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# WAAS, GLONASS, and GPS Accuracy

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FIELD TECH

# WAAS, GLONASS, and GPS Accuracy

**By Yanli Zhang, Daniel R. Unger, I-Kuai Hung, and David L. Kulhavy**

Recently released Garmin consumer-grade GPS receivers, such as the Oregon 600, eTrex, and Monterra series, have several options in their GPS mode settings. Users can decide to use just GPS signals or to add signals from Russian GLONASS satellites and/or the Wide Area Augmentation System (WAAS). According to Garmin, "With an additional 24 satellites to utilize, GLONASS-compatible receivers can acquire satellites up to 20 percent faster than devices that rely on GPS alone." (https://support.garmin.com/support/). As for WAAS, the reported typical accuracy is better than three meters 95 percent of the time (www8.garmin.com/aboutGPS/waas.html). However, these statements are not very clear about how well these two factors help improve GPS


**The Garmin Oregon 600 GPS receivers used in these accuracy tests typically sell for $350 to $400.**

accuracy on line lengths and polygon areas. In this article, we briefly discuss our findings of these settings from tests on Oregon 600 receivers. These widely available receivers typically sell for $350 to $400.

GLONASS, the Russian counterpart of the US GPS system, has provided full global coverage since October 2011 with 24 active satellites. Some GPS users may be aware that a more general term, Global Navigation Satellite System (GNSS), is becoming more widely used to refer collectively to GPS, GLONASS, Galileo (the European Union satellite system), Beidou (the Chinese satellite system), and others. In general, the more satellites a GPS receiver uses to record positions, the better the accuracy.

WAAS was developed by the US Federal Aviation Administration to help compensate for GPS measurement errors caused by ionospheric disturbances, incorrect timing, satellite orbit, multipath, and other factors. WAAS is a system of satellites and ground stations (base stations) that provides real-time differential correction signals to improve GPS position accuracy.

For our case study, we set map datum to WGS 84 and the coordinate system to latitude and longitude. The line-tracking setting offers three options: distance-based (smallest setting: one point logged for every 0.01 mile), time-based (smallest setting: one point logged per second), and automatic (the track is recorded at a variable rate that creates an optimum representation). To mimic real-world application, we used the auto setting with the "most often" rate (which provides the most detail) to track a polygon boundary. We used the football field on the Stephen F. State University campus as the study site. The field's dimensions are a length of 120 yards, a width of 53.33 yards, a perimeter of 346.66 yards, and an area of 1.322 acres. We collected data between 10 a.m. and 1 p.m. on September 23, a clear sunny day.

We walked the boundary of the football field at a normal pace using all possible GPS settings or configurations: GPS only, GPS + GLONASS, GPS + WAAS, and GPS + WAAS + GLONASS. We repeated each configuration three times. After data collection, we transferred the GPS data to ArcGIS as polygon features to evaluate each configuration's effect on accuracy of perimeter and area measurement. We used a four-inch spatial resolution Pictometry image as a background to visually check the position accuracy of polylines. As Figure 1 shows, there is no significant position difference among all the 12 polygons.

To quantify the accuracy of length and area measurements recorded with the Oregon 600, we analyzed all recorded polygons to calculate their absolute percent error for all possible GPS combinations studied, using this formula:

**Absolute % Error = ((Average Measurement – Correct Value) / Correct Value) x 100**

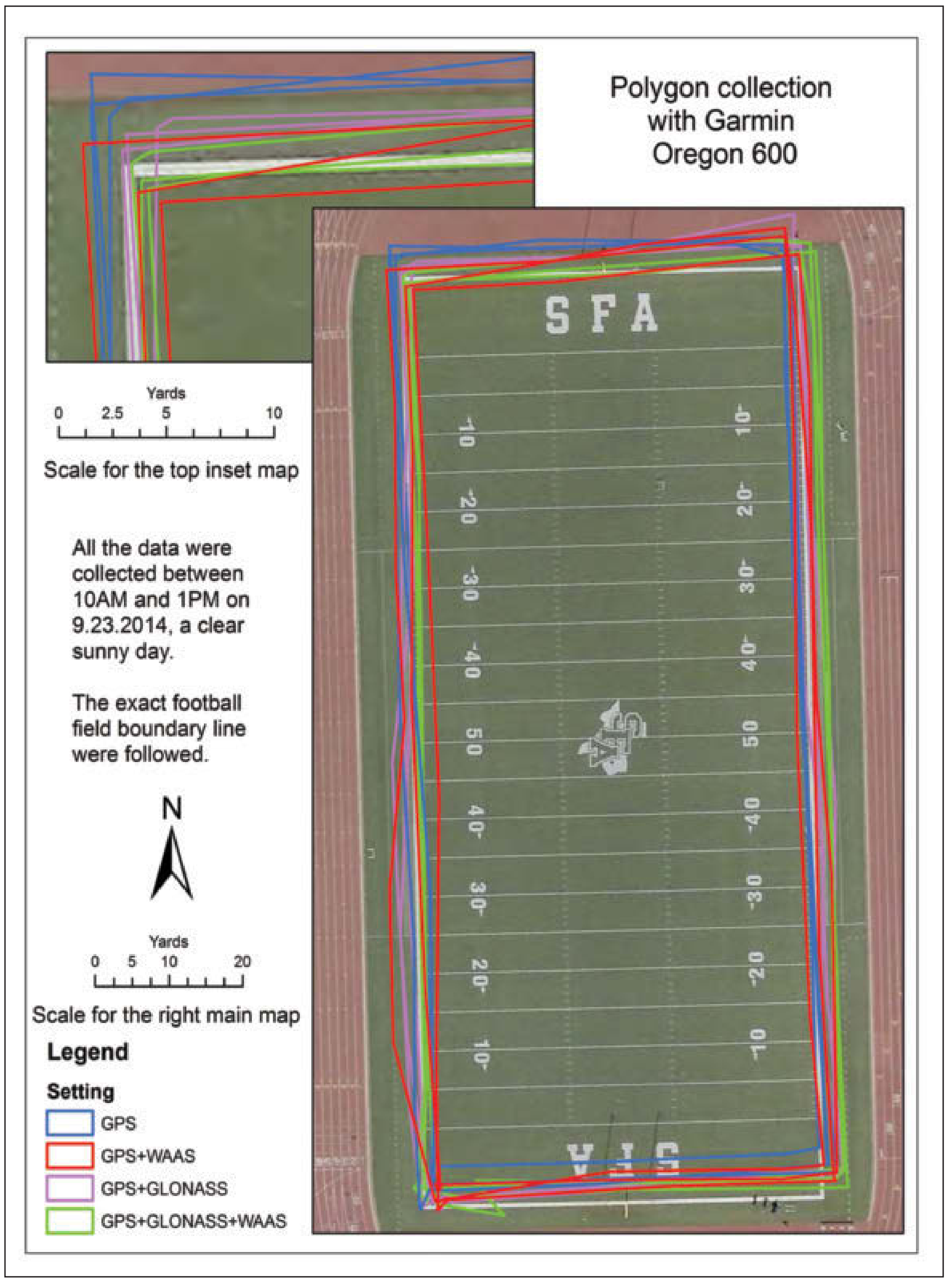


**Figure 1. Polygons collected with the Garmin Oregon 600 with different GNSS settings.**

**Table 1. Perimeter Accuracy Evaluation**

| GPS setting | Length (perimeter) measurement (yards) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | Average | Absolute % Error |
| GPS | 353.691 | 348.2 | 355.543 | 352.478 | 1.68% |
| GPS + WAAS | 347.837 | 349.764 | 347.038 | 348.213 | 0.45% |
| GPS + GLONASS | 353.032 | 357.047 | 355.257 | 355.112 | 2.44% |
| GPS + GLONASS + WAAS | 361.681 | 351.78 | 354.923 | 356.128 | 2.73% |

**Table 2. Area Accuracy Evaluation**

| GPS setting | Area measurement (acres) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | Average | Absolute % Error |
| GPS | 1.288 | 1.331 | 1.358 | 1.326 | 0.25% |
| GPS + WAAS | 1.351 | 1.353 | 1.281 | 1.329 | 0.48% |
| GPS + GLONASS | 1.385 | 1.409 | 1.373 | 1.389 | 5.04% |
| GPS + GLONASS + WAAS | 1.376 | 1.378 | 1.358 | 1.371 | 3.66% |

The results are shown in Tables 1 and 2.

For line-length measurements, using WAAS in addition to GPS improved the accuracy. Length absolute percent error was 1.68 percent using only GPS, but it decreased to 0.45 percent with a GPS + WAAS combination. In our area accuracy assessment, there was no significant difference between GPS only and GPS + WAAS. However, area accuracy error increased significantly with the inclusion of GLONASS and ranged from 5.04 percent with a GPS + GLONASS combination and 3.66 percent with a GPS + GLONASS + WAAS combination.

Why might the accuracy of the length and area measurements decline when GLONASS is used? One possible explanation is that the GLONASS signal is not being fully taken advantage of by the GPS chips or algorithms used by Garmin. Nonetheless, in our tests we found that the Oregon 600 has relatively good accuracy on length and area measurement, with or without using WAAS and/or GLONASS.


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