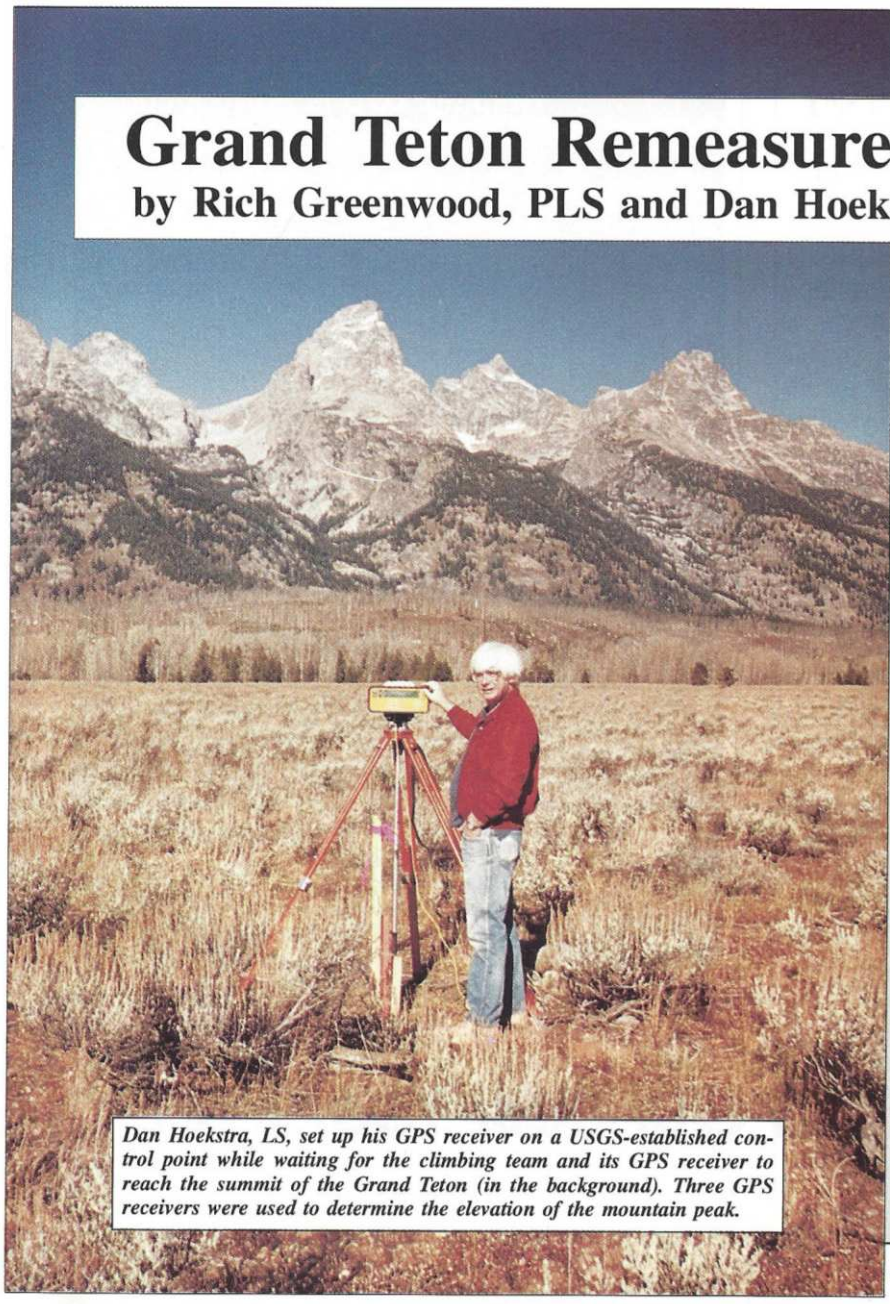
Grand Teton Remeasurement

by Rich Greenwood, PLS and Dan Hoekstra, LS



Dan Hoekstra, LS, set up his GPS receiver on a USGS-established control point while waiting for the climbing team and its GPS receiver to reach the summit of the Grand Teton (in the background). Three GPS receivers were used to determine the elevation of the mountain peak.

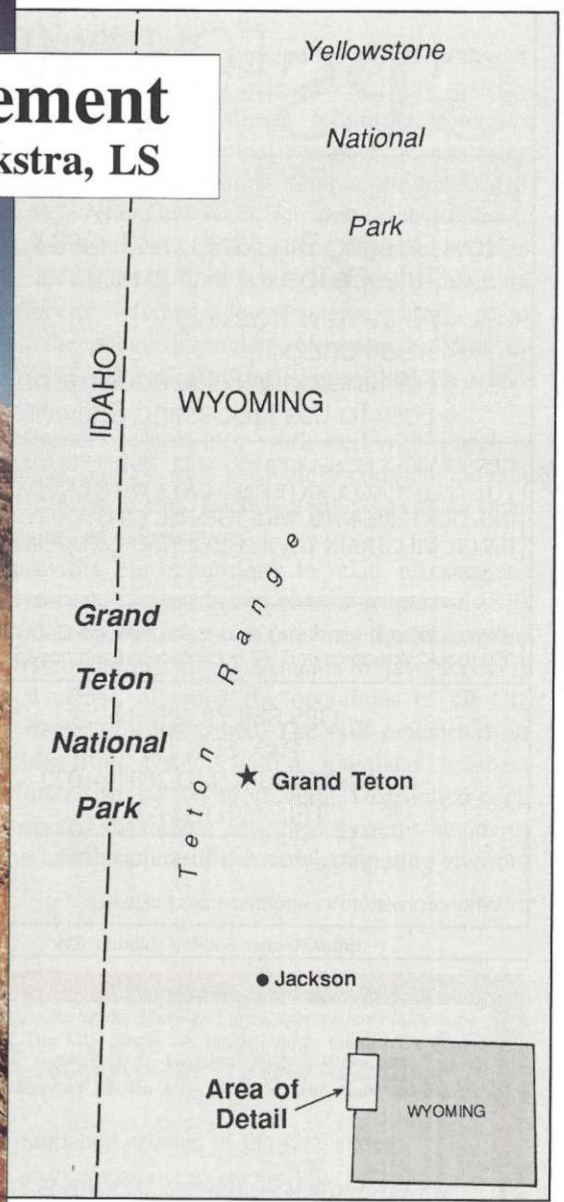


Photo by Ed Lavino

Standing 7000 feet above its surroundings in the Teton Mountain Range, the Grand Teton dominates the landscape of western Wyoming and eastern Idaho. The first ascent of the Grand Teton was claimed by Nathaniel P. Langford, a member of the Hayden Survey that was mapping the region, in 1872. His stated elevation was 13,762 feet, which was remarkably close to the actual elevation given that his ascent was later discredited by historians since his route description was too sketchy to be considered accurate and no evidence of his climb was found. The first recognized ascent of the Grand Teton is believed to have occurred on August 11, 1898, by William Owen, Franklin Spalding, Frank Peterson, and John Shive.

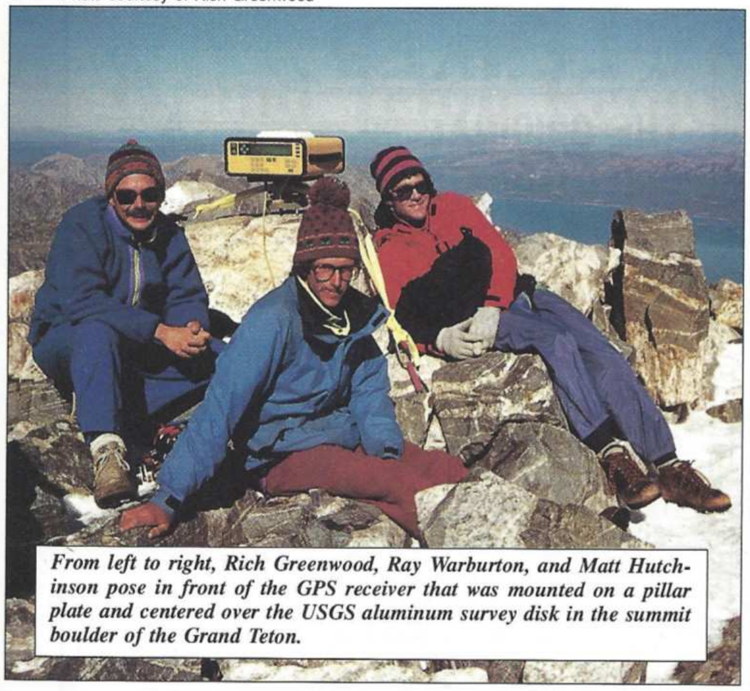
In 1968 the U.S. Geological Survey (USGS) determined the peak's elevation to be 13,770 feet. This elevation was calculated as part of a Third-order mapping survey. Grand Teton National Park Climbing Rangers placed lath tripods on the major summits of the Teton Range for the USGS surveyors. As time permitted, the Climbing Rangers drilled and cemented aluminum survey disks into the summit rocks.

The USGS surveyors observed the Teton peaks with Wild T-2 theodolites from various points along an electronic traverse around the Teton Range. Direct and reversed observations were taken at four positions on the horizontal circle and two positions on the vertical circle. The Grand Teton was observed from two locations east of the mountain in the Jackson Hole valley, and from a low summit several miles to northwest.

Five years ago Rich Greenwood, PLS, a climbing enthusiast, first discussed remeasuring the Grand Teton with his employer, Scott Pierson, PLS, of Pierson Land Surveys, P.C., Jackson, Wyoming. He had no reason to doubt the accuracy of the established elevation; however, surveyors who are also mountain climbers cannot help but think about remeasuring the mountain. Since the USGS elevation of the mountain was calculated without benefit of reciprocal vertical angles or distance measurements to the

continued on page 50

Photo courtesy of Rich Greenwood



From left to right, Rich Greenwood, Ray Warburton, and Matt Hutchinson pose in front of the GPS receiver that was mounted on a pillar plate and centered over the USGS aluminum survey disk in the summit boulder of the Grand Teton.

Grand Teton Remeasurement *continued from page 48*

summit, they contemplated carrying a theodolite and prisms to the summit. But in October of 1991, a better solution arrived in town.

A five-person Global Positioning System (GPS) survey crew from David Evans and Associates, Inc. (DEA), Portland, Oregon, began a photogrammetric control survey using Trimble 4000ST GPS receivers with microstrip antennas in Jackson Hole for the U.S. Army Corps of Engineers. Dan Hoekstra, LS, the project coordinator, had asked for Pierson Land Surveys' assistance in locating "Teton South Base," a USGS-established control point monument in Grand Teton National Park. In the course of a conversation while searching for the monument, Pierson mentioned his company's interest in measuring the mountain. Hoekstra was intrigued and soon agreed to help Greenwood measure the elevation of the survey disk located on the top of the Grand Teton.

The Grand Teton is a formidable climb in the summer. By October, the first winter snowfalls are already present on the upper reaches of the mountain, posing additional challenges to climbers. Usually two or three days are spent getting to the summit and back. Strong climbers, acclimated to the elevation and familiar with the mountain, can reach the top in a long day. Because the DEA crew was using its GPS receivers six days a week, a one-day climb was Pierson Land Surveys' only option.

Pierson and Hoekstra's initial conversation took place on a Tuesday and with winter fast approaching, the summit bid was scheduled for that Sunday, leaving only five days for some hectic planning. If this had been a single assignment, Hoekstra would have had to find and occupy at least four benchmarks and three horizontal control marks all with known and published government elevation and position (latitude and longitude). Since he was already working on a project in the area he had searched for and found more than a dozen government benchmarks and half a dozen horizontal control points. Because the Grand Teton was only a few miles from DEA's project, its control was used to determine the elevation of the Grand Teton.

In addition to the tight schedule and the ever-worsening weather, another major concern was how to mount the GPS receiver over the aluminum USGS survey cap on the summit. The cap is set in a desk-size summit boulder. Not only was the thought of carrying a tripod to the summit unappealing, but Greenwood had serious doubts about being able to set one up over the cap. However, Pierson came up with the solution: a pillar plate.

A pillar plate or "trivet" is a round brass plate, six inches in diameter and about an inch thick, with three short spikes for legs, onto which an instrument or tribrach is screwed. It is typically used at large construction sites such as dams or bridges and allows instruments to be placed directly on columns or walls where tripod set-ups would be impossible. The pillar plate is centered over a point by means of a bull's-eye bubble mounted on a short stylus, in a manner similar to the telescoping pole (also known as the fourth leg) of the Kern tripod system. The stylus fits through the hollow center post of the pillar plate. Using the bull's-eye bubble, the stylus is plumbed over the point by moving the plate about. The stylus is then removed, and the instrument threaded onto the center post and leveled.

John Dolinar, president of William H. Smith and Associates in Green River, owned the only pillar plate Pierson knew of in Wyoming. Dolinar was excited by the project and sent his Wild pillar plate via overnight delivery to Pierson.

Assembling a team of three or four climbers in Jackson Hole should have been easy, but the prospect of carrying an extra 35 pounds of survey gear and dealing with potentially lousy weather made it harder to find the personnel. Ray Warburton, a Pierson Land Surveys party chief, and Matt Hutchinson, a local climber, agreed to go with Greenwood.

On Saturday the weather still looked less than promising, but by 4 A.M. Sunday morning, although the temperature in the valley was 17°, the sky was full of stars; Saturday's storm had broken. Several hours of hiking and scrambling brought the climbing team to the Lower Saddle. At 11,600 feet, the Lower Saddle separates the Grand Teton from the Middle Teton and is the starting point for several climbing routes on the Grand.

While the Owen-Spalding route is the easiest path to the summit, that Sunday it was packed with early winter snow and ice. Instead, the team chose a slightly more difficult route on the south side of the peak where drier conditions prevailed. Being experienced climbers, the three saved a lot of time by climbing much of the route without using the added protection of ropes.

At 1:20 P.M., under perfect weather conditions (it was the last sunny day they would see for a while in the Jackson Hole area), they reached the summit. If they had arrived any later, they would have missed the last hour of the satellite visibility window. The pillar plate was fitted over the cap in the summit rock upon which Owen and

Shive had scratched their names 93 years before. After threading a tribrach onto the plate, the team members mounted the Trimble receiver on top. It was secured by a nylon sling threaded through removable climbing anchors wedged into cracks on each side of the rock.

The other two receivers were being run in the valley by Hoekstra and Ed Lavino, another Pierson Land Surveys employee. Hoekstra had instructed both Greenwood and Lavino on how to operate the GPS receivers. Radios were used for communication between the climbing team and Hoekstra and Lavino. The team's summit receiver simultaneously logged data from the four satellites that were in "view." Observations were recorded every 15 seconds by all three receivers.

After an approximately hour-long observation session on the summit, the team was anxious to begin its descent. Two long rappels avoided the worst stretches on the descent route. Five hours of trudging, scrambling, walking, and running got them to the trailhead parking lot shortly after dark, exhausted and elated. Greenwood skipped dinner and drove straight to Hoekstra's motel to download the receiver.

The new summit data was added to Hoekstra's network of more than 100 points in Jackson Hole, including six horizontal control points and 15 vertical benchmarks. The GeoLab least squares program (GEOsurv Inc., Ottawa, Ontario, Canada) spent 20 minutes readjusting the network before spitting out the number they were waiting for: 13,771.4 feet. Their position is 1.4 feet higher and 1.5 feet northwest of the 1968 USGS survey, with two standard deviations (two sigma, 95% confidence) of ±0.29 foot, which is quite close considering the previous elevation was established using one-way vertical angle observations. Even though GPS measurements alone cannot establish orthometric (based on sea level) elevations, a combination of "differential" GPS and previously established control points, such as First- and Second-order NGS benchmarks and horizontal control stations, makes GPS an excellent and efficient tool for determining the sea-level elevation and horizontal positions of hard-to-reach points, like mountaintops such as this one.

What is more notable and impressive to Greenwood than their modern, high-tech elevation measurement is the degree of accuracy attained by the earlier surveyors. Perhaps 30 years hence additional state-of-the-art technologies will bring humanity a few inches closer to the true location of this and other mountains around the globe.

Since the time that this project was completed, GEOID90, an improved high-resolution geoid height model software program, has become available. Once the summit data is run through the program, it will be possible to calculate the Grand Teton elevation to within 1cm. ▲

Rich Greenwood is a registered professional land surveyor in Wyoming, and president of the Central Chapter of the Professional Land Surveyors of Wyoming. He has climbed the Grand Teton 14 times.

Dan Hoekstra, LS, who lives in Portland, Oregon, has been a surveyor for 20 years, the last 7½ of which have been spent working for David Evans and Associates. He is a member of the Professional Land Surveyors of Oregon.