bynav

No.: AN002

Level: Public

Version: 2020.03

BY682 High-Precision GNSS Board

RTK PERFORMANCE TEST

ABSTRACT:

This report summarizes the performances between BY682 high-precision GNSS positioning and heading board (hereinafter referred to as BY682) of BYNAV Technology and three other competitor boards in different scenarios. The test results demonstrate that BY682 can provide reliable, continuous ,centimeter-level ,real time positioning in the following scenarios, with more competitive performance than other competitors.

- Open Sky environment - initialization
- Open Sky environment - static
- Urban environment - dynamic vehicle

INTRODUCTION:

To obtain centimeter-level positioning, users usually use the Real-Time Kinematic (hereinafter referred to as RTK) algorithm. Generally, the base station receiver is placed over an accurately known point, then this receiver measures GNSS carrier-phase errors and transmits differential GNSS data (including receiver type, position, observation data) to rover station, which receives correction data and performs RTK solutions immediately. Once removing GNSS propagation errors and "fixing" the carrier phase integer ambiguity, the rover station can realize RTK fixed solution and obtain centimeter-level positioning. As long as the rover station fixes position accurately, and the satellite signals keep locked, and the differential GNSS data is continuous, the rover station can continuously provide centimeter-level positioning, otherwise it would fall to decimeters or meters in error.

RTK performance varies depending on the environment in which the work is being performed. BY682, driven by a new generation of signal tracking loop and more intelligent built-in algorithm framework, can provide stable signal tracking and high precision RTK solution, and achieve excellent performance against signal blockage and jamming under challenging environments.

Tests were conducted in the following scenarios :

- Open Sky environment - initialization
- Open Sky environment - static
- Urban environment - dynamic vehicle

Test results were measured by the following criteria :

- Accuracy——centimeter-level precision is the primary factor for high precision application;
- Availability——continuous real-time positioning is needed in the working environment;
- Integrity——position status in accordance with position precision is reliable;
- Initialization time——rapid time to first fix is necessary in actual scenarios ;

This report introduces the test set-up and methodology, then presents , interprets and summarizes the results.

Test Set-up and Methodology

The test set-up is shown in **Figure 1**, the only variable is the test boards (BY682, and three other latest models from competitors), the set-up ensures:

- all the test boards use the same GNSS antenna;
- all the test boards receive the same differential data;
- all satellite signals are connected and interrupted at the same time;
- power supply is within the range of each board, and is turned on and off at the same time;
- all the test boards use the same carrier board;
- all the test boards connect serial port through N-port to ensure the consistency of serial communication and data transmission.

Test Results

1. Initialization

As shown in **Figure 2**, the base station and rover station antennas are placed on the rooftop of building with open and unobstructed view. The test boards force a loss of signal at regular intervals by turn-off the board for 20 seconds then turn-on for 120 seconds. and circulate for 140 times initial attempts.

As shown in **Figure 3, 4, 5** and **Table 1**, BY682 and board B demonstrated the fastest time to position initialization within 20s with 100% success rate, while board A and C failed 4 times in first-time position, with 37s and 28s respectively for initialization.

Figure 1 Test set-up

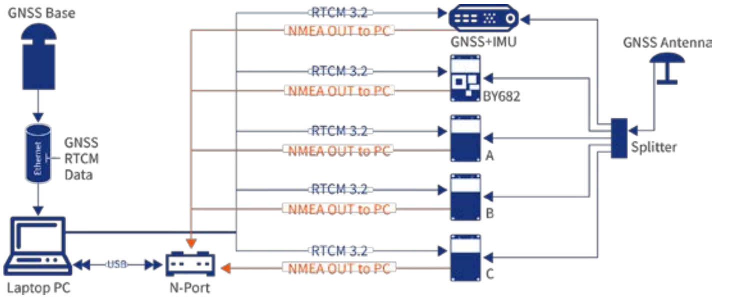


Figure 2 Antenna location

Figure 3 Percentage of time to first position

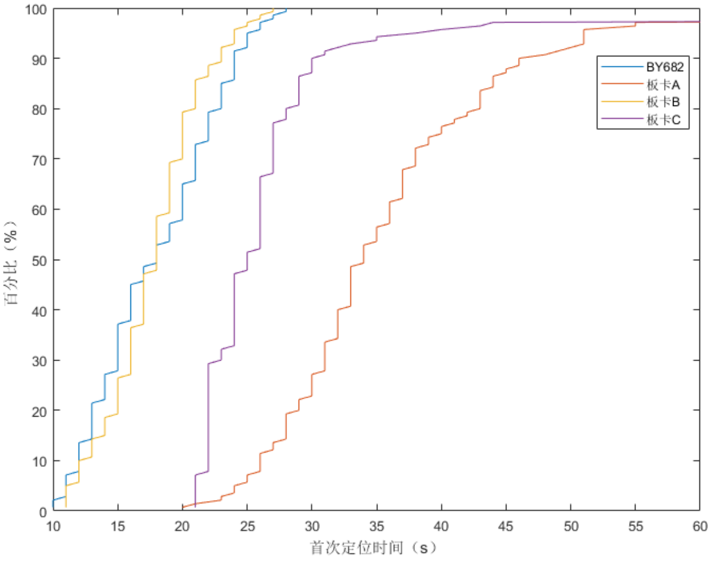


Table 1 Initialization time statistics

Model	Position Times	Fixed Times	Time to First Position RMS(s)	Time to First Fix RMS(s)	First Position Deviation RMS(s)	First Fix Deviation RMS(s)
BY682	140	139	19.23	21.89	2.21	0.94
A	136	135	37.38	51.69	17.75	0.93
B	140	124	19.65	48.67	3.43	0.89
C	136	135	28.24	42.94	11.73	26.52

BY682 demonstrated the fastest time to fix initialization with 22s on average, and the time other three boards needed exceed 40s. The first-time position deviation of BY682 is the lowest with RMS of 2.21m, board B has a slightly higher deviation of 3.43m, while the average deviation of board A and C exceeds 10m. The RMS of the first fixed position deviation of BY682, board A and board B is less than 1cm, while board C exceeds 20cm.

As shown in **Figure 5** the initial position of BY682 are very concentrated, with most of them within 2m. Board B is relatively concentrated, while board A and C has lots of position outliers more than 10 m.

Figure 4 Percentage of time to first fix

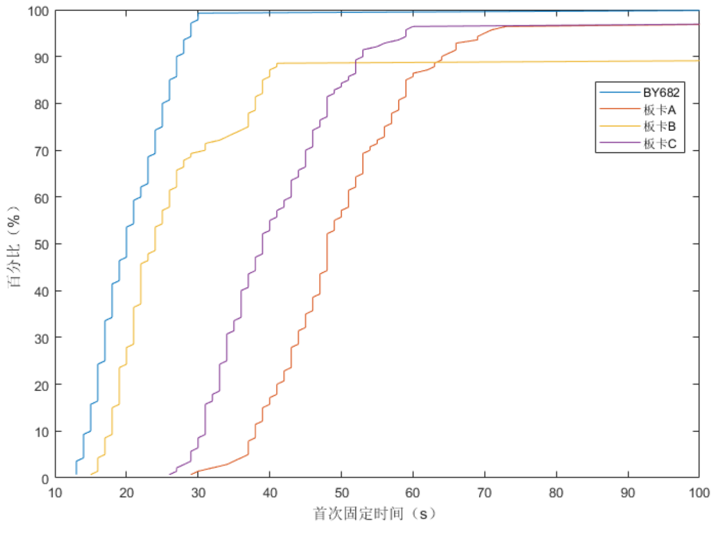
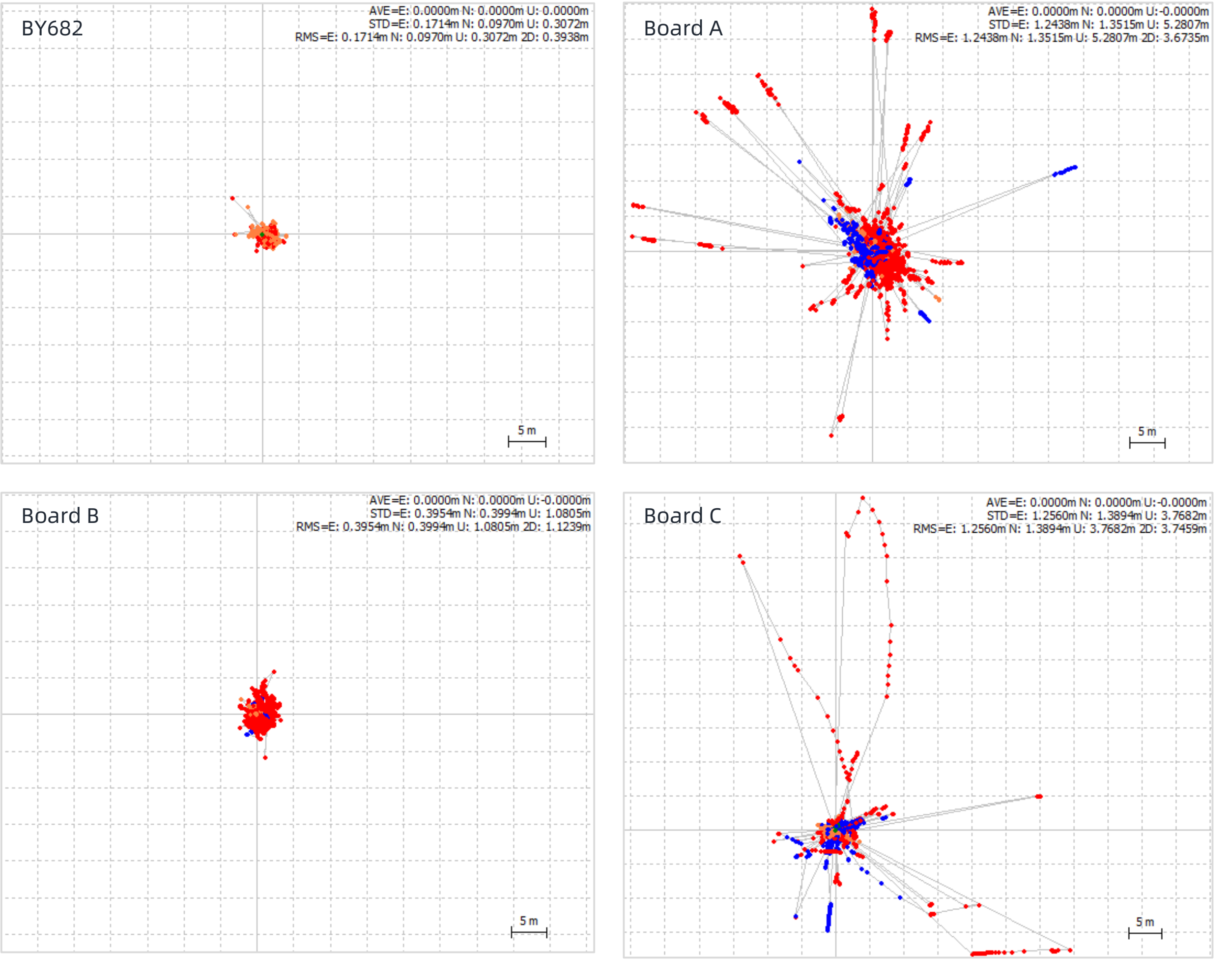


Figure 5 Initial position



2.Static Test

As shown in **Figure 6**, the base station and the rover station antennas are placed on the rooftop of building with open and unobstructed view. This static test spanned more than 24 hours under the same external conditions and all the boards keep RTK fixing.

The test results are shown in **Figure 7** and **Figure 8**, and the statistical data is shown in **Table 2**.

Figure 6 Antenna location

Figure 7 Position - static RTK

As shown in **Figure 7, Figure 8** and **Table 2**, BY682 showed the highest positioning precision in the horizontal direction (E/N) with RMS within 0.2cm, and board B also has high positioning precision with RMS around 0.2cm. Board A slightly falls behind, and board C have positioning fluctuations reaching to decimeter-level in the N-S direction.

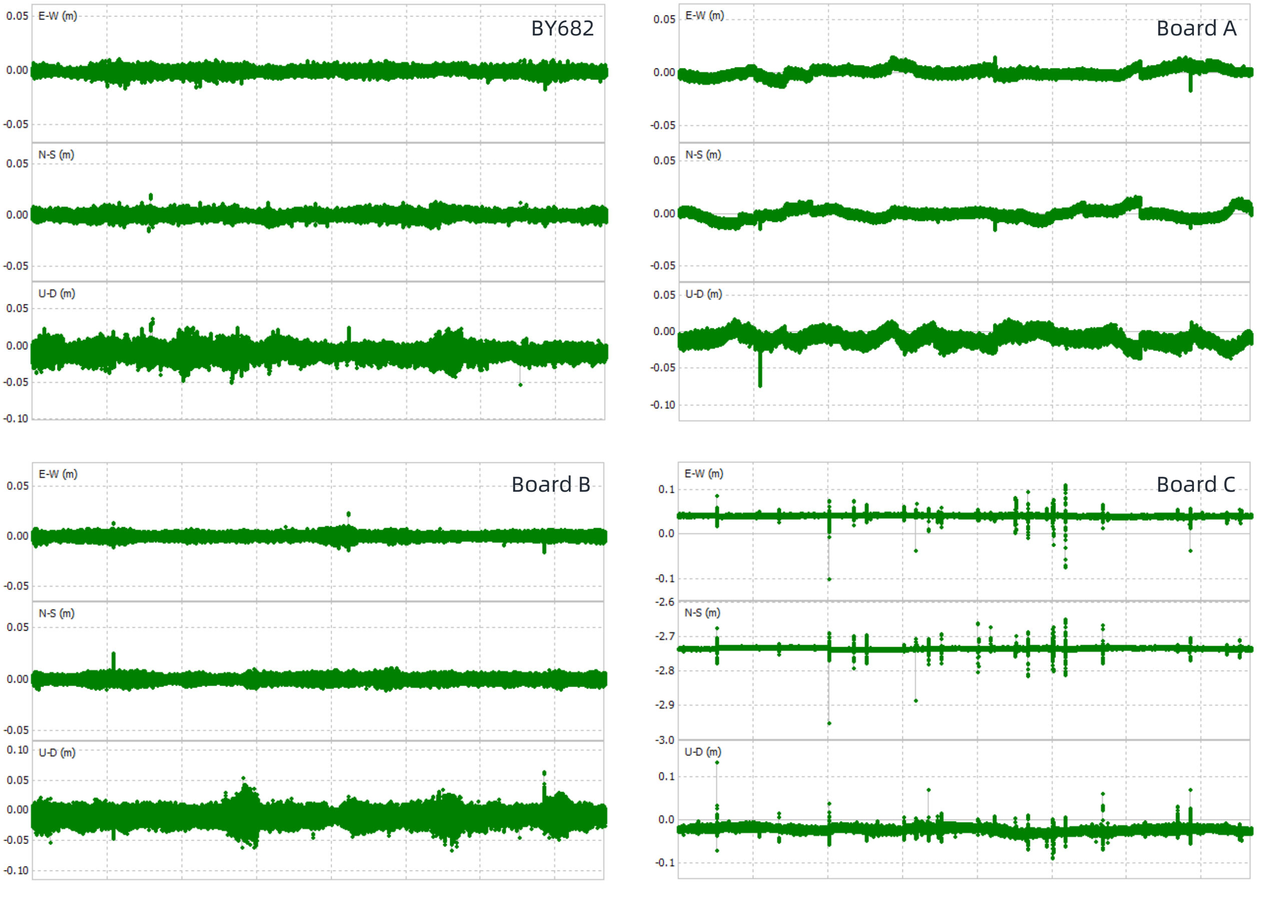
The STD in the horizontal direction of all the four boards is about 0.2cm, showing high stability, but the STD in the vertical direction of board A and BY682 is 0.2cm larger than the other two boards.

BY682, board A and B have fixed position fluctuated in a small range, but BY682 fluctuates slightly high in vertical direction, reaching to 10cm or more, and board C has lots of position outliers, resulting in decimeter-level wide range.

Table 2 Position statistics——static RTK

Model		Performance		
		STD(cm)	RMS(cm)	RNG(cm)
BY 682	E	0.16	0.16	3.99
	N	0.18	0.18	3.55
	U	0.69	1.17	13.22
A	E	0.37	0.37	3.19
	N	0.43	0.43	3.25
	U	0.70	1.14	9.01
B	E	0.19	0.19	2.85
	N	0.21	0.21	3.62
	U	0.53	1.03	8.94
C	E	0.16	4.20	21.30
	N	0.23	73.39	30.33
	U	0.47	2.29	22.40

Figure 8 Position precision—— static RTK



3. Dynamic Vehicle

The base station antenna remains in the same location as shown in **Figure 2**. The real world environment of the vehicle route is shown in **Figure 9**, which includes the most typical urban environment such as open sky, foliage canopy, urban elevated road, high-rise building, low-rise building. The dynamic test was carried out on the four boards at the same time under the same external conditions.

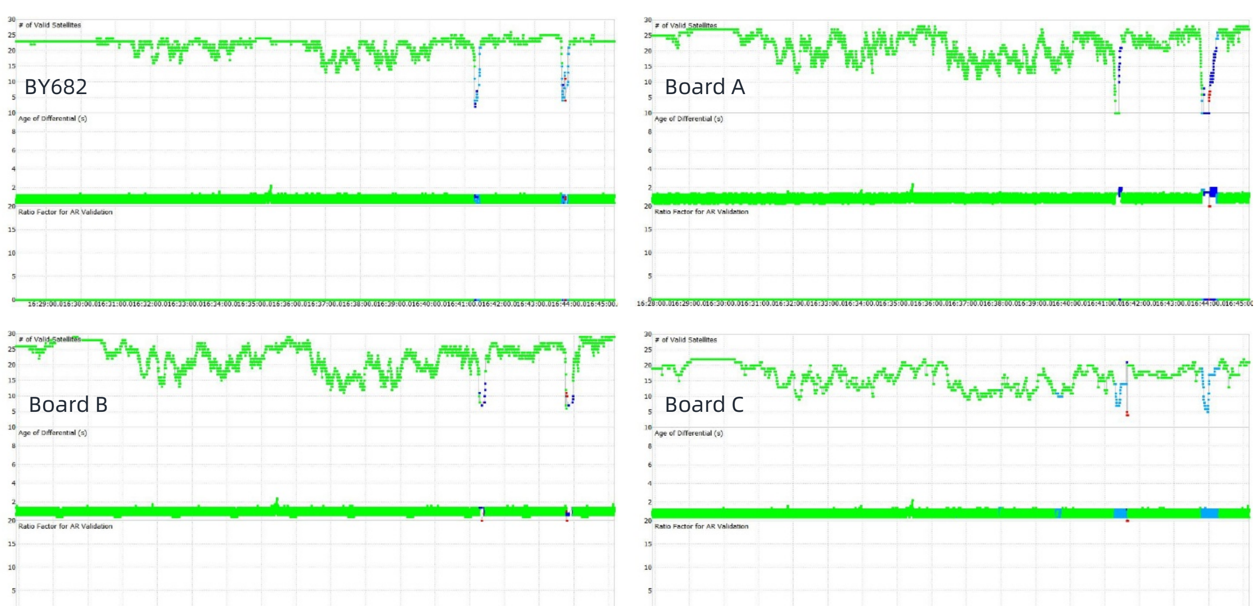
The fix errors refer to real-time position deviation exceed 0.2m between the board and the standard integrated navigation device; The reverse-processing position from the latter one are taken as reference for RMS and maximum value.

Figure 9 Typical urban environment

Table 3 Position statistics—— dynamic vehicle RTK

Model	Fixed Solution %	Number of fix errors (%)	Fixed solution RMS(m)			Fixed solution max (m)		
			E	N	U	E	N	U
BY682	98.9%	54(1.06%)	0.0272	0.0207	0.0438	0.4102	0.4445	0.4928
A	96.8%	119(1.15%)	0.1770	0.1705	0.0808	6.7144	6.3840	2.2196
B	99.6%	499(9.83%)	1.1903	0.8538	0.0836	1.5242	1.4963	1.1246
C	93.9%	225(4.35%)	0.2652	0.3447	0.0693	4.3677	2.9928	0.6516

Figure 10 Number of satellites used——dynamic vehicle RTK

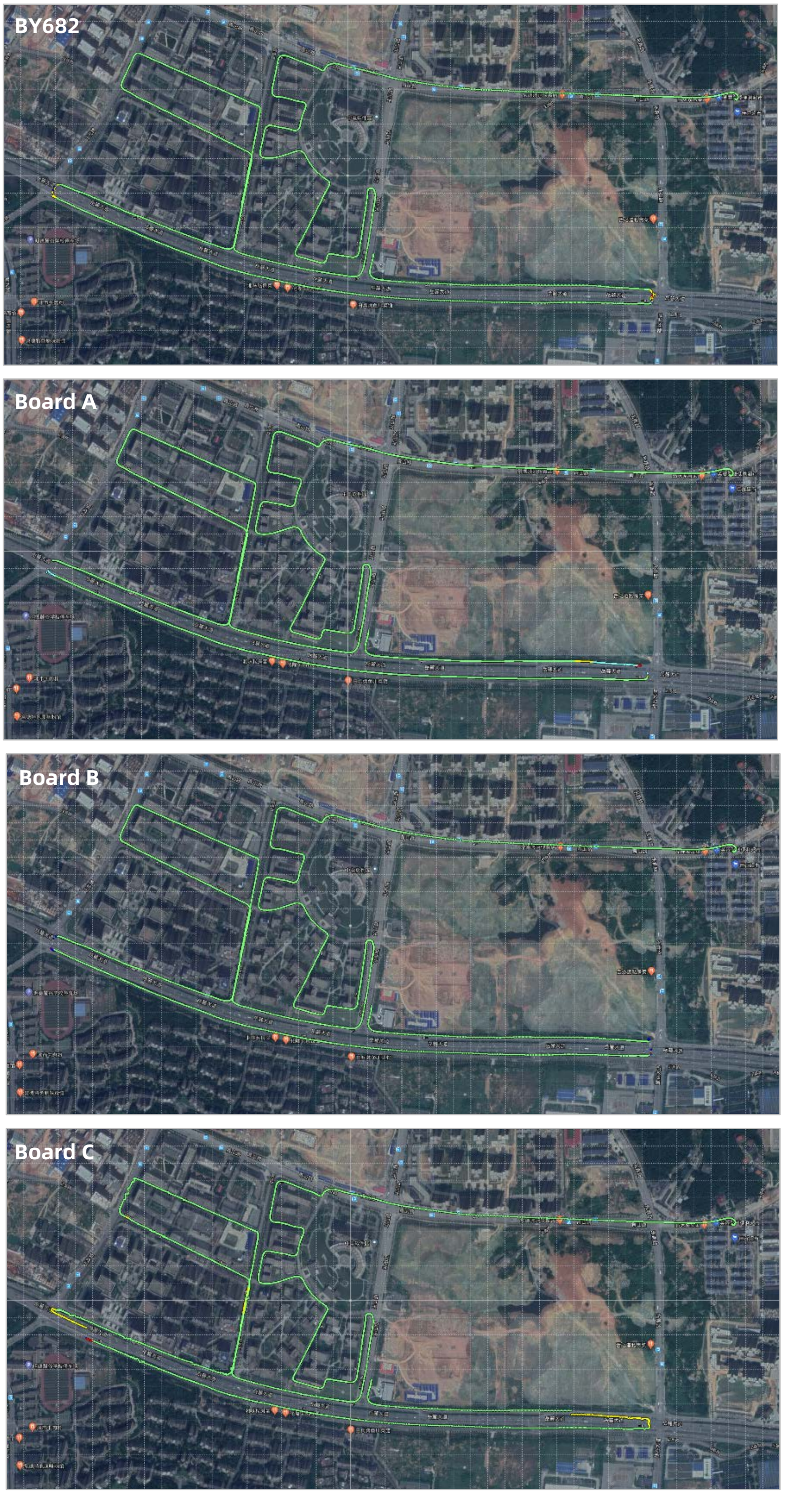


As shown in **Figure 10**, **Figure 11**, and **Table 3**, the number of satellites used in fixed solution of the four boards are only about 20 in urban environment, and drop down below 10 after the elevated road because of the extremely rigorous conditions. However, all the four boards have high fixed solution ratio, especially BY682 and board B, which reflects strong adaptability in the urban environment.

All the four boards have more than 90% fix solution ratio, especially BY682 and board B have 98% or more. Both of them can maintain fixed solution status in complex urban environment; **Figure 11** shows board A and C cannot fix solution rapidly after passing the elevated road, and board C adopts the position extrapolation strategy when passing the elevated road, but the real-time position deviate a lot from the reality.

BY682 shows the highest accuracy of dynamic fixed solution, nearly 99% of the fixed solutions have a deviation within 0.2m from the standard position. Board A has also high accuracy, closely followed by board C. Although board B has the highest number of fixed solutions, but with poor accuracy, about 9.83% of the fixed solutions have a deviation exceed 0.2m from the standard position, showing low availability in the fixed solution results.

Figure 11 Real-time position—— dynamic vehicle RTK



BY682 has the highest positioning precision and minimum fluctuation in fixed solution, with the smallest RMS and fluctuated value in each direction. The RMS of the positioning error of BY682 is less than 3cm, while board A and C are more than 10cm, and board B exceeds 1m; the maximum value of positioning error of BY682 is less than 0.5m in all directions, board C is less than 1m, and the other two 1m or more. These three still have a lot to optimize in dynamic positioning precision.

CONCLUSION:

In order to measure the performance of different GNSS receiver boards in the real world environment, we conducted tests in the following scenarios:

- Open Sky environment – initialization
- Open Sky environment – static
- Urban environment – dynamic vehicle

The positioning precision, availability, integrity and initialization time are considered as the criteria to analyze test results in detail.

During **initialization time test**, BY682 shows the highest fixed solution times, and have the shortest time to first fix, as well as the lowest first fix position deviation within 1cm. Furthermore, BY682 can initialize first position and fix around 20s in average, and board B can also receive position initialization around 20s, but takes more time in receiving fix initialization, while board A and C takes more time in position and fix initialization. BY682 has the best consistency in initialization time tests, closely followed by board B, while board A and C needs to be optimized.

The **static test** shows that BY682 has the best positioning precision in horizontal direction, board B also performs well, and board A is slightly poor, board C fluctuates a lot. However, BY682 needs to be slightly optimized in vertical fluctuation, and board C has more position outliers in static status and the performance needs to be improved too.

The **dynamic vehicle test** shows that BY682 has the highest positioning precision and the smallest positional fluctuation under the fixed solution status, and the RMS of positioning errors and fluctuated range in each direction are much smaller than other three boards, which shows BY682 can provide real-time, continuous and reliable centimeter-level position in complex urban environments.

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