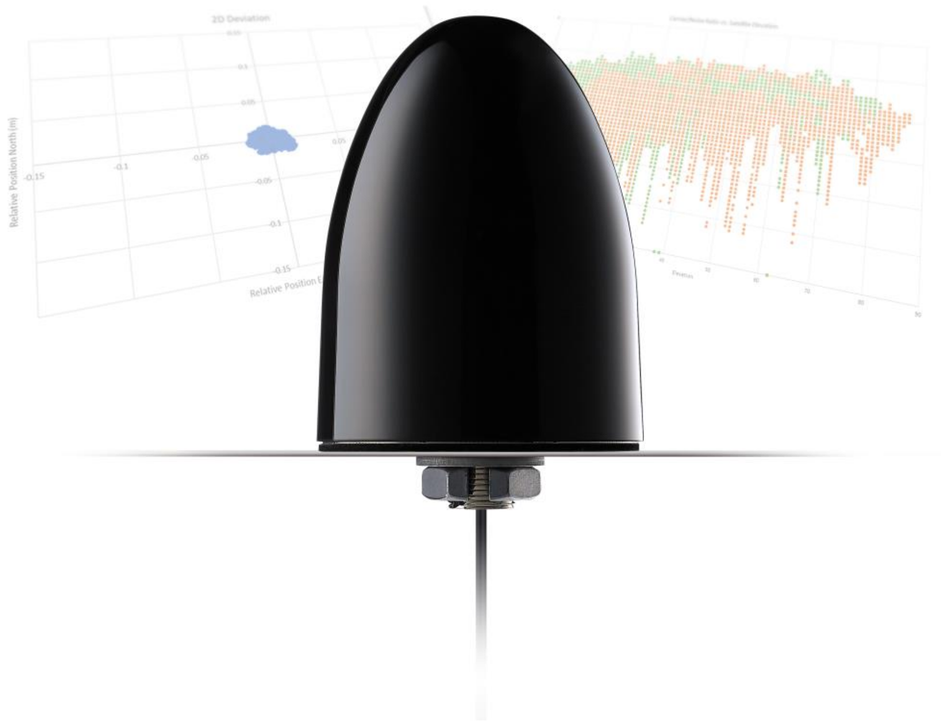
Application Note:
Centimeter-Level Positioning with Single-band RTK and High-performance GNSS Antennas



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1. Introduction

Recent commercial developments in GNSS receivers have begun to make the dream of centimeter-level outdoor positioning a reality for certain applications. These receivers use Real-Time Kinematic (RTK) or Differential GNSS (DGNSS or DGPS) methods to reduce the impact on positioning accuracy of atmospheric and similar effects.

To fully realize the potential of these systems, a high-performance single-band Quadrifilar (Quad) Helix antenna has been developed by Taoglas. The AQHA.11 provides excellent phase and circular polarization stability across frequency and space. These traits provide excellent multi-path rejection and phase center stability.

To demonstrate this potential, a DGNSS system was constructed using standard commercial off-the-shelf (COTS) receivers. The results are presented in this application note.

2. Test Setup

The system was constructed around a pair of u-blox NEO-M8P boards from the [C94-M8P](C94-M8P) evaluation kit (Figure 1).

Figure 1 u-blox C94-M8P evaluation board (courtesy u-blox)

These boards were configured as a DGNSS system, with one acting as a base station and the other as a rover. As is typical in this type of setup, the base station generates correction data and sends it to the rover. The distance between the base station and rover (the baseline) was kept short (< 2m) to minimize baseline effects. A Taoglas AQHA.11 was used as the base station antenna for all tests.

The base station was configured as an NTRIP server and provided RTCM v3.2 correction data. The rover used an NTRIP client to receive the RTCM data. Like the hardware, COTS software (u-blox u-center) was used for all data gathering and DGNSS operation. See the block diagram in Figure 2.

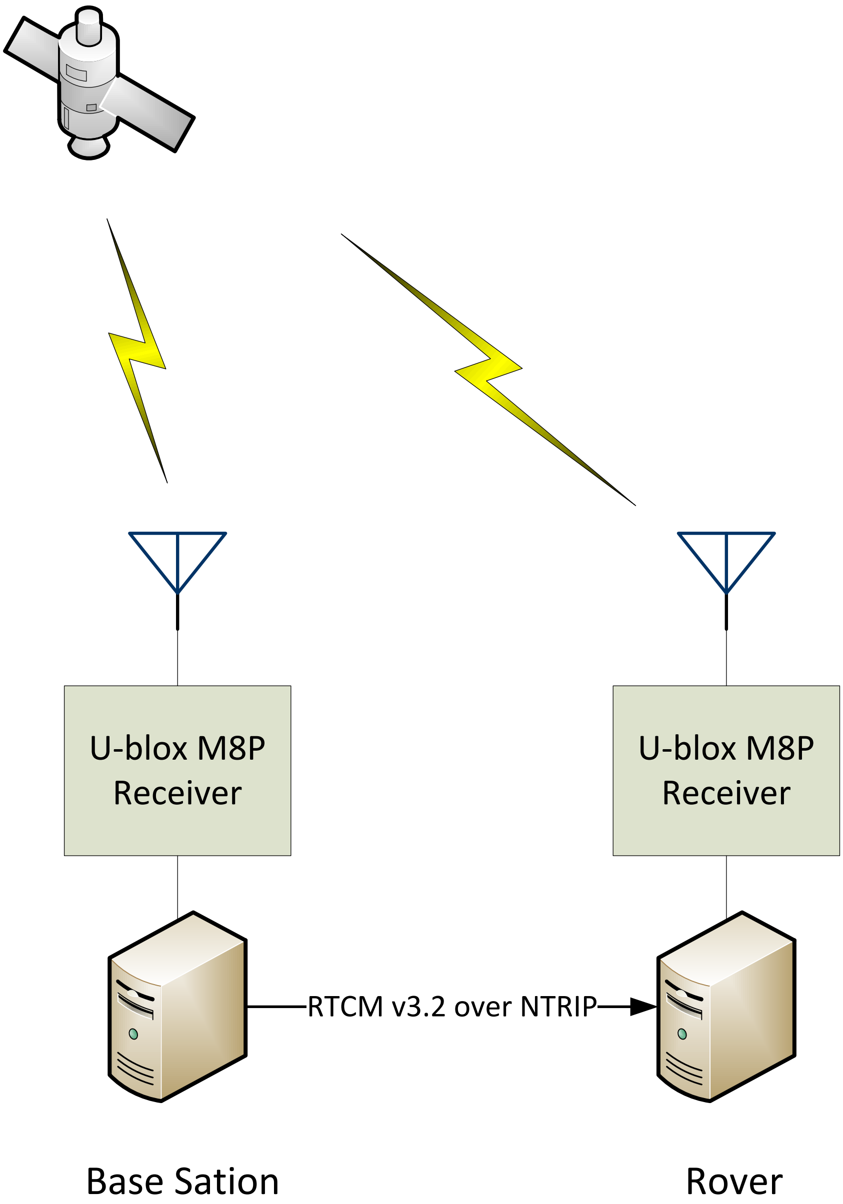

Figure 2 System configuration

To minimize the effects of satellite availability, the evaluation times were constricted to the 0000 – 0600 UTC time frame. Since the GPS constellation is periodical with a 24h period, this meant the same GPS satellites were available.

Some data points were removed during the evaluation to remove erroneous outliers. These points were:

- Data points with fewer than 5 satellites available
- Data points without DGPS in use
- Data points without a valid fix
- Data points without a relative position

More than 7 satellites were available for all evaluation times. Dilution of Precision (DOP) metrics were not restricted or constrained during this evaluation.

The rover receiver generated a relative position to the base station. This data was used for the analyses below.

From the resulting 6 hours of data (around 20k data points), the following was calculated:

- Average 2D relative position using the North/East coordinate system
- Deviation of all relative positions from the average
- Standard deviation of North, East, and 2D deviations

3. Results

3.1. AQHA.11 as Base Station Antenna

3.1.1. FXP611 as Rover

The Taoglas FXP611 Cloud is a high-efficiency flexible circuit GNSS antenna. It features wide bandwidth and light weight, making it an excellent option for weight-sensitive applications.

Figure 3 Taoglas FXP611

The position deviation data points for the FXP611 are plotted in Figure 4.

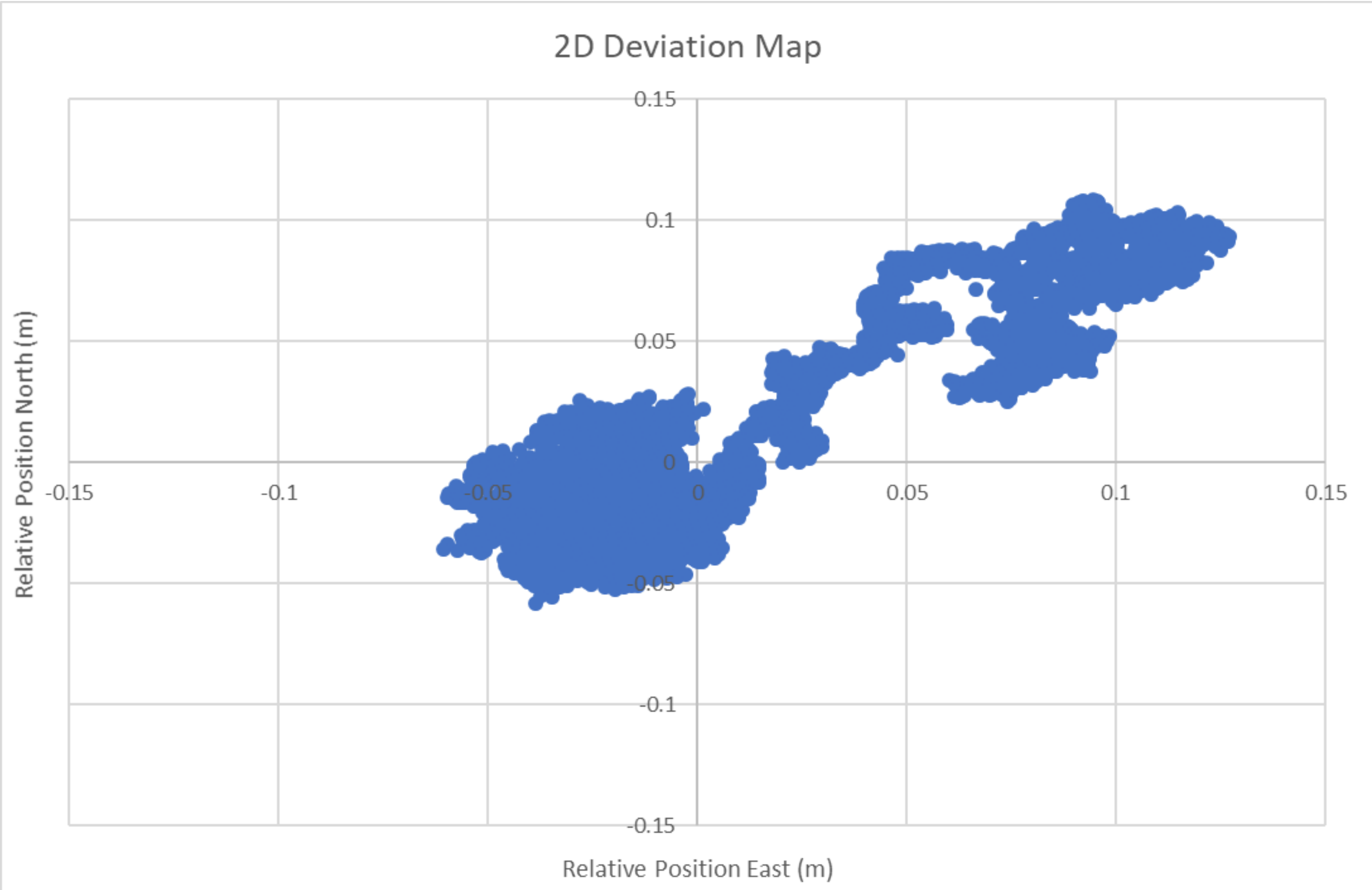

Figure 4 Relative position deviation map, FXP611 as rover

3.1.2. AQHA.11 as Rover

The AQHA.11 is a high-performance GNSS Quadrifilar Helix Antenna (QHA) supporting GPS L1, BeiDou B1, and GLONASS G1. The AQHA.11 features wide bandwidth, wide gain and axial ratio beam width, and excellent phase stability. The AQHA.11 provides an excellent choice for high-stability single-band GNSS positioning and timing applications.

Figure 5 AQHA.11 Quad Helix Antenna

The position deviation data points for the AQHA.11 are plotted in Figure 6.

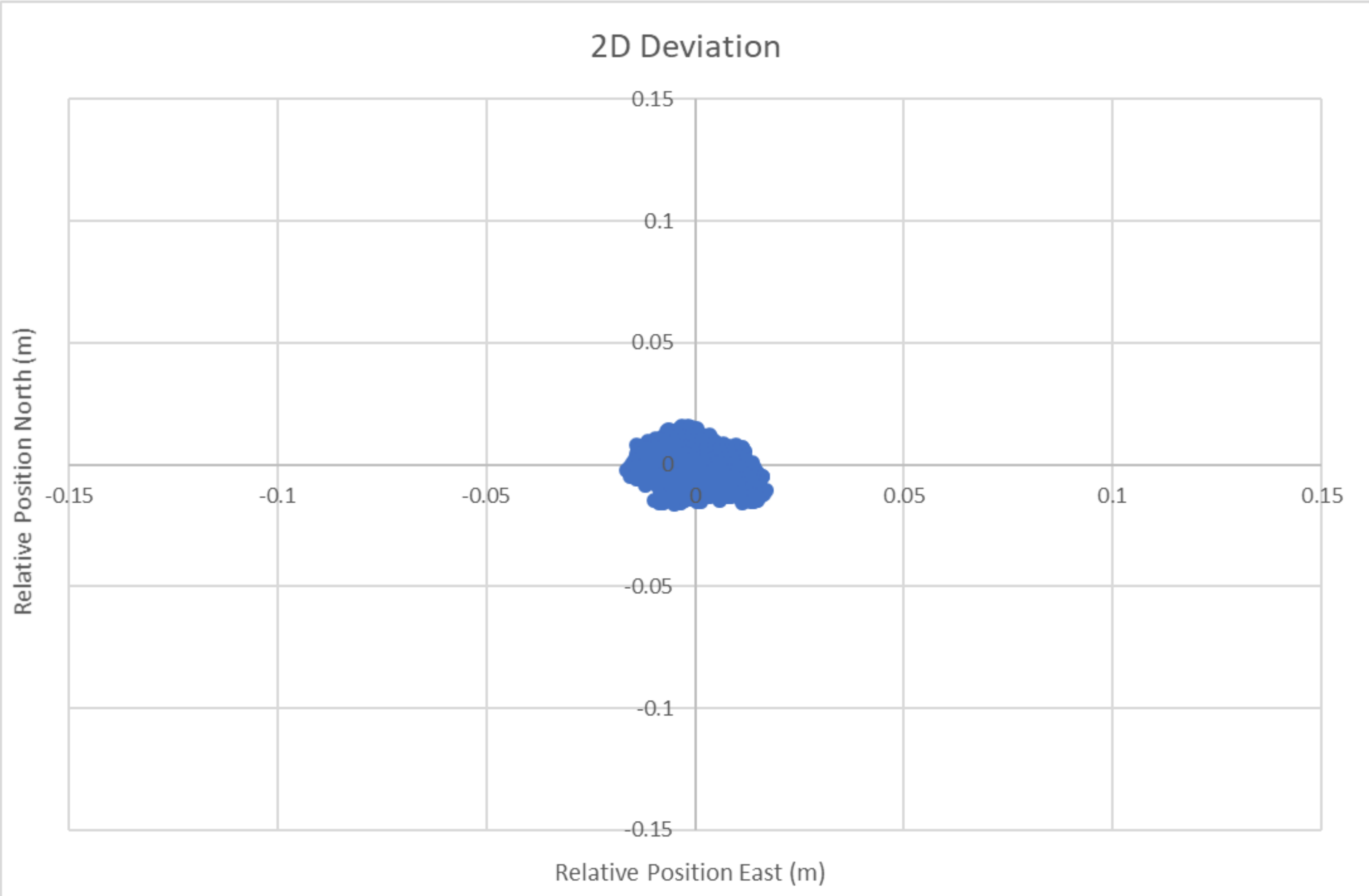

Figure 6 Relative position deviation map, AQHA.11 as rover

3.2. Results Summary

Table 1 provides a comparison summary of the results from Sections 3.1.1 and 3.1.2. A primary focus is on the Standard Deviation (SD) of the deviation map. A larger SD depicts a wider spread of positioning across the map showing a variable rate of accuracy. With the AQHA.11 however, we are clearly seeing a tighter cluster of deviation data points indicating a much higher level of positioning accuracy. Additionally, we are seeing similar metrics between the North and East indicating little or no pattern or phase bias. What we have with the AQHA.11 is a more circular pattern, indicating that the fix is highly stable and reliable by comparison to anything in the marketplace.

Metric	FXP611	AQHA.11
SD, North	3.8 cm	0.4 cm
SD, East	4.2 cm	0.5 cm
SD, 2D	3.2 cm	0.5 cm
Max-Min, North	16 cm	3.2 cm
Max-Min, East	18 cm	3.3 cm

Table 1

4. Conclusion

With modern GNSS receivers, it is possible to create a decimeter or centimeter level positioning system. A lightweight, compact antenna such as the FXP611 can be used and still benefit from RTK or DGPS techniques to provide decimeter-level positioning.

A high-performance antenna such as the AQHA.11, by contrast, can bring centimeter-level positioning and timing solutions to a whole new level for a wide variety of applications such as Autonomous Driving, Augmented Reality, Remote Monitoring and Connected Health to name a few that will deploy centimeter level accuracy.