

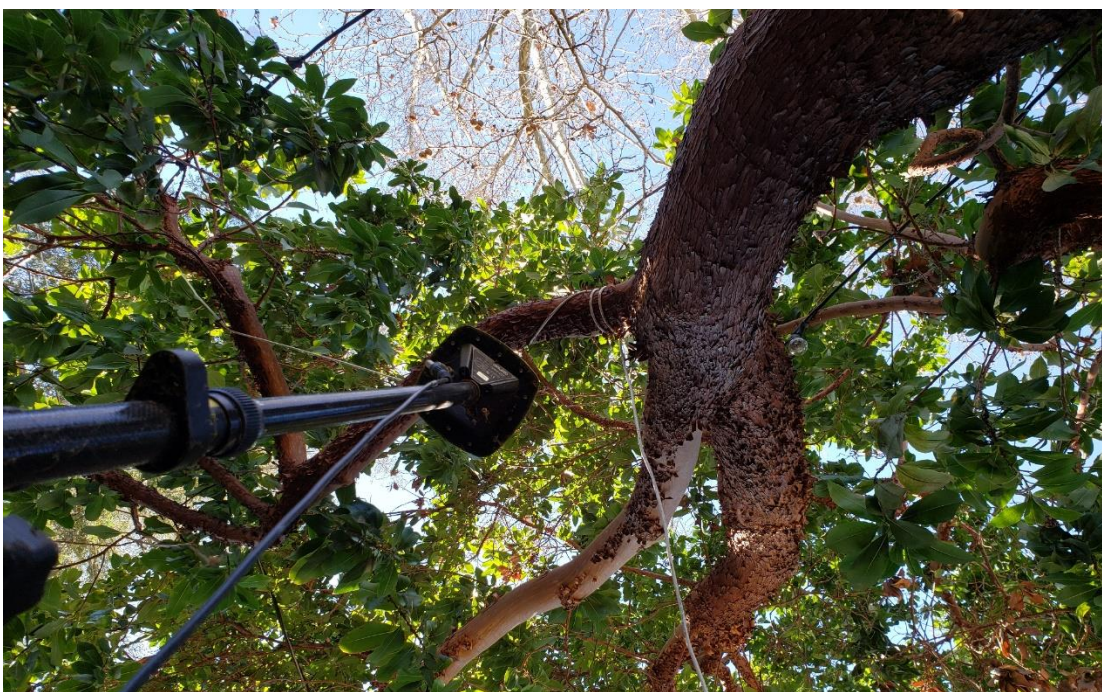
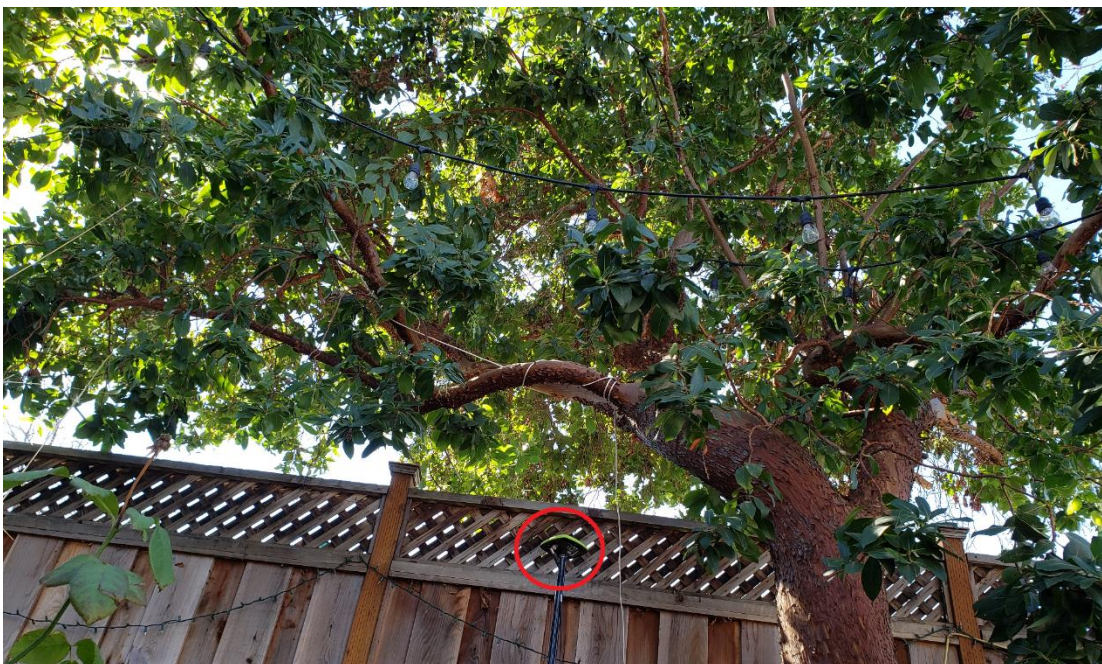
RTK Verification in Seconds with Signals Variety: A Guide to Using Signals Variety

Javad GNSS, Inc. is excited to announce a new parameter that can be used to dramatically decrease the time it takes to verify RTK observations.

Signals Variety Explanation and Test Results

Signals Variety is a parameter that increases as the differences in the GNSS signals (GPS C/A, GPS P2, GPS L2C, GLO P1, etc.) used between the different RTK engines increases. Typical *Signals Variety* values can range from 0 to 4. Higher values equate to more engines that have fixed with unique signals being used. The higher this value is, the less likely it is that this RTK solution is a "bad fix" (typically a "bad fix" is defined by the RTK coordinate being in error by more 0.20' horizontally). A more detailed explanation of the *Signals Variety* calculation is provided in the Appendix at the end of this article.

To determine the likelihood of a "bad fix" a test in a bad location for GNSS signals was conducted. An external antenna connected to a TRIUMPH-LS PLUS was used. The external antenna was located under a tree and beside a wood fence.



The only requirement to stop observing points in this test was the *Signals Variety* level. Each RTK engine in the TRIUMPH-LS PLUS can support data from up to 8 different GNSS signals. The RTK engines were manually configured so that each engine has two signals from each of the four constellations available (GPS, GLONASS, Galileo and BeiDou). This strategy was used because it was found that the RTK engines fix the fastest in poor locations when they are provided data from all the available constellations and satellites. To maximize the *Signal Variety* each GNSS signal (there are 19 available signals with the four constellations) was used no more than twice in the 4 RTK engines. To configure an RTK engine, long click on the engine in the *Engine Signal* screen and select the desired signals.

The screenshot displays the 'Engine Signal' configuration interface for four engines (A, B, C, D). Each engine has a grid of signal counts for four constellations (GPS, GLONASS, Galileo, BeiDou). The configuration is optimized for 2 signals per constellation. Below the grids, various status metrics are shown for each engine, including signal strength, lock status, and position. At the bottom, there are buttons for 'Auto Setup Engines', 'Reset Engines', 'J-Mate', 'Charts', and 'Gnss Status'.

Engine	GPS	GLONASS	Galileo	BeiDou
A	3	4	-	3
B	-	4	-	4
C	-	-	-	-
D	3	-	2	-
E	-	-	2	-
F	-	-	-	-

0(-) 10176 1(7) 13253 1(7) 11758 0(-) 11938

25/0 22/0 22/0 25/0

148 42 42 1214

9.33ft 0.661ft 46.86ft 6.00ft

0 33 0 0

Auto Setup Engines Reset Engines J-Mate -- Charts > Gnss Status

Esc 0|0|0

Optimal Engine Configuration with 2 Signals per Constellation

For 8 signals per engine to be utilized, the "Max Signals" that can be used per engine needs to be increased. This setting can be found Setup > General > RTK/DGPS > Advanced RTK Setting > Engine 1-4. Note that increasing the Max Signals will increase the demand on the GNSS processor and will decrease the RTK rate below 5 Hz when in the open where many satellites are visible. It is more desirable and beneficial to maximize the number of signals being used rather than to maximize the RTK rate.

The screenshot displays the 'Engine 1 Parameters' configuration interface. It shows various settings for the engine, including AFCL, Min Elevation, Max Signals, Reset if Far from STDL, Reset Float, Epoch Delta Time, Min SNR, Max Number of Outliers, Distribution Table, Reset on Reject, and Use GLONASS Biases. The 'Max Signals' is set to 60, and 'Use GLONASS Biases' is checked. At the bottom, there are buttons for 'Cancel', 'Apply to All', 'To Default', and 'OK'.

Parameter	Value
AFCL	Extra Low (90%)
Min Elevation	12.0
Max Signals	60
Reset if Far from STDL	0.0
Reset Float	0
Epoch Delta Time	3.0
Min SNR	30
Max Number of Outliers	4
Distribution Table	Own
Reset on Reject	0
Use GLONASS Biases	<input checked="" type="checkbox"/>

Cancel Apply to All To Default OK

Engine 1 configured with 60 signals per engine

The first test required the *Signals Variety* reach a level of at least 1.1 before stopping the point. There were 6215 points collected with 8 outliers (horizontal error greater than 0.20'). The average duration (defined as the time span between the first epoch of the saved group and the last epoch of that group) was 14 seconds. The second test required the *Signals Variety* reach a level of at least 2.1 before stopping the point. There were **over 32,000 points collected with no outliers** and the average duration was only 16 second.

Survey statistics					
Averaging		Horizontal Percentiles		Vertical Percentiles	
Points	10239	100%	0.116ft	100%	0.300ft
Distance	0.033ft	99%	0.081ft	99%	0.156ft
HRMS	0.018ft	95%	0.067ft	95%	0.123ft
VRMS	0.029ft	90%	0.059ft	90%	0.107ft
GPS	5.3	85%	0.053ft	85%	0.096ft
GLO	4.7	80%	0.048ft	80%	0.086ft
Galileo	5.7	75%	0.044ft	75%	0.077ft
BeiDou	4.9	68%	0.040ft	68%	0.067ft
QZSS	0.0	50%	0.031ft	50%	0.044ft
Per Point	15.57 sec				

A screenshot of the Survey Statistics after more than 10,000 points were collected with a Signals Variety requirement of 2.1

The *Signals Variety* parameter is found in the *Verify* settings of the *Action Group* profile.

Verify with Engines Reset <input checked="" type="radio"/>		Verify w/o Engines Reset <input type="radio"/>	
Minimum Phase-1 Duration 30 sec <input checked="" type="checkbox"/>			
Confidence Level 60		Consistency Level 0	
Confidence Guard 0.131 / 0.23 ft		Signals Variety 2.1	
Min RTK Engines At least 1		Validate Result with at least 2 engines	
Reset Engines at Start <input type="checkbox"/>		Reset Tracking at Start <input type="checkbox"/>	

Signals Variety can be used to speed up the Phase-1 of RTK Verification process (RTK engines are reset immediately after fixing and collection 1 epoch during Phase-1) the verification process. If the *Signals Variety* requirement is greater than 0 and the value is met or exceeded while a point is being collected, the RTK Verification process will advance to Phase-2 (RTK engines are not reset during Phase-2) even when the *Confidence Level* requirement has not been met. In this case the *Confidence Level* requirement does not have to be met before Accept/Reject are displayed. If the Confidence Level requirement is met before the *Signals Variety* requirement is met it will also advance to Phase-2 but the *Signals Variety* requirement must be met before Accept/Reject will be displayed.

Appendix A: Signal Variety Calculation

Signals Variety is calculated based on symmetric difference and it get the signal's set from each RTK engine for each epoch and clusterizes it by maximum symmetric difference. The maximum number of clusters is 6. With N clusters, the distance between clusters is the symmetric difference between signals. If max number of clusters is reached then the

closest one is found and replaced it by the new signal's set if the new signal's set will create a cluster with greater weight. The weight of a cluster is sum of distances to all other clusters.

Signals Variety = Averaged_Clusters_Weight / Signals_Per_Engine

Averaged_Clusters_Weight is calculated

Signals_Per_Engine is constant (8)

Simple Example: We have 2 solutions (signal's set) from the same or different RTK engines (time is not involved in the formula) and the symmetric difference is 6 signals between each. It will create 2 clusters with each cluster will having a weight 6. The averaged weight of 2 cluster is $(6+6)/2 = 6$. The *Signals Variety* = $6/8 = 0.75$.

Some theoretical values are provided in the table below. For example in this table if there are 3 fixed engines and each engine has 5 unique signals being used then the Signal Variety is 1.88.

Signal Variety Values					
	Symetric Difference Between Each Engine				
Number of Fixed Engines	4	5	6	7	8
2	0.5	0.63	0.75	0.88	1
3	1.5	1.88	2.25	2.63	-
4	3	3.75	-	-	-

Cells that don't have values are not possible due to there not being enough signals