THE American Surveyor

A Foot In The Past... An Eye To The Future

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SMART Surveying

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Which corner controls?

SMART SURVEYING

>> By Angus W. Stocking, LS

Conceptual view of SMART passenger train which will provide 70 miles of transit service in Sonoma and Marin County, CA.

CPI Surveyors James Brown (L) and Erik Vonderscheer (R) prepare the Amberg GRP for measurement.

Sonoma-Marin Area Rail Transit (SMART) is an overwhelmingly popular rail initiative in Northern California. Measure Q had an amazing 70% support of the two county (Sonoma-Marin) SMART District. One reason for voter enthusiasm is that SMART promises to be relatively inexpensive. Planners estimate that the new commuter rail system can be built for about 7.1 million dollars per mile, which compares very favorably to the cost of extending other local systems. The cost of extending Bay Area Rapid Transit (BART) to San Jose, for example, is projected to cost as much as $326.3 million per mile.

Why does the SMART initiative cost so much less? The main reason is an existing Northwestern Pacific rail corridor that runs straight through both counties involved, from Cloverdale at the north end of Sonoma County to Larkspur in central Marin County. Most of this right-of-way is now owned by the SMART district. At Larkspur, commuters can transfer to the Golden Gate Ferry to get to San Francisco. By taking advantage of the existing right-of-way and using diesel-powered trains that don't require electrification or grade separation (grade separation requires tunnels or bridges at all road crossings) SMART avoids most of the expense commonly required by new railways.

Taking advantage of this existing infrastructure will still require a lot of work, especially if SMART is to begin service

The 70 mile SMART corridor traverses through Marin and Sonoma counties. With 14 stations, it is expected to carry 5,300 passengers per day.

in 2014, as projected. The Northwestern Pacific railway has been out of service since 1994. The right of way is overgrown in many areas, two existing tunnels will need to be refurbished, and the entire track will be redesigned and replaced. One of the first steps in the redesign of the track is an accurate survey of the existing 70 miles of track. This means good coordinates at regular intervals on both rails. Planners and designers needed to know the location, super-elevation, gauge (distance between the rails), location of switches, etc. This is a major undertaking.

Brown and Vonderscheer collecting horizontal track location, top of rail elevation, gauge and super-elevation in one process. The GRP is shown with the GPS option, utilizing a Leica GX1230 RTK receiver.

Opportunity Knocks

Although the rail industry has always offered opportunities for surveyors and engineers, we are in a very unique period where huge investments are being made in freight and passenger rail infrastructure (just ask Warren Buffet!). Buffett's company, Berkshire Hathaway, Inc. recently purchased Burlington Northern Santa Fe Corp. railroad for $34 billion.

Metros across the country are also making significant investments in expansion to meet the growing needs of public transportation. Cities such as Denver, Charlotte, Portland, Phoenix, Dallas and Washington, DC are just a few that have major projects either underway or planned.

On January 28, 2010, President Obama announced the first recipients selected to receive grant funding under the High-Speed Intercity Passenger Rail (HSIPR) Program. This first round of selections under the HSIPR Program represents a down payment of $8 billion on the President's vision of a passenger rail network that will help address the Nation's 21st century transportation challenges.

The HSIPR Program has generated enormous interest and excitement across the country. The Federal Railroad Administration (FRA) received 259 grant applications from 37 states and the District of Columbia requesting nearly $57 billion in funding–far exceeding the initial $8 billion available under the American Recovery and Reinvestment Act of 2009. In total, 79 applications from 31 states were selected for funding. Surveyors who want to expand their services into new vertical markets should be taking a serious look at the ever expanding rail market.

Grant Recipients for Initial $8 Billion High Speed Rail Funding

California
Awardees: California Department of Transportation; California High-Speed Rail Authority
Total Approximate Funding (all corridors): $2.34 billion

Tampa-Orlando-Miami
Awardee: Florida Department of Transportation
Total Approximate Funding (entire corridor): $1.25 billion

Chicago-St. Louis-Kansas City
Awardees: Illinois Department of Transportation, Missouri Department of Transportation
Total Approximate Funding (entire corridor): $1.13 billion

Minneapolis/St. Paul-Madison-Milwaukee-Chicago
Awardees: Wisconsin Department of Transportation; Minnesota Department of Transportation
Total Approximate Funding (entire corridor): $823 million

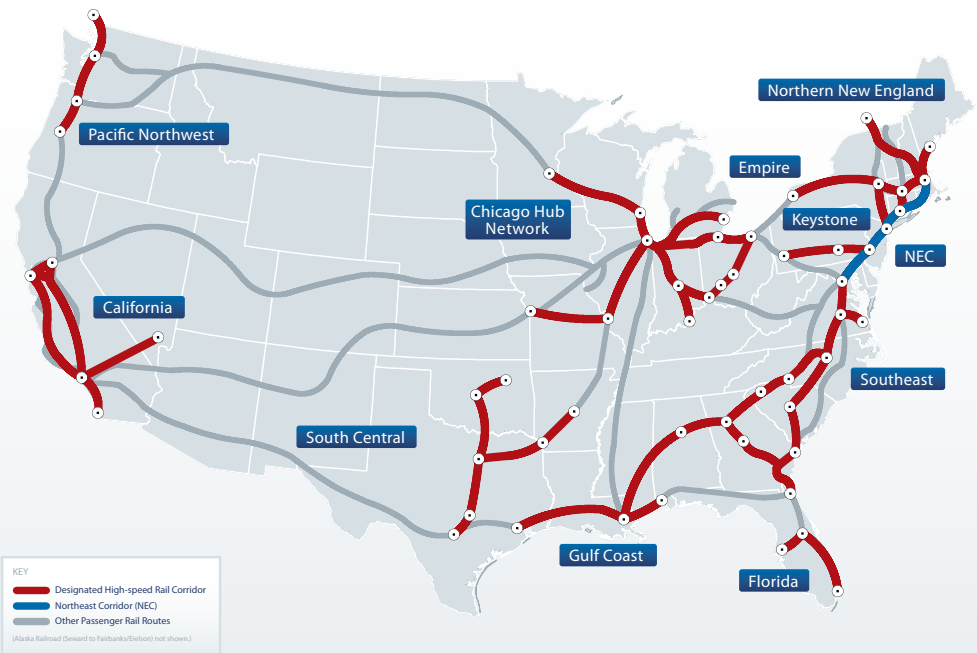
A New Way of Rail Surveying

"We worked on the railroad in the past, with SMART's lead consultant; HDR Engineering," says James M. Dickey, PLS, president of Cinquini & Passarino Inc. (CPI), a surveying firm based in Santa Rosa, California. "We knew from our previous experience that the top of rail survey could take months to complete with conventional surveying equipment."

CPI was asked to provide details of track and crossing conditions for a northern 60-mile section of the SMART corridor, with rail information at 100-foot stations. With conventional RTK or optical surveying, the work goes slowly and it's hard to reliably get sufficient accuracy. Setting and plumbing the rod at consistent points on the rounded top surface of rails, is tedious. And, counting off stations along the track adds up as well. CPI wanted to work more efficiently, while providing higher density and more accurate information to their client. The firm is known for innovative use of technology; for example, they won a 2010 American Council of Engineering Companies' (ACEC) small firm merit award for a project that combined RTK surveying and echo sounding to provide hydrographic data to the City of Napa, California.

True to form, CPI came up with a better idea for the SMART corridor work. "The project was qualifications-based and we had to figure out the best way to meet project goals. We were challenged with a very tight time schedule," Dickey explains. "We saw some information on the Amberg Technologies' GRP System FX track surveying system in *The American Surveyor* [March 2009], and we thought it might work perfectly for this."

VISION *for* HIGH-SPEED RAIL *in* AMERICA



Source: Federal Railroad Administration

Charlotte-Raleigh-Richmond-Washington, DC
Awardees: North Carolina Department of Transportation, Virginia Department of Transportation
Total Approximate Funding (entire corridor): $620 million

Eugene-Portland-Seattle-Vancouver, BC
Awardees: Washington State Department of Transportation, Oregon Department of Transportation
Total Approximate Funding (entire corridor): $598 million

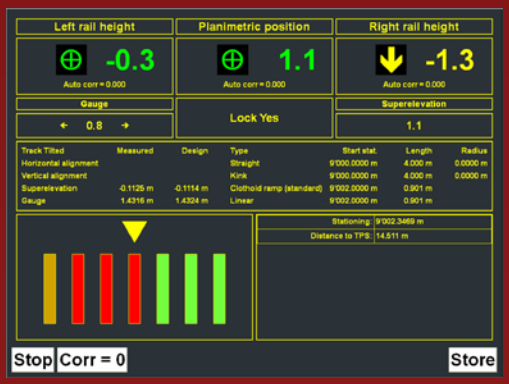
Northeast Region
Awardees: Northern New England Passenger Rail Authority; Vermont Agency of Transportation, Massachusetts DOT, Rhode Island DOT, Connecticut DOT, New York State DOT, New Jersey Transit, Pennsylvania DOT, Delaware DOT, Maryland DOT, District of Columbia DOT
Total Approximate Funding (entire corridor): $485 million in ARRA high-speed grants; $706 million in ARRA Amtrak grants ($1.2 billion total)

Cleveland-Columbus-Dayton-Cincinnati
Awardee: Ohio Department of Transportation
Total Approximate Funding (entire corridor): $400 million

Pontiac-Detroit-Chicago
Awardees: Michigan Department of Transportation, Indiana Department of Transportation, Illinois Department of Transportation
Total Approximate Funding (entire corridor): $244 million

Iowa
Awardee: Iowa Department of Transportation
Total Approximate Funding (entire corridor): $17 million

Fort Worth, TX area
Awardee: Texas Department of Transportation
Total Approximate Funding (entire corridor): $4 million



Screen captures from the GRP showing real-time track adjustment values and deviations (in millimeters) from the design alignment.

The Amberg slab track application provides guidance for right rail, left rail and planimetric position of track.

The gauge sensor of the Amberg GRP provides measurements accurate to +/- 0.3mm

A Tool for Many Applications

The American Surveyor strives to provide accurate information on the latest measurement technologies and trends. Because the Amberg GRP System FX is new, unique and used for such a wide variety of applications, several of its capabilities are highlighted here, demonstrating potential ways in which the technology can be implemented.

Real-Time Clearance Analysis & Mobile Laser Scanning

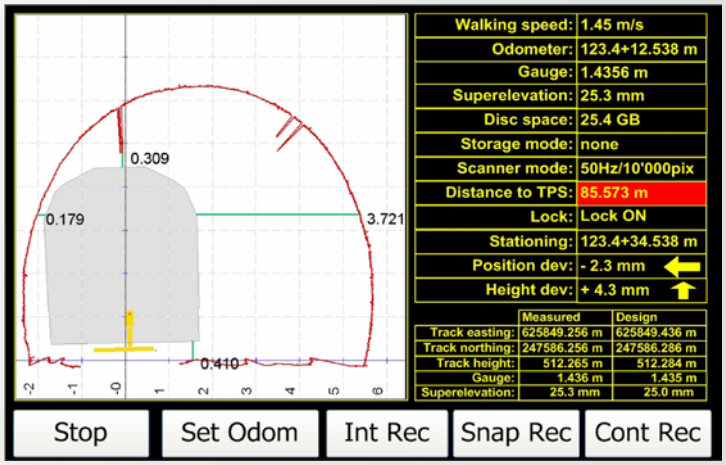
Mobile laser scanning is quickly becoming a widely used tool for 3D point cloud generation. However, it's not just about hardware. As Amberg specializes in rail applications, their software platform, "Amberg Rail" is designed specifically to address the needs of freight and passenger rail requirements with many being provided in real-time without any post-processing. By integrating precise gauge and super-elevation sensors in the GRP, a high speed (phase based) laser scanner and a robotic total station or RTK GPS, the system provides complete information in a single process of pushing the GRP down the track:

- Track Gauge
- Track Super-elevation
- Horizontal alignment
- Top of rail elevations
- Real-time clearance analysis
- High density, 3D point cloud
- Track stationing
- As-built deviations from design

Slab Track Construction for Light Rail and High Speed Rail Projects

Virtually all metros and subway systems incorporate slab track sections of track throughout their network. Unlike ballasted track, slab track is poured in concrete using a variety of methods. By loading the track design into the Amberg Rail/Slab Track software module, the GRP is used for fast and precise (mm level), real-time adjustment of the rail, as well as the final acceptance surveys. Today's light rail projects typically have a construction tolerance of +/- 3mm for the rail installation.

Amberg's expertise in high precision slab track applications has resulted in over 200 GRP's being delivered to China for their massive high speed rail development.



Screen capture from the GRP showing real-time clearance analysis and complete track information.

Amberg Technologies' (Regensdorf, Switzerland) rail and tunnel solutions are well established in Europe and Asia, but are just being introduced to the United States. Dickey asked the Kara Company, Inc. (Countryside, IL), Amberg's U.S. distributor, to demonstrate the system, which is based on a three-wheeled instrument that rides along rails. The GRP is equipped with extremely precise sensors that continuously measure track gauge and super-elevation, as well as an odometer for relative stationing. The horizontal and vertical alignment of the track is established by streaming position data (N, E, Z) to the GRP from either a Leica robotic total station or RTK GPS. All of the data are simultaneously managed in the onboard Amberg Rail software. In practice, the GRP is pushed along the track and in a single process, provides all track information. Depending on how it is configured, the GRP System FX can also be used for real-time track adjustment in slab track construction (used in high-speed and light rail projects), tamping surveys for ballasted tracks, real-time clearance analysis and 3D mobile laser scanning. (See sidebar)

"The Kara Company provided training for the system", says Dickey. "We trained four people–two field guys and two office guys–which took about a week. Once we learned the software, the field work went very efficiently."

CPI owners Tony Cinquini, P.E., P.L.S. and Jim Dickey, P.L.S. review the day's plan with surveyor James Brown.

the track. The calibration takes only a couple of minutes and works much like checking any level: the GRP is set on the track, a measurement is taken, then the GRP is turned the opposite direction (one person can do this) and a new measurement is taken and automatically evaluated by the onboard software.

> "Amberg's expertise in high precision slab track applications has resulted in over 200 GRP's being delivered to China for their massive high speed rail development."

For this project, the GRP's horizontal and vertical positioning was provided by RTK GPS. A Leica GX1230 receiver was connected via cellular modem to the California Surveying Virtual Survey Network (CSVSN). The CSVSN covered the SMART corridor and allowed CPI to start work each morning without setting up a base station or stopping every few miles to move the base station forward.

The only GRP-specific setup needed was a daily calibration of the cant sensor, which measures the super-elevation of

Although the GRP only requires one person to operate, a two-man crew was used on this project for safety reasons. CPI had estimated that the time required to complete this survey with traditional methods would have been three months. The GRP enabled CPI to cover five to nine miles a day and complete the fieldwork for the entire 60-mile corridor survey in just under two weeks.

Mike Jones, PLS, CfedS, handled the office part of the project, and says that data was collected quickly enough to create a ratio of about two-to-one, fieldwork

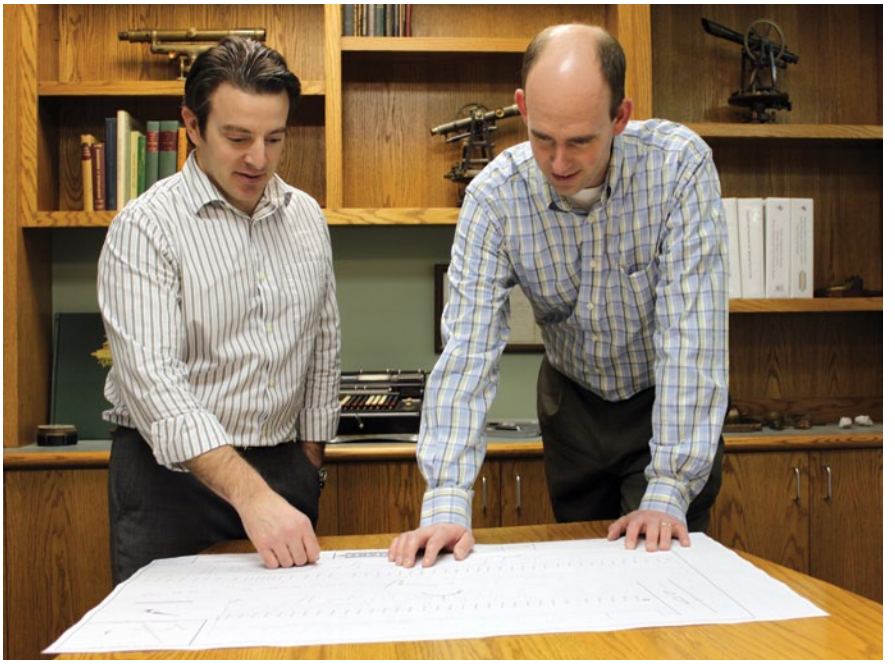
The existing Northwestern Pacific railway corridor will soon be a modern, passenger rail system.

to office work. For deliverables, he exported points from the onboard Amberg data collector (based on a Panasonic ToughBook), to a spreadsheet, and then into AutoCAD–maps were simple, basically points and coordinates in parallel. With training, fieldwork, and

office work, the entire project took about four weeks.

"The Amberg GRP saved us months of fieldwork," says Dickey, "Plus, we could do more for our client. Since the GRP and GPS were gathering data more or less continuously, we were able to provide coordinates and track data at 25-foot stationing, rather than 100-foot. We now have all the data available to provide the track data at any other interval if requested by our client." Because it was new technology for CPI, Dickey made sure that spot checks were conducted with conventional equipment and found that the GRP consistently gave precise results.

Return on investment (ROI) was substantial and the project has encouraged Cinquini & Passarino, Inc., to pursue more railroad work. This is a small firm that knows how to take on big jobs with innovative solutions.



Cinquini (L) and Dickey (R) are big proponents of advanced technologies. Early instruments used in the firm (est. 1954) are displayed in their conference room.

Rail Renaissance

In Sonoma and Marin counties, the rail initiative caught on for several reasons. Transportation that doesn't depend on crowded Highway 101 is the biggest, of course, but the SMART corridor will also include a bikeway that could dramatically increase bicycle commuting in the region, with perhaps 7,000 bicycle and walking trips each weekday.

It's no secret that much of the American infrastructure is in trouble. The American Society of Civil Engineers (ASCE) 2009 infrastructure report card gives rail a grade of C- (overall infrastructure gets a D) and says that as much as $200 billion needs to be spent by 2035 in order to maintain adequate rail capacity for freight and commuting.

Advantages cited for the SMART system include reduced emissions, improved air quality, shorter commutes, and safer travel. Given the high approval rates, area residents are obviously convinced that rail is a good idea. As rail expansion continues to grow on a nationwide basis, opportunities for surveyors to expand their services into this huge vertical market are *right on track*.

Angus Stocking worked for 17 years as a land surveyor in several different states. Now as a professional writer he specializes in surveying and related topics.

The GRP is easily loaded into the survey truck for transport.

Although the GRP only requires one person to operate, a two-man crew was used on this project for safety reasons.