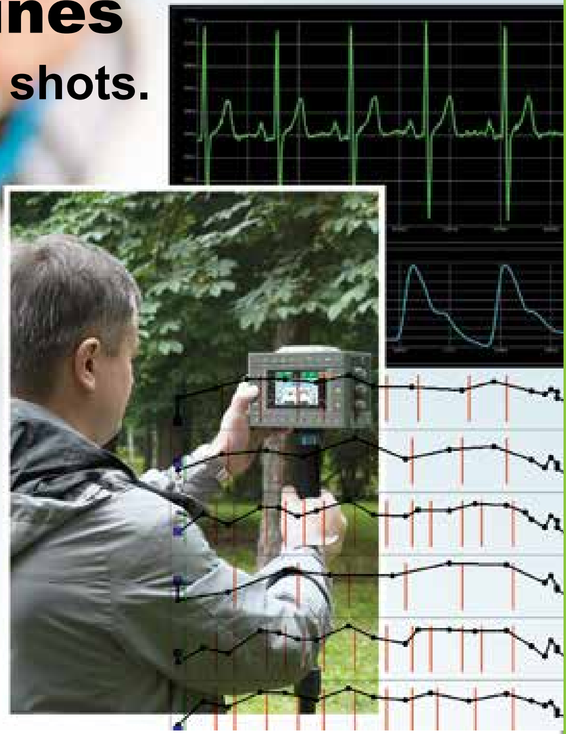
With our 6+ RTK Engines

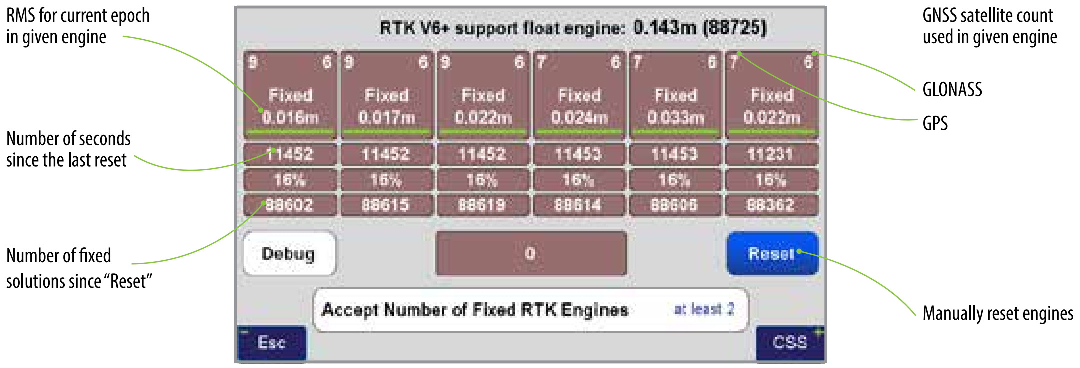
Monitor the health of your RTK shots. Verify, Record, Present and Defend.



RTK is a statistical process by nature and needs **verification**. TRIUMPH-LS has **six different RTK engines** and extensive automatic verification to ensure your shots are 100% reliable.

It also has many tools to **document** the process of your shots for **presentation** when you need to **prove** and **defend**. The screen shots on following pages can automatically be recorded and attached to each point and easily **exported in HTML format**.

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.

Spoofer Detection

With 864 channels and about 130,000 quick acquisition correlators in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS satellite PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we know that we are being spoofed and can identify the spoofed signals.

When we detect that spoofing is in effect, we use the position solution provided by all other clean signals (L1, L2, L5, etc... GPS, GLONASS, Galileo, Beidou, etc...) to identify the spoofer signal and use the real satellite measurement. If all GNSS signals are spoofed or jammed, then we alarm you to ignore GNSS and use other sensors in your integrated system.

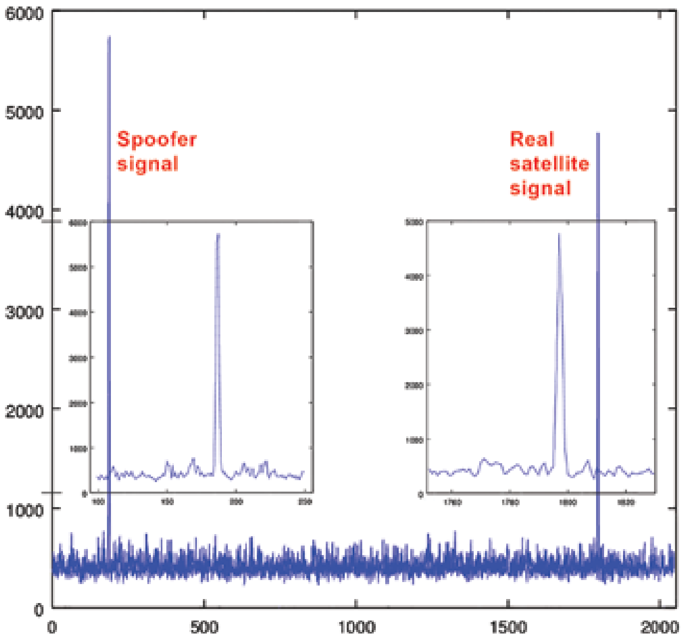


Figure 1
shows an example of a spoofer signal and a real satellite signal received at GNSS receiver.

Satellite and Spoofer Peaks

The screenshots below are from a real spoofer in a large city. The bold numbers are for the detected peaks. The gray numbers represent highest noise, not a consistent peak. "*" symbol next to the CNT numbers indicate that signal is used in position calculation. Each CNT count represent about 5 seconds of continuous peak tracking.

SAT	EL	S..	Range 1	Dopp	CNT 1	S..	Range 2	Dopp	CNT 2	dRng	dDop	N
GPS5	33	16	61.14	1382	184*	4	25.95	101	1	29.32	1201	29
GPS7	51	21	14.39	1146	184*	4	18.21	-453	1	2.80	1599	29
GPS8	30	18	65.10	-918	184*	4	4.26	-1318	1	3.68	400	29
GPS9	12	14	40.46	2966	184*	4	2.08	3795	1	26.13	-799	29
GPS13	40	16	46.92	-3525	184*	4	8.21	-4525	1	25.80	800	29
GPS15	12	14	12.46	-4336	30*	5	33.00	-1536	1	19.52	-2000	28
GPS20	24	12	13.19	-1707	107*	4	29.32	-3307	1	15.11	1600	29
GPS27	18	11	10.26	1264	184*	4	43.56	63	1	31.22	1201	29
GPS28	53	19	9.41	-2724	184*	4	7.03	-4724	1	0.46	2000	29
GPS30	81	22	13.79	-332	184*	5	34.18	1268	1	19.36	-1598	28
GLN-4	54	20	62.08	1498	1158*	5	21.72	2097	1	24.16	-1199	25
GLN5	46	20	18.04	-2097	524*	4	20.28	-3697	1	7.20	800	25
GLN0	37	18	30.37	2355	1469*	4	28.37	1554	1	6.98	801	25
GLN-1	82	18	34.92	-776	189*	4	12.54	-1576	1	21.35	800	25
GLN-2	26	12	30.96	-4358	229*	4	11.80	-3158	1	18.13	-1200	25
GLN2	21	19	59.73	288	551*	4	47.55	1097	1	11.18	-799	25
GLN4	22	15	30.59	-3361	208*	4	11.74	-5361	1	17.83	2000	25
GLN-5	21	14	20.17	276	187+	3	25.45	2275	1	4.28	-1999	25

Esc Sat: 10 7 6 4 4 0 dPos: 19.0m Age: <1s

***Figure 2** No spoofer. Only one reasonable peak for each satellite.*

Elevation Angle; Satellite Name; First Peak: Signal above noise level, Range mod 1 ms, Doppler, 5 sec count; Second Peak: Signal above noise level, Range mod 1 ms, Doppler, 5 sec count; Delta range; Delta Doppler; Noise level

SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS1	14	14	231.08	-2627	140*	9	155.13	-2627	60	74.93	0	28
GPS10	9	12	267.44	-2078	74*	4	238.41	-3278	1	28.01	1200	28
GPS11	22	13	297.36	-847	301*	3	6.45	1151	1	289.89	-1998	29
GPS13	55	21	136.95	1154	301*	9	21.70	1153	73	114.23	1	28
GPS15	49	20	278.00	-453	301*	9	168.03	-453	73	108.95	0	29
GPS17	41	22	83.28	-3212	301*	10	277.41	-3212	69	193.11	0	28
GPS19	23	14	133.13	-4590	164*	7	19.06	-4590	69	113.05	0	29
GPS20	5	8	170.96	2215	36*	3	50.73	614	1	119.21	1601	29
GPS24	22	15	54.25	-4022	177*	9	250.43	-4022	82	195.16	0	29
GPS28	58	18	50.14	1040	301*	3	268.62	1439	1	217.46	-399	29
GPS30	23	17	290.02	2593	301*	3	214.66	4592	1	74.34	-1999	28
GLN-7	30	22	159.09	2505	213*	7	274.16	2104	1	114.05	401	28
GLN-4	39	18	72.21	-450	282*	7	220.15	-3250	1	146.92	2800	28
GLN-1	34	18	92.17	-3838	259*	6	299.41	-1838	1	206.22	-2000	28
GLN0	72	23	271.81	147	283*	7	78.08	2146	1	192.71	-1999	28
GLN1	23	15	297.65	3244	129*	6	8.21	2443	1	288.42	801	28
GLN2	42	18	200.78	-742	282*	6	234.83	2056	1	33.03	-2798	28
GLN3	17	18	158.51	2584	282*	6	44.03	4583	1	113.46	-1999	28

Esc Used: 11+9+4+8+0+1=33 1 2 dPos: 21.2m Age: <1s

GPS GLN GAL BDU IRN QZ ◂ Number of satellites used in position calculation

Figure 3
In the screenshot all GPS satellites have two peaks and all are spoofed. We were able to distinguish the spoofer signal and use the real satellite signals in correct position calculation as indicated by the "" next to the CNT numbers.*

PATENTS PENDING

BEAST MODE RTK

Real 5-Hz Base Station Transmission

All RTK base stations (including RTNs) transmit data once per second. We are introducing The BEAST MODE RTK, real 5-Hz Base Station Transmission. Here are testimonials:

Well this just about has to be the most amazing single improvement I have observed.

I am most assuredly getting faster fixes under tree cover. And the ability to collect 5 times as many honest epochs in the same time period is wonderful.

My quick little test doing 3 epoch, lift to start topography actually made me laugh because it is so fast.

The only thing users need to know is that if they must use the RTK Delay setting of None for the allowable correction age, otherwise they will only see 1Hz updates. As Javad told us, extrapolate is a sin we should avoid.

I have a feeling that we are now seeing fixes, that are actually occurring 5 times as fast under tree cover. In my “bad spot” under a tree, I am making it through 10 resets in less than 10 seconds. This is simply amazing.

John Evers, PLS

In a test I just did under a tree, I would reset the RTK engines and use a stopwatch to time how long it took 2 engines to fix.

With 1 Hz it was averaging over 30 seconds and with 5 Hz it is in few seconds.

Mine is up and running fine. This thing is so fast now it is hard to believe!

Matthew D. Sibole, PLS

Be aware that increasing the transmission rate increases the battery usage of the radio and will also increase the heat generated inside it. For 2 Hz corrections you should use D8PSK or D16QAM modulation. D16QAM has the most bandwidth and is required for 5 Hz transmissions but may reduce the range of the radio some. If you are using a 35 watt radio the fan should be used with 5 Hz corrections if the output power is more than 4 watts.

Matt Johnson, PLS

Precision with TRIUMPH-LS

Our friend from Javad GNSS, Michael Glutting, recently related that a surveyor in Minnesota asked how he could use his Triumph-LS and corrections from the MnCORS real time network to accurately work within his projects previously established with HARN. The MnDOT provides mount points for various adjustments of NAD83, however, a surveyor can quickly produce reliable, highly accurate transformation parameters for a local set of known positions as this paper describes.

In 2000, Stanger Surveying of Tyler, Texas, established a GPS control network consisting of 30 monuments for my hometown of Kilgore, Texas, over an area measuring about 7 miles square (50 square miles). Even after 15 years, the network proves to be incredibly accurate and was well constructed with ties to two different HARN PACS (High Accuracy Reference Network Primary Airport Control Stations) and multiple repeat and braced vectors. This network predated the modern proliferation of CORS stations, and so there is no precise relation to the CORS and therefore no precise relationship to NAD83_2011. This means that there is some unknown translation from the Kilgore GPS Control Network of 2000 and NAD83_2011. Because of this, we must resolve these transformation values by observation.

To do this, we conducted two field campaigns. In both sessions, I placed a Javad GNSS receiver on a stable monument, POST, located at our office. The first session, I used a Triumph-1, and for the second, I used a Triumph-2, both broadcasting corrections over the Internet via TCP. The NAD83_2011 position of POST has been accurately determined by hundreds of hours of data from several different GPS receivers processed through OPUS.

In the first session, my father, J.D., and I observed five different monuments from the Kilgore network with the Triumph-LS for 90-120 seconds each. These points were the primary control Stanger established from the HARN PACS. After observing those five points I performed a preliminary localization.

In this preliminary localization, I fixed only one point (point L011_A). Three of the remaining four show very low residuals, however point L017_A, with its noticeably higher vertical residual suggests this point has been displaced since it was established in 2000, or that there is an error in the observation itself - only a repeat occupation will tell.

During the second session, we observed the five points again and used the average tool in J-Field to perform a weighted average of the two points. The second observations showed excellent agreement with the first observations. This chart shows the difference in the repeat observations for each of the five stations:

STATION	Base-Rover Vector Length (usft)	Δ 2D (usft)	Δ UP (usft)
L001	37342.3	0.097	-0.029
L009	23155.7	0.048	-0.139
L011	13559.4	0.049	-0.005
L017	24184.6	0.036	0.033
L027	2285.9	0.032	-0.005

With the five control points averaged, I began the localization process again. First I performed a minimally constrained localization holding only point L001. Notice that point L017 still appears to be an outlier.

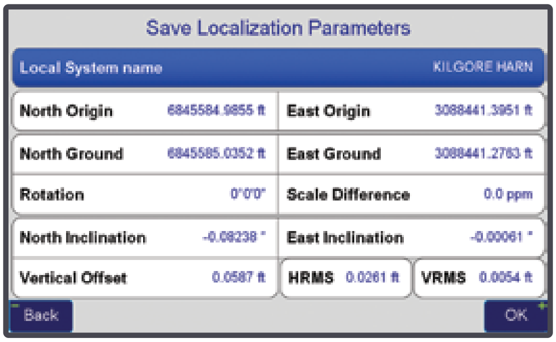
Next, I constrained horizontally to L001, L009, L011 and L027 while still only fixing point L001 vertically. The residuals predictably decrease among the points fixed.

With the residuals indicating a good fit, I turn my attention to the parameters of the localization.

From these parameters, several observations can be made immediately. Because both surveys relied upon the same definition of North, it is expected that there would be little, or no rotation. Furthermore, because both surveys relied upon the same definition of the foot, US Survey foot measured along the same grid surface, Texas Coordinate System of 1983, North Central Zone, there should be little difference in the scale factor. The rotation determined is less than half of one arc second and the scale factor being applied to best fit my survey to Stanger's original work is only 1 part-per-million, revealing very good relative agreement between the surveys.

Finally, I am ready to perform a fully constrained localization, holding all four points (still disregarding the displaced monument L017) both horizontal and vertical.

I set both the rotation and scale to zero as I do not want to redefine North nor the US Survey Foot. Now that more than one point is involved vertically, a tilted plane is calculated. Because the Stanger survey was based on Geoid96 and today's survey is based on Geoid12A, I left the tilt values intact. In this case the inclination values are so small as to be practically insignificant.



The final results indicate that the translation between the Kilgore GPS Control Network of 2000 and NAD83_2011, epoch 2010, (usft) is N: -0.0497 E: +0.1188 U: -0.0587. From this point forward, I can use this new localization system to survey in coordinates related to the Kilgore GPS Control Network of 2000 with a reference station broadcasting NAD83_2011 corrections, or I can transform coordinates from surveys related to the Kilgore GPS Control Network of 2000 to NAD83_2011.

The final step in this exercise is to use this transformation to test on known points. In order to do this, we observed five additional points from the Kilgore network that were not used in the localization. Each point was observed for 120 seconds with the Triumph-LS with corrections from the Triumph-2 onPOST. The chart below depicts the difference in coordinates determined from the LS using the localization and the original Kilgore GPS Control Network of 2000 coordinates.

These residuals can be attributed to several different sources: original survey error, current survey error, displacement over 15 years, as well as errors in the localization/transformation being used. However these results, together with the residuals from the localization, indicate that the localization, as determined, will allow me to reproduce the Kilgore GPS Control Network of 2000 coordinates within a centimeter, anywhere within the network. The total time required to perform this exercise was 4.5 hours in the field (including redundant observations) and 30 minutes of calculations, which were all made within the Triumph-LS.

Shawn Billings, PLS

Station	Base-Rover Vector Length (usft)	2D Residual (usft)	Up Residual (usft)
L007	15363.3	0.036	-0.006
L012	14416.1	0.030	0.101
L019	12900.9	0.025	0.001
L021	7553.0	0.048	0.121
L025	11238.8	0.011	0.048

What is JAVAD?

When I started surveying 16 years ago I never imagined one man could survey large acreages in the mountains of South Carolina. When we found our old GPS system was not providing the accuracy we needed in the time we needed it, we started researching all the options in the GPS market. JAVAD quickly became the first choice because of the 6 GPS engines that work together comparing redundancy calculations to acquire the most accurate measurements, ultimately eliminating the "False Fix" issue we were having with the our old GPS. When we received the unit, I was blown away by the craftsmanship and design of the Triumph LS. It combines the head unit and data collector into one, thus creating a compact design with a informative heads up display that increases overall productivity.

With JAVAD's remote assistance feature, the setup was quick and painless and the support we received from the JAVAD team, especially Adam Plumley, was a welcome surprise. Since purchasing the JAVAD GPS system we have increased our work load while reducing overhead cost, allowing us to compete with larger firms that use traditional GPS units.

On a more personal note, recently the Triumph LS and I were struck by a vehicle in the line of work. We both went over the hood of a SUV that was traveling about 40-45 MPH and I sustained minor scrapes, and bruises, while the LS only sustained cosmetic damage. It took a hit by a SUV, but when the dust settled it was still taking measurements as I scooped it up off the asphalt. Finally a company has created a a GPS unit whose durability is as good as accuracy! I love this GPS and I don't think I could ever go back to traditional GPS; it would be like driving a drag car, then going back to a bicycle.

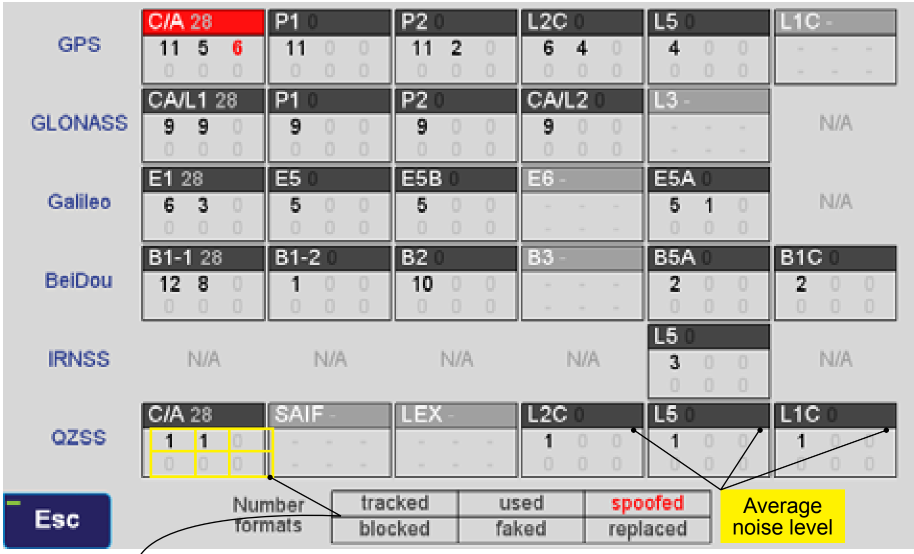
So What is JAVAD? JAVAD is the future of surveying. JAVAD is similar to the creation of smart phones, but in GPS technology. Although I don't want my competition to have JAVAD, surveyors around the world have to step up with technology. JAVAD is changing the game of surveying on a global scale, in the quest for more accurate, and reliable measurements.

Sincerely,
William C. Hutchins PLS

PIONEER SURVEYING INC

GNSS Overall View

The format and the signal definitions are explained below.



GPS L2C: L+M
GLN L3: I+Q
GAL E1: B+C
GAL E5: alboc
GAL E5B: I+Q
GAL E5A: I+Q
BeiDou B2: B5B
QZSS L2C: L+M
QZSS L1C: I+Q

Figure 4
The screenshot shows the status of all GNSS signals.

Definitions for the number of signals:

Tracked: Tracked by the tracking channels and has one valid peak only.

Used: Used in position calculation.

Spoofed: Has two peaks. Good peak is isolated, if existed.

Blocked: Blocked by buildings or by jamming. If jammed, shows higher noise level.

Faked: Satellite should not be visible, or such PRN does not exist.

Replaced: Real signal is jammed and a spoofed signal put on top of it. Because of jammer, it shows higher noise level.

Spoofer Orientation

When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver antenna (e.g. TRIUMPH-LS) horizontally and rotate it slowly (one rotation about 30 seconds) as shown in the picture and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure 5.

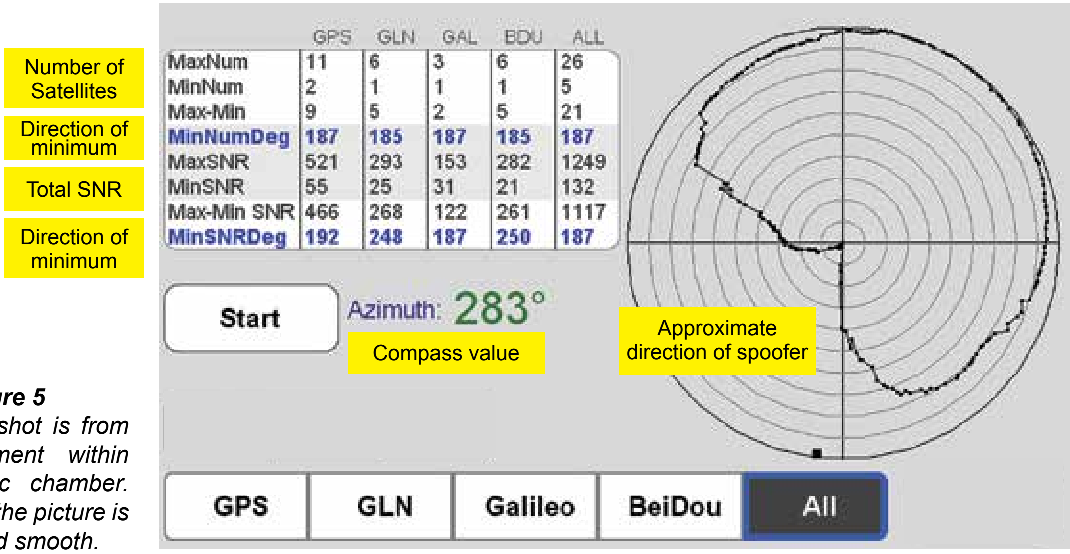
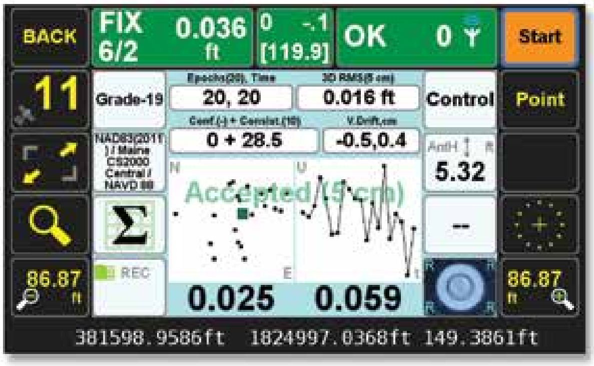


Figure 5
This screenshot is from the experiment within an anechoic chamber. That is why the picture is clean and smooth.

Double Bubble



Survey results can be documented with the on-screen image of the vial.

The vials can be viewed on the TRIUMPH-LS screen via the bottom camera.

The internal electronic levels can be calibrated with the mounted vials.

A 40 min vial for fast set up. Next to it is an 8 min vial for precision set up. All in a small package.