DRAFT

Performance Testing of the Garmin GPSMAP 76 Global Positioning System Receiver

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Introduction:

The Garmin Navigation GPSMAP 76 is a 12-channel Global Positioning System (GPS) receiver. This receiver was tested by the U S Forest Service to determine performance under Western Oregon forest canopy conditions. The tests were made between September 20 and Oct 7, 2002.

These GPS receiver performance tests were made at two sites. The first site is under Western Oregon forest canopy at the Clackamas Test Network. The other used was the open-sky National Geodetic Survey control station “Nelson” in Portland, Oregon. The tests were designed to examine the effect of tree canopy on the following:

1) The positional accuracy waypoints consisting of 1 position and waypoints consisting of 60 positions to determine what, if any, increase in accuracy occurs by averaging of more positions per feature.

2) The positional accuracy of GPSMAP 76 waypoints logged using both Internal and External Antenna.

Equipment:

This test was performed with the GPSMAP 76 using both the manufacturer standard equipment internal quad helix antenna and the optional GA-27C external antenna. The manufactures list price is $322. The external antenna is an optional item for the GPSMAP 76 the manufacturers list price is an additional $99.

The GPSMAP 76 software version 2.08 was used for all tests.

Test Network and Survey Station Data:

Forested Site: The Clackamas Test Network is located in Western Oregon on the Mt. Hood National Forest. Clackamas GPS Test Network is a site for testing P and C/A Code (resource grade) GPS receiver performance under moderate to heavy western Oregon timber canopy. The vegetation at the site consists of Douglas Fir and Western Hemlock over story, these trees are approximately 24-40" d.b.h., with a Vine Maple and Red Alder under story. The terrain at the site is nearly flat with no terrain obstructions above 20 degrees. The test network is composed of twelve points with known geographic positions. These twelve points were established by a conventional Total Station closed traverse survey, which was based on two GPS points adjacent to the site which had satellite horizon. These two points were established by static carrier phase GPS survey connected to the Oregon High Accuracy Reference Network (HARN).

Open Site: The station “Nelson” was used as a control site due to its clear-sky nature with no obstructions. Station “Nelson” is an Oregon High Accuracy Reference Network (HARN) Order B survey mark established by the National Geodetic Survey in 1998, PID-A12002.

Field Data Logging Procedures:

All GPS observations were made at approximate antenna height of 1.5 meters. The receiver or external antenna with ground plane was mounted on a tripod for all tests.

All GPS data was logged at 1 position / second.

Data Logging:

- Data was logged for 1 position / point feature with internal antenna.
- Data was logged for 1 position / point feature with external antenna.
- Data was logged for 60 positions / point feature with internal antenna.
- Data was logged for 60 positions / point feature with external antenna
- Data was logged during multiple days under varied PDOP conditions.
- Data was logged at both open and forested sites.

Office Data Processing Procedures:

The data analysis was made using Microsoft Office 2000 Excel spreadsheet application.

The National Standard for Spatial Data Accuracy (NSSDA) was used to evaluate and report the positional accuracy of (see appendix 1 for formulas). The Federal Geographic Data Committee specifies that the NSSDA be used to evaluate and report the positional accuracy of geospatial data produced, revised, or disseminated by or for the Federal Government

The NSSDA reports accuracy values at 95% confidence. In other words, 1 out of 20 measurements made with the same receiver and data logging settings under similar forest canopy conditions should have errors larger than those published in this report.

All data was analyzed in the North American Datum of 1983 (NAD 83).

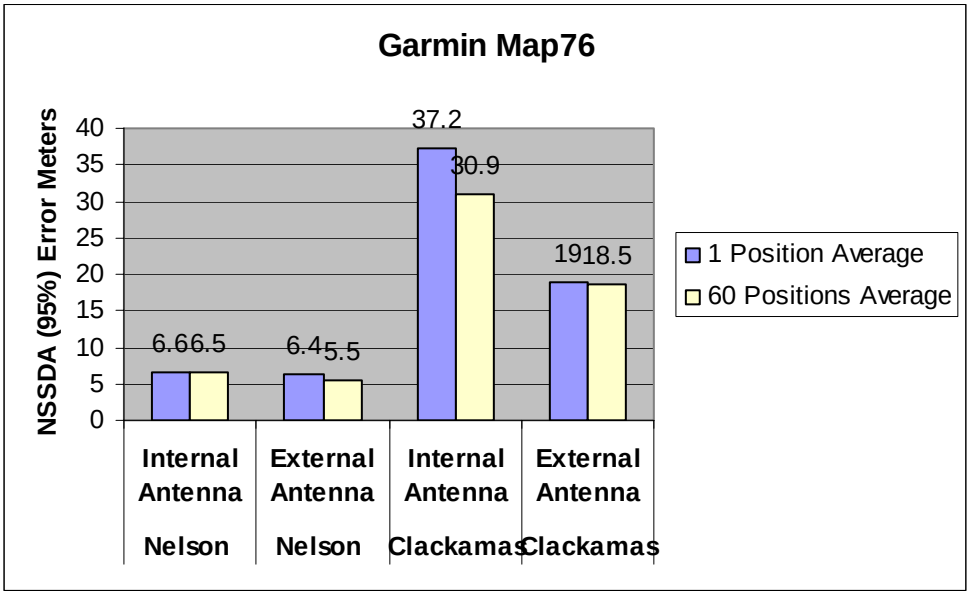
SITE CONDITIONS:

These tests were made under generally dry canopy conditions.

Test Results:

The test results for all observed data are illustrated in Chart 1.

Chart 1:



The open site accuracy at station Nelson was very good. In the open site very little difference in positional accuracy was noted was noted between both the 1 position averages and the 60 position averages using both the internal and external antenna. The observed efficiency was 100%. This data was WAAS corrected.

Forested site accuracy was slightly increased by averaging multiple positions into one feature when using the internal antenna. Interestingly only a very small increase in accuracy was noted when averaging 60 positions with the external antenna. No WAAS corrections were received. I assume due to forest canopy.

Recommendations for the GPSMAP 76:

For open sites:

- Waypoints can consist of only 1 position per feature. Little increase in accuracy is gained by using 60 position averages.
- Internal and External antennas yield similar accuracy.
- 6.5 meters at 95% confidence (NSSDA) can be achieved with these receiver settings and the internal antenna.
- WAAS should be available at open sites

For Forested Sites:

- Waypoints should consist of at 60 positions per feature if using the internal antenna.
- External antenna yields a significant increase in better accuracy.
- 19.0 meters at 95% confidence (NSSDA) can be achieved with the external antenna.
- When using the external antenna very little increase in accuracy was noted between the 1 position data and the 60 position data.
- WAAS corrects will most often not be available in canopy conditions

Appendix 1: **Horizontal Accuracy using NSSDA formulas**:

Determine the radial Root Mean Square Error (RMSE) for the GPS data set:

$RMSE_r = sqrt[\Sigma ((Xdata - Xcheck)^2+(Ydata – Xcheck)^2)/n]$

where:

Xdata , Ydata are the coordinates of the check point in the GPS data, i data, i
Xcheck , Ycheck are the coordinates of the check point in GPS test network.

Modify RMSE error to NSSDA 95% probablitiy:

$NSSDA\ Accuracy_r = 1.7308 * RSME_r$

Appendix 2: Photo of GPSMAP 76 (Photo from Garmin Navigation)