Reading the Robot Plots

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By: Mark Silver, ms@igage.com

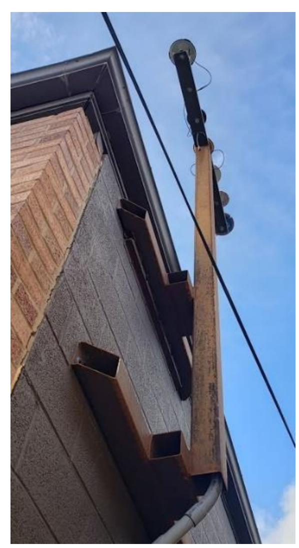
The iGage robotic test stand:

systematically dumps 1 to 4 GNSS receivers and records the subsequent Time-to-Fix and range of FIXED measurements for each receiver under test. Dumps are achieved by physically rotating the receiver upside down and then rotating it back to face skywards.

By running two (or more) receivers at once, the performance of the receivers can be compared. It is not possible to empirically compare devices; only comparative testing can be performed.

We prefer to connect to heads by cable; however we can also use Bluetooth connections. We have found that long test sessions eventually fail using Bluetooth. GxGGA sentences are required, GxGST sentences allow for plotting of estimated errors. A 2Hz update rate is preferable, however 1 Hz is adequate.

Correction Source



By default, we use a Trimble BD990 based receiver with a full GNSS antenna located on the adjacent corner of our building. We also have a dedicated GPS+GLONASS internet connected base located 3.00 KM directly east of the test location.

The resulting baseline is around 3 meters horizontal and 3 meters vertical. The Base antenna has an excellent view of the sky with no nearby obstructions. RTCM3.2 MSM, RTCM3.1, CMR+, sCMRx and RTCM2 corrections are available by NTRIP or UHF radio connection.

For longer baselines we can make a single baseline connection to the Utah Reference NTRIP network, or make a VRS based connection to a spoofed virtual base at any distance.

iGage Mapping Corporation · 1545 South 1100 East STE 1 · Salt Lake City UT 84015 · +1 801 412-0011 · f +1-801-412-0022 · www.igage.com

Comparison 'Known Good' Device

We typically compare receivers under test to an 'iGage iG8' GNSS receiver which has a fully enabled Trimble BD970 OEM engine. Having tested a myriad of competing receivers we feel that this receiver is 'best in class'.

Test Location

We typically use a test location that is:

2.5 meters south of an adjoining 1-story building
2 meters east of an adjoining 2-story building
3 meters north of a partial obstruction to the south

This location provides moderate urban canopy and is convenient to our lab.

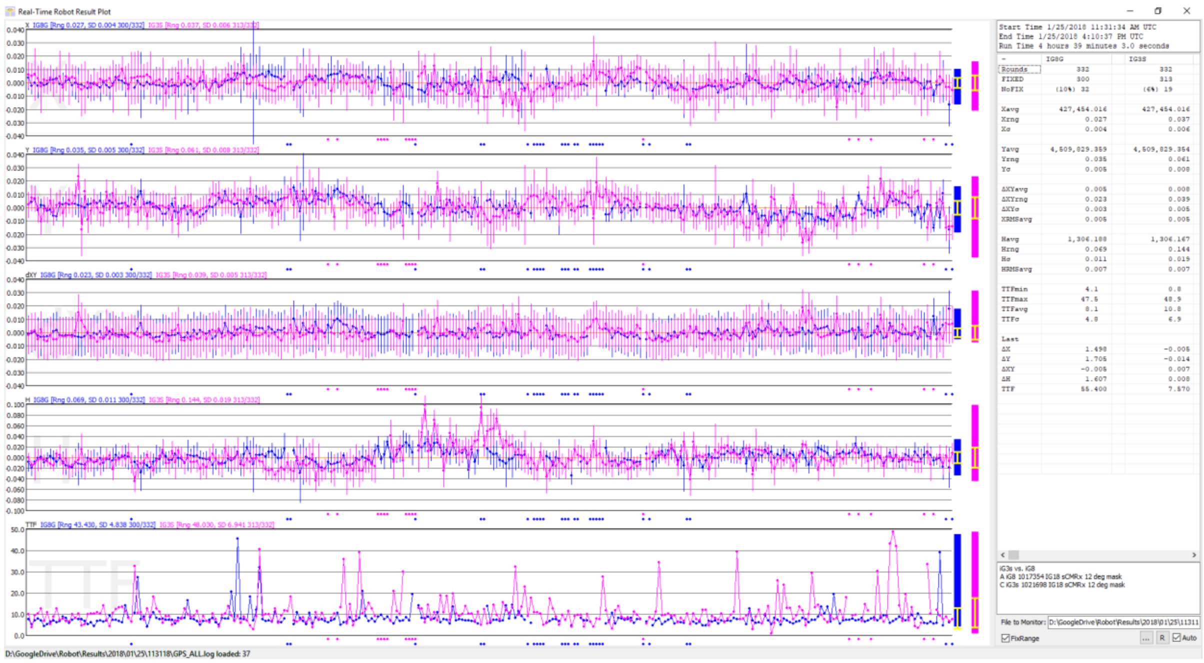
We can also easily test in the middle of an open parking lot, however there is not much to be learned from testing GNSS receivers in the wide open.

The robot is not available for hire and tests typically take over two days to setup, run and write a test report.

Plot and Data Description

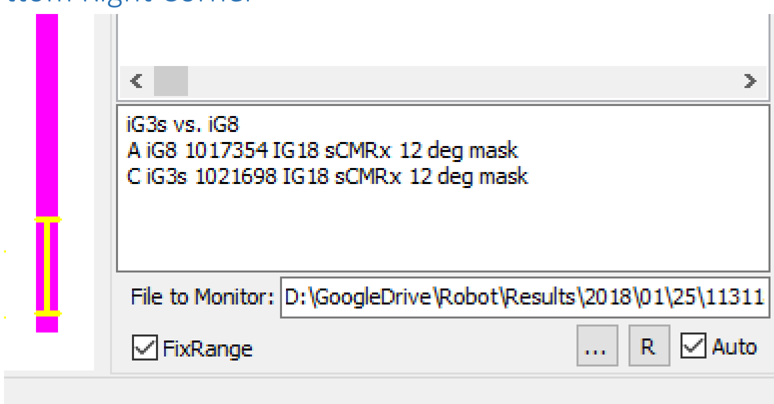
The robotic test stand has two software components: the testing program and the plotting program. The plotting program can be run simultaneously with test progresses and presents an immediate summary, both graphically and numerically of the test results.

The remainder of this document describes the plotting program output.

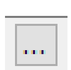


All results are presented in meters.

The Bottom Right Corner



The lower right corner of the plot screen allows the operator to pick a test result to display. Results for all devices under test are kept in a file named 'GPS_ALL.log' in the test folder (folders are automatically generated for each test using '../YYYY/MM/DD/HHMMSS/' format under a master result folder.

Clicking the  button allows you to browse for the file to display. The 'R' button will reread the selected file and the  checkbox when checked will automatically check the timestamp on the file and reload the result file if it changes.

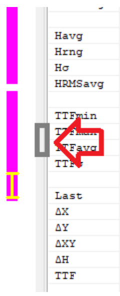
The 

checkbox will set the graph vertical ranges to +/- 4 cm for X, Y and dZ; +/- 10 cm. If unchecked, the graphing program will auto-range the results such that they fit. This can result in meaningless graphs if a receiver gets a ‘bad-fix’.

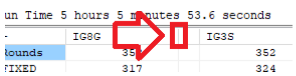
Above the current file is the text description of the test that was entered by the operator when the test was started.

The Numerical Results Panel

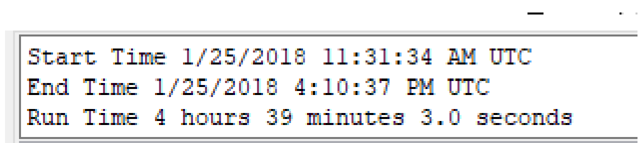
You can size the numerical results panel by clicking on the left side grip:



The data columns can be resized by clicking on the heading row:



At the top of the result panel:



The Start and End times with the computed run time is displayed. If the test is in progress, the End time is the last time that an axis reported a result. All times are displayed in GPS (UTC) time, not local time zone.

The result grid:

-	IG8G	IG3S
Rounds	355	354
FIXED	319	326
NoFIX	(10%) 36	(8%) 28
Xavg	427,454.016	427,454.016
Xrng	0.029	0.046
Xσ	0.004	0.006
Yavg	4,509,829.359	4,509,829.354
Yrng	0.035	0.070
Yσ	0.005	0.008
ΔXYavg	0.006	0.009
ΔXYrng	0.023	0.052
ΔXYσ	0.004	0.005
XRMSavg	0.005	0.005
Havg	1,306.188	1,306.167
Hrng	0.069	0.144
Hσ	0.011	0.019
HRMSavg	0.007	0.008
TTFmin	4.1	0.8
TTFmax	47.5	48.9
TTFavg	8.4	10.9
TTFσ	5.4	7.0
Last		
ΔX	-0.003	-0.002
ΔY	-0.006	0.001
ΔXY	0.001	-0.006
ΔH	-0.001	0.001
TTF	8.030	7.820

shows the designated device name on the column top.

'Rounds' is the total number of attempted dump cycles that ere attempted.

'FIXED' is the number of cycles that the receiver successfully fixed. At the beginning of a test, the operator selects a maximum time to wait. The result of each cycle is either a FIX or NOFIX.

'NoFIX' is the number of times the receiver failed to fix. We don't want to penalize a receiver for not fixing because a NoFix is better than a BadFix.

Xavg is the average easting reading (UTM Natural Zone in Meters), the Xrng is the total range of readings. Xσ is the 1-sigma standard population deviation of the X values.

Yavg, Yrng and Yσ are the northing values and Havg, Hrng and Hσ are the ellipsoid height values.

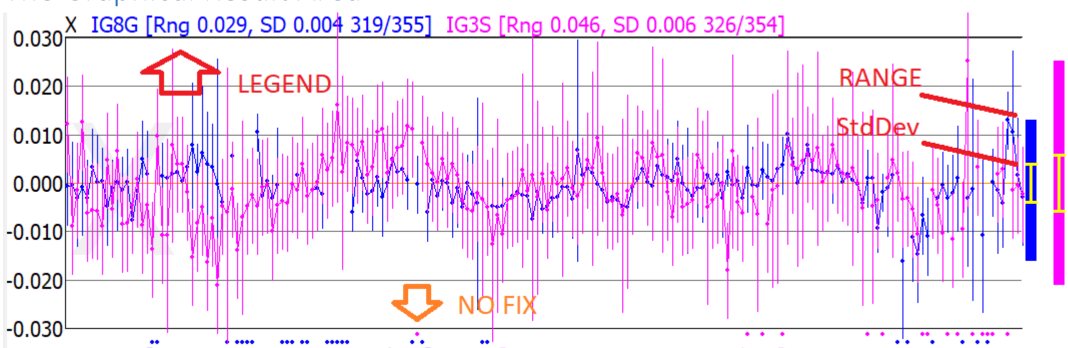
Note that the test program uses the GPGGA message and computes the ellipsoid height. Typically, the height is PC (Phase Center). Do not be concerned if the heights do not match between receivers as the L1 offset is not compensated for.

ΔXYavg is the average 2-D error from the average XY position. The Xavg and Yavg are assumed to be the 'correct' 2-D position. Then for each FIXED observation a 2D distance from the average position is computed. This is the horizontal error from the average position and the range (bounded by 0 on the lower side) and standard deviation are computed. If a receiver logs a Bad Fix (receiver result is typically in error by several meters) the XY statistics will typically blow up. In this case we will sometimes manually edit the log files and change the FIX status from Fixed to No Fix and make a note of this in the test summary.

The XYRMSavg is the average of the reported observation errors (HRMS is the rms sum of XRMS and YRMS). The HRMSavg is the average of the reported height observation errors. These values are obtained from the receiver in the GPGST NMEA message. If the GPGST message is not available, these RMS values will be reported as 0.

TTF is the Time-to-Fix in seconds. The time is computed from the moment the robot stops spinning until the receiver reports a FIXED position. However, so that intermittent fixes are not recorded, the robot requires that a receiver hold a fix for a programmed time period (typically 4 or 5 seconds). If a fix is lost, the robot continues waiting until the fix has been held for the programmed time.

The Graphical Result Area



Each dump cycle is plotted with the latest dump on the right-hand side.

If a cycle results in a NO FIX, then the dot is plotted at the bottom of the graph.

If a cycle results in a FIX, the value is plotted (X, Y, H, dXY) with the RMS error estimate plotted with error bars about the recorded position.

On the right hand side of the graph the large bars show the Minimum and Maximum measurements. The inset bars (yellow) show the 1-sigma standard deviation of the observations.

TTF is shown, bounded by 0 seconds

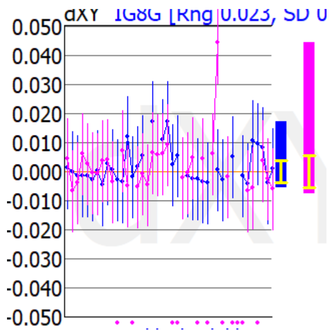
Interpreting the Results

A perfect receiver would log the same X, Y and H values after every dump cycle. The XY error (difference from the average position) would always be 0.000. The TTF might always be 5 seconds or less. Alas, this 'Best Case Scenario' is never observed.

Since the measurements are very dependent on the satellite constellation, we must take a comparative approach between the two (or more) receivers under test. Typically, we are comparing two receivers with the same correction source, however it is also possible to compare two identical receivers with different correction sources, two identical receivers with different OEM firmware revisions or two identical receivers with different tracking options enabled.

iGage

It is possible to make quick graphical observations:



In this example, the blue receiver is better. The purple receiver has a much larger range of readings, however the StdDev is very similar for both receivers. Perhaps purple only had a single Bad-Fix?

Often when testing identical receivers (with different firmware or correction sources), the difference between them is so small that we must be careful to not assign much weight to which is better or worse, both receivers are statistically identical.

Usually when testing different brands of receivers, one receiver will clearly be superior with ranges and standard deviations that are 3 to 5 times smaller than the lessor engine. Often the better receiver will also be 2 to 3 times faster.

Test Results

We typically never share the results of device testing with anyone. If receivers are provided to us at no cost for testing, we will prepare a written report for the equipment providers. Otherwise, we consider all test results to be proprietary and will not provide them to anyone outside of our company for any reason.

> We recognize the extreme legal risk in publicizing failed device tests.
>
> It is to our advantage to allow other dealers (competitors) to represent poorly performing devices.

Conclusion

We have tested a lot of receivers with the robot.

We have tested some receivers with over 20,000 dump cycles (typically testing new firmware versions.)

We have tested receivers in the open, under tree canopy and in the wide open.

We have tested with short baselines and long baselines, with full GNSS corrections, with partial constellations, with and without L2C corrections, with and without L5 corrections, with corrections by radio and by GSM.

We have tested receivers using Trimble Pivot VRS corrections and Smartnet Leica corrections.

After hundreds of tests, we feel that after a few representative tests we can generalize the reliability of RTK fixes and the device production in the real world after a few tests.

If you have provided a receiver to us for testing and you don't like the results, we are willing to test the receiver again after you make changes, however you must come and personally observe and supervise subsequent testing sessions.

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