RTN–101:
Mapping (Part 14)

"We're all pilgrims on the same journey—but some pilgrims have better road maps."
—*Nelson DeMille, Novelist*

Much of what surveyors do is essentially mapping, and much of mapping is/could/would/should be characterized as surveying. But what certainly raises the blood pressure of many surveyors is when one puts the two terms in the same sentence, as I have just done. The debate over who should be mapping, and to what standard, continues unabated. This article does not seek to wrestle with this issue, but instead seeks to inform the debaters as to the evolving resources for positioning that have been traditionally viewed as "mapping grade" or "resource grade."

These terms are fast becoming obsolete, as the precision gap that had existed between mapping grade and surveying grade narrows. The debate becomes less focused on how one does the work (or how good the results are) as it does on what the purpose of the mapping may be and who should be doing it. GNSS positioning can yield results ranging from tens of meters all the way down to tens of millimeters and can be achieved in hours or seconds.

I ask only that you do not "kill the messenger" as you read though this article. The reality is that the differences, precision-wise, between mapping and surveying are rather subtle (but only if you leave legalities and ethics out of the equation). There is a great opportunity for surveyors to add mapping to their standard product lines as they learn more about what clients want; knowing more about the resources available is the key.

>> By Gavin Schrock, LS

Mapping Grade and Resource Grade

The terms *mapping* and *resource grades* contrast survey grade in essentially just expected precisions. The terms grew from the low-cost (in both equipment and overhead) associated with the field observations that GIS professionals, resource managers, environmentalists and planners have been doing. These folks seek to map broad geographic regions for analytical purposes or asset management. Whereas a specific site topo or survey may need high precision to serve engineering design or development, these mapping folks use their data (however fuzzy it may look to surveyors) for more generalized analytical purposes. For their purposes the map treats features more thematically than specifically. To map every feature to high precision is often cost prohibitive—or at least it was.

Mapping grade meant meters, rather than centimeters, and for several decades that was what a mapper could expect. Did the method drive the product, or did the product drive the method? The resources available to the modern mapper during the beginnings of the GIS revolution of the past two decades were rather limited. Unfortunately many of the local and regional GIS have had fuzzy origins, and what is still worse is that many accept these underlying fuzzy themes as a gold standard. A

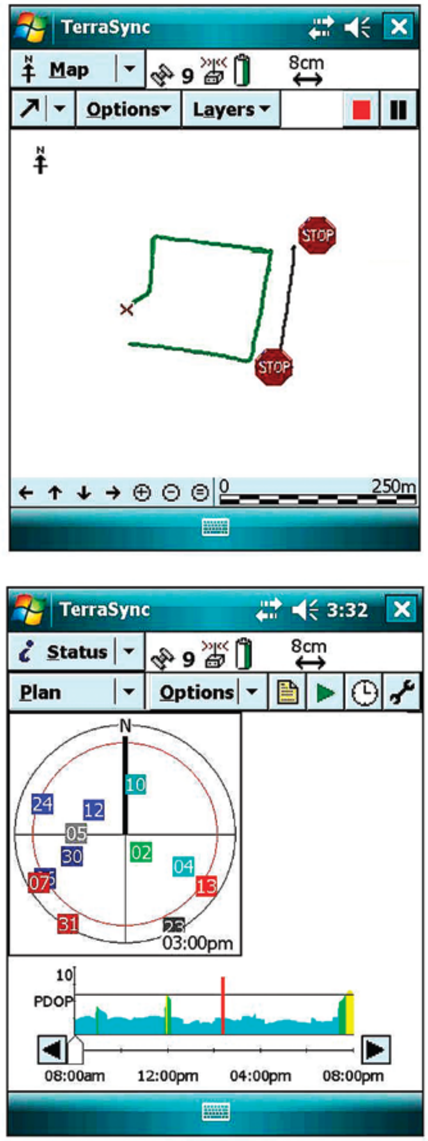

Figure 1 The user interface (UI) of field mapping software may look a bit different than surveying software but retains much of the same functionality. Left image shows a typical interface with examples of point, linear, polygonal features as well as familiar system status icons. Right image shows that the same planning, status, and quality indicators exist on these units as well.

GIS may have started with roads and cadastral bases from federal sources with inconsistencies and accuracies in the range of meters to tens of meters and then subsequent themes developed were registered to the same. Ouch.

Not that effort had not been made to improve or update these themes utilizing improved resources: photogrammetry, LIDAR, and GPS. As to the latter, the cost-effective method most used was single-frequency-post-processed. The irony is that the biggest cost involved in mapping is not the equipment or data management, but labor. For the same labor costs and with better equipment (and methods) the resultant themes could have had higher precisions from word go. Then it would have been less "mapping grade" than "mapping mode" (but more about that later). (**Figure 1**)

Advantages of Real-Time Mapping

To truly map something in the field, you need to be able to see your results up front, while you are in the field. It would also be preferable to have visual references (like a background photo or map) to help identify outliers so that you may re-shoot when needed. This advantage also holds true for surveying. The drawback of post-processing is that you may not know the quality of the fruits of your labors until long after the fact. Another mark against the oft-used post-processing applications targeted for the mapping market was the lack of observation analysis tools they offer; it was hard to determine which bad data to reject.

Real-time has been available to mappers for well over a decade, but in the realm of DGPS (single frequency). Mappers often work in a base and rover mode, or seek correctors from external sources: beacons (NDGPS, et al) or satellite-based augmentation (SBAS, WAAS being the most common). While this gave the advantages of "mapping in the field," the acceptance of results in meters simply perpetuates the fuzziness, particularly in the vertical (and how!).

This real-time option drove the development of mapping gear that could take advantage of the "instant" results: the capability to add background maps and themes on the user interfaces (UIs) is provided right on the nifty little mapping unit. Coupled with these new UIs were quality indicators providing predicted precisions (though the efficacy of such indicators were often questionable). Practices like putting the unit in a backpack with an antenna mounted on the top was practical for rough terrain, but often degrades the already poor precisions. (**Figure 2**)

Mapping Mode

Mapping can be done with dual-frequency survey gear for much the same labor costs and with only slightly higher overhead. Then why are mappers still locked into the meter mode? While equipment costs are not insignificant, mappers can buy mapping-grade gear at often a third of the cost and send three interns into the field. But the actual per-shot cost ends up being much the same on larger mapping projects. Even if a mapper agrees to have the work done in survey grade, another issue is the end product.

For mapping thematically (precision aside), these mapping units really shine. The mapping UI is designed for ease of

Figure 2 Newer mapping units have been designed with RTNs in mind. This unit can provide the whole gamut, from autonomous through network corrected, and is GLONASS ready.

gathering not only positions, but also for the all-important attributes. Instead of a single code for each shot, the mapper can add customized drop-down lists of attributes to fill in. Features often include attributes like feature-type, material, condition, connectivity with other features, photos, sizes, etc. All of these are gathered electronically rather than in field notes. GIS and mapping also classifies features and themes as spatial types: often only as points, linear and closed polygonal features. The UI of the mapping software loaded onto these units are geared to collect features in this manner.

Jim Lahm, a GPS mapping trainer with Electronic Data Solutions in the Pacific Northwest characterizes the contrast in this manner: "Survey software collects points in the field and the office software draws the map; mapping software collects data as features and draws the map in the field." It is to be noted that the differences may not be so well defined; most surveyors, when performing topo utilize "line-stringing" codes to produce linear and closed figures. But it is true that real-time mapping applications seek primarily to "map in the field".

Everything else that one would normally expect from decent real-time GPS field software is included in most mobile mapping applications: planning, tracking and quality indicators. Some have built-in NTRIP clients, cameras and even barcode readers. And the resultant data can be readily exported in GIS-friendly formats like ESRI shapefiles. So what is the real difference between surveying and mapping data collection software? Not a whole lot.

You can load mapping data collection software on most survey data collectors (controllers). Learn the (very simple) interfaces, learn to work with attributes, go forth and win mapping contracts, and amaze the clients with higher precisions. You then have the equipment that can take full advantage of RTNs, with a product they understand.

Mapping clients are now seeking better vertical. Good vertical for themes was put on a back burner for many mappers as it was often cost prohibitive. Surface water, floods, water rights, drainage, water supplies and distribution–more and more these are surfacing with heightened desirability for good vertical. (**Figure 3**)

Non-RTN Mapping Options

It is a good idea to become versed in the non-RTN mapping options (**Figure 4**) that these potential clients are used to, as these have become the status quo for the "mapping community":

- **Post-Processed Single Frequency** Not optimal for true in-the-field mapping, with results in the meter to foot range. Vertical is an afterthought.
- **Global Solutions** These come from the "clock-and-orbit" folks. Arrays of sensors or CORS, often belonging to the International GNNS Service (IGS) and numbering in the hundreds across the globe (denser in Europe and North America) focus on products, available in real-time and in post-process flavors that rely on very tight clock and orbit data. These are available from such sources as Jet Propulsion Laboratory (JPL) and Natural Resources Canada (NR Can), and as services such as Precise Point Positioning (PPP). One drawback of such services is that

Figure 3 This handheld unit has its own built-in receiver, but the user has chosen the option of connecting to a more powerful dual-frequency receiver. In this example of shoreline work, better vertical was needed than the mapping unit could provide on its own.

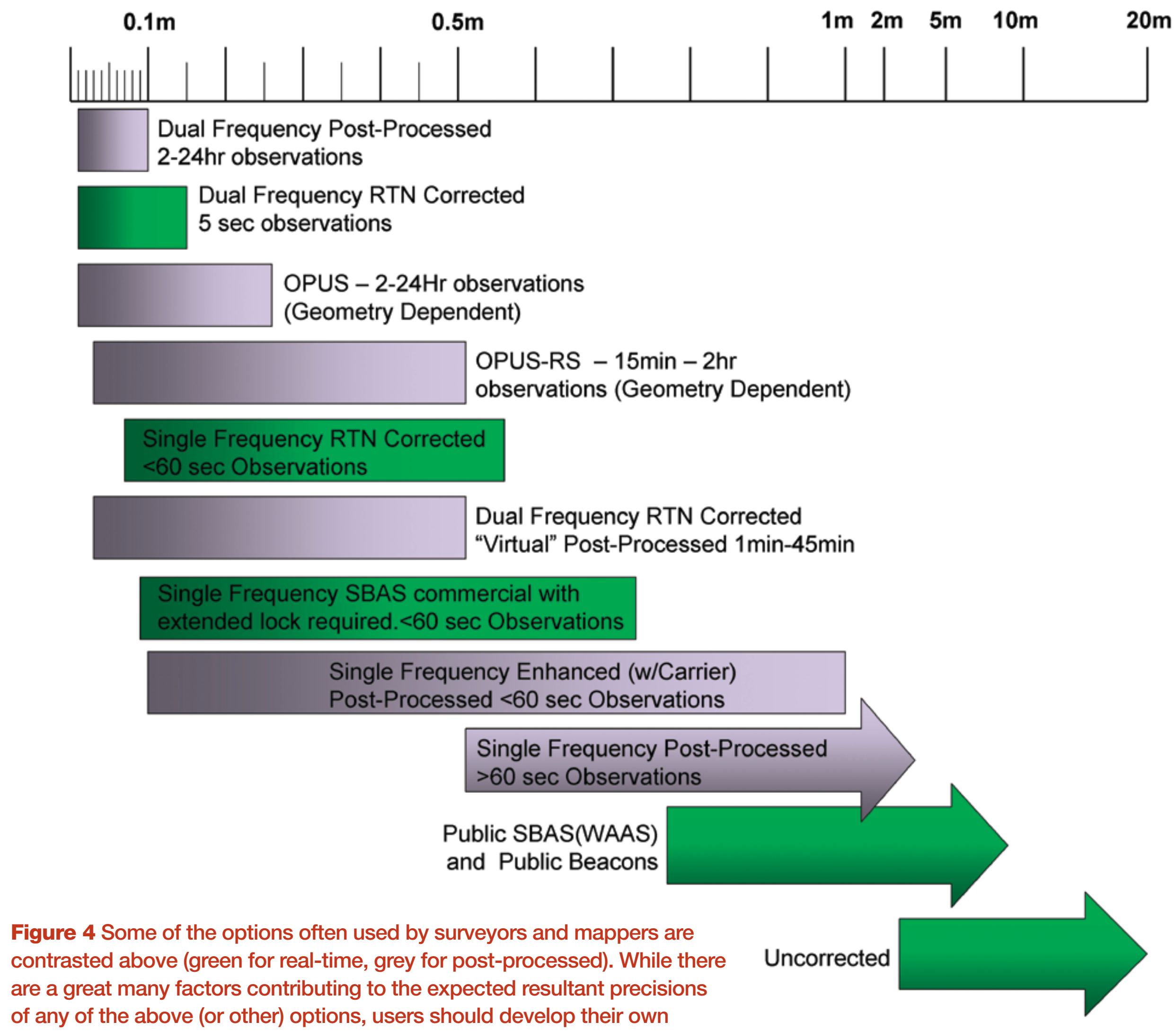

Figure 4 Some of the options often used by surveyors and mappers are contrasted above (green for real-time, grey for post-processed). While there are a great many factors contributing to the expected resultant precisions of any of the above (or other) options, users should develop their own sense of the trade-offs in costs/time/precision for any given solution.

NOTE: The ranges of expected precisions shown represent those that may only be gained though proper procedures. Any option may yield bad results in the wrong hands or under poor conditions.

lock must be maintained in the field for extended periods. Results can range from 10cm to 50cm (absolute) with claimed ranges of much tighter for relative results. With additional constellations coming online there is a lot of future promise in these types of solutions.

- **OPUS-RS** This new addition to the popular online positioning service is post-processed, designed for resource-grade purposes. While this service is new, wider usage will provide feedback to get a better handle on the range of results that can be expected, but for now users are reporting tenths to feet. Longer observations are needed than most mapping projects would like.
- **"Sort of" Dual Frequency** A number of solutions available for mapping units add some processing of carrier. Some have characterized this as "one-and-a-half frequencies." Available in real-time and post-processed flavors, the major drawback is the need to maintain lock for long periods.
- ***Space-Based Augmentation Systems** Be this the FAA Wide Area Augmentation System (WAAS) which is free, or commercial services like OmniSTAR, these utilize very widely spaced ground sensors to develop correctors that are broadcast directly from dedicated satellites. Again, there is a need to maintain lock for extended periods. While this is very well suited for agricultural uses in wide open fields, throw in a few trees or other poor sky conditions and this option becomes less than optimal. Results for WAAS are in the realm of meters, while some SBAS, like OmniSTAR can achieve results in decimeters (under the right conditions).
- **DGPS** Single frequency with correctors from wide area beacons or local bases. Still in the realm of feet or meters, with vertical 2-3 times worse than horizontal.

RTN Options

RTNs improve existing mapping options across the board, and more:

- **Post Processing** Simply the design of an RTN, with stations spaced relatively close together, ups the resources for post-processing.

- **"Virtual" Data** Excellent for situations where real-time communications may be a challenge, or the comms drops in the field, this takes advantage of the same modeling used in developing network real-time correctors by adding that to the static data normally available from the RTN CORS. Shorter observation times are needed than for similar post-processed observations.
- **DGPS Plus** The benefits of network corrections are not limited to dual-frequency work. Network modeling is applied to correctors that can be utilized by single frequency (and one-and-a-half frequency) gear. 10cm is not uncommon.
- **Dual Frequency** Surveying using mapping software. 1cm-2cm horizontal with vertical from 3cm-5cm.

Souping-Up Mapping Gear

A lot can be done to improve the performance of a mapping-grade unit. Units available from a number of manufacturers are designed as single-unit hand-helds. Examples include the Topcon GMS-2, Leica SR20, and the Trimble family of Geo and Pro series. These units are built for mapping mode and include a large screen, built-in receiver, antenna, wireless (WiFi, good if you are mapping around a coffee shop), and Bluetooth (to connect to peripherals). While the internal L1/L2 antennae offered with newest handhelds rival some of the external rover antennae, the normal "waist-high" position for use (yes, a human will block signal and the multipath off my bald spot is a real hazard), plus the difficulty in "plumbing" over a point may diminish the precision.

Some of these units can be configured and augmented to yield better precisions:

- **External Antennas** The first step is adding an external antenna, preferably on a pole. There are jacks and adapters on these units to accommodate external antennas and settings to override the internal antenna.
- **Real-Time Connections** You can use the built-in wireless capability to connect to the RTN via existing or even portable WiFi hotspots (*e.g.*, set up a broadband router in your truck). You could even set up a radio (that is getting corrections from the RTN via NTRIP) and broadcast corrections locally. Some mapping units can connect to external radios or use a portable beacon-relay. More common is connectivity via cell phone or cellular modem (cable or Bluetooth) for a more traditional RTN experience.
- **Peripherals** Cameras, laser rangefinders, depth sounders and others. Either by cable or Bluetooth.
- **External Dual-frequency Receiver** Cutting to the chase: all of the capability of a survey rover while simply using the mapping unit (and its software) as a data collector. This is becoming increasingly popular. Some can connect to an external receiver via cable or Bluetooth and override the internal receiver.
- **Scalability** What the client wants, the client can get; you can mix and match not only hardware and software, but select from a wide range of methods and solutions to suit what results are desired. A good policy is to go for the best that you can up front, and once clients see the amazing results, they get hooked.

New Lines of Business

There are now mapping units specifically designed with real-time and RTNs in mind. Units like the Trimble ProXRT include all of the real-time options already discussed, and also utilize GLONASS. And there will be many more to follow. It's a good time for surveyors to become the experts in such capabilities.

As higher-precision solutions become more widely available, so does the need to carefully consider repercussions, evaluating proper context, accuracy statements, and liabilities. These are the value-added elements that surveyors are best suited to address. Think of it like a sports car: you need to put such power in the right hands. Surveyors will need to learn slightly new methods, work with new hardware and software, and develop new products.

The mapping-survey debate may continue indefinitely, but in the interim there is great potential for an expanded role for surveyors in the realm of mapping. Let's not drop this ball.

Gavin Schrock is a surveyor in Washington State where he is the administrator of the regional cooperative real-time network, the Washington State Reference Station Network. He has been in surveying and mapping for more than 25 years and is a regular contributor to this publication.