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The Series

THE ENGINEERING FIELD NOTES SERIES is published periodically as a means of exchanging engineering-related ideas and information on activities, problems encountered and solutions developed, or other data that may be of value to Engineers Service-wide.

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Field personnel should send material through their Regional Information Coordinator for review by the Regional Office to ensure inclusion of information that is accurate, timely, and of interest Service-wide.

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1988 *Engineering Field Notes* Article Awards

Happy New Year! Hope you had a fine '88. *Engineering Field Notes* did!

In fact, we had a great year—publishing Engineering folks' experiences in such diverse fields (among many others) as:

- Lowered Pressure Off-Highway Tires
- Global Positioning System
- Turnkey Contracting
- Low-Cost Trail Bridges
- Reducing Forest Service Roads Program Costs
- Remote Campground Water Systems
- GIS
- Satellite Imagery for Forest Inventory

Engineering Field Notes is pleased to have provided a means for Forest Service Engineers at all levels and in all Regions to share their experiences. We feel that this sharing is vital to doing more with less, and we applaud each of our authors.

It is now time for you to tell us which 1988 articles you feel were most informative, beneficial, and interesting; which articles helped your office save money; which articles helped you develop more effective ways of getting your work accomplished.

Once you have chosen 1988's top three (3) articles, please complete the rating sheet on the following page. Rate only three articles. Rate them from 1 (best) to 2 (second best) to 3 (third best). And if you feel that an article has helped or will help the Forest save money or other resources, please let us know. Remember, with *Engineering Field Notes* it is one person/one vote—so your vote counts!

After you have voted, cut out the rating sheet along the dotted line, fold and staple it closed, and mail it back to us at EFN. (For your vote to count, we must receive your rating sheet by January 31, 1989.)

Contests aside, my sincere thanks go to each and every EFN author, as well as to all EFN readers, who made 1988 a great year. Each one of you deserves a pat on the back for helping to foster an environment where information and experiences are viewed as valuable resources and are shared accordingly.

Hey, wait a minute—why not make it your number one New Year's resolution to share your experiences through Engineering Field Notes *in 1989!*

—Dennis Carroll (D.CARROLL:W01A)
Editor, EFN

1988 Engineering Field Notes Awards

Article	Author	Choice (1, 2, 3)	$ Saved
January/February			
Fourth International Conference on Low Volume Roads	Jerry Bowser		
Road Program Costs: The Road Maintenance Management Information System	David Badger		
Modified Aggregate Surfaces & Bituminous Surface Comparisons in Region 8	Douglas E. Scholen		
Green Book Survey/Design Program for the HP-71B Computer	Richard A. Rasmussen		
Safety in the Office	NFAP		
March/April			
Roads Program Costs: Continuing Efforts Addressing the Issue	Michael D. Harper		
Timber Bridge Technology	Clyde G. Weller		
Forest Service Implementation of Federal Guidelines for Dam Safety--1987 Progress Report	Skip Coghlan		
Space Shuttle Handheld Photography: A Unique Archive of Imagery	Jerry D. Greer		
Facilities Training System--Sharing Our Facilities Training Resources	George J. Lippert and William E. Brownfield		
May/June			
Road Program Costs: Continuing Efforts Addressing the Issue	Dale R. Petersen		
ROads Analysis & Display System (ROADS)--Its Best Use	Michael D. Harper		
Lodes, Millsites, & Yellow Jackets--The Salmon Experience	Donald V. Gray		
Space Shuttle Large Format Camera Photography in Resource Management	Jerry D. Greer		
National Strategy for a Geographic Information System	Steve Brink		
Evaluation of the Trimble Advanced Navigation Sensor	Anthony E. Jasumback		
Forest Inventory & Assessment With Satellite Imagery in the Western States	Henry M. Lachowski and Harry L. Bowlin		
July/August			
Road Program Costs: Continuing Efforts Addressing the Issue	Billy J. Reed		
Guidelines for Basic Data Input to a Geographic Information System	Carolyn K. Holland		
Reverse Photogrammetry: A Better Method of Locating Lines in the Field	Wayne Valentine		
Radon Gas--An Invisible Safety Hazard	NFAP		
Evaluation of Turnkey Contracting	Hal Peterson		
Field Design, Data Collection, & Plotting With the HP-41cx	Mike Dixon		
Low-Volume, Low-Cost Trail Bridges	Rick Ellison		
A Preventive Maintenance System at the North Central Forest Experiment Station	John A. Jakel and Gail M. Helwig		
September/October			
Road Program Costs--Continuing Efforts Addressing the Issue	James Heck		
Generator-Powered Water System for a Remote Campground	Rochelle L. Liggins		
Rottne Logging Equipment on the Black Hills National Forest	Gregory M. Bohls		
Remote Water-Level Monitor	Mary Denise Little		
New Reinforced Soil Walls & Fills	Michael Burke		
Electronic Notebook Program for the HP-71B Computer	Richard A. Rasmussen		
Lowered-Pressure Off-Highway Tires for Road Construction	Bruce Brunette and Neil Newlun		
Four Years of Using GPS	Vic Hedman		
November/December			
Road Program Costs: Continuing Efforts Addressing the Issue	Michael D. Harper		
Warning: GPS & NAD 83 Are Coming	Wayne W. Valentine		
Organizing Engineering Information	Loyd Dille		
Career Development--The Key is Personal Planning	Chris Schwarzhoff and John Lupis		
Factors Affecting Aggregate Surfacing Raveling	Stephen L. Monlux		
Road Construction Special Project Specifications--Remote Access Available for Regions 1, 4, 6, & 8	John Holt and Fong Ou		
Technical Evaluation of Dimension-II Civil Engineering Software	Washington Office Systems Operations, Analysis, & Development Group		

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Road Program Costs: Continuing Efforts Addressing the Issue

Tamera M. Rizek
Budget Analyst
Washington Office

National Workshop

As part of our Service-wide efforts to control the costs of the Forest Road Program as well as other Engineering programs, the National Engineering Program Development and Budget Workshop was held October 4–7 in Reno, Nevada. This was the first national meeting since 1984 that was sponsored by the Washington Office (WO) Engineering Program and Budget Branch. The theme of the workshop, "Roads to the Future," tells of the approach used to promote understanding of and identify ways to improve program development and budgeting processes. The workshop objectives were to:

(1) Present and discuss the budget process from development and presentation through allocation and execution.

(2) Review, explain, and discuss the fiscal year 1991 Program Budget Instructions.

(3) Review the improvements in the ROad Analysis and Display System (ROADS) and promote the use and understanding of the system.

(4) Review the status of the 1990 Resource Planning Act (RPA).

Among the attendees were representatives from the WO Engineering Program and Budget Branch, Regional Budget Coordinators, Forest Engineers, Milford Jones (Deputy Director for WO Engineering), and Jim Wolfe (Region 10 Director of Engineering and Aviation Management). Guest speakers were invited to provide insights into and understanding of special issues and concerns facing Engineering. Among the speakers were Judy Levin (WO Recreation), Gerry Farmer (WO Program Development and Budget), John Wells (WO Timber), and Chuck Davis (Region 4 Fiscal and Accounting).

The Future

After opening remarks, Milford Jones presented the national perspective on key issues facing Engineering in the near future. These issues range from meeting 1995 work force goals and supporting the Recreation initiative to the continued forest road controversy and our charge-as-worked accounting.

We spent much of the first day taking a long look at our future; we discussed the long-term Forest Service roles that the 1990 RPA will define, viewed the videotape "National Forest Roads Controversy," discussed the need for closer coordination between Recreation and Engineering as programs and budgets are developed, and participated in a detailed review and discussion on the fiscal year 1991 Program Budget Instructions. We also took a look at the future of information management, with particular interest in the integration of ROADS Project Listing and Forest Road Investment data bases with other data bases and accounting systems, such as STARS, TSPIRS, and TMIS.

ROADS Improvements

Three major improvements to ROADS were presented to the group.

The first major improvement relates to how outyear program information, which is required for budget development, will be reported. For the fiscal year 1991 program, new codes have been added to the National Forest System template that incorporate the ROADS data into the Program Development and Budget (PD&B) data base. Field submissions now will be collected with other planning data that are sent to PD&B. This change will simplify data submission for every Region.

The second major improvement affects all Forest Service employees who record expenditures of Forest Road Program funds. We identified the minimum activities that must be tracked to provide managers with the means to analyze and monitor economic efficiency and to control costs associated with the Forest Road Program. In all, 32 work activity codes that were previously required by ROADS have been eliminated—a 47-percent reduction. The remaining work activities are those expenditures that will be "charge as worked" for fiscal year 1989 and future years.

The third major improvement relates to how current-year program information is to be analyzed and reported. The ROADS detailed spreadsheet will be discontinued after reporting the final accomplishments and expenditures for fiscal year 1988. With the submissions of the fiscal year 1989 appropriated budget and fiscal year 1990 President's budget information, the ROADS data previously analyzed by the detailed spreadsheet will be analyzed and reported using a Forms Entry System data base—the Forest Road Investment Data Base. This change will end the need for many Forests to work during off-hours, as was required using the spreadsheet.

New Software

The details of the Forest Road Investment Data Base and actual workings of the software were presented to the group. In a workshop format, representatives from each Region had the opportunity to get hands-on experience as they used the program to enter, edit, analyze, and upword report data. All were pleased with the ease and efficiency of the new software.

A better understanding of the program development and budgeting process along with the areas for improvement identified at the workshop will, in turn, improve the efficiency and effectiveness of our Engineering program management efforts at the Washington Office, at Regional Offices, and on each National Forest.

Evaluation of the NAVCORE-1 Global Positioning System

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Introduction

The Rockwell-Collins NAVCORE-1 Global Positioning System (GPS) receiver was evaluated at the Lubrecht GPS Test and Evaluation Facility near Missoula, Montana, in October 1987. The goal was to gain experience with GPS receiver equipment and to determine the operating characteristics of the NAVCORE-1 receiver both in the open and under a tree canopy.

The NAVCORE-1 is a single-channel, course/acquisition (C/A) code receiver that uses signals from the navigation timing and ranging (NAVSTAR) GPS satellites to determine its three-dimensional position anywhere in the world in the World Geodetic System-84 (WGS-84) coordinate system of latitude, longitude, and elevation. The unit consists of a receiver-processor, double helix antenna with preamplifier, control display unit (CDU), and connecting cables; it weighs about 10.3 pounds (figure 1). The power supply (not shown) consisted of a 12-volt battery pack that weighed 10 pounds and operated the unit for about 3 hours. Rockwell-Collins mounted this equipment on an aluminum backpack frame (figure 2) that weighed 8.7 pounds. The total package weight for this evaluation was about 30 pounds and could easily be carried by one person. The double helix antenna with preamplifier was mounted on a tripod for easy setup over a station and was set to maintain the antenna about 3 feet above the station or ground.

Test Courses

The receiver was evaluated on test courses A and B, special station A41, first-order station Lubrecht, and a section of Garnet Range Road (figure 3). All courses have been tied by ground survey (EDM) to WGS-84 first-order control point so that the latitude, longitude, and elevation of each point are known.

Course A is a seven-point closed traverse containing 4.74 acres located on gentle rolling terrain in a clearcut with no obstruction to the horizon above 15 degrees. This unobstructed view of the satellite was designed to provide optimum position accuracy. Positions determined on this course can be used as a base for comparing data from other courses.

Special station A41 is located adjacent to course A in a dense grove of 10- to 15-foot tall Hawthorn (hardwood) brush. The leaves were expected to attenuate the signal considerably.

Figure 1.—Rockwell-Collins NAVCORE-1 global positioning system.

Course B is a seven-point closed traverse containing 4.38 acres of gentle rolling terrain in a thinned area of young lodgepole pine (8 to 10 inches dbh, 40 to 50 foot height). The lodgepole has been thinned to spacing levels of 10 by 10, 14 by 14, 20 by 20, and control. Stations are located in each of these tree spacing levels. Any potential problems with canopy and signal attenuation would show up on this course.

First-order station Lubrecht (not shown in figure 3) is located in an opening (15-degree horizon) near the Lubrecht Experimental Forest headquarters building. It was established from a GPS first-order survey and can be used as a base station.

Six miles of Garnet Range Road (from its intersection with Highway 200) have been digitized by photogrammetric means with ties to control stations at various locations. This route could be used to check the operation of a receiver in its mobile mode (for example, when it is mounted on a vehicle).

Test Procedures

The test facility at Lubrecht has been established to evaluate position-locating equipment. It has several open and closed traverses, both in the open and under a variety of canopy conditions, and has specific points all tied to first-order ground control. This control is in the WGS-84 latitude, longitude, and elevation.

Figure 2.—The unit was easily transported by one person.

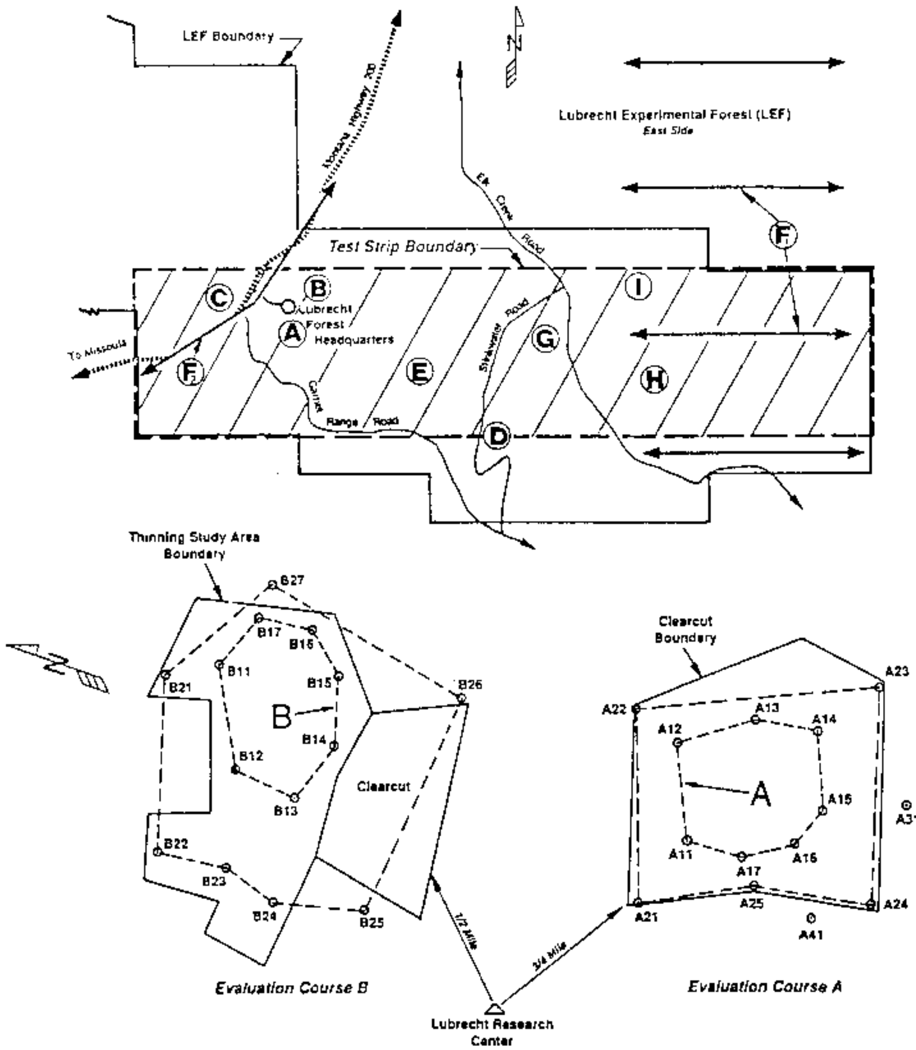

Figure 3.—Schematic of evaluation courses A and B.

Courses A & B

A run on courses A and B consisted of placing the instrument at a station, recording the data, and proceeding to the next station until the traverse or course was completed. On some runs, only a partial traverse was completed. In two cases, only one point constituted a run (figure 4).

At each station, the tripod-mounted antenna was placed over the point, and after a short pause, usually less than a minute to allow the ratings to stabilize, the instrument's indicated position (latitude, longitude, and elevation) was read and recorded. These positions were recorded as single or multiple readings. On single readings, the instrument's position was read and recorded only once for each station. Multiple readings consisted of ten readings taken as fast as the operator and recorder could read and write.

In addition to position, the time, GDOP (geometric dilution of precision), and SV number (satellites being used) were recorded for each station. The receiver's satellite selection mode (AU—Automatic or MA—Manual) and operational mode (SU—Survey or L—low dynamic) for each run were recorded as well. Generally, when moving between stations, the receiver was switched to the L mode. When the antenna was placed over the station, it was switched to the SU mode before recording data.

Lubrecht Station

The tripod-mounted antenna was placed over the point, and eight readings of latitude, longitude, and elevation were read and recorded as fast as the recorder could read and write. These eight segment readings were recorded about every 2 minutes for approximately 1 hour. Before recording each segment, the time, GDOP, and SV number also were read and recorded. The receiver was in the AU mode of satellite selection and SU mode of operation.

Course E (Garnet Range Road)

This test consisted of driving the road with the antenna (without tripod) mounted on the roof of the vehicle and the receiver in the AU mode of satellite selection and L mode of operation. The course started near the junction of the road and Highway 200 and continued along the road for approximately 2 miles. At each change in the direction of the road, the vehicle was stopped, and the time, GDOP, SV number, latitude, longitude, and elevation were immediately recorded.

Run #	Stations (in open) AU	MA	S	MU	SV#	GDOP	A11 Dist. (ft)	A11 Elev. (ft)	A12 Dist. (ft)	A12 Elev. (ft)	A13 Dist. (ft)	A13 Elev. (ft)	A14 Dist. (ft)	A14 Elev. (ft)	A15 Dist. (ft)	A15 Elev. (ft)	A16 Dist. (ft)	A16 Elev. (ft)	A17 Dist. (ft)	A17 Elev. (ft)	A11 Dist. (ft)	A11 Elev. (ft)
1	–	√	√	–	6,9,12,13	4.8-5.0	39	-49	19	-7	32	-33	28	-26	41	-7	26	-10	23	+3	35	-3
2	–	√	√	–	6,9,12,13	5.0-6.7	26	+3	19	-13	22	-7	39	+7	31	-23	47	+3	23	-3	35	-36
3	–	√	√	–	3,9,11,13	3.7	29	-23	13	+39	16	+33	12	+30	18	+39	10	+52	22	+69	5	+62
4	–	√	√	–	3,9,11,13	3.8-4.0	5	+59	21	+56	22	+43	8	+62	19	+33	20	+33	16	+46	5	+16
5*	√	–	√	–	8,11,12,13	4.3-4.7	23	+7	34	+13	37	+16	53	+30	38	+26	37	+16	44	+20	34	+33
6*	√	–	√	–	8,11,12,13	4.2-4.3	55	+49	45	+72	43	+62	53	+85	46	+66	44	+66	41	+79	16	+66
7	–	√	√	–	6,9,12,13	4.9-5.7	23	+75	23	+89	11	+79	4	+36	8	+46	18	+43	17	+59	–	–
8	–	√	√	–	3,9,11,13	3.7-3.9	16	+26	17	+66	20	+49	22	+30	12	+20	20	+33	7	+26	9	+56
9	–	√	–	√	6,9,12,13	4.8-4.9	36	-41	16	-10	17	+9	10	+26	2	+21	17	+6	15	+10	11	+27
	Station (under canopy)						A41															
10	√	–	–	√	3,9,11,13	3.8-3.9	116	+182														
11	√	–	–	√	3,9,11,13	3.9	112	+148														
	Stations (under canopy)						B11		B12		B13		B14		B15		B16		B17		B11	
12	√	–	–	√	6,9,12,13	4.8-5.1	91	+52	59	+43	58	+23	34	+13	110	-49	11	+125	60	+167	51	+72
13	–	√	√	–	3,9,11,13	3.7	77	+115	29	+59	78	+46	99	+79	–	–	–	–	–	–	–	–
	Stations (under canopy)						B21		B22		B23		B24		B25		B26		B27		B21	
14	√	–	–	√	6,9,11,13 3,9,11,13	3.8-5.1 3.7-3.8	36	+95	37	+82	27	+79	98	+272	78	+207	58	+138	74	+148	82	+138

*–Do not use data for other comparisons, SV No. 8 has a bad on-board clock.
Dist–Horizontal position error (difference between receiver indicated position and actual known position in feet).
Elev–Elevation error (difference between receiver indicated elevation and actual known elevation in feet).
AU–Receiver operating in Automatic Satellite Selection Mode.
MA-Receiver operating with satellites manually selected.
S–Single reading of lat/long and elevation taken at each station.
MU–Multiple readings of lat/long and elevation taken at each station.
SV#–Satellites being tracked by receiver.
GDOP–Geometric dilution of precision (indication of the fitness of the satellite geometry to determine the users' position with a reasonable accuracy – the smaller the GDOP the better).

+Instrument indicated elevation above known elevation.
-Instrument indicated elevation below known elevation.

Figure 4.—Data collected on A and B.

Discussion

The evaluation produced information on the effects of tree canopy on the receiver operation and the receiver's capability for locating roads and mapping. The evaluation also determined some operating characteristics of GPS and the Rockwell-Collins NAVCORE-1 receiver.

Operating Characteristics

The equipment was very easy to operate and user friendly. The CDU, which is the input-output device for the receiver (figure 1), was easy to read and functional. It provided the output data from the receiver-processor (for example, position on input commands from the operator).

The CDU has a menu that tells the operator which key to depress for the various functions available. The following are some of the functions most used during this evaluation:

(1) *Position*, which displays the present latitude, longitude, and elevation of the antenna in WGS-84 coordinates.

(2) *Bad Satellites*, which displays any satellite that has been coded unhealthy or bad navigation by the GPS control segment.

(3) *Deselect Satellite*, which allows the operator to prohibit the receiver from using a satellite regardless of its health. It selects the satellites the unit will use. Normally, the receiver automatically selects the best satellite to use and automatically rejects any that have been coded unhealthy while in the AU mode.

(4) *Low Dynamic* (L) mode of operation, which provides improved accuracy when the movement of the unit is limited to less than 300 feet per second.

(5) *Survey* (SU) mode of operation, which provides improved accuracy when the unit is stationary.

(6) *Status*, which provides information on the identity of the satellites being tracked and whether the unit is tracking the signal or reacquiring the signal or data collection.

(7) *User Error*, which displays the satellites being tracked and the GDOP, which indicates how good the position will be. The smaller the GDOP, the better.

(8) *Mode*, which indicates the current mode of operation, such as SU, L, or normal tracking.

Effects of Tree Canopy

In comparing the horizontal position errors (Dist.) in figure 4 for Runs 1–4, 7–9, (open area) to those for Runs 10–14 (under tree canopy), it seems that the position errors are generally greater for Runs 10–14. By adding up all the position errors for each station on Runs 1–4 and 7–9 (1,077) and dividing by the number of readings (55), an average position error of 20 feet was obtained for the station in the open. If the same were done for Runs 10–14, (1,472 ÷ 22 = 67 feet), an average position error of 67 feet would be obtained for those stations under a canopy. This indicates that tree canopy does affect the operation of the receiver and position accuracy. Positions determined under a tree canopy, on the average, are three times less accurate than those determined in the open. The same is true of elevation error. For operation in the open, the maximum elevation error was 89 feet (Run 7), with several readings in the 69- to 79-foot range. Under the canopy, the maximum elevation error was 272 feet (Run 14), with several readings in the 167- to 207-foot range. These results are based on limited data, and some of them contain anomalies, such as those in Run 14—the larger position error from station B24 through B27 as compared to station B21 through B23.

Before taking the readings at station B24, the power supply for the receiver was replaced and the satellite set changed from SV number 6, 9, 11, and 13 to 3, 9, 11, and 13. With the change in satellite, the GDOP changed from about 5.0 to 3.8, which should have improved the accuracy. (The smaller the GDOP, the better the performance of the receiver). However, the position errors were greater.

When operating under the canopy, sometimes the receiver would lose track of a satellite when moving between stations and did not reacquire track unit stationary at the next point. Possibly, when setting up on a station, after placing the receiver in the SU mode, a longer time interval should have been observed before taking the readings. However, in all cases, the readings seemed to have settled down. Perhaps the canopy had attenuated the signal enough to cause the receiver to momentarily lose track. Monitoring the receiver status to detect any loss of track during the interval may be necessary.

Data from both under the canopy and in the open, obtained under more identical conditions of time, GDOP, and SV sets, are necessary to verify these results. Also, further evaluation is necessary to develop procedures for operating under the canopy. If the antenna can receive the signal and the receiver can track it continuously for several minutes, the error under the canopy should be the same as in the open.

Bad Satellites

The effects of using a bad satellite on position can be shown by comparing the position errors obtained on Runs 5 and 6 to those from 1–4 and 7–9 for each station. In every instance, except at station "A11" (Run 1), the position errors obtained on Runs 5 and 6 were greater than on the others. This was because satellite set 8, 11, 12, and 13 was being used and satellite 8 has a bad onboard clock, which caused large position errors. *Data from Runs 5 and 6 should not be used for other comparisons.*

The GPS control segment operational command determines the status of all systems on the satellites. If one is not operating correctly, the satellite is coded unhealthy. The receiver detects this unhealthy code, automatically rejects the satellites, and selects the next best satellite. However, because the land-surveying community (using different measuring techniques) can use satellite 8 even though the clock is bad, the satellite is set healthy, and the receiver operator must deselect it for best results. The NAVCORE-1 receiver is intended for general resource management use and not as a surveying instrument. Surveying instruments are usually larger, heavier, and not as portable.

Multiple Versus Single Readings

The instrument will read position (latitude and longitude) to the nearest one hundredth of a second. These readings are continually changing by several hundredths of a second, even though the instrument is stationary and operating in the SU mode of operation. This "jitter" makes it hard to take a single reading. Therefore, for this evaluation, single readings at each station of Course "A1" were compared with multiple readings, or the average of ten readings, at each station to determine position error.

For comparison, Runs 1 and 9 were chosen because they used the same satellite set (6, 9, 12, and 13) and had very nearly the same GDOP (4.8 to 5.0 and 4.8 to 4.9, respectively). Run 1 had single readings, and Run 9 had multiple readings. The graph in figure 5 shows that for each station, the multiple readings gave consistently less distance error, or a better position, than a single reading taken at each station. The average distance error for all stations of Run 1 was 30 feet, while it was only 16 feet for Run 9. If the distance error for all single reading runs (1, 2, 3, 4, 7, and 8) is averaged by station and compared to Run 9, regardless of satellite set and GDOP, the multiple readings give the best position, except at station "A11" (figure 6). A possible reason for the difference at Station "A11" may be a failure to allow the instrument enough warmup time after the initial turn-on. This was the first station on the course.

The average position error for the single reading of Run 1 was 30 feet. For all single reading runs (Runs 1, 2, 3, 4, 7, and 8), the average was 20 feet, and for the multiple reading Run 9, it was only 16 feet. This is expected; the single readings were an average value and compared more closely with the

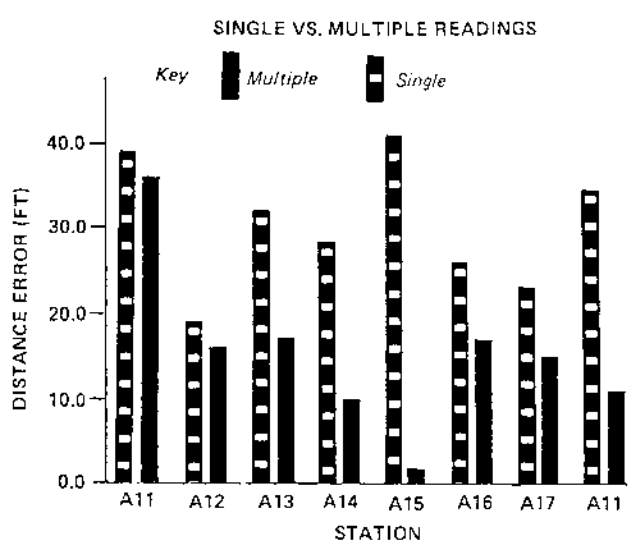

Figure 5.—A comparison of single and multiple readings.

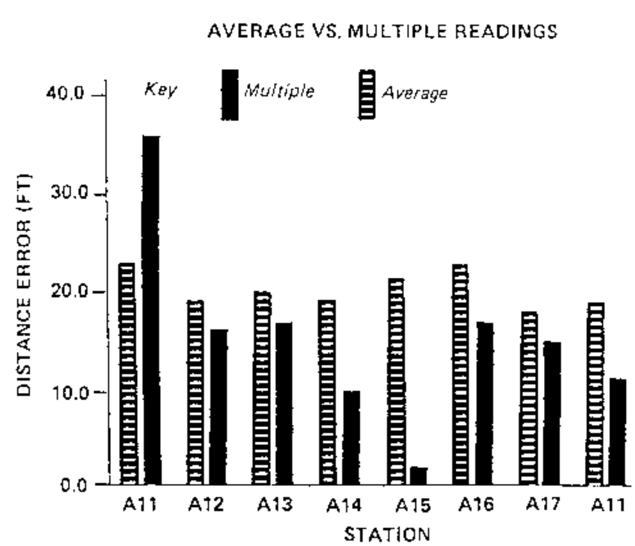

Figure 6.—Single readings compared to multiple readings on course "A11."

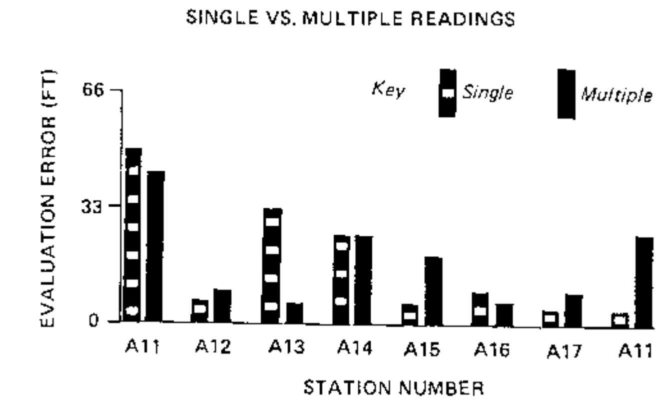

Figure 7.—Elevation error on single and multiple readings for each station.

multiple value. Therefore, multiple readings will give a better position than just a single reading at each station.

Figure 7 is a graph of elevation error obtained from multiple readings of elevation versus a single reading for each station. The elevation error for multiple readings is the difference between the average of ten elevation readings from the NAVCORE-1 and the known elevation for each station. A single reading is the difference between a single elevation reading and the known elevation.

From the data shown in figure 7, there seems to be no advantage in multiple readings over a single reading. However, from other runs, where only single readings were taken (data not shown), errors as high as 89 feet were obtained, with a GDOP of 6 or less. Therefore, for best elevation accuracy, use the average obtained from multiple readings, such as the ten readings arbitrarily used in this test.

Long-Term Effects

The unit was allowed to remain stationary at the Lubrecht station for a long time to study the effects of time, changing satellites, and GDOP on position accuracy. The antenna was placed over the point, and the receiver operated in the SU and AU modes. The operator recorded time, position, elevation, GDOP, and satellite set being tracked as fast as the data could be read and recorded. Data were collected in this manner for about 1.5 hours.

Graphs of the results are shown in figures 8 and 9. The results did not turn out as planned, but they do give some information on operating the unit. Initially, the receiver used satellite set 6, 8, 11, and 12. However, satellite 8's bad onboard clock caused large position errors from 1032 to 1103 hours (figure 8), even though the GDOP was good (less than 5 during that time). Although satellite 8 has a bad clock, it has been coded healthy for use by the surveying community. Therefore, the receiver used the data from satellite 8 to determine position. Had its health code been set bad, the unit would have automatically rejected it and selected another satellite.

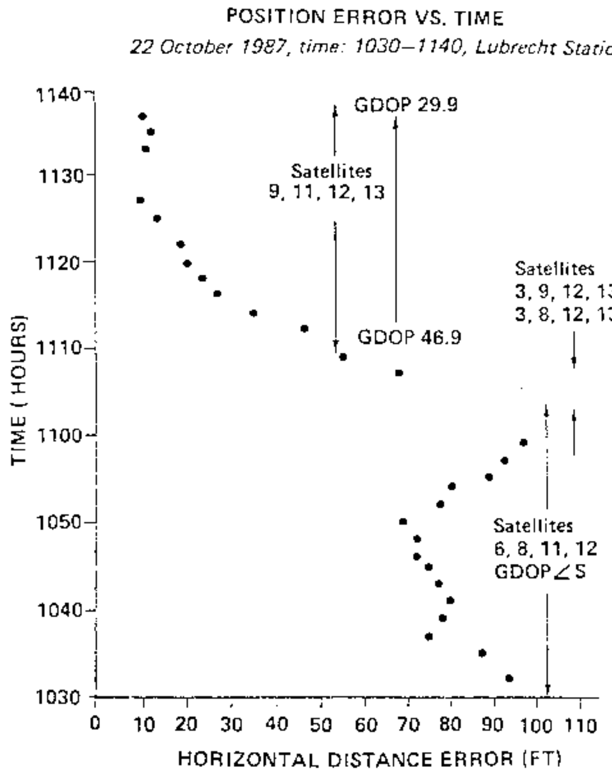

Figure 8.—Position error versus time.

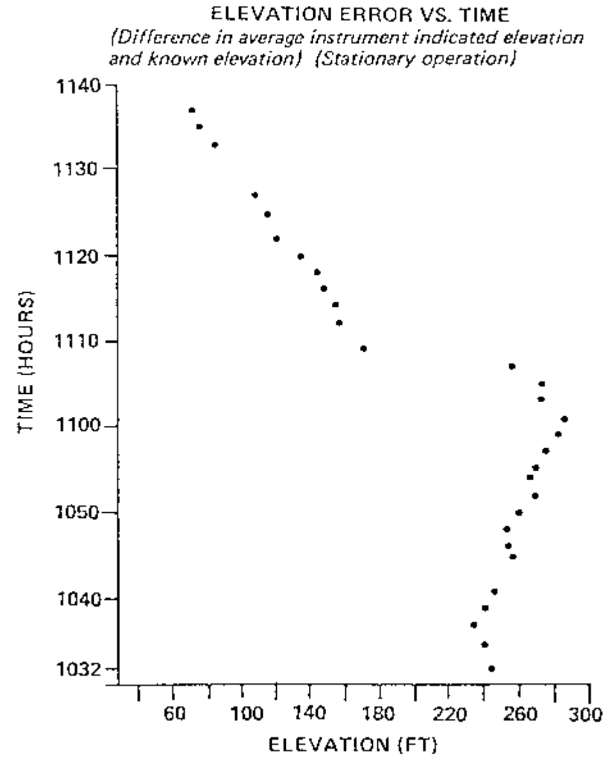

Figure 9.—Elevation error versus time.

At about 1103 hours, the receiver determined from ephemeral broadcast data that satellites 6 and 8 were about to set and satellite 3 had come into view and offered a better GDOP than the current satellite set (6, 8, 11, and 12). The receiver attempted to acquire satellite 3. However, it had a bad health code. After a few minutes, the unit automatically rejected satellite 3 and by approximately 1107 hours had acquired and locked on satellite set 9, 11, 12, and 13 (the only remaining satellites available). At about this time, 1107 hours (figure 8), the position accuracy began to improve and continued to improve until about 1125 hours, when it stabilized at about 12 feet position error. During this time, the GDOP dropped from 46.9 to 29.9 at 1138 hours. This is still a very large GDOP. The data collection was stopped because 9, 11, 12, and 13 were the only satellites available, and almanac data indicated the GDOP would not improve. These data show that even with a very large GDOP, after about 15 to 20 minutes of stationary operation, the receiver will give good position data. What would have happened with a low GDOP (less than 5) is unknown. We believe that the receiver would have taken only a couple of minutes after locking on a satellite set to give good position data or minimum position error.

Figure 9 is a plot of elevation error versus time for the same time period. During this time, the instrument-indicated elevation was always higher than the known elevation. Again, the plot more or less follows that of position error versus time (figure 8). The elevation error is fairly large while tracking the bad satellite 8 from the start to about 1105 or 1107 hours. At about this time, satellites 6 and 8 were setting and 3 was rising. However, the receiver automatically rejected it and locked on the only four available satellites (9, 11, 12, and 13). From then on, the elevation error continually improved until the test was terminated, at which time the elevation error was down to 72 feet. From the graph, it seems that it would have continued to improve had the test continued. Again, if the GDOP had been 5 or less, the receiver would have given better elevation data in only 2 or 3 minutes.

Road Location for Map Revision

The NAVCORE-1 receiver was used to determine the location of a road, and the results were compared to those obtained with photogrammetric means. The lower portion of Garnet Range Road, "Course E" of the GPS Lubrecht Evaluation Facility (figure 3), was chosen for the comparison. It has been digitized by photogrammetric means and represents a good base for comparison (figure 10).

Road location data were obtained by simply placing the antenna (without the tripod) on top of the vehicle and driving the road at 5 to 10 miles per hour. At each change in road direction, the car was stopped and a single reading of latitude and longitude was taken. The resulting plot of the road is shown in figure 11 and compares favorably with the photogrammetric method shown in figure 10.

There is an anomaly at one data point (figure 11), but the reason for it is unknown. It was probably caused by topography blocking the signal from a satellite, which caused the receivers to lose track and select another satellite. It did drop one satellite and pick up another at this point and, after a few minutes, changed back to the original satellite. This problem could be averted in the future by monitoring receiver status data more closely. Any time it indicates a momentary loss of track, or a change in satellite, simply

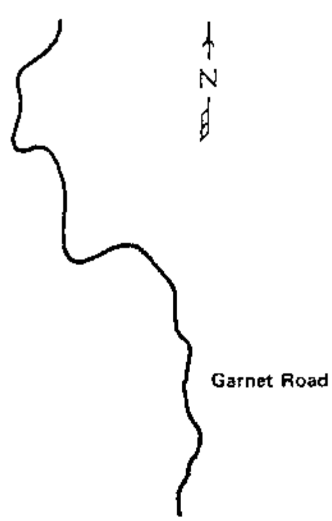

Figure 10.—Photogrammetric road location.

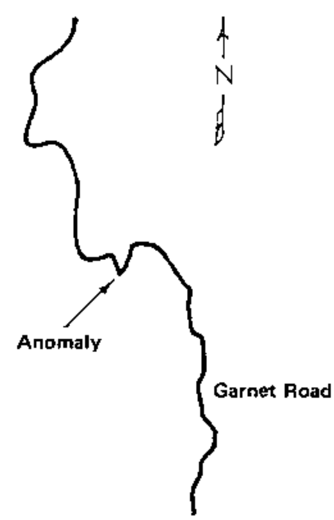

Figure 11.—GPS road location.

allow a couple of minutes before taking position data. These data show that this unit could be effective for determining road location for mapping.

The GPS system takes far less time and effort than is required with photogrammetry. The same should be true for determining trail location. The unit is person portable.

These data were obtained using a satellite set that included satellite 8, with its bad clock and large position errors. Had a different satellite been used, perhaps the location would have followed the photogrammetric location even closer.

Area Determination

The areas of Course A1 (traverse located in the open) and Course B1 (traverse located under a tree canopy) were calculated from the receiver data obtained on multiple reading runs and found to be 5.25 and 4.11 acres, respectively. The areas obtained from the GPS receiver data and from a timber cruising crew and the actual areas are shown in table 1.

The timber cruising crew came very close to the actual area. They were off by a maximum of 0.03 acre. The area determined from the GPS data is off considerably more. For Course A1, GPS was about 0.50 acre over, and for Course B1, it was about 0.25 acre under the actual acreage. This error is probably too large for most Forest Service work unless the position accuracy can be increased through differential techniques. It would be interesting to try the system on a large area of perhaps 40 acres to determine whether the error is constant and also to verify these results.

Conclusions

Data from the evaluation indicate that there was a degeneration of position accuracy when operating under a tree canopy. Apparently, tree canopy attenuates the signal, which affects the position accuracy obtained with this instrument when operated with only a short pause after setup. Positions determined under a canopy can be three times less accurate than those in the open. Perhaps monitoring the receiver status for a longer time to ensure it is continuously tracking the same four satellites without momentary loss of track before recording data would increase accuracy. Further evaluation is necessary to develop operating procedures for working under a canopy and to verify these results for specific conditions of GDOP and satellite set used.

We recommend that multiple recordings of position be taken at each station. Their average will give better accuracy than a single reading because instrument readings usually fluctuate by hundredths of a second even though the

Table 1.—Comparison of areas obtained for Courses A1 and B1.

	Course A1 (acres)	*Course B1 (acres)*
GPA receiver	5.25	4.11
Cruising crew	4.72	4.35
Actual area	4.74	4.38

instrument is stationary and in the SU mode of operation. Ten multiple readings were arbitrarily chosen for this evaluation and seemed to give adequate results, but use as many as you can.

It is doubtful that areas determined from the GPS receiver data will be useful for most area-determining work in the Forest Service unless position accuracy can be increased by differential techniques. In this evaluation, an error as high as 0.50 acre in about 5 acres was obtained.

Nonsurvey users of GPS should be cautioned about using satellite 8. It has a bad onboard clock that can cause large errors in position. This will not be a problem when the new satellites are launched. The receiver would automatically reject it if its health code were set bad, but in this case it has been coded healthy so it can be used by the surveying community where different signal-measuring techniques are used.

It seems that data from the GPS unit can effectively determine road or trail location for mapping. A road location plot obtained with GPS data from this evaluation compared favorably with those obtained by photogrammetry.

For further information on the NAVCORE-1 Global Positioning System, contact A.Jasumback:R01A.

Women in Engineering: Region 5

Alan H. Ambacher
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Region 5

In 1986, a few people began discussing establishing a workshop designed specifically to deal with issues affecting women working in Engineering in Region 5. A workshop could provide a forum to address the unique set of concerns and problems women were experiencing.

Following the decision to proceed, a planning committee was formed by advertising for members and facilitators for a "quality opportunity," resulting in a very skilled and enthusiastic cadre being brought together to design and conduct a workshop. In May 1987, the first Women in Engineering (WIE) workshop became a reality, followed by the second WIE workshop in February 1988. The 1987 workshop centered on defining the issues, while the 1988 session attempted to identify solutions and develop an action plan.

Individual Recognition

While everyone who participated contributed to the success of the WIE workshops, the following individuals made the extra effort to take a lead role in designing the workshops, serving on committees, and doing the followup work that is necessary for workshops to be successful:

Loretta Banta	Region 3 (formerly Six Rivers National Forest)
Pauline Davis	Region 6 (formerly Klamath National Forest)
Steve Eastwood	Plumas National Forest
Larry Gruver	Tahoe National Forest
Debbie Hall	Eldorado National Forest
Bob Harris	Regional Office
Cheryl Hilleary	Plumas National Forest
Jan Indermill	Shasta Trinity National Forest
Vicki Jowise	Eldorado National Forest
Linda Keydeniers	San Bernardino National Forest
Connie Relph	San Bernardino National Forest
Gloria Robbins	Eldorado National Forest
Vivian Sanchez	Cleveland National Forest
Melissa Totheroh	Regional Office
Kathleen Toland	Klamath National Forest
Debbie Taylor	Region 6 (formerly San Dimas TDC)
Rhonda Williams	Regional Office
Linda Zaleon	Region 4 (formerly Tahoe National Forest)

WIE I

Objectives

The main objectives of the workshop were to:

(1) Help participants gain an understanding of their own strengths and weaknesses.

(2) Reflect on issues resulting from the presence of women in the engineering work force.

(3) Discuss the Forest Service culture and the effect it has on employees.

(4) Gain understanding regarding the differences between men and women so they may work together more effectively.

(5) Interact with successful individuals from within and outside the Forest Service.

(6) Help individuals develop personal and career strategies.

(7) Provide feedback to management on how the Forest Service could enhance the retention of women.

Meeting Structure

The objectives of the meeting were accomplished through a variety of lectures, small group discussions, and large group feedback. To encourage networking and interaction among the participants, group lunches and dinners were offered. Although logistics for these arrangements were difficult to arrange, the payoff was high.

Results

Attendees left the meeting with a new energy and commitment to making something happen. To ensure that the WIE effort would not end with a workshop and letter to management, suggestions were made for a followup session, and WIE II was held in 1988.

The workshop's Listening Committee summarized the key issues and resolution strategies identified by the larger group. One of the major results of the workshop was a letter to the Assistant Regional Forester, Engineering, that identified ways to enhance the retention of women as expressed by the workshop attendees. The content of the letter is presented below.

Letter to Management

I almost left the Forest Service because of the following:

Supervisor's Performance. The person who has the best qualifications for the job is not always the best supervisor. Employees suffer under an unqualified supervisor. Attendees' complaints ranged from poor communication to a supervisor thwarting their advancement.

Lack of Challenge or Career Potential. The employee feels dead-ended with little hope of change. Individual's potential is neither recognized nor tapped. Career choices are unclear; advancement opportunities are not known.

Policy Conflicts. The employee is at odds with various policies that may conflict with personal ethics. He or she refuses to compromise integrity or to misrepresent the truth for the sake of politics.

Sexual Discrimination and Sexual Harassment. Both exist in many forms, and those who file justified complaints may suffer greatly from the backlash from both men and women.

Not Fitting In. These feelings are often a result of the strong Forest Service culture—sometimes it is hard to fit the mold or feel like part of the team. This is most difficult for new employees and those who are in some way different from most of the other Engineers (such as women and minorities).

Impostor Syndrome. Low self-esteem and feelings of not being technically competent are common among women employees. This results in an insecurity about one's worth as compared to fellow employees.

Unfunded List. Those on the unfunded list felt unwanted, unappreciated, and pressured to leave. Employees not on the list sometimes felt threatened or disagreed with the way management handled the situation.

Resolution strategies for ways to improve retention include the following:

Support Family and Career Compatibility. Management should recognize the importance of family needs and responsibilities. Women should not be forced to choose between having children and pursuing careers. It is time to offer alternatives and to put emphasis on the employee as a person, spouse, parent, and so on. When the workshop participants were asked to finish the sentence, "If I ever leave, it will be because...," the response most often given was because of family obligations.

Child Care Facilities. These should be located at or near the workplace and affiliated with the Forest Service.

Dual Career Consideration. Assist couples who both work outside the home in finding jobs near each other through counseling and relocation services. Read recently written papers on the dual-career-couple issue (such as *A Study of Dual Career Couple Placement Policies and Procedures in Region Five* by Erin Connelly, Tahoe National Forest), and look for ways to implement their recommendations.

Health and Wellness Programs. Support and nurture programs that concentrate on the employees' physical and mental health (such as exercise classes and stress management).

Part Time/Job Sharing/Home Work. Be creative when it comes to exploring ways for a parent with young children to continue working. Grant parental leave when appropriate.

Mobility. Should mobility be a prerequisite for career advancement? Recognize the impact that frequent moving has on employees and families and consider alternatives.

Career Enhancement. While some progress already has been made in this area, we feel there is still room for improvement. One negative side effect has been the occasional "fast-tracking" of female employees—sometimes interpreted as management's attempt to set women up for failure. Pushing women up the career ladder before they are ready is a "lose-lose" situation.

Career Counseling. Train and encourage supervisors to discuss career goals with their workers and the steps they need to take to achieve their goals. Continue such efforts as the *Engineering Career Planning Guide.*

Developmental Opportunities. Give more management support to details, cross training, workshops, and other opportunities by giving them wide distribution and a more reasonable lead time. Provide supervision experience where lacking.

Upward Mobility. Establish bridge positions, upward mobility positions, and opportunities for promotion in place.

Technician Advancement. Change the belief that an employee without a degree is not qualified to perform managerial jobs by opening up higher grade jobs to technicians.

Improve Communication. That men and women do not always communicate well is an accepted fact. When this occurs in the workplace, it can undermine or destroy the trust and credibility vital to a productive working relationship. Of course, miscommunication happens everywhere, and the more we understand about why it happens, the more we can do to prevent it.

Information Flow. Management should do a better job of distributing information to all levels of the organization and of answering employees' questions in a straightforward manner.

Networking. Recognize the need for women to set up their own networks and to join existing ones. Support communication among women at work as you would among the men.

Recognition. Let employees who do a good job know you appreciate it—if appropriate, present them with an award for their outstanding work. Support women in breakthrough positions, and recognize that they are performing two jobs. In addition to their regular duties, they are busy educating others about themselves and working toward acceptance of women in the work force.

Commitment. Continue to sponsor such programs as the WIE workshop and to monitor their success; use questionnaires to check progress. Identify and act on problems as soon as possible. Make it clear through word and action that harassment and discrimination will not be tolerated.

WIE II

Objectives

The unofficial theme of the workshop was: "We (WIE) can make a difference." The purpose was to pick up where WIE I left off by developing action items for the "burning issues" identified during the 1987 session. The outcome involved solutions from participants and management.

Meeting Structure

At the first WIE workshop, participants identified the issues and concerns that were threatening the retention of women in Engineering in the Region. The 1988 session was structured so small work groups would have ample opportunity to deal with the selected major issues, to develop recommendations that individuals could take to make a difference, and to identify actions the organization needs to follow.

More than 70 women and men attended this workshop. Regions 3, 4, 6, and 9 and two outside agencies sent representatives.

A consultant attended the workshop to show participants how to become more effective by being active participants. He reiterated throughout the meeting that the group needed to keep "them" (management) to their word that the group had the opportunity to come up with pertinent ideas and recommendations to which "they" (management) would listen and respond. Through active meeting participation, people were challenged to "make a difference, no matter what." The consultant suggested that participants should not just complain, but should take the responsibility to try and make a change.

Results

The 1988 session started by reviewing the list of "burning" issues from the 1987 meeting to identify those that participants wanted to explore as small groups. From this list of issues, the group identified six topics on which to work. These six topics were: changing unacceptable behavior, orientation, dual careers, training, career ladder for technicians, and personal satisfaction and motivation.

The six topics selected and the actions developed to deal with them are presented below.

Changing Unacceptable Behavior

Group 1

Problem. Unacceptable behavior is behavior that undermines an individual's credibility, reputation, safety, or self-esteem.

Why is it a problem? Because it causes a decrease in morale, productivity, retention, quality, commitment and safety. It increases hostility, grievances, and creates a poor work environment.

Suggested next steps:

(1) Restructure Forest Service away from "paramilitary" attitudes.

(2) Recognize differences and emphasize women's and men's strengths.

(3) Eliminate character assassination.

(4) Create a climate for supervisors to deal effectively with sexual harassment.

Group 2

Problem. There are three types of unacceptable behavior: verbal, mannerisms, and hazing and bullying.

Why is it a problem? It is nonproductive, unprofessional, and stressful; it causes low morale and motivation; it creates a poor work environment and may result in grievances; and it affects people mentally and physically.

Suggested next steps:

(1) Mannerisms—seven actions were developed to deal with profanity, suggestive pictures, put-down humor.

(2) Hazing—five actions were developed to deal with double standards, individuals being set up to fail (or for failure) by others, and higher expectations for work by women than for comparable work by men.

(3) Bullying—three actions were developed to discourage people from taking over discussions and disregarding women's input.

Orientation

Problem. Some new employees lack general knowledge about the Forest Service systems and specific knowledge about the unit and job expectations.

Why is it a problem? Primarily, people feel isolated, unappreciated, afraid, unbelonging, frustrated, out of control, misled, confused, unmotivated or unacknowledged, overwhelmed, disappointed, and unimportant. In addition, retention is low, employee's potential is lost, and production is lost. Successful recruitment and adaptability are lacking.

Suggested next steps. Thirteen actions were identified, including:

(1) Establish unit "Welcome Wagon."

(2) Create network for new employees.

Dual Careers

Problem. Problems associated with dual careers include placement, mobility, schedules, nepotism, child care, and promotions in place.

Suggested next steps:

(1) Placement actions include providing Government-wide vacancy lists, educating employees to change the attitude of the organization toward dual-career placement, becoming more flexible to accommodate placement needs, and enforcing or implementing uniformity Region- and Service-wide.

(2) Mobility actions include providing referral services (day care, housing, doctors, and so on).

(3) Schedule actions include providing shorter sessions and training; providing child care at training sessions, meetings, and workshops; spreading out sessions throughout the year; and allowing work to be done at home.

(4) Nepotism should be addressed by management to seek changes in the outdated laws. Employees should be able to work for or within units managed by their spouses, with certain checks and balances.

(5) Some child care actions are addressed under schedules. Other actions include providing education, incorporating day care centers within Forest Service buildings, providing summer care, creating co-ops, and allowing children in the office in certain situations.

(6) Promotion in place is covered under mobility and placement.

Training

Problem. Individual's needs for employee development are not being met in three categories: technical, managerial, and personal.

Why is it a problem? Lack of development creates a lack of motivation and initiative, as well as stress. It does not allow employees to fully use personal skills. It is perceived as a loss of control.

Suggested next steps:

(1) Provide appropriate individual training.

(2) Share communication.

(3) Make supervision a certified position; accomplish through evaluations.

Career Ladder for Technicians

Problem. Similar career obstacles exist for both 802- and 810-series employees. However, Regional Office and Forest Engineering management show a lack of genuine concern and understanding toward the technicians (802 series) by obviously limiting career ladders.

Suggested next steps:

(1) Work force planning—assemble a task force to prepare an analysis of the Regional Engineering work force, develop a Regional Engineering work force plan, and prepare a Regional recruitment plan that includes technicians and wage grades as well as professional Engineers.

(2) Information-sharing actions developed include creating an information network to ensure that information is passed down from management and stressing that individuals need to go and seek this information.

(3) Create a network of engineering technicians who want to share ideas, vacancy announcements, possible encounters with discrimination, and methods to advance in their present positions.

Personal Satisfaction and Motivation

Problem. The lack of motivation and personal satisfaction has a detrimental effect on the organization and the individuals in it.

Suggested next steps—management:

(1) Increase recognition.

(2) Reduce stagnation and increase challenges to develop a more positive attitude.

(3) Clarify direction in the organization, in careers, and on specific projects.

(4) Increase understanding of self-motivation.

Suggested next steps—employees:

(1) Resolve conflicts with other workers, including those who belittle or undermine your decisions, work, and so on.

(2) Acknowledge personal problems that may be causing your lack of motivation.

(3) If there is no support for change, look at how you are presenting the change and consider a different approach.

(4) Recognize that you may have a fear of success, a fear of failure, or a fear of taking risks.

(5) Define any barriers.

Suggested next steps—everyone:

(1) Just say "thank you"—it's contagious.

Where Are "WIE" Going

The Region is now moving into the implementation process. An action plan has been developed, and committee work groups have been formed to accomplish specific tasks in the plan. The first formal status report will be given at the next Forest Engineer meeting by each committee chairperson.

The participants from both years' workshops are individuals with the energy, creativity, and positive attitude vital to the health of the Forest Service. Through such continued efforts as the WIE workshops, which encourage employees at all levels to work together to solve problems that hinder or reduce efficiency in the workplace, the Forest Service will continue to hold its place among the top Federal agencies for workers. Members of the Regional management team told the participants at this year's workshop that management does not have all the answers. The elimination of the "we/they" attitude is an excellent way to start the problem-solving process. The ways and means for solving problems increase greatly when individuals feel directly involved in the process.

Developing Road Logs & Inventories Using the HP–71B

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Cibola National Forest, Region 3

Introduction

The need for a more effective road log and inventory method on the Cibola National Forest prompted experimentation with Hewlett-Packard's HP–71B hand-held computer as an input and storage device (figure 1). Previous problems encountered with pen-and-paper road logs included inconsistent reporting, lost and damaged forms, and misinterpretation of recorded information. We hoped that the HP–71B and a custom-written program for the HP–71B could overcome these problems while adding the benefit of quick storage to our IBM-compatible microcomputer. Once the data were in the microcomputer, users would be able to extract selected information. The road log program is the result of these efforts.

Description

The road log program is written in HP–BASIC (a slightly modified version of regular BASIC) and is about 20K long. It takes advantage of the HP–71B's continuous memory, large memory capacity, durability, portability, communications ability, long battery life, and user-defined keyboard (figure 2).

Figure 1.—An HP–71B (in a protective field case), showing the program name, type, and size.

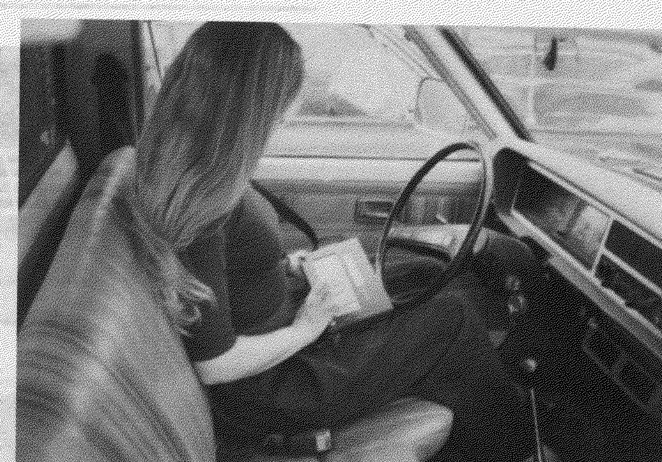

Figure 2.—The HP–71B can be used almost everywhere in the field.

The program uses subroutines for each item type and for various optional functions associated with file "housekeeping." This structuring allows the user to modify the program relatively easily by editing, deleting, or adding extra subroutines without affecting the function of the remaining parts of the program.

An integral part of the "system" is the ability to download data into the microcomputer from the HP–71B, using some simple new commands that fully exploit file transfer capabilities (figure 3). Fortunately, Hewlett-Packard has provided excellent manuals with their products, and learning just about anything is as simple as finding the description in the large index of each manual.

Materials

To run the road log program and transfer data to an IBM-compatible microcomputer, you will need the following:

1 HP–71B	$375.00
1 32K memory module	145.00
1 IL (interface-loop) module	95.00
1 link program	75.00
1 IL/PC interface card (PC board)	150.00
2 IL cables	included
1 keyboard overlay	included
1 microcomputer (IBM-compatible or Hewlett-Packard)	in place?

These items may also come in handy:

More memory modules (32K, 64K, 128K, 256K, and so on)	$145.00 to 600.00
1 digital cassette drive	400.00
1 pack of cassettes for the drive	75.00
1 Thinkjet printer	350.00

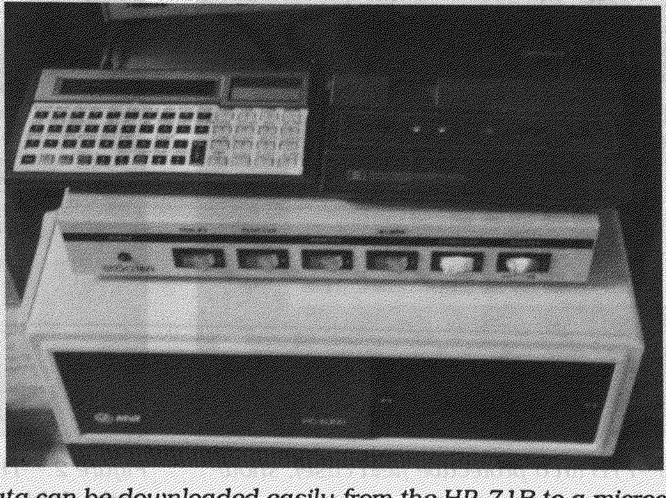

Figure 3.—Data can be downloaded easily from the HP–71B to a microcomputer.

These last items run directly off of the HP-71B and are useful tools for data storage and printing if the microcomputer is unavailable for some reason (figures 4 and 5). In addition, the extra memory allows users to collect more data before running out of internal data storage space in the HP-71B.

Running the Program

The only equipment necessary to run the program in the field is the HP-71B, with one 32K memory module installed. To eliminate the inevitable foulups associated with learning a new system, we recommend that the user perform several imaginary road logs at his or her desk before setting out for the field. From that point on, program operation should be a matter of answering the questions the program asks.

The program consists of two main sections: Data File Setup and Data Collection. The first section is usually run through only once for each field day. The second section consists of questions about the road and associated structures and is where the user does the bulk of the work. For brevity, many of the "housekeeping" and optional functions of the two sections have been omitted from the following description.

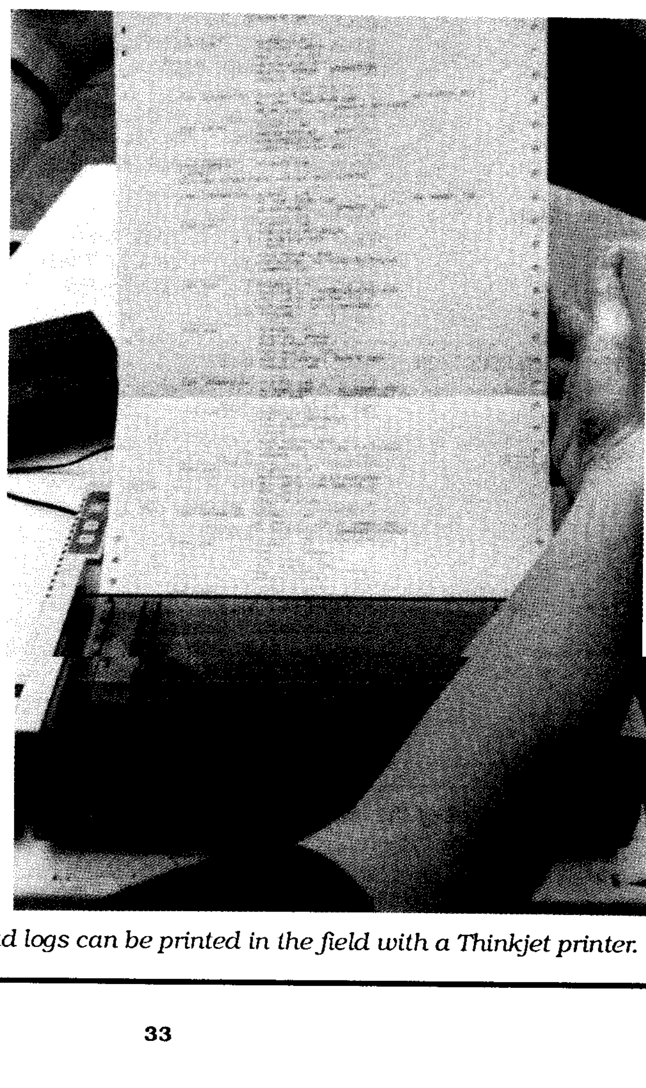

Figure 4.—Road logs can be printed in the field with a Thinkjet printer.

```
::::::::::::::::::::::::::::::::::::::::::::::::::::
****************************************************
ROAD NAME: JUAN TABO REC AREA             ROAD #: 333
STARTING AT: SH 556  TIME//DATE: 15:07:05 // 88/08/09
TAKEN BY: WALT KEYES

*********************************************
:::::::::::::::::::::::::::::::::::::::::::::
ITEM: SURFACE         MILEPOST: 0.00
                      SURFACE TYPE: BI     WIDTH: 16
                      MAINTAINED BY: STATE
                      COMMENTS: TO 0.05
.....................................................
ITEM: CATTLEGUARD     MILEPOST: 0.05
                      WIDTH: 21             # OF GRIDS: 3       MATERIAL: CONCRET
                      WORK:                 SIGNING: TYPE II
.....................................................
ITEM: SURFACE         MILEPOST: 0.06
                      SURFACE TYPE: BI     WIDTH: 16
                      MAINTAINED BY: COUNTY
                      COMMENTS: ON INDIAN LAND
.....................................................
ITEM: CATTLEGUARD     MILEPOST: 0.2
                      WIDTH: 21             # OF GRIDS: 3       MATERIAL: CONCRET
                      WORK:                 SIGNING: TYPE II
.....................................................
ITEM: SURFACE         MILEPOST: 0.21
                      SURFACE TYPE: BI     WIDTH: 16
                      MAINTAINED BY: USFS
                      COMMENTS: GOOD SHAPE
.....................................................
ITEM: SIGN            MILEPOST: 0.28
                      SIGN TYPE:  DESTINATION
                      SIGN ON RIGHT SIDE
                      2 POSTS
                      POSTS MADE OF:  WOOD
                      SIGN MESSAGE:  MULTILINE TEXT FOLLOWS
                      COMMENTS:  WORN OUT/REPLACE
.....................................................
ITEM: SIGN            MILEPOST: 0.28
                      TEXT LINE 1:  ^ JUAN TABO P.G.
                      TEXT LINE 2:  ^ LA LUZ TRAILHEAD
                      TEXT LINE 3:  LA CUEVA P.G. =>
                      TEXT LINE 4:
.....................................................
ITEM: INTERSECTION    MILEPOST: 0.32
                      RD. NAME: LA CUEVA   RD. NUMBER: 333B
                      ON THE: RIGHT        COMMENTS: NEEDS CRACKS SEALED
.....................................................
ITEM: OTHER           MILEPOST: 0.4
                      DESCRIPTION: T.C. LOOP HERE
                      COUNTER ON RIGHT 10FT
                      COUNTS RT LANE

.....................................................
ITEM: SIGN            MILEPOST: 0.85
                      SIGN TYPE:  WARNING
                      SIGN ON RIGHT SIDE
                      POSTS MADE OF:  WOOD
                      MAIN TEXT/WORDING:  INTERSECTION
                      COMMENTS:  OK
.....................................................
```

Figure 5.—Printout of the road log shown in figure 4.

```
.....................................................
ITEM: INTERSECTION   MILEPOST: 0.98
                     RD. NAME: TIERRA MONTE SUBDV             RD. NUMBER: 333C
                     ON THE: RIGHT        COMMENTS: NOT SIGNED
.....................................................
ITEM: SURFACE        MILEPOST: 1.00
                     SURFACE TYPE: BI     WIDTH: 14
                     MAINTAINED BY: USFS
                     COMMENTS: THIN CHIP SEAL
.....................................................
ITEM: COMMENTS       MILEPOST: 1.00
COMMENTS:
OCCASIONAL POTHOLES/NEEDS CHIP SEAL/NEEDS CLEARING
.....................................................
ITEM: INTERSECTION   MILEPOST: 1.26
                     RD. NAME: PICNIC LOOP                    RD. NUMBER: 333L
                     ON THE: RIGHT        COMMENTS: EXIT
.....................................................
ITEM: SIGN           MILEPOST: 1.46
                     SIGN TYPE:  DESTINATION
                     SIGN ON RIGHT SIDE
                     2 POSTS
                     POSTS MADE OF:  WOOD
                     SIGN MESSAGE:  MULTILINE TEXT FOLLOWS
                     COMMENTS:  OK
.....................................................
ITEM: SIGN           MILEPOST: 1.46
                     TEXT LINE 1:  ^ PIEDRA LISA TRAILHEAD
                     TEXT LINE 2:  JUAN TABO P.G. =>
                     TEXT LINE 3:  LA LUZ TRAILHEAD =>
                     TEXT LINE 4:
.....................................................
ITEM: SIGN           MILEPOST: 1.47
                     SIGN TYPE:  WARNING
                     SIGN ON RIGHT SIDE
                     POSTS MADE OF:  STEEL
                     MAIN TEXT/WORDING:  SHARP RT TURN
                     COMMENTS:  5 MPH
.....................................................
ITEM: INTERSECTION   MILEPOST: 1.65
                     RD. NAME: NONE       RD. NUMBER: 333E
                     ON THE: RIGHT        COMMENTS: SMALL P.G.
.....................................................
ITEM: SIGN           MILEPOST: 1.79
                     SIGN TYPE:  DESTINATION
                     SIGN ON RIGHT SIDE
                     2 POSTS
                     POSTS MADE OF:  WOOD
                     SIGN MESSAGE:  MULTILINE TEXT FOLLOWS
                     COMMENTS:  OK
.....................................................
ITEM: SIGN           MILEPOST: 1.79
                     TEXT LINE 1:  ^ LA LUZ TRAILHEAD
                     TEXT LINE 2:  JUAN TABO P.G. =>
                     TEXT LINE 3:
                     TEXT LINE 4:  OK
.....................................................
ITEM: INTERSECTION   MILEPOST: 1.89
                     RD. NAME: P.G. LOOP  RD. NUMBER: 333L
                     ON THE: RIGHT        COMMENTS: ENTRANCE
.....................................................
```

Figure 5. (cont.)—Printout of the road log shown in figure 4.

```
.........................................................
ITEM: SIGN             MILEPOST: 2.35
                       SIGN TYPE:  WARNING
                       SIGN ON RIGHT SIDE
                       POSTS MADE OF:  STEEL
                       MAIN TEXT/WORDING:  U-TURN TO RT
                       COMMENTS:  10 MPH
.........................................................
ITEM: OTHER            MILEPOST: 2.59
                       DESCRIPTION: PARKING LOT
                       LA LUZ TRAILHEAD


.........................................................
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
***********************************************

END OF ROAD AT MILEPOST: 2.68              ROAD #:
                       TIME: 15:34:11      DATE: 88/08/09
                       ENDING POINT: LA LUZ THD PKG LOT          RD NAME:
                       TAKEN BY:   ||||||||||||||

*******************  END  ********************
:::::::::::::::::::  END  :::::::::::::::::::::
```

Figure 5. (cont.)—Printout of the road log shown in figure 4.

First Section

Upon startup, the program confirms its existence, prompts the user for information concerning the configuration of the HP–71B and its memory, and asks for the starting point of the road, the time, date, road name, and worker's name. This program segment allocates virtually the entire remaining free memory to data storage and then transfers operation to the second section.

Second Section

This section uses the HP–71B's "user" keyboard to give specific keys specific functions (subroutine calls in most cases). The keyboard overlay provides the user with the name of the function performed by each key. For instance, pressing the "CMP" key initiates a series of questions concerning culverts. Some user keys enter whole words into the display when pressed.

At the end of each function, the machine records the data to an internal data file after giving the user a chance to review and/or discard these data. The user is then prompted to press another user key, which selects another item for which to collect data.

Data Transfer

The hardware and software must be connected by the HP–IL (interface loop) to transfer data between the HP–71B and a microcomputer (figure 6). Once that connection is made (see section on materials), data files can be written onto a disk on the microcomputer either as binary data or text (figure 7). They then can be imported into spreadsheets and data bases (we have used *Lotus 1–2–3* so far). A *Lotus 1–2–3* macro that converts the imported columnar data into a data base-style row-and-column format usable with *Lotus 1–2–3*'s data base options has been written (figure 8).

Figure 6.—Connecting elements of the system is easy with plug-in cables.

Data Base Use

Lotus 1–2–3 data bases have been set up using this equipment and software (figure 9). *DBASE III PLUS* or any other software with "file importation" capabilities should be able to pick up the data from disk. However, the software must have some method of sorting the columnar data that the HP–71B puts out into its various data base fields.

Summary

The Cibola National Forest has developed a combination of hardware and software that allows workers to quickly gather standardized and complete logs of road drainage structures, signs, termini, and other items. Fast downloading of the resulting data to a microcomputer for printing and/or storage in a data base offers secure and retrievable data-handling and querying possibilities. In addition, printing and magnetic storage of data directly from the HP–71B are easy with a Thinkjet printer (figure 10), data cassette drive (figure 11), or external disk drives.

The modular nature of the software involved allows users to customize the data-gathering and/or storage and query aspects of the system to meet their needs. To modify the system, as developed, users should be familiar with HP-BASIC, as well as *Lotus 1–2–3* macros, HP–71B commands, and DOS.

So far, the system has been of value mainly in support of our road maintenance contracting operations. We hope to use our new data with TIS and our sign inventory (both of which are required data), which should help us realize substantial cost savings.

```
NEW
NEW
NEW
NEW
NEW
NEW
NEW
NEW
87/06/11
254
09:58:22
NEWRD!
MOUNTAINAIR RD
T CONDOS

CO RD
SURFACE
0.00
LAST SURFACE REFL 1967
AG
FS


16
INTERSECTION
0.00
CO RD B-051
BOTH


B-051
UNKNOWN
OTHER
0.00
GATE

DOUBLE STEEL
STEEL TUBING


START DITCH
0.00

RIGHT




INTERSECTION
.02

LEFT



UNKNOWN
LOWER PARKING
CULVERT
.08
STEEL
LEFT
2

30
```

```
RIGHT



CULVERT
2.94
STEEL
LEFT


32
24
SIGN
2.95
WOOD
RIGHT
GOOD
WARNING
1
ROUGH ROAD
CULVERT
3.26
STEEL
LEFT

PULL DITCH INTO CMP
32
24
END DITCH
3.3

RIGHT
DEEPEN 12 IN



GRADEDIP
3.7
WORKING
LEFT



GRADEDIP
3.84
WORKING
LEFT




CULVERT
3.92
STEEL
LEFT


32
24
START DITCH
3.92

RIGHT
```

Figure 7.—The road-log data are imported from the HP-71B to a microcomputer in this format.

```
     ITEM      M.P.     DIAM.   LENGTH  SIDE      MATERIAL  SGNTYPE  SGNSAYS NUMPOSTS WIDTH    NUMGRIDS    RD#    RDNAME    SURFACE COMMENTS COMM
SDK?
   NEWRD!                                                                                                                      254      MOU
   SURFACE  0.00                                                                   16                                 AG                LAST
   INTERSECT0.00                       BOTH                                                              B-051   UNKNOWN               CO RD B-051
   OTHER    0.00
   START DIT0.00                       RIGHT
   INTERSECT.02                        LEFT                                                              UNKNOWN  LOWER PARKING
   CULVERT  .08      24        30      LEFT      STEEL
   INTERSECT.11                        RIGHT                                                             UNKNOWN  UNKNOWN              WAREHOUSE PAR
   INTERSECT.14                        RIGHT                                                             UNKNOWN  UNKNOWN              LOWER PARKING
   NEWRD!                                                                                                                              245      CAPI
   SIGN     .06                        LEFT      WOOD      ROUTE MAR245      1                                                         REPLACE
   SURFACE  .06                                                                    14                                 NA                POOR
   INTERSECT.23                        LEFT                                                              358      UNKNOWN              CO MTCE
   STREAM   .28                        RIGHT                                       20                                                  CONCRETE FORD
   SIGN     .23                        LEFT      WOOD      DESTINATICAPILLA C1                                                         GOOD
   SIGN     1.08                       RIGHT     WOOD      ROUTE MAR245 LT   1                                                         WEATHERED
   CATTLEGUA2.36                                 CONCRETE                          10        2
YPE 2
   STREAM   2.56                       LEFT                                        10                                                  CONC CUTOFF
   SIGN     2.57                       RIGHT     WOOD      ROUTED WOCIBOLA NF2                                                         GOOD
   CULVERT  2.62     24        32      LEFT      STEEL
   SURFACE  2.56                                                                   14                                 NA
   CULVERT  2.88     24        32      LEFT      STEEL
   START DIT2.89                       RIGHT
   CULVERT  2.94     24        32      LEFT      STEEL
   SIGN     2.95                       RIGHT     WOOD      WARNING  ROUGH ROAD                                                         GOOD
   CULVERT  3.26     24        32      LEFT      STEEL
   END DITCH3.3                        RIGHT
   GRADEDIP 3.7                        LEFT
   GRADEDIP 3.64                       LEFT
   CULVERT  3.92     24        32      LEFT      STEEL
   START DIT3.92                       RIGHT
   CULVERT  4.00     24        32      LEFT      STEEL
   END DITCH4.07                       RIGHT
   OTHER    4.07
   START DIT4.07                       LEFT
   GRADEDIP 4.09                       LEFT
   GRADEDIP 4.13                       LEFT
   END DITCH4.13                       LEFT
   GRADEDIP 4.27                       LEFT
   INTERSECT4.42                       LEFT                                                              245D     BARTOLA
   GRADEDIP 4.44                       LEFT
   SIGN     4.46                       LEFT      WOOD      ROUTE MAR245      1
   START DIT4.46                       RIGHT
   LEADOUT  4.49                       LEFT
   COMMENTS 4.5
   GRADEDIP 4.52                       LEFT
   END DITCH4.59                       RIGHT
   START DIT4.64                       RIGHT
   COMMENTS 4.63
   END DITCH4.71                       RIGHT
   COMMENTS 4.84
   START DIT4.84                       RIGHT
   END DITCH4.89                       RIGHT
   BRIDGE   4.93               20                CONCRETE                          14
PE II
```

Figure 8.—A macro converts the data from the format in figure 7 into a row-and-column format usable with Lotus 1–2–3.

ITEM	M.P.	DIAM.	LENGTH	SIDE	MATERIAL	WKNEEDS	SGNSOK?
CULVERT	.08	24	30	LEFT	STEEL		2
CULVERT	2.62	24	32	LEFT	STEEL		
CULVERT	2.88	24	32	LEFT	STEEL		
CULVERT	2.94	24	32	LEFT	STEEL		
CULVERT	3.26	24	32	LEFT	STEEL	PULL DITCH INTO CMP	
CULVERT	3.92	24	32	LEFT	STEEL		
CULVERT	4.00	24	32	LEFT	STEEL		
CULVERT	5.2	24	32	LEFT	STEEL	HOLE ON INLET	2
CULVERT	5.2	24	32		STEEL		2
CULVERT	5.2	24	32	LEFT	STEEL		2
CULVERT	6.06	24	30	RIGHT	STEEL		2
CULVERT	6.15	24	30	RIGHT	STEEL		2
CULVERT	6.36	24	32	RIGHT	STEEL		2
CULVERT	6.43	24	32	RIGHT	STEEL		2
CULVERT	6.51	24	32	RIGHT	STEEL		2
CULVERT	6.73	24	32	RIGHT	STEEL		2
CULVERT	6.94	24	36	RIGHT	STEEL		2
CULVERT	7.04	24	36	RIGHT	STEEL		2
CULVERT	7.1	24	40	RIGHT	STEEL		2

Figure 9.—Querying the Lotus 1–2–3 *data base in figure 8 for "culverts of 24" diameter" produced this printout.*

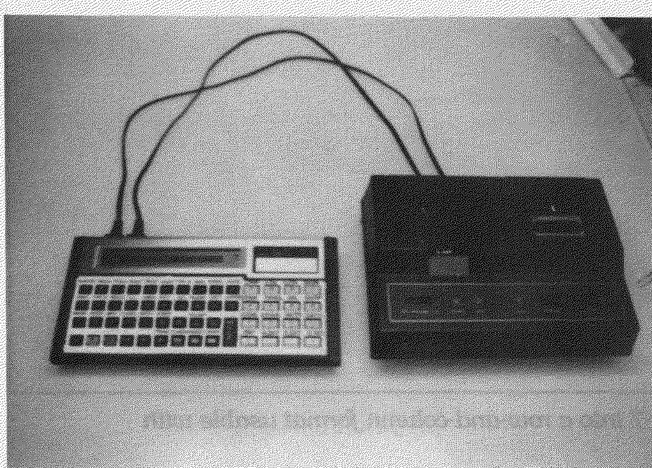

Figure 10.—A data cassette drive provides extra storage space in the field.

Figure 11.—A complete field system includes the HP–71B, a data cassette drive, and a Thinkjet printer.

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