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Engineering Field Notes

Engineering Technical Information System

1984 *Field Notes* Article Awards

Technology Transfer & You

Making a Good Road System Better

How the Off-Duty Environment Affects
On-Duty Production & Safety

Close Range Photogrammetry at Work
on Tough Measuring Jobs

Cross-Country Ski Trail Planning,
Development, & Operation
Considerations

Transportation Analysis Memory

Automated Road Design System

The Software Spot



Engineering Field Notes

Administrative Distribution

- Professional Development
- Management
- Data Retrieval

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1984 *Field Notes* Article Awards

It's January again--time to poll our readers on their choices for the best Field Notes articles published during 1984. Each year, based on a survey of our readers, we reward the authors of the three articles receiving the most favorable response.

Field Notes tries hard to provide useful information to those of you in the field as well as those of you who manage or supervise projects from the office. Did you find any articles especially informative or useful this year? Did any articles help you to develop more effective methods of doing your job? Did any articles help your office save money--or time?

If you have benefited from any of 1984's Field Notes articles in any way, please complete the rating sheet on the following page. To do this, choose the three (3) articles you found most informative, beneficial, or just plain interesting, and rate them from 1 (highest) to 3 (lowest). And--if you believe an article helped the Forest Service save money, please indicate the amount you believe was saved or could be saved.

Remember, do NOT rate more than three (3) articles.

After you have voted, cut out the rating sheet along the dotted line, fold and staple it closed, and mail it to the Washington Office. To be counted, ALL RATING SHEETS MUST BE DELIVERED TO THE WASHINGTON OFFICE BY JANUARY 31, 1985.

Wait! Before you get back up, why not start writing YOUR article for 1985's Field Notes?

1984 Field Notes Awards

Article	Author	Choice (1, 2, 3)	\$ Saved
<u>January</u>			
Technological Improvements: What's in It for You?	Petersen, Dale R. (WO)	_____	_____
The HP-41CV Electronic Notebook System	Lunsford, Randy J. (R-6)	_____	_____
Subdivision Program for the HP-41C	Grauberger, Robert A. (R-5)	_____	_____
A Partner in Equipment Development	Burbank, Farnum (WO)	_____	_____
A Method of Measuring Road Surface Wear	Armstrong, Clinton L. (R-3)	_____	_____
Flood Prediction--Using the National Weather Service Dam-Break Program	Self, Bill C. (R-4)	_____	_____
<u>February-March</u>			
New, Improved Chain Saw Chaps	Putnam, Stuart E. (MEDC)	_____	_____
Computerized Listing of Roads on the Five Year Timber Sale Action Plan	Johnson, Allan A. (R-9)	_____	_____
Use of Geotextiles as Bridge Paving Underlayment	Faurot, Richard A. (R-9)	_____	_____
Big Lightning Creek Flood Repairs	Eriksson, Mervin (R-1); Leibbrand, Lou (R-1)	_____	_____
Laws Governing Rights-of-Way Across Arizona Lands	Travis, Janet L. (R-3)	_____	_____
<u>April-May</u>			
A New <u>Field Notes</u> Feature: The Software Spot	Connolly, Constance A. (WO)	_____	_____
Tree-Planting Machines--Can You Afford One?	McKenzie, Dan W. (SDEDC); Hatfield, David C. (SDEDC); Dykeman, Kenneth K. (SDEDC)	_____	_____
Identifying Road Capacity and Traffic Service Level	Ou, Feng L. (WO); Hessel, Allan J. (R-6); Nordengren, David R. (R-6)	_____	_____
<u>June-August</u>			
R-5 Engineering Technology Transfer	Mandigo, James E. (R-5)	_____	_____
Polybutylene Piping	Kuetemeyer, Edward N. (R-1)	_____	_____
Lagoon Repairs by Underwater Divers	Kringler, Harry (R-1)	_____	_____
Patterson Iron Removal System	Kuetemeyer, Edward N. (R-1)	_____	_____
<u>September-October</u>			
The Ouachita National Forest Deluge of '82	Donahue, Charles (R-8)	_____	_____
Outdoor Testing of Reflective Sign Materials	Nettleton, Tom (MEDC); Mrkich, Dale (MEDC)	_____	_____
Maximizing Results in a Volunteer Program	Greer, Jerry D. (NFAP)	_____	_____
Geometronics Update: Forest Service Past, Present, and Future Azimuths	Gossard, Terry W. (WO)	_____	_____
Lining Deteriorated Culvert Pipes on the Jones Valley Road	McCrea, Robert (R-5)	_____	_____
<u>November-December</u>			
NOTE: The <u>Field Notes</u> November/December issue was the special 4-year Bibliography.			

CHOOSE ONLY THREE ARTICLES

(CUT ALONG THIS LINE) →

COMMENTS: _____

NAME _____

(OPTIONAL)

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Technology Transfer & You

*Dale R. Petersen
Staff Engineer
Washington Office*

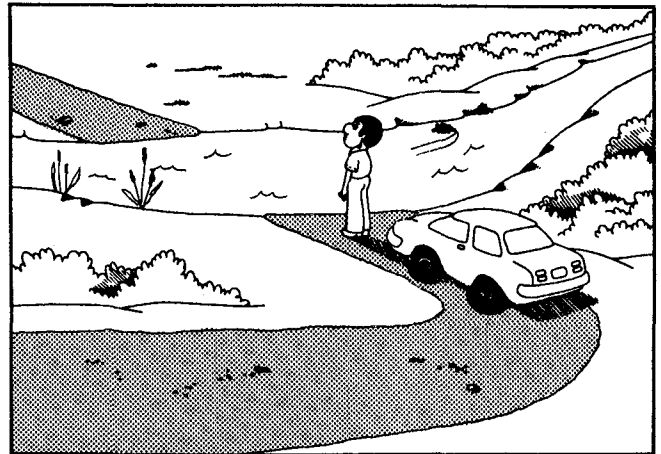
INTRODUCTION

We all participate in technology transfer. We did so when we learned to drive a car--quite a change from walking or riding a bike! If you know how to type, you have learned a new technology that is quite different from using a pen or pencil. Some of us have learned to use a computer--again, a major change. Everyday, we are involved in many technology changes or transfers without realizing it. Some come about easily, some with great difficulty.

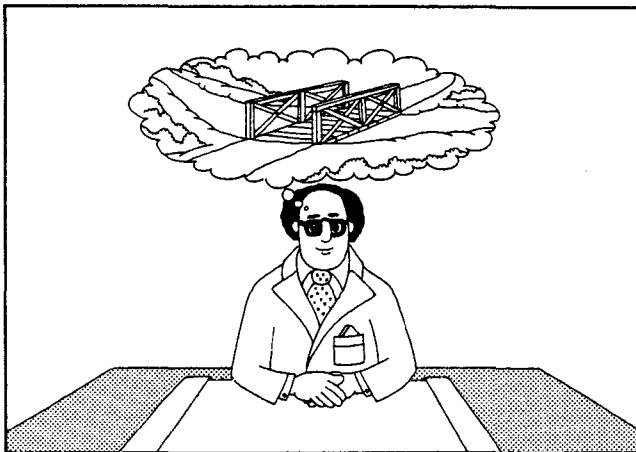
In our work, we undergo technology changes constantly. Local units initiate or respond to some changes. Other changes occur because national efforts provide opportunities for doing so.

This article presents information on a forthcoming FSM 7117, "Technology Applications," and how it may affect you.

First, let's be sure we have a specific audience with a specific and significant problem.



Top administrators must have a real desire to see the proposed technology used, or resources simply won't be available to get the job done.



HISTORY

The Forest Service has a record of using new technologies. Just examine the changes during your career. You will note there are many. No doubt we have a few frustrated employees who have tried to accelerate technology transfer. For a variety of reasons, these folks received a "no" answer to their effort to procure or develop new technology. Policy and conservatism occasionally prevented us from making changes we thought would be improvements.

FSM 7117, "TECHNOLOGY APPLICATIONS"

This new Manual material should make it easier for us to introduce new technologies to the Forest Service. The objective is to "develop and/or use new, effective technologies which can substantially reduce the cost of Forest Service end products or operations or can improve their quality." When approved, the policy will be to:

- (1) Use, procure, or develop new technology whenever economic.
- (2) Share new technology development, procurement, and application with other Forest Service units to avoid duplication.

The key is to be aggressive in applying new technology that is economical. The corollary is to share it. In so doing, there should be a smaller gap between the "haves" and "have nots." Not only should this policy accelerate technology transfer, but it should reduce duplication of efforts, too.

Recently, one Region wanted a computerized specification library for quick contract assembly of selected parts. Another Region had been using one for 10 years! No doubt others had duplicated the effort. Implementation of FSM 7117 should cut down the amount of duplication.

Sharing information is expected with conference systems, data bases, and other techniques. Region 5, for one, is off to a good start in this area. Refer to the June-August 1984 Engineering Field Notes article, "R-5 Engineering Technology Transfer."

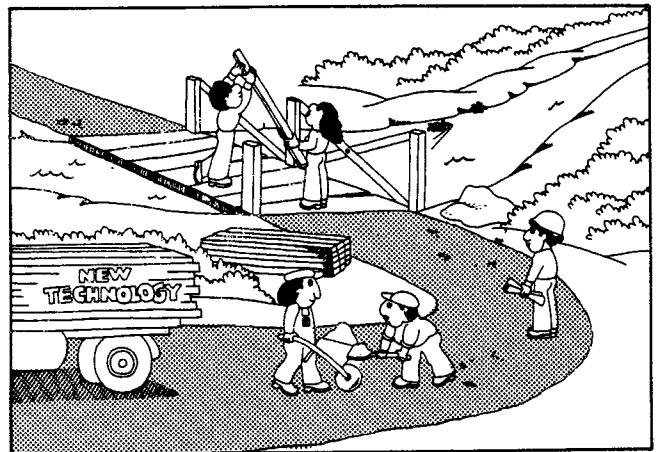
IMPLEMENTATION

Reviews by the Washington Office should aid the implementation of the new policy following a training period. In the past, written or unwritten policy may have hindered technology transfer. Until the draft FSM 7117 is approved, you are encouraged to pursue the new policy, which should be official by the time this article is published. By "unleashing" your ideas, you can have a head start on the new policy. In so doing, your unit will be a leader--with others eager to follow. Thus, the Forest Service will maintain itself as the world's most progressive and efficient land management agency.

REGIONS, FORESTS, & DISTRICTS ARE KEY

Since fiscal year 1982, Washington Office Engineering has reduced its technological improvements budget by one-third. This has been in response to the Regions' input on the program and to the responsibilities study, which indicated that a reduced Washington

A number one requirement is to perceive a definite need for help and then be willing to become involved, learn about, and adopt the proposed technology.



Office effort was in order. This means that Regions, Forests, and Districts will have a greater responsibility for obtaining and implementing new technology. This is another good reason for the new policy--to ensure this will happen.

NEW TECHNOLOGY
IS ESSENTIAL

As our society and many others--some of them too late--have learned, new technology is the lifeblood of the future. Now you have greater opportunity AND responsibility than ever before to initiate and use new technology. As you participate in the technology transfer process, you will know that you are doing your best to keep the Forest Service on the leading edge. And besides, it should be exciting and fun!

Making a Good Road System Better: Creating a Data Base for the Surfacing Design & Management System

*Andrea Myslicki
Project Manager
Labat-Anderson Incorporated
& Frank Carmichael
Project Manager
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Washington Office*

MORE ROAD for the MONEY

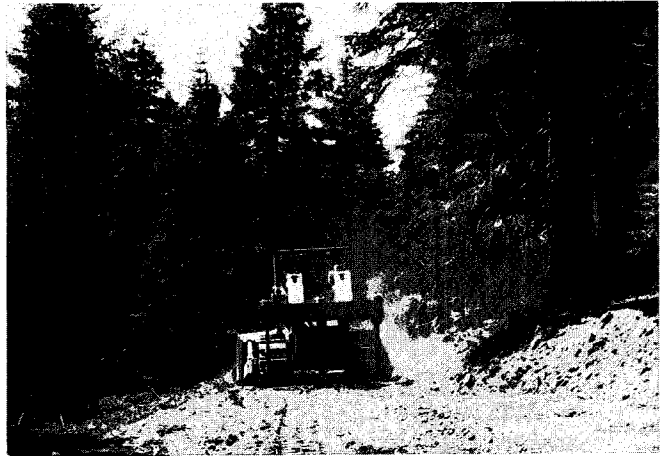
With more than 320,000 miles of roads, the Forest Service has one of the largest road systems in the world. Because 95 percent of these roads are aggregate-surfaced or unsurfaced, the Forest Service road system presents Engineers with a formidable design and management challenge. One tool currently being used to meet this challenge is the automated Surfacing Design and Management System (SDMS), which incorporates design, performance, and cost models and produces optimal surfacing design alternatives.

The SDMS is a useful surfacing-thickness design and management system, but now the Forest Service has an opportunity to improve the system by creating a road surface performance data base. With an annual roads expenditure of \$500 million to \$600 million per year, the Forest Service could save millions of dollars a year by making even very modest improvements in the way it designs, maintains, and operates its roads (see figures 1 and 2).



Figure 1.--About a quarter of the Forest Service's annual road budget goes to maintenance, such as this grading of an aggregate road on California's Six Rivers National Forest.

Figure 2.--A first step in road building:
bulldozing a logging road in Six Rivers Na-
tional Forest.



The SDMS is a computer program that calculates and maximizes surfacing design and rehabilitation strategies using information about available construction materials, expected traffic volumes and loads, various costs, required surfacing performance, and materials characteristics. This automated system offers the designer several advantages. Rather than having to labor over complex calculations, the designer can instead concentrate on optimum surfacing strategies and consider the economic tradeoffs of each. Equally important, the designer can consider many more important factors than would be possible using manual design methods--factors such as levels of reliability and seasonal variation in materials and traffic volume. By predicting the performance of the road surface, the system also provides an invaluable planning and management tool that helps planners better predict future budgeting needs and manpower requirements, thereby allowing them to make the most of available funds.

As with any computer-aided design system, the more accurate the information used to construct the models, the more accurate the models are--and the more accurate the models, the more successful the system the models support. This is true in the case of the SDMS. During the trial implementation of the SDMS, Engineers who used the program generally agreed with its results in designing bituminous pavements. At the same time, they felt that models for aggregate road surfaces were inadequate and sometimes produced overly conservative--and therefore costly--designs. In the case of aggregate-surfaced roads, the structural model used is based upon the current USDA Forest Service design method,

Figure 3.--Roads are built to carry this kind of traffic; here, a timber hauler ties down logs before heading down the mountain.



which combines the AASHTO design equation for flexible pavements with the U.S. Army Corps of Engineers' Thickness Design Charts. In the case of unsurfaced roads, there are no design parameters at all. Recognizing the worldwide lack of information about aggregate and unsurfaced roads, Forest Service Engineers understood that to improve the system significantly it would be necessary to develop a road surfacing performance data base. The Engineers also recognized that an improved model would need to better take into account the unique characteristics and circumstances of Forest Service roads. Even within the boundaries of a single Forest, let alone within an entire Region, these roads can encounter great extremes of climate and topography. They also can encounter other factors such as very heavy axle loads, seasonal traffic variations, and low-volume traffic (see figure 3).

With these factors in mind, the Forest Service contracted with the University of Texas at Austin in 1981 to do a study of the feasibility of assembling such a data base--the first phase of a pioneering three-phase study on the performance of aggregate and unsurfaced roads that is being followed with interest by road engineers in this country and around the world.

PHASE I:
DATA BASE
FEASIBILITY
STUDY

The first phase of the project was a study regarding the feasibility of creating a data base to be used in direct connection with the SDMS to improve surfacing-thickness design methodologies and maintenance planning. In particular, the study concentrated on the following:

- (1) Identifying and selecting variables to be included in the data base.
- (2) Reviewing data collection practices.
- (3) Developing a sample plan for systematically collecting data.
- (4) Reviewing formats and operational guides for collecting information.
- (5) Developing a plan for a pilot study.
- (6) Developing a long-term management plan for the data base system.

With these efforts complete, research engineers at the University of Texas concluded that the project was not only technically feasible but necessary to improve the SDMS. They also concluded that, even under the most conservative assumptions, the substantial long-term savings in total transportation costs for the Forest Service would far exceed the cost of gathering such a data base. In light of these findings, the Forest Service initiated Phase II of the project, a pilot study designed to check the performance and operation of each of the devices and methods proposed for measuring variables in the data base.

PHASE II: PILOT STUDY

The Forest Service contracted with Austin Research Engineers, Incorporated (ARE), to conduct the Phase II pilot study. This study was designed to evaluate available equipment alternatives for measuring surface performance and to develop procedures, forms, computer software, and instructions for implementing a Service-wide data base.

ARE gathered data on 10 test road sections in Wenatchee, Snoqualmie, and Olympic National Forests in Washington State. These test sections were chosen to represent different types of surfacing and varying elevations, as well as a range of temperature, moisture, topographic, and traffic conditions. Study data was later analyzed using techniques proposed for use in the Service-wide data base.

Finally, the pilot study recommended equipment to be used in collecting data in the Phase III effort. For gathering data on road performance, the recommended equipment was the AASHTO Rut Depth Gauge, the Mays Meter (for measuring roughness), the rod and

level (a grid system for calculating aggregate loss), and a dust pan and wire brush (for measuring surface looseness).

For measures of variables that affect the rate of road deterioration, the study recommended several pieces of equipment. For onsite materials characterization, it recommended nuclear devices for in-place density and moisture, as well as a Dynaflect for deflection. For materials characterization, it recommended the resilient modulus test, Atterberg limits, gradation analyses, and moisture-density curves. The study also recommended bore holes for measuring layer thickness, lateral trenches for measuring subgrade deformation, mechanical inductive counters for measuring traffic, the use of log board feet for measuring vehicle loads (as checked with portable wheel-load weighers), and local weather station data and onsite temperature recorders and rainfall gauges for measuring environmental factors.

In addition, the report recommended that the data base be developed in stages in lieu of a more costly and intensive primary study encompassing a full range of test conditions and variables.

PHASE III:
CREATING
the DATA BASE

Under Phase III of the data base project, which began in July 1984, at least 32 road test sections in Regions 1, 5, and 6 (on the Nezperce, Six Rivers, Klamath, Siskiyou, and Six Rivers National Forests) will be studied for a 2-year period. The following factors will be examined to determine their impact on road performance:

- (1) Aggregate thickness (a thin surface being less than 6 inches and a thick surface being more than 10 inches).
- (2) Road grade (a level grade being less than 3 percent and a steep grade being greater than 15 percent).
- (3) Subgrade material (coarse and fine).
- (4) Rainfall (low rainfall being less than 50 inches per year and high being more than 70 inches per year).

Analyses of unsurfaced roads will of course omit the first factor. Performance measurements will be taken on roads with sufficient logging traffic (20

to 40 vehicles per day) to ensure that deterioration is measurable. Each test section will be selected to represent a unique combination of these factors--for example, a steep grade section with a thick aggregate surface and coarse subgrade located in the high-rainfall northern section of Siskiyou National Forest.

This time, ARE is working with Labat-Anderson Incorporated (LAI), a Washington, D.C.-based firm with expertise in data base management and environmental analysis. ARE is responsible for selecting and managing the field teams and performing the engineering analysis of the collected data. LAI is responsible for selecting the data base management system, screening data submitted by field teams, creating and maintaining the data base, and coordinating ARE's efforts.

To ensure Regional cooperation, the Forest Service's Washington Office sent letters notifying Regional Foresters and Directors of Engineering about the study and requesting their assistance and ideas. Regional Forest Service personnel will be kept abreast of project findings and other useful data the study produces as it becomes available. The Regional Offices, in turn, have appointed three Coordinators: Bob Hinshaw of Region 1, Ted Stuart of Region 5, and John Steward of Region 6.

All three of these Forest Service personnel are Geotechnical Engineers, and all have helped enlist the assistance and ideas of road design and maintenance personnel in those National Forests where potential tests sites are located. Contacts in these Forests, in turn, have suggested candidate sites, provided knowledgeable guides for field reconnaissance, and made other necessary arrangements and introductions.

The Opening Stages: Selecting Test Sites. All test sections will be sufficiently long tangent sections. Team researchers see the resulting exclusion of curved sections as an unfortunate but unavoidable limitation in view of available funding, which ultimately determines the number of factors that can be analyzed. But safety also argues for sufficiently long straight test sections: because roughness testing requires a constant speed, turns immediately before or after a short tangent section would make stopping or maneuvering dangerous. Researchers agree that 1,000-foot sections would be

Figure 4.--A good candidate aggregate test section on Oregon's Siskiyou National Forest--reasonably straight, with good sight distance.



ideal, but they have had to settle for sections 500 feet to 800 feet long on the twisting roads of the Pacific Northwest (see figure 4).

At their first meeting in July, the team members determined that the history of the given road should be taken into account, along with such factors as the quality of engineering and construction and the amount of maintenance. Because they want to evaluate currently existing road standards, the ARE/LAI team and their Forest Service counterparts also agreed that test sections should be selected from roads that have been built fairly recently.

Results of the First Field Trip. The first week-long field trip was conducted from August 5 through August 12, with Adrian Pelzner, Chief Materials Engineer of the Washington Office, representing the Forest Service; Dr. Philip Sczerzenie representing LAI; and Larry Caldwell, Len Moser, and Scot Gibson representing ARE.

The trip began with a Monday meeting in Medford, Oregon, where the team presented an overview of the project to Forest Service representatives. For the rest of the week, the project team and various National Forest employees traveled to five Forests in three States and identified and selected potential test sites. The trip also gave team members a chance to start building good working relationships with local Forest Service personnel, who will advise the team about developments and needs in their respective Forests and Regions during the 2-year project period.

The Future of the Project. After the field trip, ARE began gathering, testing, and certifying the equipment to be used in the project. In late September, the ARE team returned to the various test sites to measure deflection, roughness, aggregate looseness, rut depth, in situ moisture and density, aggregate loss, and aggregate thickness. The team also collected samples of subgrade material for laboratory testing. These data will be collected on 53 sections in preparation for making the final selection of the 32 test sites.

Once these selections have been made, the team will meet once more with Forest Service representatives to discuss in detail how data from these tests can be used to enhance, modify, and revise the SDMS effectively.

Also, ARE and LAI are evaluating work that Region 1 Coordinator Bob Hinshaw and others did on the Nezperce National Forest to measure the variability of subgrade moisture (see figure 5). Not wanting to duplicate the work of others, the team will review this data to see if it is compatible with moisture data to be collected in the Service-wide data base.

In connection with the data base project, the Forest Service will examine some peripheral areas that may yield results early in the project. The following "rapid accomplishment areas" have been established:

- (1) Field measurement of initial and terminal serviceability on earth- and aggregate-surfaced roads.
- (2) The effect of grading policies on surface performance.



Figure 5.--Region 1 Coordinator Bob Hinshaw (third from left) briefing the project team on his subgrade moisture data on Idaho's Nezperce National Forest.

- (3) The effect of the spring thaw on performance.
- (4) The measurement of logging truck tire pressures.
- (5) A comparison of specified road surfacing materials and subgrade characteristics with actual present values.
- (6) Measurements of seasonal traffic distribution as related to road deterioration and maintenance.
- (7) A comparison of loaded and unloaded logging trucks as they affect roads.

CONCLUSION

The project team members appreciated the many courtesies shown to them by Forest Service employees during the week-long field trip; and they feel that the data base project is off to a good start. In the discussions that have taken place to date, there has been widespread support for the project both within and outside the Forest Service. In the meantime there is much to do and much to learn. Future Field Notes articles will report on the progress of the project as well as any preliminary findings. The readers of Field Notes are encouraged to send their comments and suggestions to Andrea Myslicki, Project Manager, Surfacing Data Base Project, 1111 19th Street North, Suite 600, Arlington, Virginia 22209.

How the Off-Duty Environment Affects On-Duty Production & Safety

*Darrell McNenny
Regional Environmental Engineer
Region 1*

THE OFF-DUTY/ ON-DUTY RELATIONSHIP

Many Forest Service crews not only work together but also live together, "recreate" together, eat together, and may even cook together in a very close and controlled environment. This aspect of their Forest Service experience can either be one of fond memories or of miserable times. In either case, the attitudes and relationships they develop during off-duty hours have a direct effect on production and safety during on-duty hours. Crew supervisors have a very significant responsibility to their crews to ensure that this off-duty environment is both safe and enjoyable.

ROLE of CREW SUPERVISORS

Facility Planning

Working within his or her authority and responsibility, the supervisor needs to ensure that existing facilities are safe, clean, and suitable for the number and type of crew members that will be using them. Modifications and repairs may be required. If a remote camp is to be established, crew supervisors will be intimately involved in planning decisions and implementation, including construction of facilities.

Knowing When To Ask for Help

The many aspects of crew facilities are complex. This is why the Forest Service hires specialists in these areas. If there is any question as to the safety or adequacy of a facility or a utility, such as an electrical or water system, it is the responsibility of the supervisor to request assistance. Likewise, if design help is needed for modification or new facilities, help is available from Forest or Regional personnel.

The Crew Supervisor as the Example

No one influences a crew's attitude toward safety and production more than the crew supervisor. This influence is magnified in the off-duty setting. If a crew senses a change in the crew supervisor's

attitude from on-duty to off-duty, they will respond accordingly. In many instances, such as a remote camp, crew supervisors are placed in the same close controlled environment as the crew they supervise all day. Their examples and attitude in this off-duty setting will not only dictate the safety and sense of enjoyment of the off-duty experience but also safety and production on the job.

The Crew Supervisor as the Enforcer

A well-maintained and clean crew facility is a safe, enjoyable, and productive environment. The crew supervisor shares this responsibility with higher management. Crew supervisors need to work with the crew to establish schedules and methods for keeping facilities clean and safe. They must also be responsive to complaints and be aware particularly of crew members who are uncooperative or not doing their share. Without being obtrusive, crew supervisors should inspect facilities almost daily for cleanliness, neatness, operation, safety, adequacy, and apparent problems. They may also assist higher management personnel on more formal routine inspections, which should be held as often as necessary but not less than twice per month. The crew supervisors should also be available for discussions if specialists are called in to review a particular area or problem.

The Crew Supervisor as the Trainer

The role that the supervisor plays in on-the-job training and identification of training needs is well established. However, there is also a need that relates to the off-duty crew member's health and well-being. The first requirement is that crew supervisors must be adequately trained so that they can be aware of the needs of the crew. The need for first aid and defensive driving skills are somewhat apparent. Less apparent may be such needs as understanding basic safe food-handling practices for crews in which crew members are cooking for themselves or in small groups.

CREW FACILITY STANDARDS

Crew facilities range from modern crew quarters at ranger stations to remote field camps where trailer houses, recreation vehicles, or even tents may be used. The crew supervisor shares the responsibility with higher management to ensure that the facility is appropriate for the intended use and meets minimum standards.

Site

Sites should be high, dry, and well drained. Low, wet areas, areas with tree hazards, and bug-infested areas should be avoided. South-facing aspects are

most desirable, particularly in northern climates. Capability for development of adequate water supply and sewage disposal may dictate final site selection.

Shelter

Separate and equal facilities shall be provided for men and women. A minimum of 50 square feet of usable floor space per person is recommended for short-term use and up to double that amount for long-term, permanent use. Tents with floors are acceptable as sleeping quarters for summer crews in relatively dry climates, but more permanent facilities should be constructed if the site is to be used at least seasonally for the foreseeable future.

Water Supply

Crew supervisors are personally responsible for ensuring that the water supply meets the quality requirements of FSM 7420. If there is any doubt in their minds, they should require all employees to boil all drinking and cooking water for at least 5 minutes prior to use. Water used on-duty for drinking must also be taken or hauled from a potable source. At a minimum, supplies used for crew facilities must be disinfected and routinely tested for bacteriological contamination at least monthly. It may be the crew supervisors' responsibility to maintain the system and test the water. In any event, they will want to ensure that this is being accomplished as part of their responsibility to their crew. Technical specialists at the Forest and Regional Offices are available and should be called on whenever development of a new water supply is being considered or when a problem is suspected with an existing system.

Toilet Facilities

In general, separate toilet facilities should be provided for men and women. Dual-use facilities are acceptable for temporary or short-term use if a lockable door is provided. Facilities may range from modern bathrooms at developed sites to primitive pit or vault toilets at remote, low-use field camps. In either case, crew supervisors should ensure that these facilities are adequate for the intended use, provide sufficient privacy, are routinely cleaned, and meet various Forest Service, State, and local standards for sewage disposal. As with water supplies, Forest or Regional technical specialists should be consulted if new facilities are proposed or if problems are encountered with existing facilities.

Showers & Handwashing Facilities

These are amenities that are taken for granted at developed sites but may be sadly lacking at some field camps and remote stations where use is low or intermittent. It is at these sites that crew supervisors must be particularly aware of the specific situation and call on the ingenuity of themselves and their crews to provide at least minimum facilities for the sake of proper hygiene. It is not unreasonable for crew supervisors to expect these facilities to be provided prior to occupancy of a site for long-term use or by large crews.

Solid Waste

Proper handling of garbage and trash may also be a responsibility of crew supervisors. They must work with the crews to ensure that solid waste does not accumulate in kitchen and sleeping areas, that it is properly stored in fly-tight containers, and that it is hauled to an approved landfill at least at the end of each 4- to 10-day tour. Use of camp pits for disposal generally is not acceptable.

Food Service

From a health, safety, and even a production standpoint, food service is one of the most critical off-duty activities. This is particularly true at this time throughout the Forest Service since "Fixed" and "Modified Food Service Facilities," as defined in FSM 7490, are being abandoned in favor of "Semiprivate" or bachelor cooking. The unfortunate result of this transition is severely inadequate facilities coupled with a general lack of safe food-handling knowledge by employees who are expected to cook for themselves and even for other small groups of employees. Crew supervisors may be involved in decisions such as what kind of cooking facilities will be provided, whether or not an experienced cook will be hired, and so on. Their ability to help in making these decisions is not only based on their evaluation of the crew's abilities but their own understanding of required food service facilities and safe handling practices.

Foodborne Illness. Foodborne illness may be caused by biological, chemical, or physical hazards, with biological hazards being the most prevalent. In many cases, illness may not be severe or long lasting, but crew supervisors should be familiar with incubation periods and symptoms so they can at least recognize the possibility that food may be involved and perhaps prevent further occurrences.

Biological Hazards. Biological hazards are classified as either infections or intoxications. Infections occur from ingesting food that contains live, harmful microorganisms. Intoxication results from ingesting food that has either naturally occurring toxins present or is contaminated by microorganisms that give off toxic or poisonous wastes. The four major foodborne diseases of bacterial origin are Staphylococcus aureus intoxication, Clostridium botulinum intoxication, Clostridium perfringens infection, and Salmonella infection.

Incubation periods range from 1 to 6 hours for staph, 8 to 22 hours for clostridium perfringens, 6 to 48 hours for salmonella, and 12 to 36 hours for the deadly botulism. In all cases except botulism, abdominal pain and diarrhea will be present, with vomiting and nausea also prevalent with staph and salmonella cases. It is suspected that the common case of "summer flu" among Forest Service crew members may, in fact, be mild food poisoning.

Chemical Hazards. Chemical contamination can occur at any point along the food supply chain and at the food service facility. This concern centers on pesticide contamination, excessive use of food additives, toxic metal contamination, and contamination by chemical cleaners or solvents stored improperly next to food products.

Physical Hazards. Faulty equipment can result in physical hazards such as microwave oven radiation, glass chips, metal curls from can openers, etc.

Food Service Problems & Prevention

Crew supervisors can play a key role in the prevention of foodborne illness by ensuring that proper equipment is available and by working with their crews to establish safe food-handling practices.

Unsafe Temperatures. Handling prepared foods of a potentially hazardous nature at room temperature and using unsafe refrigeration and hot holding temperatures is directly responsible for a large percentage of foodborne illnesses. Crew supervisors need to ensure that proper refrigeration is provided, particularly at field camps. In addition, supervisors should be aware of crew cooking habits and ensure that the crew is aware of proper food storage, preparation, and holding temperatures. The rule of thumb, "keep hot foods hot and cold foods cold," is a good lesson for all to remember and will serve as

a reminder to keep potentially hazardous food below 45 °F or above 140 °F so that microorganisms cannot multiply so rapidly.

Poor Personal Hygiene. Poor personal hygiene is one of the primary contributors to bacteria that cause foodborne illnesses. Again, crew supervisors should ensure that washing and bathing facilities are provided, particularly in field camps. They should also be aware of any crew member with particularly poor hygiene habits and speak to these individuals in a confidential manner.

Cross-Contamination. One of the problems with several persons cooking in the same facility, as is the growing custom at many Forest Service sites, is the potential for cross-contamination between raw food products and cooked or ready-to-serve products. Such items as cutting boards, slicers, graters, and grinders may not be cleaned and sanitized from one use to the next; bacteria is transferred from raw products to ready-to-serve products in this manner. Crew supervisors should be aware of this problem and insist that each crew member thoroughly clean each utensil, counter, and cutting board after every use.

Unsanitary Dishware and Equipment. Again, multiple cooks represent a hazard to each other unless they accept the responsibility for properly cleaning all dishware and utensils after each use. Crew supervisors should insist that this be done.

Infected Food Handlers. Food service personnel with infected cuts, burns, sores, boils, sore throat, nasal discharge, diarrhea, and similar problems present a significant hazard in a food service operation. Likewise, a crew member with similar problems who is cooking with or for other employees presents an opportunity for spread of staph, strep, and various other infections. Supervisors should be alert to the general health of each crew member and take whatever steps might be necessary to preclude the spread of any disease through the food service operation.

Unsafe Food-Handling Procedures. Many cooks are guilty of poor food-handling procedures, such as improper thawing of frozen food at room temperatures or in warm water, slow cooling and reheating of foods, use of leftovers that have sat at room temperature for extended periods, and failure to

reheat or maintain food at safe serving temperatures of 140 °F. Crew supervisors need to be aware of these problems and instruct crew members in proper procedures as the need is indicated.

Improper Food Storage. If several crew members use the same refrigerator, the potential for the raw foods of one individual to contaminate the prepared foods of another is significant. Food products in a refrigerator or cupboard should be covered, and raw foods should not be stored above or in contact with prepared foods. A problem somewhat unique to Forest Service crews is refrigerated food that spoils while employees are away on fire or other details for extended periods. Crew supervisors should periodically inspect storage areas and accept the responsibility for throwing out spoiled food products.

Insects and Rodents. Crew supervisors should be familiar with the droppings, rub marks, gnawings, and tracks of various pests and take appropriate action to pest-proof facilities or exterminate pests as appropriate. Generally, pesticides should not be used unless applied by a knowledgeable exterminator.

Chemicals Stored Near Food. Since cleaning and sanitizing compounds, solvents, and other nonfood chemicals may be used in crew facilities, it is important to provide separate space away from food products for these materials. Crew supervisors should be aware of this problem and be alert to improper storage procedures.

Close-Range Photogrammetry at Work on Tough Measuring Jobs

W. H. Valentine
Geometronics Engineer
Region 1
& Roger Crystal
Geometronics Engineer
Region 6
& Gerry Salsig
Photogrammetric Engineer
Region 5
& J. B. Stewart
Photogrammetric Engineer
Region 3

Close-Range Photogrammetry (CRP) is beginning to be recognized within the engineering community as an effective method to use for difficult measuring and mapping requirements. It is a rapid, accurate, and low-cost means of measuring, mapping, and documenting objects, areas, and sites. Field operations are relatively simple and quick, requiring only basic measuring equipment to provide control.

Camera requirements are the main consideration for field operations. A metric camera, that is, one with a distortion free lens, calibrated geometry, and reference marks, is preferred. Although it is technically feasible to use nonmetric cameras, experience has shown that accuracy is better and subsequent plotting problems will be reduced by using metric cameras.

Plotting of two-dimensional drawings, such as building elevations, can be done on analogue instruments available at Regional Offices. Objects or sites requiring full three-dimensional plotting, such as topographic maps, are better handled with an analytical plotter. All Regions have access to the Geometronics Service Center (GSC) analytical plotters. GSC photogrammetrists are gaining experience in CRP and will be able to provide assistance.

At least four Forest Service Regions have recent experience in using CRP. Other organizations are also making use of this versatile measurement tool. Below, examples of several applications are presented to stimulate ideas for possible use of CRP in your own measuring, recording, or site-mapping projects.

BRIDGE SITE
MAPPING--
STANISLAUS
NATIONAL FOREST
(SUMMIT CREEK)

The Summit Creek Trail Bridge site is located high in the Sierra Nevada Mountains. A bridge spanning 140 feet, 60 feet above the stream bed, will carry a foot trail at this site. The north side of the site drops off rapidly, becoming vertical with overhangs. The south side is somewhat more gentle, with slopes of 70 percent to 100 percent, made up mostly of irregular rock outcrops and boulders. Mapping the intricate contours of this site by traditional field methods would be both time-consuming and dangerous. A good portion of the north side is not accessible to ground survey. Although the physical characteristics of this site make field topographic surveys very difficult, they actually make CRP mapping easier.

A site map was prepared in 1:120 scale with 2-foot contours. Two stereo models (four pictures), exposed facing each other from opposite sides of the stream, gave adequate coverage.

Project photography was exposed using a Wild P32 camera, with a 12-foot separation between exposures in each stereo model. Factors affecting exposure separation included local site conditions, the plotting instrument to be used, and scale of the map.

Control targets were prepared in advance using a simple black and white pattern in alternate quadrants reproduced on paper with a Xerox copier. Horizontal control was established by trilateration using total station Electronic Distances Measuring (EDM) equipment. Vertical control was established by differential leveling.

Each of the two stereo models was set up for map compilation in a Jena Topocart stereo plotter. Preliminary dial settings for each model were obtained by analytical methods. Each model provided a side (horizontal) view of the terrain, instead of the more conventional vertical aerial view. Plotting of overhangs, in which the contours cross each other,

presented no problem. A set of eleven surveyed test points were used for accuracy checks. The standard error of the elevation differences was only 0.06 feet.

The whole job (survey to final map) took less than 8 person-days. Figure 1 shows a similar bridge site on the Klamath National Forest that was mapped using CRP. Note the crossed contours at the overhangs. To date, a total of three bridge sites in Region 5 have been mapped using CRP.

STRUCTURAL
MONITORING--
MT. HOOD
NATIONAL FOREST
(MULTNOMAH FALLS
LODGE)

This historic and picturesque lodge was built in 1925 by the city of Portland, Oregon, for the Forest Service. Settlement has been occurring at the west end of the structure, and pressure grouting has been tried to prevent further settlement. CRP was selected as a method for monitoring the results. Permanent target positions were established along the north-facing facade of the lodge, and a survey base line was established along the highway in front of the structure. Nine camera stations were established along the base line, and photos were taken at 1-, 2-, and 7-month intervals using a Wild P32 camera.

Measurement of the photography was accomplished using a Jena Topocart stereo plotter. Photo triangulation data were adjusted using Simba Software, resident at the Fort Collins Computer Center. Data evaluated after every measurement have shown little or no significant new settlement.

Another purpose of the project was to demonstrate to architects, archaeologists, and others how CRP can be used to document historical sites. The north side of the 135-foot structure was plotted at $\frac{1}{4}$ inch per foot. Every rock, window, door, or other discernible feature of the building side was recorded as to shape, size, and location (see figure 2).

ARCHITECTURE/
ARCHAEOLOGY--
BITTERROOT
NATIONAL FOREST
(ALTA RANGER
STATION)

Alta Ranger Station was the Forest Service's first Ranger Station. It was built at Alta, Montana, on the west fork of the Bitterroot River in 1899 by Rangers H. C. Tuttle and Than Wilkerson. In 1904, the site reverted to private ownership under a mining claim. The Lions Club of Hamilton, Montana, purchased the site in 1941 and donated it back to the Service for preservation as a historical landmark.

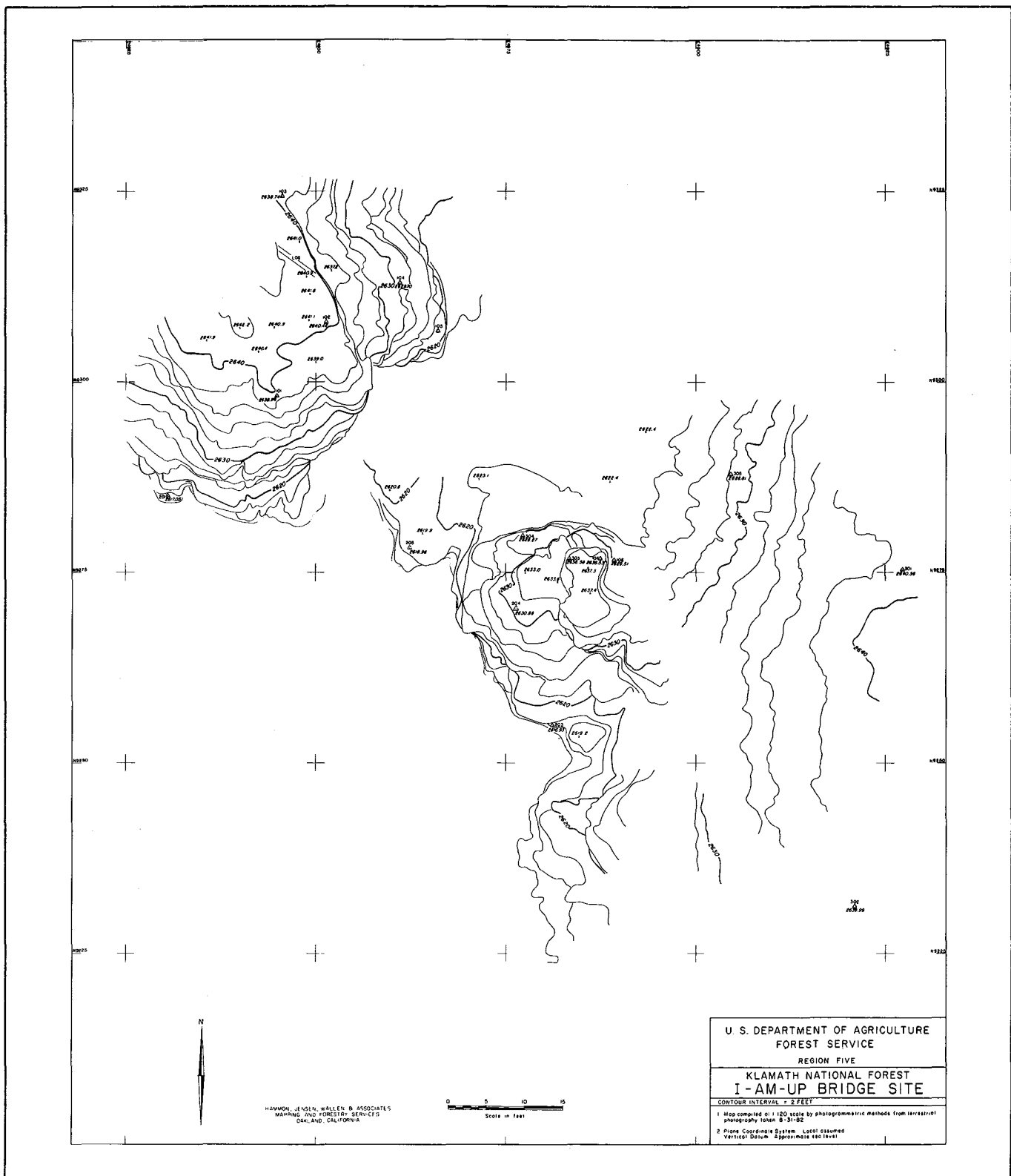


Figure 1.--Bridge site mapped using Close-Range Photogrammetry.

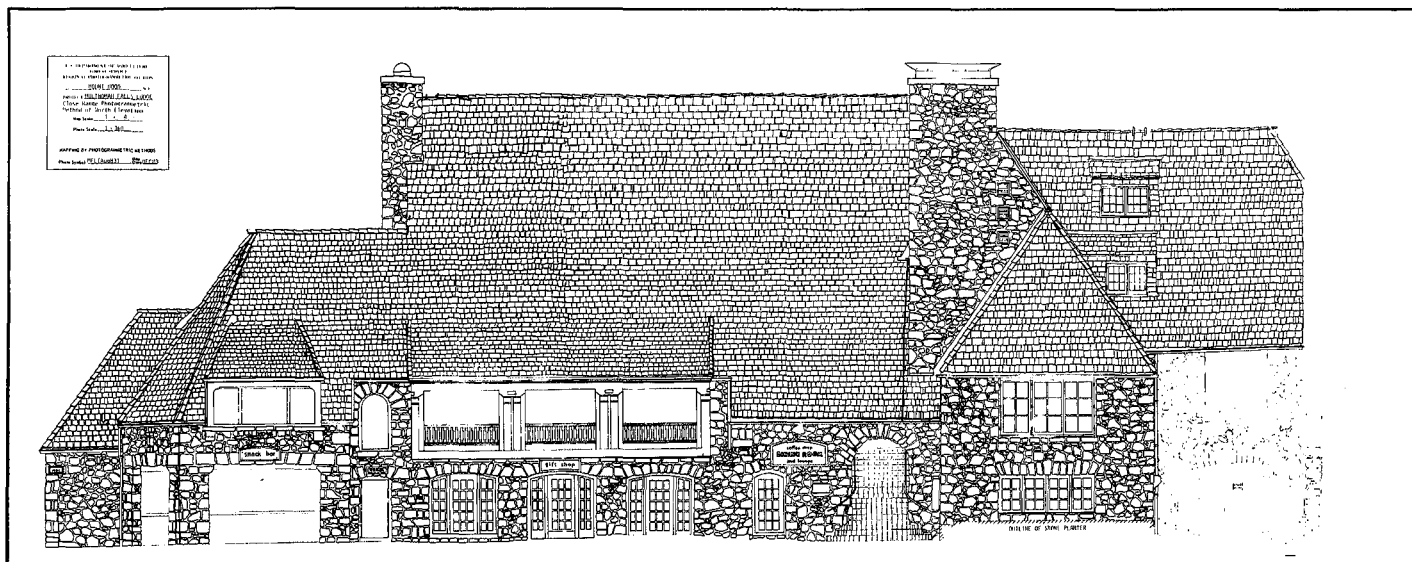


Figure 2.--Photogrammetric mapping of Multnomah Falls Lodge.

CRP was used to document the structure last year (see figure 3). Photos were taken with a Wild P32 camera, and stereo models were plotted with a Jena Topocart. Control was established using vertical and horizontal level rods set up near the building.

ARCHITECTURE--
CORONADO
NATIONAL FOREST
(GUARD CABIN)

The Region 3 Cultural Resource Management Group requested the Photogrammetry Unit's assistance in creating a graphical record of a guard cabin on the Coronado National Forest (see figure 4).

The location of this cabin was at the Deer Creek Administrative Site adjacent to the Galiuro Wilderness. The cabin was to be removed to make room for new facilities that were to be built at the site.

The reason for this graphical record was two-fold:

- (1) To create a historical record of this cabin, which was the original building at this Administrative Site.
- (2) To demonstrate to the Forest archaeologists that this type of service and product was available to them.

The Cultural Resource Management Group provided a stereoscopic pair of photographs that were enlarged 3.5 times from the original 35-millimeter slides. The photographs were taken with a 35-millimeter camera that had a 50-millimeter lens. The scale dimension provided was the height of the door at 6 feet.

The following recommendations are made for similar close-range photogrammetry projects in the future.

- (1) The photographs must be taken perpendicular to the front of the object. The horizontal spacing between the photographs should be on a 1:20 ratio. The distance to the object from the camera stations should be the same. The horizontal center axis of the photographs must be at midheight of the object, with the camera stations at the same elevation. The photographs must cover the same view.
- (2) Any camera can be used as long as the focal length is known. If very detailed or accurate measurements are needed, a metric-designed camera must be used.

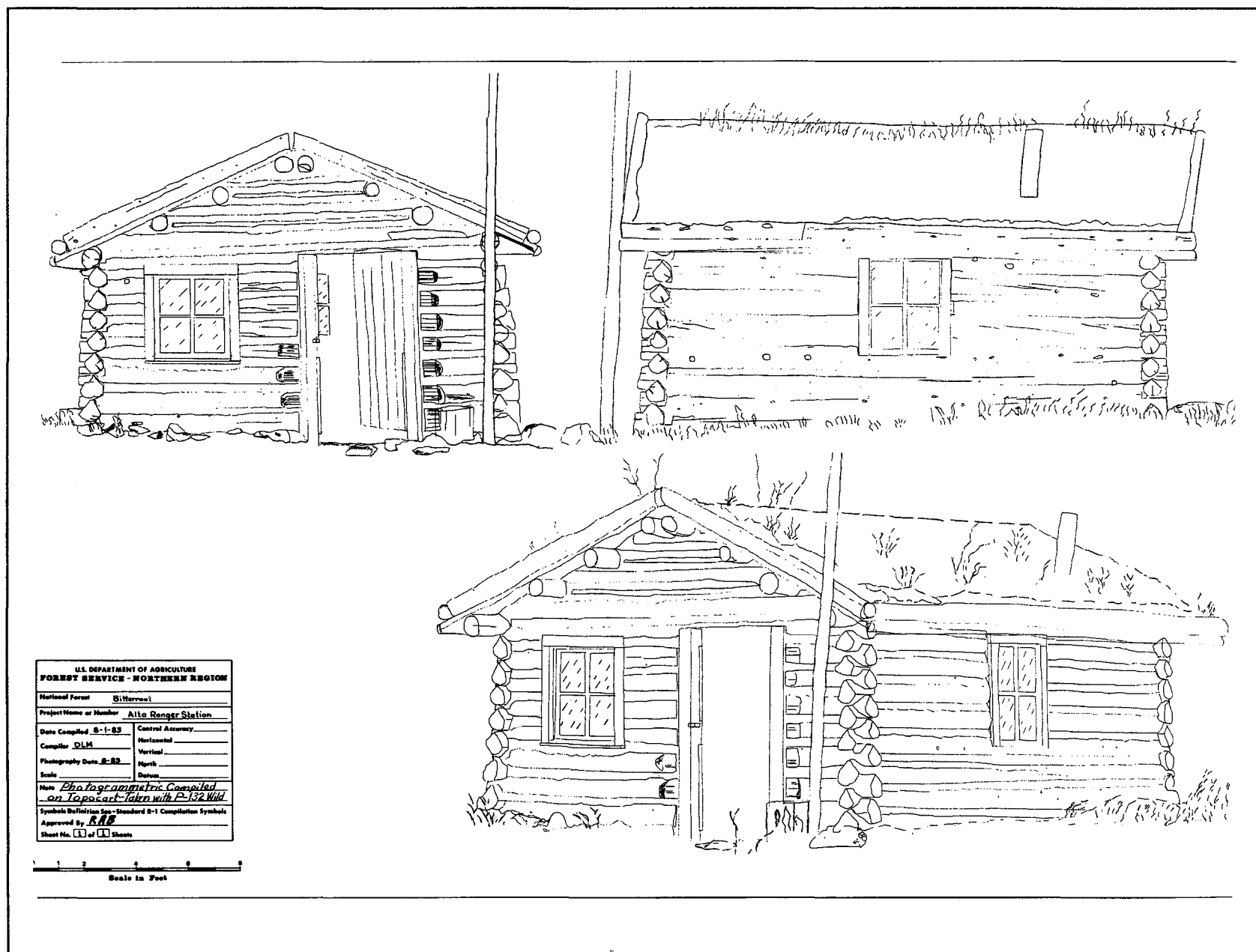
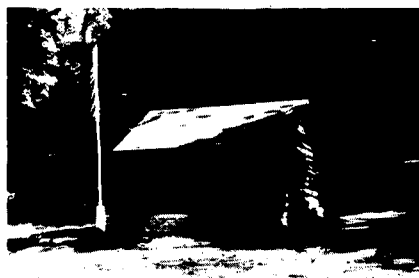
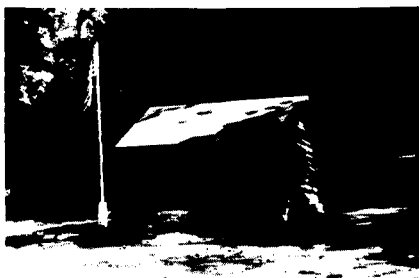
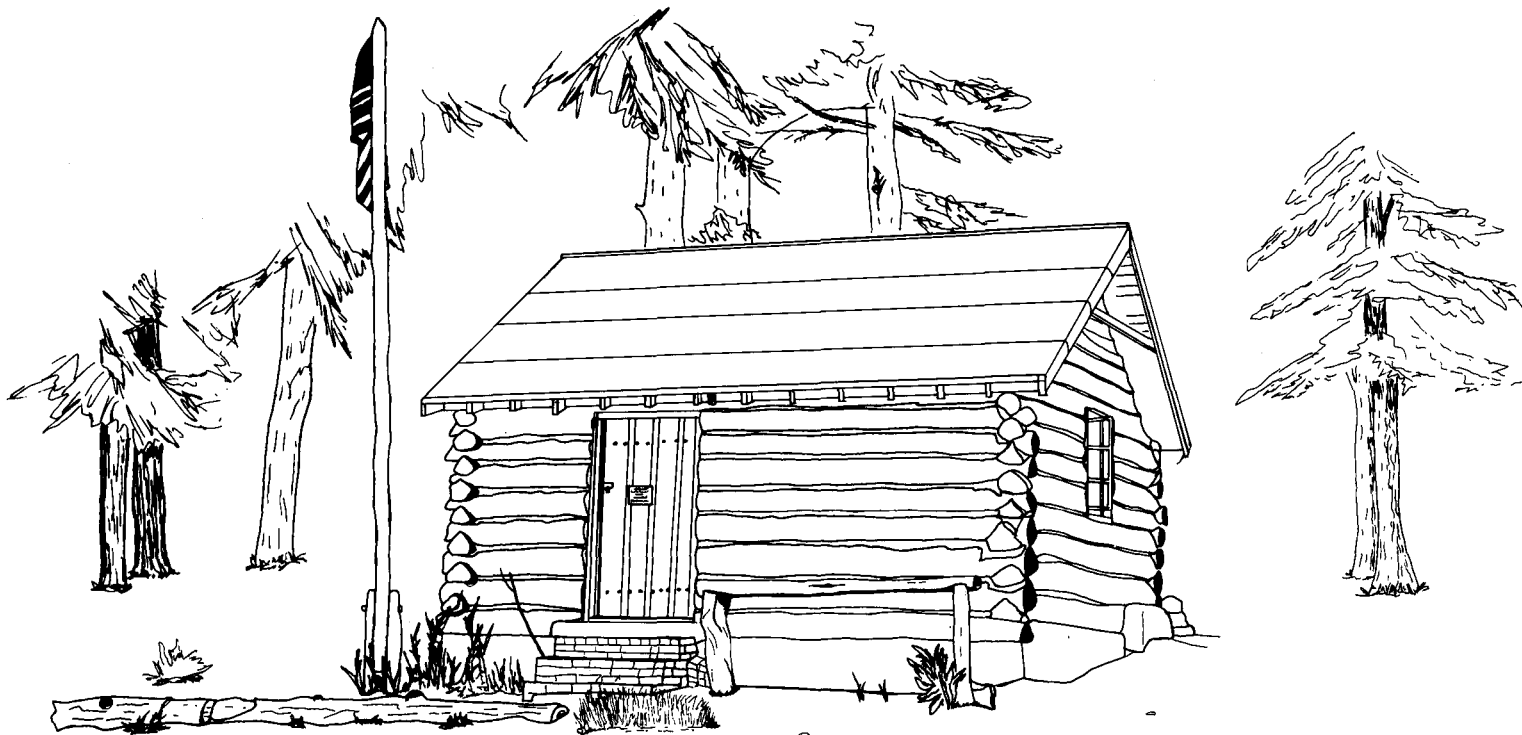


Figure 3.--Alta Ranger Station.



Recreation Cultural Resources
Reproduced from terrestrial photographs,
with PG-2 stereoscopic plotter.

September 28, 1981

Figure 4.--Coronado National Forest guard cabin.

- (3) Four control points and the distance between two of these points are required. The distance to the camera stations is required for all points. These points will form a square or a rectangle at the edge of the object or viewed area.
- (4) The original film and one set of prints of the photographs are required for this type of project.

ARCHAEOLOGY--
KANIKSU NATIONAL
FOREST (BEAR PAW
ROCK)

Bear Paw Rock is a petroglyph site located on a near vertical rock outcrop on the shore of Lake Pend Oreille in northern Idaho. The site is well preserved, having escaped most of the ravages of vandals. CRP was used to document the site in its current state. Photography was obtained with the Wild P32. Control was established by placing level rods and range poles in the scene.

The stereo model was plotted with the Wild BC1 analytical plotter. This project is interesting because of the technical approach used. The rock had been plotted previously by a private firm, using an analogue instrument; however, the first plot was an oblique view, and the glyphs appeared foreshortened. In addition, it appeared that the first model had been improperly set, introducing distortions in the plot. The first photos, however, did have the glyphs highlighted with chalk, making them more visible. A new plot, in the correct perspective and without distortions, was needed. New photography was taken with new control. Common points appearing in both old and new photography were measured using the BC1 plotter and the new photography. The old photography with the chalked glyphs was then reset in the BC1 using the common points as control, and the final plot was then compiled (see figure 5). The versatility of the analytical plotter enabled this project to be completed successfully.

EROSION
MEASUREMENTS--
NEZPERCE
NATIONAL FOREST
(HORSE CREEK
PROJECT)

Some years ago, several cut slopes on new road construction were monitored with close-range, nonmetric stereo photography with the idea that erosion occurring from the cut slopes could be measured. Actual photo measurement was delayed until analytical instruments capable of handling non-standard photography were available. Recently, this project was partially resurrected, and the erosion that occurred at several sites during the period

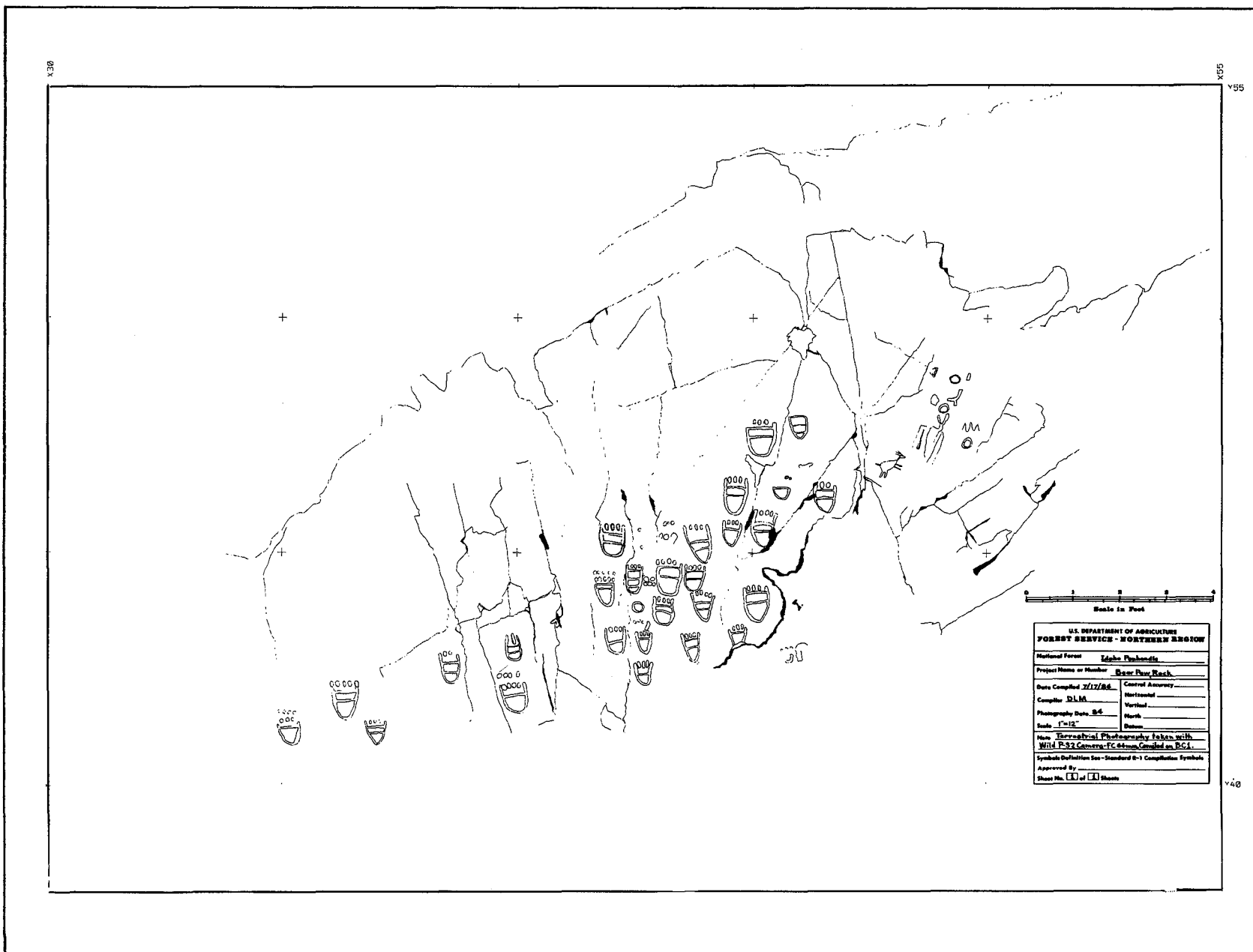


Figure 5.--Bear Paw Rock.

of 1 year was measured. Erosion of about 1 centimeter was reliably detected. Measurement accuracy could be improved further by using calibrated cameras.

BRIDGE
INSPECTION--
ENGINEERING
NEWS-RECORD

Those interested in the application of CRP to bridge inspection should read the April 19, 1984, issue of "Engineering News-Record," which carries an interesting article telling how to measure the deflection of a bridge under load as part of an inspection program.

Engineers and other specialists in the Forest Service are urged to consider CRP as a tool to assist in difficult measuring, mapping, or documenting jobs that are frequently encountered. In these times of shrinking workforce and tighter budgets, along with other traditional pressures, CRP can be a real help.



United States
Department of
Agriculture

Forest
Service

R-9

Reply to: 7100 Engineering Operations

Date: August 1, 1984

Subject: Publication Recommendation, Engineering Technical Information System:
Paper by Roger Pekuri, "Cross Country Ski Trail Planning, Development
and Operation Considerations"

To: Chief

Enclosed are two manuscript copies of a paper by Civil Engineer Roger Pekuri, Superior National Forest. The paper is adapted from the text of a speech Roger gave at a Forest recreation specialists' meeting last year. Our review shows it to be a comprehensive, well written and practical treatment of the major considerations in planning, development and operation of cross country ski trail systems. We recommend that it be published as a Field Notes article.

The paper reflects Roger's engineering and skiing backgrounds, which combine to provide a high degree of technical expertise and knowledge of the sport and users' needs.

Roger has been continuously active in recreational and organized competitive skiing during and since college days. He has spent many hours in his Forest Service engineering capacity, and on his own time, in ski trail and trail bridge planning, layout and construction.

Roger was a top-20 member of the U.S. Ski Team in 1976 and 1980, finished second in the 50 Km National Championships in 1976, and continues to compete successfully in many other regional and national events (long and ultra-distance running as well as skiing). He is an active member of the Central Division Ski Team and Master's Team, U.S. Ski Association. Before Forest Service employment, he was involved in development of the Michigan Tech cross country ski trail system, and worked with local clubs in trail layout.

More recently, Roger has participated in development of a system in Michigan which is in use as an Olympic training site facility. His work on National Forest recreational trails and trail bridges has been largely on the Superior and Ottawa National Forests.

We believe the article will be especially helpful to those who, like most of us, do not have Roger's background.

NORMAN G. SEARS
Acting Director of Engineering

Enclosure

cc: Ottawa N.F. - Pekuri
Superior N.F.
RRWL - G. Lundy



Cross-Country Ski Trail Planning, Development, & Operation Considerations

*Roger Pekuri
Civil Engineer
Superior National Forest
Region 9*

The following considerations are intended for guideline reference when planning, laying out, constructing, and maintaining cross-country ski trails. The principles discussed apply to both groomed and non-groomed trails, with user safety always in mind. Trail layout requires imagination, blending the need for interesting, scenic trails with ease and economy in maintenance and grooming. It is the thought process that goes into layout and construction that determines the extent of the user's enthusiasm for and use of the trail later on.

TRAIL PLANNING & OBJECTIVES

Before any field work is scheduled, give careful thought to identifying the objectives of the trail system and to planning its development from the conceptual to the use stage. Geographic location, anticipated amount and type of use, visual quality, and cooperative arrangements with the private, State, and local sectors are considerations to be explored to ensure efficient trail development, use, and maintenance.

Locate trail systems only where an identifiable need has been established. Systems can be located near population centers to allow for quick access from home to evening or weekend skiing; they can be in more remote or wilderness areas, often in cooperation with resort owners, to handle weekend or vacation use. Whatever the need, the system should be located so that demand is fully satisfied; the trails are responsive to the management plan for the area, and the terrain is suitable for trail construction and has scenic value.

Tools for assessing terrain and scenic potential include local family maps, aerial photos, and land type association and ecological land type maps (with descriptions). Review of the Forest Plan and recreation opportunity spectrum classes (with reference

maps) will give insight into area management objectives for development levels and recreation opportunity.

Explore the possibilities of cooperative or voluntary service arrangements with private parties, such as resort owners or associations, or with State or local government agencies for all or portions of the construction and maintenance. Often, a cooperative arrangement can help supply construction dollars or transfer maintenance costs to the users--to the benefit of all. Trail grooming by a cooperator can relieve the Forest Service of personnel needs while benefiting the cooperator. This is particularly true of grooming reliably performed by a resort, resort association, or club on nearby trails.

Determine the degree of grooming (if any) to be performed. The majority of high-use trail systems should be planned so that grooming will ensure skiing safety and enjoyment. The current trend in demand is for more groomed trails. This does not preclude planning nongroomed trails in the more remote areas. The need for both types exists--which type to provide at a particular site must be well thought out.

Parking is a major problem that is often overlooked, and parking lot planning is critical. Snow removal from lots is often difficult and a responsibility that nobody really wants. A good planning effort for skiing facilities should include some planning for parking.

TRAIL LAYOUT

Ideally, a trail system should consist of trails of varying difficulty levels to accommodate skiers of different abilities. Each trail should be rated and signs posted for the highest difficulty level to be encountered at any point along it. The rating should be posted on signs along the trail. Novice ("easiest") trails should originate at and return to the trailhead. Intermediate ("more difficult") trails should radiate off the novice trails and occupy areas farther from the trailhead. Advanced ("most difficult") trails should be located farthest from the trailhead and tie into the intermediate trails. It is not desirable to connect intermediate or advanced trails directly to the trailhead because novice skiers could inadvertently start off on trails too advanced for their abilities. Novice skiers should be able to start and finish at the trailhead without being forced to use more advanced

trails. The general scheme, then, should be to keep the easiest trails closest to the trailhead and the most difficult farthest away.

Recommended trail lengths for half- and full-day skiing are given in table 1. Providing cutoffs on a system of basic loop trails can accommodate skier needs for different distances.

Generally, trail system composition should be as follows: 25 percent easiest, 50 percent more difficult, and 25 percent most difficult, based on total system length.

The levels of trail difficulty planned for a system should take into account the grooming needed. Generally, grooming will result in safer skiing, so an increased number of more and most difficult sections can be included. Nongroomed trails tend to develop downhill runs that become rough and increase in difficulty as skiers snowplow and fall down. Therefore, groomed trails may include all three difficulty levels, while nongroomed trails should generally include only easiest and more difficult levels; figure 1 shows a nongroomed trail. Also, grooming frequency must increase with trail difficulty to maintain the safety and quality of the skiing experience.

Visual Principles of Trail Layout. Trail layout should use basic visual management principles related to a varied skiing experience, such as incorporating known scenic points into the trail experience. A variety of features such as overlooks or vistas, lakes, bluffs, meadows, clearcuts, rivers, and unique trees make a trail interesting and divide it into memorable segments. The trail should pass through or by as many different types

Table 1.--Recommended trail lengths.

Trail Difficulty	Length (Kilometers)	
	Half Day	Full Day
Easiest	5	10
More Difficult	7	15
Most Difficult	10	20



Figure 1.--Skiing along a downhill on a narrow, ungroomed cross-country ski trail.

of timber and vegetation as possible. This adds variety to the experience. Clumps of mature white pine are a pleasing sight after skiing through a uniform stand of mixed birch and aspen. Even tag alder can be a pleasant change. On the trail, the skier should encounter as many different sights, terrains, and moods as the forest settings can provide. Figures 2 through 5 provide examples of interesting variety on a ski trail.

Minimize trail junctions to reduce the number of decisions a skier must make. This aids in maintaining one-way traffic flow on the system and allows skiers to navigate the system more easily during first-time use. Locate junctions on level ground or tops of hills to eliminate stopping difficulties in the junction area after descending a hill. Junctions should present the skier with as few choices as possible; for instance, a preferable junction might include the main through-trail with only one side trail either entering or leaving.

Trail layout generally should avoid crossing steep south-facing slopes, which are prone to early melting. If south-facing slopes must be crossed,



Figure 2.--Ski trail through birch and balsam fir--differing timber types--and touching the upper edge of a clearcutting unit.



Figure 3.--Ski trail leaving a clearcut and entering a conifer stand.



Figure 4.--Example of trail location along a timber type boundary, showing two distinct timber views.



Figure 5.--Example of trail alignment along the edge of a clearcut unit.

consider laying the trail through conifer vegetation for shading--or on the flattest part of the slope for least sun angle.

It is preferable to lay out trails for one-way traffic. This provides safer skiing and a more solitary experience. However, even with proper signing to direct one-way flow, there are always skiers who

inadvertently or intentionally ski the trail backwards. Wherever possible, therefore, trails should be laid out for safe skiing in either direction.

Grooming Needs. If grooming is planned, the layout should accommodate this need. Grooming equipment should be able to travel the trails in the same direction as the skiers and negotiate curves and hills without "bogging down" or having to back up and edge forward. Trail loop layout should allow grooming of the entire system with a minimum of "dead-heading" or doubling back.

If the trail is also designed for summer uses, keep trail structures such as puncheon walkways to the edges of wet areas. This will allow skiers and grooming equipment to cross the area on frozen ground in a straight path. Bridges that are used in both summer and winter can be hazardous. Snow cornice on a bridge can be very deceiving; skiers may think they are centered on the bridge when they really are not. Also, such factors as snowload and grooming machine weight must be considered before using the bridges during the summer.

TRAIL GRADE & ALIGNMENT

One of the most important aspects of trail alignment is fitting the trail to flow smoothly with the terrain, resulting in a curvilinear trail that is pleasing to look at and enjoyable to ski (see figures 6 and 7). Skiers want to ski and to enjoy the forest and scenery; they usually are not concerned with getting from point A to point B in the shortest time possible (except, perhaps, to escape the sameness of a poorly designed trail). When locating a particular segment, the trail line should take advantage of the terrain ahead; the flagged line should be compatible with the land forms and exciting to ski. Initially, the flagged line may appear "too curvy" and raise unjustified concerns; clearing will usually smooth and blend the curves with the linear alignment. In general, limit straight sections of trails to no more than 200 or 300 feet.

General Rules for Trail Layout. General rules of thumb for laying a trail on the land include the following:

- (1) Try to locate the trail on ridges, low hills, or subtle rises to facilitate drainage.



Figure 6.--Example of curvilinear trail alignment.



Figure 7.--Example of curvilinear trail alignment.

- (2) Do not locate sharp curves at the bottom of downhills.
- (3) Cross streams at right angles if possible. If a trail bridge is required, make the approaches as flat as necessary for safe skier approach speeds (see figure 8). Bridge railings can be intimidating and hazardous when a skier enters a bridge at excessive speed (10 to 15 miles per hour or faster). Railings are definitely dangerous if the snow accumulates to the same depth as the rail height.
- (4) To minimize excavation, avoid sidehill locations where cross slopes exceed 7 percent.
- (5) When laying a trail through swamp, flag a curvilinear alignment or skirt the edge for views of both upland and swamp.
- (6) Try to avoid wet areas, those that are last to freeze in the fall and first to thaw in the spring.
- (7) Generally, avoid ice crossings (lakes and rivers) so that trail safety will not depend on ice conditions.
- (8) Try to avoid areas with excessive surface boulders.

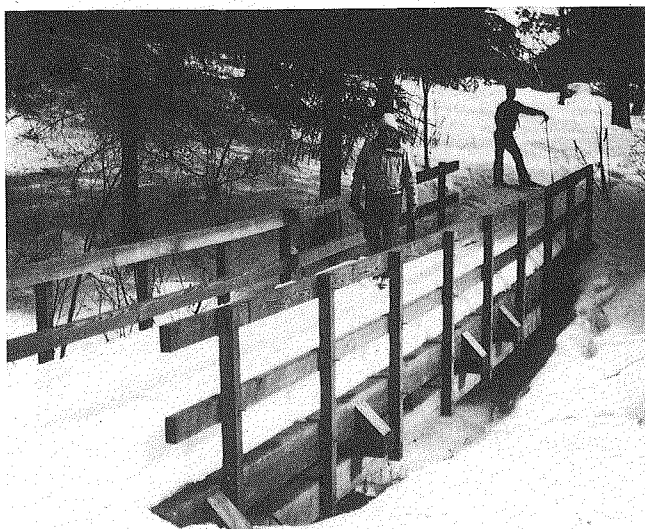


Figure 8.--Example of trail bridge and approaches.

Applying the rule of thumb for grade composition (one-third uphill, one-third downhill, one-third flat), try to distribute the hills and flats so that the physical demands on the skier are equalized along the trail. This also adds variety and anticipation to the skiing experience.

Curves. The sharpness of curves should be appropriate for the terrain and for the speed a skier will carry through them. Sharp curves must be smooth enough for skis to "track" reasonably well in the grooves and for groomers to negotiate. Generally, a 10-foot radius curve is about as sharp as a groomer or skier can comfortably follow. Sharper curves may cause the skis to jump out of the tracks and, thus, require low travel speed.

Curves at bottoms of hills or in other high-speed areas should be gradual enough to give the skier every reasonable advantage in making the turn--taking into account the wide range of skier abilities. The higher the speed that is carried through a curve, the more gradual the curve should be.

Downhills. Downhills are often the most difficult aspect of trail layout. The downhills must be consistent with the planned difficulty level of the trail. Setting limits for downhill grades for each difficulty level will help achieve rating uniformity between different trail systems. The following recommended grades for the three trail levels are comparable to limits observed on many established trail systems in the Midwest:

- EASIEST: A maximum sustained downhill of 5 percent to 8 percent, with a maximum allowable pitch of 10 percent to 15 percent. These trails accommodate the beginner skier. Try to keep maximum travel speeds below 10 miles to 15 miles per hour. Pitch is used to denote sections of downhill runs that are steep but short--generally 20 miles to 50 feet, depending on difficulty level.
- MORE DIFFICULT: A maximum sustained downhill of 10 percent to 15 percent, with an occasional maximum allowable pitch of 20 percent. This class accommodates the average skier. Try to keep maximum travel speeds below 20 miles to 25 miles per hour.
- MOST DIFFICULT: A maximum sustained downhill of 15 percent to 20 percent, with an occasional maximum allowable pitch of 25 percent. This class accommodates the expert or advanced skier. Try to keep maximum speeds below 30 miles per hour.

Choosing the best route for a downhill run is most important for safety reasons. The majority of injuries on ski trails result from falls on downhills. The route selector has to use imagination and experience to visualize how a hill will ski. The selector must anticipate different skiing conditions and estimate maximum travel speed. For example, the route designer should envision skiing down the hill in question during icy, spring conditions. The trail must be safely skiable under these fast conditions by skiers of the skill level for which it is intended; for example, the trail must be wide enough, curves should not be too sharp, trees or other obstructions should not encroach, downhill speed should be manageable.

No matter how a trail complex is rated and signed, some people cannot resist the urge to take on challenges they may be unequal to. It is not uncommon to find inexperienced skiers crashing down most difficult trails. To some extent, the route selector may be able to protect even these people from their folly.

A final aspect of the downhill section is the runout (see figure 9). Runouts are flat or uphill sections used to decrease speed after a downhill run. They give the skier a chance to regain control and composure after the downhill rush. The length of the runout should vary depending on the length and grade of the downhill; it can run from 30 feet to 100 feet and be straight or slightly curving.

Uphills. Uphills must be carefully laid out and complement the downhills. An otherwise enjoyable ski trail can earn a bad reputation if there are too many herringbone or sidestep climbs. Uphills should generally be skiable (kick and glide), with only occasional herringbone and few if any sidestep sections.

Most National Forest trails are intended for recreational ski touring rather than the more rigorous demands of competitive nordic skiing. Ski touring implies a slower, relaxed pace, weaker kick, and less grip. Uphills should be moderate enough to accommodate this.

Easiest trails should have no herringbone sections. More difficult trails may have occasional herringbone sections less than 30 feet in length. Most difficult trails may have occasional herringbone

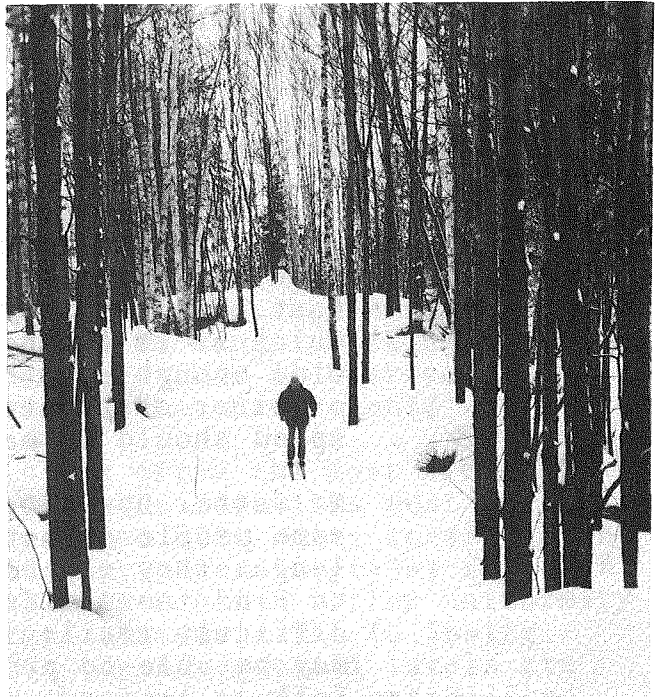


Figure 9.--Example of downhill run with runout.

sections longer than 30 feet but generally no more than 60 feet to 80 feet.

It can be misleading to use a fixed maximum gradient to define a herringbone hill. This limit varies depending on snow conditions and skier ability. Generally, however, an uphill of 10 percent to 15 percent can require herringboning. Where possible, flat or slightly downhill segments should break up long uphill sections. This gives the skier a chance to recover and prevents the uphill from becoming "overwhelming."

The grooming equipment is another important consideration in uphill layout. A trail cannot be groomed if the machine cannot negotiate the hills and turns.

Table 2 sets forth guideline limits for uphills. These guidelines are based on a 5-kilometer trail loop; they are generally representative of uphill maximums on well-planned recreational ski trail systems in the Midwest. Some moderate increases in these limits may be necessary and justified in more mountainous areas. Where this is necessary, the maximums should be consistent with standards common to the general area--conforming to what the skier's expectations are.

Trails through predominantly flat or gently sloping land should take advantage of available terrain to provide uphill-downhill breaks in an otherwise flat trail. For example, consider a proposed trail area where the terrain is essentially flat but slopes gently in one general direction. Instead of laying out a flat trail cutting across the slope (following the contour line), have the trail "wander" up and down the slope to introduce some "hills" (even if the "hills" are slight.) This will result in a more varied trail and give the skier a chance to "work and loaf" alternately.

TRAIL WIDTH & TREAD

Trail width requirements vary depending on such factors as terrain, steepness of trail, sharpness of curves, amount of use, and number of tracks. Generally, in flat or gently rolling terrain, single-track groomed trails should be cleared 6 feet to 8 feet wide, and one-way, double-track trails cleared 10 feet to 12 feet wide. Two-way, double-track trails should be wider, up to 14 feet, to provide a safe trail. When laying out trails 6 feet to 12 feet wide, consider how to keep summer 4-wheel

Table 2.--Guidelines for uphill climbs.

	Maximums		
	Easiest	More Difficult	Most Difficult
Greatest Single Climb (elevation gain of single continuous climb)	35 ft	70 ft	140 ft
Elevation Differential (lowest to highest point on trail)	100 ft	250 ft	500 ft
Total Climb (sum of all elevation gains)	150 ft	400 ft	650 ft
Greatest Sustained Gradient (over 150 ft trail distance)	7.5%	12%	17%
Greatest Short Gradient (under 50 ft trail distance)	10%	20%	--

drive vehicles off the trail. Proper layout or location of the trail can usually solve this problem.

Widths for Uphills, Downhills, and Curves. Uphill sections should include extra clearing width for areas where herringbone or side-step climbing techniques may be necessary. The extra width should be one and one-half times the normal width, up to 14 feet maximum. This widening will help keep ski tips from catching on brush, trees, or unpacked snow at the edge of the trail.

Downhills require extra widening commensurate with the speed of the hill. The lower portions and run-outs require the most widening, the upper portions the least. Normally, the middle third of a downhill should be cleared one and one-half times the normal width. Starting two-thirds of the way down the hill to the bottom and through the runout, the trail should be cleared twice the normal width.

It is important to note that some downhills will require more widening than suggested to eliminate

potentially hazardous conditions. Safety is the bottom line.

Curves, especially on downhills and runouts, also require extra widening commensurate with the sharpness of the curve and the speed a skier will carry through it. Remove problem trees, rocks, or other obstructions on both edges of the clearing. On the inside of the curve, remove trees that lean excessively into the trail. The outside of the curve usually presents the major safety concern because centrifugal force tends to push the skier to the outside. Watch for individual trees, rocks, or other obstructions that protrude from the general clearing limits. Sharp branch stubs pointing up the trail can be especially hazardous.

Terrain Considerations in Trail Layout. Ski trails, especially those in wilderness, often have to be constructed without mechanized equipment. Therefore, make construction, maintenance, and use easier by routing the trail on the smoothest ground available. Avoid obvious problem areas such as ledges, boulder fields, holes, humps, and stumps. Also avoid routing that requires cutting down large trees. The resulting stumps are difficult to remove or blend into the tread.

Avoid excessive side slopes. They make grooming and skiing more difficult. Adverse side slope can be roughly defined as exceeding 7 percent or more than a 1-foot drop in an 8-foot width across the trail (8:1 slope).

Avoiding adverse side-slope conditions is difficult in hilly areas. Where the conditions are unavoidable, it may be necessary to build up the downhill side with cleared logs, branches, rocks, or other material to hold the snow and help level the trail. Also, the uphill side can be excavated, although it requires more work. Often, a combination of both will yield the best, most cost-effective results.

For best drainage, it is preferable to route trails along ridges or similar land forms. This allows runoff to flow naturally away from the trail. Good drainage is particularly important for early fall and late spring skiing when wet conditions prevail.

Grubbing the Trail. Grub the "tread area" to produce a reasonably smooth path for the groomer. This is particularly important during periods of little

snow. For a single-track trail, grubbing a minimum 6-foot width is sufficient. A double-track trail should be grubbed at least 10 feet wide.

Grubbing consists essentially of removing logs, branches, stumps, and exposed roots that form high spots or humps and filling in the low spots to form a relatively smooth tread. The low spots can be filled in with soil, logs, rock, brush (compacted), and other other material.

The difference between the high and low spots should be no more than 6 inches to 8 inches across a 10-foot width. This will allow the groomer to do an adequate job of packing, dragging, and cutting a track with minimum snow cover--10 inches to 12 inches.

Exposed rocks, tree stumps, and brush stubs in the tread area are a particular nuisance; they tend to catch skis and damage the grooming machine, drags, and cutters. An otherwise excellent trail can be difficult to groom and unsafe to ski if the "tread area" is not properly prepared.

Clear overhead branches and other obstructions to a minimum height of 10 feet above average maximum snow depth over the full width of the trail.

When Trails Intersect Roads. When a trail must cross a road, keep the width to a minimum (as shown in figure 10) to make the trail less obvious to operators of such vehicles as ATV's, off-road vehicles, 4x4 light trucks, and pickups. Sometimes, even when this is done, appropriate barriers or signs are necessary to deter unwanted traffic.

When motorized equipment is used to construct a trail, the equipment operator needs to know that the trail entrance is meant to be narrow. In fact, it may be advisable to construct the first 100 feet by hand.

Do not consider ski trails and facilities complete until they have been used successfully for at least one season. Normally, the first season of use will point out needed improvements, such as additional clearing, minor trail realignment, drainage work, and signing.

TRAILHEADS

The trailhead is the key to proper use of the trail system, and its planning and design are important. A trailhead's primary function is to provide safe

Figure 10.--Example of narrow width of trail clearing after crossing an unplowed road.



and adequate parking at the desired starting point. Keep in mind that the size of the plowed parking area will control the upper limit of trail use, so it must be based on careful demand estimates.

Planning should identify and evaluate suitable alternative locations at an early stage. Coordinate site selection, design, and construction between landscape management and engineering specialists and the local land manager and staff.

The following are important aspects to consider when designing and building the trailhead.

- (1) Design trailheads for snowplowing efficiency and adequate snow storage. Make arrangements with local highway authorities for scheduling trailhead plowing with normal road plowing operations.
- (2) Location of the trailhead entrance should provide adequate sight distance, based on type of road, traffic, and driving speed.
- (3) Trailhead entrance road and parking area grades should generally be less than 3 percent to 5 percent to avoid vehicle slippage problems.
- (4) Trailheads should include adequate information and map boards explaining system layout and other trail information.
- (5) In deep snow areas, higher than normal sign mounting or vertically adjustable signs and bulletin boards may be needed.

TRAIL SIGNING,
MARKING, MAPS,
& INFORMATION
SERVICES

Various levels of signing and marking may be used on trail systems to communicate information needed by the user. All trails require a minimum of signing and marking. Generally, the more extensive systems require more informational signs and marking.

Using hiking trails and roads as ski trails can be a big problem. Grooming machines used on deep snow damage road signs and summer trail signs.

The Pocket Map. Perhaps the most useful information medium is the pocket map carried by the skier. Used with on-trail "locator" or destination signs, the pocket map keeps skiers informed of their locations on the trail. The following items should be included on the map:

- (1) Show only essential information pertaining to trail use, such as ski trails, roads, snow-mobile trails, railroads, shelters, lakes, streams, named peaks or high hills, and trail-heads. The maps should be uncluttered. Geographic information helps the skiers keep their bearings and determine progress.
- (2) Print the ski trails in contrasting colors or shades to make them stand out from other map detail.
- (3) Mark the trails with arrows to show the correct directions of travel, and note distances between trail junction points. Distances can be expressed in kilometers or miles or both. The international cross-country ski trail distance standard is kilometers (even in this country). Many skiers prefer kilometers with mileage equivalent in parentheses.
- (4) The legend should show the symbols for the different trails, roads, parking areas, shelters, and trail junctions. Trail junctions may be shown by numbers or letters in a circle. The map should define the symbols that are posted on the trails to indicate levels of difficulty and show the trails marked accordingly. The difficulty symbols are a green circle for easiest, a blue square for more difficult, and a black diamond for most difficult. Each symbol contains a terrain graphic symbol indicating relative steepness.

Signs on the Trail. Trailhead signing should, as a minimum, include a system layout map, trail name or names, and directional signs for the start of the trails. More extensive signing can include a bulletin board with trail system map, rules of use, warnings of hazards, location of nearest emergency assistance, and general trail information. The trailhead sign should explain on-trail signing. A standard "Know These Signs" poster is available from Central Supply for this purpose.

Sign trail junctions with either a letter or number, corresponding to those on the trail map, or have a trail locator map posted with a "You Are Here" nail or pointer designating the appropriate junction. Figure 11 shows a sample junction sign. Orient locator maps in the junction so that the view ahead along the main trail or trail choices corresponds with the map view. This helps the skiers orient themselves; they can look at the map, see the trail choices, and look up to see the same choices on the ground.

Post arrows indicating the correct direction of travel at junctions. "Do Not Enter" signs may be

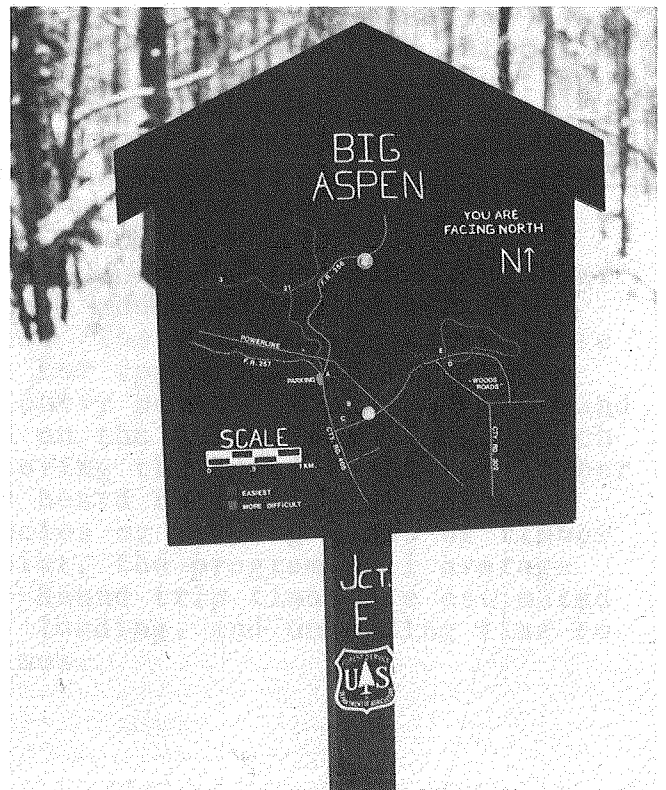


Figure 11.--Example of signing at a junction point.

appropriate for openings on trails on heavily used systems.

Post level of difficulty signs at junctions to confirm the difficulty level of the trail chosen. If vandalism of signs at junctions is a problem, it is desirable to post a second, reconfirming difficulty symbol a short distance from the beginning of the trail (out of sight of the junction). Even without vandalism, this can be a desirable safety practice, especially on most difficult trails.

Locate standard reassurance markers ("blazers") along the trail at intervisible locations, 40 inches above normal snow level, except where clearing limits define the trail. Blazers for ski trails are 5-inch by 7-inch elongated blue diamonds. In remote or wilderness settings, tree blazes may be used in lieu of blazers to better fit the setting.

Additional signing might include interpretive information signs, distance markers, "Caution," "Hill," or "Trail Closed" signs.

Place "Caution" and "Hill" signs so that they are clearly visible to approaching skiers. If a downhill contains curves not visible from the top, a "Curve Ahead" sign below the "Caution" or "Hill" sign may be needed.

Other
Information
Services

Take advantage of information services available through newspapers, radio, television, skier associations, other Forest Service units, the private sector (such as clubs or resorts), and local and State government to inform and educate the public regarding winter recreation opportunities, safety, trail use, and related matters.

Transportation Analysis Memory: A Method of Using the Transportation Information System for Reporting Timber Haul & Road Maintenance Costs

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Region 4*

INTRODUCTION

Costs incurred when using Forest Development Roads to transport timber and other resources are often considered in timber sale appraisals, land resource planning, and transportation planning. The Transportation Analysis Memory (TAM) system calculates route appraisals using information in the Transportation Information System (TIS) data base. TAM retrieves data about the preferred haul route and calculates timber haul and road maintenance costs. Timber haul costs are based on round trip times and distances, using current logging truck operation costs; and road maintenance costs are based on user-supplied maintenance rates. TAM is not a network model. The preferred directions of haul resulting from a manual or automated network analysis are prestored in TIS and retrieved by TAM for summarizing road data to calculate haul and maintenance costs.

In calculating haul and maintenance costs, the user indicates at which road and milepost timber will enter the road system. The user can designate more than one entry point for appraisal; costs will be calculated for each entry point. Costs per thousand board feet are based on the volume per truck, which is determined by entering the species and the number of logs per thousand board feet (size of timber). If more than one species or varying sizes of timber enter at an entry point, the program will average the load per truck. Round trip times are estimated by adding a standby, loading, and unloading time to the actual travel times.

DEVELOPMENT & USES

TAM was developed to eliminate the need to calculate haul and maintenance costs by hand and redetermine the shortest haul route each time a timber sale is appraised. The authors felt that models such as the Timber Transport Model required expertise that was not available or perhaps not necessary on smaller Forests, while familiarity with TIS exists on all Forests. TIS provides a vast amount of data on the road system that can be summarized into an informative and useful report about timber haul.

TAM can be useful in a variety of ways. It produces haul and maintenance costs for a timber sale appraisal that would otherwise be calculated by hand. Transportation planners can summarize haul and maintenance costs between the log mill and alternative points on the road system where new roads might be constructed, which could influence the route selection. Haul and maintenance costs of a timber sale can also be calculated to measure the viability of the offering.

With the multiple entry point feature of TAM, the use of Forest roads in an entire 5-year action plan can be calculated, assisting in road management and maintenance planning.

Costs associated with reconstruction that change the characteristics of a road segment can be measured easily by entering those changes in the data base, using the convenient updating routines of TIS. The preferred haul route stored in TIS can also be changed to assess the effects of right-of-way problems, emergency conditions, or other political concerns.

DATA COMPILATION Three types of data are used in TAM:

- (1) Preferred haul directions prestored for each road in TIS.
- (2) Cost, travel, and load tables prestored in a special TIS record.
- (3) Location and volume for a particular timber sale entered when running the program but not stored in the data base.

The first two categories are stored in TIS by the Forest Data Base Manager. The third category--timber sale data--is entered by a user when the program is run.

Loading the Preferred Haul Routes. TAM requires preferred haul routes to be prestored in TIS by nodes, which are indicated by a milepost along the road. Therefore, a road number and milepost identify every significant point on the road system. Intersections or significant changes in grade are likely nodes. At the intersection of two roads, a node is identified for each road. Management section termini need not be identified because TAM will compare node data with management section data in TIS to provide information about all the management sections between the nodes.

For each node, the preferred direction of haul is indicated by storing in TIS the identification of the node that a road user would go to next. Thus, the data needed for each node are the following:

- (1) The node number, which is the road number and milepost.
- (2) The node number to go to next.
- (3) The elevation of the node to calculate grades.
- (4) An optional description of the location.

An example for gathering this information is shown in figure 1. Nodes are identified along road 10200 at each intersection. Additional nodes are located where significant changes in the grade are observed on the contour map or where the road crosses representative contours on the map.

Directional data is gathered by finding the next node in the direction of haul or the next road if the current node is at an intersection. In the example, the next node for the node at milepost 2.8 on road 10200 is milepost 2.1 on road 10200 as indicated by the arrows. More complicated is determining the next node for milepost 2.1 on road 10200, which is milepost 0.0 on road 10200, not milepost 19.7 on road 10871. The next node for milepost 0.0 on road 10200 is milepost 19.7 on road 10871. In other words, at an intersection, there are two nodes "on top of each other," and if the haul path turns off of one road onto another, both nodes are included in the data. Although this convention makes data coding a little more complicated, it allows an intersection to be stored and identified for all roads at the intersection.

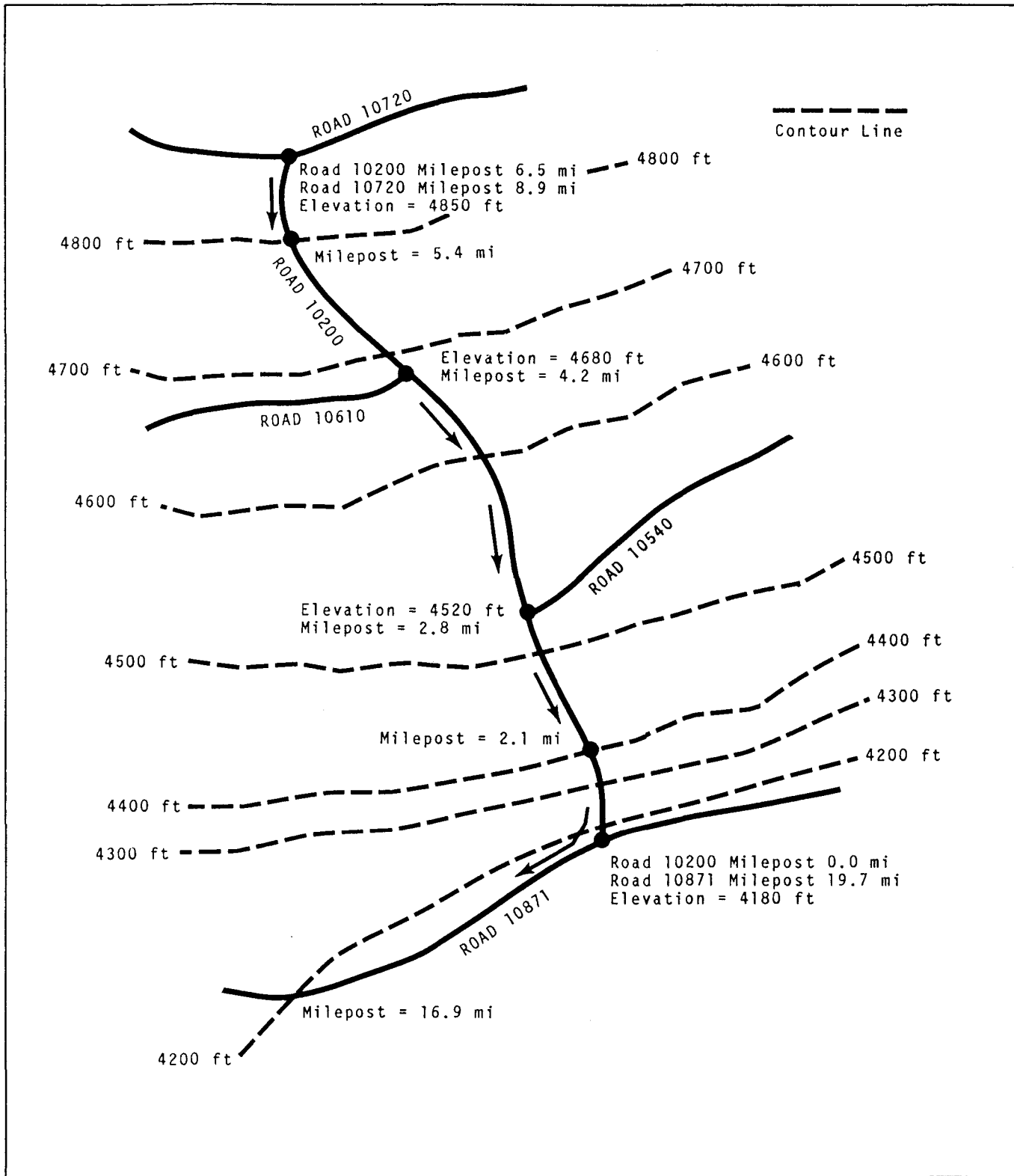


Figure 1.--Information to gather for a typical road. Arrows indicate haul direction.

Figure 2 shows what input into TIS would look like for road 10200. All the nodes on road 10200 are stored in a features or generic record and can be easily retrieved or changed in TIS. Further information about the data entry procedures is provided in the TIS "User's Guide."

Destination points are labeled "MILL" and stored as the next milepost for the node adjacent to the mill. TAM will only calculate a single designated route for each node, with a single destination for each route. Typically, the destination will be the closest mill.

Users may need to add non-Forest Service roads to the data base so that the entire haul route is stored. TIS is designed to do this; the user enters the road as something other than a Forest Development Road in the "systems" component of the TIS data base. Standard TIS reports exclude non-system roads identified in the systems component.

Cost & Data Tables. The following tables are needed for TAM and should be prestored in TIS under a dummy road number labeled "TAM." Tables can be added to a data base by adding the data in the file TIS*R4.TABLES while in the TIS update routine, or tables can be developed by the user.

- (1) Travel Times. This table contains round-trip travel times in minutes per mile based on surfacing type, number of lanes, grade, and traffic service level.
- (2) Standby, Loading, and Unloading Times. This table contains nonhaul time in the truck's round trip. This nonhaul time includes standby, loading, and unloading times, based on species and volume per log.
- (3) Loads per Truck. This table contains the gross volume in board feet per log truck. Gross volume per truck is based on timber species and volume per log.
- (4) Maintenance Costs. The maintenance rates for the Forest are stored for each class of road defined by primary maintainer, maintenance level, surface type, and number of lanes.
- (5) Haul Costs. These current operating costs for logging trucks are stored: fixed cost per year,

Road Number
1* 10200, 21*NODE,

Milepost	Direction of Link Next Road if Different	Next Milepost	Elevation	Optional Location Description
26* <u>6.5</u> ,	27* _____,	28* <u>5.4</u> ,	31* <u>4850</u> ,	321* <u>Jct 10720</u> :
26* <u>5.4</u> ,	27* _____,	28* <u>4.2</u> ,	31* <u>4800</u> ,	321* _____ :
26* <u>4.2</u> ,	27* _____,	28* <u>2.8</u> ,	31* <u>4680</u> ,	321* <u>Jct 10610</u> :
26* <u>2.8</u> ,	27* _____,	28* <u>2.1</u> ,	31* <u>4520</u> ,	321* <u>Jct 10540</u> :
26* <u>2.1</u> ,	27* _____,	28* <u>45.0</u> ,	31* <u>4400</u> ,	321* _____ :
26* <u>45.0</u> ,	27* <u>10271</u> ,	28* <u>19.7</u> ,	31* <u>4180</u> ,	321* <u>Jct 10271</u> :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
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26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :
26* _____,	27* _____,	28* _____,	31* _____,	321* _____ :

Figure 2.--TIS network data.

driver cost per day, variable cost for paved roads per mile, variable cost for unpaved roads per mile, and haul season.

EXECUTION

The following command will execute TAM:

```
@XQT TIS*R4.TAM
```

An example of the input is shown in figure 3 and typical outputs are shown in figures 4 through 7.

APPLICATION

TAM was presented in the Region 4 Forests at the Transportation Planning Workshop in January 1984 and will be implemented on many of the Forests in the near future. The system is currently in use at the Ashley National Forest.

***** TRANSPORTATION ANALYSIS MEMORY *****

ENTER CODE (OR "H" FOR HELP)
FOR THE TYPE OF REPORT YOU ARE ENTERING DATA FOR
>H

TYPES OF REPORTS AVAILABLE

- 1- LISTING OF ROAD SEGMENTS ON HAUL ROUTE AND APPRAISAL
- 2- LISTING OF ROADS ON HAUL ROUTE AND APPRAISAL
- 3- ROAD NETWORK FLOW SUMMARIES
- 13- LISTINGS 1 AND 3
- 23- LISTINGS 2 AND 3

**** ROUTINES TO READ TIS DATA ****

- 4- PRINTOUT OF NODES IN DATA BASE
- 5- PRINTOUT OF TABLES IN DATA BASE USED BY TAM

- 10- INFORMATION ABOUT TAM

ENTER CODE (OR "H" FOR HELP)
FOR THE TYPE OF REPORT YOU ARE ENTERING DATA FOR
>23

ENTER DATA BASE NAME

>TSXXXX

FOR ENTRY POINT 1:

ENTER ROAD NUMBER AT ENTRY POINT

>100720

ENTER MILEPOST AT ENTRY POINT

>7.2

** DATA ABOUT TIMBER AT ENTRY POINT **

ENTER SPECIES OF TIMBER

>PP

ENTER VOLUME OF THIS SPECIES IN MBF

>600

ENTER GROSS NUMBER OF LOGS PER THOUSAND

>10

ENTER SCALE DEFECT (PERCENT OF TIMBER DEFECTIVE--5 FOR 5%)

>5

ENTER ANOTHER SPECIES OF TIMBER (OR RETURN)

>

HIT RETURN IF DONE, OR FOR ENTRY POINT 2

ENTER ROAD NUMBER AT ENTRY POINT

>100610

ENTER MILEPOST AT ENTRY POINT

>1.0

** DATA ABOUT TIMBER AT ENTRY POINT **

ENTER SPECIES OF TIMBER

>LP

ENTER VOLUME OF THIS SPECIES IN MBF

>500

ENTER GROSS NUMBER OF LOGS PER THOUSAND

>30

ENTER SCALE DEFECT (PERCENT OF TIMBER DEFECTIVE--5 FOR 5%)

>10

ENTER ANOTHER SPECIES OF TIMBER (OR RETURN)

>

HIT RETURN IF DONE, OR FOR ENTRY POINT 3

ENTER ROAD NUMBER AT ENTRY POINT

>

>

Figure 3.--Typical input.

HAUL AND MAINTENANCE CALCULATIONS

ENTRY POINT 1
NET VOLUME 570.00 MBF

ROAD	ROAD SURFACE	TRAFFIC LEVEL	SERVICE ONE WAY MILEAGE	ROUND TRIP TRAVEL TIME MIN	* MTCE LEVEL	MTCE COST
100720	NA	D	1.70	10.37	3	.54
100200	NA	C	6.50	33.15	3	2.07
100871	AGG	B	19.70	66.98	4	9.27
US40	BIT	A	10.50	74.27	5	.00

TOTAL MTCE COST PER MBF \$11.88

TOTAL TRAVEL TIME 186 MIN

TOTAL MILEAGE PAVED 10.50

TOTAL MILEAGE UNPAVED 27.90

HAUL COST CALCULATION

- ADJUSTED ROUND-TRIP TRAVEL TIME IN MINUTES 186 MIN
- STANDBY, LOADING, UNLOADING TIME IN MINUTES/TRIP 56 MIN
- TOTAL ROUND-TRIP TIME (LINE A + LINE B) 242 MIN
- AVERAGE NUMBER LOADS/DAY = 720 MIN./TOTAL ROUND TRIP TIME 2.98 TRIPS
- AVERAGE NET VOLUME EXPECTED TO BE HAULED PER TRUCKLOAD 4807. BOARD FT
- TOTAL NET VOLUME TO BE HAULED/TRUCK/DAY (LINE D*LINE E) 14.32 MBF
- TRUCK COSTS:
 - FIXED DAILY TRUCK COSTS:
ANNUAL FIXED COST OF \$15176. / HAUL DAYS PER YEAR OF 150. \$ 101.17 /DAY
 - DAILY TRUCKDRIVER COST \$ 213. /DAY
 - VARIABLE DAILY TRUCK COSTS:
TRIPS/DAY FROM LINE D OF 2.98 X 2 SINCE ROUND TRIP X
(TOTAL UNPAVED MILES OF 27.90 * COST/MILE OF 1.12 +
TOTAL PAVED MILES OF 10.50 * COST/MILE OF .37) =\$ 209.38 /DAY
 - TOTAL TRUCK COSTS/DAY (G1+G2+G3) \$ 523.47 /DAY
- HAUL COST PER MBF (G4/F) \$36.56 /MBF

ENTRY POINT 1 SUMMARY

HAUL COST PER MBF	\$36.56
MTCE COST PER MBF	\$11.88
TOTAL COST PER MBF	\$48.44

Figure 4.--Output for entry point 1.

HAUL AND MAINTENANCE CALCULATIONS

ENTRY POINT 2
NET VOLUME 450.00 MBF

ROAD	ROAD SURFACE	TRAFFIC SERVICE LEVEL	ONE WAY MILEAGE	ROUND TRIP TRAVEL TIME MIN	MTCE LEVEL	MTCE COST
100610	NA	D	1.00	11.30	3	.32
100200	NA	C	4.20	21.70	3	1.34
100871	AGG	B	19.70	66.98	4	9.27
US40	BIT	A	10.50	74.27	5	.00

TOTAL MTCE COST PER MBF \$10.93

TOTAL TRAVEL TIME 175 MIN

TOTAL MILEAGE PAVED 10.50

TOTAL MILEAGE UNPAVED 24.90

HAUL COST CALCULATION

A. ADJUSTED ROUND-TRIP TRAVEL TIME IN MINUTES 175 MIN
B. STANDBY, LOADING, UNLOADING TIME IN MINUTES/TRIP 86 MIN
C. TOTAL ROUND-TRIP TIME (LINE A + LINE B) 261 MIN
D. AVERAGE NUMBER LOADS/DAY = 720 MIN./TOTAL ROUND TRIP TIME 2.76 TRIPS
E. AVERAGE NET VOLUME EXPECTED TO BE HAULED PER TRUCKLOAD 4131. BOARD FT
F. TOTAL **NET VOLUME** TO BE HAULED/TRUCK/DAY (LINE D*LINE E) 11.40 MBF

G. TRUCK COSTS:

(1) FIXED DAILY TRUCK COSTS:

ANNUAL FIXED COST OF \$15176. / HAUL DAYS PER YEAR OF 150. \$ 101.17 /DAY

(2) DAILY TRUCKDRIVER COST \$ 213. /DAY

(3) VARIABLE DAILY TRUCK COSTS:

TRIPS/DAY FROM LINE D OF 2.76 X 2 SINCE ROUND TRIP X

(TOTAL UNPAVED MILES OF 24.90 * COST/MILE OF 1.12 +

TOTAL PAVED MILES OF 10.50 * COST/MILE OF .37) =\$ 175.38 /DAY

(4) TOTAL TRUCK COSTS/DAY (G1+G2+G3) \$ 489.47 /DAY

H. HAUL COST PER MBF (G4/F) \$42.94 /MBF

ENTRY POINT 2 SUMMARY

HAUL COST PER MBF \$42.94

MTCE COST PER MBF \$10.93

TOTAL COST PER MBF \$53.87

Figure 5.--Output for entry point 2.

TOTAL FOR SALE	
AVERAGE MAINTENANCE COST	\$11.46 PER MBF
AVERAGE HAUL COST	\$39.37 PER MBF
TOTAL COST	\$50.83 PER MBF

Figure 6.--Averages of both entry points.

FLOW OF TRAFFIC OVER ROAD SYSTEM

ROAD 100720		
SEGMENT		NET VOLUME
M. P. 7.20----> 8.90		570
ROAD 100200		
SEGMENT		NET VOLUME
M. P. 6.50----> 4.20		570
M. P. 4.20----> .00		1020
ROAD 100871		
SEGMENT		NET VOLUME
M. P. 19.70----> .00		1020
ROAD US40		
SEGMENT		NET VOLUME
M. P. 45.50----> .00		1020
ROAD 100610		
SEGMENT		NET VOLUME
M. P. 1.00----> .00		450

Figure 7.--Output of traffic distribution.

Automated Road Design System

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An Automated Road Design System was proposed and detailed in a feasibility study entitled "Feasibility Study Report for Automated Road Design System/Graphics," prepared and presented to the Washington Office Engineering Staff in September 1983. This article has been prepared for publication in Field Notes at this time for the purpose of increasing awareness of the potential for using the least squares technique in new ways to improve the efficiency of Forest Service employees. The system concept is adaptable to any road design system.

INTRODUCTION

This paper documents a conceptual framework for developing an Automated Road Design System (ARDS). The proposed system will automatically select a cost-effective location (L) line based on the survey data of a preliminary (P) line and the road designer's specifications. It will also be an interactive and user-friendly system, allowing the designer to make design adjustments easily. Road Design System (RDS) will be integrated in the proposed system for quantity computation.

THE PROPOSED SYSTEM

The proposed system will produce interactive graphics displays and hard copies of L-line, profile, cross section, and prints of earthwork quantities and design parameters. Two types of system inputs are P-line data, which will be obtained from field survey, and road design standards, which will be determined by the road designer. The procedure for using these inputs to design and obtain L-line and other outputs is discussed in this section and shown in figure 1.

The system begins with P-line data as input. The designer then enters the P-profile design standards,

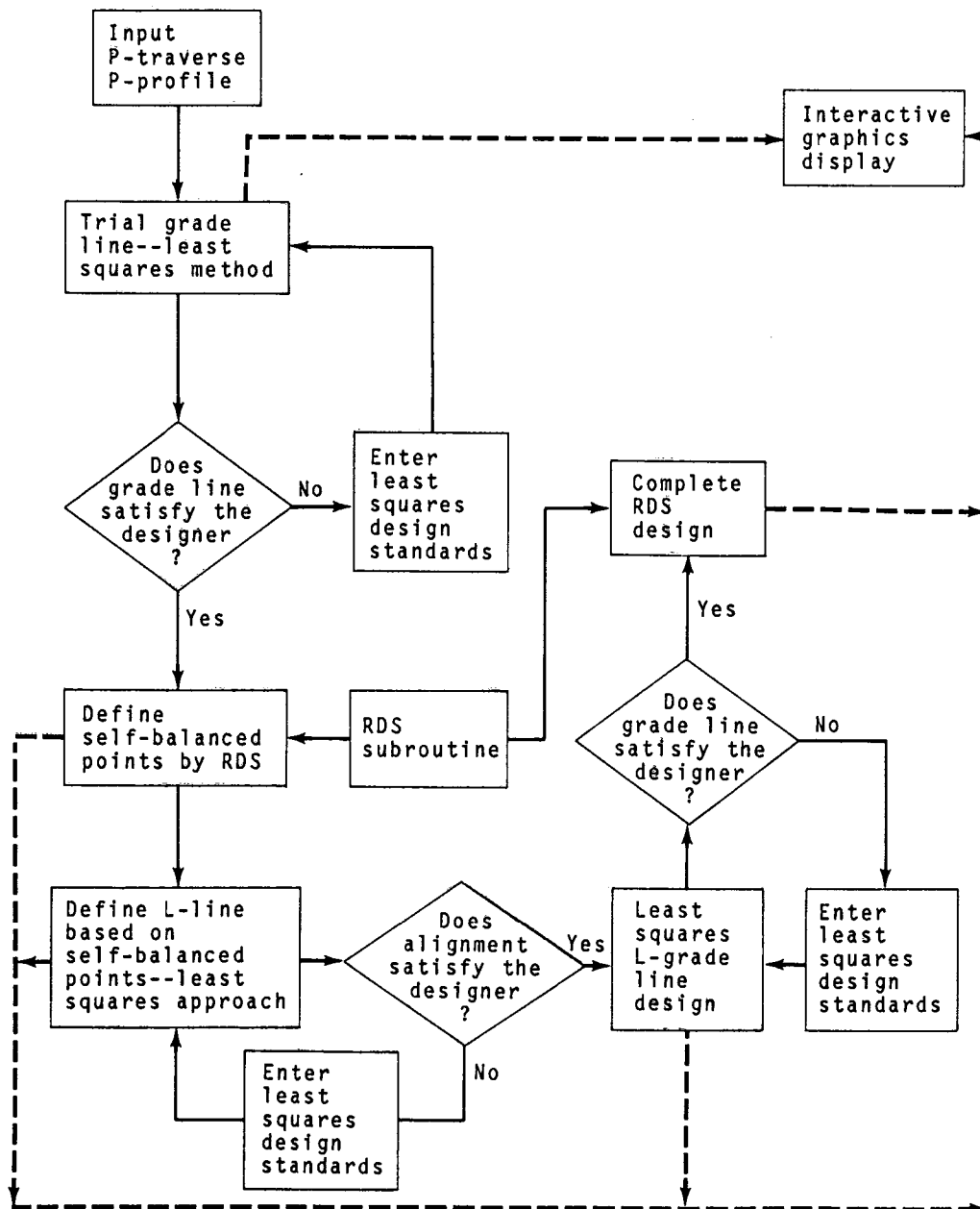


Figure 1.--Flow diagram of Automated Road Design System.

which are used to control the least squares technique in developing a trial grade line for the P-ground profile.

Based on the trial grade, RDS is used to compute self-balanced points. The system uses the designer's prescribed L-line standards to control the least squares technique in developing the best-fit tangents and curves from the self-balanced points. The L-line, P-line, and self-balanced points can be shown on a graphics terminal or plotted off line on a pen plotter. At this point, the designer can revise the L-line standards and rerun to produce alternate L-lines or make L-line adjustments using any available procedure. Following this, the system calls RDS to develop the L-line ground profile. Then, the system uses the prescribed L-grade line standards to control the least squares technique while developing the L-grade line.

After developing the L-grade line, the system calls RDS to develop final design quantities. The system repeats this step, adjusting either L-grade line or L-line, until the final balanced earthwork has been calculated. Finally, the completed design is produced on the Federal Aid Sheets. Notice that L-line expresses the location of road, horizontally and L-grade line, vertically.

METHODOLOGY

The least squares technique will define trial grade line, L-alignment, and L-grade line by selecting the most cost-effective tangents and curves based on given design standards.

Two types of design standards are:

- (1) Allowable depth of cuts and fills on P-profile or L-profile.
- (2) Allowable value of earthwork indicator.

Assume

L_{ij} = distance between previous station i and following station j ;

H_n = difference in elevation between the self-balanced point and the intersection of L-line with cross section n ; and

k = an earthwork indicator for equivalent 100 feet of L_{ij} ;

then

$$L_{ij} H_n \leq k.$$

Figure 2 illustrates the graphical definition of k .

Tangents. Using the coordinates of self-balanced points from a P-line assumes that coordinate y is a function of coordinate x . That is,

$$y = b_1 + b_2 x \quad (1)$$

The least squares solution of equation 1 is

$$(A^T A)^{-1} A^T Y = B \quad (2)$$

where

$$A = \begin{bmatrix} 1 & x_1 \\ 1 & x_2 \\ 1 & x_3 \\ \cdot & \cdot \\ \cdot & \cdot \\ 1 & x_n \end{bmatrix} = \text{the matrix of data } x_i \quad (3)$$

(i from 1 to n is the number of observation);

$$A^T = \begin{bmatrix} 1 & 1 & 1 & \cdot & \cdot & 1 \\ x_1 & x_2 & x_3 & \cdot & \cdot & x_n \end{bmatrix} = \text{the transpose of } A; \quad (4)$$

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \cdot \\ \cdot \\ y_n \end{bmatrix} = \text{the vector of data } y_i; \quad (5)$$

Curves. A typical circular equation is

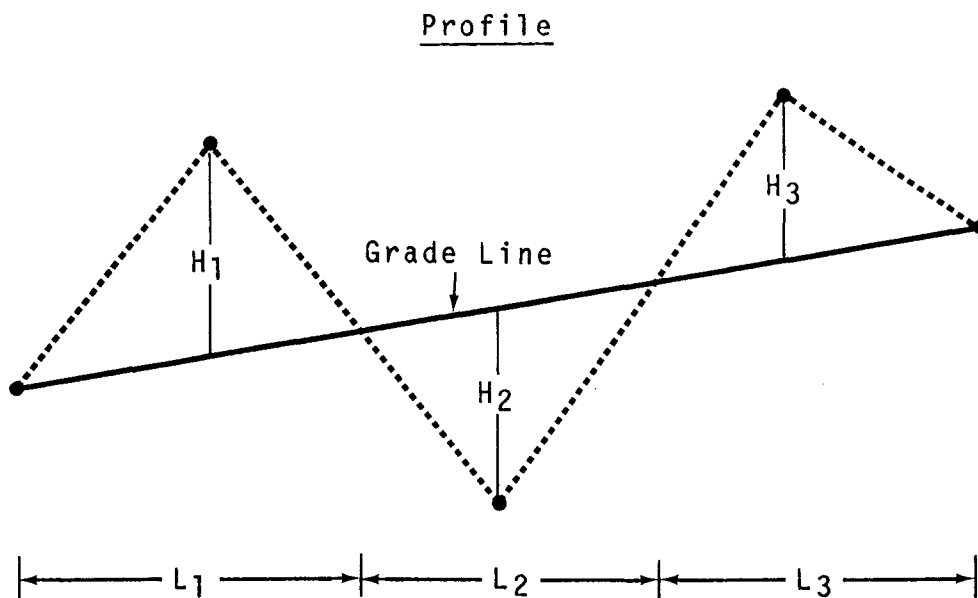
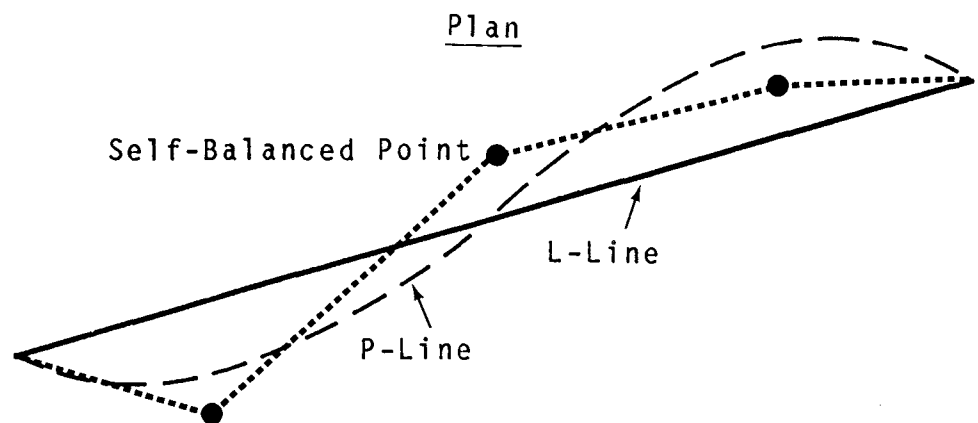
$$(x - x_o)^2 + (y - y_o)^2 = R^2 \quad (6)$$

Where x_o and y_o are coordinates of the center of the circle and R is the radius. By changing the form of equation 6, we obtain

$$x^2 - 2x_o x + x_o^2 + y^2 - 2y_o y + y_o^2 - R^2 = 0$$

or (7)

$$x^2 + y^2 - 2x_o x - 2y_o y + x_o^2 + y_o^2 - R^2 = 0.$$



$$\text{Estimated } K = \frac{100 (L_1 H_1 + L_2 H_2 + L_3 H_3)}{(L_1 + L_2 + L_3)} = 100 H'$$

Where H is the difference in elevation between the self-balanced point and the grade line, L is the distance between two stations, and K is the product of 100 feet times the average elevation, H' .

Figure 2.--Graphic definition of earthwork indicator.

Assume

$$z = -(x^2 + y^2);$$

$$d = -2x_o;$$

$$e = -2y_o; \text{ and}$$

$$f = x_o^2 + y_o^2 - R^2.$$

Then equation 7 becomes

$$z = dx + ey + f. \quad (8)$$

By solving equation 8 with the least squares approach, we may obtain the coordinate for the center of the circle, (x_o, y_o) or $(-d/2, -e/2)$ with radius

$R = .5\sqrt{d^2 + e^2 - 4f}$. Two basic matrices for the least squares solution are:

$$A_c = \begin{vmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ 1 & x_3 & y_3 \\ \vdots & \vdots & \vdots \\ 1 & x_n & y_n \end{vmatrix} \quad \text{and} \quad Z_c = \begin{vmatrix} z_1 \\ z_2 \\ z_3 \\ \vdots \\ z_n \end{vmatrix}$$

Procedure. The procedure for the automatic selection of the L-line has been discussed previously. The road designer should use the following steps.

- (1) The P-traverse and P-profile must be determined.
- (2) Based on the P-profile, the preprocessor develops a trial grade line by using a least squares linear method of controlling the cuts and fills. The designer sets design standards on the maximum cuts and fills, by road section, that could be produced by the least squares method. By varying this standard, longer or shorter tangent grades can be developed that have an impact on the self-balanced points on the P-traverse cross-sections. The system will automatically develop the vertical curves and run RDS, as shown in figure 3.
- (3) The preprocessor calculates this grade line and shows it on a graphics terminal or other plot-

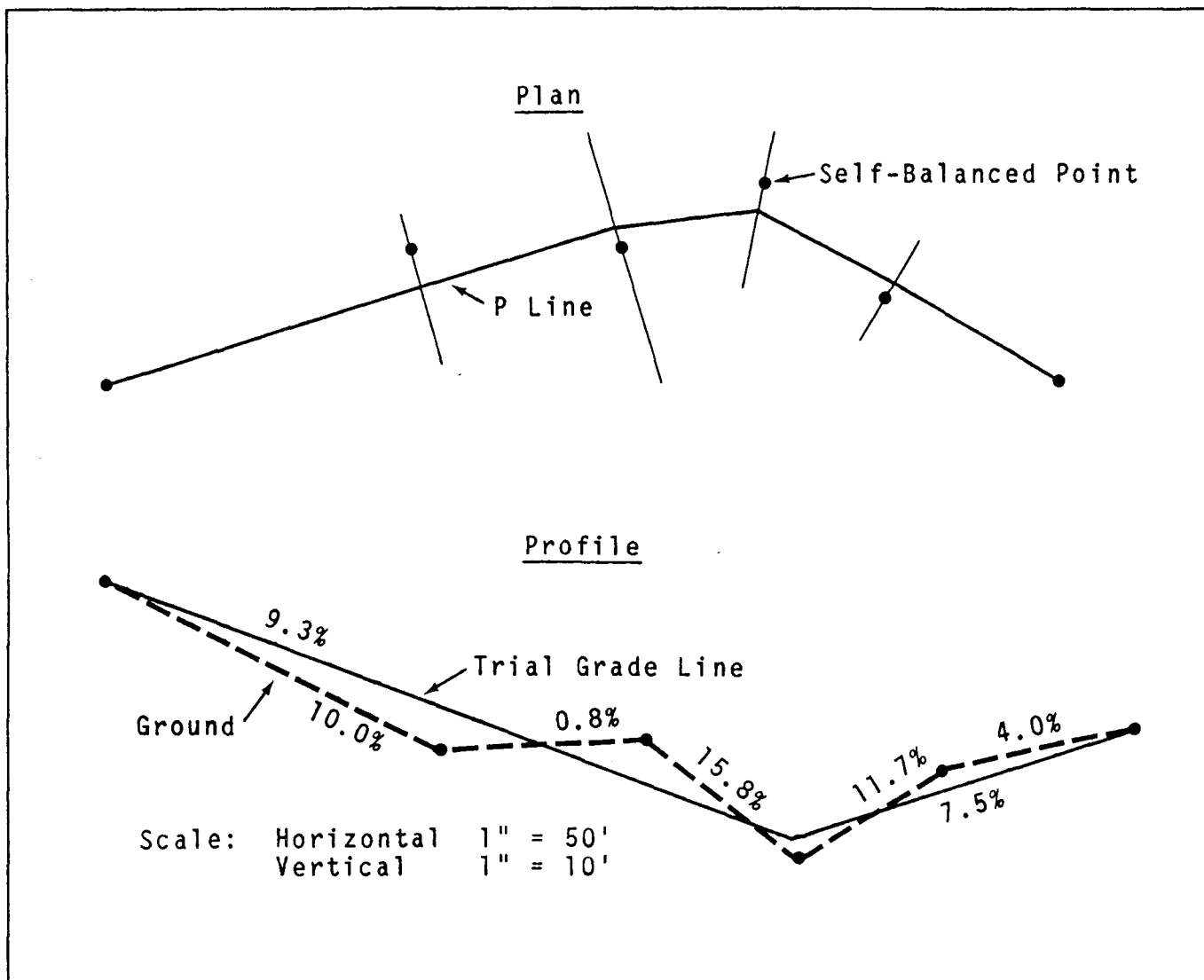


Figure 3.--Plan and profile.

ting system. At this time, the designer has an opportunity to revise the previous standard for another least squares grade line development or simply to override the trial grade by entering control parameters through any acceptable method.

- (4) The preprocessor submits the trial grade and other information in RDS format to obtain a self-balanced point on each cross-section. The designer will provide and the preprocessor format any additional information needed by RDS to run self-balanced points.

- (5) The postprocessor shows this information (along with P-line and cross section) on the graphics terminal or produces a hard copy print of it.
- (6) The self-balanced points developed by RDS are used to select an L-alignment. The tangents are produced by a linear least squares fit of the self-balanced points, and the curves are a least squares circular curve fit.

In this least squares analysis, the side slope must be used as a weight factor to reflect the quantity of earthwork. The coordinates of self-balanced points can be derived using analytical geometry from P-line coordinates, offsets of self-balanced points, and the bearing of P-line.

Using the percentage of side slope as the weight factor, equation 2 may be modified and shown as:

$$(A^T W A)^{-1} A^T W Y = B \quad (9)$$

where W is the matrix of weight factor and other terms are as defined previously.

Based on equations 1 and 9, the least squares analysis can begin to design a road with multiple tangents and curves. From one end of the road, the first three self-balanced points must be used to develop a linear regression line. The designer adds the fourth point to the equation after a three-point tangent is developed to see whether the fourth point belongs to the same tangent. The process of entering new points one at a time continues until a new point causes the tangent to be rejected. Notice that a tangent is developed by fitting a line to a set of points so that the sum of offsets of these points from the line is minimized. When the sum of these offsets exceeds a given value (or constraint), this regression line is rejected; that is, the newly added point does not fit the tangent developed with the previously selected points. The line between the first two points will serve as the tangent if a satisfactory regression line cannot be obtained by using three or more points. The earthwork indicator standard will be the constraint on the departure from the P-line in evaluating the acceptance or rejection of a tangent line. This is illustrated in figure 4. The figure shows four tangents, three of which--tangents 2, 3, and 4--have been rejected because they violate the established constraints.

They yield an earthwork indicator higher than that set by the standard.

Following the development of the first tangent, the preprocessor forms a second tangent, using the first three points not considered by the first tangent. Once again, points are added to the new tangent one at a time until one does not fit the given evaluation criteria. The line between the first two points will serve as the tangent if one cannot be formed using three or more points.

After developing the second tangent, the designer checks to see if the points of the first tangent also belong to the second tangent. Figure 5 shows an example in which tangent 6 fits the three points better than tangent 5 does, therefore, tangent 6 is selected as the second tangent.

After all the tangents have been developed, the preprocessor adjusts the first and last tangents if the ends of these tangents are not exactly on the ends of the road (landing area or road intersection). The adjustment can be made by using the weight factor to define a pivot point for rotating the tangent. For example, if the length of the tangent is L and the earthwork indicator for both ends of the tangent are K_a and K_b , the distance from the pivot point to one end of the tangent is:

$$L_b = \frac{L \sqrt{K_a}}{\sqrt{K_a} + \sqrt{K_b}}$$

or

$$L_a = \frac{L \sqrt{K_b}}{\sqrt{K_a} + \sqrt{K_b}}$$

After the rotation of end tangents is completed, a preliminary L-line is obtained. This is shown in figure 6.

The next step is to develop a curve by least squares analysis for connecting each pair of adjacent tangents. The curve for each pair of tangents sharing the same point of intersection (P.I.) is calculated with equations 8 and 9. Figure 7 shows a preliminary curve.

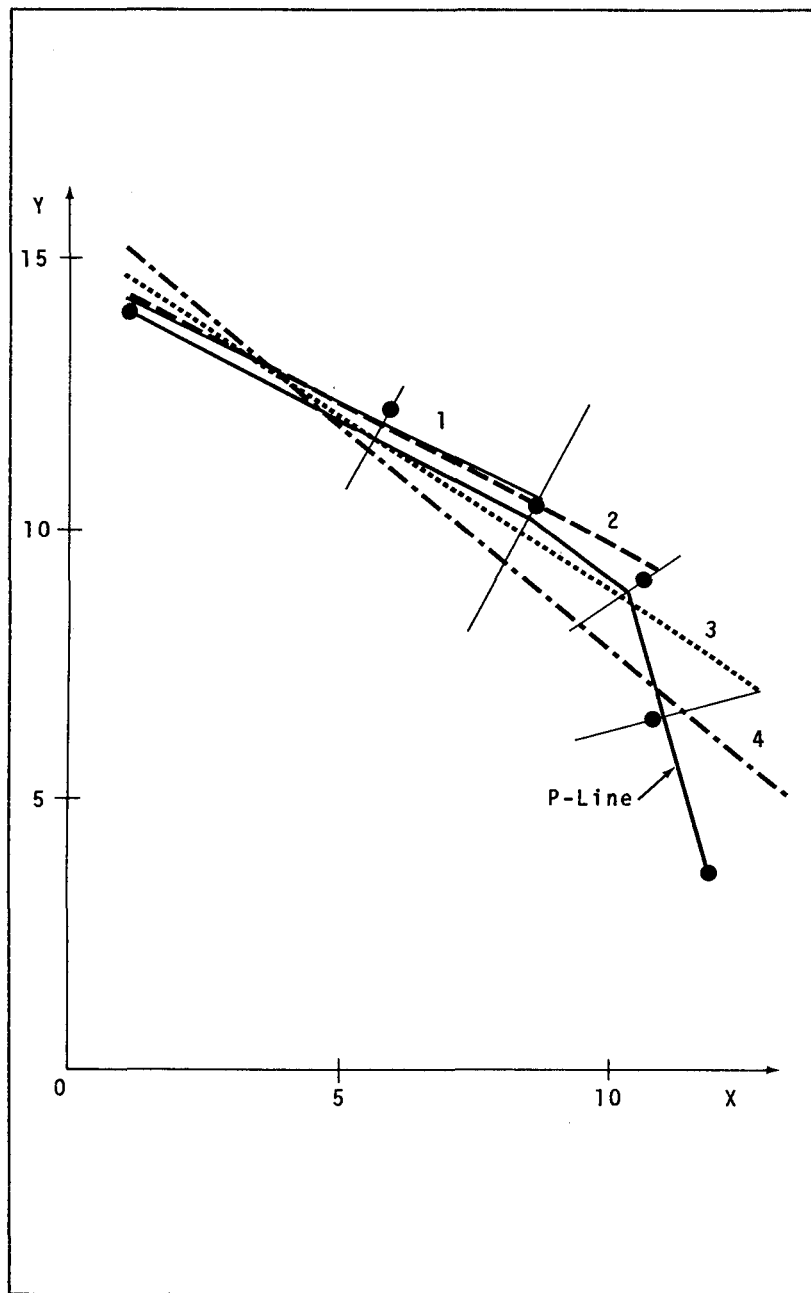


Figure 4.--Trial L-lines.

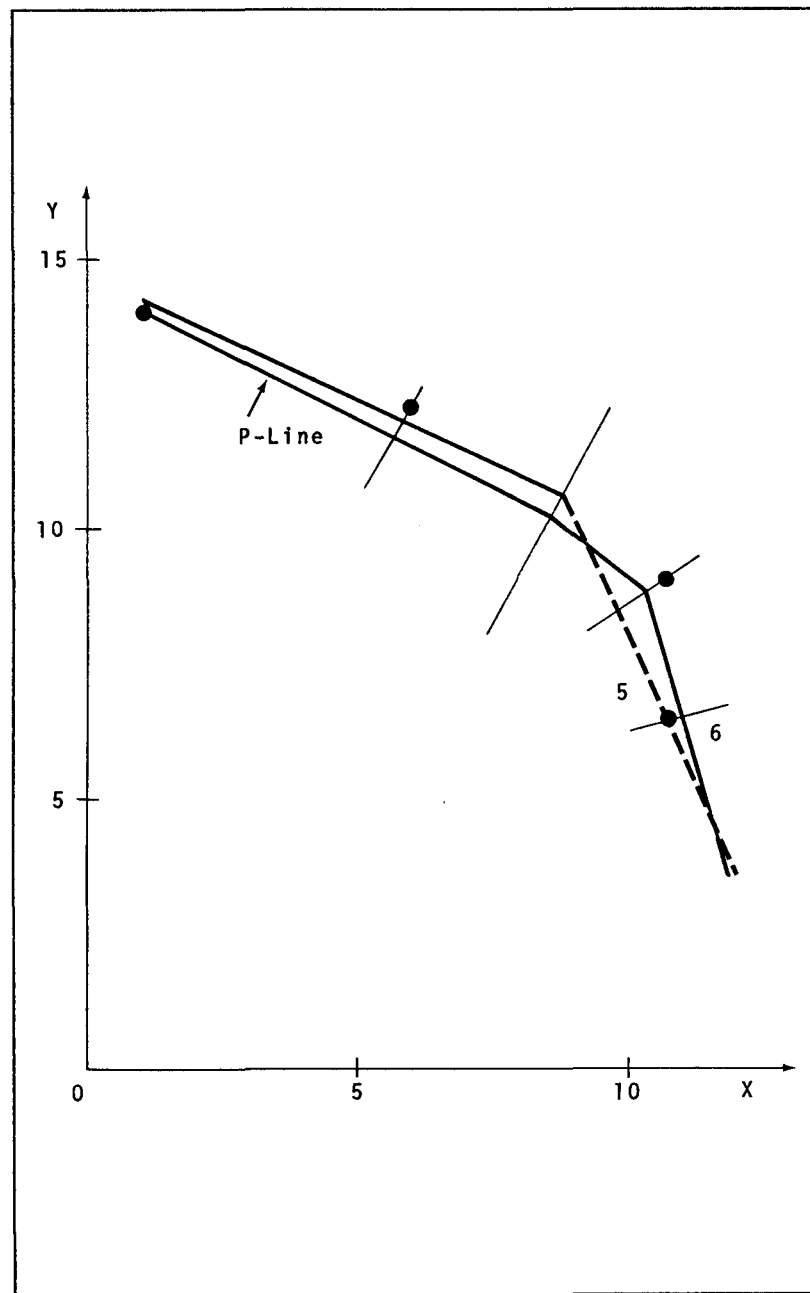


Figure 5.--Trial L-lines.

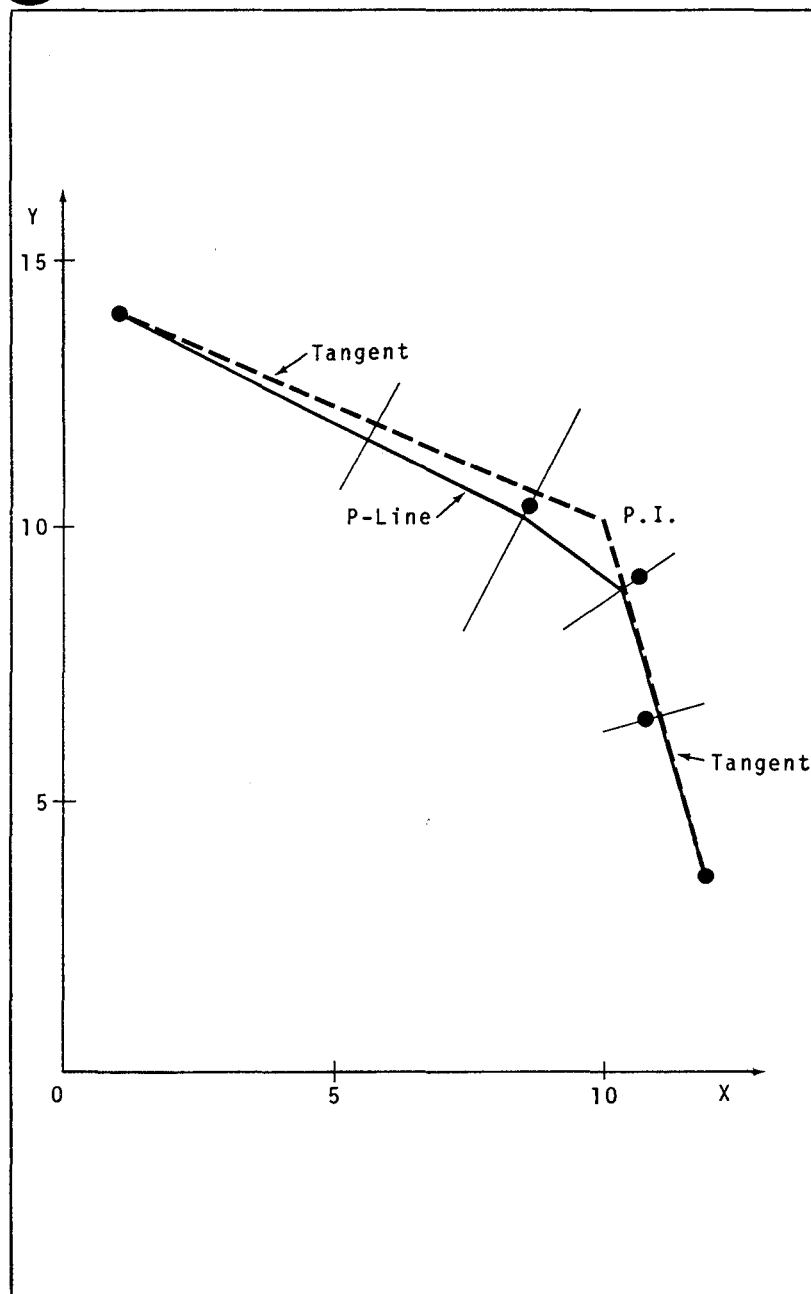


Figure 6.--L-line: preliminary.

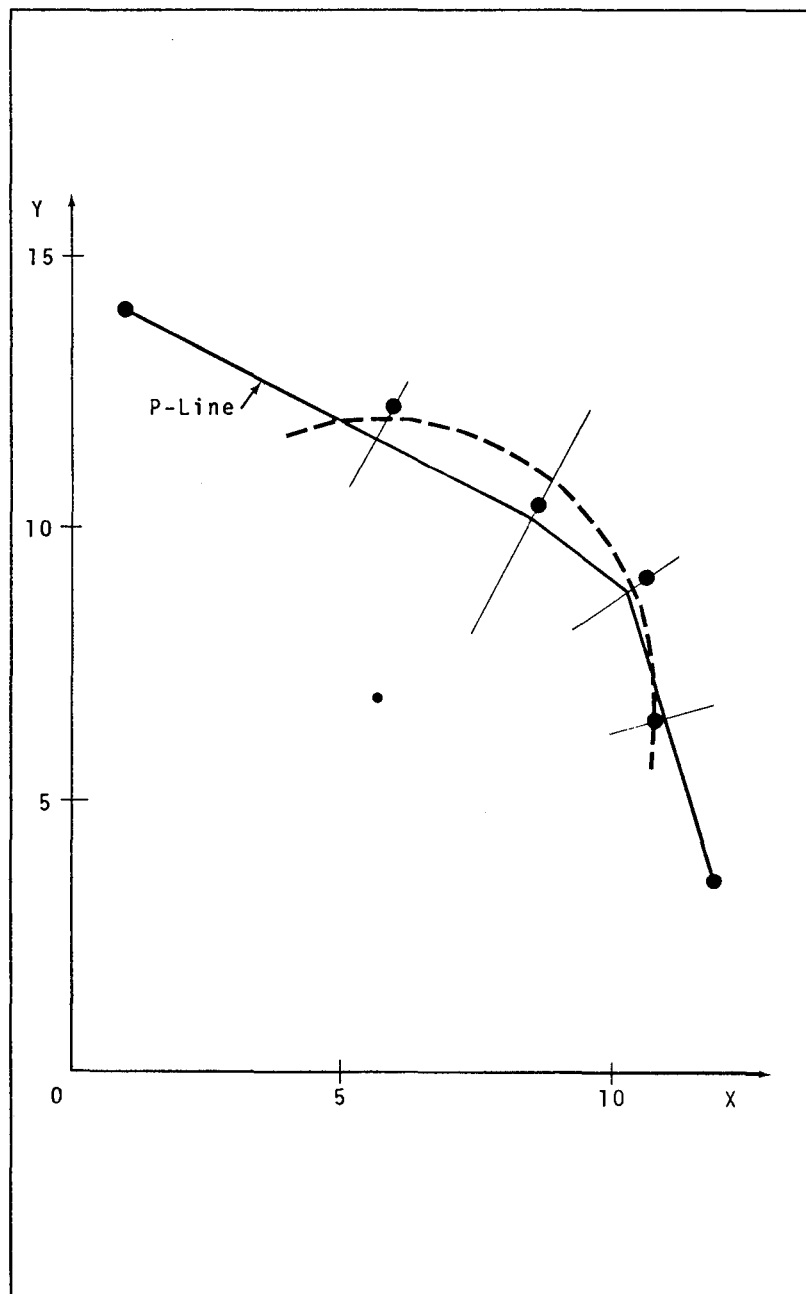


Figure 7.--Curve: preliminary.

After completion of preliminary design, an adjustment between the tangents and curves is necessary to obtain a smooth L-line because the self-balanced points used for defining a curve and that are used for developing the tangents are not exactly the same. In this adjustment, increases or decreases in cuts must be offset equally by decreases or increases in fills. An approximation procedure for this adjustment is described below:

- (1) Visualize two radii from the center of the first circle that are perpendicular to the tangents and that intersect with the tangents and the curve at points A_1 , A_2 , B_1 , and B_2 , respectively (figure 8).
- (2) Compute the length of A_1B_1 and A_2B_2 .
- (3) Compute the average earthwork indicator from the beginning of the tangent to point A_1 and from A_1 to P.I.; these are denoted by k_1 and k_2 , respectively.
- (4) Use the ration of k_1 and k_2 to determine a point between A_1 and B_1 that will result in an equal change in the earthwork for the tangent and curve by passing both the tangent and curve through this point.
- (5) Repeat steps 1 through 4, using subsequent P.I.s, to obtain the adjustment factors for the rest of the tangents and curves.
- (6) Modify all tangents by calculating the P.I. for each adjacent tangent pair by passing the tangent through their respective C points.
- (7) Use the curve radius for each P.I. as determined from equations 8 and 9.

Using this procedure, the results of figures 6 and 7 are adjusted and are shown in figure 9.

SUMMARY

This article has described preliminary automated graphics road design concepts for Forest roads based on a least squares approach. The first step in implementing these concepts is to develop the test software that will perform the outlined procedures. This automated design system will improve design efficiency and make possible the evaluation of more alternatives.

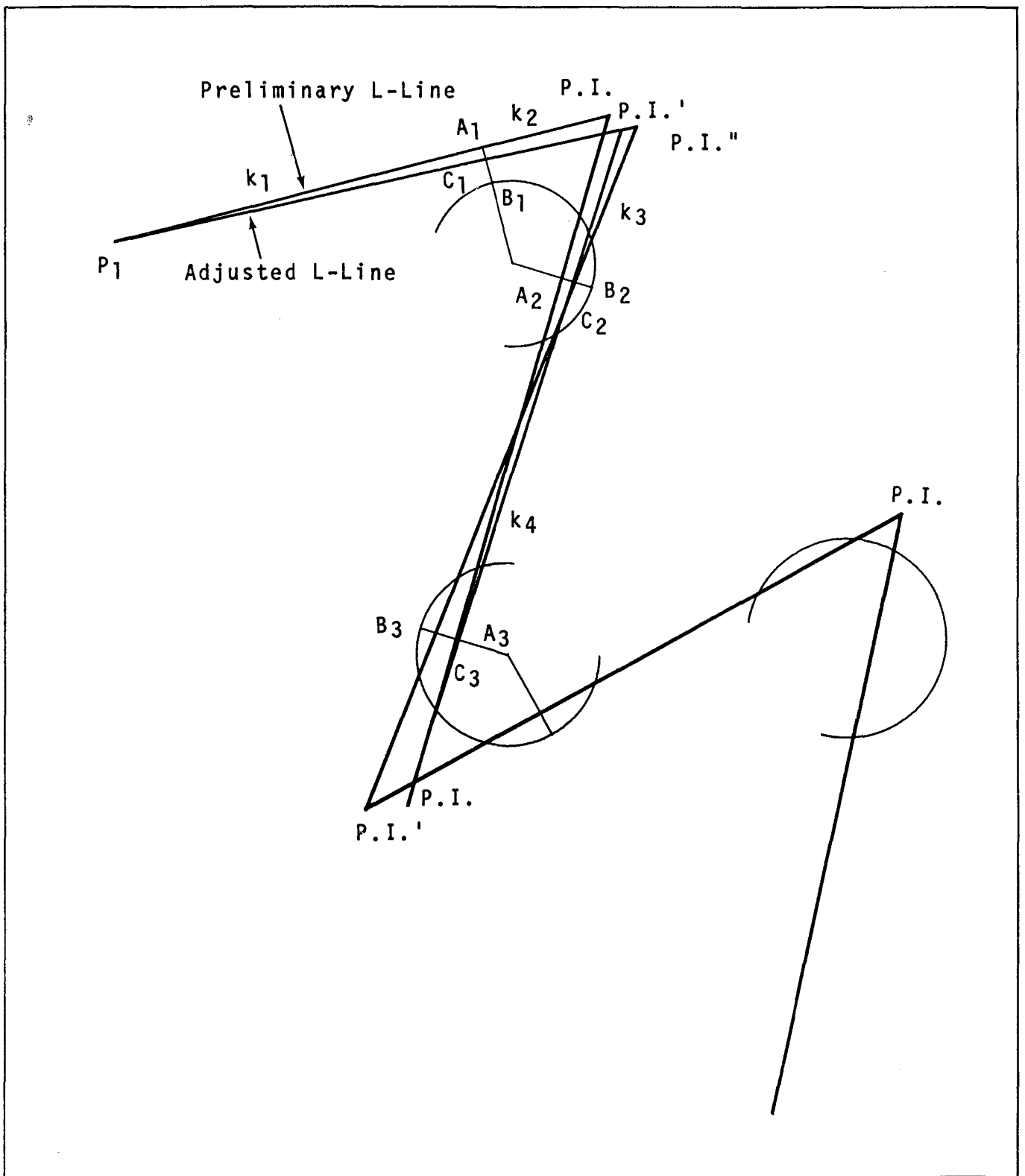


Figure 8.--Preliminary L-line and adjusted L-line.

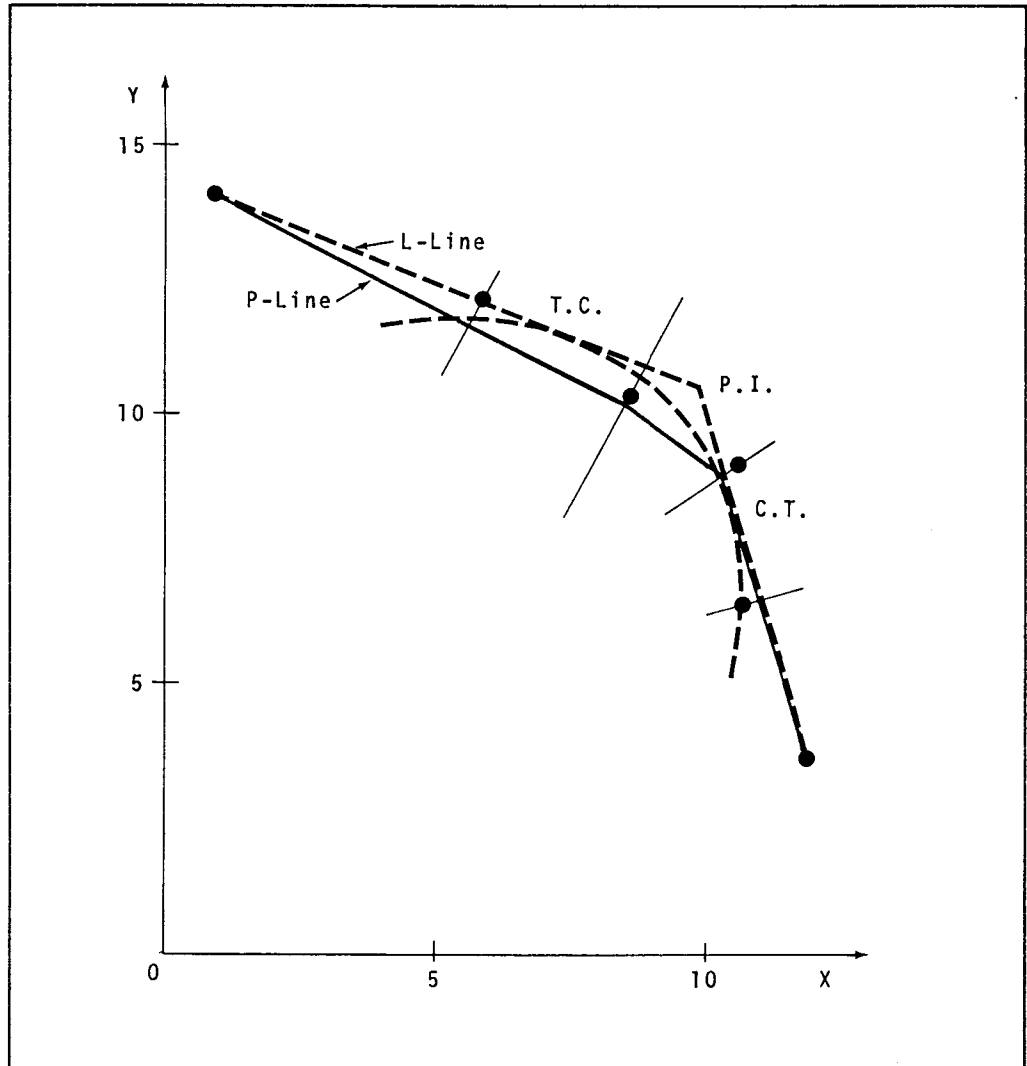


Figure 9.--Adjusted
L-line.

THE SOFTWARE SPOT



United States
Department of
Agriculture

Forest
Service

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Eureka, MT 59917

Reply to 7100

Date July 11, 1984

Forest Service - USDA
Engineering Staff, Room 1113 RP-E
Technical Information Center
PO Box 2417
Washington, DC 20013

The following HP-41CV program is submitted for inclusion in the Engineering Field Notes software spot:

1. Name - Recon.
2. Hardware - HP-41CV with extended function and memory module, HP-IL module and HP-82162A printer.
3. Language - HP-41CV.
4. Description - A calculator program for reconstruction field design. Input variables are three rod and distance shots on both sides of centerline plus half widths, slope ratios and centerline cut/fill. Program calculates slope stake information and earthwork quantities. Has been effectively used for field design on eight miles of double lane road and numerous smaller projects where spot widening was required. Slope stakes are set while you design.
5. Bill Carel or Bill Burtt, R-1 Kootenai NF, Zone I, Eureka, MT (406)-296-2536. Program was developed by Bob Graham.

Gene L. Gibson

GENE L. GIBSON
Zone Engineer



FS-6200-11b (7 81)

BUDGET
ELECTRONIC
SPREADSHEET

If you work with a budget and have access to an electronic spreadsheet, the one-page data set summary shown in figure 1 may help. It was developed using Lotus 1-2-3 on an IBM microcomputer. The example is for a Washington Office Engineering unit. It is applicable to any unit by making the spreadsheet fit local needs. A unit's entire budget can be displayed on an 8½-inch by 11-inch sheet, including prior year history for reference. The beauty of the electronic spreadsheet is its flexibility and ease of use. Inserting, deleting, or changing format or data is quick and easy. The spreadsheet allows you to write formulas, to copy, or to add or subtract, such as for the subtotals and totals in the columns. Since totals can be computed horizontally or vertically, spreadsheet changes are quick and accurate. Data Set A could contain one format, but the spreadsheet allows you to quickly print only selected data to meet specific needs--for example, Data Set A without the historical data. Changes can be made in minutes. Typing is eliminated. A professional can format and enter or change data as easily as with pencil and paper. When done, so are the arithmetic and printing.

Data Set. The data set itself is self-explanatory. Other data sets of similar data can be created for projects, salary tables, or subunits. By doing so on the same spreadsheet, other data sets can be used separately and can "feed" Data Set A.

Want More Information? For additional information or assistance in understanding the above spreadsheet or installing it on your computer, contact Dale Petersen, Washington Office Engineering Staff, at (703) 235-2378.

***** TI FY 1985 BUDGET SUMMARY (CURRENT TO 6/6/84) * PLEASE REPORT CHANGES. DATA SET A *****													
(DOLLARS IN THOUSANDS)													
(1) ACTIVITY	(2) TRAVEL	(3) PUBS	(4) ADP	(5) TRAINING	(6) CRU	(7) OPNS	(8) SPEC PROJ	(9) SALARIES	(10) TOTAL-(9)	(11) FY85 TOTAL	(12) FY84	(13) FY83	(14) FY82
ADE	5.60	0.00	10.90	0.90	0.00	1.50	0.00	75.43	18.90	94.33	85.62	88.35	80.00
ED	12.50	8.00	0.00	2.50	0.00	0.00	0.00	120.60	23.00	143.60	150.25	179.72	126.00
GEOM	25.10	28.00	195.60	6.10	15.00	25.50	29.00	528.50	324.30	852.80	1191.96	1278.76	1284.51
MATERIALS	5.60	2.00	0.00	1.00	0.00	0.00	232.50	81.57	241.10	322.67	293.71	329.89	250.00
NPAP	18.00	6.35	3.50	1.80	53.30	46.20	56.10	122.66	185.25	307.91	250.00	250.00	577.38
R/S	5.60	2.00	0.00	0.50	0.00	0.00	20.00	61.51	28.10	89.61	88.90	82.99	118.00
PESIP	1.60	1.00	0.00	0.80	0.00	0.00	0.00	57.08	3.40	60.48	48.18	49.84	40.50
SA&D/SYSC	9.50	19.35	130.80	2.30	0.00	11.00	0.00	167.65	172.95	340.60	734.08	955.54	921.00
Sub Total	83.50	66.70	340.80	15.90	68.30	84.20	337.60	1215.00	997.00	2212.00	2850.70	3215.09	3397.39
NRDC	87.70	5.00	10.00	2.00	83.00	85.00	196.20	1456.20	468.90	1925.10	1984.80	2055.00	2205.18
SDEDC	115.10	12.00	12.00	32.00	70.00	117.30	418.30	1119.30	776.70	1896.00	2112.80	2755.00	3597.83
Sub Total	202.80	17.00	22.00	34.00	153.00	202.30	614.50	2575.50	1245.60	3821.10	4097.60	4810.00	5803.01
TOTAL	286.30	83.70	362.80	49.90	221.30	286.50	952.10	3790.50	2242.60	6033.10	6948.30	8025.09	9200.40
FY84	298.80	98.70	931.70	39.70	143.30	318.20	1009.20	4108.70	2839.60	6948.30	6948.30	NA	NA
FY83	273.40	118.57	1283.70	45.54	151.90	613.82	1538.20	3888.62	4144.47	8025.09	NA	8025.09	NA

Figure 1.--Sample budget summary spreadsheet.

TECHNOLOGY TRANSFER DATA BASE

Emphasis is increasing on technology transfer. Numerous groups are using conference systems for this purpose. This is a good start that is quick, easy, and informal. To archive and retrieve information, a technology transfer data base is useful. While there are, or potentially can be, FLIPS, microcomputer, or various FCCC data bases for this purpose, one is ready for use now.

This technology transfer data base was developed as part of a Washington Office Engineering effort to manage technology projects. It resides at FCCC, using an Intel Systems 2000 (S2K) data base. At present, eight data bases are in use. New ones can be established without limit simply by creating a valid value for each data base wanted. For example, each Region and each Forest could have a data base. How a system is to be managed would be up to line and Staff at any organizational level. To have the widest use, Service-wide access to known technology transfer data bases is important.

The data base can store and retrieve the following:

- (1) Data base name and access code.
- (2) Project name, number, and contact for data.
- (3) Project origin and program element it supports.
- (4) Accounting and cost data.
- (5) Planned implementation date.
- (6) Project description and benefits data.
- (7) Three separate locations for comments.

As much or as little of the data base can be used as desired. Other data base items in addition to those listed above are available and could be useful.

Entering and retrieving data can be done by anyone having a knowledge of FCCC and S2K. Screenwriter software for FLIPS is available to provide full screen format data entry and update; while not operational for the technology transfer data base, it could be with nominal time to install it. Screenwriter would provide the present operational data base with greater speed and ease of use by inexperienced S2K users. A user's manual is available for the present system.

Want More Information? For additional information or assistance in installing a technology transfer data base, contact Dale Petersen, Washington Office Engineering Staff, at (703) 235-2378.



Engineering Technical Information System

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. Articles are usually less than six pages, and include material that is not appropriate for an Engineering Technical Report, or suitable for Engineering Management publications (FSM 1630 and 7113).

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