Radio Testing with GNSS RTK System

2019-01-18 by Stefan Witanis and Sarika Nagaraj

Overview

GNSS RTK receivers need to receive RTK corrections from the base station to work in high precision RTK mode. One way of transmitting such data is via radio. The reliability and range of the radio link directly affects RTK operation and overall system performance. This report demonstrates the importance of a reliable radio link within an RTK system, and illustrates the performance differences between several different radio models.

In July 2018, Swift engineers performed a special field test to compare five radios in a typical agriculture environment. In January 2019 additional two 2.4 GHz radios were tested.

Radios Under Test

1. XetaWave Xeta9, 900 MHz, 1 W, Ethernet Interface (courtesy of elevatewireless.com)
2. FreeWave FGR2, 900 MHz, 1 W, Serial Interface (courtesy of freewave.com)
3. Satel Satelline Easy, 460 MHz, 1 W, Serial Interface (courtesy of satelusa.com)
4. Microhard Pico P2400, 2.4 GHz, 1 W and 100 mW, Serial Interface
5. Ubiquiti Bullet M2, 2.4 GHz, 0.63 W, Ethernet Interface
6. FreeWave GX-CE, 2.4 GHz, 500 mW and 100 mW, Serial Interface (courtesy of freewave.com)

Test Location and Setup

The test was done in Gilroy, California, on Frazier Lake Road.

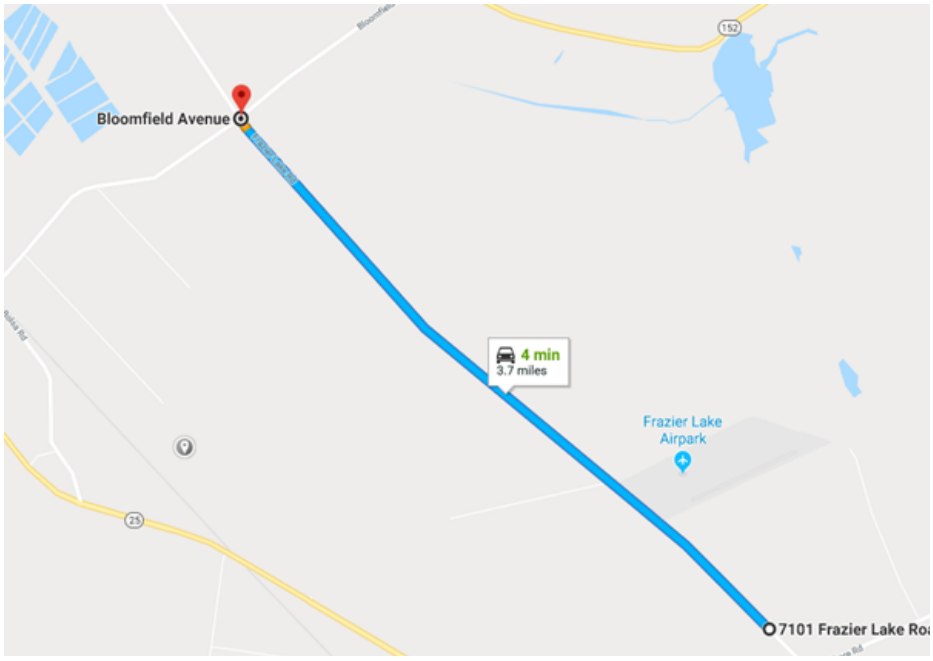

Fig 1. The test road is 6 km (3.7 mi) long, flat, and with an open sky and no obstructions. It allows a line-of-sight between transmitter and receiver radio antennas.

Fig 2. Test road view from the base station location.

Two Duro receivers with the latest firmware and GPS500 mini-survey antennas were used for each test.

Fig 3. Base station vehicle. This car was stationary during the test. GNSS and radio antennas were mounted on the car's roof.

Fig 4. Rover test vehicle. GNSS and radio antennas were mounted on the car's roof.

Test Procedure

In each test, a pair of radios was used. One parked vehicle was used as a base station and another vehicle was used as a moving rover. GNSS and radio antennas were mounted on the car's roof. Each radio was connected to an omnidirectional antenna with a similar gain.

Each test started with two vehicles parked next to each other at the base station location. Once the rover obtained RTK fixed solution and started logging, the rover system was driven northwest along Frazier Lake Rd, away from the base, until the RTK solution was completely lost. After that, the vehicle was turned back and driven towards the base station. Each test comprised of three drives: two at 50 km/h (30 mph) and one at 80 km/h (50 mph).

The picture below depicts an example speed plot from one of the tests. Position mode is indicated by the line color.

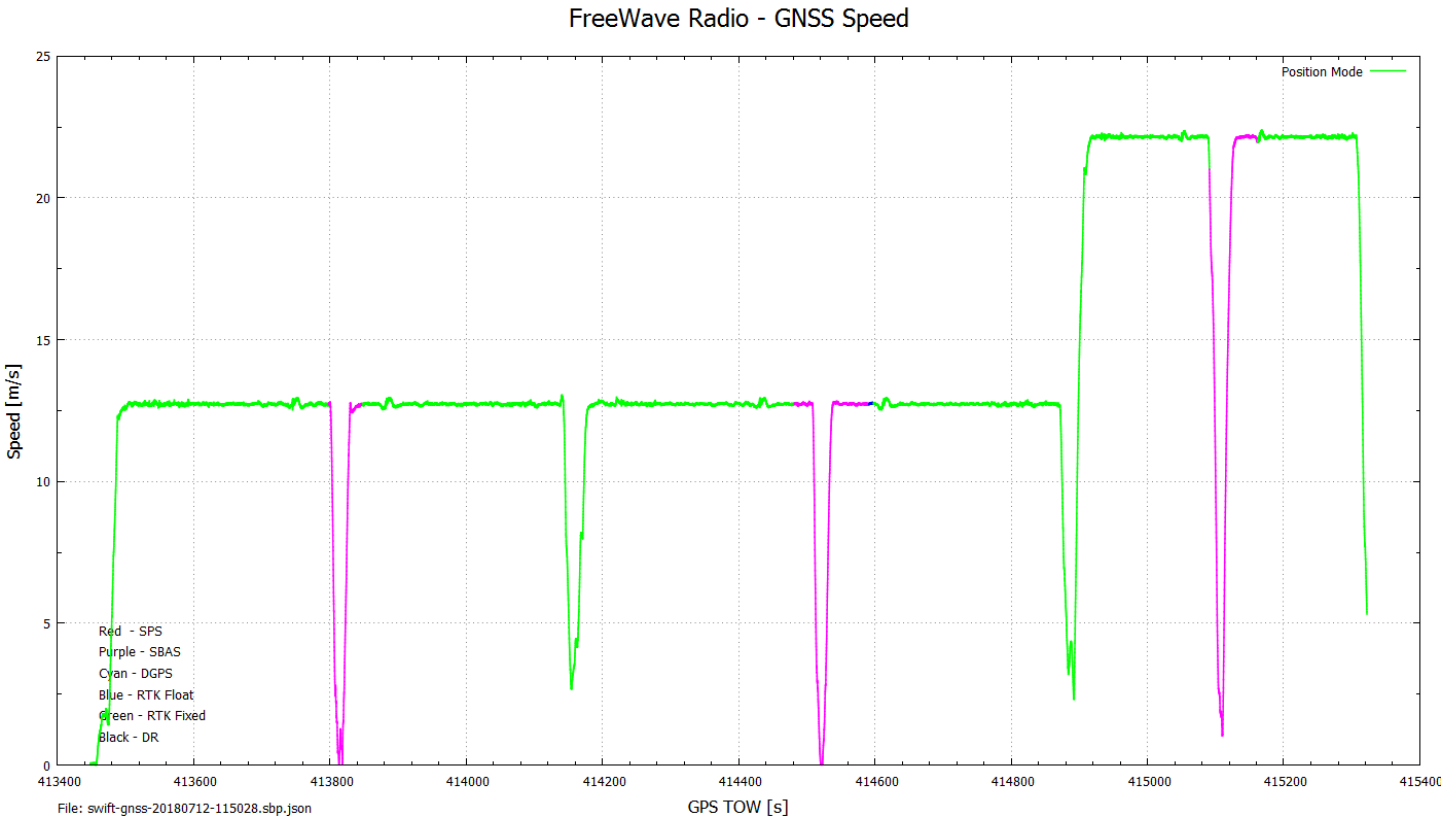

Fig 5. Rover vehicle speed profile during tests.

During the test, a Swift Binary JSON log was collected on rover's PC by the Swift Console program.

Baseline and Corrections Age Plot Description

The following pages contain Baseline and Corrections Age plots from each test. The purple line with scale on the left indicates rover distance from the base station while in RTK mode (fixed or float). Green line with scale on the right side indicates age of RTK corrections. In a normally operating system with a short baseline, the age of corrections varies between 0.2 and 2.2 seconds. Any higher age value indicates missing corrections data. The base station was sending data at 1 Hz rate.

Base Station Data Gaps Effect on Rover

The Duro rover receiver was set with a 30 second timeout for missing RTK corrections. Although the GNSS receiver can provide RTK position even without the most recent corrections (up to the timeout limit), position accuracy is degraded. Occasional correction data gaps below 5 seconds do not make a noticeable position accuracy degradation. Such ranges are marked green in the tables below. Longer data gaps make more noticeable position errors. Data gaps of longer than 20 seconds are marked yellow in tables below. Best RTK performance can be expected when base station data gaps are occasional and do not exceed 5 seconds.

Radio 1: XetaWave Xeta9, 900 MHz, 1 W, Ethernet Interface (UDP Protocol)

Fig 6. Radio, rover and base antennas.

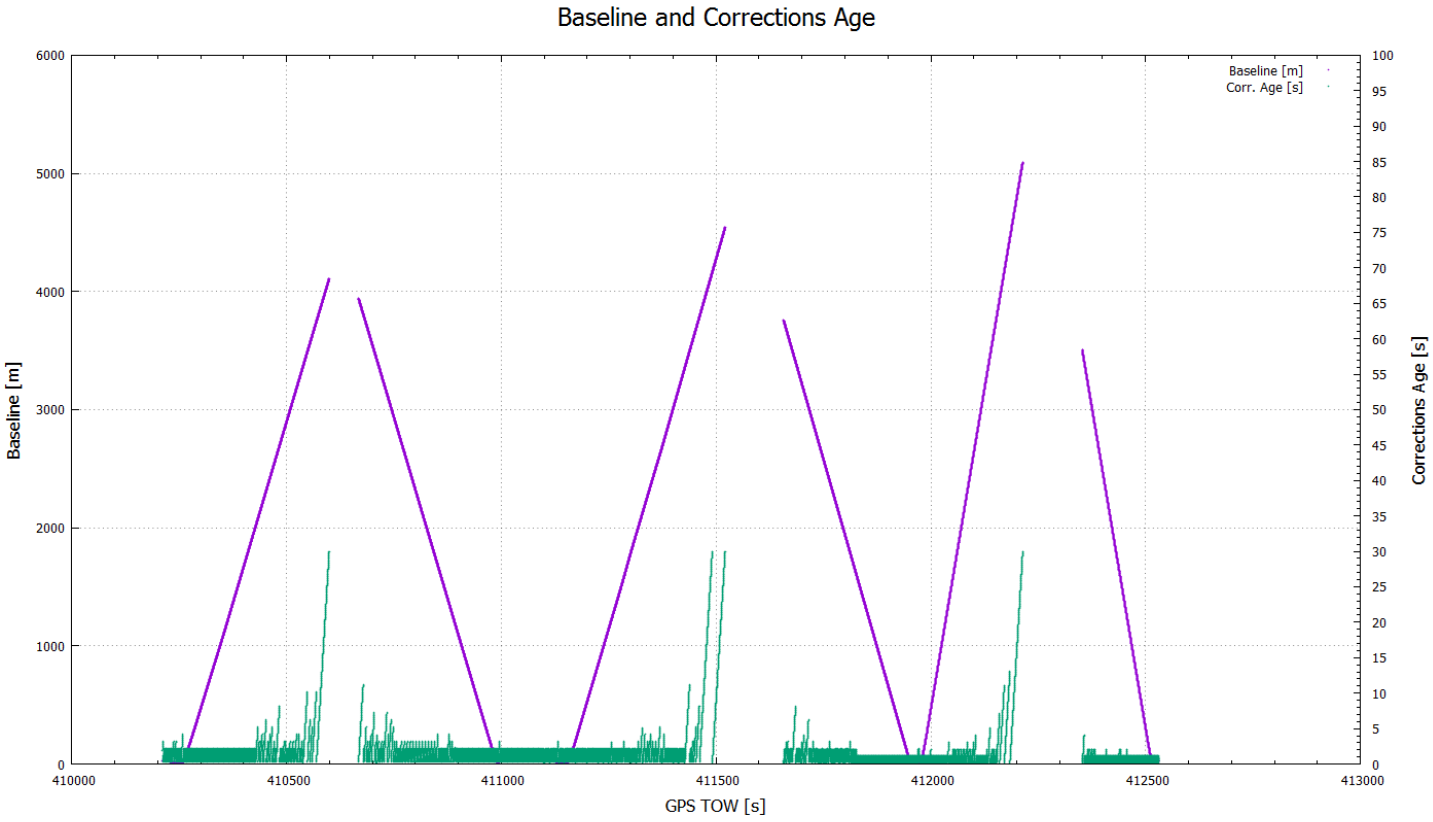

Fig 7. Baseline and Corrections Age

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	4.1	4.6	5.1
First RTK lost when driving away from the base	km	4.1	4.6	5.1
First obtained RTK when driving towards the base	km	3.9	3.7	3.5
First data gap above 5 seconds when driving away from the base	km	2.1	2.1	3.4
Last data gap above 5 seconds when driving towards the base	km	2.9	3.0	3.5
First data gap above 20 seconds when driving away from the base	km	4.0	4.0	4.8
Last data gap above 20 seconds when driving towards the base	km	3.9	3.7	3.5

Radio 2: FreeWave FGR2, 900 MHz, 1 W, Serial Interface (RS232)

Fig 8. Radio, rover and base antennas.

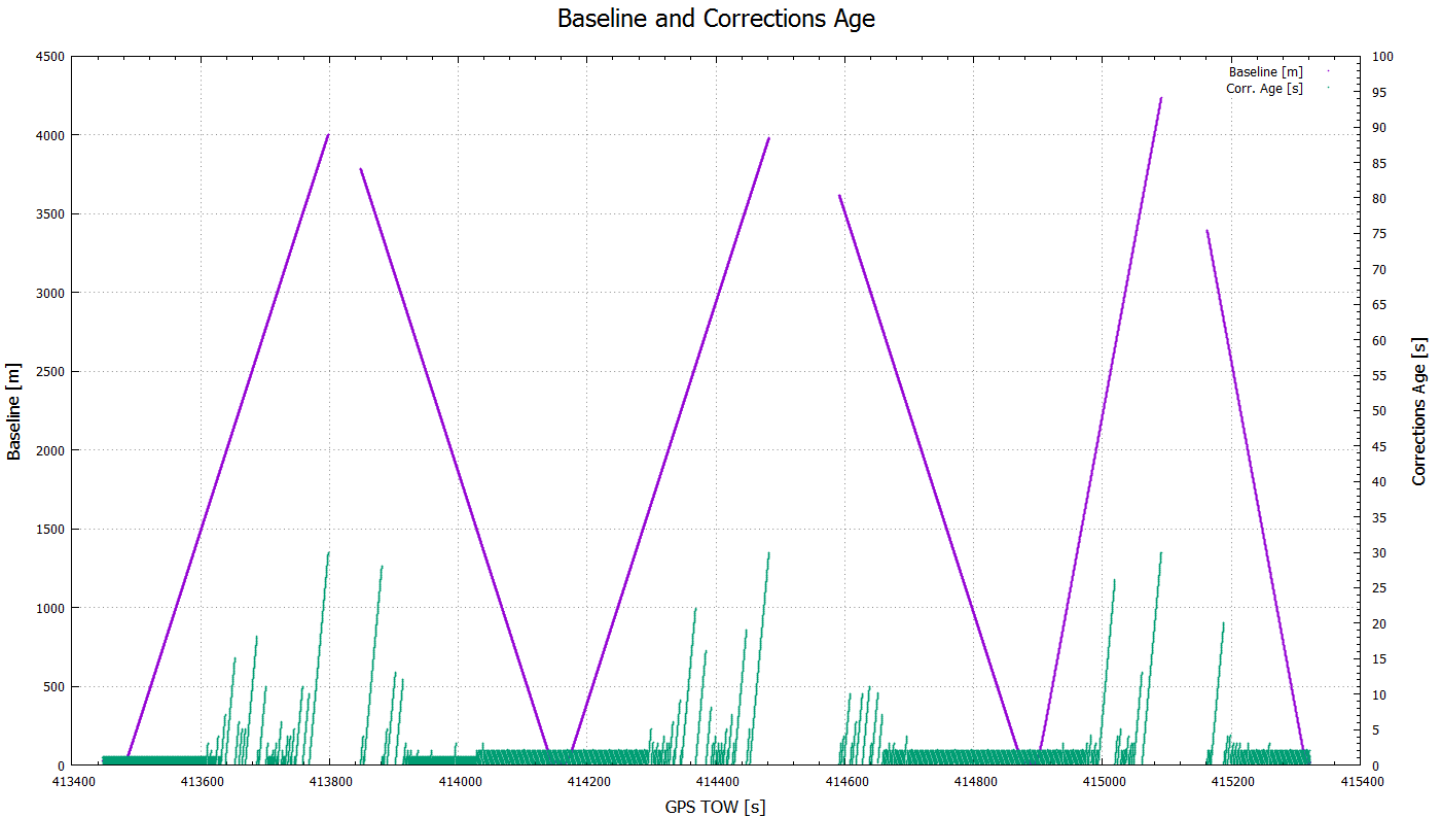

Fig 9. Baseline and Corrections Age

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	4.0	4.0	4.2
First RTK lost when driving away from the base	km	4.0	4.0	4.2
First obtained RTK when driving towards the base	km	3.8	3.6	3.4
First data gap above 5 seconds when driving away from the base	km	1.9	1.6	2.2
Last data gap above 5 seconds when driving towards the base	km	2.9	2.7	2.8
First data gap above 20 seconds when driving away from the base	km	3.8	2.5	2.5
Last data gap above 20 seconds when driving towards the base	km	3.3	3.6	2.8

Radio 3: Satel Satelline Easy, 460 MHz, 1 W, Serial Interface (RS232)

Fig 10. Radio, rover and base antennas.

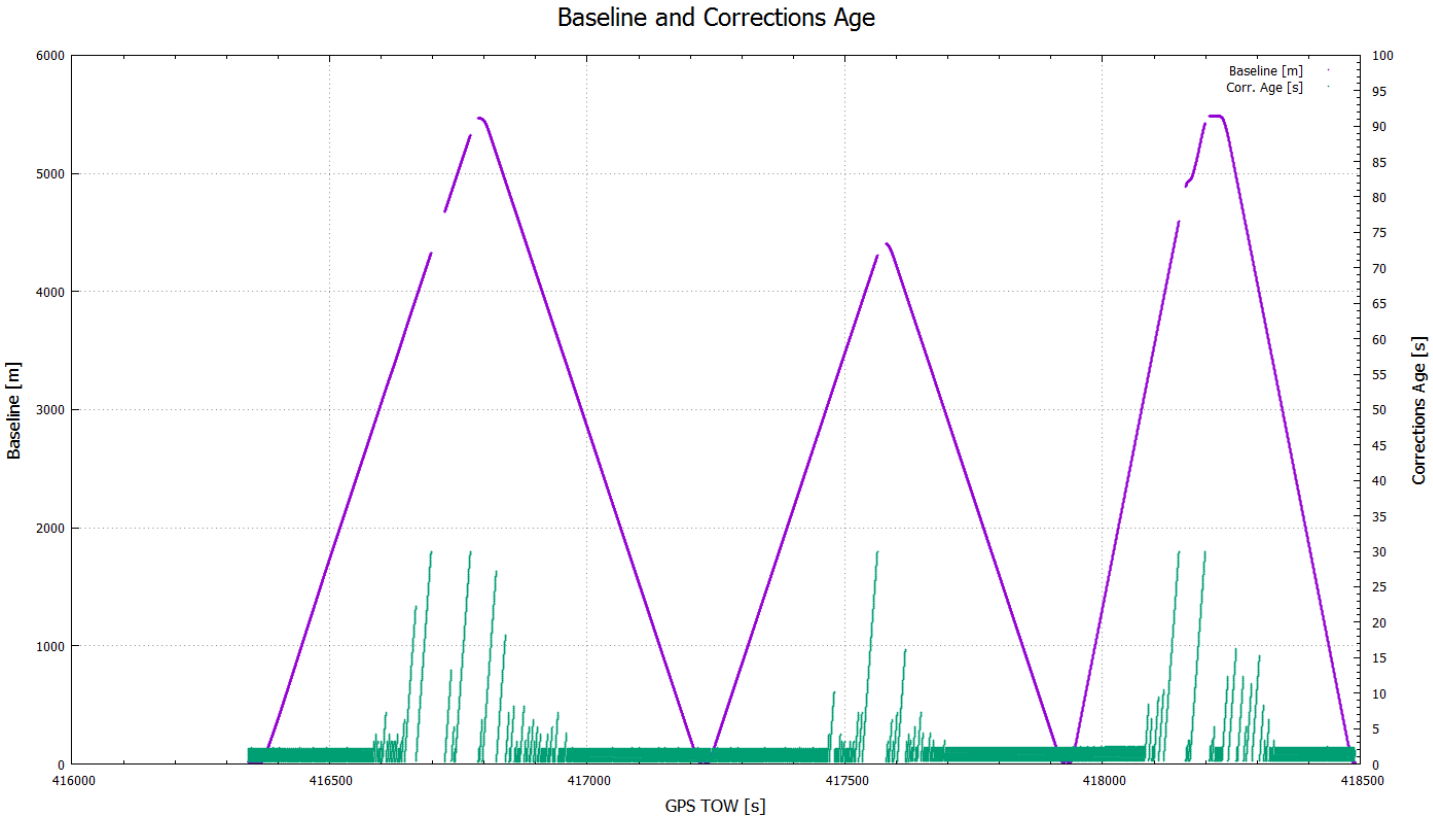

Fig 11. Baseline and Corrections Age

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	5.5	4.4	5.5
First RTK lost when driving away from the base	km	4.3	4.3	4.6
First obtained RTK when driving towards the base	km	5.5	4.4	5.5
First data gap above 5 seconds when driving away from the base	km	3.1	3.1	3.2
Last data gap above 5 seconds when driving towards the base	km	3.6	3.6	3.5
First data gap above 20 seconds when driving away from the base	km	3.9	4.2	4.4
Last data gap above 20 seconds when driving towards the base	km	5.1	4.4	5.5

Radio 4: Microhard Pico P2400, 2.4 GHz, 1 W, Serial Interface (RS232)

Microhard MHS035420 antennas were used at base and rover.

Fig 12. Radio, rover and base antennas.

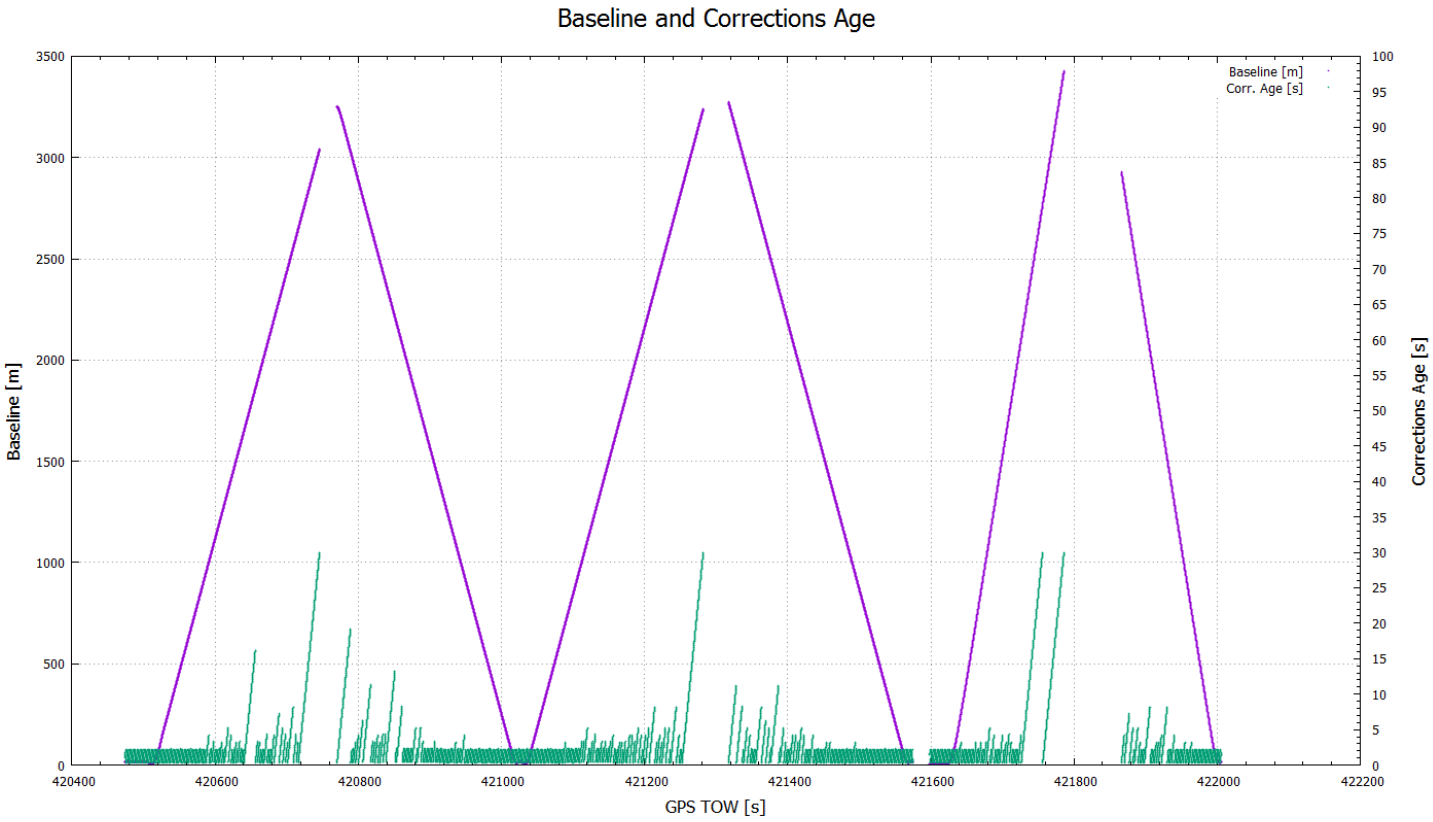

Fig 13. Baseline and Corrections Age.

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	3.3	3.3	3.4
First RTK lost when driving away from the base	km	3.0	3.2	3.4
First obtained RTK when driving towards the base	km	3.3	3.3	2.9
First data gap above 5 seconds when driving away from the base	km	1.3	1.1	1.1
Last data gap above 5 seconds when driving towards the base	km	1.7	1.9	1.5
First data gap above 20 seconds when driving away from the base	km	2.9	3.1	2.5
Last data gap above 20 seconds when driving towards the base	km	3.2	3.2	2.9

Note: two low speed drives and one high speed drive are in separate logs. Above plot shows combined data.

Radio 4: Microhard Pico P2400, 2.4 GHz, 100 mW, Serial Interface (RS232)

Additional test was performed with this radio at 100 mW with L-com HG2412UP-NF (base) and Microhard MHS035420 (rover) antennas shown in the pictures below.

Fig 14: Base and Rover Antenna

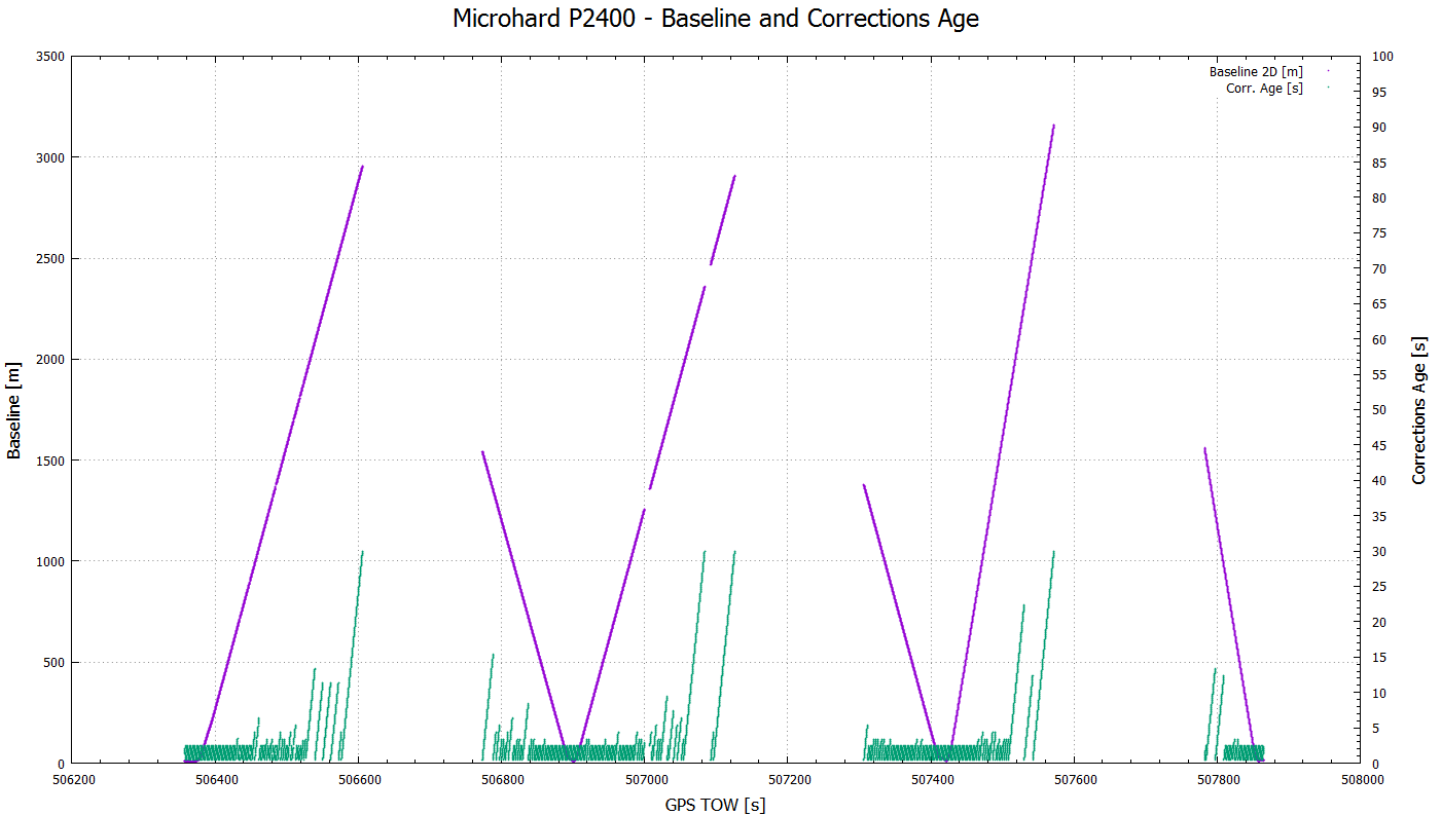

Fig 15. Baseline and Corrections Age.

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	2.9	2.9	3.1
First RTK lost when driving away from the base	km	2.9	1.2	3.1
First obtained RTK when driving towards the base	km	1.5	1.3	1.5
First data gap above 5 seconds when driving away from the base	km	1	0.7	1
Last data gap above 5 seconds when driving towards the base	km	0.7	1	1.2
First data gap above 20 seconds when driving away from the base	km	2.8	2.2	2.1
Last data gap above 20 seconds when driving towards the base	km	1.3	1.3	1.2

Radio 5: Ubiquiti Bullet M2, 2.4 GHz, 0.63 W, Ethernet Interface (UDP Protocol)

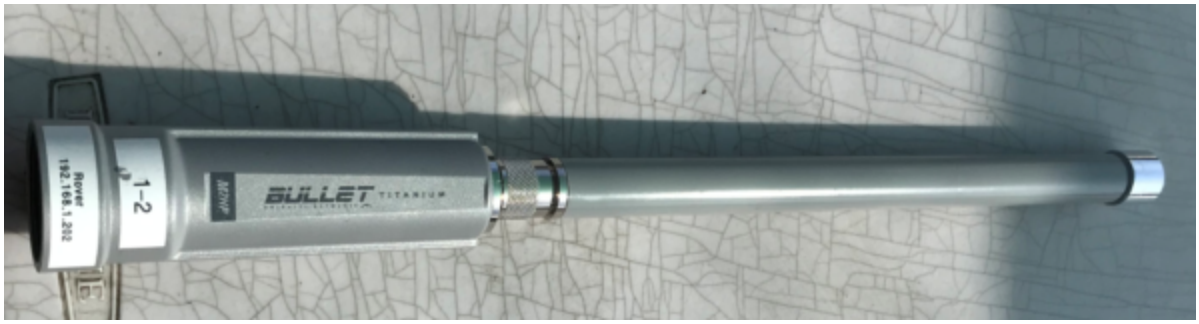

Fig 16. Radio with antenna

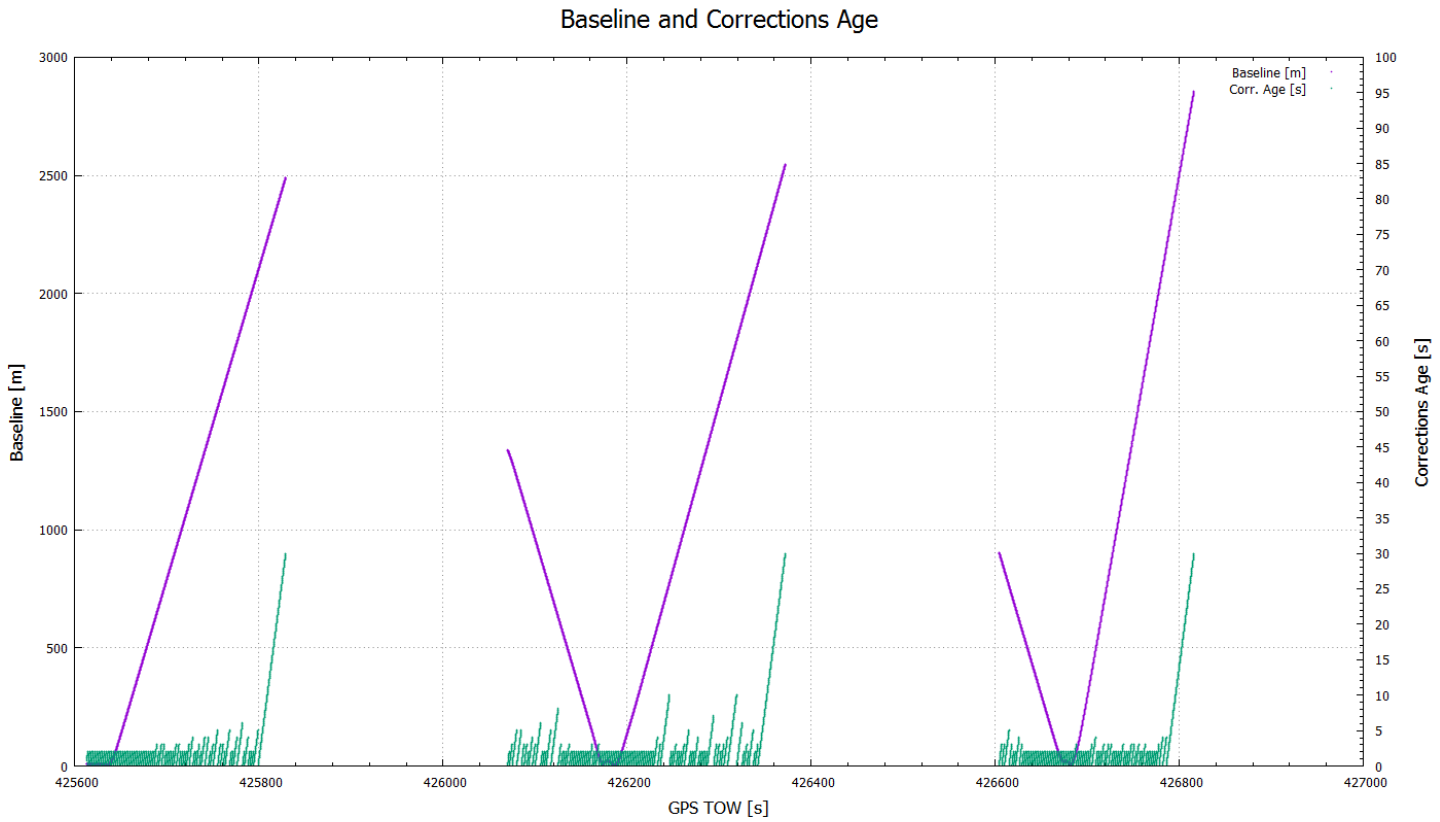

Fig 17. Baseline and Corrections Age.

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	2.5	2.6	2.9
First RTK lost when driving away from the base	km	2.5	2.6	2.9
First obtained RTK when driving towards the base	km	1.3	0.9	-
First data gap above 5 seconds when driving away from the base	km	1.5	0.7	2.3
Last data gap above 5 seconds when driving towards the base	km	0.6	0.7	-
First data gap above 20 seconds when driving away from the base	km	2.3	2.4	2.6
Last data gap above 20 seconds when driving towards the base	km	1.3	0.9	-

Note: system did not achieve RTK fix on the way back to the base at the higher speed.

Radio 6: FreeWave GX-CE, 2.4GHz, 100 mW, Serial Interface (RS232)

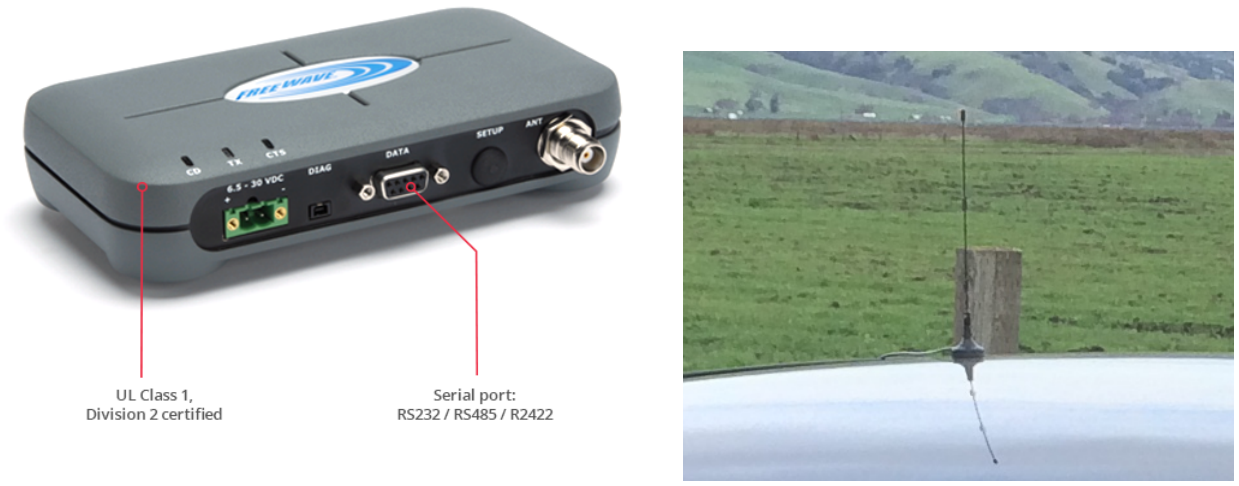

Fig 18. Radio and Antenna

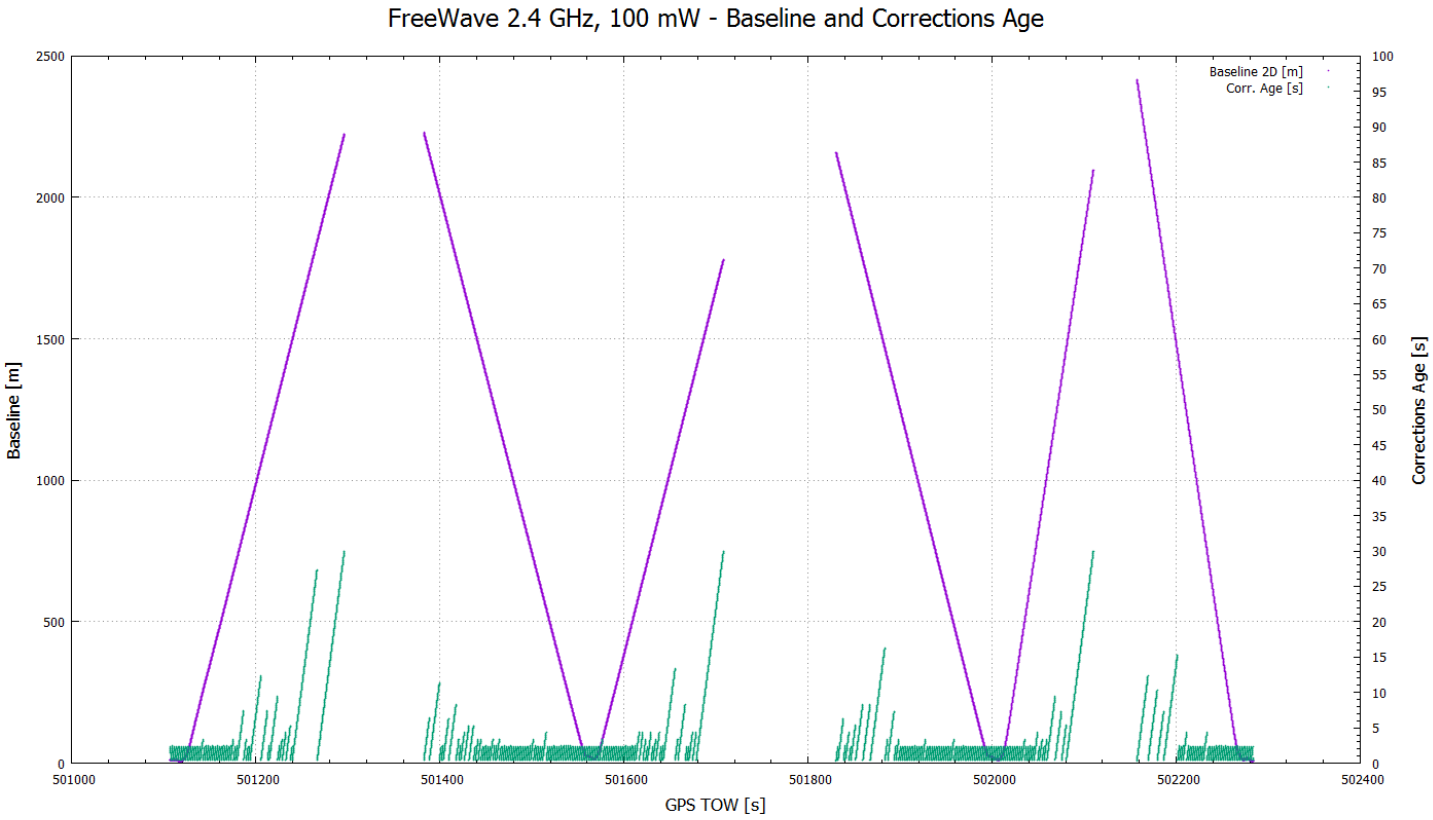

Fig 19. Baseline and Corrections Age.

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	2.2	1.7	2.1
First RTK lost when driving away from the base	km	2.2	1.7	2.1
First obtained RTK when driving towards the base	km	2.2	2.1	2.4
First data gap above 5 seconds when driving away from the base	km	0.8	1.0	1.1
Last data gap above 5 seconds when driving towards the base	km	1.6	1.3	1.4
First data gap above 20 seconds when driving away from the base	km	1.8	1.6	2.0
Last data gap above 20 seconds when driving towards the base	km	2.2	2.1	2.4

Radio 6: FreeWave GX-CE, 2.4GHz, 500 mW, Serial Interface (RS232)

Test was performed with same radio as above but with power transmission at 500 mW. Antenna used were the same as above.

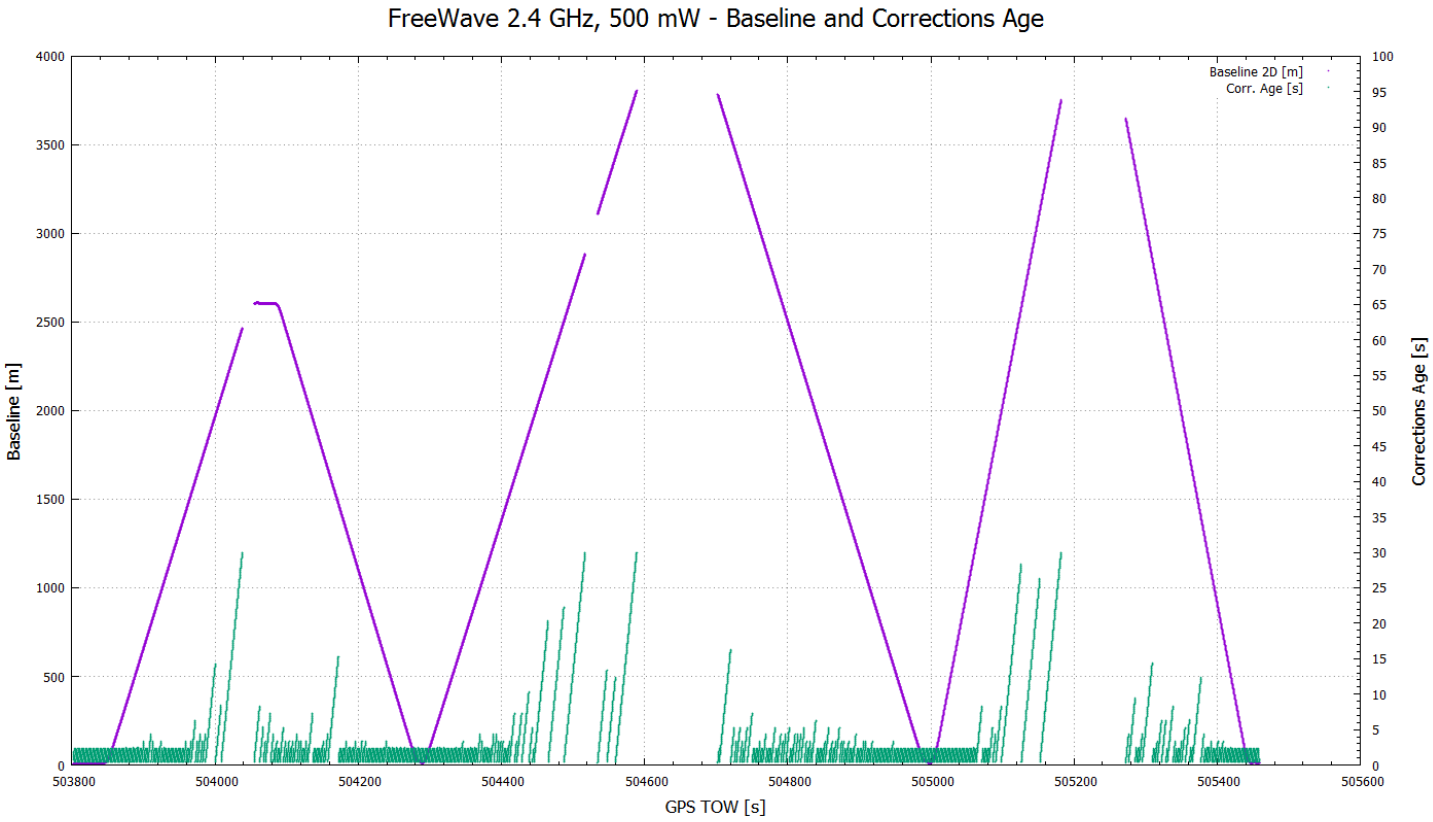

Fig 20. Baseline and Corrections Age.

Measured distance from base station to:	Units	Run 1 (50 km/h)	Run 2 (50 km/h)	Run 3 (80 km/h)
Max RTK range achieved	km	2.4	3.8	3.7
First RTK lost when driving away from the base	km	2.4	2.8	3.7
First obtained RTK when driving towards the base	km	2.5	3.7	3.6
First data gap above 5 seconds when driving away from the base	km	1.5	1.6	1.3
Last data gap above 5 seconds when driving towards the base	km	1.5	1.5	1.4
First data gap above 20 seconds when driving away from the base	km	2.3	2.2	2.3
Last data gap above 20 seconds when driving towards the base	km	2.5	2.8	3.7