SinoGNSS®
By ComNav Technology Ltd.

# WHITE PAPER

The new Quantum™ Algorithm by
ComNav Technology – July 2016


## ABSTARCT

The latest Quantum™ algorithm, as an upgrade of ComNav Technology Quan™ Algorithm, is a brand new technology that improves dramatically the stability and reliability of RTK positioning in complex environments, as well as providing a *DP-filter* enhancement for the ComNav GNSS products. This new algorithm can be easily achieved through firmware upgrade (Version 2.5.2 and above). With this advanced smoothing filter in standalone mode, applications such agricultural guidance, fleet management, where pass-to-pass accuracy is important will largely benefit from. Moreover, Quantum™ technology can be provided on all ComNav OEM boards and OEM-based receivers. This white paper describes the performance enhancements with Quantum™ algorithm, and the latest test results.

## INTRODUCTION

In recent years, GNSS technology has largely improved efficiency and productivity for surveying professionals, especially in high-accuracy GNSS positioning fields. However, the positioning stability and reliability are still the main issues that concern most GNSS manufacturers. After years of research, ComNav Technology Ltd. has developed Quantum™ technology to provide superior positioning stability both in RTK and single-point mode at a superior level. With RTK surveying Quantum™, users are able to see lesser jumping points in harsh environments, and higher positioning accuracy even in float solution (Fig.3a-3c). Also Quantum™ provides better CORS compatibility, which means that our products can perform well in areas with poor CORS geometry distribution (Tab.3). In terms of single-point positioning, testing shows it provides smoother and consistent performance, reaching 20 cm pass-to-pass accuracy.

## QUANTUM™ OVERVIEW

Quantum™ technology is a comprehensive algorithm that largely improves the positioning capability of ComNav GNSS products, mainly from three aspects: observation data quality, reliability of RTK positioning and smoother single-point solution.

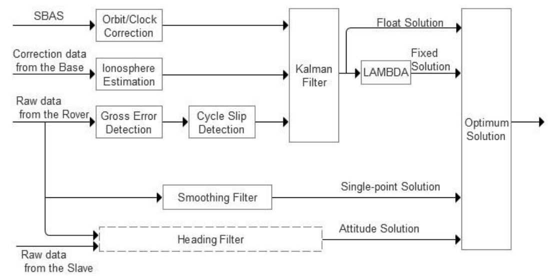



*Fig.1: Flowchart of QUANTUM™ Algorithm*

Observation data quality is the fundamental part of GNSS positioning, and it must be stable and reliable in ideal environment. However, users commonly work in complex environment, which largely reduces the signal acquisition capability and observation data quality. To solve such problems, Quantum™ technology is designed to fast cycle slips detection in complex environment. It also improves the self-correlation and cross-correlation of signal acquisition.

To improve stability and reliability of RTK solution, Quantum™ technology uses a new *Robust Adaptive Filtering Algorithm* which applies the error estimation techniques to detect and remove the blunder errors in the observables. This new adaptive filter algorithm has the advantages of the Kalman filter, adaptive Kalman filter, error estimation and sequential Least-square estimation methods. By applying this method, the jittering of the ambiguity fixed solution is dramatically reduced. Using this new adaptive filtering technique also improves the accuracy and stability of the floating-point solution with the net result that positioning far more robust.

In addition, considering the increasing number of available GNSS constellations in view, Quantum™ adopts frequency-offset auto-detection for GLONASS, which provides better compatibility than any other brands. It also extends the capability to acquire correction messages from CORS especially in areas with poor CORS geometry distribution.

In the single-point positioning, we adopted a new smoothing filter, *DP-filter,* which comprehensively implements carrier phase, delta-carrier phase, pseudorange and Doppler observation. Carrier phase is more accurate, less noisy and much resistant to multipath effect. From the merits of the carrier phase, with dual-frequency signals, the smooth positioning method improves positioning accuracy and creates a robust solution, immunise from the effects of noise and ionospheric errors.

## PERFORMANCE ANALYSIS

To show performance improvements of Quantum™, we did comparison tests from various aspects, and test results were based on the previous version 2.30 firmware compared with the new-released 2.5.2 firmware that has Quantum™ algorithm. All test results were provided by ComNav research and development centre.

### RTK Positioning/Fixing Performance Test

The first test is to compare Quantum™ performance in RTK mode from firmware version 2.30 with firmware version 2.5.2 and a product of an industry competitor. We used ComNav K708 OEM boards as the base and rover in different firmware versions, and the similar product model of base and rover in competitor side. The base stations were installed 8-Km away from rovers in clear sky condition. Moreover, to ensure reliability of the test results, the signal from the GNSS antenna was splitted into three receivers (ComNav T300 antenna). All tests were carried out in heavy tree canopy environment (see Fig.2).

*Fig.2: Test environment (Tree Canopy, Shanghai)*

Fig.3a – 3c show the height rover position errors in meters, and attitude/longitude errors in Fig.4. It can be seen that Quantum™ technology (firmware version 2.5.2) remarkably improves the percentage of fixed solutions and provides smoother float solution.

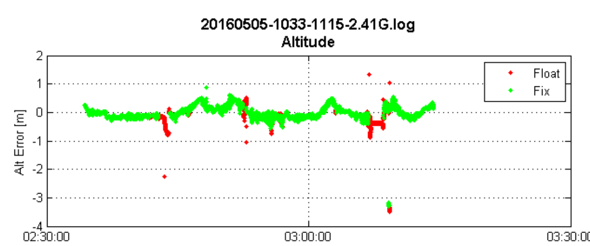



*Fig. 3a Rover position error - K708 2.5.2 [m]*

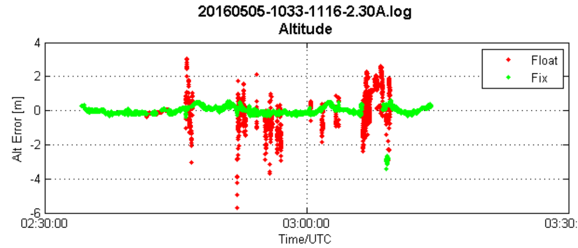



*Fig. 3b Rover position error - K708 2.3.0 [m]*

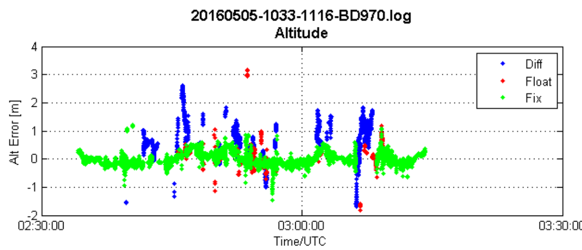
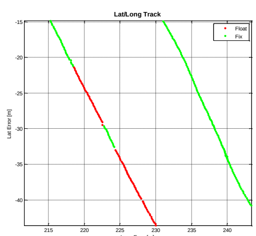
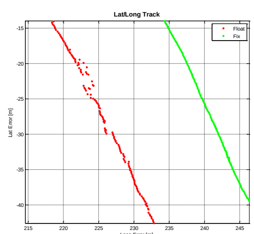


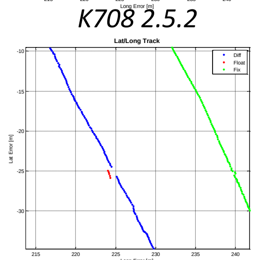

*Fig. 3c Rover position error – competitor A [m]*




*K708 2.5.2*




*K708 2.30*




*Competitor A*

*Fig.4 latitude/longitude error comparison*

Another test was conducted to check the performance of fixing ambiguity in RTK solution. The test setup is same as above, and Table 1 summarizes the RTK fixing performance around 3 hours in terms of total epoch number, fixed epochs and fixed percentage.

| Name | K708 2.5.2 | K708 2.30 | Competitor A |
|---|---|---|---|
| Total epochs | 12000 | 12000 | 12000 |
| Fixed epochs | 10477 | 9919 | 9705 |
| Fixed percentage | 87.31% | 82.66% | 80.88% |

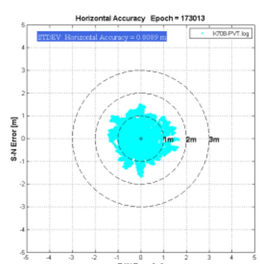
*Table1. RTK fixing performance*

**Single-point Performance Test**

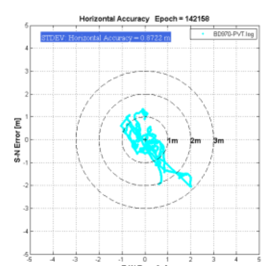
In clear sky conditions, we tested K708 OEM boards (version 2.5.2 firmware) with products from other two competitors. Testing time lasted 2 days with dual-frequency single-point mode. Table2 and Fig.5 show the significant advantage in reducing horizontal and vertical errors.

| Name | K708 2.5.2 | Competitor A | Competitor B |
|---|---|---|---|
| Constellations | | BD2+GPS+GLO | |
| Total epoch | 173013 | 142158 | 172799 |
| Horizontal RMS(m) | 0.8089 | 0.8722 | 0.7446 |
| Vertical RMS(m) | 1.4000 | 1.7575 | 1.4617 |

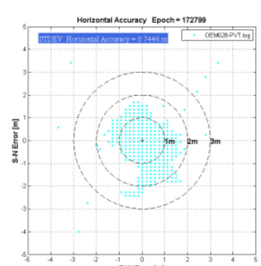
*Table2. Single-point performance*



*K708 2.5.2*



*Competitor A*



*Competitor B*

*Fig.5 single-point positioning error*

To show the positioning performance with *DP-filter*, two ComNav K708 OEM boards were setup in parallel with one ComNav T300 antenna mounted on a trolley. One was running with *DP-filter* (version 2.5.2 firmware), another was running in previous firmware (version 2.30). The testing trolley was traveling at speeds of 7-10 km/hour through a playground. Fig.6a-6b shows that it largely reduces positioning jumps with *DP-filter*.

*Fig.6a Single point positioning (version2.30)*

*Fig.6b Single point positioning (version2.5.2)*

**Compatibility Test**

In the compatibility test, the ComNav T300 receiver was used in a CORS network with a weak geometry distribution and the average baseline range superior of 40 km. in the following Table3, the ambiguity fixing performance is presented and the successful fixing rate is improved by 10%. At the same time, the average initialization time is reduced by 20% from the version 2.30.

| **Firmware version** | **2.30** | **2.5.2** |
|---|---|---|
| Total epoch | 1057 | 1057 |
| Fixed epoch | 556 (52.6%) | 673 (63.7%) |
| Initialization time | 9 | 9 |
| Successful initialization rate | 7 (77.8%) | 9 (100%) |
| Average initialization time | 27s | 22s |

*Table3. RTK performance in CORS mode*

## Conclusion

In summary, the new Quantum™ algorithm improves the stability and reliability of the RTK solution particularly in complex environments, and truly helpful for users working in urban areas with many buildings and heavy tree canopies. For the single-point positioning mode, Quantum™ algorithm demonstrates a smoother positioning solution, which well suits precise agriculture guidance, automatic pilot systems, and in general all applications where pass-to-pass accuracy is critical. Also when engaged in area where GNSS Network RTK corrections are available, the new Quantum™ algorithm allows the users to acquire and keep high accurate solutions even if the CORS network exhibits a poor geometry distribution.

ComNav, as the first GNSS OEM Board manufacturer of China, owes the core high-accuracy GNSS positioning algorithms, and continuously improves the quality of GNSS products over the time. It is also certain that much more high-quality GNSS products will be developed by ComNav in the near future.

For more information visit: *http://www.comnavtech.com*

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