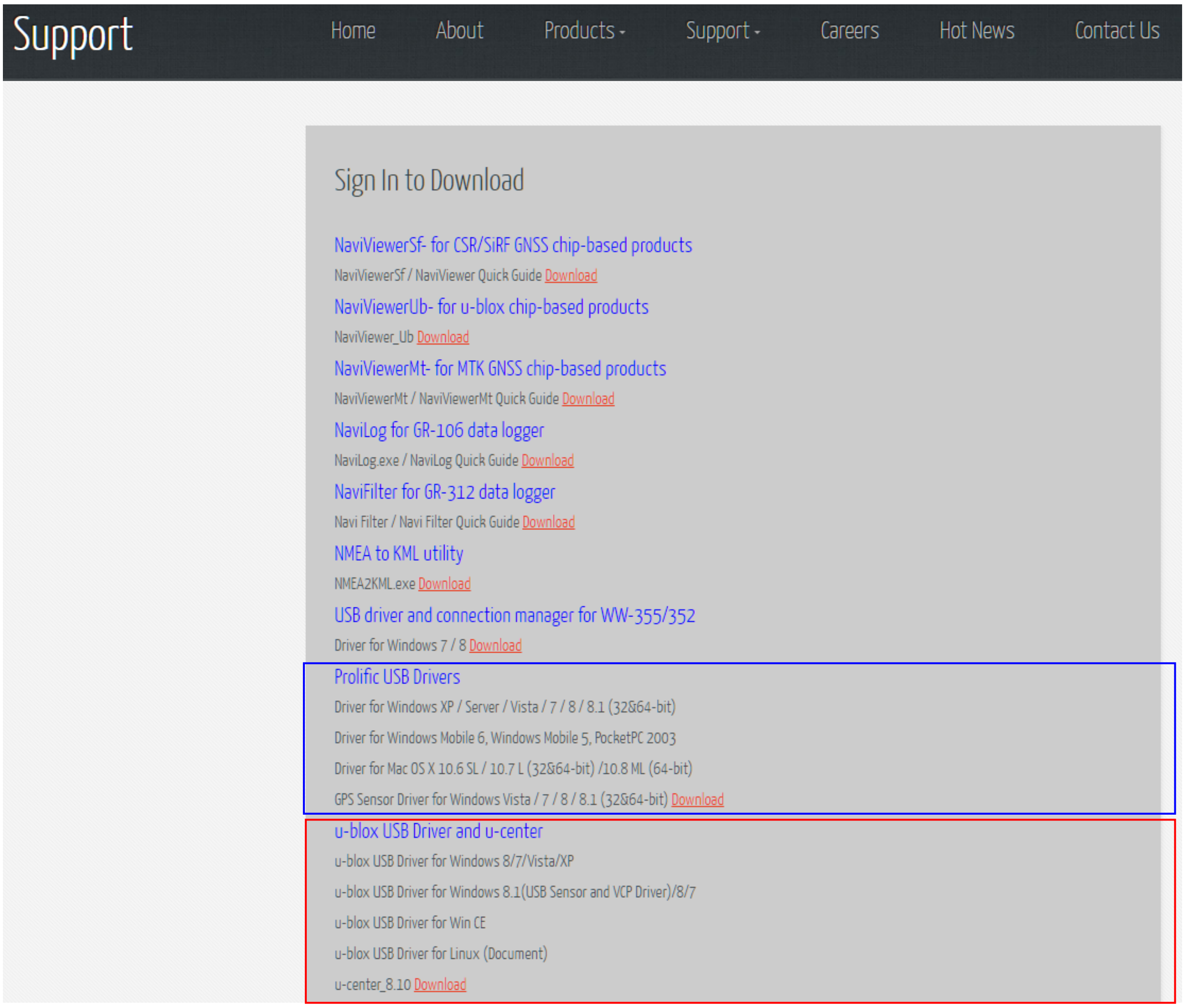


6.2 USB Drivers

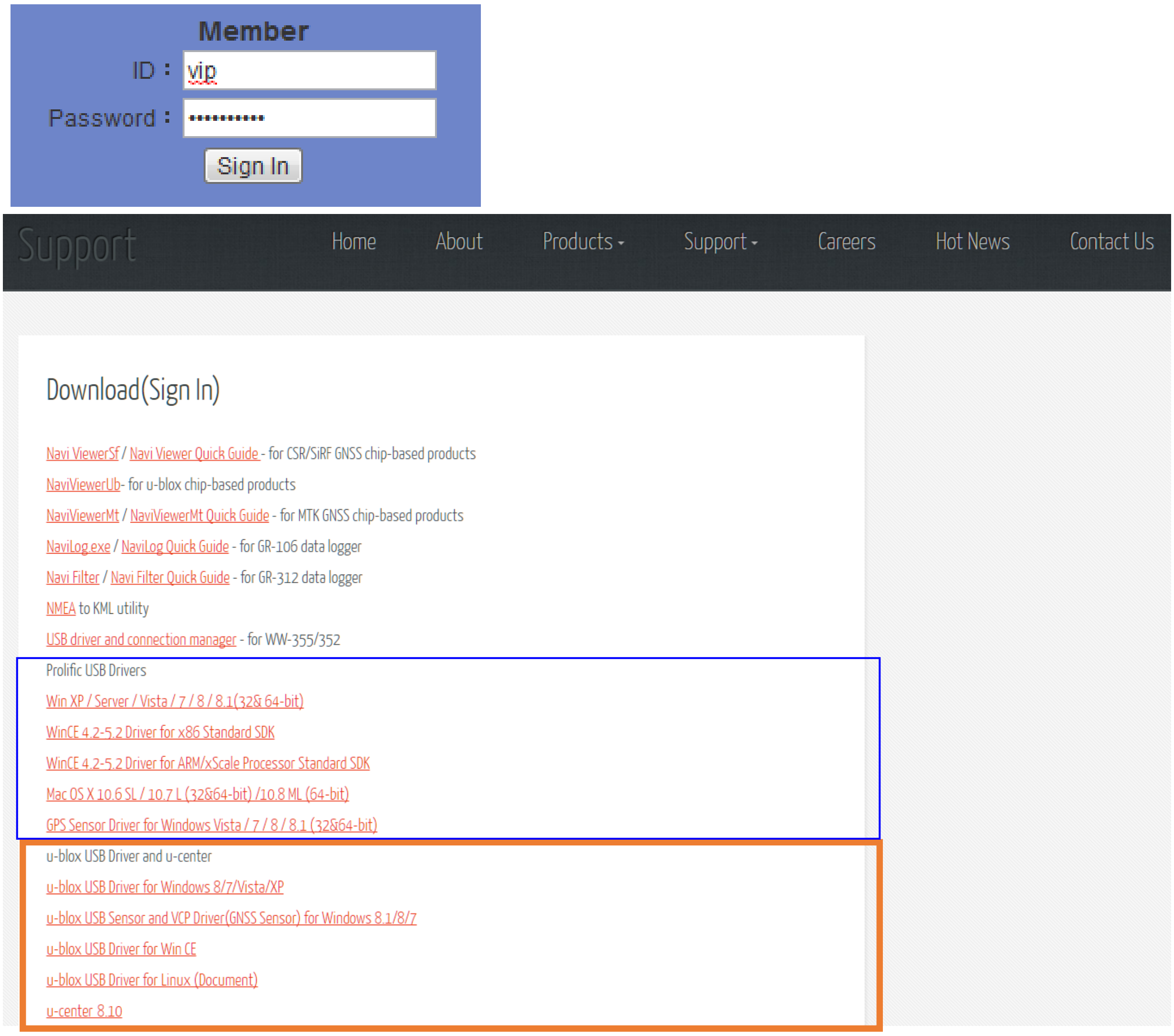
USB drivers are available from Navisys download link as shown below: http://www.navisys.com.tw/support.html

For USB interface, please select u-blox USB driver. For TTL, RS232 interfaces, please select the Prolific USB driver.

The USB drivers for Linux and *BSD are embedded in the kernel.



- Click on Download and it prompts for ID and password. Enter ID and Password and then click on Sign In to download the drivers. The default password is "navi-utility". Navisys may change the ID and password.



6.3 Tips in Designing

The GNSS signal is pretty low, less than -130 dBm, which is easily interfered by the EMI of application circuit.

Interference checking

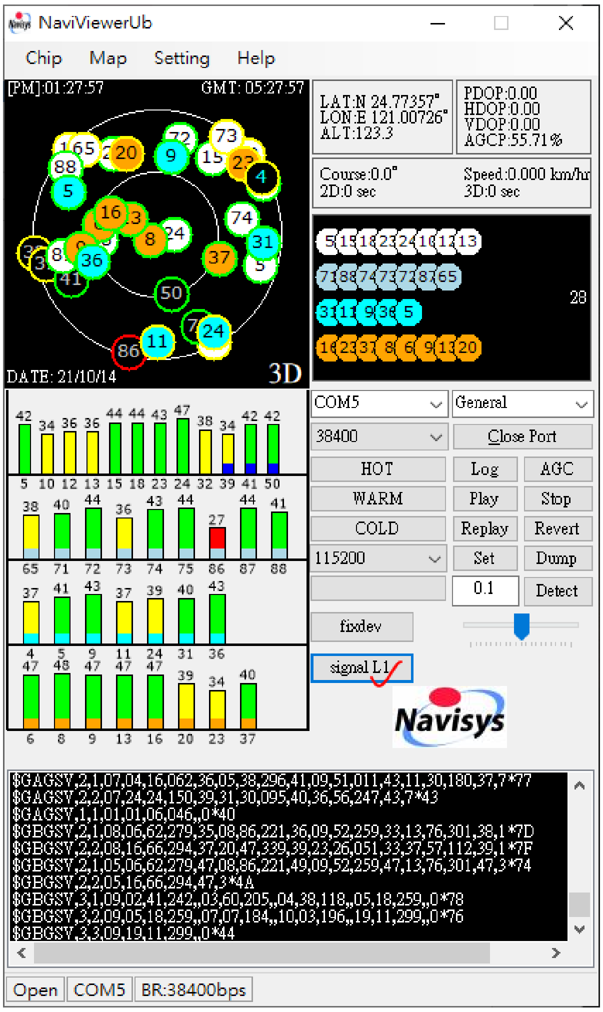
1. Check the signal reception status of GNSS standalone with GNSS viewer tool.
2. Observe the performance when the receiver moves around the host machine.
3. If you want to find a location for installing GNSS unit, choose the location with best signal reception displayed by NaviViewerUb.
4. If the location of the receiver has determined, this tool could be used to check the interference severity.

For more interesting news, please visit following web link:

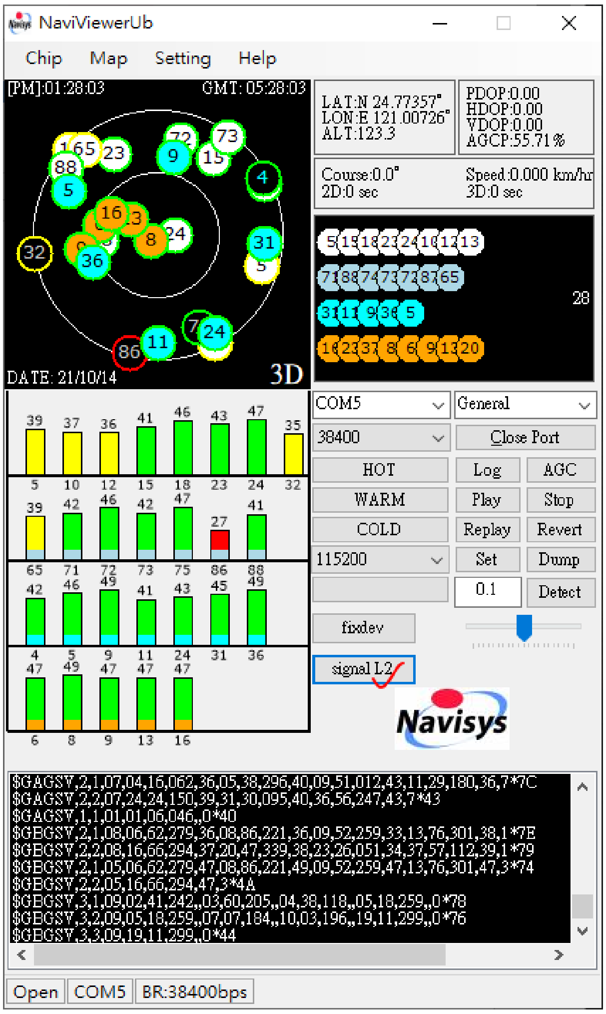
http://www.navisys.com.tw/tips.html

NaviViewerUb GNSS Viewer Tool

L1



L2



1. Signal strength is represented by the bar length and color. At the bottom, different colors are for different satellite systems as shown next. Please note that for GPS, it is one color only.
   - Blue: ≧ 50, green: ≧ 40, yellow: ≧ 30, red: < 30
2. Satellites of different systems are displayed by different bar colors. Please see also Help.

3. One can toggle signal L1 or signal L2 to see SVs received on different bands.

6.4 Antenna Placement

The SAW filter inside GR-903 provides 40dB out of band attenuation. Normally, a cellular antenna would not interfere it.

In case of harmonic or other in-band signal source weaker than -130dBm, suggest to put that antenna at least 10cm away from GR-903. For other stronger in-band signal source, longer distance away from GR-903 is required.

6.5 Ordering Information

GR-903X, X = U, V etc.

U	Disk Only, w/o magnet
V	Disk + Pedestal (w/ magnet)

6.6 Related Documents

[1] ZED-F9P Interface description, UBX-18010854
https://www.u-blox.com/en/docs/UBX-18010854

[2] ZED-F9P Moving Base application note, UBX-19009093
https://www.u-blox.com/en/docs/UBX-19009093

[3] Radio Resource LCS Protocol (RRLP), (3GPP TS 44.031 version 11.0.0 Release 11)

7 Electrical and Environmental Data

Electrical Data

Power Supply (VDC)	3.3 ~ 5.5
Power Consumption	120 mA / average tracking (USB) 10Hz update rate, # of SVs tracked: L1:37, L2:27
USB I/O (V)	VIH: 2.0 ~ VDD_USB (VDD_USB: 3.3V) VIL: 0 ~ 0.8 VOH >= 2.8 VOL<= 0.3
Protocols	NMEA (Rover default), u-blox binary, RTCM 3.3 (Base)

Environmental Data

Operating temperature	-40 ~ 85℃ (-20~60℃ for backup battery)
Storage temperature	-40 ~ 85℃ (-40~60℃ for backup battery)
Vibration	5Hz to 500Hz, 5g
Shock	Half sine 30g/11ms
RoHS compliant	Yes