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The author and Matt Sibole, PS and member of the Javad team at the June 2017 JAVAD workshop. PHOTO BY NATE DEARYAN.

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JAVAD Triumph-LS Rover A Technical Review PART 1

hen Marc Cheves, the editor of American Surveyor, first approached me about doing a technical review of the JAVAD Triumph-LS, an RTK/RTN rover, I jumped at the chance—given that it included JAVAD's

offer to loan me a full system. To date I have had the equipment for almost three months, interviewed developer Javad Ashjaee himself, as well as several dozen JAVAD owners, and attended a two-day JAVAD seminar in Arkansas.

I suspect that few, if any, equipment reviews have entailed first-hand "demo" use of equipment for such a lengthy period. I'm technically savvy and frankly expected to spend a week or two at this. However, I had not anticipated the extensive features built into the JAVAD rover. Kudos to JAVAD for its generosity—and to the JAVAD support team.

Overview

The "LS" in JAVAD's Triumph-LS is an abbreviation for Land Surveyor. In fact, the system's hardware and software is designed by and for land surveyors. At this stage the software (called J-Field) is in its fourth year of refinement, although its genesis goes back at least several decades.

Unlike any other system I know, the LS releases system enhancements without cost to owners about every six to eight weeks. These are largely not bug fixes. Many are what any other maker would characterize as major releases. They are always in response to user requests, or in response to "must-have" additions that the JAVAD support team—all active professional land surveyors or engineers scattered across the country—has tagged as critical. J-Field is easily the most robust software for GPS receivers that I have encountered. I will have far more to say about that later in this review.

>> PATRICK C. GARNER, PS





The author waiting for a hotspot connection with the Triumph-LS and monopod. PHOTO BY PATRICK GARNER.

Shawn Billings (in orange shirt) demonstrating use of the JAVAD J-Tip at the June 2017 JAVAD workshop. PHOTO BY NATE DEARYAN.

As noted, the JAVAD Triumph-LS is a high precision GNSS receiver. I'll describe the guts of the unit shortly, but as an overview, the LS is utterly unique in the survey field in that it forgoes the usual "data collector and antenna on a stick" design that drives all other manufacturers. Instead, JAVAD houses the antennas and the guts of the data collector in a single waterproof, magnesium case designed to sit on a monopod.

Instead of being forced to look down to waist level to observe readings—where a data collector is mounted on a pole by all other equipment makers—the user can stand naturally and look directly into the head-level display. I kept my unit at a height of 5.7 feet, which is at about eye level for me. The more I used it the more I concluded that going back to the antenna on a stick design would be difficult for any surveyor, once they had collected a few points with the LS.

How did JAVAD have the confidence to make this design leap? How could the company have totally disregarded what every other manufacturer was offering? The change was partially because Javad Ashjaee, JAVAD's founder, largely created the paradigm now being used by everyone else. The antenna on a stick design was one he had vetted, refined and has now moved beyond. In effect, the data collector-antenna on a rigid rover pole is so *yesterday*.

So who is Javad Ashjaee? He received his Ph.D. in Electrical Engineering from the University of Iowa in 1976; he also holds an advanced degree in mathematics. He was Bill Trimble's third employee in 1981, where he started and personally wrote the entire software for the Trimble 4000 series. Industry insiders say he was quickly acknowledged as a sort of GPS genius.

When he left Trimble he founded the famous Ashtech (remember, his last name is Ashjaee), which then became Javad Positioning Systems, which was then purchased by Topcon, where he designed all the Topcon TPS products. Then in 2007 Javad founded JAVAD GNSS in San Jose, California. He employees over 100 engineers and designers, and manufacturers all of the LS components, base stations and radios for RTK surveying is his San Jose facility. JAVAD does not go out of its way to say as much, but it is the only



The JAVAD Triumph-2 base.

US-based manufacturer making survey grade receivers in this country. That means, American Made.

In the middle of that more than 35-year timeframe, between stints at Trimble, Ashtech, Topcon and now JAVAD, he became the first to integrate GPS and GNSS signals. Every other manufacturer said it couldn't be done, but in 1992 he succeeded. It took more than a decade for other companies to figure out what he'd achieved. Creating receivers that could use both American and Russian satellites had been a goal of his for years. As he noted to me in an interview in mid-2017, "It is obvious that the more satellites, the better. Now, GLONASS has better signals that make the integration even more helpful."

During that time Javad made a lot of money, patented numerous innovations and is viewed in the industry as one of the giants. I was told repeatedly during my research that Javad has a "soft spot" for surveyors, and that much of his energy today is directed toward making devices that make a land surveyor more accurate and more productive. It's an unusual story. When I asked him, *"Why surveyors?"*

He replied, "Survey products are the most complicated and encompass multiple technologies. It is a nice challenge to make a very complicated process look easy, to hide all the difficulties under the hood."

In other words, he thrives on intellectual challenges and is not content to sit on his many laurels. I suspect he also enjoys making equipment that is several generations more advanced than his competitors. I asked him at the end of our interview if he had played a direct role in designing the LS rover and he replied, "Yes, down to the level of screw sizes and connectors."

Has he succeeded in this goal to "hide all the difficulties under the hood"? That question is what I'll address as I dig a bit deeper.

Technical Discussion

To begin I will note that for complete technical data as published by JAVAD, visit *www.javad.com*. Hours of reading awaits the intrepid surveyor. That said, after using the Triumph-LS rover, my opinion is that the LS is what it purports to be. That shouldn't be surprising given the designer's enormous experience.

I have used and owned GPS units from other makers—but the JAVAD was a surprise. Whereas other GNSS suppliers tend toward increasing simplification, JAVAD offers surveyors precise and detailed information about each shot—which, of

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course, any accuracy-obsessed surveyor should demand from the instrument.

Can JAVAD's collection processes be customized by the individual surveyor? Sure. Want to observe 180 epochs and not ten? That's a couple second field edit of the software. Need to quickly ID an unexpected object? That's a couple seconds as well.

Need to locate a lost boundary corner? Preload the record survey and the LS will direct you to the probable location (and its built-in metal detector, the J-Tip, which attaches to the end of the monopod, will tell you posthaste if that 2" pipe still exists).

Need photogrammetry on a difficult to reach encroachment? The rover's built-in cameras are so precise that you can do so to accuracies of within hundreds of a foot. The same built-in cameras allow you to photo record every corner (or object) you set up over.



Want to leave an audio reminder to yourself about a particular point you used? Just activate the voice recorder. Need to stake 1,000 feet of roadway gutter and 40 utility boxes? The software provides that option.

The rover hardware is similarly robust. Instead of providing the user with the usual two engines, the LS has seven engines (it initially had six, and a seventh was recently added) that track all satellites simultaneously. I have spoken to well over 25 JAVAD users in the course of my research and there was a constant theme I heard from all: They shifted to the JAVAD system because, under impossible tree cover, it gets reliable shots where other systems cannot. This unusual ability is largely due to its large number of channels—up to 864, depending on the configuration of the rover/base system-RTK rate, multiple engines and advanced multi-path reduction.

As I drilled down into the JAVAD's workings I began to think of it as a Range Rover among a parking lot of Subarus. Both brands of vehicle are all four-wheel drive, but the Land Rover keeps climbing when treacherous terrain leaves the other drivers shaking their heads. My own extensive testing confirmed the opinions of JAVAD users. No tree cover—and I include clustered oaks, white pines, pitch pines, maples and poplars—prevented the LS from getting reliable shots with an consistent accuracy of between 0.03 and 0.05 feet.

When I attended a two-day JAVAD seminar in Hot Springs, Arkansas in June of 2017, one of the registrants, Nate Dearyan—a disensed surveyor and LS owner—smiled, observing what would normally be difficult setup points that had been purposely set under heavy canopy by Shawn Billings, the instructor. Dearyan said with delight, 'It's so nice. At a JAVAD GPS seminar, your work points are always in the shade.''

"The JAVAD LS gets almost impossible shots because of its 864 channels and 6 engines."

Triumph-LS (the rover)

The JAVAD LS is able to get these previously impossible shots largely because of its robust technology. In addition to actively using up to 864 channels, depending on the base (including GPS L1/L2/L2C/ L5; GLONASS L1/L2/L3; SBAS L1 and WAAS), the rover is operating at true—not interpolated—5 Hz speed. As I noted the LS employs 7-parallel RTK engines. It has superb (and patented) multi-path reduction. A user has the option to add Galileo E1/ E5A/E5B/AltBOC and BeiDou B1/B2 (the system I tested came with the GPS/ GLONASS option, 10 Hz RTK and 10 Hz recording speed). Accuracy, as with all receivers, depends on the function selected. JAVAD specifies:

STATIC ACCURACY

- Horiz 0.3 cm + 0.5 ppm
- Vertical 0.5 cm + 0.5 ppm

KINEMATIC ACCURACY

- Horiz. 1 cm + 1 ppm
- Vertical 1.5 cm + 1.5 ppm

RTK ACCURACY

- Horiz. 1 cm + 1 ppm
- Vertical 1.5 cm + 1.5 ppm

DGPS ACCURACY

- < 0.25 m (post-processing)</p>
- or 0.5 m real time

The rover is built on a magnesium chassis, with all connectors and cards completely waterproofed. There's a short video on the JAVAD website in which the rover is allowed to fall from a height of about five and a half

feet onto a concrete pad that has about an inch of snow-cover. It bounces several times against the concrete; the operator picks it up and continues to use it. The display shows no evidence of having been dropped. (I didn't try this experiment myself!)

The LS is a relatively lightweight unit. The LS rover without the monopod is 5.5 pounds, or 2.5 Kg. That's about 30% lighter than comparable rovers. The monopod itself weights less than two pounds, so the combined rover/monopod comes in at about seven pounds.

In addition, the standard LS package includes 5 Hz raw data recording; various communication channels (UHF or 4G/ LTE/3G); RAIM; interference viewing; JAVAD's "Lift & Tilt" technology (more about that below); an internal high performance geodetic antenna; WiFi; Bluetooth; USB host; USB OTG; 8 GB microSD card; tilt compensation that can be set by the user (at no extra cost); 20 hours plus of power when the two internal batteries are fully charged; an integrated controller and JAVAD's surveying software, J-FIELD (at the date of this review in version 2.0.5.8+). The two batteries fully charge after about two hours.

Numerous options are available (at additional cost), such as: an interference shield; recording speeds between 10 and

QUICK START GUIDE TO THE TRIUMPH-LS WITH J-FIELD 2.0

USERS GUIDE TO THE TRIUMPH-LS

JAVAD User Guides beside the JAVAD J-Tip metal detector. PHOTO BY PATRICK GARNER.

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The JAVAD Triumph-LS beside the JAVAD monopod. PHOTO BY PATRICK GARNER.

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The JAVAD HPT901BT spread spectrum radio modem. PHOTO BY PATRICK GARNER.

100 Hz; faster RTK/DGPS—10 Hz to 100 Hz; an IRNSS option; and accessories, including the J-Tip metal detector (see my earlier *American Surveyor* review of this superb invention), the collapsible monopod that replaces a typical rover pole, and a new backpack designed specifically for the LS.

The monopod—JAVAD's ingenious rover pole replacement—is made by Benro and furnished with a double level in 8 and 40 minute vials. The quality is excellent. Frankly, the monopod was one of the first things I recognized as an utterly logical tool that no other maker offered. It collapses to a total length of 23-inches. Compare that to the length of your RTK pole. (Of course you can still use a rover pole with your LS, if you insist.) JAVAD has designed their entire system from the ground up.

Triumph-2 (the base)

For RTK surveying JAVAD offers base stations in several configurations (GPS and GLONASS, as well as static). The units are compact and come with USB, Bluetooth and WiFi. Like the LS the internal battery in the base supplies >20 hours of power when fully charged.

I was furnished with a Triumph-2 base, a compact and lightweight device that can be

mounted over a known station or used as an autonomous position. Another base option, one that I did not review, is the Triumph-1M, which is far more expensive. But then the 1M also operates at 864 channels versus 216.

Radio Modem

JAVAD also manufactures radio modems in nine different configurations, including spread spectrum (SS) and many UHF versions. The units are compact and available in 1, 4 and 35W versions. Like the base, they can be mounted in several configurations.

UHF radios, whether JAVAD or another brand, require a federal license to operate. My test unit was a 1W HPT901BT frequency hopping SS radio—the non-UHF version not requiring a license—and was recommended to be set up at a distance of 10-50 feet from the base. I usually set it up at about 20 to 30 feet from the base.

External Battery

JAVAD also furnished me an external battery in case of unexpected loss of power while on a job. I never needed to use it, as the rover has a 20-hour battery. When the rover got to less than 12-hours of reserve, I simply recharged it.

RTN Functions

In addition to the LS working from a base-radio modem combination as an RTK receiver, it can be set up quickly as an RTN GNSS receiver. In my own testing I used the LS (1) as an RTK unit with JAVAD's base (the Triumph-2) and its spread spectrum radio, (2) as an RTN unit with SmartNet, perhaps the largest network in North America, and (3) as an RTN unit with my state CORS network, which in Massachusetts in maintained by the state DOT.

When testing the LS in RTN mode with either SmartNet or the CORS network, I used my iPhone as a hotspot, creating a WiFi connection to allow internet service. This technique works when a user is in an area with strong cellphone reception, but if the reception is poor or intermittent, the LS connection may be lost. When I spoke to the JAVAD support team I was advised that a SIM card was a better option. Monthly cost for a SIM is between \$25 - \$50 in today's market, plus the initial cost of the card (which runs about \$75).

JAVAD has its own free post-processing service that is similar to OPUS. JAVAD calls it DPOS. The advantage of using DPOS is that it processes both GPS and GLONASS data. The downside to using an RTN network is that a surveyor cannot use JAVAD's DPOS processing, so one has to weigh the convenience of a CORS network against the slightly greater positioning accuracy obtained when using a fixed or automatous base/radio combination.

Note: This review will continue in the next issue, where the author will assess the software and support that comes with the Triumph-LS.

Patrick Garner is a Professional Land Surveyor in Massachusetts who has been in private practice for over 35 years. A principal of Patrick C. Garner Co., Inc., he frequently conducts technical seminars, does peer reviews for cities and towns, and works as an expert witness in Massachusetts courts. He also provides 18 on-line continuing education courses through RedVector, many of which focus on legal and technical issues in land surveying.