Corridor Alignment Beats Winter Odds With Inertial Survey

By Julian G. Schmidt

Time and terrain are twin threats to any attempt at corridor alignment in the rugged high country of the American Rockies.

Union Pacific knew of these threats but their new project was critical, not only for them but also for the nation. Some major energy suppliers needed a way out of the remote mountains near Evanston, Wyoming, and it would take 37 miles of track to do it.

In this country, winter can fall overnight and can be lethal if your project manager has sliced time to the bone. This created a dilemma for Union Pacific because it was already late in October; however, they could not wait until spring to run the survey for the new railroad.

A conventional survey (transits and elevation rods) through this tortuous terrain that juts between 6,500 and 9,000 feet would take months under ideal weather conditions. But at this time of year, such a time frame carried with it a dead certainty that they would be stopped cold in six feet of snow before the project would be completed. Unless all data could be gathered before winter hit, the project would have to lie dormant for an entire Wyoming winter, which meant that it might as well be scrapped before it could begin.

In an effort to pierce the puzzle, Union Pacific contacted The Schemmer Associates Inc., Omaha-based consulting engineers who have had 21 years' experience in unlocking the mysteries of enigmatic survey situations.

Their solution was adroit, but its bold unorthodox logic may appear to be magical when compared with a conventional survey. This approach was a combination of aerial topography and a revolutionary technique known as Inertial Survey.

Inertial Surveying is virtually unknown outside the most sophisticated surveying circles, having only been available for non-military use since 1975. What it does is utilize the same types of accelerometers, gyroscopes and computers as are used in space guidance systems to locate and record the path of space vehicles, except in this case, these instruments locate and record the path along the survey route.

The advantages are astounding. First, rather than walk the entire survey route with transit and level rod, Inertial Surveying allows you to ride or fly over it, which means that the speed with which you can complete a job increases almost exponentially with its size. Second, any type of vehicle can be used; since Inertial Survey equipment measures motion in three planes, you can use anything that moves (it doesn't matter how fast)—car, four-wheel-drive vehicle or helicopter. Third, accuracy is extremely impressive—as great as one-in-20,000.

Setting-Up

Briefly, this is how The Schemmer Associates set up the Inertial Survey for Union Pacific's 37-mile corridor alignment in Wyoming.

Few references existed to offer a hint of where the alignment for the proposed railroad was. Only U.S.G.S. monuments 20 miles apart and occasional section corner markers were evident, so some ground work by conventional methods was necessary to set the stage for the Inertial Survey.

First, a process called monumentation was performed, in which primary reference points were established every four to five miles along the route by placing a piece of pipe in the ground. These primary distances were further broken down into a dozen or more "intermediate control points," which, over the 37-mile route, totalled 102.

Establishing these control points completed the conventional survey work. Now the question remained: "Would they be able to finish in time?" The first threat of winter cold and wind had already begun, and flurries of snow were beginning to leave their mark on the survey points. By conventional means, it would take at least two and one-half months to complete the survey . . . the job would be paralyzed. Inertial Surveying was the only hope.

Not For Beginners

Inertial Surveying is subject also to that universal law: "The greater the benefit, the greater the risk."

Inertial Survey equipment is very expensive, so it must be used properly and expeditiously. Pitfalls and costly mistakes which might be mere nuisances in a conventional survey are magnified in Inertial Surveying; therefore, high degrees of responsibility, concentration, skill and experience are required on the part of the survey personnel. One minor misinterpretation, one momentary lack of vigilance, one tiny detail overlooked in preparation or anticipation, and the entire effort could rebound to a costly burden.

According to the Schemmer Associates Inc., thorough preparation is paramount. In the words of Art Petersen, Project Manager for Schemmer, "Anticipate, anticipate, anticipate! Try to imagine the worst set of adversities, then be prepared to deal with all of them.

"Always think, and know how to think, logistics. For example, first we intimately familiarized ourselves with the site. That's imperative on a job this big and with this many points.

"Then we determined a logical numeric system for identifying the points and placed metal tags and signs on each one for that purpose. This helps assure both speed and accuracy, and prevents getting lost or duplicating a point or compounding an error.

"Make sure all points can be found under all weather conditions. Put salt around the point so that, in case of a snowfall, it will melt. Use stakes with flags. Carry a metal detector in case of snow.

"Take into consideration that each point must be located so that it is accessible by a four-wheel-drive vehicle or helicopter.

"Anticipate food and fuel requirements before you begin your Inertial Survey run. Once you start, you can't stop.

"If possible, try to anticipate alternate routes to run the survey. Ask yourself, 'How can I reach the points if a sudden flood, landslide or snow storm destroys this route?' "

In choosing the type of vehicle for running the Inertial Survey, three major factors are considered: Distance, type of terrain and time. If distances are great, points to be surveyed are sparse, time is extremely limited and terrain is too rugged for a land vehicle, a helicopter may be the expedient. However, if the points to be surveyed are relatively close together and the terrain is not too rough, a land vehicle (generally a 4x4) is more efficient. A land vehicle also offers the advantages of locating points in covered areas (in trees, brush, snow, etc.) or in heavy residential or timber areas, plus the ability to continue the survey throughout the night. Naturally, if the survey is to be conducted over an existing length of railroad track, a high-rail-mounted vehicle is ideal.

Both Helicopter And 4X4

With both primary and intermediate control points established, the only field work that remained was to run the Inertial Survey itself. What this entailed was for two survey technicians, trained to operate and interpret Inertial Survey equipment, to ride in the survey vehicle, stopping at each point so the on-board equipment could record longitude, latitude and elevation of that point.

The Inertial Survey was run in two steps. First, primary points were covered by means of a helicopter (because distances between points were great). Then the equipment was transferred to a four-wheel-drive van to pick up the intermediate control points. Here, distances were short, and the vehicle was frequently required to maneuver in tight places such as trees, brush and boulders.

Processing Inertial Survey Data

Inertial Surveying equipment is an integral system comprising the accelerometers (which establish three-plane coordinates at any selected point) and an on-board computer connected to these accelerometers. As the vehicle containing this equipment moved over the survey route, the on-board computer recorded the three coordinates on cassette tape. The system, consisting of accelerometers, gyroscopes and a computer, measures acceleration and time in a force field from a stable platform, beginning at a U.S.G.S. benchmark. This data is converted into the three coordinates at any point along the route.

The cassette was then taken to an off-line computer—a mobile system located in a motel room near the site—where it was converted into a hardcopy print-out of the three-plane coordinates for each point.

This hard-copy print-out was then sent to The Schemmer Associates Inc.'s office computer, where it was processed into a base map (plat) by a computer-driven drum plotter at a scale of 1 inch = 2,000 feet, which was then traced onto mylars and completed for delivery.

In their final form, the plats presented horizontal and vertical control data consisting of latitude and longitude converted to the appropriate State Plane Coordinate System and elevations on predetermined control monuments and recovered section corners. The proposed center line of the

EXPANSE—Wide open spaces and mountains two miles high are covered within minutes with the Inertial Survey technique.

VAN USED—The Inertial Surveying crew uses a four-wheel drive van to scale the rugged terrain.

JAGGED ROCK—A rock-topped mountain poses no problem for the Inertial Survey crew.