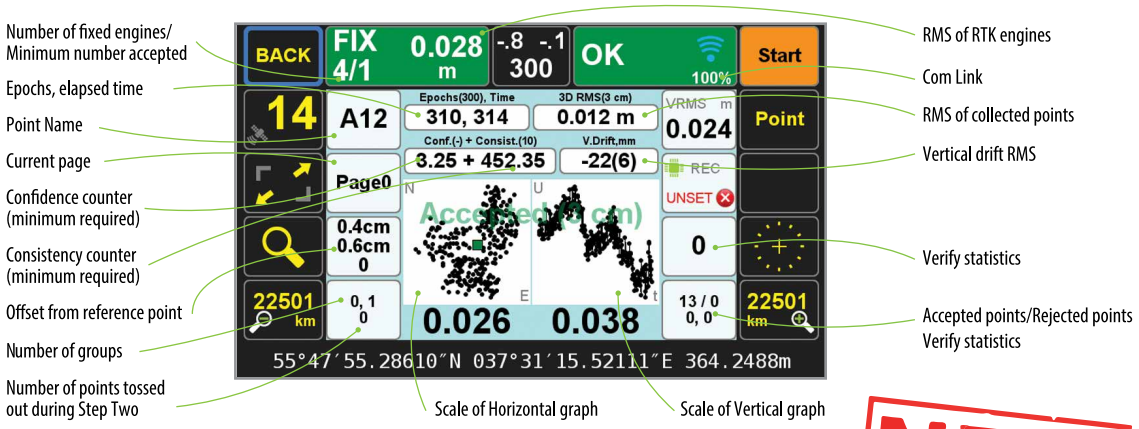
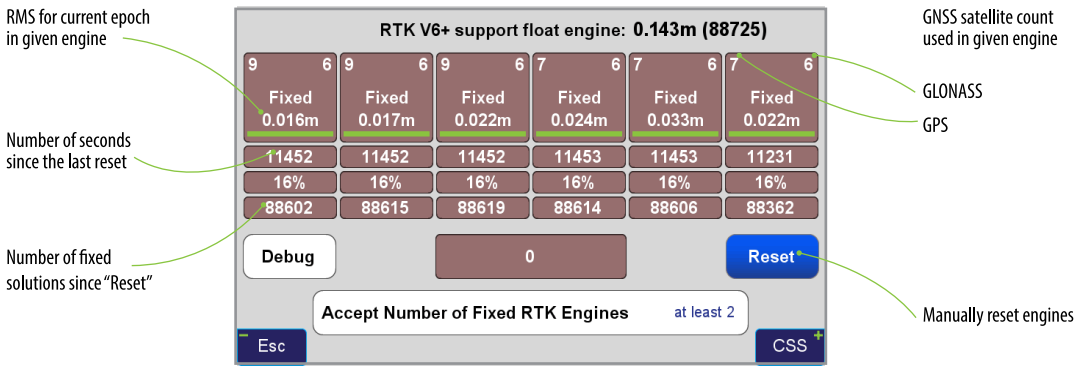
# RTK V6+

## six engines plus one support




NEW

## Auto Verify... Auto Validate...




This vigorous, automated approach to verifying the fixed ambiguities determined by TRIUMPH-LS gives the user confidence in his results and saves considerable time compared to the methods required to obtain minimal confidence in the fixed ambiguity solutions of other RTK rovers and data collectors on the market today. The methods required by other systems are not nearly so automated, often requiring the user to manually reset the single engine of his rover, storing another point representing the original point and then manually comparing the two by inverse, all to achieve a single check on the accuracy of the fixed ambiguities. Acquiring more confidence requires manually storing and manually evaluating more points. Conversely, J-Field automatically performs this test, resetting the multiple engines, multiple times (as defined by the user), provides an instant graphic display of the test results, and produces one single point upon completion.

Read details inside and compare with other receivers that require Multiple Point survey, Manual Evaluation, Single Engine, and Single Ambiguity Check per Point.

With TRIUMPH-LS you need Single Point survey, Automated Evaluation, Multiple Engines, and Multiple Ambiguity Checks per Point.

# VB-RTK

## Reliable, Fast, Accurate, Less Cost

Get on the Grid with VB-RTK. For over a decade American surveyors have been using the National Geodetic Survey's Online Positioning User Service. Surveyors employing RTK have been a significant share of the user segment of OPUS.

**A significant share of OPUS users are surveyors using RTK.** Often a surveyor will set up his base on a new, unknown position and allow an autonomous (or standalone) position to be used for the base coordinates. While he is performing his RTK work with fixed vectors between his base and rover, he stores data at the base to be submitted at a later time to OPUS. Once he is finished with his work, he downloads this file to his computer, converts the file if necessary, and submits it to OPUS. He then receives an email response back with a precisely determined coordinate for his base station. He then must take this coordinate, relate the coordinate to his project coordinate system, and then translate the work from the autonomous (or standalone) position he used in the field to this new coordinate. This procedure can produce excellent results and anchors the survey to the NSRS. The down side to this is that there are several steps that must be carefully observed and each of these error prone steps costs time.

With J-Field data collection software, Javad has been automating many tasks that surveyors have been doing for years, making the tasks more efficient and reducing sources of potential error. One example, "**Verify RTK with V6 Resets**", is being recognized by surveyors across the country as the most accurate and efficient way to confidently determine RTK positions. Rather than taking a shot, manually resetting (or dumping) the receiver and taking a second shot for comparison, Verify RTK does this automatically with a user defined number of reset iterations.

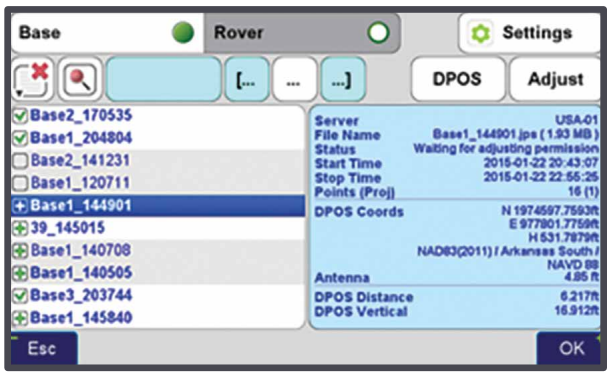
Javad has continued this automation philosophy by dramatically simplifying the process of translating a survey from an autonomous base position to precise geodetic coordinates with **VB-RTK (Verify Base – RTK)**. Using the Javad GNSS, Data Processing Online Service (DPOS), which is powered by the proven Javad GNSS Justin processing engine. **This multi-level process is done in J-Filed completely automatically.**

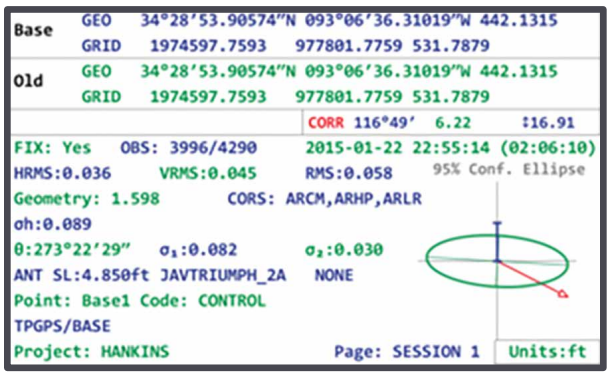
Once an RTK session has been completed, the user returns to his Javad base receiver and presses "Stop Base" on the Triumph-LS. **At this point, the raw data file that has been recording at the base during the session, is wirelessly downloaded from the base to the Triumph-LS. When the download is complete, the user returns to his office and connects the Triumph-LS to the internet.**

When internet connection is made, the file is automatically transmitted to one of the Javad GNSS servers for post processing. Once data and ephemerides are available for the session, **DPOS** processes the file and returns results to the waiting Triumph-LS. This all takes within minutes.

Once results are returned, the new coordinates for the base are shown related to your coordinate system (including localization systems).

If the user is not satisfied with the results of the DPOS solution and wants it revert back to the



## Concepts Behind RTK Verification

Fundamental in the determination of GNSS solutions is calculating the correct number of full wavelengths (so-called ***fixing ambiguities***) in order to figure out the distances from the satellites to the receiver. In doing Real Time Kinematic (RTK) surveying, we need it fast and we need it to be correct.

Multipath, the reflections of GNSS signals from ground and nearby objects and structures create their own indirect measurements from the satellites to the GNSS receiver. It's as if your measuring tape is bent around an obstacle such as a tree instead of a free and clear line of sight between two points. No calculator is going to improve this result.

TRIUMPH-LS has sophisticated hardware to distinguish between the direct and indirect signals and remove most of the indirect signals. It also reports the amount of indirect signal that has been removed. The worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. It is the task of the RTK engines to isolate such indirect signals and then exclude them from the calculations.

If too many of the signals are affected by severe multipath or indirect signals, no solution may be found. Remember, indirect signals are analogous to the bent measuring tape! When you're preforming RTK surveying, observe your environment and come to recognize that the structures around you are like mirrors for GNSS signals.

The other aspect impacting the veracity of a fixed solution is when there are weak GNSS signals. Frequently, weak signals are due to their penetration directly through tree canopy.

While **TRIUMPH-LS** can't move the obstacles that are creating multipath out of the way, its sophisticated hardware has advanced multipath reduction sub-system, its tracking software is designed to handle even the weakest signals, and its **J-Field** software provides reliable RTK solutions like no other system with its **Automatic RTK Verification System** (patent pending). J-Filed also has ample tools to demonstrate the reliability of the solution or warn against questionable results. You can readily see that without such tools other systems can provide you wrong and misleading solutions.

**J-Field** uses six RTK engines (Figure 1) running in parallel plus a support engine to monitor and aid the six engines. Each engine uses a different criteria and mathematical method tailored to resolve ambiguities in different conditions. These six parallel engines not only verify robust solutions but also maximize the possibility of providing solutions in all conditions.

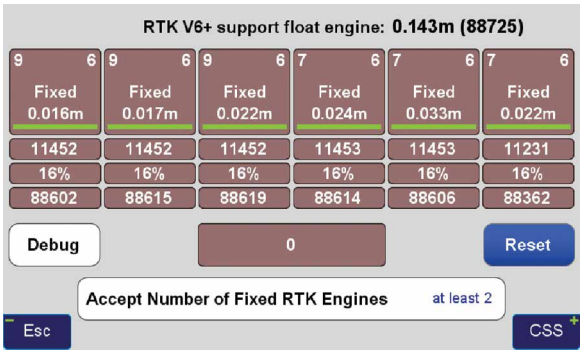



***Figure 1*** *V6+ six RTK Engines*

**User Defined Verification Tools**

**J-Field** provides the option for you to specify the **Minimum Number of Fixed RTK Engines** in verifying solutions **N** times before a position is automatically accepted where **N** is a user defined value.

J-Field employs two metrics to evaluate the performance of its RTK system of six engines: **1) Confidence Counter, and 2) Consistency Counter.** (Figure 2)

**Confidence Counter**

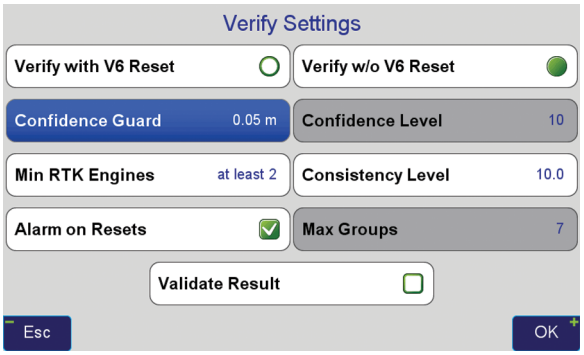



***Figure 2*** *Verify Settings*

This metric is incremented each time an engine is reset, ambiguities are recalculated, and the solution is in agreement with the previous ones (as defined by the **Confidence Guard (CG)**, default value 5 cm) is achieved. The Confidence Counter increments by 1, 1.25, 1.5, 1.75, 2.0, and 2.5 depending on the number of reset engines that fix in that epoch.

**Consistency Counter**

The Consistency Counter is incremented each time a solution is in agreement with the previous ones (as defined by the Confidence Guard) irrespective of engines being reset or not. The Consistency Counter is incremented by 0.0, 0.1, 0.25, 0.5, 1.0 and 1.5 depending on the number of fixed engines used in that epoch. Note that one fixed engine gets no credit and 6 fixed engines gets a **Consistency Credit** of 1.5.

Using these Confidence and Consistency verification tools, J-Field has two options to achieve reliable RTK solutions: **1) Verify With Automatic RTK Engines Resets** and **2) Verify Without Automatic RTK Engines Resets.**

**Verify with Automatic RTK Engines Resets**

This method has two steps: **1) Confidence Building** and **2) Smoothing and verifying**.

**• Step One**

In Step One, fixed engines are reset and solutions are collected into groups. Each group contains all the epochs located within a specified radius (the CG value) from its center and new groups are created as necessary so that all epochs fall into at least one group. Each group has its own Epoch Counter, Confidence Level and Elapsed Time. A point may fall into more than one group. The current best group is shown within [ ] and others within ( ). Step One continues until a group reaches the Confidence Level. (Figure 3)

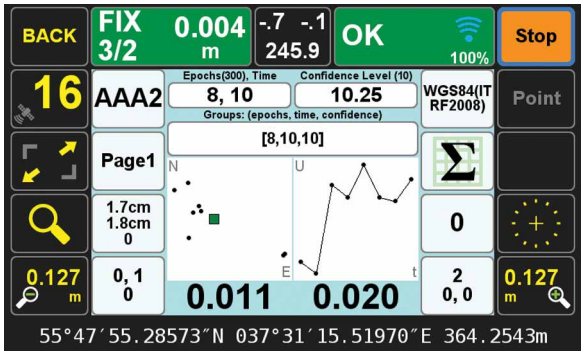



***Figure 3*** *End of Step one*

**• Step Two**

In Step Two, engines are not reset and solutions which are inside the CG of the selected group are added to that group for the remaining number of epochs that user has requested (Epoch Number, EN). Solutions that are outside the CG of the selected group, will be ignored but counted and on each such epoch, the RTK engines will reset. If the number of ignored points reaches 30% of EN, the whole process will restart. J-Field has 6 parallel RTK engines. You can specify the minimum number of engines required to be fixed to provide an epoch solution in Step Two. If the number of groups exceeds the Max Group the process restarts at Step One. This is to reduce the possibility of creating too many groups and rare false solutions in difficult environments. (Figure 4)

In both steps the Consistency Counter is also incremented as mentioned earlier.

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this reset function to any one of the U1 to U4 hardware

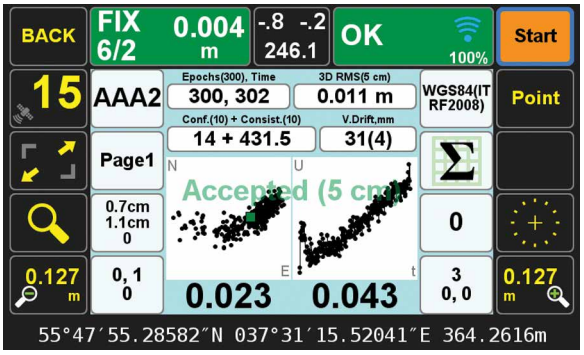



***Figure 4*** *End of Step 2*

buttons in front of the TRIUMPH-LS for easy access.

**Verify without Automatic RTK Engines Resets:**

In this method we don't force the RTK engines to reset but rely mostly on the Consistency Counter. There will be only one group as selected by the first epoch. Solutions that are not within the Guard band of the current average will be thrown out. If more than 30% of solutions are thrown out, the process will restart.

The horizontal and vertical graphs presented in both approaches also help the surveyor to evaluate the final solution. The linear drift of the vertical solution and its drift RMS are also shown above the vertical graph. A high linear drift (more than few centimeters) reveals severe multipath or, in rare cases, a wrong ambiguity fix. Pay close attention to the vertical drift and the horizontal and vertical scatter plots of epochs. Consider the scatter plots as doctors examine X-rays to determine anomalies.

The desired **Confidence Level** and **Consistency Level** are user selectable. Default values are 10. These parameters along with the desired number of epochs must be reached before a solution is provided.

In either case there is also a **Validate** option which, when selected, will reset all engines at the end of the collection and continues with 10 more epochs to validate if the solution is within the desired boundary of the Confidence Guard. (Figure 2) Minimum number of engines for the Validation Phase is user selectable.

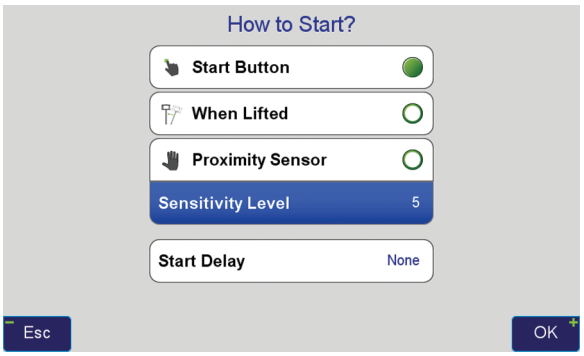



***Figure 5*** *How to Start*

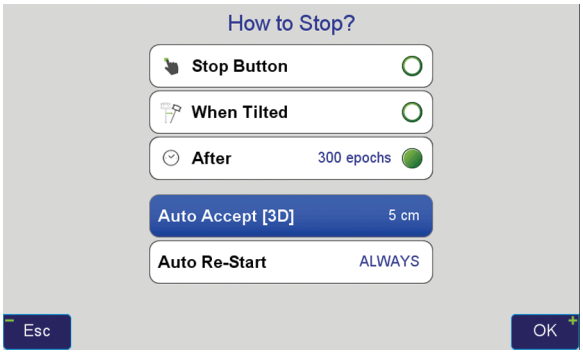



***Figure 6*** *How to Stop*

In either case, if Auto-Accept is activated, the position will be automatically accepted if the RMS of the final solution is less than what user has selected in the Auto-Accept screen. (Figure 6)

You can also use **Auto-Restart** if you want to monitor structures or test the RTK system unattended. (Figure 6)

**Screen Shots of Action Screen**

Action Screen shows detailed information about each point collected. Screen shots can automatically be attached to each point and saved at the end of each collection (Figure 7). In **Verify with Automatic RTK Engines Resets** screen shots at the end of both Step One and Step Two are saved (Figures 3 and 4). In Action screen there are 8 white boxes that selected items can be viewed on them.

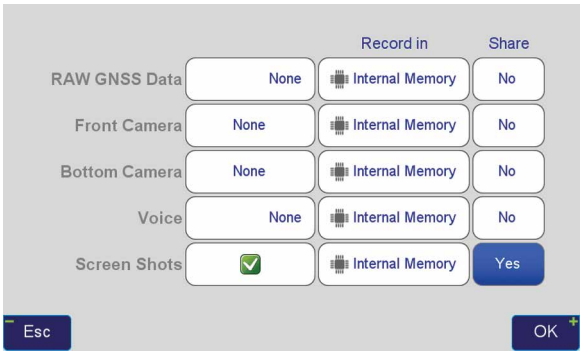



***Figure 7*** *What to record screen*

**Review Screen**

View cluster of all points. Select the desired point to see its point cluster (Figure 8). Click the icons to see additional details about that point (Figure 9) including the distance and direction to the current point (Figure 10).

The effects of multipath, ionosphere, orbit, and other sources of problems somewhat exponentially increase as the baseline length increases. In a VRS/RTN scheme your **actual** baseline length is the actual distance to the nearest base station. The **virtual** base station that is mathematically created is not the actual length. We strongly recommend using your own base station near your job site in a Verified-Base RTK (VB-RTK) scheme.

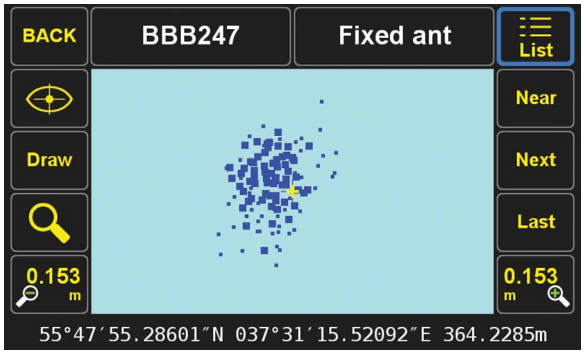



***Figure 8*** *Review screen shows cluster of 386 points*

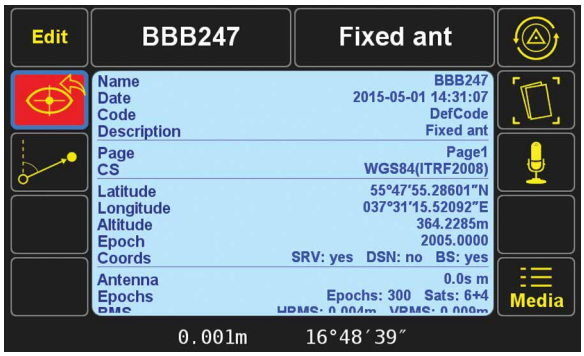



***Figure 9*** *Detailed information on selected point (scroll to see all information)*


***Figure 10*** *Distance and direction from the current point to the selected point*

In addition to providing you with the most reliable RTK solutions (especially true in remote areas where cell coverage is hit or miss), using your own base receiver allows you to easily tie your solutions to well-established IGS/NGS spatial reference systems through Javad's exclusive Data Processing Online Service (DPOS) and J-Field's user-friendly Base/Rover Setup. Note that post-processed results returned to the Triumph-LS using DPOS are dependent on the availability of orbital data from NGS and may require several hours. For further reading about DPOS, its integration into J-Field and the streamlined approach developed by Javad for setting up the base and rover, please check out Shawn Billings' excellent article on VB-RTK on our

website. Point your browser to: *http://www.javad.com/jgnss/javad/news/pr20150219.html*

Alternatively, if you don't have access to IGS-type stations to use DPOS, you can select an open area near your job site and use TRIUMPH-LS to obtain its position via RTN networks for about 5 minutes. You may repeat a couple of times for assurance. Then transfer this position to the TRIUMPH-1 or TRIUMPH-2 to use as the base station near your job site. The Base-Rover setup screen in the TRIUMPH-LS makes this job very easy.

**Instantaneous Multipath charts**

TRIUMPH-LS removes most of the multipath instantly on every epoch. Click on the Satellite icon to see the Signal Strength of satellites and then click the "+" key to see the multipath charts.

Figure 11 shows the amount of code phase multipath that TRIUMPH-LS has removed; relative to a fixed level. That is why negative numbers are in this figure. Units are in centimeter. Noting the signs in this figure, the amount of multipath in some satellites is in excess of 5.6 meters.

Figure 12 shows the amount of carrier phase multipath that TRIUMPH-LS has removed relative to a fixed level. Units are in millimeter. Noting the signs in this figure, the amount of multipath in some satellites is in excess of 4 centimeters.

| SAT | EL | L1 | P1 | P2 | L2C | L5 | SAT | EL | L1 | P1 | P2 | L2C | L5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GPS2 | 29↑ | 273 | 281 | -76 | -- | -- | BDU11 | 75↑ | 362 | -- | -- | -- | 305 |
| GPS6 | 44↑ | 55 | 201 | -60 | -5 | 189 | BDU12 | 36↓ | 288 | -- | -- | -- | 200 |
| GPS12 | 70↑ | 183 | 190 | -90 | -94 | -- | GPS3 | 10 | -- | -- | -- | -- | -- |
| GPS14 | 25˜ | 281 | 317 | -97 | -- | -- | GPS29 | 3 | -- | -- | -- | -- | -- |
| GPS17 | 23↓ | 332 | 364 | -74 | 6 | -- | GPS32 | 3 | -- | -- | -- | -- | -- |
| GPS24 | 53↓ | 117 | 566 | 67 | -64 | 124 | GLN7 | 3 | -- | -- | -- | -- | -- |
| GPS25 | 30↑ | 243 | 218 | -42 | -50 | -34 | GLN19 | 12 | -- | -- | -- | -- | -- |
| GLN1 | 10↑ | 305 | 229 | -126 | -404 | -- | | | | | | | |
| GLN8 | 16↓ | 26 | 87 | -484 | -617 | -- | | | | | | | |
| GLN9 | 32↑ | 359 | 301 | -246 | 55 | -- | | | | | | | |
| GLN15 | 31↓ | 276 | 203 | -93 | -2 | -- | | | | | | | |
| GLN16 | 84↑ | 235 | 309 | -133 | -109 | -- | | | | | | | |
| GLN17 | 39↓ | 52 | -84 | -156 | -52 | -- | | | | | | | |
| GLN18 | 69↑ | 190 | 168 | -177 | -184 | -- | | | | | | | |
| GAL12 | 68˜ | 680 | -121 | 246 | -- | 32 | | | | | | | |
| SB127 | 25˜ | 469 | -- | -- | -- | 319 | | | | | | | |
| SB128 | 15˜ | 206 | -- | -- | -- | 322 | | | | | | | |
| QZ193 | 13↑ | 550 | 513 | -- | 56 | 55 | | | | | | | |
| BDU2 | 16˜ | 299 | -- | -- | -- | 275 | | | | | | | |
| BDU5 | 25˜ | 269 | -- | -- | -- | 230 | | | | | | | |
| BDU8 | 25↓ | 145 | -- | -- | -- | 143 | | | | | | | |

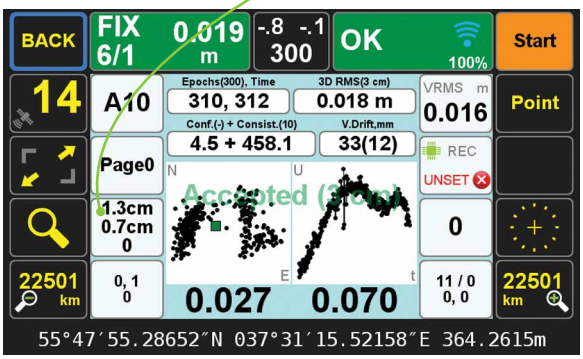
***Figure 11*** *Code Phase multipath removed (cm)*

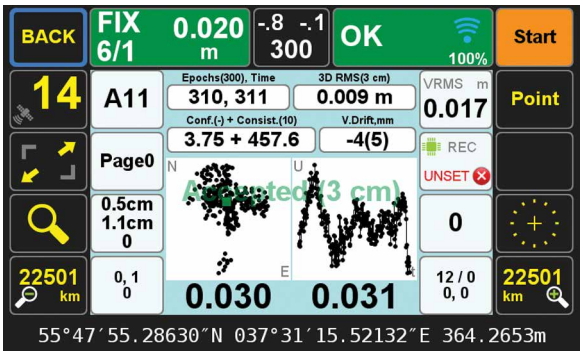
| SAT | EL | AZ | L1 | P1 | P2 | L2C | L5 | SAT | EL | AZ | L1 | P1 | P2 | L2C | L5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GPS2 | 29↑ | 154 | 7 | 7 | 2 | -- | -- | BDU11 | 75↑ | 158 | -6 | -- | -- | -- | -5 |
| GPS6 | 44↑ | 98 | 11 | 9 | 2 | 2 | -13 | BDU12 | 36↓ | 60 | -6 | -- | -- | -- | -14 |
| GPS12 | 70↑ | 282 | 7 | 8 | -2 | -2 | -- | GPS3 | 10 | 26 | -- | -- | -- | -- | -- |
| GPS14 | 25˜ | 302 | 5 | 8 | -4 | -- | -- | GPS29 | 3 | 229 | -- | -- | -- | -- | -- |
| GPS17 | 23↓ | 58 | 6 | 9 | -6 | -2 | -- | GPS32 | 3 | 346 | -- | -- | -- | -- | -- |
| GPS24 | 53↓ | 196 | 1 | 4 | 13 | 1 | -12 | GLN7 | 3 | 297 | -- | -- | -- | -- | -- |
| GPS25 | 30↑ | 282 | 4 | 8 | 7 | 1 | -32 | GLN19 | 12 | 210 | -- | -- | -- | -- | -- |
| GLN1 | 10↑ | 34 | 1 | 4 | -15 | -23 | -- | | | | | | | | |
| GLN8 | 16↓ | 344 | 12 | 15 | 17 | 25 | -- | | | | | | | | |
| GLN9 | 32↑ | 316 | 0 | 2 | -3 | -6 | -- | | | | | | | | |
| GLN15 | 31↓ | 142 | 5 | 5 | 0 | 1 | -- | | | | | | | | |
| GLN16 | 84↑ | 266 | 2 | 2 | -11 | -18 | -- | | | | | | | | |
| GLN17 | 39↓ | 44 | -1 | -4 | -12 | -10 | -- | | | | | | | | |
| GLN18 | 69↑ | 188 | -1 | 3 | -1 | -6 | -- | | | | | | | | |
| GAL12 | 68˜ | 108 | 0 | -26 | 0 | -- | -14 | | | | | | | | |
| SB127 | 25˜ | 160 | 7 | -- | -- | -- | -4 | | | | | | | | |
| SB128 | 15˜ | 130 | 9 | -- | -- | -- | -11 | | | | | | | | |
| QZ193 | 13↑ | 68 | -3 | -1 | -- | 1 | -19 | | | | | | | | |
| BDU2 | 16˜ | 132 | -7 | -- | -- | -- | -17 | | | | | | | | |
| BDU5 | 25˜ | 154 | -4 | -- | -- | -- | -7 | | | | | | | | |
| BDU8 | 25↓ | 54 | -10 | -- | -- | -- | -20 | | | | | | | | |

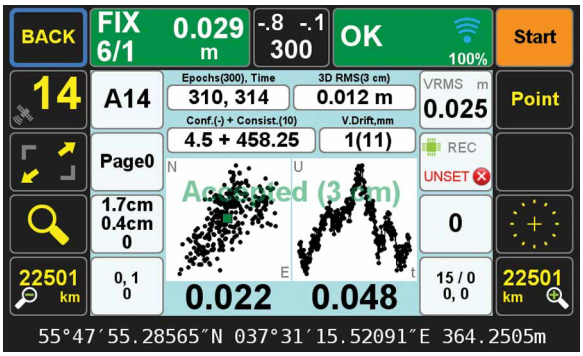
***Figure 12*** *Carrier Phase multipath remove (mm)*

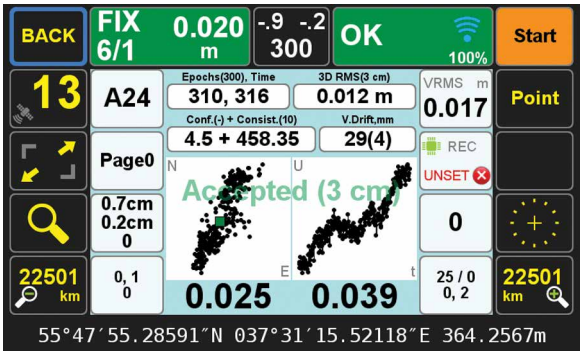
**Multipath Showcase**

Graphs in the following examples show multipath effects in a 13.8 km baseline where about 1/3 of the rover sky was blocked by a tall building. This box shows horizontal (top) and vertical (bottom) offsets from the actual coordinates of the point (earlier surveyed for test).



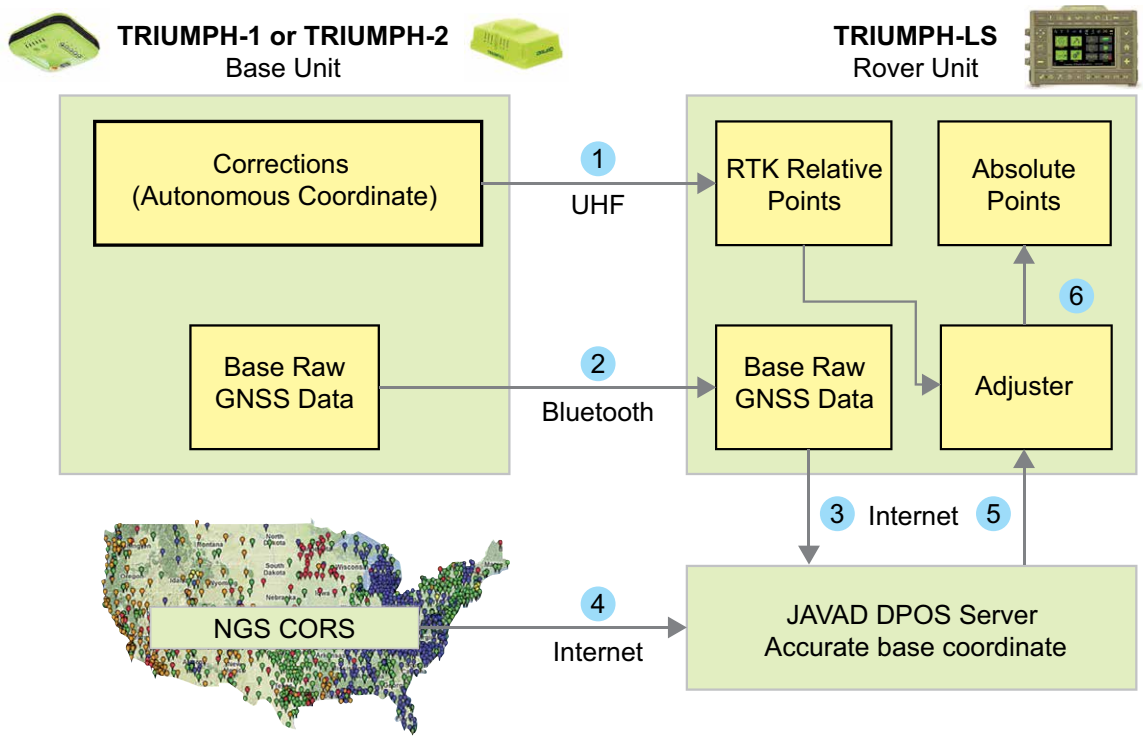




**Javad Ashjaee, Ph.D.**

original RTK positions, he simply clicks "**Undo**". This process is immune to base instrument height errors because the internal vectors between base to rover are related to the antenna, not the ground point. So, an accidental entry for the base height of 543' instead of 5.43' can be resolved by VB-RTK.

**In addition to the advantages of having your RTK base station near your work area, which gives you much more accurate and faster fixes, especially in difficult areas, and saving you the RTN charges; perhaps most important of all, your work is now precisely related to one of the most accurate geodetic control networks in history - the NGS CORPS.** Every rover point is only two vectors removed from the CORS (CORS to base, base to rover). This means that you can return again someday to find your monuments easily and accurately. This makes your records incredibly more valuable to both you and future surveyors. J-Field also has the unique ability to load and view every point you have ever surveyed from all the projects in its system. By combining this feature with a **distance filter** in its advanced set of filters, you can easily view all the points you have previously surveyed within a given distance of a point in your current project. Having an easily accessible record of nearby georeferenced coordinates is very beneficial as you may have previously located monuments in past surveys that are beneficial in your current project. J-Field allows you to easily copy these selected points into your current project, eliminating the need for you to resurvey them. All of this is available automatically on the world's most advanced RTK rover - **the Triumph-LS**.




**You do 1, the rest is automatic**

*Introducing*

# RAMS

## Remote Assistance & Monitoring Services


JAVAD has gone and done it again! The brilliant minds at JAVAD GNSS have created yet another incredible first in surveying history: Remote Assistance & Monitoring Services (RAMS).

The RAMS Viewer is an elegant web interface. Using your own web browser, RAMS Viewer allows you to connect to your Triumph-LS from anywhere in the world when both your computer and Triumph-LS have access to the Internet.

RAMS is much more than just a remote data manager. Every function of J-Field that is available to the operator of the Triumph-LS that's in the field, is available to the remote viewer!

This incredible tool has many uses including facilitating live support by the PLS Support Team directly to Javad customers in the field, structural monitoring, training and other educational opportunities presented to large audiences in real time.

Using the Files tab, upload files to the Triumph-LS remotely from the office to the field... or right there on your desk in the office. Likewise you can download files wirelessly to the cloud or your own PC using RAMS Viewer.

Using the Status tab, quickly collect 18 screen shots in close succession showing your receiver's vital statics and bringing it all together at that very moment.

RAMS Server, the program running on the hosting computer, is at the heart of it all. This means you can set up RAMS Server locally on your own PC and keep it all in-house, or leverage the Internet using Javad's hosting server.

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