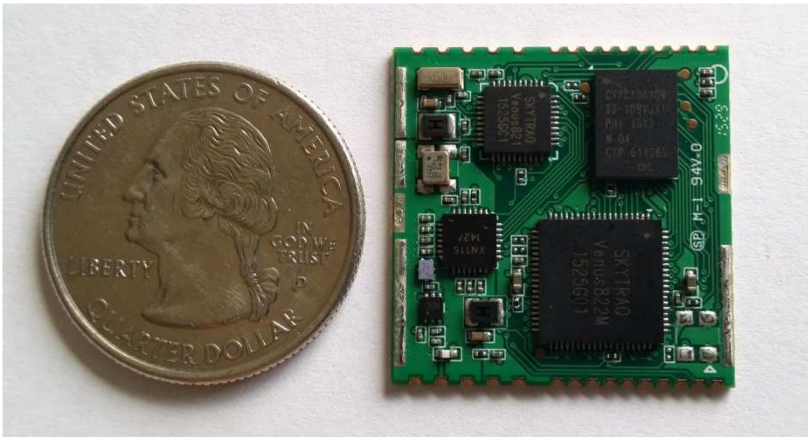
Lowest Power, Smallest Size RTK Receiver Module



S2525F8-BD-RTK

“S2525F8-BD-RTK” OEM RTK Module

- Support RTK base and rover modes
- GPS L1 + BDS B1 + SBAS
- Tracks up to 28 satellites
- RTK position accuracy: centimeter-level
- 25mm x 25mm, 70mA @ 3.3V
- Update Rate 1Hz

Mode	Output	Output Baud Rate	Input	Input Baud Rate
Rover	NMEA-0183	9600 ~ 115200*	RTCM-SC104 3.0, 3.1 or SkyTraq-Raw	57600
Base	SkyTraq-Raw	38400 ~ 115200**		

* default 115200

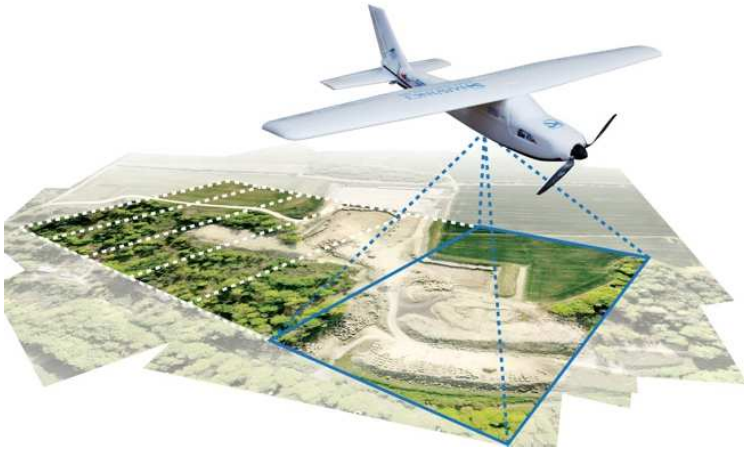
** when switching to base mode, need to manually change to 57600 to work with rover

Also High-Performance GPS/BDS Receiver

- L1 C/A Code
- GPS / SBAS / QZSS
- Sensitivity: -148dBm cold start, -160dBm tracking
- Update Rate: 2 / 4 / 5 / 8 / 10 / 20 / 25 / 40 / 50 Hz
- Position accuracy: 2.5m CEP
- Velocity accuracy: 0.1m/sec
- Timing accuracy: 10nsec
- 50mA @ 3.3V

Potential RTK Applications

UAS Mapping



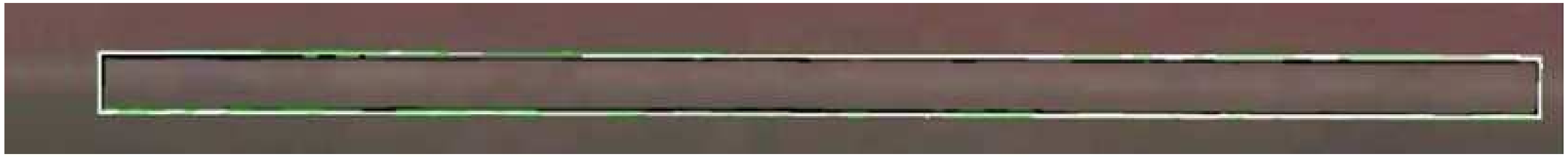
Agriculture

Driverless Vehicle

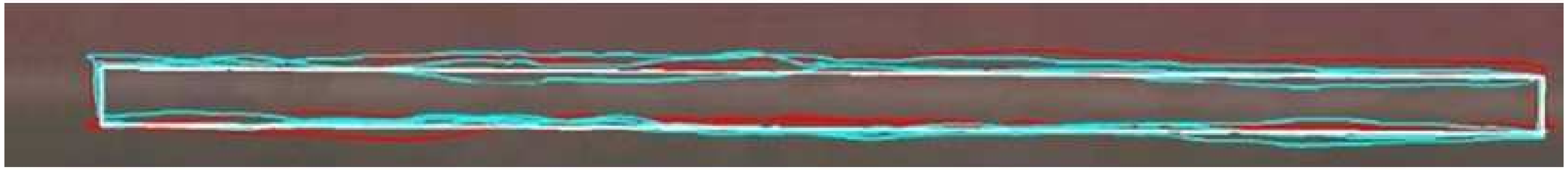
Surveying

Construction

Accuracy: GPS vs DGPS vs RTK

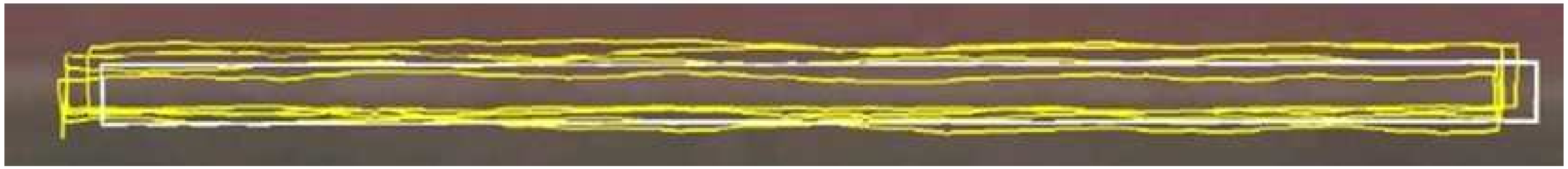


RTK, 3 diff days
1.5Km baseline



DGPS, 2 diff days

GPS, 2 diff days



Other brand GPS
on another day

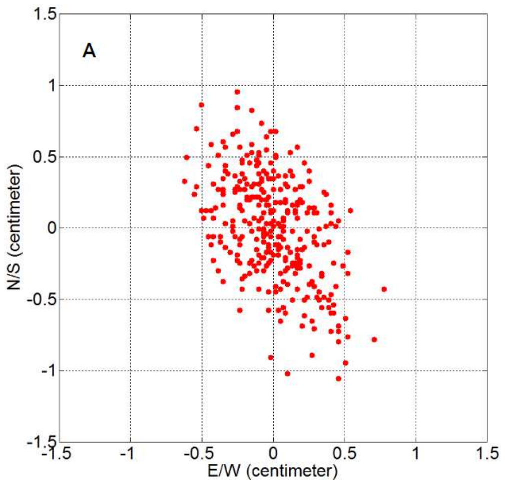
RTK receiver tested on 3 different days, tracks overlap.
Its tracks serve as reference track for comparison.

DGPS result is near reference track, but don't over lap well.

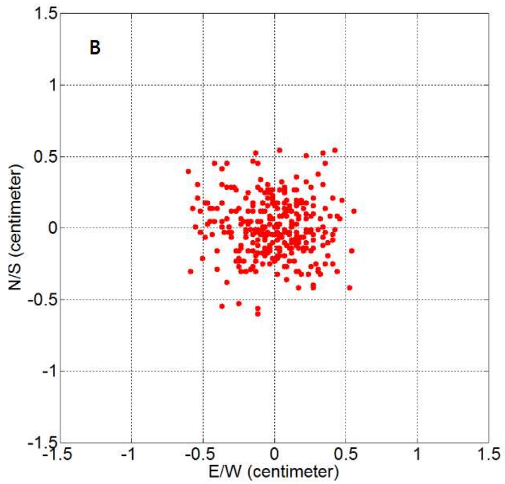
GPS result deviates on different day due to atmospheric delay error, don't overlap well.

Other brand GPS result deviates on different pass in a testing on the same day, don't overlap well.

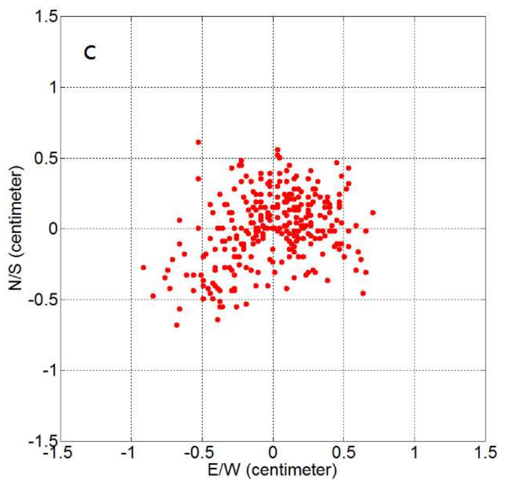
Baseline vs Accuracy



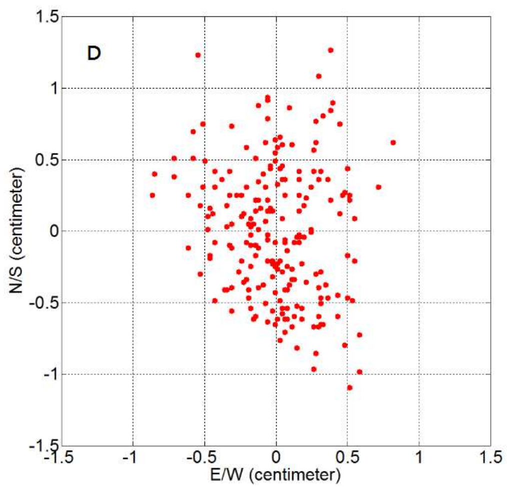
Baseline 0.5km TTAF 1 minute
Accuracy 0.8 cm R95 (300sec)



Baseline 1km TTAF 1.5 minutes
Accuracy 0.6c m R95 (300sec)



Baseline 1.5km TTAF 2 minutes
Accuracy 0.7 cm R95 (300sec)



Baseline 6.3km TTAF 2.4 minutes
Accuracy 1.0 cm R95 (300sec)

Rover Antenna: TW2710
Test Environment: Open Sky
Mode: Real-Time

A. Testing done by road side around 8:50AM with cars passing by or stopping for red light, thus result noisier even with shorter base line

B. Testing done on roof of a 20 floor building around 6:25AM

C. Testing done by road side around 11:20PM without cars passing by

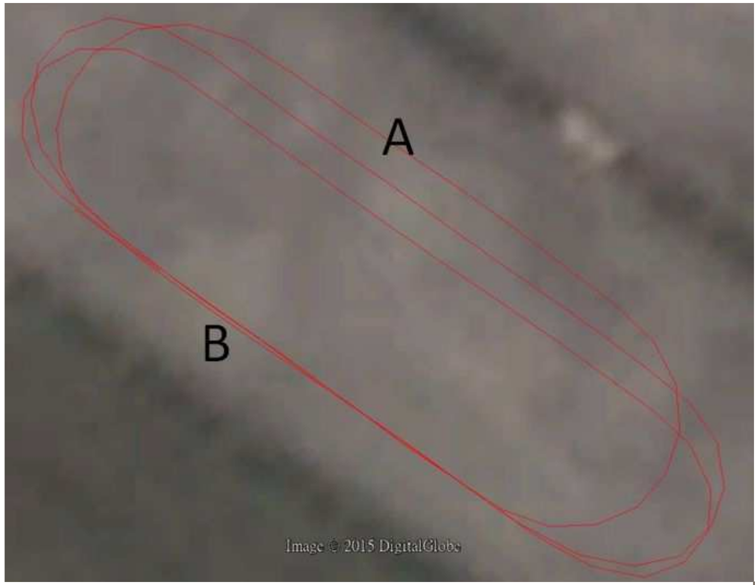
D. Testing done in an empty parking lot around 9:30AM

TTAF: Time To Ambiguity Fixed

Dynamic Performance

Max speed 81Km/hr, 1.7Km baseline, blue : single, yellow : float, green : fixed

Performance on Heavy Rainy Day



4.5km baseline, testing on a severe rainy day, getting mostly float solution

Section A: car drove on adjacent 3 lanes separated roughly 2 meters apart
Section B: car drove on the same lane on each pass

Although it's mostly float solution with small number of fixed solution, the 3 tracks on section A are distinctively on separate lanes running in parallel, and the 3 tracks on section B roughly overlap, nearly as good as from fixed solution

Notice how the tracks look distinctly accurate and different from the GPS results shown in previous slide even when the result is mostly float solution

Precision Time & Position Stamp* (1/2)

- Input: rising edge on TRIG pin as trigger
- Output: PSTI,005 message with time and position occurrence estimate on the trigger
- Accuracy
  - Time: 100nsec
  - Position: max 1msec moved distance error on top of RTK positioning error

If 50km/h speed ➔ maximum 1.4cm error on top of RTK positioning error

***** Available only for S2525F8-BD-RTK-5S and -10S 5Hz and 10Hz RTK version with precision time/position stamp

Precision Time & Position Stamp* (2/2)

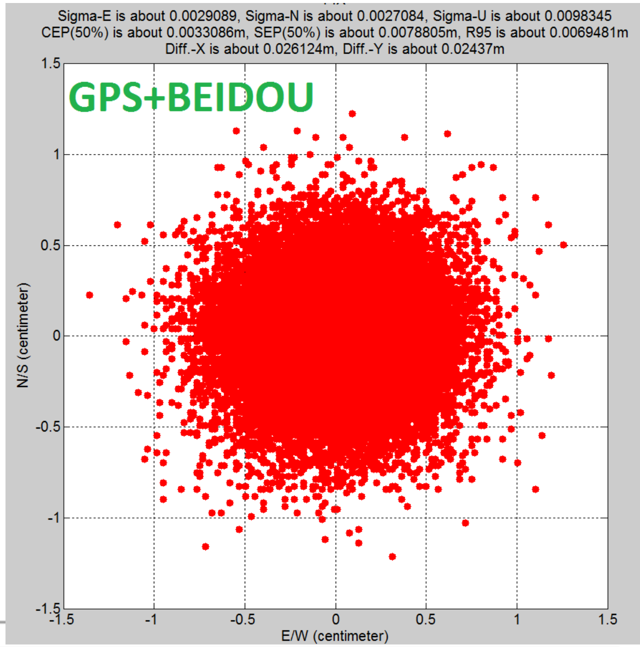
- Alternative RTK, at 50Km/hr speed 10Hz RTK rate, 139cm distance moved between 2 RTK points. When movement is not constant velocity, incorrect to linear interpolate ➔ not possible to derive precise position from time stamp

- PSTI,005 offers direct centimeter-level accuracy RTK position stamp ➔ maximum error of 1.4cm on top of RTK's 1cm + 1ppm error at 50Km/hr speed ➔ far accurate than simple time stamp offered by alternative RTK solutions

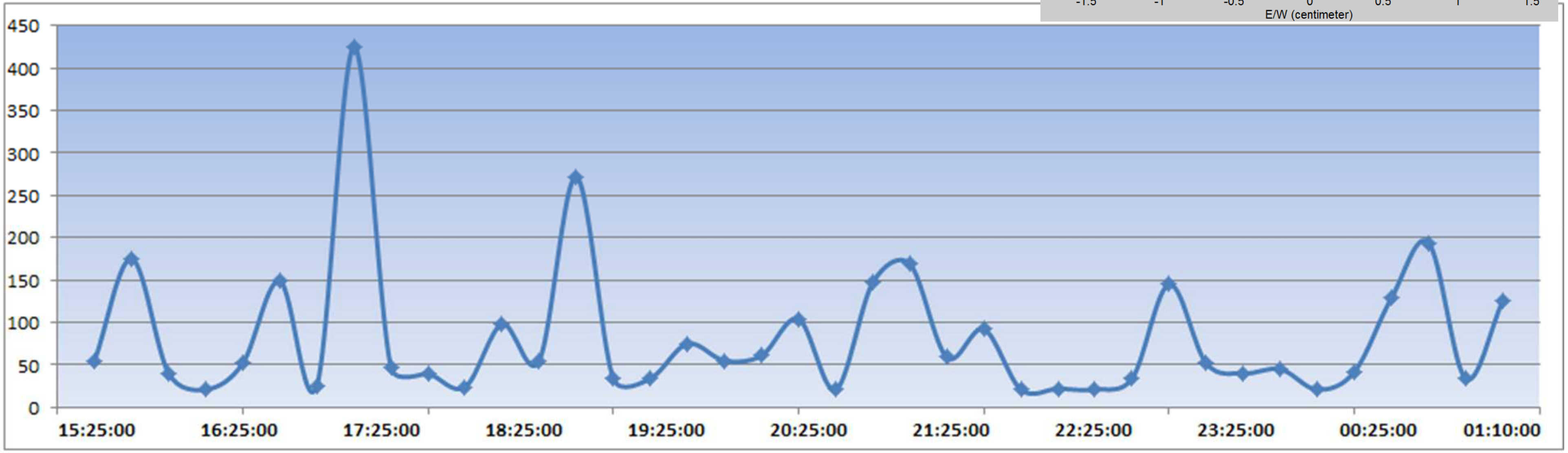
Performance Comparison (1/4)

15 meter baseline
HX-CSX601A antenna
Power on 900sec, off 10sec
10 hour testing
S2525F8-BD-RTK GPS/BDS mode

Plot of all RTK fix points
(0,0) is true location



TTAF (sec)



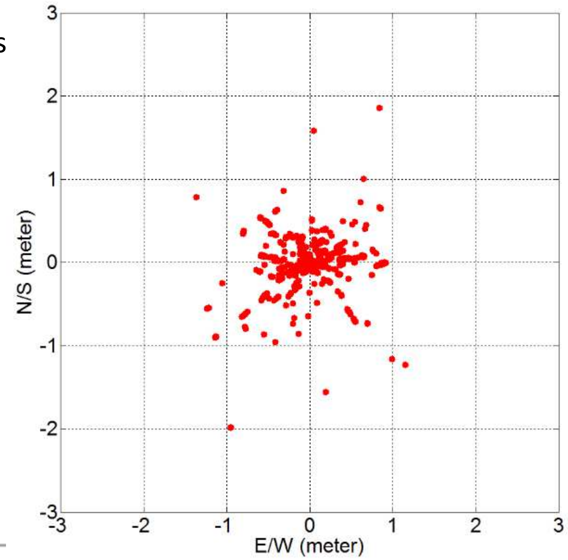
UTC time

Performance Comparison (2/4)

testing another brand single-frequency GPS/GLONASS RTK receiver

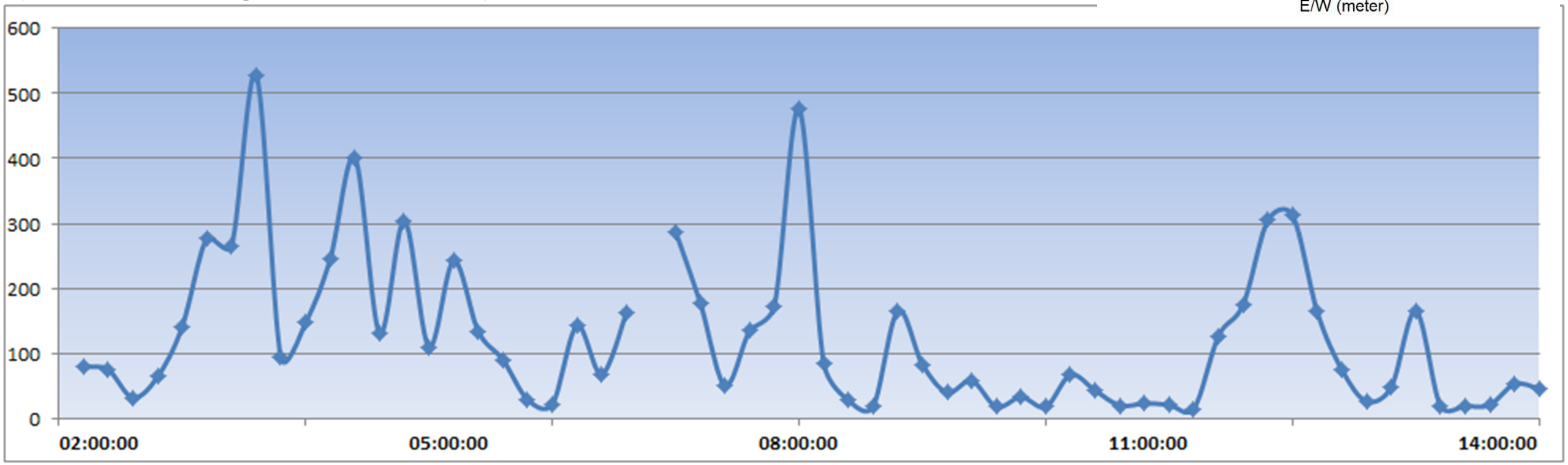
2.4 meter baseline
Antenna: TW2710
Power on up to 900sec, off 10sec
12 hour testing

Plot of all RTK fix points
(0,0) is true location



Time-To-Ambiguity-Fixed
(sec, when converged to true location)

1 time no RTK fix solution in 900sec



UTC time

Performance Comparison (3/4)

testing another brand single-frequency GPS/GLONASS RTK receiver

2.4 meter baseline
Antenna: TW2710
Power on 900sec, off 10sec
12 hour testing

1st column: time to get 1st RTK fix solution
2nd column: time that RTK fix solution converged to true location
Yellow color: trials that has RTK fix solution matching true location from beginning

time(sec) to get FIX solution // UTC 02:00:00	
1st FIX	stable FIX (continuous 30s)
16	80
29	75
32	32
11	64
13	141

time(sec) to get FIX solution // UTC 03:00:00	
1st FIX	stable FIX (continuous 30s)
25	277
240	265
107	528
67	94
41	147

time(sec) to get FIX solution // UTC 04:00:00	
1st FIX	stable FIX (continuous 30s)
105	245
78	401
19	131
14	304
17	110

time(sec) to get FIX solution // UTC 05:00:00	
1st FIX	stable FIX (continuous 30s)
149	242
12	134
90	90
17	29
22	22

time(sec) to get FIX solution // UTC 07:00:00	
1st FIX	stable FIX (continuous 30s)
106	142
15	68
162	162
55	X within 15mins
67	287

time(sec) to get FIX solution // UTC 08:00:00	
1st FIX	stable FIX (continuous 30s)
177	177
27	51
135	135
173	173
113	476

time(sec) to get FIX solution // UTC 09:00:00	
1st FIX	stable FIX (continuous 30s)
32	85
12	28
10	18
93	165
27	83

time(sec) to get FIX solution // UTC 10:00:00	
1st FIX	stable FIX (continuous 30s)
40	40
14	58
11	18
28	33
18	18

time(sec) to get FIX solution // UTC 11:00:00	
1st FIX	stable FIX (continuous 30s)
20	67
13	43
15	20
15	23
21	21

time(sec) to get FIX solution // UTC 12:00:00	
1st FIX	stable FIX (continuous 30s)
15	15
31	127
152	175
222	305
22	313

time(sec) to get FIX solution // UTC 13:00:00	
1st FIX	stable FIX (continuous 30s)
140	164
13	75
20	26
48	48
15	165

time(sec) to get FIX solution // UTC 14:00:00	
1st FIX	stable FIX (continuous 30s)
19	19
19	19
14	21
19	53
46	46

Performance Comparison (4/4)

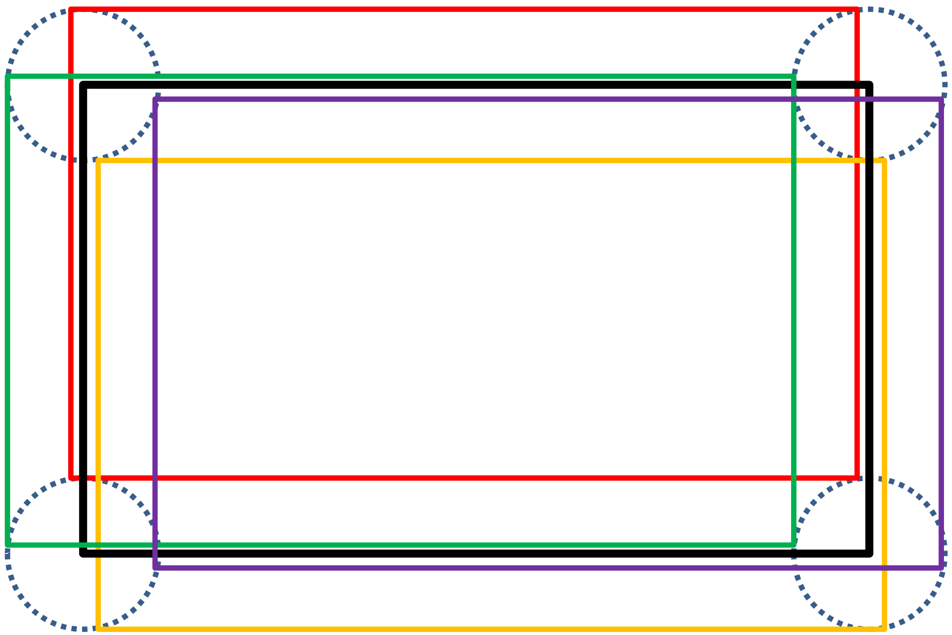
- Unlike consumer GPS that works nearly everywhere, RTK receiver works only outdoors under open-sky with very little interference
- With dual-satellite system, single frequency RTK receiver can have varying TTAF as seen on page-5, page-6, and page-8
- With GPS-only single frequency RTK receiver, it may sometimes unable to get RTK fix solution or may have deviated RTK fix solution due to too few usable GPS satellites
- As Beidou (BDS) system is not fully operational yet, users outside Asia will see lesser total number of satellites and performance will be between GPS-only mode and GPS/BDS mode as shown on page-5 and page-9.
- S2525F8-BD-RTK receiver performance will be better than any existing single-frequency GPS RTK receiver on the market due to additional Beidou satellites that it could use.
- GNSS Radar may be used to find out about the satellite situation in your region: http://www.taroz.net/GNSS-Radar.html

GPS Receiver

- Most GPS receivers use C/A code to measure position
- A C/A code chip is roughly 300 meters
- GPS receiver can determine position with resolution to fraction of a C/A code chip, resulting in 2.5 meter CEP 50%* accuracy from 4 or more GPS satellites

* 2.5m CEP 50% means 50% of the location points fall within 2.5m radius.
It is equivalent to 95% confidence level falling within 5 meter radius

GPS Receiver Error



A rectangular land with 4 corners measured using GPS at different time on different days. When plotted on Google Earth, these 4 measured corners defined rectangular lands may have area shifted by 0 ~ +/-5 meters.

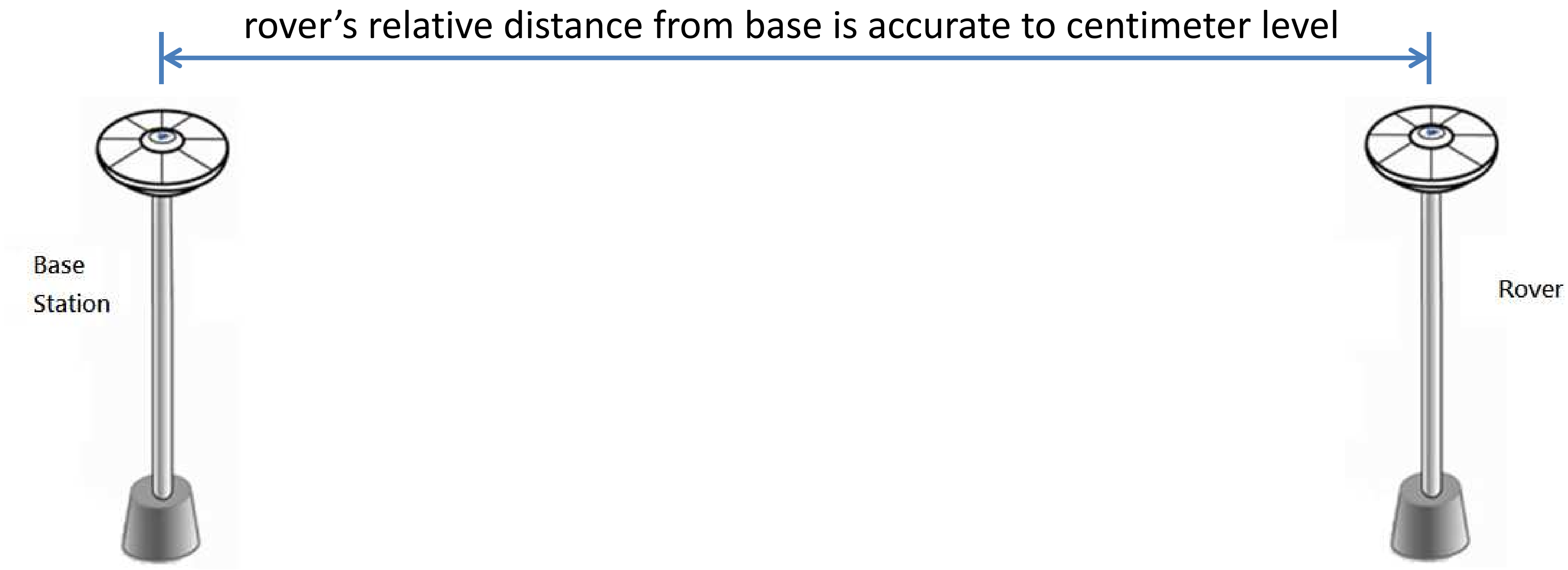
Shifted 10 meters for the worst case +5m and -5m shifts.

This is mostly due to ionosphere and troposphere delays.

RTK GPS Receiver (1/2)

- RTK GPS receiver counts carrier cycles to determine relative position from base station
- Each carrier cycle has wave length of 19cm
- RTK receiver can determine relative position from base station with resolution to fraction of a carrier wavelength, resulting in centimeter-level position accuracy

RTK Receiver (2/2)

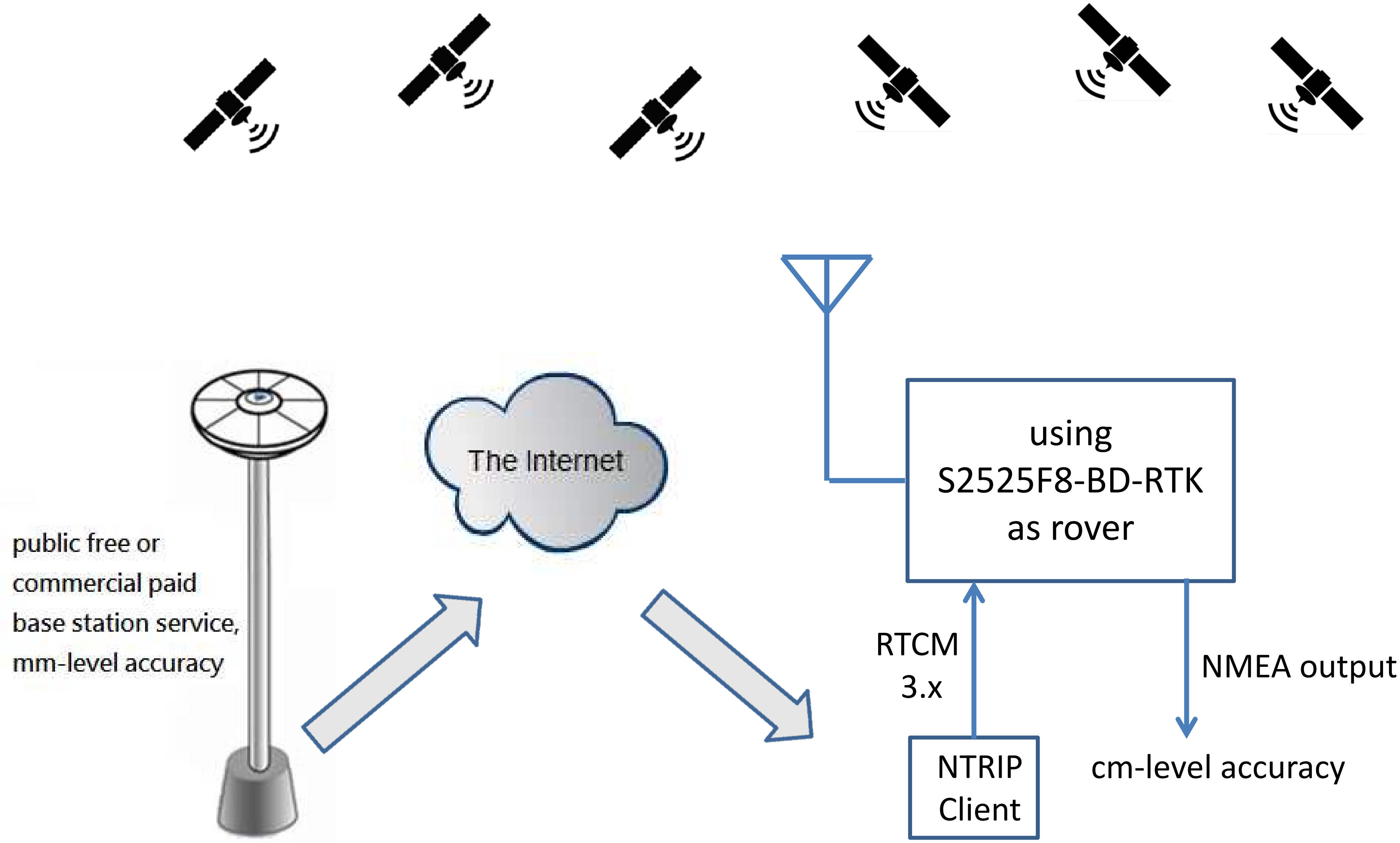


If base position* is accurate to millimeter ➔ rover position* will be accurate to centimeters

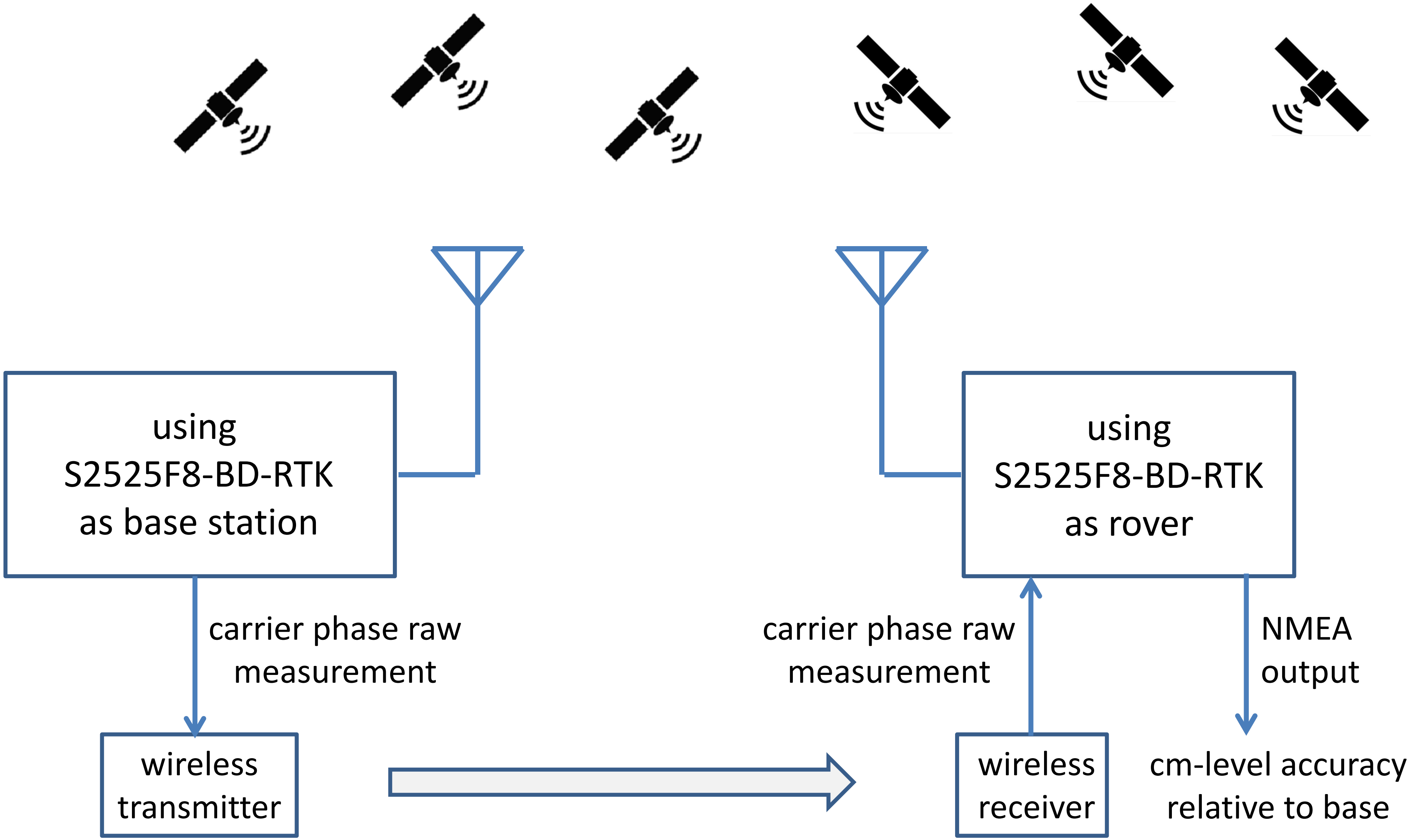
If base position* is accurate only to meters ➔ rover position* will only be accurate to meters but relative distance from base is still accurate to centimeters

* position refers to the latitude and longitude numbers reported by base or rover

Usage Configuration 1



Usage Configuration 2   1/4



Usage Configuration 2 2/4

- If a known surveyed point exists with centimeter position accuracy, placing base station S2525F8-BD-RTK antenna there, and enter the location coordinates into S2525F8-BD-RTK, then the rover NMEA output will have cm-level position accuracy.

RTK Usage Configuration 2 3/4

- If no known surveyed point exists, place the base station S2525F8-BD-RTK antenna at some fixed location that is to be later used as *reference point*.
- After base station S2525F8-BD-RTK self-surveyed, take note of the latitude/longitude location reported, to be entered as base station location for future use; also mark the physical location of the *reference point* for future use.
- Using this method, the rectangular land defined by 4 corners measured by GPS receiver that we shown earlier, if measured using RTK receiver over many different days, will only have area shifted in centimeters on Google Earth, not 10 meter!

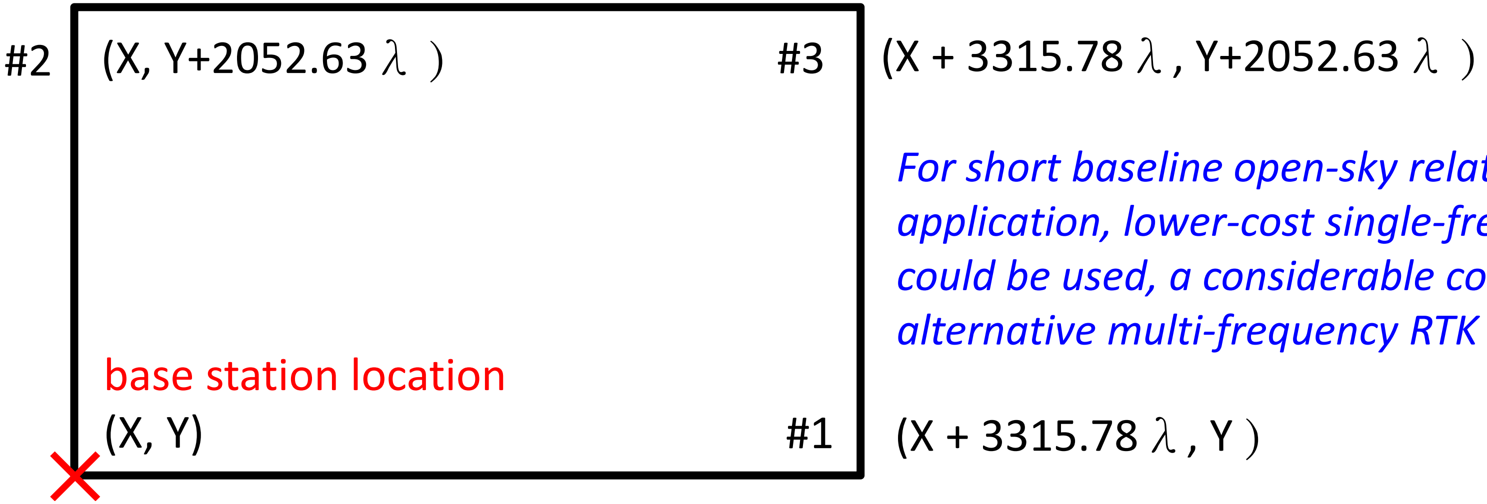
Usage Configuration 2   4/4

With base set at a fixed location, the RTK rover determines the other three corner locations as

#1: 3315.78 wavelength to the right
#2: 2052.63 wavelength to the north
#3: 3315.78 wavelength to the right and 2052.63 wavelength to the north

Once base (X,Y) is given a fixed coordinate, when RTK rover measures the other 3 corner coordinates at different days, the results will only differ by fractional wavelength, yielding centimeter-level accuracy relative to the base.

With this kind of rover-to-base relative positioning application, once base is set at a fixed location, accuracy of the (X,Y) coordinate that we measured, meter or centimeter, is not important, so long as the same (X,Y) coordinate number is used for base location, and base antenna is placed at same location afterwards when using rover to measure position.

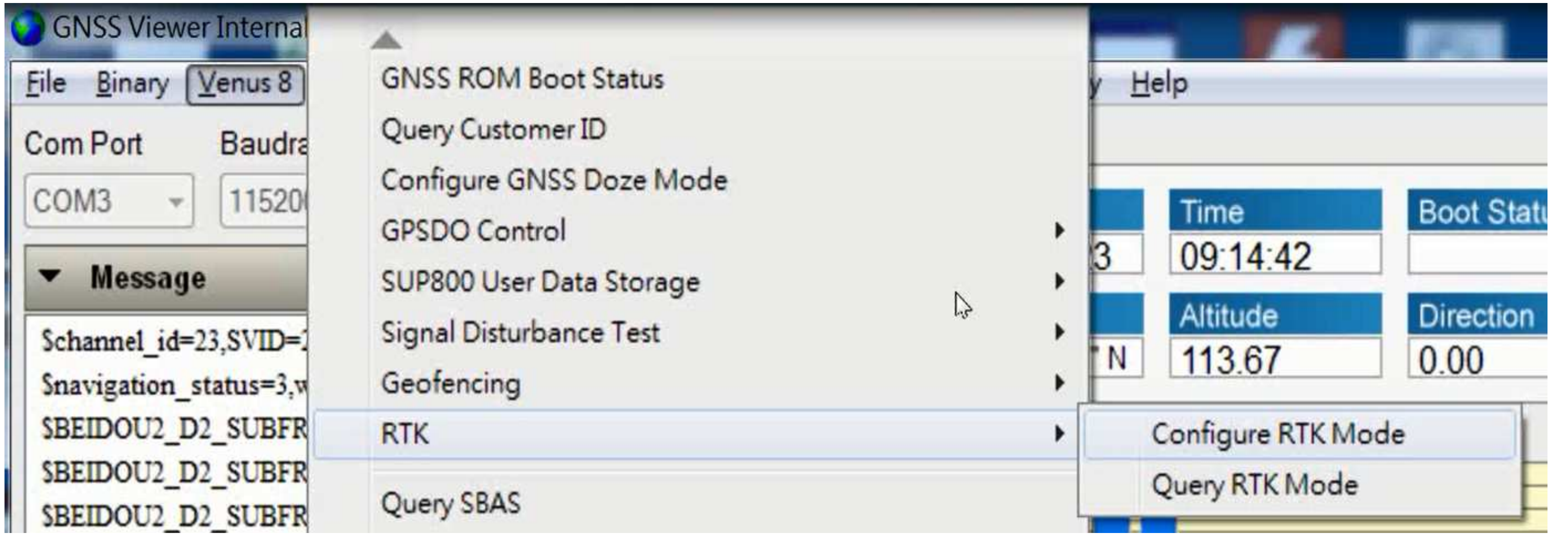


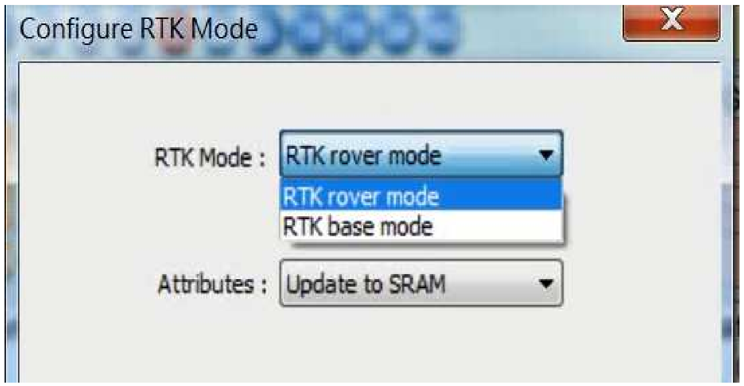
For short baseline open-sky relative positioning application, lower-cost single-frequency RTK receiver could be used, a considerable cost saving from alternative multi-frequency RTK receivers.

Setup as Rover

- From GNSS Viewer*

  Venus8 → RTK → Configure RTK Mode → RTK rover mode



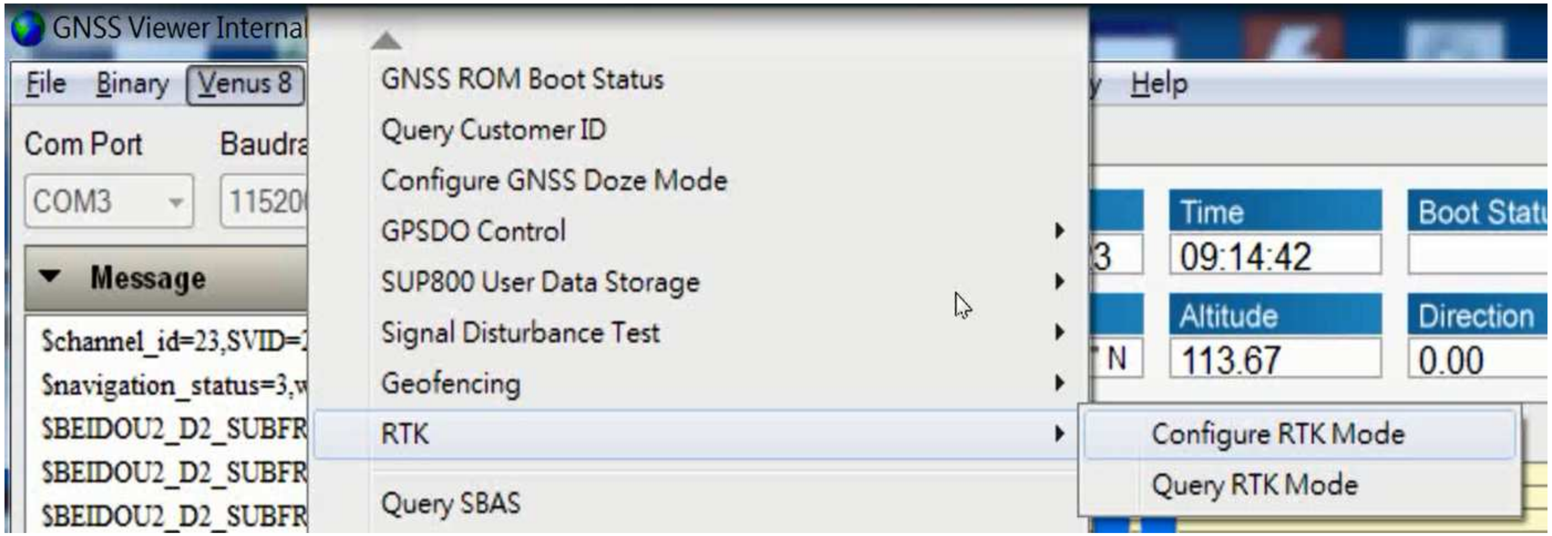


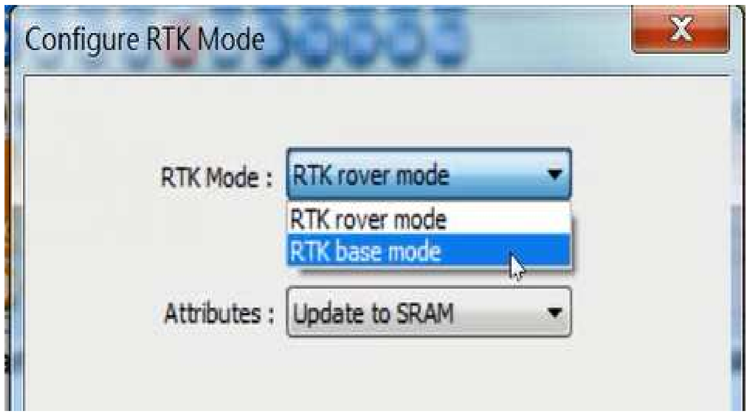
* Using SkyTraq GNSS Viewer
V2.0.166 or higher

Setup as Base (1/2)

- From GNSS Viewer

  Venus8 → RTK → Configure RTK Mode → RTK base mode

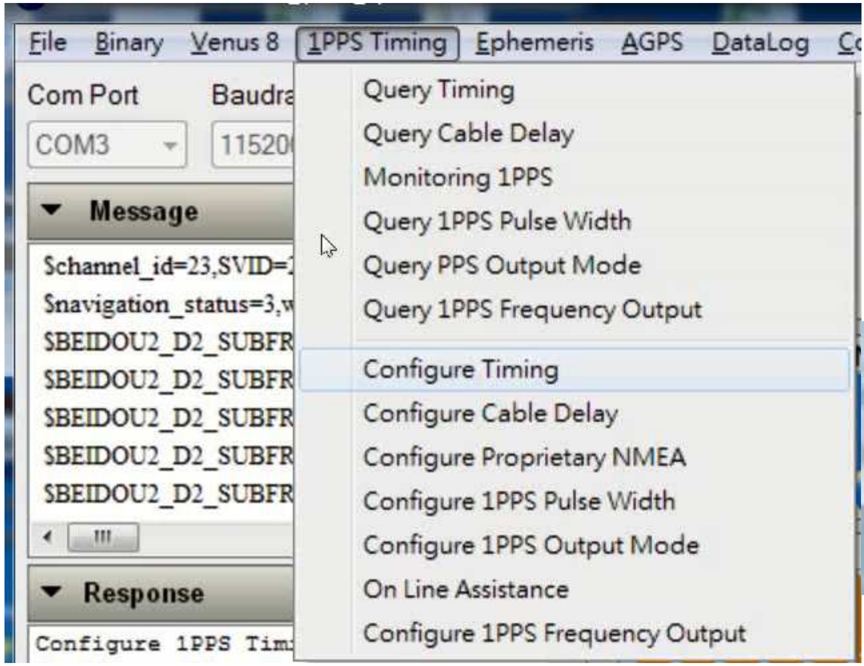


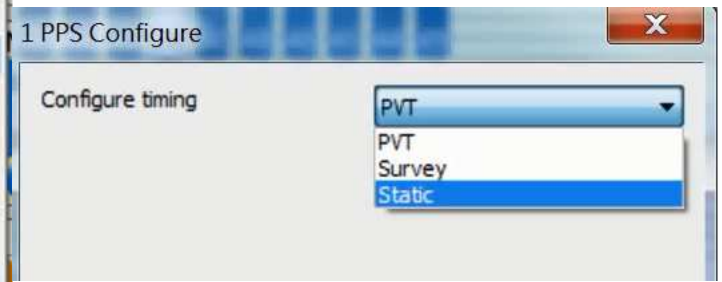


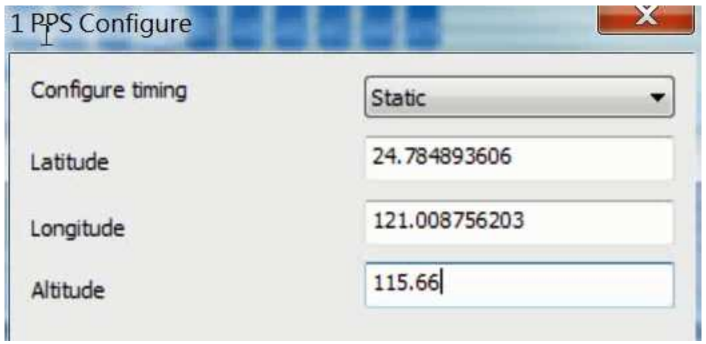
Setup as Base (2/2)

- From GNSS Viewer

  1PPS Timing → Configure Timing → Static (*input base position*)



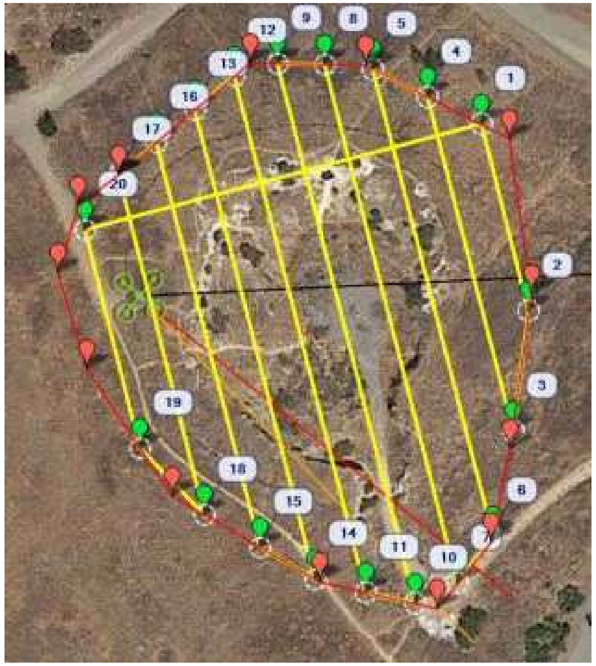




Application Example 1

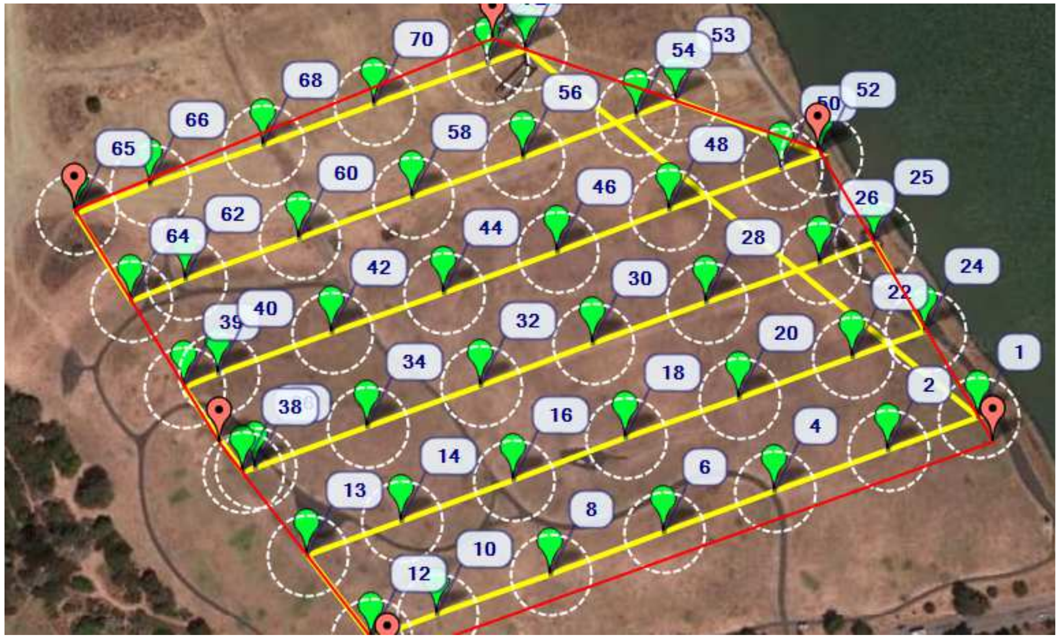
- Precision Machine Control

  Once coordinates of the polygon corners are determined by the rover, precision steering of machine can be controlled by the autopilot software using the cm-level accuracy position provided by the RTK rover



Application Example 2

- Precision Aerial Imaging
  - RTK rover equipped UAV can take photo at predefined locations, centimeter-level exact, resulting in images that are always taken at the right spot, always consistent.
  - Acquire same amount of image data when flying against or with the wind.



Known Issue

- BDS is not defined in RTCM 3.x spec yet. Each company has proprietary RTCM 3.x base-station BDS implementation. So limited compatibility with existing base station for BDS initially, but GPS portion is compatible. We'll provide support for additional different brand BDS base station as more information becomes available.

- GLONASS inter-channel bias is known to cause compatibility issue for different brand base & rover GPS/GLONASS RTK receivers, causing GLONASS portion not working for RTK when using rover with different brand base-station. Thus GPS/GLONASS RTK receiver will only have GPS satellites for RTK when used with different brand public base stations; in same situation as GPS/BDS RTK receiver could only use GPS satellites for RTK in US or Europe when connecting to public base station.

- When same RTK receivers are used for base and rover, then all receivable signals in the two satellite navigation systems can be used.

Available Models

	RTK Maximum Update Rate			Time/Position Stamp
	1Hz	5Hz	10Hz	
S2525F8-BD-RTK	X			
S2525F8-BD-RTK-5		X		
S2525F8-BD-RTK-5S		X		X
S2525F8-BD-RTK-10			X	
S2525F8-BD-RTK-10S			X	X

Lowest Power, Smallest Size

Empower your outdoor machine control, UAV aerial imaging, or GIS data collection applications with centimeter-level accuracy RTK technology !