United States
Department of
Agriculture

Forest Service

Engineering Staff

Washington, DC

Engineering Field Notes

Volume 30
January–April
1998

Engineering Technical Information System

1997 *Engineering Field Notes* Article Awards

Well, another year has passed, and it's time again for you to let us know which articles you believe were most informative, beneficial, and interesting; which articles helped your office save money; and which articles helped you accomplish your work more effectively and efficiently.

Despite the cutback to three issues per year, the quality and diversity of the articles have not diminished. We still share information in many diverse fields—geometronics, ecosystem roads management, facilities and other structures, and geotextiles. Through *Engineering Field Notes* (EFN), we continue to provide a way for Forest Service engineers, at all levels and from all Regions, to share their knowledge and experiences. We believe sharing is vital, especially now that so many of us are short-staffed. We applaud all who took the time to share.

After selecting your three favorite articles, please complete the rating sheet on the following page. Rate the articles from 1 (best) to 3 (third best). If you believe an article has or will help the Forest Service save money or other resources, please let us know. Remember, this is a one-person, one-vote system—so your vote really does count!

Once you have voted, cut the rating sheet along the dotted line, fold and tape or staple it closed, and mail it back to us. In order to be counted, your rating sheet must be received no later than June 1.

Thanks to each of our authors and readers who made 1997 another great year. You each deserve a pat on the back for your help in fostering an environment where information and experience are viewed as valuable resources and are shared accordingly.

If you have never submitted an article, think about the projects you've worked on, the experiences you've had. Why not take the time to record at least one of them on paper? You don't have to be a writer, and you don't have to be concerned with format. Just write it in your own style and submit it (with photographs if you have them) to your Regional EFN Coordinator. They are listed on the inside back cover of every issue of EFN. Who knows, next year you could be one of our winners!

1997 *Engineering Field Notes* Awards

Article	Author(s)	Choice (1,2,3)	$ Saved (✔)
January-April			
Construction Certification Program	Brenda Styer	_________	________
New Facilities Program at the Missoula Technology and Development Center	Steve Oravetz Keith Simila	_________	________
Restoration of the Historic Vierhus Playhouse	Cherie Peacock, P.E.	_________	________
Water Quality Effects of Three Dust-Abatement Compounds	Kathy Heffner	_________	________
Water/Road Interaction Technology Series	Jeff Moll	_________	________
May-August			
Retaining Wall With an Eye on the Past	Robert L. Freel	_________	________
Stress-Skin Panel Construction of a Small Cabin	Gerald Herbrandson	_________	________
Sustainability—Building Green for Both Humans and the Environment	Anna J. Jones-Crabtree	_________	________
September-December			
Faster, Better Data for Burned Watersheds Needing Emergency Rehab	Henry Lachowski Paul Hardwick Robert Griffith Anette Parsons Ralph Warbington	_________	________
Lasersoft Instructions	Jeff Moll	_________	________
Road Maintenance Frequency vs. Sediment Production	Richard Kennedy	_________	________
Stabilization and Protection of the Cape Creek Shell Midden	Carl Davis Dan Mummey	_________	________

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Name ______________________________
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Forest Service—USDA
Engineering Staff
201 14th Street SW
Washington, DC 20250

Forest Service—USDA
Engineering Staff
Attention: K. Hutchinson
201 14th Street SW
Washington, DC 20250

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1998 Forest Service Engineers of the Year

Congratulations to the winners of the 1998 Engineer of the Year awards:

- Managerial Engineer—Andrew E. Gililland from the Angeles National Forest in Region 5
- Technical Engineer—Dr. Jim McKean from the Regional Office in Region 5
- Engineering Technician—Jim Tierney from the Mt. Hood National Forest in Region 6

An award ceremony was held April 9, 1998, in Washington, DC, to recognize the winners for their achievements. The Acting Director of Engineering presented each winner with a special plaque and a cash award. A summary of the winners' accomplishments is included on the following pages.

The winners were selected from an excellent list of Regional and Station candidates. Congratulations to the following finalists in all categories:

Managerial	**Technical**	**Technician**
Robert Kirkpatrick	Douglas McCelland	Bob Hayes
Marv Froistad	Duane Yager	Patrick Marah
Terry Brennan	Chris Ida	Paul Standing
Gary W. Campbell	Gretchen Barkmann	Bob Varga
Kerry Lackey	Shane A. Brown	Clint Dotson
Chuck Lapicola	Pete Bolander	Ken Guillard
Sue LeVan	Mike Hires	Dick Crockett
	Janey Fraley	Mary Doran
	Rob Aiken	
	Said Abubakr	

Andrew E. (Ed) Gililland, Managerial Engineer of the Year

Andrew E. (Ed) Gililland has provided outstanding leadership for the Angeles National Forest as an Engineering Manager and as a Forest Staff Officer through the Forest's many changes and challenges. Over the past few years, the Angeles has experienced fires, floods, earthquakes, and riots. Each occurrence has added to the workloads in special-use permits, recreation, vegetative management, and law enforcement. Under Ed Gililland's direction, Engineering has consistently risen to each new demand and provided sustained, exceptional support for all programs.

Examples of Ed's leadership and participation include:

- Serving on burned area rehabilitation teams and performing considerable watershed protection work after each major fire.
- Clearing the roads and accomplishing structural evaluations after each earthquake.
- Reviewing permits ranging from new state-of-the-art telescope installations at Mt. Wilson observatory, to Mobil Oil's new transmission pipeline into the Los Angeles area, to new digital communication equipment facilities and towers on the mountaintops surrounding Los Angeles.
- Serving on teams and overseeing work to put South Central Los Angeles back to work after the 1992 riots. A program called Opportunity LA was established on the Angeles to provide employment opportunities for disadvantaged youth and accomplish Forest work. Through this program, some 139 buildings were remodeled or received heavy maintenance and/or painting and more than 50 people were provided with employment.
- Meeting "Consent Decree" deadlines for providing barracks with restrooms for male and female residents by identifying skills and abilities needed and available and developing teams to accomplish the work. Ed received an award from the Deputy Regional Forester for his efforts in this project.

As Forest Engineer and Staff Officer, Ed has always been involved with all aspects of management of the Angeles National Forest and has been a vital part of the Forest Leadership Team. He has served details as Deputy Forest Supervisor and District Ranger, and regularly serves as Acting Forest Supervisor. Because of his efforts in the Forest's reorganization process, Ed has received awards for his leadership in developing the Forest Reorganization proposal and his contributions to the team.

As the Forest Engineer, Ed has excelled in leading Engineering to improve service in the face of declining budgets. Of particular note is his leadership in facility management and improvement. He led the effort to develop a Forest-wide facility master plan that defines facility needs and priorities for all facilities including FA&O and Recreation. As a result, the Angeles has been able to effectively use all funds that have become available to remove unneeded buildings, reduce maintenance and improvement backlogs, and build needed facilities through the minor construction program. In each of the last 6 years, facilities and/or roads projects have been added to the program of work in the fourth quarter because of Ed's leadership in finding innovative ways to get additional work done. Through this program flexibility, the Angeles has helped the Region with year-end budget balancing. The Regional Office recognized Ed's leadership by recommending that an adjacent forest use Ed as a consultant for its minor construction program.

In addition to being a valuable asset in all aspects of management of the Angeles National Forest, Ed has helped make tremendous strides in improving the Forest's facilities, water systems, and utility systems. Ed has led Engineering into full automation of all design and drafting functions, and the fleet management group was one of the first in the Region to begin development and implementation of automated systems for fleet maintenance and management functions. Through effective delegation of authority to his assistants, consultation with technical experts in the Regional Office, and close coordination with local agencies, cooperators, and permittees, Ed has been able to ensure that Engineering exceeds expected results consistently through the years. Examples include working with:

- Engineers from California Department of Transportation (Caltrans) on issues relating to reopening State Highway 39, herbicide use, interstate highway repair, drainage replacement on forest highways, and selection and NEPA clearance of debris disposal areas. The reopening of Highway 39 project included the determination of the appropriate method of slope stabilization and repair of the roadbed at a landslide. A portion of Highway 39 had been closed by the landslide, had not been maintained, and was slated for abandonment. Ed worked with Caltrans to get maintenance performed, stop erosion and resource damage, and pursue the necessary funding to reopen the highway. In 1997, a service road was established across the landslide area and administrative traffic was able to traverse this critical access route for the first time in 18 years.

- County and city engineers on road-related issues. Ed has recently worked out a proposal with Los Angeles County in which the County will use some $5 million to rebuild a road through the Angeles if the Federal Government provides $2.5 million.

- Civil engineers and health professionals at the Los Angeles County Health Department and Public Works Department during an outbreak of *giardia* and *cryptosporidium* infestations in the Forest's water systems. Ed developed a Forest-wide water system improvement program and was recognized across the Nation as having the most current knowledge of *cryptosporidium*, its effects, and how to treat infestations.

Ed is also very active in his community. His involvement includes:

- Facilitating and participating as a member of the High School Planning Team.

- Providing leadership as the President of the Big M Booster club and as an active member of the football and track booster clubs at Monrovia High School.

- Making presentations dealing with fire prevention, other Forest Service related topics, and careers for Boy Scout groups, Cub Scouts, church groups, and local schools.

- Serving on his church's board of trustees and as a Sunday school superintendent and adult Sunday school teacher.

- Participating as a member of the American Legion.

Ed strives to maintain his personal professionalism, skills, and knowledge. He has completed several management courses on his own time. He has been upgrading his skills in working with volunteers and has recently completed a 15-unit correspondence course on building inspections. Ed is also a member of the Civil Engineering Book Club.

The many groups and conferences at which Ed has made presentations include the Low Volume Road Conference, the technical symposium of the Akron Tire and Rubber Group, and the Interagency Motor Equipment Advisory Committee conferences.

Ed has worked hard to maintain the appropriate level of professional engineering skills on the Angeles during times of downsizing. In fact, even with further downsizing planned, Ed has ensured that there will be a place in the organization for civil engineering student placement through stay-in-school or co-op appointments. Over the years, Ed has had a part in bringing at least six employees into professional positions in the Forest Service. Under his direction, the Angeles has offered review courses for professional tests, including the water system operator exam and the PE test.

Ed has been mentor and confidant to rangers, other staff officers, and employees of the Angeles National Forest for many years and has also served as a career counselor. Ed has had an effective and positive influence on the professional and managerial growth of subordinates and peers and has received special recognition for his role in serving as a mentor to women in the Forest Service.

Jim McKean, Ph.D.
Technical Engineer of the Year

Throughout his Forest Service career, Dr. Jim McKean has been especially dedicated to the development and application of new techniques that make Forest Service land management more efficient. He has consistently performed at an unusually high level in his job and has proven himself valuable in traditional project engineering work and in the integration of engineering principles into ecosystem and watershed management.

Jim has achieved a high level of expertise in geotechnical engineering and has contributed his knowledge to forest engineering projects. His normal technical work includes slope stabilization designs, site drilling investigations, foundation designs for bridges and buildings, geophysical exploration of sites, analysis of groundwater conditions, design of drainage systems and retaining walls, and engineering geologic studies. In addition to his normal technical work, Jim has pioneered the following new technologies:

- Prefabricated geocomposite groundwater drains. These synthetic drains replace conventional gravel drains and save Region 5 about $100,000 per year on engineering project costs. Jim also designed a combination laboratory/field monitoring program that validates the performance of these drains. The field monitoring phase received $90,000 in CTIP program funding.

- A mechanistic method of analyzing the role of landslides in sediment movement in watersheds in a project with colleagues at the University of California at Berkeley. The project has produced a validated model that is being used by the Umpqua National Forest, the Bureau of Land Management, Weyerhauser Corporation, and Louisiana Pacific Lumber Company.

- An objective method to directly quantify the natural long-term background rate of soil movement on hillslopes due to topsoil creep. Jim received $50,000 in support from Lawrence Livermore National Laboratory for this innovative project.

- High tensile strength geogrid materials embedded in a fill to allow fill placement at very steep slope angles. The savings in the Region 5 ERFO program from the use of this technology are approximately $100,000 per year.

As a specialist in the rapid investigation and engineering design response required by the ERFO program, Jim has been recognized several times by southern California forests for his sustained support of their ERFO work.

The following examples demonstrate how his work in this area has saved the Region thousands of dollars:

- He designed repairs for 23 storm-damaged sites on a single road on the Sierra National Forest. The total cost of reconstruction of this road was about $1.2 million.

- He coordinated a Geotechnical Strike Team that did conceptual repair designs of 110 sites in 1 week on the Klamath National Forest. The total repair cost of these sites was about $3 million and the strike team did their initial investigation for a total cost of about $10,000. Jim received a letter of appreciation from the Klamath Forest Supervisor and the Region 5 Regional Engineer for his efforts.

Jim has also been a leader in developing applications of remote sensing technologies for Forest Service ecosystem management. His efforts include:

- Designing a 4-year project using remote sensing methods to study the occurrence and effects of landslides on Forest Service land. For this project, NASA provided $400,000 in funding, flight time on two of their aircraft, computer time, and technical assistance from their staff at the Ames Research Center.

- Working with colleagues at the Pacific Southwest Station and the Remote Sensing Applications Center on a project using digital aerial photography to evaluate sediment movement in streams and its effects on aquatic habitat. This $50,000 project is being funded by the EPA.

- Investigating the production of high-resolution DEM's from airborne scanning laser data in cooperation with coworkers at the University of California at Berkeley. The project has already proven the ability of these laser data to generate very accurate, high-resolution digital terrain models, even beneath a closed timber canopy. This project will have many applications in Forest Service ecosystem management, including modeling hydrologic and sediment moving processes in watersheds.

Jim routinely gets involved in the more technically difficult or politically sensitive projects, including the reopening (after many years of controversial closure due to a large landslide) of State Highway 39 on the Angeles National Forest and working on analyses and monitoring of the landslides in the U.S. Highway 50 corridor. This major highway was closed by slides for almost a month in the winter of 1997, and there was intense public questioning of whether Forest land management caused or aggravated the slides. He has mediated disagreements with the Audubon Society over erosion and landslide control measures needed on fire salvage roads and has served as an impartial outside representative helping resolve a timber sale challenge to the San Juan National Forest in Region 2.

In addition to his national support of ecosystem management, Jim has provided international support, including:

- Doing United Nations Forestry Work. He has worked extensively with the United Nations South Pacific Forestry Development Program based in Suva, Fiji. In this work, Jim has taught short courses and provided advice on road engineering, sanitary engineering, watershed management, water system engineering and operation, and remote sensing of forest resources. He has been asked by the United Nations to design and supervise a pilot watershed management program on the island of Mangaia in the Cook Islands. A major component of this program will be control of erosion from abandoned farm roads. Some of this work has been funded by the United Nations Food and Agriculture Organization (UNFAO) or the United Nations Development Programs (UNDP) and Region 5 Engineering.

- Supporting the community forestry work of the Institute of Pacific Islands Forestry Work (IPIF), based in Honolulu, and working primarily in the Federated States of Micronesia. Jim has been a speaker at several IPIF workshops on management of mangrove forests and has provided the Forest Service Pacific Islands Forester with technical advice about road engineering, erosion control, watershed management, and remote sensing of forest resources. He received a Certificate of Merit from the IPIF for sustained work on watershed management in small Pacific Island nations and a letter of appreciation from the national government of the Federated States of Micronesia for training provided in road engineering in mangrove swamps. He has also been an advisor to the Guam office of the National Resources Conservation Service regarding the design of their watershed management program.

- Designing a remote sensing program to do an inventory and providing advice about the proper use of remote sensing technologies for the inventory of the El Ocote Preserve tropical rainforest. The El Ocote is the Klamath National Forest's sister forest in Chiapas, Mexico.

Jim is a recognized leader in his community and was a San Francisco Bay Area Federal Employee of the Year finalist in 1992. Other activities that he is involved with include:

- Providing financial and personal support to the Contra Costa County Food Bank.

- Demonstrating computer technology, remote sensing techniques, and proper trail construction and maintenance techniques to Boy Scout troops, speaking at a local high school's annual Career Day for students, and counseling several local high school students about science and engineering careers.

- Participating as an active member of a local ski club and in the annual Region 5 Clay Cup, a ski race for Region 5 employees and their families.

Jim has advised graduate students at the University of California at Berkeley, California State University at Sacramento, and San Jose State University about their research projects. He has helped many of these students with funding, research ideas, logistical support, and assistance in their field work and has volunteered much of this help on his own time. He has also worked directly with undergraduate students at the California State University at Sacramento, California State Polytechnic University at Pomona, San Jose State University, and Pasadena City College on engineering projects that the students did cooperatively for the Forest Service.

Jim has a bachelor's degree and a master's degree from Colorado State University and a master's degree in geotechnical engineering and a doctorate from the University of California at Berkeley. Beyond his extensive formal academic training, he has also actively participated in continuing education courses to expand his abilities. He has received training in soil cement engineering, the Watershed Erosion Prediction Project (WEPP) model, road obliteration design and analysis, stream classification systems, watershed analyses, engineering design of keystone retaining walls, soil nailing, computer programming, and biotechnical slope stabilization. He also was invited to attend a prestigious Penrose Conference on practical applications of radioisotopes.

As a Registered Geologist and Certified Engineering Geologist in California, Jim is a member of the following organizations: University of California at Berkeley, Geotechnical Engineering Society; International Association of Engineering Geologists; American Association of Engineering Geologists; and American Geophysical Union. He has also served on several committees, including:

- National Research Council, Transportation Research Board, Committees on Geotextiles and Exploration of Earth Materials.

- Review committee for the Forest Service's *Slope Stability Manual*.

- Review board responsible for the Region 1 assessment of the effects of the 1995 and 1996 flood on the Clearwater National Forest. This assessment was mandated by the Region 1 Regional Forester and has important implications for road engineering throughout the western United States.

Jim often represents the Forest Service in technical presentations given before peer professional groups, such as the American Society of Photogrammetry and Remote Sensing, the American Geophysical Union, and the Association of Engineering Geologists. He has given numerous presentations at Forest Service training sessions and workshops on subjects including engineering aspects of watershed analyses, remote sensing and GIS applications, computerized slope stability analyses, topographic mapping and terrain modeling software, and design of small dams. He was asked by the University of California at Berkeley's Extension Service to develop and teach short courses on low-cost slope stabilization engineering and groundwater analysis and drainage design. He taught these very popular courses to about 500 engineers throughout California.

Technical Publications that Jim has written include the following:

McKean, J., and P. Baisyet. 1994. *Watershed Management on Islands of the South Pacific: Tonga, Cook Islands, Pohnpei (Federated States of Micronesia) and Palau.* UNDP/FAO South Pacific Forestry Development Program, RAS/92/361. Field Document No. 5.

McKean, J. 1993. *Soil Creep and Earthflows: Geomorphic Analysis Using Cosmogenic Isotopes and Remote Sensing.* Ph.D. thesis, University of California, Berkeley.

McKean, J., W. Dietrich, R. Finkel, J. Southon, I. Proctor, and M. Caffee. 1993. *Quantification of soil production and downslope creep rates from cosmogenic Be accumulations on a hillslope profile.* Geology 21: 343–346.

McKean, J., and S. Buechel. 1991. *Remote sensing of forested earthflows.* Proceedings of the 3rd Forest Service Remote Sensing Applications Conference, Tucson, Arizona. American Society of Photogrammetry and Remote Sensing. pp. 198–206.

McKean, J., S. Buechel, and L. Gaydos. 1991. *Remote sensing and landslide hazard assessment.* Photogrammetric Engineering and Remote Sensing LVII: 1185–1194.

McKean, J. 1987, 1982. *Landslide damage to the Mosquito Ridge Road—Tahoe National Forest.* USDA Forest Service, Region 5. Earth Resources Monograph 12: 56–62.

Bobbe, T., and J. McKean. 1995. *Evaluation of a digital camera system for natural resource management.* Earth Observation (March): 46–48.

Jim Tierney, Engineering Technician of the Year

Jim Tierney is an outstanding performer who has distinguished himself by preparing, coordinating, managing, and implementing a very large program of work on the Clackamas River Ranger District of the Mt. Hood National Forest. He has demonstrated his management skills by taking command of an overwhelming program of work that resulted from catastrophic flooding and involved such complex issues as emergency access needs, critical environmental issues, and a reduced workforce.

Jim has been acting as the Infrastructure Team Leader, directly supervising 17 persons and managing a staff of 42 persons covering the Estacada and Clackamas Ranger Districts. As Infrastructure Team Leader, he is directly responsible for roads, recreation, land, fleets, trails, facilities, and special uses. He also frequently serves as Acting District Ranger and Acting Zone Engineer.

As an experienced technician, Jim's road manager skills have been proven by his involvement with road maintenance appraisals and his assessment of 18 alternate haul routes covering 68 MMBF of landlocked timbered land. Jim is involved with the flood program, congressional requests, safety, timber sales, facilities, trails, and road maintenance, and he provides leadership in watershed restoration. His specific contributions include:

- Developing an effective project and financial tracking system that meets the needs of a highly complex program. The system provides quick and accurate accounting and reporting and is used as a model for others. Additionally, Jim developed an analysis of projects to determine the priorities of the many projects that were blocking access for emergency resource management activities, commercial timber sales, and flexible access management. He incorporated the District's Access Travel Management (ATM) Plan and provided the insight and analysis to others where they should make ATM modifications. This analysis included creative alternatives for accomplishment and a sequence of events for when whole drainages were inaccessible for use or management.

- Assessing the needs of the Ranger District during a time of workforce reduction and high demand for field data for flood restoration. Jim's program of work included more than 250 flood projects that cost more than $13 million.

- Providing leadership by assigning goals and objectives that led to the integration of ERFO, emergency supplemental flood repair, and watershed restoration in the Clackamas River watershed.

- Participating in the proposal for classification of the Clackamas River as a Scenic Byway. The Clackamas River corridor is one of the most traveled forest highways in the Nation.

- Implementing major changes in the strategy for and direction of the Fish Creek drainage that received national media news releases.

Jim has also been instrumental in raising the quality of both communications and collaborative working relationships with the Oregon Department of Transportation (ODOT), the Federal Highway Administration (FHWA), Portland General Electric (PGE/ENRON), and Cascade Utilities. Involvement includes:

- Developing agreements with ODOT, PGE, and Cascade Utilities to assist each other in providing emergency access (and, eventually, permanent solutions) for the Timberlake Job Corps, 3 Lynx, and Ripplebrook communities of 400 people who were stranded. When the 1996 floods occurred, ODOT had to abandon the State Highway 224 project site to work on an Interstate 84 project. Jim pulled together Forest Service, Cascade Utilities, and PGE equipment to reopen Highway 224 to administrative traffic. Highway 224, which accessed the 3 Lynx community, was temporarily closed to the public due to heavy flood damage. Jim provided resource access to the 3 Lynx community and met their emergency needs for food, water, clothing, and shelter.

- Coordinating the flood repairs on Highway 224 with ODOT. This included finding 250,000 cubic yards of rock and preparing environmental documents consistent with a Wild and Scenic River corridor, northern spotted owl habitat, and late successional reserve (old growth). Jim incorporated innovative measures to ensure rapid vegetative regrowth and bioengineering in rip-rap areas. Repairs on Highway 224 included 20 sites for $7.5 million, a slide area for $440 million, and a newly relocated road for $3.5 million.

Jim's leadership and managerial skills are also demonstrated by his involvement with the following:

- Recruiting and hiring three student program employees, allowing Engineering to exceed employment hiring goals in underrepresented categories. He was an outstanding mentor to these students.

- Developing and implementing the Northwest Forest Plan's Jobs in the Woods program, providing retraining for displaced forest workers.

- Hiring locally without competition to accommodate emergency flood relief. Jim also was able to detail surplus equipment operators and fleet equipment and organize alternate work schedules to meet the emergency flood relief needs.

Within the community, Jim has participated in SOLV (Stop Oregon Littering and Vandalism) activities. This includes beach cleanup and also cleaning up dumping sites on both private and forest lands and watersheds. He has been a keynote speaker at the local Kiwanis club and participates with the local school as referee in softball and cheerleading activities.

Jim brings a unique blend of innovation, common sense, effective communication, and technical skills to challenging situations.

Cadastral Boundary Survey Using Global Positioning System Equipment

Rocky Hildebrand
Gila National Forest Land Surveyor
Lands Substaff and GPS Coordinator

Purpose

The purpose of this project was to mark and post a portion of the forest boundary in the Burro Mountain unit of the Gila National Forest with the use of Global Positioning System (GPS) surveying equipment.

History

In May 1896, Ricard L. Powel, under group 299, was awarded the contract for the survey of Township 21 South, Range 16 West, New Mexico Principal Meridian. As his notes state, he did the exterior boundaries and the subdivision of the township. Under his instructions, he used native materials for his monumentation and set bearing trees where feasible.

About 1936, a General Land Office (now the Bureau of Land Management) survey crew went through, remonumenting the corners from original evidence that they were able to find, using brass-capped iron pipes. They were not doing a retracement survey; therefore, if they could not find a corner, no brass cap was set.

For many years, the land surveying on the Gila National Forest was done by force account crews. These crews would go out each summer into the Forest

Figure 1. *View of the Burro Mountain unit on the Gila National Forest*

and camp on a district, surveying the lands for that district. In 1986, the program on the Forest changed, so we no longer did force account land surveying. With the reduction in budgets, a new and different method had to be found.

The Gila is now using co-op agreements with local surveyors and contracting for the surveying and posting of the forest boundaries. Under the co-op plan, the landowner hires a surveyor to survey a property, then the surveyor meets with the Forest, and we provide property-boundary sign posts and monuments to mark the boundaries to forest standards. We also provide funding for the monumentation, posting, and filing of all plats with the counties. Under the agreement with the surveyor, all surveys are done to State and Federal standards. We receive a plat of the survey and require the surveyor to file another plat with the county. We have also had 3-year, indefinite-quantities contracts that we use if we need a right-of-way survey or other special survey. It was under this contract that the project described in this article was done.

Prework

As with past projects, the Gila does the prework, collecting data and survey notes and searching and locating corners for the contractor. This has allowed us to reduce our contract prices on prior projects. A thorough search was made for information on previous surveys and plats filed in the Grant County courthouse. We searched our Forest Service records for

Figure 2. *Contract personnel prepare to post line*

Figure 3. *Contract personnel posting line*

previous section and quarter-corner searches done in the proposed survey area. Copies of the original surveyor's notes were obtained to aid in the search for controlling corners in the survey area. Primary base series (PBS) maps of the project were assembled from the cartography office. With this information and the cartographic feature files (CFF's), we were able to determine the geographic coordinates. Using Autocadd and the CFF coordinates, State plane coordinates were determined and recorded on the PBS maps. The State plane coordinates provided adequate accuracy for us to locate a search area on the ground for determining the actual location of the initial ground search area.

The corner search was accomplished using ATV's that the Forest has modified so that GPS equipment can be mounted on the vehicle and use the

Figure 4. *Contract personnel checking position of monumented corner*

vehicle's electrical system to power the equipment. The equipment consists of a 12-channel Trimble Pro XL and an Omnistar 6300a real-time receiver. The State plane coordinates calculated in the office for the initiating corner were loaded in the Pro XL to create waypoints by which we could navigate to the section or quarter corner search area.

Armed with this information and the aid of the Trimble Pro XL Pathfinder GPS unit and the Omnistar receiver, we searched for the controlling corners. When the first corner was found, it was occupied with the GPS unit to determine its true State plane coordinates. Using the State plane coordi-

Item	**Units**	**Unit Price**	**Total**
Corner Search	6 ea.	$265.00	$1590.00
Corner Maintenance	12 ea.	132.50	1590.00
Corner Monuments	16 ea.	132.50	2120.00
Control travel	19 mi.	1272.00	24,168.00
Property line post	10 mi.	466.40	4664.00
Property line measure	10 mi.	1166.00	11,660.00
Plat of survey	4 pg.	159.00	636.00
Reports	1	265.00	265.00
Project Total			$46,693.00

nates and the original survey notes, a new position was calculated for the next corner, which was entered as a waypoint in the GPS unit. We then navigated to the next corner. This method was repeated with each found corner, resulting in a more accurate projected location of the corner to be searched. The results were that we were able to locate four of the original stones that were set in 1896 as well as six brass caps that had not been found by conventional search methods. The waypoint method of locating corners always put us within 15 feet of the actual location of the corner and in most instances within 5 feet. Therefore, if the searched-for corner was not found, we were confident that it had been removed or destroyed.

The Gila had an indefinite-quantities contract with E. Schaaf & Associates, Inc., of Delta, Colorado. The contract was awarded October 1, 1994, and expired September 30,1997. The contract was a conventional contract, calling for surveys to be conducted using traditional methods and instruments, such as theodolites, EDM, and the like. We contacted Mr. Schaaf and discussed our idea of performing a survey using GPS equipment to determine his interest and the feasibility of obtaining USGS-required accuracies. Mr. Schaaf was very interested in the concept and agreed to come to the Gila and view the project area and discuss methods that could be used, the time involved, and the cost.

Contract Execution

The project area consists of rolling hills with some moderately deep arroyos and small canyons. Ground cover is heavy to moderate oak brush and small trees with an open canopy. Access is via two low-standard forest

Figure 5. *The Forest Supervisor (Abel Camarena) and engineering Technician Mike McIntosh check corner monumentation*

roads, with the majority of the area being accessible to ATV's. After viewing the project area, we agreed that the entire project could be surveyed using the Cadastral Grade GPS units (Trimble 4000si). Accuracy of these instruments is ±1 centimeter. Estimated time for accomplishment of the project was discussed and agreed to be 10 days. The contract modification was approved and Mr. Schaaf and his crew arrived shortly thereafter to commence work.

On the first day, the crew, along with Gila personnel, proceeded to the field and located an area where the contractor could establish a project control point using the Trimble 4000si GPS equipment. While this was occurring, we reviewed the scope of the project as well as the data we had obtained on the section and quarter corners, where they were located, and how to access them. Using the control point established the first day, the base unit was put into operation with a radio link to provide real-time corrected positions throughout the project.

Based on coordinates furnished by the Forest Service that were obtained from our initial search, the GPS units were used to establish geodetic coordinates for two found corners. With this data, the contractor then occupied the position of the other found corners to establish geodetic accuracy coordinates. This portion of the work was along a township line; therefore, corners that were not found could be reestablished by single proportion. Coordinates were calculated for the missing corners. Using this data, the contractor was able to navigate to the exact position for the missing corner and set the corner.

Figure 6. *One of the project control points*

Using the GPS units and the coordinates of the established corners, the contractor was able to navigate between two of the controlling corners and post the forest boundary. Using the same units for the line, a crew member would pace out approximately 300 to 400 feet and set a boundary post on line. Coordinates were established on the post. Using these coordinates, the location of each boundary post is shown on the final plats.

Section 24 of this township contains 120 acres of private land that was also located and monumented using the GPS equipment. The private land is an HES inholding that was described by aliquot parts, but had never been

Figure 7. *Found original ¼ corner stone*

surveyed. Locating the inholding required subdividing the section and setting eight 1/16 corners and posting the boundary. The costs of the survey and posting were paid for by the landowner. The Gila worked cooperatively with the landowner by providing the monuments, the posts, and the boundary signs.

Cost Comparison

Using the prices established with E. Schaaf & Associates under the present indefinite-quantities contract, the following is a breakdown of what the work would have cost using conventional methods.

With the Contracting Officer's approval, the Forest negotiated with Mr. Schaaf on a cost of accomplishing the same work using GPS methods and basing the cost on a per-day cost. Mr. Schaaf and I reviewed the project on the ground so that he was aware of the work that would be involved. His estimation of time required to accomplish the work was 10 days, at a cost of $1,300 per day. The per-day cost was accepted with the stipulation that the number of days paid for would be actual days used and not the estimated time. The project was actually completed in 8 working days, a 20-percent savings:

Estimated project cost	$1,300 per day for 10 days	=	$13,000
Actual project cost	$13,00 per day for 8 days	=	$10,400

Savings

Method	Time	Contract Cost
Conventional	20 days	$46,693
GPS	8 days	$10,400
Savings	60 percent	77.7 percent

Conclusion

We feel that this project successfully demonstrated that under a moderate to light canopy, GPS equipment is a viable alternative to surveying and boundary posting, as well as a cost-efficient alternative in these days of reduced budgets. The project realized 60-percent savings in time required by the contractor to accomplish the work and 77.7-percent savings in the cost of completing the project.

The project was accomplished to State of New Mexico and Federal statutes and contract specifications.

GIS Data Collection Project

Frank Sutton
Project Leader
San Dimas Technology Development Center

Introduction

Recent advances in rugged field computers and powerful pen-based mapping software have prompted a reevaluation of the current methods used by the Forest Service to capture geographic information system (GIS) data. The San Dimas Technology and Development Center (SDTDC), under the GIS data collection project, was assigned the task of exploring alternative feature positioning and data management platforms that will increase the speed, quality, and efficiency of field data collection.

GIS Data Collection Project Description

The Forest Service is actively using GIS data to evaluate complex land-management alternatives. Collection of accurate and reliable field data for use in GIS has traditionally been a cumbersome and expensive task, often involving separate site visits and requiring repetitive steps to accumulate all needed data.

The GIS data collection project will catalog a range of existing hardware and software products used to collect field data on such linear features as roads, trails, streams, logging profiles, and power lines. The project has been funded by both the Engineering and Recreation Technology and Development programs for FY 1998, and the Watershed/Riparian/Soil/Air steering committee has also agreed to provide project funding for FY 1999. The project involves cooperation from both Technology and Development Centers (San Dimas and Missoula), the Geometronics Service Center, and the Remote Sensing Applications Center. A committee of experts composed of Forest Service employees will be assembled to guide the project to its completion.

This article will describe the GIS data collection project and introduce pen-based mapping and data collection systems as a means of rapidly obtaining GIS data for a multitude of Forest Service applications.

Project Questionnaire

A questionnaire addressed to Forest GIS Coordinators was mailed via Data General in the early part of December 1997. Coordinators were asked to provide information on current collection methods used, the volume of data collection work performed, and field unit data collection needs. A total of 20 responses were received by early February 1998, but the Center is requesting more participants in the survey to further evaluate field needs and concerns regarding GIS data collection. To ease processing and allow Forest Service employees to view responses, the questionnaire was placed on the Forest Service intranet (FS Web) at the following URL:

http://fsweb.sdtdc.wo.fs.fed.us/programs/eng/gis/gis_questionnaire.html

Questionnaires may be viewed and submitted using a Web browser pointed to the above URL. Units without FS Web access who wish to participate may request a questionnaire to be sent by DG or IBM mail by contacting Frank Sutton on DG (F.SUTTON:W07A) or IBM openmail (fsutton/wo,sdtdc). Your help is appreciated.

Existing Field Data Collection Problems

The main cause of errors in the field is the inability to immediately observe end results of data collection. Real-time mapping provides instant feedback, so data can be seen as they are collected. Reduction of any raw measurements occurs immediately, and what is displayed on the field computer's screen is the map as it is being built. Traditionally, visualization of data occurs after postprocessing the data on the office computer. Up to this point, the surveyor may not be aware of errors or omissions in the data. Errors that may occur with the conventional postprocessing approach are:

1. Missing features that are not detected while the surveyor is in the field.

2. Not enough data are gathered; site is only partially surveyed.

3. Inconsistency between electronically stored data at the office and what is recorded in the field.

Validation of data is an important aspect of any survey. Errors may result from surveyors forgetting either partially or completely to survey certain features. These features are difficult to catch if there is nothing to compare to. Part of the motivation of a real-time approach to collecting GIS data is that these errors will become obvious and can be corrected while surveyors are still in the field.

Components of a Real-Time Mapping System

A system containing the following components is suggested. Each of these components will be discussed below.

- GPS receiver.

- Pen-based computer.

- Core mapping and data management software.

- Laser rangefinders and other input devices.

GPS Receivers

Inexpensive and compact P(Y)-coded GPS receivers are now available for use by the Forest Service. These units will remove the effects of selective availability and anti-spoofing imposed by the Department of Defense. The latest receivers have been shown to be effective under forest canopy conditions, and now may produce real-time accuracies adequate for the majority of Forest Service resource mapping needs.

Pen Computers

Computer hardware has gone through remarkable changes in recent years. Smaller size, increased processor power, increased storage capacity, and decreased cost are some of the technological changes that have taken place. The trends are expected to continue, with more manufacturers producing low-cost computers capable of withstanding the harsh environments typical of the Forest Service.

New models of pen-based computers are appearing that offer features that make mobile computing in harsh field conditions possible. Field ruggedness, compactness, low power consumption, and user-friendliness have become the focus of many of the manufacturers.

A pen computer consists of a flat display with an incorporated digitizer that records the traces of a pen (stylus) in contact with the display surface. The pen is the input device that replaces the traditional mouse and keyboard found on desktop computer systems.

The majority of the pen computers on the market use a monochrome liquid crystal display (LCD) and an Intel 80386DX-compatible processor. Processors manufactured by Advanced Micro Devices have become a popular choice by makers of pen computers because of low heat output and decreased power requirements. Several of the latest models offer Intel Pentium central processing units. Batteries are generally nickel metal hydride or lithium ion. They typically last a maximum of 4 hours, so it is essential that a sufficient number of batteries are taken along for field work.

Sufficient computing power is essential when selecting a pen computer. Tasks such as handwriting and voice recognition are CPU-intensive and require immediate feedback to the user. Having adequate RAM (random access memory) will speed graphics-oriented applications.

SDTDC will be evaluating several brands of pen-based computers that are currently on the market. Factors such as durability under harsh field conditions, speed, ease of use, and price will be examined under the project.

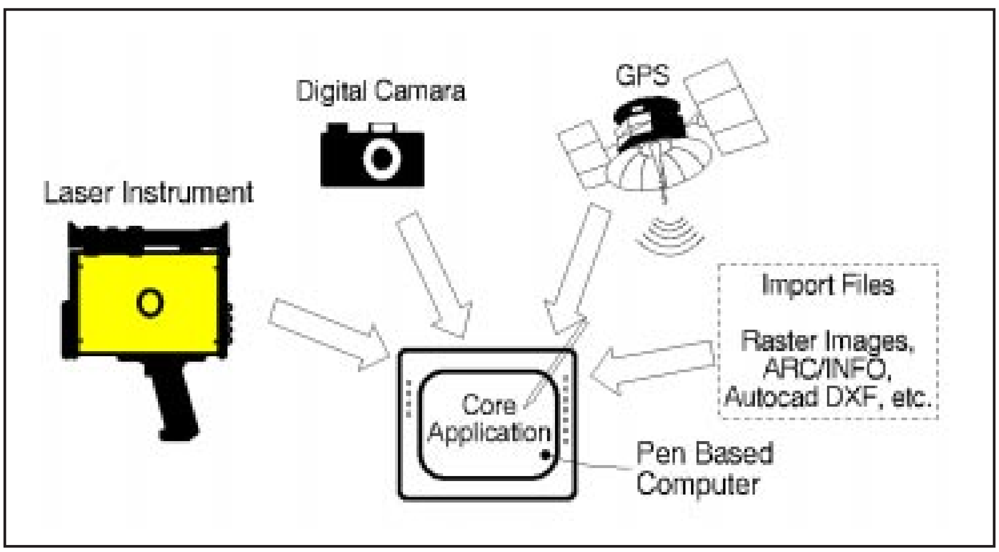

Figure 1. *Various input devices of a field data collection/mapping system*

Mapping Software

Mapping and data management software is available from several vendors. Several packages use Arcview as the graphics engine, with a modified user interface and custom interfaces to various hardware input devices. Some of the features contained in off-the-shelf software packages are outlined below.

1. *A graphical user interface (GUI).* Most pen-based applications run under a multitasking environment such as the Microsoft Windows operating system (OS), allowing the software to run on both field and office computers. Adding capabilities to the mapping application would be simplified under the Windows OS by its interapplication communications capabilities, allowing other applications and drivers to send data to the core mapping application. A large software base of existing applications exists for Windows, extending the usefulness of the field computer. Examples of such software that can be applied to field computing are handwriting and voice-recognition engines. Another advantage of a GUI is user-friendliness, minimizing the amount of training required for a user to become proficient with the application. Instant online help is available, eliminating the need to carry software manuals to the field.

2. *Visual map display.* A display of the map and data being constructed in real time is what sets modern mapping and data collection software apart from traditional GPS receivers attached to data recorders.

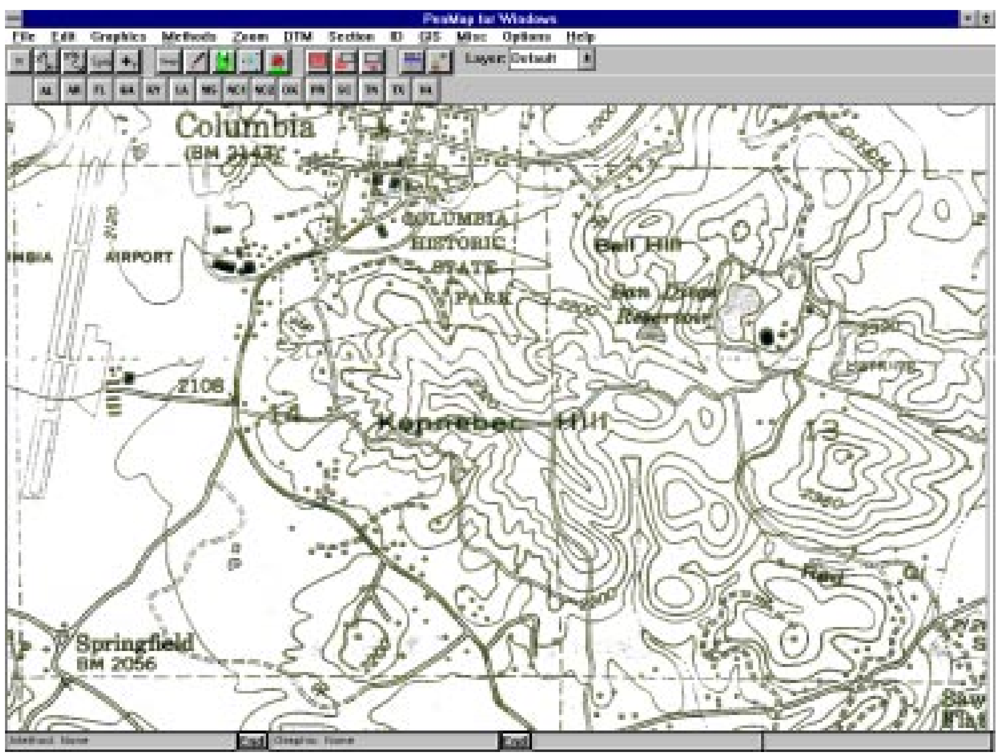

Figure 2. *A raster image derived from a USGS 7.5′ quadrangle is displayed in the PenMap application using Rasterback, a feature of PenMap for Windows. (Image provided by Condor Earth Technologies, Inc.)*

Rapid CAD-like panning and zooming capabilities ease the visualization of the data and speed the collection process. All raw data and measurements are reduced before the surveyed features are plotted onto the display, making it unnecessary to post process any data at the office.

3. *GIS Capabilities*. To provide a useful data capture system that will interface well with the Forest Service GIS, modern mapping and data collection software has the ability to record multiple feature attributes that are tied to the special data. The ability to transfer selected ARC/INFO coverages from the Forest Service IBM system to the field computer, useful for field data validation, will be evaluated.

4. *Database form customization*. The ability to design custom database forms that match differing Forest Service data requirements increases the versatility of the data collection system, making it useful for multiple resource areas. GUI features such as pull-down lists and voice activated text boxes contained in the database forms speed attribute collection.

5. *Interfaces to multiple input devices*. With the large array of survey instrumentation such as GPS receivers, laser rangefinders, total stations, and alternative input devices such as digital cameras and barcode readers, flexible systems that interface with these devices are available.

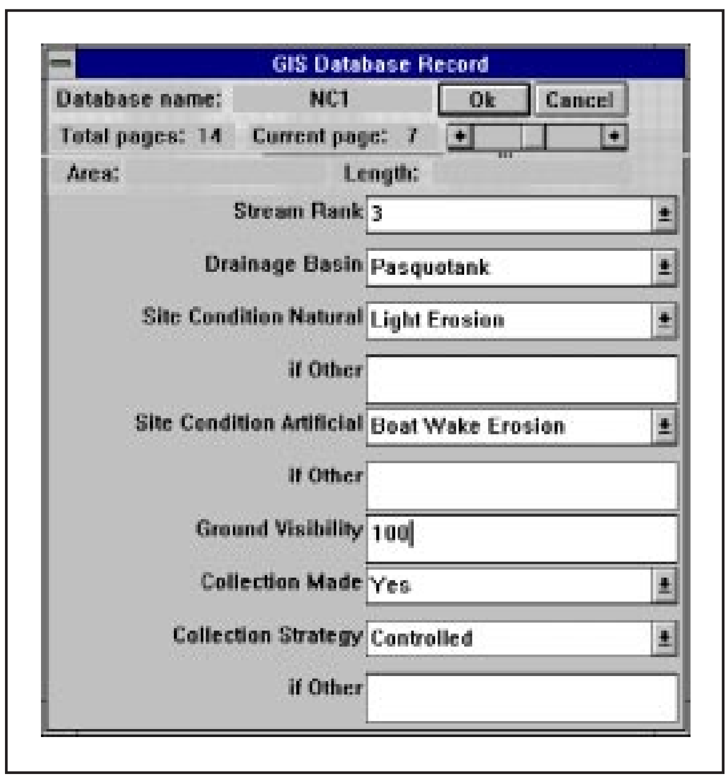

Figure 3. *Database form in PenMap constructed for stream inventories*

As the market continues to change, with more vendors offering improved mapping and data collection systems, it will be a goal of the GIS data collection project to update the range of data collection systems to ensure that Forest Service field units are aware of the most applicable, cost-effective, and timesaving solutions.

PenMap, an Example of a Real-Time Mapping Application

SDTDC has evaluated PenMap, an off-the-shelf product sold by Condor Earth Technologies of Sonora, California, that operates on IBM-compatible computers running Microsoft Windows 3.lx or Windows 95. Other mapping and data collection software will be evaluated during the course of the GIS data collection project. PenMap can be thought of as an electronic plane table, capable of recording survey measurements using a variety of input devices and survey methods. PenMap allows viewing and editing of data in real time, eliminating the need for post processing.

PenMap is most useful running on a powerful pen-based computer with a 486 processor or higher. Because of PenMap's features and versatility, it has shown to be useful not only to resource managers interested in capturing information for the GIS, but also to engineers, technicians, and surveyors as a powerful tool for many field surveying and computational tasks. Some of PenMap's more useful features are outlined below:

1. *Multiple input methods.* The PenMap application collects special information from an array of survey instruments (see appendix) or by hand input. Survey methods such as traversing, chain and offset, resectioning, and distance/bearing are provided with the software. Adjustment is possible with the traverse method. With the resection method, up to six reference points may be used in calculating the instrument's location. Computation can be determined from angle and distance, angle only, or distance only; the latter being useful for accurate positioning using laser range finders.

2. *Display of collected data over raster or vector maps or images.* Data can be displayed over digital ortho quads or other images using Rasterback, a utility for importing raster images into PenMap as a backdrop to a survey.

3. *User Customization.* A form generator is provided with PenMap to allow custom database forms to be constructed. Forms can be made to match a wide variety of data collection applications. The database forms first record attributes and then links them to a feature on the ground. The form can be called and edited any time during the survey. Database forms also accept input from devices such as digital cameras and barcode readers. Users can also create custom buttons that act as a shortcut to selecting a layer, survey method, graphic, or database form corresponding to the feature being mapped.

4. *On-site dynamic terrain modeling (DTM).* PenMap includes powerful 3–D terrain modeling features previously found only on high-end office CAD systems, but with the added advantage of instant data visualization and onsite error checking. The software allows the dynamic generation of contours as 3–D points are gathered. Break

lines or barrier lines can either be constructed dynamically or by connecting existing points with a line. These DTM features can be useful to engineers or surveyors wishing to accurately construct surface models and compute volumes onsite. Up to five surfaces can be generated and their corresponding volumes computed relative to a datum surface. A sectioning feature computes the line resulting from the intersection of a vertical plane with an existing surface. The profile of the line is then displayed.

5. *Multiple file import and export formats.* Arc/Info, Autocad DXF, Genio, and other formats are supported.

PenMap software with standard instrument interface is available to the Forest Service for $995. PenMap with a GPS interface costs $1,895. The license agreement allows one installation of PenMap on a field computer and one installation on an office computer. More information can be obtained from Condor Earth Technologies, Inc., 21663 Brian Lane, Sonora, CA 95370. Phone: (209) 532-0361. Internet: http://www.condorearth.com.

Other Software Packages

After a market search, several other mapping and data collection products have been found, but these have not yet been evaluated. As these products are tested, and as new ones appear, results will be posted on the SDTDC intranet site at http://fsweb.sdtdc.wo.fs.fedts.us/programs/eng/gis/gis.html. The appendix at the end of this article lists several products by name, company, phone number, and internet URL.

Laser Rangefinders

Obtaining positional data with a reasonable level of accuracy using GPS devices has traditionally taken too long or has been hindered by the dense canopy or deep canyons that are common in many forest environments. Although there have been dramatic improvements in GPS under these conditions, laser rangefinders, sometimes called laser instruments or laser guns, offer an alternative by rapidly obtaining measurements of features without physically occupying them.

Laser rangefinders are useful for mapping numerous points such as signs, utility poles, trees, and topography. Features are mapped in a matter of seconds by simply aiming and triggering the instrument from a known point. Raw measurements from the instrument's sensors, including distance, tilt (inclination), and azimuth (the angle referenced from magnetic north), may be reduced to 3–D coordinates by a computer connected to the instrument via an RS232 interface. Higher priced models may include sensors that measure tilt, plus an electronic compass for measuring azimuth. This gives laser instruments qualities similar to total stations and gives them the ability to provide the 3–D coordinates of a feature based on a known point.

Appendix
Vendor Listings

Real-Time Mapping and Data Collection Software

PenMap: Condor Earth Technologies (209) 532-0361;
http://www.condorearth.com

Field Notes: Penmetrics Inc. (541) 752-9000; http://www.penmetrics.com

GeoLink: GeoResearch, Inc. (800) 436-5465; http://www.georesearch.com

Aspen: Trimble Navigation Ltd. http://www.trimble.com

VoCarta: Datria Systems Inc. (800) 583-9509; http://www.datria.com

Pen-Based Computer Manufacturers

Alps Electric (408) 432-6522; http://www.alps.com/k2500

Texas Micro (800) 627-8700; http://www.texmicro.com

Fujitsu (800) 831-3183; http://www.fpsi.fujitsu.com

Itronix (800) 441-1309; http://www.itronix.com

Telepad (703) 834-9000; http://www.telepad.com

Teklogix (800) 633-3040; http://www.teklogix.com

Norand Corp. (800) 553-5971; http://www.norand.com/terminals.html

Husky Computers (813) 530-4141; http://www.wpihusky.com

Laser Range Finder Manufacturers

Criterion Laser Technology Inc. (303) 649-1000; http://www.lasertech.com

Advantage Laser Atlanta, Inc. (770) 446-3866; http://www.laseratlanta.com

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