Product**Review**

By Shawn Billings, LS

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Nikon Nivo C

Nikon's history stretches back over 90 years. It began as a merger of several smaller firms in Japan along with eight German technicians. Originating as Nippon Kogaku, K.K., or Japanese Optical Company, today Nikon is in a strategic joint venture with Trimble Navigation to offer conventional surveying equipment, specifically total stations, theodolites and levels. This alliance has been in place since 2003 and has allowed Trimble to expand its lineup of conventional guns by rebranding some of the Nikon instruments. However, the new Nikon Nivo C series instrument goes well beyond putting a new name on older technology, and instead merges the strengths of Japanese manufacturing with European styling.

While the predominant association contributing to the Nivo C is Nikon and Trimble, other manufacturers have also left a mark. Just over a decade ago, the survey division of German manufacturer Zeiss joined with Spectra Precision. Shortly after, Spectra was acquired by Trimble Navigation, which has continued to expand on Zeiss innovation.

Upon first handling the Nikon Nivo C, I was impressed by its diminutive size and weight. It barely tips the scales at nine pounds (including two onboard batteries and tribrach) and stands only a foot tall, reminding me of the Zeiss Elta R50 (later known as the Trimble 3300) which weighed a shade under eight pounds and stood 10.5 inches in height.

The Nivo C has a built-in, very capable, data collection software and interface on board. It features Spectra Precision's Survey Pro for Windows CE, the same software that began in the late 80s under Tripod Data Systems.

The Nikon Nivo C offers sophisticated data collection in a Windows CE environment, a large touch screen, reflectorless distance measurement with a respectable range, and two onboard hot-swappable batteries, all in a light, compact package.

While I have always preferred the feel of a data collector with a full alphanumeric keypad and easy to read screen, the little Nivo has removed my absolute resistance to the idea. Considering the market acceptance of data collectors that have virtual keypads, it isn't too great a leap to consider onboard collection that uses the same basic

RUN & GUN SURVEYING

Traditionally, surveying with a transit, theodolite, or total station has placed the active equipment in a stationary location and the passive equipment (sight pole or prism) at the point being located. The vast majority of points we locate have followed this doctrine with the only real exception being the occasional resection.

With the Nikon Nivo C series, a new method of determining positions is available. The following method is simply another "tool in the toolbox". It won't be practical for all jobs, but I've shared several potential applications for this method at the end of this article. For now, let's have a look at what I call "Run and Gun Surveying".

A standard prism pole has a 5/8 inch x 11 thread for receiving prisms. A standard tribrach has the same 5/8 inch by 11 thread for affixing to a tripod. Thus a tribrach can be mounted to a prism pole. Attaching a bipod to that same prism pole now affords a somewhat stable platform for an instrument to be locked onto.

With this configuration, an instrument setup can be achieved in 30 seconds. Since the unit is on a pole, the height can be maintained throughout a survey session, requiring only one initial instrument height measurement. With the Nivo weighing in at less than 9 pounds, this compares similarly to the weight of an RTK rover with a data collector (which could reasonably be estimated at 6+ pounds). Finally, with the onboard data collection of the Nivo, points can be collected without the need of an external collector, particularly resection points.

I tested this set up for an afternoon along our test site. My primary method of point observation was the resection. I set up two prism poles with prisms at random points at far ends of my "project site". I then set up on the first point to be located (which is a known point) with the Nivo on a prism pole. I measured to both prisms, assuming a direction to the first and turning the angle and distance to the second. This established my assumed control baseline. Next, I set up and performed a resection, using the two baseline points, on each of the nine known points in our test site, treating each as an unknown point.

With the pole point on the traverse nail and the bipod feet firmly planted in the ground, I turned the angles and shot the distances. The view through the scope was somewhat jumpy, but I was able to point fairly well. I was careful to keep a free hand lightly on the pole at all times, just in case the pole tipped over.

I moved from point to point in two ways; carrying a satchel across my shoulder and taking the instrument from the tribrach, and carrying the pole with the tribrach attached in hand with the instrument at my side. Setups were still relatively quick with this method (about 60 seconds) and offered some peace of mind while moving from point to point. The other way I attempted to move was much faster, but required a great deal more care. I simply left the instrument on the pole, keeping the pole mostly vertical, leaned slightly against my shoulder. Setups were much faster this way (about 30 seconds).

I performed resections and took a few reflectorless shots after the resection, just like sideshots from a typical setup. For the most part I moved without hurry (it was my day off), but I was able to get about 60 shots in about three hours. Had I been in production mode, I probably could have collected closer to 80, and perhaps more, depending on the ratio of resections to reflectorless sideshots, which could be had more quickly. Resection points required from 2-3 minutes per point, depending on which method I used to move from point to point.

Back at the office I had a network of points based on a baseline with an assumed direction and assumed translation. For comparing to the "true" coordinates, my first step was to rotate and translate the Run and Gun coordinates. In order to kill two birds with one stone, I used a rigid body, least squares transformation that determines the best rotation and translation from one coordinate system to another, without affecting the point's relationship to each other. As a by-product, the routine gives the differences, or residuals, from each coordinate system (control and observed). Of the nine points observed, the average horizontal difference from the control values was 0.021 foot (U.S. Survey). The worst horizontal position differed by only 0.052 foot (U.S. Survey). Vertically, I expected much worse due to instability, but was pleasantly surprised to find that the average difference was only 0.023 foot (U.S. Survey), with the worst being 0.066 foot (U.S. Survey). The baseline distance was 878.83 feet (U.S. Survey) and the points were generally along the baseline at varying distances. The reflectorless sideshots also proved to be accurate by comparing repeat shots taken to the same point from different resection points.

Ultimately I produced a contour map at one-foot intervals of a strip of land 70 feet wide by 600 feet long using resection points and reflectorless measurements to bare spots in the ground. The results looked very reasonable.

If I were to use this method very much, I would likely invest in two 360° prisms for baseline control, although, there could be multiple control points used for different perspectives along a site, and there is no reason the control points couldn't be stable targets measured reflectorlessly. The

results are as good as any RTK rover I've used and I was able to perform the entire survey by myself.

For a surveyor who needs to catch a few points and is working alone, this method would potentially be a fit, depending on the site. Obviously, you need visibility to at least two control points from every point being located, so overgrown sites may not be appropriate. You also need ground that will permit holding a bipod in place while you are observing the shots.

This method could also be used with a robotic setup. Perhaps you only need five shots that are obstructed from the robot. Shoot a point with the robot, take the prism off, put the instrument on, backsight the robot, and turn in the few obstructed shots without the need of traversing the robot ahead.

The method offers the ability to locate points with as much precision as RTK, albeit somewhat slower, with only one operator and adds the flexibility to locate not only the occupied point but also to radially measure to points in the vicinity of the occupied point. While not a fit for all situations, the Run and Gun Surveying method steps out of the box and offers more flexibility from an already highly capable instrument. (Note—this method is the author's own work and may not be supported or recommend by the manufacturer. Use caution—I'm not liable for your clumsiness).

interface without the added bulk of "one more thing" to tote around all day.

The final characteristic that stands out from the European heritage of mergers and acquisitions is the endless drive, clamp-free design of the horizontal and vertical motion knobs. No more recentering the knobs when all of the play has been used–you can turn the full circle of the instrument with the knob alone if you wish.

The Nikon Nivo C is a reflectorless total station with dual axis compensation. The reflectorless range is stated to be from 1.5 meters (4.9 feet) to 300 meters (984 feet). In testing I found this to be a very reasonable estimate of range as I was able to read a distance to a concrete power pole (which would be technically something less than "white") at a distance of over 960 feet. I was also able to read a dark power pole at a range of 750 feet. While this range doesn't break any records, it reaches twice the range of my second generation reflectorless instrument and is very capable.

The angular and distance accuracy of the instrument is model dependent. The instrument I was issued was a Nivo 2.C indicating it was a 2-second instrument with a distance accuracy of ±2mm plus 2ppm. The other models available are the 3.C and the 5.C which are 3-second and 5-second instruments, respectively, with distance accuracies ±3mm+2ppm.

Measurement speed was incredible. In prism mode, by the time I pressed the measurement key the distance was usually determined in about one second. Reflectorless required more time depending on the range and reflectivity of the surface being measured. When in reflectorless mode, the laser pointer is automatically turned on. In prism mode, the pointer can be optionally turned on by the operator.

Looking through the scope, one first notices the blue tinge of the 30x magnified, erect image. This tint is for the protection of the operator as it blocks a significant amount of red light, particularly the inadvertent reflection of the laser pointer directed at a prism. Without this protective coating the full force of the coaxial laser pointer (if turned on) would be focused on the operator's eye, a potentially dangerous circumstance. As a result, the laser pointer is not visible through the scope except when pointed at a prism. With the laser pointed at a wall or a tree, the red dot is visible to the bare eye, but is invisible through the scope.

For those who have for their entire careers carefully leveled their instruments with 30 second per 2mm tube level vials,

The screen on the Nivo C is generously proportioned and bright even in the outdoors. With a little practice you can press the yellow MSR button with your thumb and adjust the knob with your fingers while peering through the optics.

The light weight of the Nivo C makes it extremely portable, and since no extra equipment is needed, traversing is faster and easier.

the world is changing. The instrument comes standard with an optical plummet (as tested) and is available with a laser plummet with four levels of intensity. It is fitted with a 10-minute per 2mm circular level vial. The internal compensators (which have a range of 3.5 minutes) apply corrections to the vertical and horizontal angular measurements rendering fine leveling unnecessary. These compensators have been in use for more than a dozen years now in total stations and manufacturers are quickly recognizing that tube levels are outdated and superfluous.

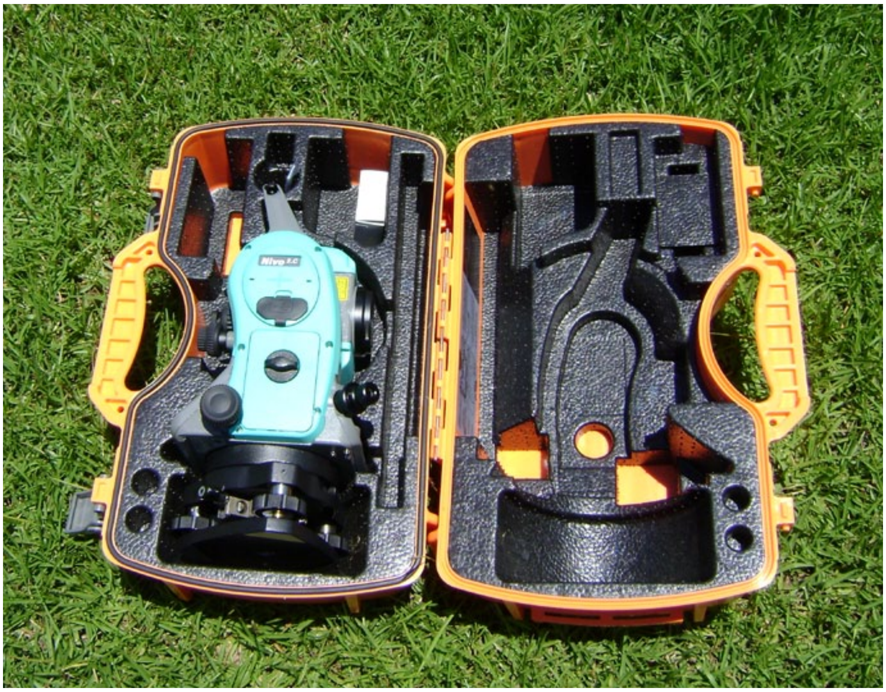
The unit is powered by two tiny Lithium Ion batteries that can run the instrument for 12 hours of continuous measurement (2.C model) or 7.5 hours (3.C and 5.C models). At a rate of two shots per minute those times more than double. I found the battery life to be very satisfactory. I have seen some Windows driven devices discharge by simply sitting on the shelf. Some have even discharged substantially over the space of a weekend. The Nivo exhibited no such issues and seemed to maintain a charge for weeks with no significant discharge issues.

The operating system is Windows CE version 6 and runs very quickly with the Marvell PXA300 XScale processor rated at 624 MHz. Once the unit is turned on for the first time, or is turned on after a full shutdown, the unit flashes a Nikon splash screen and then the familiar desktop screen appears. This takes about 12 seconds from the time the power button is pressed. If the unit is simply put on standby, it powers up almost instantly with the exact screen from when powered down.

The desktop has four icons: My Device, Recycle Bin, Survey Pro and TS Mode. My Device opens the main folder containing all of the other folders stored on the unit's 128 MB RAM and 128 MB Flash memory as well as the Control Panel options. Survey Pro opens up Spectra Precision's onboard data collection program. TS Mode opens a generic program for using external data collection. Personally I would also like a separate option to allow a user to manually take a measurement for those rare times he might prefer a field book for the job at hand.

At times I have been somewhat critical of Survey Pro's menu structure. With a full keyboard, shortcuts can allow a user to quickly jump from one operation to another. Forcing the user to exclusively work through menus when a full keyboard of shortcuts is available hampers efficiency, however the menu structure is perfectly suited for a device with a reduced keyboard or no keyboard.

There are several quick offset techniques, particularly for reflectorless opera-



The Nivo C instrument station is complete with this small box and a tripod. With Survey Pro software on board, it presses the question, "Why am I still toting an external data collector?"

tions. The ability to work in a projection, such as State Plane, with the scale factor automatically applied is available. All of Survey Pro's familiar utilities are available, such as importing control and exporting ASCII files (which can even be done to an external device such as a card reader or thumb drive through the instrument's host USB port), working with alignments, auto linework, Digital Terrain Models, Collection for direct shots, repetition shots, stake out routines, inverse calculations, COGO calculations, Roading, and adjustments (rotate, translate, scale and compass rule traverse adjustments).

If you're like me, you sometimes perform calculations in the field. How do you do sophisticated curve and predetermined area calculations on a total station? I found it rather easy to disengage the tribrach lock in those situations and carry the gun to a shady place to sit and work, either under a tree or in the truck. Laying the little gun in my lap and pecking on the rather generous 2-inch by 3-inch, landscape screen was fairly easy. I did wish that the pop-up keyboard could have exploited more of the screen real estate which would have allowed for bigger buttons. I was surprised, though, at how easy it was to pick the keys with the stylus (which is kept in the handle of the instrument when not in use). I was able to perform several rather daunting intersections and predetermined area calculations with the onboard routines, and when I was in doubt about a particular routine's protocol, I was able to view the Help files for Survey Pro on the screen.

I can honestly attest that there were no lock ups or program bugs. Not one. While I didn't press every button in the program (there are a *lot* of options and features) I believe the stability of this set up was a testament to Survey Pro's maturity.

I found that I really enjoyed using onboard collection. For one, I didn't miss keeping up with my cabled data collector. Secondly, the instrument fit neatly in a very durable case that measures about 1.4 feet in length, less than a foot in height, less than 0.7 foot in width, and weighs about five pounds. It felt more like a lunch box than a survey instrument. I was also impressed at how fast I could be set up and ready to shoot. Not worrying with an external collector (cabled or not) meant that as soon as the gun was leveled and centered, I was ready to work.

The Quick Shot routine is appealing. Pressing the F1 key at the top left (marked by a star) kicked the Survey Pro software from the standard menu-driven display to a view that looks more like a total station display. The horizontal and zenith angles are displayed as well as the slope distance. Pressing the yellow measure key takes a shot which can be stored in your active Survey Pro Job file. For staking a point, the program directs the user to the turned angle by superficially setting the angle to the point being staked as zero. Simply turn the instrument until you see zero for the horizontal angle. Pressing the same yellow key makes a measurement and the display updates to give a large graphic of the in/out, left/right, cut/fill to the design point. Once the point is set, you can then store the "as staked" measurement.

Ergonomically, I might have designed the instrument for simultaneous, ambidextrous use by putting the vertical motion knob at the left hand while the horizontal motion remains at the right. This would only be practical if I were fully invested in making onboard collection work, but I believe this instrument is up to that task. Were I truly committed to onboard collection, my hands would be completely free of an external collector and I could work more quickly using both hands instead of one. As it was, I found my left hand looking for something to do, while my right hand operated the knobs, initiated measurements, and entered point data for storage. Besides this small request I found the ergonomics to be very good. The measurement key can be actuated with your right thumb while still looking through the scope.

The batteries that power the unit are placed in the left and right standard of the gun and are hot swappable. With the unit on, I was able to open the left door and pull the battery out, put it back in, close the door and then open the right door, pull the other battery out and place it back and close the door without any interruption to the operation of the unit. A simple quarter-twist knob hinges the door open and allows the battery to be removed.

The frame around the objective lens is threaded to accept a Solar filter. With an ephemeris and a GPS receiver for time and position, I was able to quickly get an accurate, reproducible bearing from the sun.

I highly recommend the Nikon Nivo C series to anyone who is looking for a solid utilitarian instrument. Onboard data collection is now viable with Survey Pro, and the instrument is a pleasure to use. While the 2.C model lists for around $14k, a quick Internet search suggests it can be had for somewhat less.

Author's note: At Intergeo in Germany, after I reviewed the C, Nikon added the Nivo 1.C–a one-second model–to the product line-up.