A Personnel Scheduling Management System for Washington State Department of Transportation Construction Field Offices

An Investigation of Current Practices, Needs, and Design Specifications

WA-RD 161.1

Final Technical Report
July 1988

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

A PERSONNEL SCHEDULING MANAGEMENT SYSTEM FOR WASHINGTON STATE DEPARTMENT OF TRANSPORTATION CONSTRUCTION FIELD OFFICES:

AN INVESTIGATION OF CURRENT PRACTICES, NEEDS AND DESIGN SPECIFICATIONS

by

Margaret E. Blau
Transportation Engineer

Washington State Transportation Center (TRAC)
University of Washington, JE-10
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

Washington State Department of Transportation Technical Committee

William P. Carr
Associate Research Director

Bill Carter
Program Development Engineer

John S. Davis, Manager (Acting)
Management and Operations Office

Allan D. McDonald
Project Engineer

Final Technical Report

Research Project Y 3399
Task 35

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

July 18, 1988

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 161.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
A PERSONNEL SCHEDULING MANAGEMENT SYSTEM FOR WASHINGTON STATE DEPARTMENT OF TRANSPORTATION CONSTRUCTION FIELD OFFICES: AN INVESTIGATION OF CURRENT PRACTICES, NEEDS AND DESIGN SPECIFICATIONS	July 18, 1988
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Margaret E. Blau	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Transportation Center (TRAC) The University of Washington, JE-10 The Corbet Building, Suite 204; 4507 University Way N.E. Seattle, Washington 98105	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO. Y3399, Task 35
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, KF-01 Olympia, Washington 98504	13. TYPE OF REPORT AND PERIOD COVERED Final Technical Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report describes the current status of personnel scheduling management in Washington State Department of Transportation's construction field offices, assesses the current status, and outlines a conceptual personnel scheduling management system that may improve the existing situation. The report develops a model of personnel scheduling that becomes the basis for comparing current field office practices. Instead of a unified personnel scheduling management system for all the offices, four general levels of scheduling, labeled Informal, "To Do" List, Bar Chart and Network, were found. These are described in the report in detail.

The assessment confirmed the existence of several constraints on personnel scheduling at the construction field office level. These constraints limit the field office Project Engineer in managing personnel schedules by restricting the schedule balancing options normally available in project management. This is particularly true with respect to the project dimension of the scheduling model. Most of the constraints come from outside the field office.

A unified personnel scheduling management system concept is outlined, based on patterns of scheduling already in existence at the field offices. Despite the constraints, this system concept is expected to provide most Project Engineers with ways to improve their current personnel scheduling practices. Three design approaches, a manual approach, a spreadsheet approach and a network approach, are suggested.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
personnel scheduling, personnel management, construction personnel scheduling, project management, scheduling systems	

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	190	

DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGMENTS

The author wishes to express sincere appreciation to Professor Robert Shawcroft for his dedicated and abundant assistance in the preparation of this manuscript. In addition, special thanks to the members of my review committee at the Washington State Department of Transportation, Mr. John Davis, Mr. William Carr, Mr. Bill Carter and Mr. Allan McDonald, who guided the project and answered numerous questions.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

The Washington State Department of Transportation (also referred to as the Department of Transportation, WSDOT, and DOT) is a governmental agency that has been mandated to "provide a multimodal transportation system which meets the social and economic needs of the state."[1] To fulfill the mandate, the Department must design, construct and maintain various facilities statewide, such as roadways and alternate transportation modes. One of the larger components within the Department is the construction section.

The Department's construction section must oversee the building of new facilities and the replacement of older facilities to the best known standards and specifications. The responsibility for maintaining these standards in construction lies in the on-site inspection of the various projects. These on-site inspections are handled through small units of the Department called construction field offices (also called project offices and field offices).

Headed by a Project Engineer, each construction field office is responsible for ensuring that the contractors properly construct departmentally designed projects within a district. All aspects of construction management, including finances (to a certain degree), inspection, testing and records are included within this office. The Project Engineer is responsible for his office's program management. As part of this, he must be able to balance all of the projects assigned to him with all of the resources given him in a cost-effective and timely manner. This includes being able to keep all of his staff busy at slow times and to spread work appropriately at busy times, while ensuring that the projects are completed with as few problems as possible. To do this, he must undertake what can be termed personnel scheduling.

STATEMENT OF THE PROBLEM

Staff at WSDOT headquarters level are concerned with funding, overall personnel levels and general project initiation and management. At this level, personnel management includes

---

[1]"Managers Set Strategic Objectives," Interchange, Washington State Department of Transportation, September 1987, page 2.

- setting goals for total numbers of full-time employees within each district, and
- creating a way to estimate the number of personnel needed on a contract based on items of work and total estimated time for completion.

The Department, as part of its personnel management, has been encouraging the construction field offices to perceive the management of their offices in a similar fashion. Because the Department has been placing emphasis in recent years on developing a "team" way of thinking, the priority for construction field offices has become more effective and efficient project management:

> For several years, one of our highest stated training needs has been project management for Project Engineers and assistants. . . . [One] of our most critical areas is the management of manpower, money, and time, and the "firing line," so to speak, is out there in the Project Engineer's office. . . . [W]e are not as efficient as we could be "out there". . . . Somehow, we've got to give them [the lower and middle managers] the tools to work the problem in the field where it is. [Schuster IDC, 1-12-79]

The tools that have been developed since 1979 for the Project Engineers include a training program in various management procedures. Included are courses in office management and supervisory methods.[2] As part of the effort, as well, the Department has invested in microcomputers and several programs with possibilities for project management, most notably LOTUS 1-2-3 and Microsoft PROJECT, with training offered in each of these.

Personnel management at the field office level remains a significant concern. No uniform personnel scheduling management system is available to the project offices and methods to manage personnel as well as schedule controls are lacking. Project engineers need to handle constant schedule changes generated by contractors, the public, the Department, employees and others. These changes involve altering or adjusting personnel schedules. The methods for managing work loads in these ways, as well as schedule controls, are lacking.

Frequently, the project office, which is given a great deal of autonomy, develops a method of dealing with scheduling that resembles crisis management, here called reactive management. The personnel scheduling is handled in immediate reaction to a situation rather than as an anticipated and planned response. The Project Engineers seem to have come to expect that they have to operate in a

---

[2]Washington State Department of Transportation, Training Program Study, October 1985. An assessment of the management training program is found on pages 10-17.

reactive manner. Consequently, an attitude that planning and monitoring personnel usage is useless has emerged. This study does not presume that reactive management can or should be eliminated altogether, rather that personnel scheduling techniques can be recommended that will improve the construction field office operation.

A study of construction Project Engineers done in 1986 [Andreas IDC, March 10, 1986] discovered that they felt that they were not focused on the major portion of their job: the work of the contractors. The study states

> The majority of the Project Engineers agreed with the complaint from the contractors that "Project Engineers aren't on the job." The predominant reasons give for this were: general office administration; too much paperwork; too many projects; spread too thin.
>
> The Project Engineers identified several items that contributed most heavily to their workload and again the predominant issues were: personnel organizing and scheduling; paperwork and change order processing.
>
> A majority of the Project Engineers felt they operated under a high level of stress. The stress was induced by: general office management; understaffed and/or inexperienced staff; and personnel management [page 3].

The study indicated that 71 percent of the Project Engineers felt their time was most taken up by personnel scheduling and organization. Other findings indicated that "Project Engineers do not feel that they have the authority to manage their resources to get the job done. Essentially, three areas were identified: policies and external controls; FTE[3] limitations and hiring and promotions handled by others than themselves" [page 4]. With such limitations placed on their authority, the Project Engineers may not perceive that they could do scheduling in such as way as to enhance their productivity in other areas of their job.

OBJECTIVES OF THE STUDY

This report provides

- an understanding of the current state of personnel scheduling in the Washington State Department of Transportation's construction field offices;

[3]FTE stands for full time employee(s).

- an understanding of the problems that the construction field office Project Engineers face in personnel scheduling;
- an assessment of the methods used to deal with personnel scheduling; and
- preliminary designs of systems that could help field office Project Engineers manage personnel scheduling in a more effective, systematic and less reactive manner.

The problems encountered by field offices will not disappear. Indications are that they will worsen with simultaneous shortages of funds and deteriorating highways. It will be important, therefore, to respond to these problems in a more effective, cost-conscious and timely manner.

Several assumptions have been formulated for this report. One series of assumptions is focused on the idea that construction field offices need a personnel scheduling management system. Its importance is assumed from the study previously mentioned that noted that Project Engineers felt they focused more on "personnel organizing and scheduling" than on "being on the job" where the contractors are working (i.e., construction project management). A more uniform personnel scheduling management system is assumed to be able to relieve the Project Engineer of some of the time consuming aspects of personnel scheduling and thus free him to do more direct construction management. The personnel scheduling management system is presumed to employ two types of scheduling: planning and operational. These two types of scheduling are also assumed to be operating simultaneously in the field office.

A second premise is that the current state-of-the-art of personnel scheduling management at the construction field office level of the Department of Transportation is based mainly on reactive management, rather than on a treatment of the whole system based on foreknowledge and assessment. Assumed as part of this is that the reactive response is one of the root causes for the lack of a personnel scheduling management system.

A third assumption is that it is possible to improve procedures and systems for planning and managing resources (personnel, time, equipment and funds) so that an adequate response to scheduling changes can be formulated and acted on quickly and effectively. The systems designed would fit into the current levels of scheduling found at the Department of Transportation so that the Project Engineers could adapt one or more of them easily into their own methods. Because several

levels of scheduling are assumed to exist at DOT, most systems also ought to be upgradable as the construction field office gradually increases its sophistication in personnel scheduling.

Finally, an improved system is presumed to increase productivity and decrease engineering cost overruns. Office morale and communications should be improved through more effective and planned resource allocation. Additionally, potential engineering cost overruns may be recognized in advance, affording the opportunity to identify and evaluate alternatives.

BACKGROUND LITERATURE

An extensive search was made into a number of subjects that were thought to be linked to the development of a personnel scheduling management system for construction field offices. No references were found that directly correlated, though each of the following fields of study contributed to the overall preparation of this report.

The Department considers the Project Engineers to be, essentially, project managers. Literature from the project management field, therefore, was used to contribute project management ideas to the personnel scheduling management system. Kertzner (1985), for example, has written a definitive text on most of the aspects of project management that could apply. He defined project management as getting something (a project) done within a time and budget at the desired performance and technical levels while using resources effectively and efficiently. Key elements of this include

- balancing resources (time, money, equipment and personnel),
- maintaining quality control and monitorings,
- defining projects as work with definite start and end dates, and
- planning as a key to control.

Kertzner also identified five project stages: conception (a problem is identified), definition (or scope), production (or design), operations (or construction), and divestment (or final records and acceptance). Other areas within project management that were identified include problems and conflicts that the project manager could encounter, and the requirement that project managers be flexible.

A specific type of project management is construction management. A body of literature dealing with construction management was also explored. Two viewpoints on construction management, one on the human aspects and the other on the technical aspects, surfaced. Fryer (1985), for example, defined management as dealing basically with people first, and spoke of the necessary ability of the project manager to see the whole project. Organization, leadership, communication, decision making, problem solving, change, personnel planning and development, health and safety were key elements of this consideration. Levy (1987), on the other hand, wrote about the technical features of projects that he saw as important to the project manager: contracts, legal rights, estimates, contract awards, change orders, documentation and safety.

Two publications by H. Randolf Thomas dealt with time and schedule performance [1985a] and contract claims [1985b] in relation to highway construction projects. These two reports focused on the identification of causes for contractor claims and how claims situations might be avoided by better scheduling. The first publication investigated how certain state DOTs determined time limits for project construction. Focus was specifically project design levels of scheduling, and no mention was made of construction field office personnel scheduling for inspection. The second report identified categories of claims and how these claims were resolved.

General scheduling literature was more concerned with actual scheduling techniques. Frequently, the best known network tools, the GANTT charts and PERT (Program Evaluation and Review Technique)/CPM (Critical Path Method) were described in detail, with other methods not so well covered.

Personnel management literature was only superficially helpful. Most personnel management material was written from the standpoint of personnel office information systems and were more interested in work history and how to deal with employees over the life of their jobs with the company. Several authors dealt with the technicalities of computerizing personnel systems, but seldom got into the aspect of personnel scheduling. The only aspects that remotely impinged on this report were the suggestions for improving productivity.

The Washington State Department of Transportation has installed microcomputers within the field offices and has encouraged the use of various programs for greater productivity. Project

management software, available to the construction field offices, is part of this report. The only place where extensive review of the over 400 programs available that claim to do project management were found was contemporary literature in the form of popular computer magazines found on newsstands. These reviews helped in understanding what programs are available and some of their limitations.

Literature covering expert systems and information systems in general was helpful for background, especially in system design. Expert systems are usually concerned with fields far removed from project management, but the research methodology for this report includes reviewing with the Project Engineers (who could be termed "experts") their scheduling techniques, problems and limitations, and incorporating them into a personnel work load scheduling management system. Expert systems procedures for distilling information were essential to this process. General information systems literature placed the system design into the context of databases, which connect all kinds of pieces of information together into a cohesive whole. Any system design must be able to correlate pieces of information.

INTENDED READERSHIP

This report is primarily aimed at construction field office Project Engineers. It is intended that the suggested personnel scheduling management system concept in this document be practical and applicable to current personnel scheduling problems. Though the systems have not been fully designed or implemented, such design and implementation is encouraged.

Washington State Department of Transportation headquarters and district staff involved in personnel planning and scheduling should also benefit from this report, especially since they are involved with the construction field office's staffing level projections in a direct way. This report is expected to be relevant for design Project Engineers as well, though the problems they encounter are not specifically addressed.

Another group of readers that may benefit from this report are other states' Departments of Transportation. Problems encountered in the construction of highways and transportation facilities are similar in all states, even though handling the problems may vary widely. Methods encountered here may be adaptable to these other state transportation agencies. At the very least, the systematic

identification of the problems encountered in Washington with suggestions for potential solutions should be helpful.

ORGANIZATION OF THIS REPORT

This report is aimed at developing and describing alternatives to help construction field offices within the Department of Transportation manage their personnel. The methodology used to develop these alternatives and recommendations is divided into the following chapters:

- **Chapter 2. The Construction Field Office and Work Load Scheduling Issues**. A general model of what personnel scheduling management entails within the construction field office is described. Included are what a construction field office is within the Department of Transportation, project phases in relation to the field office, the function and organization of the construction field office and personnel scheduling elements as they concern the field office.
- **Chapter 3. Summary of Current Field Office Practices**. The main focus of this section is a description of the current state of the art in personnel scheduling for construction field offices. Questionnaires and interviews were used to ask the Project Engineers to describe their personnel scheduling methods. The material gathered from these questionnaires and interviews is presented in tables to illustrate the current situation.
- **Chapter 4. Analysis of the Current State of Personnel Scheduling Management**. This section uses the model of Chapter 2, the data collected in Chapter 3 and the descriptive information from the Project Engineers to assess the personnel scheduling management systems used in the construction field offices. Information from the questionnaires and interviews is used to establish whether the current personnel scheduling management methods match the model described earlier. Control, or lack thereof, over the various aspects of scheduling is discussed, as are the frustrations the Project Engineer encounters. Examples of existing systems are used to illustrate the assessment. Gaps in knowledge are also noted and analyzed.

- **Chapter 5. Preliminary Design Concepts for a Personnel Scheduling Management System**. In this chapter, a general description of the system design concept objectives and requirements for the personnel scheduling management system are presented. Products (or reports) for planning and operations as well as the transforming processes required to produce the reports are described.
- **Chapter 6. System Design Approaches**. Using the requirements established in Chapter 5, three alternative approaches to system design with varying levels of complexity are proposed, both manual and computerized. Existing software is used to help produce some of the systems. As the system designs are described, they are assessed for how well they attain the goals set by the objectives and requirements.
- **Chapter 7. Summary, Conclusions and Recommendations**. This chapter summarizes the study, draws conclusions and makes recommendations for personnel scheduling management within the construction field offices at the Washington State Department of Transportation. Recommendations are split into three sections: those that the field office can implement, those that must be implemented from the outside, and possible future enhancements to the system.

CHAPTER 2
THE CONSTRUCTION FIELD OFFICE AND PERSONNEL SCHEDULING ISSUES

INTRODUCTION

This chapter identifies the role and function of a construction field office in WSDOT and presents an applicable personnel scheduling model. Personnel scheduling management is defined as the matching of staff resources with projects so that the projects are completed within reasonable time and budget limits and the staff are fully utilized. While the entire departmental structure is involved in personnel management, the focus of this study is personnel management within the construction field office. This chapter presents first the construction field office's structural placement within the Department of Transportation and its role in the life-cycle of a project. A model is then presented that discusses the role of personnel scheduling management in dealing with projects and employees within the field office.

ORGANIZATIONAL STRUCTURE

General Departmental Organization

Figure 1 illustrates the general organization and hierarchy of the DOT. Headquarters, located in Olympia, is concerned with the general administration of all aspects of the Department, including (but not limited to) personnel, projects, budget and special services. Headquarters also formulates policies for the entire Department and sets district goals.

Districts, of which there are six, are geographically divided into two groups by the Cascades. Figure 2 illustrates the physical location of the district boundaries and the construction field offices. The districts are where project design and construction occur. Specific personnel and project issues are dealt with at this level. Within the administration of the district are several specialized services, including design (which may be physically within the district main offices, in a construction field office or in separate design field offices) and construction field offices.

Formerly, many of the construction field offices handled not only the inspection of construction projects but also the preparation of both Design Reports and Plans, Specifications and

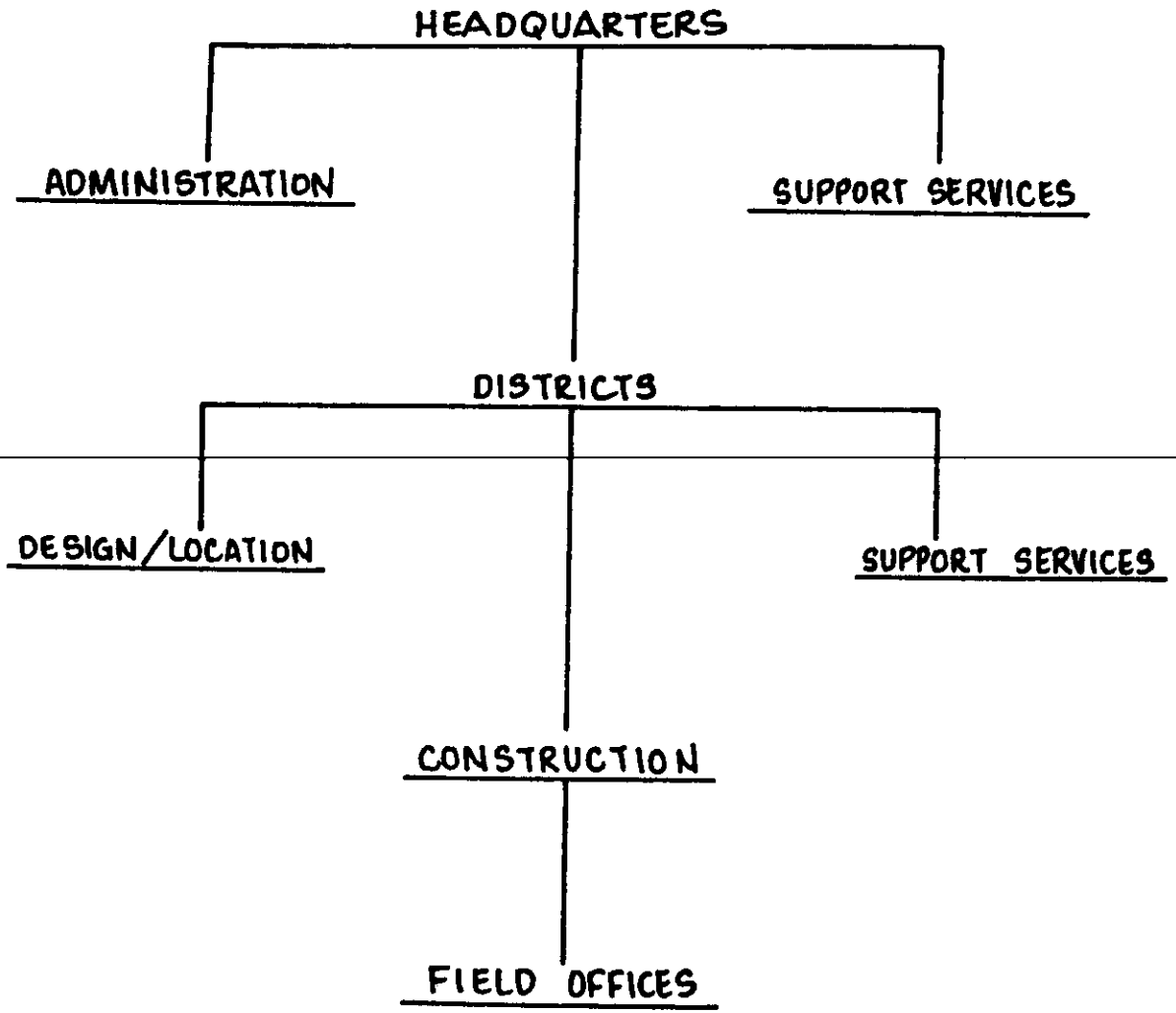


Figure 1. General Organization of the Washington State Department of Transportation

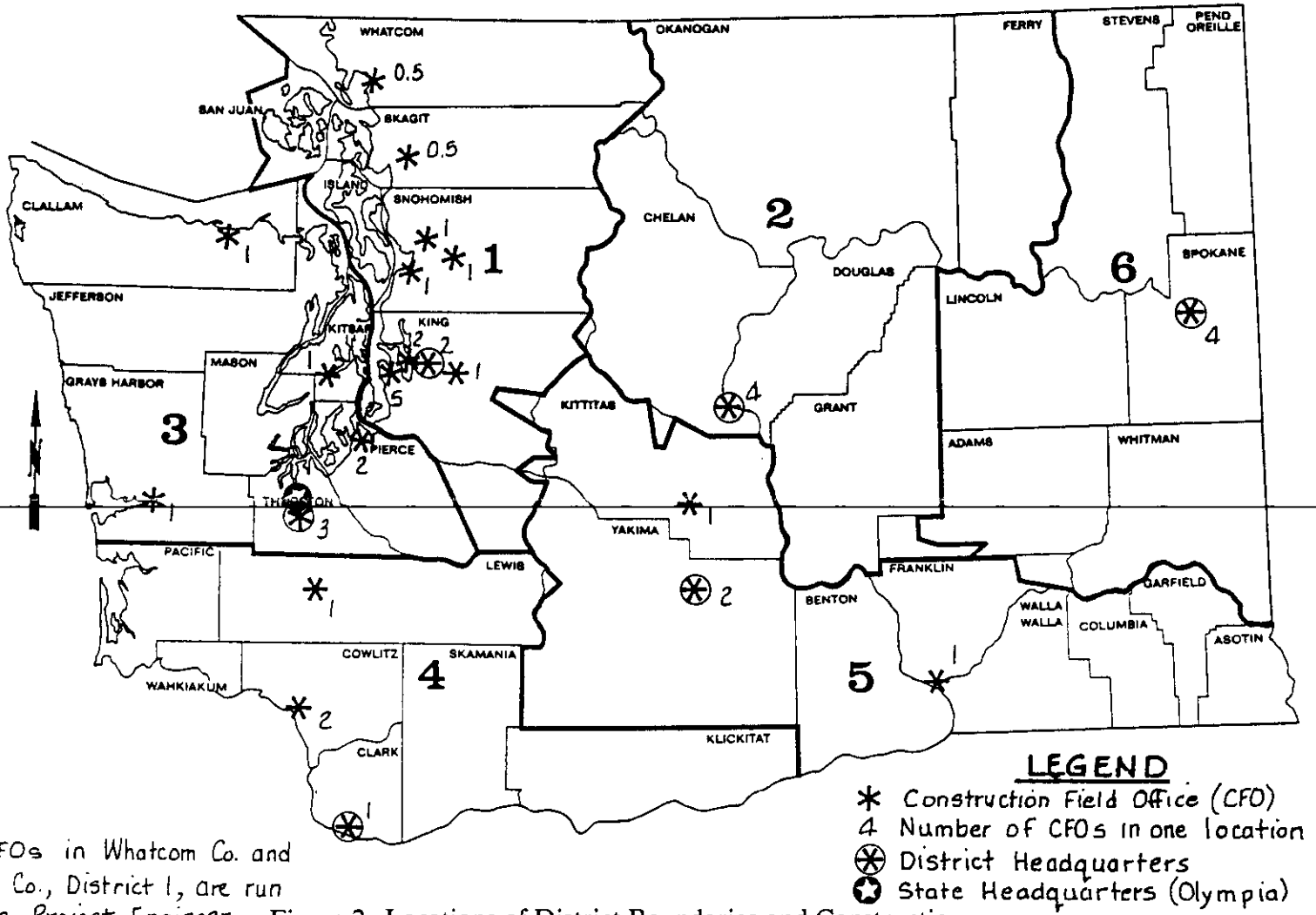


Figure 2. Locations of District Boundaries and Construction Field Offices in Washington

Estimates (PS&E). Through design centralization,[4] the district office has taken over the direct responsibility for design from these field offices. Because headquarters allows the districts a good deal of autonomy in the administration of their districts, each district is allowed to set up a centralized design function to meet its own needs.

While some construction field offices maintain a design capacity, this has changed from total project design responsibilities to fulfillment of limited design tasks:

- field surveying for design projects if no other survey crews are available;
- technical data and other information collection for the district design team; and
- specialty or small (i.e., short duration, usually four months or less) design projects (such as bridge painting plans).

This has been done in part to make more effective use of personnel in the project offices.

Project Cycles and the Construction Field Office

The role of the construction field office within the Department can be shown by following a project from start to finish. Figure 3 illustrates this process, using as a basis Kertzner's [1984] definition of project cycles, which he breaks into five phases: conception, definition, production, operations and divestment. On the figure, for clarity, these phases are numbered 1 through 5. While Kertzner's phase explanations do not match the Department exactly, they are close enough to help understand the process.

Figure 3 shows that two distinct project sub-cycles exist within DOT. The first is exclusively a design cycle and encompasses Kertzner's first three project phases, while the second is exclusively a construction cycle involving Kertzner's last two project phases. The dividing point between the two phases is the ad date,[5] set at headquarters prior to project design.

---

[4]Design centralization is a policy formulated by headquarters whereby each district centralizes the design function. This can mean that either the management of the design function is at district headquarters under a single manager, the Project Development engineer, or that the actual design function is in a physically central location (usually district headquarters), or both.

[5]The ad date is the target date set by headquarters by which the project's PS&E is expected to be ready to come out of planning and design and go into construction. The key element in ad date setting is availability of construction funds.

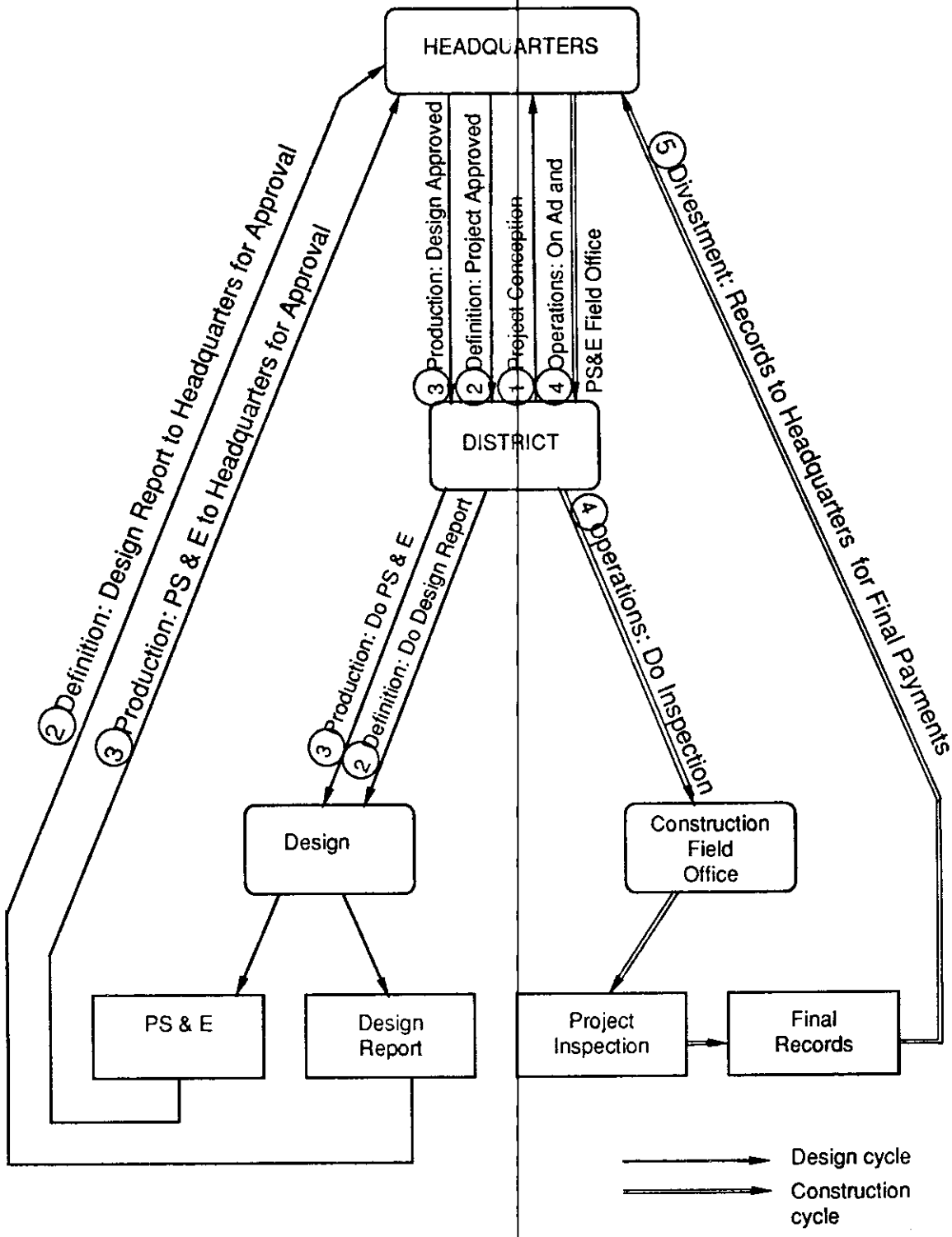


Figure 3. Project Cycles

Conception, which is the first step, is a complex interaction between headquarters, the districts, the Transportation Commission and the state legislature. The result of this interaction is the prioritization, programming and funding of highway construction projects for the next several years. This is updated biennially.

The definition phase, Step 2, involves the District in specific projects. This phase is where the Design Report is created by the design team. This report includes the design concept, recommendations for design alternatives, and various special studies required by the project's scope. Information, special studies and designs, and approvals flow between headquarters, district and design teams frequently. Often, headquarters experts (for example, environmental personnel) aid district designers with any problems or special studies required for projects.

After the Design Report is completed, it goes back to headquarters for approval. Once that approval is given, the production phase, Step 3, begins. This is when the district prepares the PS&E. Included are the drawings and other information used by the contractors to construct the project. During this phase, Special Provisions ("specials") are written that set the award and start dates through designation of the bid opening date.[6] Project duration is estimated and included in the specials as work days.[7] As part of the estimation of project duration, the design team may also create a preliminary critical path (CPM) of various project tasks.

As the PS&E is completed, headquarters and the district communicate frequently regarding design problems. Any special designs required (such as bridges) are often done by headquarters and then included in the plans. After its completion, the PS&E is sent to headquarters for review and approval. Because the construction field office Project Engineer was tentatively assigned at the

---

[6]Award and start dates are based on the ad date and are usually delineated in terms of time in days after the ad is placed. The award is usually expected four to six weeks after the bid opening (a date defined in the contract), though it can be as short as one week after bid opening. The contract is signed (executed) a maximum of 20 calendar days after award, and the maximum start date (the latest day to start construction after contract execution without penalties) is 10 working days.

[7]Work days are based on the critical path (minimum completion time) of a project and are the number of days a contractor has to finish the project. No calendar dates are connected to the work days. Days on which the contractor cannot do critical work are called non-work days and represent a suspension of work not counted against the contract's work days.

project's conception, theoretically the PS&E review would include review by the constructing field office.

These first three stages of a project are related indirectly to the construction field office because of the delays in the construction start dates that can occur during them. First, the design process itself may take years to complete. Unless the project is being "pushed" for some reason, the design takes at least four months (small, simple jobs such as bridge painting) to a year or more, with the most complex projects taking several years. Most of this time is spent in the definition phase, often due to special studies, public meetings and scope adjustments. These definition phase tasks can greatly delay the ad date, thus delaying when the construction field office will receive the project.

Second, the ad date is flexible. Ad dates depend on construction funding, not season of the year. Many projects are "on ad" (advertised for contractors' bids in newspapers and journals) during the non-construction season, delaying the actual start date (which is based on working days, which are related to the ability to work on a particular day), unless a seasonally independent task or series of tasks in the contract can be started.

In Figure 3, the second sub-cycle of a project directly concerns project construction. By the time the project reaches the construction field office, about two months before the ad date, several constraints (project scope, bid opening date, and expected contract execution) are set. After the award of the project, which is the concern of district and headquarters, not the construction field office, the contractor is set. Headquarters sends the PS&E to the district, which gives it to the project office; the project office is then expected to oversee the construction and closure of the project with little outside help. Exceptions include (but are not limited to) certain change orders, materials testing that must be done at district or headquarters, and unexpected problems requiring re-designs.

The construction phase, Step 4, begins with what Kertzner calls operations: contract administration as construction is carried out. Preliminary work, such as staking, is done so that the contractor is not delayed in completing the project. As construction progresses, the staffing level on the project changes in response to contractor needs. Within the field office, the primary objective of project inspection is to ensure that the contractor complies with the contract documents and to inspect and test the materials incorporated into the work. Part of this goal includes making sure the project is

completed on time by using construction field office personnel effectively so that contractors are not delayed.

During the last part of construction and after the contractor completes his work, the fifth and final phase, divestment, occurs. For the DOT, this is the completion of final estimates, which are required at headquarters 45 days after the contractor finishes [Washington State Department of Transportation Construction Manual, page 1-67]. The contractor's final payments are based on the acceptance of these estimates by headquarters. Because construction field office personnel have been so close to the contract and have kept up the construction progress records, they fill out these final estimates, as well as final project records which support the estimates. The final records are due as soon as possible after contract completion.

The construction funds are handled by the field office, as are the inspection and final estimates and records of the contractor's work, overlapping the operations and divestment phases. Headquarters and the district do not get overly involved unless requested to do so by the field office. Therefore, the second sub-cycle of a project is marked by its detachment from other DOT business.

Organization of the Construction Field Office

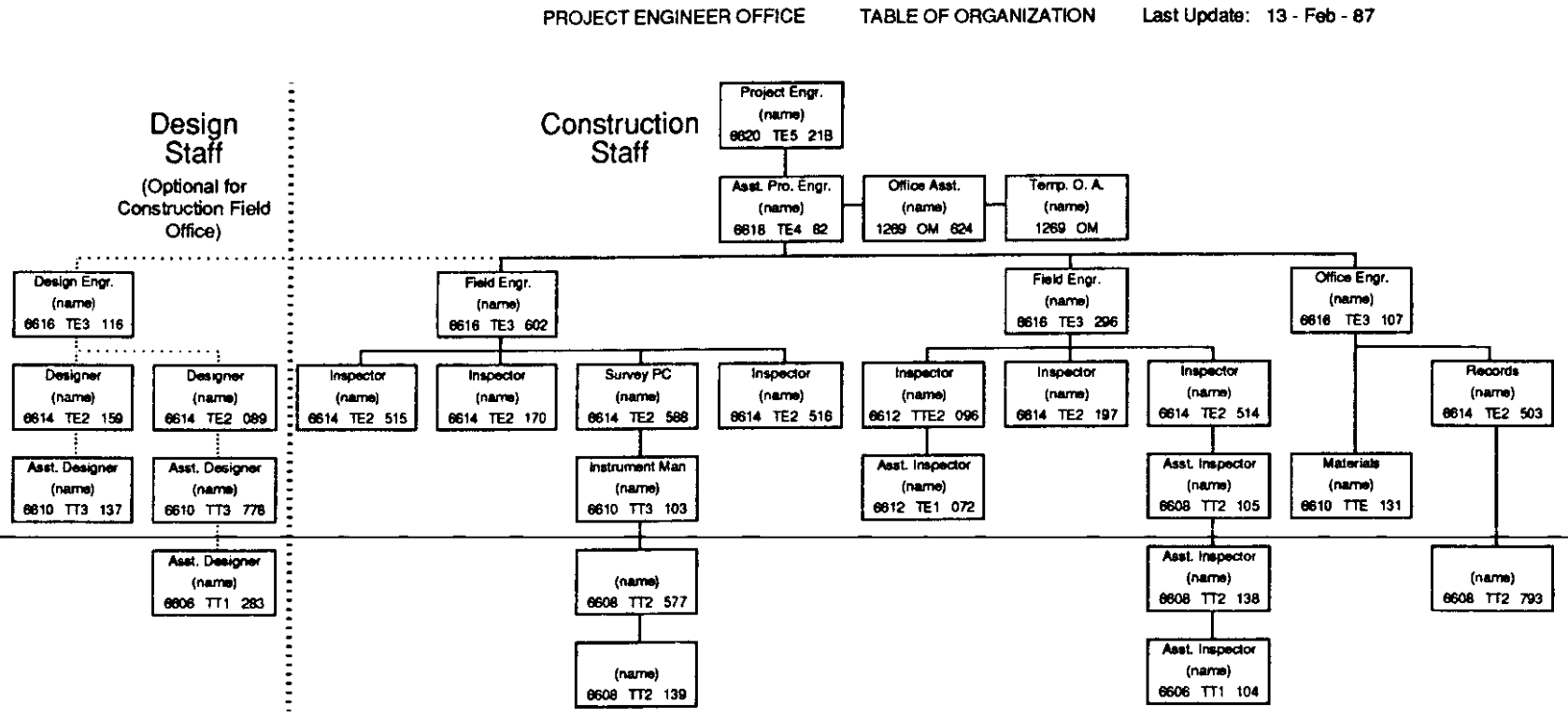
Purpose

The construction field office's major purpose is to administer the construction contracts with contractors building the state transportation projects while ensuring that the projects are built to departmental and federal (if applicable) specifications. To ensure fulfillment of this purpose, the construction field office is obligated to have sufficient staff with the necessary skills available to inspect all the projects assigned.

Personnel

Figure 4 is an example of a Table of Organization (abbreviated TO) for a typical construction field office. At the head is the Project Engineer and his assistant. They direct both personnel relations (recommendations for promotion, interviewing, discipline and general personnel management) and project management. Final project construction responsibility is theirs.

The TE-3s on Figure 4 are middle level engineers in charge of several projects and personnel. Frequently, a construction field office is divided into areas of responsibility, such as inspection (under



Note: TTE2 stands for Temporary Transportation Engineer 2; TTE stands for Temporary Transportation Engineer

Figure 4. Typical Construction Field Office Table of Organization

the chief inspector), surveying (under the chief surveyor, as needed), and materials and final project records (under the office engineer). Depending on project size, number and/or type, the office may require more than one chief inspector.

The project inspectors are the TE-2s on Figure 4. Each is responsible for one, or at the most, two projects. Offices with only one or two major projects have several TE-2s per project in charge of major inspection tasks. The project inspector ensures that the contractor complies with all the project specifications and provisions. He or she also supervises the materials tests and records construction progress. The survey crew party chief and the main designer on any design project are also TE-2s.

Technicians and entry level engineers (TT-1, TT-2, and TT-3/TE-1s[8]) on Figure 4 are next. Technicians can be assigned to one project as the inspector's assistant, or to several or all of an office's projects as paving or survey crew. They test materials and issue and receive tickets for materials brought on site. They help the office engineer with records; some may also help in the office in design or earthwork calculations. Generally, unless these technicians are TT-3s with years of experience or special skills, they are not assigned to handle a project's inspection alone, or supervise others.

Included in the field office TO is a field office assistant who handles correspondence, supplies, office finances, the telephones and visitors. Often, due to proximity to the inspection work, he or she can be promoted into the technician levels if qualified.

Types of Employees Available

The Project Engineer draws on several types of employees. Permanent employees (both full- and part-time), including all technicians and engineers up to the TE-3 level, are unionized and work under specific rules for the type of work allowed. When these employees are full project inspectors, they have at least one year's experience (usually more) with the Department, are qualified to do the varied duties of the project inspector and are familiar with the departmental policies applying to project construction. In some cases, they have specialized in one or more areas of inspection.

---

[8]TE-1s differ from TT-3s only by the fact that the TE-1 has a BSCE degree; they are equivalent classifications. Also, in both the technician and engineering ranges, the higher the number, the more experienced the employee.

A second group are temporary employees. The temporaries are not allowed union membership or other benefits and can be hired for as little as one day or as long as nine months, though the position that they fill must be approved by headquarters. Project Engineers may hire anyone who has applied into a temporary slot. Temporaries may become seasonal if they come back for four consecutive seasons on a cyclic basis. Temporaries almost always fill technician slots because of their inexperience and lack of departmental training.

Seasonal employees, the third type, belong to the union and are given most of the benefits of permanent employees; the only difference is that they work more than five and less than nine months in a calendar year. The position is cyclic in nature, always beginning and ending about the same time, with similar duties from year to year. Project Engineers have little choice about whom they can hire as a seasonal employee; they must take the first one listed regardless of qualifications needed. The flexibility characteristic of a temporary employee is lacking, though seasonal employees may fill engineering level jobs because of their experience.

A fourth group, project employees, are not often used by construction field offices unless a particular expertise is required that cannot be found at the DOT. They are hired for the duration of the specific project only. They are not members of the union and are not eligible for promotional (in-house only) positions, though they are eligible to take open competitive (open to the public) exams for entry level positions if they qualify.

PERSONNEL SCHEDULING IN CONSTRUCTION FIELD OFFICES

So far, projects and personnel as they exist within DOT and the construction field office have been discussed. Most projects are ready to construct when the field office receives them, and personnel with a variety of skills in inspection are available to ensure timely construction to specifications. To match the personnel and projects required for construction requires the generation of a balanced personnel schedule. A generic model of scheduling and what this entails is developed here. This model is used in the remainder of the report as a focal point for discussion.

Elements of Scheduling

Scheduling consists of combining and balancing three essential elements, personnel, projects and time. The top portion of Figure 5 illustrates the typical approach to creating a complete personnel schedule using these elements. Projects are fixed in a time based on ad date and duration. Office personnel are assigned to projects. Combining these two charts allows an assessment of how personnel are used over time. Unreasonable personnel assignments appear when the latter chart is reviewed. The essential issue in personnel scheduling is to "optimize" the use of personnel over time, which is done by controlling the occurrence of projects in time and/or the assignment of personnel to projects.

Each of these elements can be used at varying levels of detail. Each element also contributes important information to the whole schedule. Thus, the elements can be perceived as interconnected or as three dimensions of a total system, as illustrated by the cube at the bottom of Figure 5. The point of origin on the cube is No Scheduling, where time, personnel or projects are brought together. As each element increases its distance from the origin, the level of detail increases. The personnel axis can range, for example, from a total office personnel count to numbers by classification level to all staff listed individually by name. The time axis, which can include any division of time as appropriate, would typically be in units ranging from years to days. The project axis can consider projects as whole entities or detail them into tasks and sub-tasks.

It is important to note that if only two axes are used in scheduling that the resulting information is flat, lacking depth. This leads to the assumption that using only two elements of the three does not necessarily create a schedule. Also, when a system uses only very gross levels of detail, only a small cube, centered in the lower left corner of the total cube, results. This leads to another assumption, that using such gross levels of detail could allow the user to miss information essential to personnel scheduling. Thus, various scheduling systems could be described by how well they fill the cube and utilize the information available from the interconnections.

A further consideration in defining a personnel scheduling system is the difference between planning and operations. Planning is defined as the anticipation of longer term schedules (six months to several years) in some logical fashion. It is subject to change as projections become reality. Operations is defined as short-term scheduling, with the plan put into immediate action. Revisions are

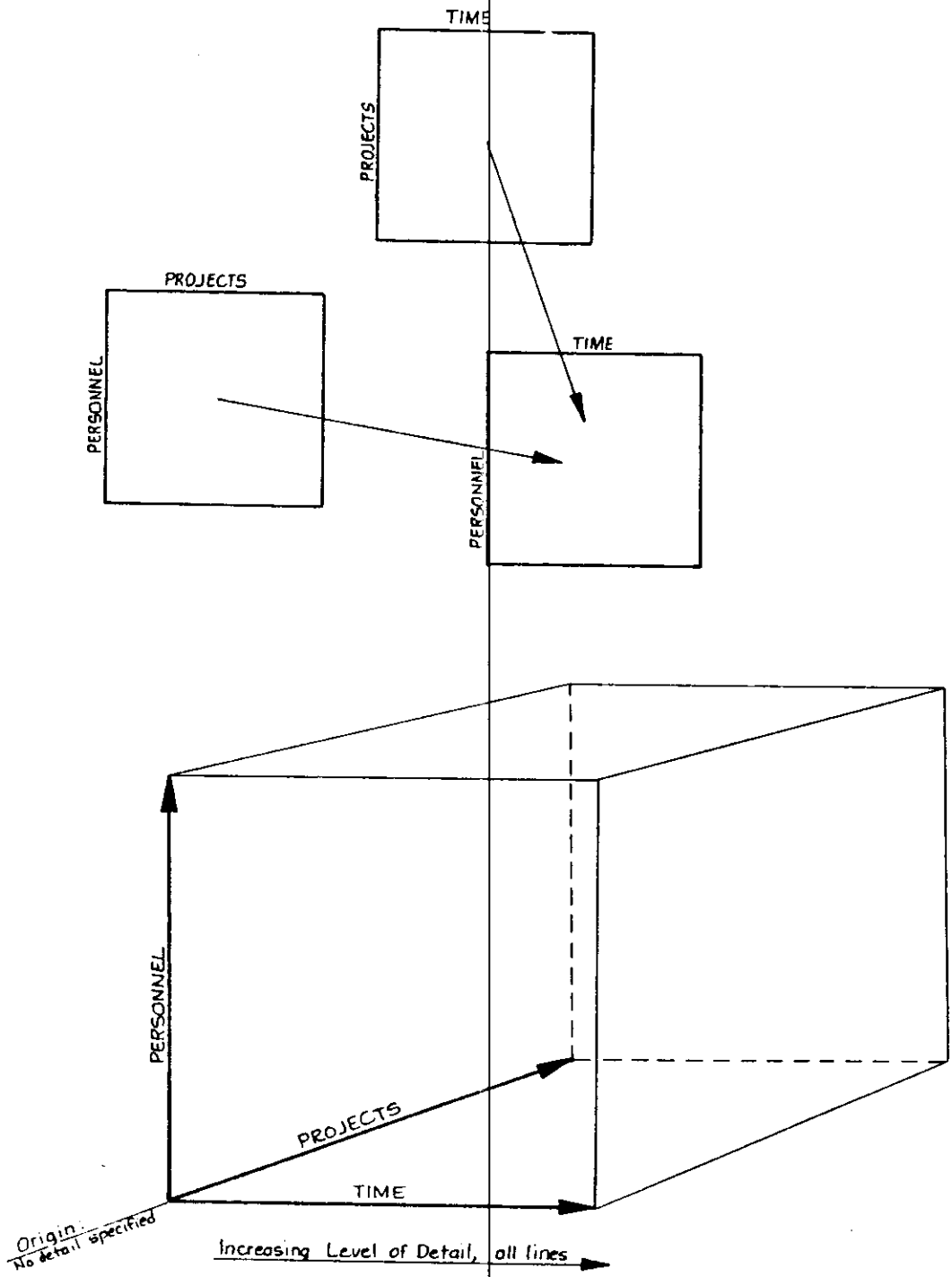


Figure 5. Model of Personnel Scheduling

made constantly as the situation changes. Monitoring and updating are integral parts of this phase, because the actual situation changes frequently.

Construction Field Office Model of Personnel Scheduling

The concepts presented in the preceding section are shown in the generalized view of scheduling in Figure 6. Projects and human resources are apportioned to the field office from other departmental levels. The Project Engineer assigns his available resources to the office's projects, resulting in a personnel schedule.

A more refined picture of the project office process is presented in Figure 7, which reflects both planning and operational considerations. In planning, expected future projects and anticipated human resources are assigned together over a range of time and balanced with the use of available information. If a balance is not achieved on the first iteration, all the elements are open to alteration. The expected final result is the preliminary personnel schedule.

There are three options for adjusting the schedule if an assignment scheme does not balance, as shown in Figure 7. Altering the project task schedule consists of adjusting the timing of the project (or project tasks). Altering the resource pool involves adding or subtracting staff in the office itself. Altering the assignment comprises adding or subtracting staff from specific projects or a series of project tasks and establishing secondary tasks to take up slack time. As the balance becomes realistic, a preliminary personnel schedule is produced.

The planning schedule for the next construction season and/or calendar year is started as the last season slows. As changes occur and are brought to the attention of the field office, the planning schedule is adjusted. Because of the nature of this schedule and the information available to create it, the level of detail does not need to be very great in any of the dimensions.

Operations scheduling is used when projects are under way. It is a dynamic, constant balancing of personnel assignments. Continual reassessment is necessary as project schedules and available personnel change over the short term. During this assessment, or monitoring, the type of change taking place is established. If a task changes, then the project task schedule will need to change. If the human resources change, then the resource pool must be altered and assignments adjusted. If both change, personnel are rematched with ongoing project tasks or secondary

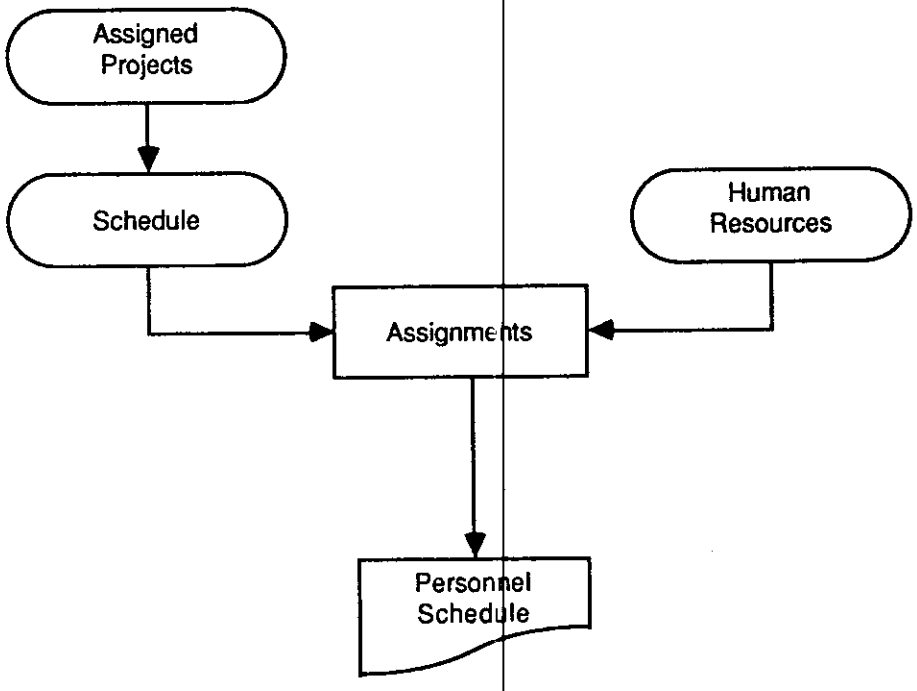


Figure 6. General Diagram of Personnel Scheduling within Field Office

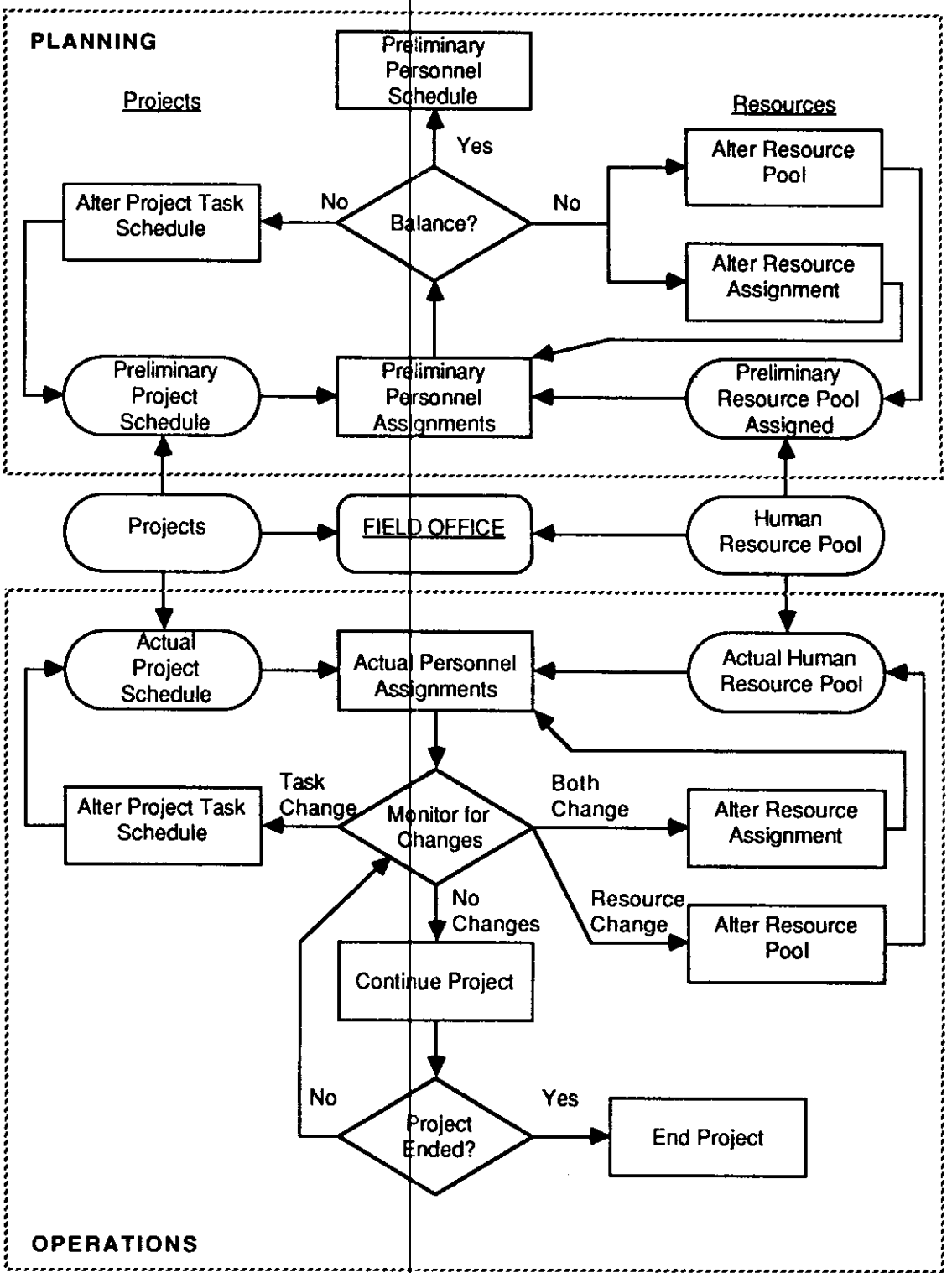


Figure 7. Flowchart of Planning and Operations Personnel Scheduling

assignments to account for the alteration. Monitoring is necessary to determine schedule changes so that personnel assignments can be adjusted to allow construction to be completed as efficiently and effectively as possible without wasting resources.

In both of these cycles, no matter which element of scheduling is affected, the personnel assignments always end up being adjusted. If one section of the model, for example the source pool, becomes unbalanced, the other sections shift in response and the whole must be modified. Therefore, an interdependence exists between project tasks, time and personnel. The timing of the adjustments of these elements are the only difference between the two phases: changes in the planned personnel schedule do not have to be adjusted immediately, whereas the operational personnel schedule must be rebalanced right away.

Methods for Creating a Personnel Schedule

On the basis of these dimensional elements, the two phases of personnel scheduling, and what the Project Engineer perceives as his need for a personnel schedule, the Project Engineer chooses one of four general levels of "scheduling" identified by Shawcroft [1986] to create the best balanced match between people, projects and time. No uniform system exists that the Project Engineer can adapt, and the choice of scheduling level is based on how it suits him. The descriptions below are based on how each level characteristically handles the phases and the elements of personnel scheduling, and vary from extremely informal to highly sophisticated. Whether the first two levels (informal and "to do" lists) can truly be scheduling is questionable because they do not use all three dimensions considered essential to creating a personnel schedule. All of these levels, in diverse forms, can be found in DOT project offices.

Informal levels are usually mental. The Project Engineer associates personnel and projects in his mind to generate the field office's personnel work load. Written forms of schedules of any kind are rare and reliance is placed on the Project Engineer's memory. Formalized longer range scheduling is also rare. Typically, this level of scheduling is based on years of experience.

"To do" list levels of scheduling formalize the project element by writing down a list of "things to do," in this case, projects or project tasks. The items on the list are usually unrelated to each other.

Key personnel (e.g., project inspectors) may be assigned to a project or task, depending on the Project Engineer's perceived need. Time may be involved, but only in a minor and informal way.

Bar chart levels of scheduling formalize the time element, adding when a task must or will occur to the list of "things to do." Time is considered essential to the schedule, and projects and personnel are assigned on a timeline. The charts created are generally static and cover fairly long periods. Project tasks are not related to each other, and updating is difficult.

Network levels of scheduling explicitly formalize the relationships between tasks within a project. The effects of changes on one task can automatically propagate changes in following tasks related to the first task. Resource demand, because it is interconnected with tasks, also changes automatically as tasks change. Time is dynamic, so that both longer and shorter range scheduling are important. Updating is one of the keys to maintaining this level of scheduling.

SUMMARY

In this chapter, the relationship of the construction field office to project cycles and the Department has been discussed. A personnel scheduling model related to field office scheduling has also been presented. Chapter 3 presents a summary of current field office practices as found through questionnaires and interviews while Chapter 4 assesses the field office using the scheduling model.

CHAPTER 3
SUMMARY OF CURRENT FIELD OFFICE PRACTICES

INTRODUCTION

This chapter discusses the current construction field office practices in personnel scheduling management, using material collected from the Project Engineers through questionnaires and interviews. The data collection methodology is explained first. Then the field office systems are reviewed using the separate issues raised in planning and operations to create tables that examine the level of detail, problems and problem solutions.

DATA COLLECTION METHODOLOGY

An important reason for this research is to establish the issues involved in personnel scheduling management at the construction field office level. The methodology used in examining these issues involved sending a questionnaire to and interviewing the construction field offices' Project Engineers. Other states' departments of transportation were interviewed as well to ascertain how they do personnel scheduling at the level equivalent to the construction field office. The objectives of the questionnaire and both sets of interviews were to

- determine existing personnel scheduling practices and procedures;
- identify scheduling problems and constraints; and
- obtain suggestions for what would be useful in a personnel scheduling management system.

Questionnaires

The basic information on how each Project Engineer perceives personnel scheduling, project management, and the policies, procedures and problems surrounding the issue was collected by using a three part questionnaire. The first part furnished basic information about the field office (number, type and size in dollars of projects, and number of personnel) while the last two parts identified the process the Project Engineer uses to manage personnel scheduling in planning and operations. In the questionnaire, planning was defined as personnel scheduling that takes place prior to the ad date and

operations as personnel scheduling that happens after the ad date. This dividing point was chosen because the ad date is when the Department commits itself to building the project and the construction field office becomes directly involved.

The questionnaire was developed from records about WSDOT policies and procedures for field office management, literature on project management, construction management and personnel scheduling, and information deemed to be missing from other background studies. A draft questionnaire was developed and submitted for review and critique to five Project Engineers in five different districts.

The final 29-item questionnaire was distributed to all construction field office Project Engineers in Washington. Included with the questionnaire was an explanatory cover letter and a stamped, addressed return envelope. The envelope had enough postage for the Project Engineer to include examples of any written scheduling sheets he might have created. The letter explained that responses would remain confidential. Appendix A contains copies of the letter and questionnaire that were sent.

Of the 37 construction field office Project Engineers in Washington, 32 returned a completed questionnaire, an 87 percent response rate, indicating an unusually high interest in the issues involved. Table 1 shows the response broken down by district.

The results of the questionnaire are summarized in tabular form and the practices discovered are discussed in this chapter. An extensive statistical analysis was not considered useful after some experimentation with questionnaire information in statistical form. The questionnaires also formed the basis for the interviews with the Project Engineers as the second step in the process.

Project Engineer Interviews

Of the 37 field office Project Engineers, 19 (51 percent of the total and 59 percent of those responding to the questionnaire) were interviewed for a more detailed understanding of how they schedule personnel and solve related problems. The Project Engineers who consented to the interviews had the following characteristics:

Table 1. Response to Project Engineer Questionnaire

District	Number of Construction Field Offices	Response	Percentage	Location with respect to Cascades
1	13	12	92	W
2	4	4	100	E
3	8	6	75	W
4	4	4	100	W
5	4	2	50	E
6	4	4	100	E
Entire State	37	32	87	

- all of the interviewees had answered the questionnaire before the interview;
- 7 of the 19 (37 percent) were in construction field offices east of the Cascades (Districts 2, 5 and 6);
- 9 of the 19 (47 percent), covering four districts, were either based in offices located in rural areas, or did work in mainly rural areas;
- each of the four levels of scheduling described in Chapter 2 was represented; and
- each of the 19 represented one or more types of projects (large and small, complex and simple, critical and non-critical) that can be found over the state.

Each interview lasted at least an hour and sometimes included more people than just the Project Engineer. Informal meetings after the interviews furnished additional information helpful to the research.

Information from the interviews as well as some of the more descriptive questionnaire results as they relate to evaluating existing systems are discussed and analyzed in more depth in Chapter 4. Appendix B contains a brief general outline used for the Project Engineer interviews.

Other States

In addition to the objectives mentioned above, the interviews of Project Engineers or their equivalent in other state departments of transportation were intended to

- provide an understanding of their methods of personnel scheduling management;
- discover if any states had evolved a construction field office level personnel scheduling management system; and
- ask for any suggestions those states could make regarding personnel scheduling management that potentially could be applied to the Washington State Department of Transportation.

For this section, a literature search was used to identify states with potential personnel scheduling management systems. Other DOTs were contacted by telephone to explore their personnel scheduling at the level equivalent to the construction field office. These methods of data collection were chosen as the quickest ways to gain the information required.

The literature about personnel scheduling at the most basic level, the construction field office equivalent, was scarce. Most of the available literature described capital management programs (headquarters level), personnel management systems (headquarters level, usually computerized, and dealing with information on individuals rather than personnel scheduling), and pre-construction management (district and headquarters level). However, two studies sponsored by the Transportation Research Board did appear to have information that touched on potential personnel scheduling management systems that seemed to include the construction field office level. Use of these two studies and H. Randolf Thomas's study [1985a] of time and schedule performance mentioned in Chapter 1 determined the choice of four of the five state DOTs interviewed.

The first study, Construction Contract Staffing by Copas and Pennock [1978], focused on state departments of transportation and "construction engineering manpower [as] directly related to the scheduling of construction projects" [page 1]. The study made a distinction between long-range manpower[9] planning (headquarters and district level) and short-term manpower projections (project level with district review). The authors applied the "basic functions of management . . . planning, organizing, leading, and controlling" [page 1] to the study of engineering manpower in several states, noting how the different states provided the required personnel to staff the construction projects. The

[9]This study and the following one used the term "manpower" throughout, so this report does the same in discussing the Copas/Pennock and Newman/Hejl studies.

focus of the study was to understand how various agencies plan manpower (in the sense of agency wide manpower projections): the personnel policies involved, the detail level of the planning, and how these are related to construction management. The study included recommendations that agencies should develop a suitable model of construction manpower management based on "a management systems approach" [page 1]. No model was proposed, and only agency level personnel management was studied. Two of the four states reviewed in depth in the Copas and Pennock study, Louisiana and Michigan (which was also studied in Thomas), were chosen as interview states to find out if either had incorporated the recommended model into their short-term manpower projections (field office level).

The second study, Development of a Construction Engineering Manpower Management System: System Design Manual by Newman and Hejl [1978], described a system of procedures that, beginning at headquarters level and gradually going to the district office side of the project level, included many of the personnel planning issues required in construction engineering management. All of the procedures described were hand methods, with various charts and graphs included where they were considered necessary to ease scheduling. The focus was from the aspect of headquarters and district planning, and little was directly related to construction field office personnel scheduling. Two of the twenty states that were funding participants in the Newman and Hejl study, Ohio (which was also studied in Thomas) and Wisconsin, which were thought to be potential users of this or a similar system, were chosen as interview states.

The fifth state, North Dakota, was suggested in one of the Project Engineer interviews. He mentioned that North Dakota might be doing something with personnel scheduling management, possibly as a computerized system.

Staff from these five states were interviewed by telephone after the Project Engineer interviews. None of them had a true construction field office personnel scheduling management system installed, and nothing of significance that could be applied to Washington was presented. Appendix C contains descriptions of the five interview state DOT's inspection methodologies, structures and personnel scheduling tools used, if any. Input from these states are incorporated into the recommendations in Chapter 7.

CONSTRUCTION FIELD OFFICE LEVELS OF SCHEDULING

General

According to the information from the questionnaires and interviews, almost all the responding engineers did some form of preliminary personnel scheduling (or planning), and virtually all of them attempted some form of operational personnel scheduling. Though usually informal, the operations phase also included some type of monitoring. Before specific planning and operations results are reviewed more closely, two general features that penetrate the entire existing personnel scheduling management system are examined.

The first general feature concerns who in the project office does, or helps to do, the personnel scheduling. The questionnaire asked, under both planning and operations, who were involved in scheduling. Table 2 indicates that almost all Project Engineers, most of their assistant Project Engineers and about two-thirds of the TE-3s were included. A few TE-2s were also included, but not very often. In no case was only one person, at any level, responsible for the entire personnel schedule.

The second general feature that affects both planning and operations concerns the levels of scheduling used at the DOT. Each Project Engineer used a scheduling level with which he was comfortable. Most of these Project Engineers had years of experience, both as assistant Project Engineers and Project Engineers in construction field offices, dealing with the wide variety of scheduling changes necessitated by the nature of the work. Based on these years of experience, many variations of personnel scheduling had developed.

Each variation can be placed into one of the four general levels of personnel scheduling (informal, "to do" lists, bar charts and networks) that have been described in Chapter 2. Table 3 was developed using information gleaned from the combination of answers to all the questions. The table lists the four levels along with the percentage of responding field offices using them, both for the entire state and for field offices located either east or west of the Cascades. It shows that most Project Engineers have been using either "to do" lists or bar charts for personnel schedules, and the trend holds true for west of the Cascades especially. East of the Cascades the construction field offices are more evenly split between levels of scheduling. The use of networks for personnel scheduling is very low.

Table 2. Construction Field Office Personnel Involved in Scheduling

Level	Planning (in %)	Operations (in%)
Project Engineer	96.8%	96.9%
Assistant Project Engineer	87.1	90.6
TE-3s	64.5	65.6
TE-2s	6.4	6.2

Table 3. Use of Scheduling Levels In Construction Field Offices

Level	State	West of Cascades[1]	East of Cascades[1]
Informal	13%	5%	30%
"To Do" List	44%	50%	30%
Bar Chart	37%	45%	20%
Network	6%	0%	20%

Note: [1]The total number of responding field offices west of the Cascades is 22; east is 10. These numbers were used to establish percentages west and east of the Cascades respectively.

To create Table 3, no distinction was made between planning and operations. Projects could be awarded at any time of year, and planning scheduling could include projects in progress. In fact, the field office's typical scheduling procedure was to use a single schedule that combined the two types of schedules, drawing off information necessary for different types of specific reports (i.e., headquarters' quarterly personnel needs reports, or a weekly schedule for the project inspector). The project cycles allow for a natural division of field office personnel schedules into planning and operations, so separate discussions of each is fruitful; within the construction field offices, the two types of schedules are combined in practice, though one may be emphasized over the other.

At this point, the distinction might be drawn between "to do" lists and bar charts as they are defined for this study. One of the characteristics of "to do" lists is that they lack time, one of the three dimensions of scheduling. If a system created by a construction field office lacked the dimension of time, it was considered to be part of a "to do" list system. Bar chart systems, on the other hand, would obviously have made an effort to connect time to the other dimensions, creating a personnel schedule.

Planning

Planning, as defined earlier, is personnel scheduling that takes place before the ad date. The Project Engineer forecasts the next season or year's projects to determine how his personnel will be utilized and whether he needs more permanent or temporary staff. The planning stage is marked by uncertainty because the Project Engineer cannot be assured that the projects assigned to him will actually be inspected from his office, or when the projects will arrive.

Why Plan?

The questionnaire asked the Project Engineers for the major reasons behind their planning, if they did plan. Table 4 indicates that three reasons, to determine adequacy of personnel and equipment and to schedule their people with projects, were important to most of the Project Engineers. (The percentages add up to more than 100 percent due to the acceptability of multiple answers.)

Figure 8 shows the Quarterly Man Power Summary, which District 1 has used to request information from the construction field office about personnel needs. The summary is not a schedule

QUARTERLY MAN POWER SUMMARY

PROJECT ENGINEER

REPORT PERIOD July 1985

MAN MONTHS REQUIRED	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOT
LOCATION 1+10%	8	8	8	8	8	8	9	7	6	7	0	0	77
CONSTRUCTION 1+10%	22	20	23	19	9	6	5	5	8	17	22	23	179
ADMINISTRATION 8+10%													
RE. ASSIST. OFF. ENGR., SECRETARY (1) (1) (4) (2)	9	9	9	9	9	9	9	9	9	9	9	9	108
OFFICE TOTAL	39	37	40	36	26	23	23	21	23	33	31	32	364

364/12 = 30.3

EMPLOYEE ROSTER

34 PERMANENT

_____ ON LOAN TO

_____ BORROWED FROM

_____ IN TRAINING

4 TEMPORARY

38 TOTAL

NOTE: REQUIRED MAN POWER SHOULD INCLUDE 10% TO COVER ANNUAL AND SICK LEAVE

SURVEY & MATERIALS INSPECTION TO BE INCLUDED IN LOCATION OR CONSTRUCTION.

RESUBMITTED 7/3/86

Figure 8. Quarterly Man Power Summary (Example from District 1)

Table 4. Reasons for Planning

Reason	%
Determine Personnel Adequacy	94
Assign Personnel to Projects	88
Determine Equipment Adequacy	84

per se (no projects are listed), but the Project Engineers mentioned in the interviews that they did their planning specifically to fill out this form. It is general enough to allow the Project Engineer to use any of the levels of scheduling to fill it out. Other districts also request their Project Engineers to hand in information regarding future personnel needs, though it may not be in this same form. The information is also important to headquarters for planning funding for projects.

Detail Levels of the Planning Schedules

Several Project Engineers mentioned during the interviews that permanent personnel levels and projects are assigned to the construction field office from the outside, that ad dates can change up to the actual advertisement of the project, and that the project's tasks can alter with scope changes. Many of the Project Engineers, therefore, did not desire to make planning schedules too detailed, even though they needed to determine what their requirements were for the season or year.

This desire for less detail on planning schedules were supported by answers to several other questions from the planning section of the questionnaire. Most Project Engineers, in dealing with these uncertainties (whether the project would be ready to construct on the ad date listed, and whether the office originally assigned would inspect the project), decided to do their preliminary personnel schedules at a fairly gross levels, as indicated by the following tables.

Table 5 lists the level of detail the Project Engineers used in their planning schedules; 81.3 percent used either the project as a whole or a gross level of tasks to determine schedule. Table 6 indicates that 74.9 percent scheduled either without a time period designated or used months, a fairly gross level of time. Table 7 indicates that, if personnel were assigned, and a document created, it was frequently a list of projects with key assignments.

Table 5. Level of Detail - Planning

Level of Project Detail	%
Project as a Whole	34.4
Gross Schedule of Tasks	46.9
Detailed Schedule of Tasks	15.6
Other	3.1

Table 6. Time Period Used - Planning

Time Period	%
None	34.3
Project	6.3
Month	40.6
Week	12.5
Day	6.3

Table 7. Documentation

Written Product	Total Number Indicating	Number Exclusive
None	4	4
List of Projects with Key Assignments	20	8
List of Projects with All Assignments	10	4
Schedule of Personnel Work Load with Time Periods	10	3
List of Project Tasks with All Assignments	7	0

Table 7 also indicates multiple answers for the type of documentation used, if at all. Those Project Engineers who used a single type of document exclusively did so for all projects, regardless of other factors. Several Project Engineers mentioned during the interviews that, for them, the size and complexity of the project dictated the type of document produced; the more complex and larger projects required more detailed schedules even in planning.

The reason that size and complexity caused the Project Engineers to consider more detailed documentation seemed to be that when projects became very large (in dollars and complexity), the amount of forewarning to the field office increased. From fairly early in the design process the construction field office is notified of its assignment to the project. While the project office does not involve itself with the design, it is aware of the project's scope and major requirements. Carefultracking by that field office and district is then begun to make sure that the construction field office has sufficient staff to handle the project. All other projects assigned to that office are assigned on the basis of their ad date and duration in relationship to the major project's ad date and requirements.

As an example of this, one Project Engineer mentioned that he had a large project that originally had been scheduled to go "on ad" on July 1, 1987. He knew about the project at least a year earlier. His task, when he learned about the assignment, was to ensure that his staff were ready for the project; looking over his preliminary schedule, he saw that a couple of smaller assigned projects would need to go to other offices if the major project was to be handled properly. So he made arrangements with the district to reassign those. At the time of the interview, the major project's ad date had just been delayed until October, and he was reworking his preliminary personnel schedule to accommodate this delay. The delay had left him with some extra people with slack time, so he was hoping either to lend out crew or add a project.

Problems Encountered in Planning

It is important to understand both what problems can limit the effectiveness of planning and what problems the Project Engineers do not perceive as affecting planning. Table 8 indicates both of these aspects of planning problems.

The first three problems on the table, uncertainty of the start date, uncertainty of when project activities will actually occur, and the lack of detailed project schedules, have two common characteristics. The first and most noticeable is that they focus on the project dimension of scheduling. The second, which is more inferential, is that the project data required by these three problems must come from outside of the construction field office. Activity schedules and dates come from the design team and headquarters and, as mentioned, are variable.

The second set of problems on Table 8 are those considered by the Project Engineers to be of little concern. Lack of procedures, information and time for scheduling do not seem to impact or constrain the planning. The common feature of these problems is that the Project Engineers perceive them as under their control, at least partially. They do not perceive a need for faster or better "tools" to help them schedule; all the problems are from the outside. Internal problems do not matter because they do not seem to be restrictive.

An investigation was done to see if there were any common characteristics shared by those engineers who answered in the minority (i.e., those who considered project activities and start dates was not important, or who considered lack of procedures, information and time to be important). No associations appeared except that some of the newer (or more recently promoted) Project Engineers considered a personnel management system to be important or extremely important.

Solutions to Planning Problems

During the interviews, the Project Engineers were asked what kind of solutions they used to balance the schedule in planning. Given that projects were outside of the Project Engineers' control, both in terms of start date and assignment to their offices, the Project Engineers answered, in almost every case, that they adjusted the personnel to accommodate. In the planning stage, this meant reassigning planned project duties, applying to headquarters through the district for more personnel, either permanent or temporary, or asking the district office to help find places or work for personnel who would become extraneous in the future.

Operations

Operations, as defined for the questionnaire, is personnel scheduling that takes place after the ad date. As mentioned, operations scheduling is office specific, dependent on the arrival of the PS&E

Table 8. Potential Problems that Could Limit Planning Effectiveness

Problem	Not Important	Important	Extremely Important
Problems Considered Important:			
Uncertainty of Project Start Dates	2	7	19
Uncertainty of When Project Activities Will Actually Occur	3	9	17
Lack of Detailed Project Schedules	8	5	14
Problems Not Considered Important:			
Lack of Procedures or Methods to do Work Load Scheduling	20	3	3
Lack of Adequate Personnel Information	18	3	6
Lack of Adequate Equipment Information	18	5	4
Lack of Time to Analyze Task Level Assignments	16	6	5
Lack of Time to Make Project Level Assignments	16	6	4

Note: 1. Numbers indicate total number of respondents. Numbers across do not reach the same totals because some answers were left blank. Maximum total is 32.

2. The categories "Not Important" and "Extremely Important" are from combined answers on the questionaire. "Not Important" combines "unimportant" and "somewhat unimportant." "Extremely Important" combines "very important" and "extremely important."

at the construction field office and the contract award, which can happen any time of year and which makes scheduling particularly complex. The operations schedule is also more dynamic, is subject to rapid change and requires constant updating and adjustment to ensure that no delays occur in project construction.

Detail Levels of the Operations Schedules

It has been stated that the Project Engineers tended to use the same technique for both planning and operations. Tables 9 and 10 support this to a limited degree. Table 9 lists the personnel detail level assigned and illustrates that the majority of Project Engineers schedule only key personnel. Table 10 lists whether the Project Engineer breaks down the project into tasks; two-thirds indicated that either no task breakdowns occurred, or that task breakdowns occurred only for specific projects. This indicates the use of a level of detail similar to that of planning.

As Tables 11 and 12 show, only one third of the Project Engineers documented their operational schedules. This indicates less documentation than is evident in the planning stage. Of these, about one-half used weeks as the unit of time while most others developed monthly assignments. This level of detail is greater than that encountered for planning purposes.

Monitoring

One question asked the Project Engineers was whether they evaluated, or monitored, personnel schedules as affected by project changes and, if they did, how they responded. Tables 13 and 14 together illustrate the response.

Table 13 indicates that almost a third of the Project Engineers did not monitor for changes, in effect indicating that they might not be doing personnel scheduling during this phase. Of the other two-thirds, the majority monitored all projects. Table 14, which was developed from descriptions of how monitoring is used, indicates that the monitoring happens mostly as needed or daily. The majority of those responding also indicated that the results of monitoring were used to update schedules.

Problems Encountered During Operations

Table 15 was generated from Question 11, the Operations section of the questionnaire, and indicates what problems could limit use of personnel evenly over the calendar year. (For the complete

Table 9. What Personnel are Assigned at Project Start?

Key Personnel	65.6%
All Personnel	31.3%
Both	3.1%

Table 10. At What Level of Project Detail?

Whole Project Only	31.3%
Specific Tasks, Some Projects	40.6%
Specific Tasks, All Projects	28.1%

Table 11. Is a Written Schedule Generated?

Yes	37.5%
No	62.5%

Table 12. If Yes, What Time Period is Used?

Week	50.0%
Month	41.7%
Project Duration	8.3%

Table 13. Project Changes and Personnel Work Load Evaluation

Are project changes evaluated in relation to personnel work load?

No	31.3%
Yes, on some projects	15.6%
Yes, on all projects	53.1%

Table 14. Frequency of Evaluation

If yes, how frequently?

As needed	36.4%
Daily	31.8%
Weekly	9.0%
Bi-weekly	4.6%
Monthly	0%
Bi-monthly	4.6%
Quarterly	4.6%
No answer	9.0%

Table 15. Potential Problems That Could Limit Even Personnel Use Over Calender Year

Problem	Not Important	Important	Extremely Important
Problems Considered Important:			
Lack of Reliable Project Schedule from Contractor	2	4	23
Lack of Detailed Project Schedule from Contractor	4	8	17
Lack of Updated Project Schedule from Contractor	6	6	17
Uncertainty of when project activities will actually occur	1	11	17
Lack of Time to Respond to Schedule and/or Personnel Changes	4	10	14
Problems Not Considered Important:			
Staffing Problems	17	4	5
Lack of Time to Analyze Task Level Assignments	19	5	4
Lack of Procedures or Methods to do Work Load Scheduling	16	5	5
Problems Considered Equally Important and Not Important:			
Lack of Detailed Project Schedule from WSDOT	10	5	13
Absenteeism of Staff	11	9	10
Lack of Alternatives for Keeping Personnel in House in Off Season	11	6	10

Note: 1. Numbers indicate total number of respondents. Numbers across do not reach the same totals because some answers were left blank. Maximum total is 32.
2. The categories "Not Important" and "Extremely Important" are from combined answers on the questionaire. "Not Important" combines "unimportant" and "somewhat unimportant." "Extremely Important" combines "very important" and "extremely important."

question, see the Questionnaire, page 11, in Appendix A.) Not all of the potential operational problems in Question 11 are listed on Table 15 because not all produced strong responses.

The top section of Table 15 lists five potential problems considered by the Project Engineers to be important. These are similar to the planning problems of Table 8. The lack of reliable, detailed and updated contractors' schedules, uncertainty of when project activities will occur and lack of time to respond to project and/or personnel changes have the following characteristics: the focus is on the project (except for a portion of the last problem listed) and the schedule data must come from the outside, in this case, from the contractor.

The second section of Table 15 lists three potential problems considered to be unimportant by most of the Project Engineers. Staff problems, lack of time and lack of procedures again appear. As in planning, these problems are indicating that a lack of tools to schedule are not considered a problem; rather the problems all come from the outside.

Staffing problems have been pointed out in much of the project and personnel management literature as probably creating difficulties for the project manager. The Project Engineers indicated the opposite. On Table 15, "staffing problems" is a combination of four problems (lack of personnel information, lack of inspector interest in projects, lack of field office staff capability and lack of staff team work) that were suggested to the Project Engineer in the original question. The number of Project Engineers who indicated a level of importance for each of the four problems rated them so closely that the four seemed like a single, unimportant problem.

An attempt was made to identify any common factor influencing the Project Engineers who answered in the minority for these two sets of problems. The only relationship between outside factors and a minority answer concerned the lack of procedures for scheduling. As in planning, some of the newer or more recently promoted Project Engineers considered a methodology for scheduling important to extremely important.

Three potential problems surfaced that had a mixed response. These are listed in the third section of Table 15. They showed enough of a difference from the rest to require further examination. Two of the three, the lack of a detailed WSDOT project schedule and the lack of alternatives for keeping personnel in-house during the off season, are almost evenly split between not important and

Table 16. District Representation: Staff Absenteeism

District	Unimportant	Important	Extremely Important	No Answer
1	2	4	5	2
2	3	1	0	0
3	2	1	3	0
4	2	1	0	1
5	1	0	1	0
6	1	2	1	0
All Districts	11	9	10	3

Notes: 1. Numbers indicate total number of respondents.
2. The categories "Not Important" and "Extremely Important" are from combined answers on the questionnaire. "Not Important" combines "unimportant" and "somewhat unimportant". "Extremely Important" combines "very important" and "extremely important."

extremely important. To find out if any common factors appeared to explain this (such as, are the engineers who answered in one way or the other of a certain type or located in one area), several charts were made. No associations surfaced between answers and respondents.

This is not the case of the third problem listed, staff absenteeism. For this problem, the Project Engineers are evenly divided between all three categories of importance. Table 16, a district breakdown of the answers, indicates that most districts are similarly balanced in answers.

However, more District 1 Project Engineers indicated that staff absenteeism was important or extremely important than other districts' Project Engineers. While all districts have their share of urban projects, District 1 has the largest urbanized center in the state, with the majority of its construction field offices located in or around this center. Of the Project Engineers who indicated answers of important or extremely important, most (8 of 9) were working with projects related to urban area problems, which are usually large, complex and stressful. Shift work and overtime are

frequent and project inspectors can accumulate so much annual leave (vacation), sick leave and comp time[10] that the Project Engineer can have difficulty counting on the person being available when desired.

Solutions to Operations Problems

Operations schedules must change in response to the contractor's constant revision to what he is doing. As Figure 7, Chapter 2 shows, the Project Engineer must choose the way he will rebalance his personnel assignments; he will alter the resource pool, the project task schedule or the resource assignments. This works in two ways: at times, the construction inspection tasks are so numerous that they require stretching office resources thin; at other times, inspectors are idle with little to do. Questions 8 and 9 in the operations section asked the Project Engineers to note which solutions they used to cover both situations. All solutions listed are used to some degree, with some used more than others, as Table 17 illustrates by presenting the solutions and the percentage of Project Engineers using them. Note that these percentages indicate using the solution any number of times, including only once.

Certain solutions would be used less frequently, or would be avoided by many Project Engineers. Those solutions used least often when demand exceeds resources (changing inspection methods, requesting more permanent staff positions and asking the contractor to adjust the schedule) require the Project Engineer to request outside help in adjusting his personnel schedule, either from headquarters (changing inspection methods and new crew possibilities) or from the contractor (adjustments to the contractor's schedule). Permanent transfer of crew, when resources exceed demand, also requires outside help from district and/or headquarters, but is avoided entirely by 60 percent of the Project Engineers. Also, of all the solutions listed, only one, asking the contractor to adjust the schedule, does not adjust either the resource pool or alter the resource assignments.

---

[10]Annual and sick leave is accrued in hours per month; the number of hours for annual leave can be accrued to 240 hours before vacation must be taken or the hours lost. 240 hours is six weeks' leave. Sick leave is accrued at 8 hours per month with no limits. Comp time stands for compensatory time and is based on accumulating hours instead of overtime pay; 240 hours total leave time (accrued at one and one half hours time per overtime hour worked) may be based on mandatory overtime pay is invoked.

Table 17. Resource Demand Problems and Percentage of Project Engineers Who Use Particular Solutions

Solution	%
I. Problem: Demand Exceeds Resources Available	
Add Temporary Personnel	100.0
Add Overtime	100.0
Shift Personnel	100.0
Assign Office Staff to Field	96.1
Borrow Crew	92.3
Assign Project Inspectors More than One Project	88.5
Change Personnel Assignments	84.6
Change Inspection Methods	65.4
Request More Permanent Staff Positions	61.5
Ask Contractor to Adjust Schedule	46.1
II. Problem: Available Resource Exceeds Demand	
Previous Season's Paperwork	96.7
Send Personnel to Training	90.0
Assign In-Office Odd Jobs	90.0
Design Function Part of Office	80.0
Constant Construction (No Winter Shutdown)	80.0
Temporarily Lend Out Crew Members	76.7
Permanently Transfer Crew Members	40.0

SUMMARY

In this chapter, the data collection methodology has been discussed, and the information collected has been presented. More than half of the construction field office Project Engineers, in both planning and operations, used less formal scheduling techniques (informal and "to do" lists). The reason given for this was that the project schedules were outside of their control. Conversely, they did not feel the need for faster or better tools for scheduling than that which already exists. In the next chapter, what the data show is explored in more depth using the four levels of scheduling and the model of personnel scheduling management presented in Chapter 2.

CHAPTER 4
ANALYSIS OF THE CURRENT STATE OF PERSONNEL SCHEDULING MANAGEMENT

INTRODUCTION

The indications from the previous chapters are that the Project Engineers do carry out purposeful personnel scheduling management. It is also clear, however, that their efforts are impacted and constrained from both outside the construction field office as well as from within it. This chapter analyzes the construction field office personnel scheduling management practices by examining representative scheduling techniques and responses to constraints. After the analysis, the questionnaire and interview results are more closely scrutinized to understand more completely the limitations operating on the construction field office in terms of personnel scheduling.

In examining the techniques used at the Department, the levels of scheduling mentioned in Chapter 2 (informal, "to do" lists, bar charts and networks) will be used. It is questionable whether the first two levels can actually be termed "scheduling." One of Webster's definitions of scheduling is "a production plan allocating work and specifying deadlines."[11] The definition implies that resources (people) are doing assigned work (projects or tasks) within a time frame, which covers the three dimensions of scheduling mentioned in Chapter 2. When a dimension, such as time, is missing, it is difficult to call the result a "schedule."

EXAMPLES OF PERSONNEL SCHEDULING AT WSDOT

The model of the personnel scheduling process presented in Chapter 2 is used below to make the assessment of the current construction field office practices easier. The levels of scheduling previously discussed are presented as representative systems and analyzed for the characteristic ways planning and operations are done. Each level treats the three dimensions of scheduling differently; these differences are important to understanding current field office scheduling.

---

[11] Webster's II: New Riverside University Dictionary, The Riverside Publishing Company, 1984, page 1043.

Certain characteristics of personnel scheduling management are common to all the systems found at the Department. One of these is the delegation of day-to-day scheduling to the chief inspector or the project inspector. This occurs only when the crew scheduled for a project is the same from day to day, not when a crew change is required. If a different size or type of crew is required, the Project Engineer becomes directly involved in the process.

A second common characteristic is the high level of distrust of the contractor's progress schedule and the written updates received. Almost all the Project Engineers mentioned, either in the interview or on the questionnaire, that the contractor's progress schedule cannot be trusted to tell what the contractor actually plans to do and when. Often, the reason the Project Engineers gave for this schedule inaccuracy is that the contractor does not understand scheduling, though investigations of actual causes have not been done. Contractors' progress schedules are covered in more depth in the section on limitations, after the four levels of scheduling.

A third characteristic, related to the second, is the reluctance of almost all Project Engineers to ask the contractor to alter his schedule. Though the Standard Specifications state that certain types of inspection services require more than a few hours' notice, Project Engineers seldom enforce the requirement. Two reasons behind this may be that the Project Engineers do not wish to delay the contractor in any way and that the notification requirements have not been fully tested in court.

Informal

Typical System Features

The informal level of scheduling, used by 13 percent of the Project Engineers statewide, is the least detailed and simplest. Characteristic attitudes toward scheduling are marked by a lack of interest in time, paper and planning. Frequently, this technique is difficult to describe; one Project Engineer called this a "thought process -- ongoing." When several Project Engineers who used this process were asked to explain their system, the descriptions were disjointed and terse. Below is a compilation of typical features found in informal field offices.

Planning. Planning is done reluctantly, and only to fulfill the departmental requirement for an office personnel needs assessment. The usual sequence of "scheduling" is to look at an upcoming projects list, compare it against known office staff, and fill in the form. No balancing is attempted.

Planning is considered unreliable and/or a waste of time. One Project Engineer mentioned that headquarters had sent him a form to use in planning; he tried it, but found it did not work for him because there were too many project start date changes.

Putting anything down on paper is avoided as well, because of the frequency of revisions in project starts and activity schedules. Time is of little concern because the Project Engineer perceives that no matter what he does, the project will progress and be completed -- some time.

Operations. The short-term scheduling most frequently associated with operations is the greatest concern. Any assignments to projects do not occur until after the ad date; at that time, the project inspector is assigned. Further concentration on scheduling takes place after the pre-construction meeting[12] (precon), because that is when the Project Engineer knows what the contractor is planning. To these Project Engineers, the contractors "drive" the schedules and the field office accommodates the contractors' needs.

Typically, the Project Engineer is aware, by field inspection, of a project's current status, though warning of construction scheduling changes that affect the field office is short, usually a day or less.[13] One Project Engineer stated that nothing more formal in scheduling was required for his people because the "contractors only know [emphasis his] today what they are doing today."

The response to changes is reactive rather than planned. These Project Engineers wait for changes and do not try to foresee what changes might occur. The attitude seems to assume that if something is planned for, it will not happen, so planning is really of little worth.

All the Project Engineers interviewed agreed that the process is mental. Crew shifts are done in the Project Engineer's mind based on personal examination of the construction progress. The Project Engineers who used this level of scheduling also did not feel the need for more detail or written schedules because the majority of the projects were straightforward (requiring similar task sequencing

---

[12]A pre-construction meeting (called a "pre-con") is required by all contracts prior to the start of the construction of a state project. At this meeting will be all the state and federal agency representatives as well as the contractor and others involved in the project. The purpose of the meeting is to discuss thoroughly the contractor's progress schedule for construction.

[13]The short notice applies to all contractors; contractors as a group tend to notify all DOT construction field offices on a short notice basis. The construction field office response to these notices is different for each type of scheduling.

for almost all projects) and not very complex ("mostly repavers"). The repetitiveness of the projects did not require much detail.

Personnel held the majority of the attention of these Project Engineers. When crews were established, the crews were meant to be able to do more than one task: surveying and paving inspection, for example. Scheduling per diem[14] took some thought, because the Project Engineers have noticed abuses of it and were reluctant to use it. Attention was paid to assigning crews to projects that are in proximate areas, and project inspectors in some offices were assigned to contractors with whom they work well, if possible. Furthermore, the Project Engineers would intervene in the personal lives of crew members if what happens off duty affected their ability to do their jobs.

A departmental change that all these Project Engineers said affected them negatively in operations scheduling is design centralization. Before design centralization, the Design Report and PS&E preparation were incorporated into the function of the office. As construction slowed or stopped for most projects in October or November, the design function would become the project inspector's job. With design centralization, most design functions (except those mentioned in Chapter 2) were removed from the construction field office. The Project Engineers have been experiencing difficulties in using the abbreviated design assignments as fillers for short time periods when little inspection work is available. The informal offices have become less flexible in their ability to find alternatives for their personnel.

Assessment of the Scheduling Process

The units used in the informal process for each of the three dimensions depend on the need of the moment. Time is of little concern, though months are used for the departmental quarterly report. Personnel assignments are fluid, depending on the current state of construction. Projects as a whole are the main concern, though there is an understanding of the construction project's progress and the need to have available the necessary inspection personnel. The Project Engineers do not seem to have

[14]When a project is located far (at least one and one half hours' drive one way) from the project office, the project inspector and crew find living quarters close to the project, staying there a week at a time, paid for by the department through per diem. The project inspector keeps in touch, usually daily, with the construction field office.

a sense of an operational time line (how long a task will last, for example), only that the sequence is about the same as usual.

The Project Engineers' attitude toward personnel scheduling management is both simple and difficult to describe. On the one hand, the Project Engineers consider that the chaos that is construction management at the DOT will continue regardless of efforts on their parts. Therefore, no tools for scheduling are required. All problems come from outside sources, so the outside sources are responsible for solving them.

This attitude extends to the new technology introduced into the construction field offices in the forms of microcomputers and various programs. Most of the Project Engineers who do mental scheduling leave the micros in the main office for use by the other engineers for engineering (geometric design, final records, surveying and right of way, for example). They have said they do not want to tie up their micros for work other than the main focus of the office: engineering.

On the other hand, because the process is based on years of construction experience ("based on history"), the attitude is difficult to define. Although they view outside problems negatively, the Project Engineers deal well with personnel and immediate changes in schedules.

The advantages of this technique include little paperwork and a major focus on personnel. The result is that these Project Engineers are available at all times to help solve the immediate problems that their crews encounter. As mentioned, the help offered does not stop at construction difficulties but also extends to personal lives. Project completion is ensured by concentration on covering the inspection tasks, whatever that requires, and responding swiftly to immediate needs.

One of the disadvantages of this technique is that the lack of paperwork extends to some records. The Project Engineers expressed reluctance to commit schedules to paper. This means that if a project must be reopened after completion, the paucity of written records about scheduling prevent others from understanding some of what happened. Furthermore, without documentation to show how the scheduling is done, this may not be a true personnel scheduling technique.

A second disadvantage is that this technique and the information it imparts are very difficult to pass on to someone else if the Project Engineer is away or leaves. The assistant, who is being trained for a future Project Engineer's job, will not necessarily be able to do informal scheduling; he or she

may not have the background or inclination. This means that the assistant Project Engineer in a construction field office with informal personnel scheduling generally is experimenting with other scheduling techniques and comparing the results with the Project Engineer's scheduling. Often, this leads to some confusion on the part of the assistant about how to do personnel scheduling because the Project Engineer's own method is indescribable.

"To Do" Lists

The "to do" list level of scheduling, used by 44 percent of the Project Engineers statewide, includes more variety than the informal level, with more detail. This level adds simple documentation, which usually consists of lists of projects and project inspectors. Unlike informal levels, planning is done more seriously, though operations remains the major focus. Characteristic attitudes include resignation toward departmental policies and a disinclination to use microcomputers, though there are a few exceptions. Below are features typical of "to do" list systems.

Typical System Features

Planning. Planning is done readily, but only to fulfill departmental requirements. Almost all the Project Engineers mentioned that they list the projects expected to come in and add the key personnel names. Most expressed interest in scheduling individuals when they were at the project inspector level or above (TE-2 or higher) and creating floating crews out of the remaining personnel. One Project Engineer used the Table of Organization (TO) to compare available staff with projects; another listed project inspectors across the top of a sheet of paper and projects down the middle for use in mental matching. A third estimated needs by using engineering costs, project durations and an estimated inspection cost per person. Balancing the personnel schedule using the TO is also common.

Plans developed for the departmental requests are not usually directly connected to operations. They may be used to remind the Project Engineer of his thinking earlier before the job actually came in house. However, the majority of personnel scheduling takes place after the ad date or the pre-con. One Project Engineer stated that "there are so many variables that, other than planning for key people and equipment, the detailed scheduling would be a waste of time and resources." Another stated that "this type of detailed planning is not effective with contractor/state/political/media/weather [sic] adjusted projects."

Operations. Systems that have developed with this technique usually consist of something similar to Figure 9 (though many variations exist). This figure is a picture of a magnetic board that uses columns to delineate projects. Individual, color coded magnets contain a project number, a person's name, or an equipment number. All projects indicated on the board are in-house.

The project inspector, assigned to a project from start to finish, and his vehicle number are at the top of the column with the contract number. No time line is indicated. The remaining magnets, representing personnel and equipment are distributed according to need. Survey crews have a general "survey crew" magnet, with individual names listed in the survey section. Other marked off areas contain magnets with unassigned vehicles and vehicles that are in the shop for repair or maintenance. Staff on any kind of leave are also in a separate section, as are extra tags. Location projects are on magnets and in separate columns on the left side.

Updating is done in two ways. The chief inspector meets with the Project Engineer frequently to report construction progress, specifically to ensure efficient use of crews. The Project Engineer also makes personal on-site visits at least weekly to check the contractor's progress and ensure that the contractor's schedule reflects the actual situation. As in the informal systems, the Project Engineer generally allows the contractor to "drive" the schedule.

These Project Engineers also focus their attention on the personnel in their offices, but to a lesser degree than is evident in offices with the informal systems. For example, almost every Project Engineer using this scheduling level mentioned that on-the-job training was automatically part of operations. Project Engineers ensure that employees who are unskilled in certain areas are trained by putting them with experienced supervisors. The attitude seems to be that employees are part of the Project Engineer's job but not the majority of it.

Assessment of the Scheduling Process

The units used in the "to do" list process for all three dimensions are at a gross scale. Usually, one of the dimensions is either missing some information or absent altogether (such as time). Projects can be whole projects or broken down into major tasks. Personnel assignments are usually project inspectors or chief inspectors by name. Assignments are "permanent" until a change is required by either contractors' progress or winter shutdown.

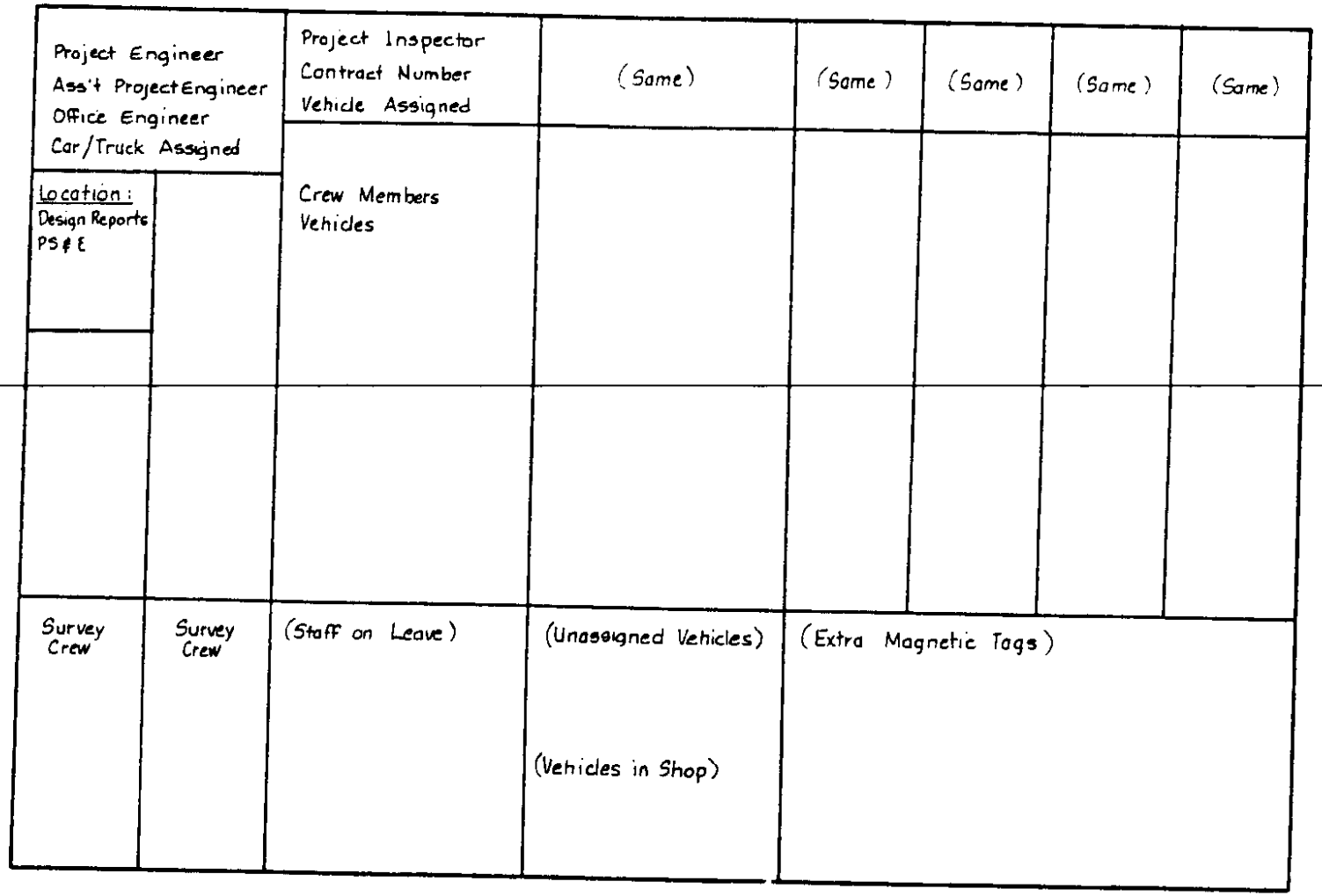


Figure 9. "To Do" List Level of Scheduling Example

The Project Engineers' attitudes on scheduling issues vary widely. Most of them would agree that detailed planning was seldom justified. Several mentioned that they had attempted more detailed scheduling at one time but had abandoned it because the schedule revisions happened too quickly to allow them to maintain the schedules. Others mentioned the problem created when they expected a project to come to their office for construction inspection only to find that funding or other problems had stopped the project indefinitely.

Most Project Engineers expressed a lack of concern over "missing pieces" in the schedule. The schedules fulfill their purpose adequately, to the Project Engineers. For example, time was frequently connected with engineering costs in their minds. Because engineering costs were considered "uncontrollable" at the construction field office level, due to delays and costs incurred from outside the field office, the common response was "everything will work out in the end."

A major amount of scheduling is still based on the "gut feelings" (experience) of the Project Engineers. One Project Engineer felt he was overstaffed, but could not pinpoint on paper why he thought so. Another felt that the Department does not have the flexibility that private companies do in scheduling and dealing with problem employees. Two others mentioned that they lacked information to do reasonable scheduling, which then led them to feel uninformed and to "guesstimate" schedules.

A variety of attitudes were evident when microcomputers were discussed. The attitudes ranged from one Project Engineer who did not want to know how to turn his computer on to another who wanted to use it for scheduling. Some had tried using the micros, but found the programs for scheduling of little value to them; others would not use the micro because it was too important for engineering and too few machines were available.

There are several advantages to this type of scheduling over informal scheduling. Often, documentation exists that can be used for back up data. Paperwork is not increased to a great extent because of the simplicity of the system. The lists are available for everyone to refer to without constant consultation with the Project Engineer. Secondary task lists for slack times can be created as well.

The major disadvantage to this technique is that it cannot truly be called "scheduling." Most of the schedules created by this technique focus on projects. Projects almost always are listed first, personnel are often treated in lumps or clusters, and time is missing. Planning is not considered as

important as operations, and planning and operations are not necessarily connected, even tentatively. With the lack of certain pieces of information comes the inability to anticipate changes that come quickly, creating a reactive management situation.

Bar Charts

Bar charts, used by 37 percent of the DOT construction field offices, are both simple and complex. They are differentiated by documentation that includes all three dimensions, the ability to create histograms and thus balance personnel use, and a greater focus on planning. Following is a compilation of several typical features of bar chart systems. Bar charts at DOT are created in a manual, computerized or combination of systems. Two different systems, one manual and the other computerized, are described; then features common to all systems are assessed.

Typical System Features

Manual Version. One typical manual system is partly displayed in Figure 10. It is done on graph paper with months at the top. The months deliberately cover twenty squares of the graph paper, representing work days. Along the left side is either a project contract number or a project description. Inside the chart are a series of colored bars that delineate the project inspector and assistant project inspector involved in a project. In the lower right corner is a legend matching colors and project inspector names. Overlapped bars of the same color mean that the project inspector is scheduled to work part time on two projects.

Each project is divided into at least three segments: ad date to construction start date, start date to final records, and final records to completion date. The project inspector is not assigned to the first or third segments. If the project inspector assignment is affected, the construction segment may be divided into subtasks. For example, a project may have subtasks such as "procurement" (for certain materials, this segment dictates the start date), "grading," "structure," or "settlement." "Procurement" and "settlement" do not need a project inspector, so he or she is assigned to a different project.

The manual bar charts are generally the simpler ones, with a gross scale for all three dimensions. They are reasonably quick to create, and the focus is more on planning, because they are static. A new bar chart must be created each time major changes occur.

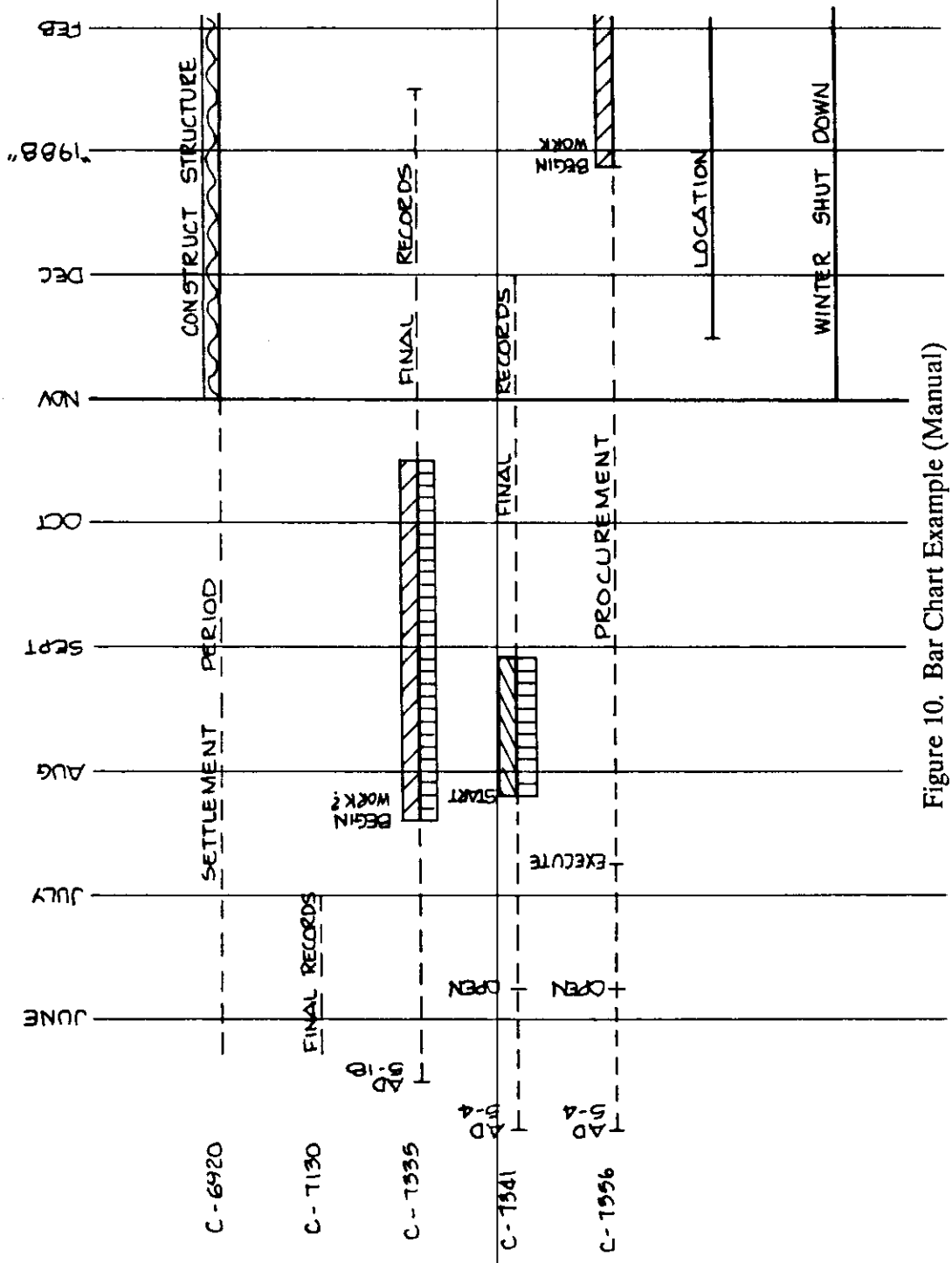


Figure 10. Bar Chart Example (Manual)

Computerized Version. The second example was created in LOTUS 1-2-3. Two reports result from this system: an estimate of a single project's personnel needs and an estimate of a total office's personnel needs. Figures 11 and 12 illustrate the two reports.

The first report (Figure 11) lists personnel needs for a project in a table that breaks out major types of inspection tasks (surveying and various tasks under "project quality control"). Employee classifications are listed in groups under the tasks. Time across the top is by weeks, starting with the date of the week's Monday. The final result is person-weeks by classification. The second page of the report graphically represents the information in a histogram of personnel use, demonstrating the weekly needs for each classification for that project.

Figure 12 illustrates a similar report covering the total office. The first page is a table in which the first column contains the first day (Monday) of a calendar year of weeks. The next columns are titled with the personnel classifications and list the total man-weeks required for each week. The second page shows the histogram for total office staffing needs by week.

Computerized bar chart systems almost always are based on either LOTUS 1-2-3 or Microsoft PROJECT. The combination of manual and computerized systems usually use charts created in LOTUS 1-2-3 with manually drawn bars showing assignments at a highly detailed scale. The LOTUS 1-2-3 charts are as static as the manual ones, because all changes must be entered manually. Microsoft PROJECT, which draws bar charts automatically, requires only a few changes to recalculate both the bar charts and the histograms.

Planning. Both types of bar charts are useful for planning, though the manual ones are more focused on planning. All of the manual charts cover at least one construction season, and most a full calendar year. All of them list ad dates. Months can be divided further into quarter-months, though the month seems to be the important division. Key personnel or at least classifications of key personnel are listed.

Updating is done when information is available. For the manual chart users, this can be once per month, but more likely it is once every two or three months due to the necessity of redrawing the chart. Balancing involves adjusting the staff to accommodate project changes: the project changes are noted and then the bars are redrawn and necessary adjustments made.

Job like this is strictly a guess as to needs even though it is supposed to start this fall.

CONTRACT BRTHB	YEAR	87																			
	MONTH	5	5	6	6	6	6	7	7	7	7	8	8	8	8	8	9	9	9	9	10	10
Green River to Hoffstadt Bluffs	DAY	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14	21	28	5	12
SURVEY CREW: *(TE2																						
ALIGNMENT	TT3/TE1	0	0.0	0.0	1.0						1.0	1.0	1.0	1.0		1.0	1.0					
EARTHWORK	TT2/TT1																	1.0	1.0	1.0		
DRAINAGE	TT2/TT1)*																					
SURFACING																						
SUBSTRUC.																						
SUPERSTRUC.															1.0							
MISC.																						
SUBTOTAL		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
GUAL. CONTROL:																						
PROJECT INSP.	TE3	1.0									0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	TE2																					
EARTHWORK	TE2																				1.0	1.0
	TT3/TE1																					1.0
	TT2/TT1																				1.0	1.0
DRAINAGE	TE2																				1.0	1.0
	TT3/TE1																					
	TT2/TT1																				1.0	1.0
STRUCTURES	TE2																					
	TT3/TE1																					
	TT2/TT1																					
SURFACING	TE2																					
	TT3/TE1																					
	TT2/TT1																					
MISC.	TE2																					
	TT3/TE1																					
	TT2/TT1																					
SUBTOTAL	TE3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	TE2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
	TT3/TE1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	TT2/TT1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
TOTAL	TE3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	TE2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0
	TT3/TE1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	TT2/TT1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	2.0	2.0	4.0	2.0	2.0	2.0	2.0	2.0	4.0	2.0

CONTRACT BRTHB	YEAR	87								
	MONTH	10	10	11	11	11	11	11	12	
Green River to Hoffstadt Bluffs	DAY	19	26	2	9	16	23	30	7	
SURVEY CREW: *(TE2										
ALIGNMENT	TT3/TE1									
EARTHWORK	TT2/TT1									
DRAINAGE	TT2/TT1)*									
SURFACING										
SUBSTRUC.										
SUPERSTRUC.										
MISC.		1.0								
SUBTOTAL		1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	
GUAL. CONTROL:										
PROJECT INSP.	TE3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	TE2									
EARTHWORK	TE2	1.0	1.0							
	TT3/TE1	1.0	1.0							
	TT2/TT1	1.0	1.0							
DRAINAGE	TE2	1.0	1.0	1.0	1.0					
	TT3/TE1									
	TT2/TT1	1.0	1.0	1.0	1.0	1.0				
STRUCTURES	TE2			1.0	1.0	1.0				
	TT3/TE1									
	TT2/TT1									
SURFACING	TE2									
	TT3/TE1									
	TT2/TT1									
MISC.	TE2									
	TT3/TE1									
	TT2/TT1									
SUBTOTAL	TE3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	TE2	2.0	2.0	2.0	2.0	1.0	0.0	0.0	0.0	
	TT3/TE1	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	
	TT2/TT1	2.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0	
TOTAL	TE3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
	TE2	3.0	2.0	3.0	2.0	1.0	0.0	0.0	0.0	
	TT3/TE1	2.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	
	TT2/TT1	4.0	2.0	3.0	1.0	0.0	0.0	0.0	0.0	

Figure 11. Bar Chart Example (Computerized)

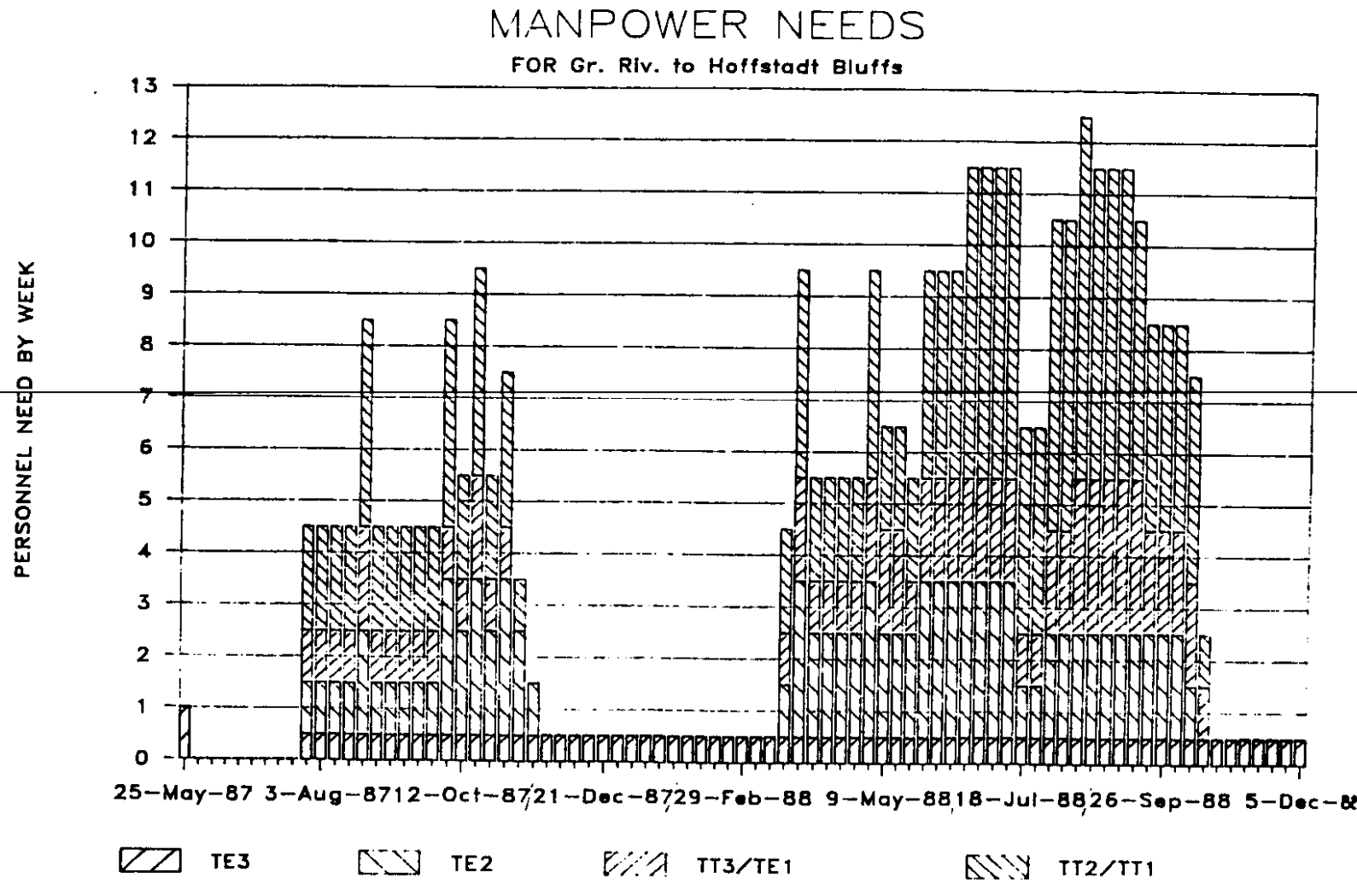


Figure 11. Bar Chart Example (Computerized) (Continued)

MANPOWER NEEDS SUMMARY DATE 14-May-87

All jobs plus office

date DATE	TE3	TE2	TT3 TE1	TT2 TT1
11-May-87	3	4	3	4
18-May-87	3	3	2	2
25-May-87	4	3	2	2
01-Jun-87	3	3	3	4
08-Jun-87	3	2	2	2
15-Jun-87	3	3	3	3
22-Jun-87	3	3	3	3
29-Jun-87	4	3	3	3
06-Jul-87	2.5	3	0	2
13-Jul-87	2.5	3	0	2
20-Jul-87	2.5	3	0	2
27-Jul-87	3	3	1	3
03-Aug-87	3.5	3	1	3
10-Aug-87	3.5	3	1	3
17-Aug-87	3.5	3	1	3
24-Aug-87	3.5	5	3	7
31-Aug-87	3.5	4	2	5
07-Sep-87	3.5	3	1	3
14-Sep-87	3.5	3	1	3
21-Sep-87	3.5	3	1	3
28-Sep-87	4.5	3	1	3
05-Oct-87	3.5	6	2	7
12-Oct-87	3.5	5	1	5
19-Oct-87	3.5	6	2	7
26-Oct-87	3.5	6	2	7
02-Nov-87	4	7	3	9
09-Nov-87	4	5	1	5
16-Nov-87	4	4	1	4
23-Nov-87	4	3	1	4
30-Nov-87	4	3	1	4
07-Dec-87	4	4	3	6
14-Dec-87	4	4	2	5
21-Dec-87	4	3	1	3
28-Dec-87	4	3	1	3
04-Jan-88	5	3	2	3
11-Jan-88	4	3	2	3
18-Jan-88	4	3	2	3
25-Jan-88	4	4	2	3
01-Feb-88	4	4	2	3
08-Feb-88	4	4	2	3
15-Feb-88	4	4	2	3
22-Feb-88	4	4	2	3
29-Feb-88	4	4	2	3
07-Mar-88	4	4	2	3
14-Mar-88	4	4	2	3
21-Mar-88	4	5	3	5
28-Mar-88	4	9	6	11
04-Apr-88	4	9	7	10
11-Apr-88	4	8	6	8
18-Apr-88	4	9	6	8
25-Apr-88	4.5	9	6	8
02-May-88	5	11	9	12
09-May-88	5	9	8	8
16-May-88	5	9	8	8

PAGE 1

Figure 12. Bar Chart Example (Computerized)

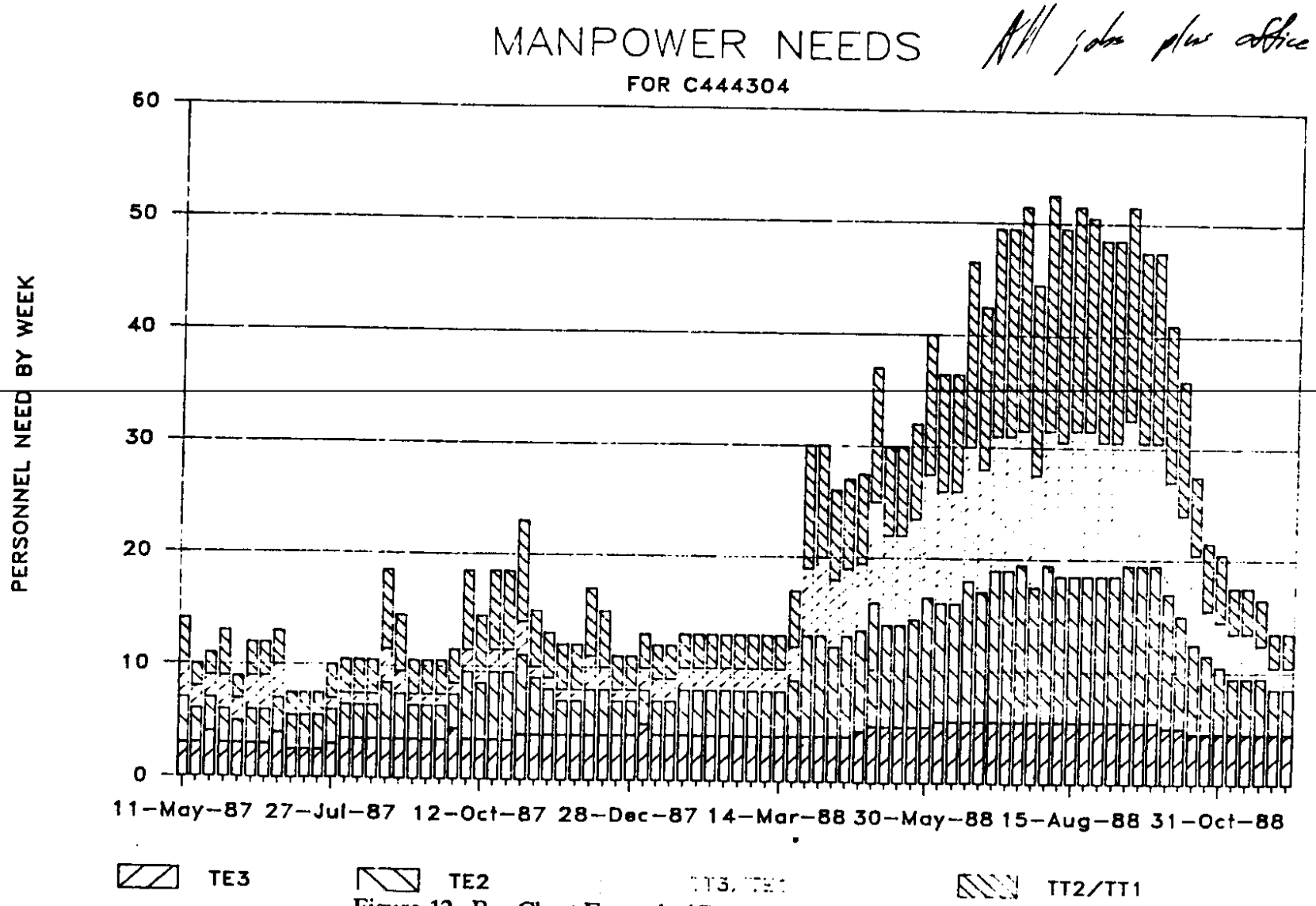


Figure 12. Bar Chart Example (Computerized) (Continued)

Operations. The computerized versions are created mainly to deal with the task of short-term scheduling. The level of detail is almost always weeks or days, classifications and/or personnel names and project tasks. Monitoring contractors' progress seems to be easier because several of these Project Engineers mentioned using the contractor's bar chart (such as in Figure 13) and making up their own bar chart to record actual construction progress.

Assessment of the Scheduling Process

For those Project Engineers who are using bar charts to help them schedule personnel, an increase in computer use is noticeable. In the interviews, Project Engineers mentioned using not only the two micro programs listed (LOTUS 1-2-3 and Microsoft PROJECT) but also the mainframe bar chart (see Figure 14). The mainframe program only schedules project tasks without paying attention to personnel needed for inspection. Most Project Engineers want to use computers to help them; however, they hesitate to use a micro for scheduling when it is so badly needed by others for engineering.

Bar chart schedulers who use either LOTUS 1-2-3 or Microsoft PROJECT frequently add engineering cost estimates to the schedule and track the expenditure of engineering funds.[15] The tracking is based on estimated hourly costs for personnel and equipment and lump sums for other costs (per diem, office overhead, non-field office expenses, etc.). Tracking occurs for both planning and operations. The purpose of tracking during planning is to estimate total monthly expenditures for the project office; this gives the Project Engineer an idea of where shortfalls may occur. During operations, tracking ensures that enough funds are available (or are requested) to cover remaining inspection costs for project completion.

One of the attitudes of these Project Engineers is that they not only recognize the problems coming to them from the outside but they feel challenged to control, as best as possible, the impact to their personnel schedules. They are in the position of being more able to anticipate and plan for

---

[15]The expenditures of all construction monies for a project in the construction field office are the responsibility of the construction field office. A portion of these monies, based on a percentage of the contract, are specifically designated for and related to field office operation (salaries, office overhead, testing). They also include non-field office expenses (district and headquarters administration, lab fees, project site visits by non-field office personnel). The construction field office is responsible, as well, for ensuring that the departmental charges do not overrun the percentage allowed.

CONTRACT PROGRESS SCHEDULE

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
_____, WASHINGTON, ZIP _____

HIGHWAY SR 522 | CONTRACT # 3253

PROJECT TITLE SR 527 TO WOODINVILLE DRIVE

SHOW DATE CONTRACT TIME STARTS | WORKING DAYS 25

ITEMS	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1 REMOVAL ITEMS																					
2 PLANE BIT. PAVEMENT																					
3 PRE LEVEL CL B																					
4 ELECT ITEMS																					
5 GUARD RAIL / SIGNS																					
6 WEAR COURSE CL B																					
7 TRAFFIC ITEMS																					
8 MH / C.B. / JUNCT BOX ADJ																					
9 ROADSIDE CLEAN UP																					
10																					
11																					
12																					
13																					
14																					

INSTRUCTIONS:

1. *Show date Contract Time Starts.*
2. *Fill in pertinent items for the contract; such as, clearing & grubbing, grading & draining, surfacing, CTB, paving or oiling, bridge excavation, bridge substructure, bridge superstructure, miscellaneous items.*
3. *Show by pencil or color the number and sequence of working days allotted to each item shown.*

NOTE: *Use two or more sheets if necessary for working days or items.*

CONTRACTOR Everett, Washington 98203

BY J.T.

DATE 4-27-87

DOT FORM 421-004 REVISED 10

Figure 13. Contractor's Progress Schedule: Bar Chart Example

DATE 02/24/86 CRITICAL PATH ENGR.

CS NO. 3112 SR NO. 005 PROJ-NO. 3058 129TH SW I C

TAIL	HEAD	TIME	DESCRIPTION	ES	EF	LS	LF	TF
0	5	4	MOBILIZATION		4		4	*
5	6	15	PR & RAMPS DRAINAGE	4	19	33	48	29
5	10	5	CLEAR & BRUB FR LINE	4	9	4	9	*
5	32	2	TEMP BARRIER & BERMS	4	6	5	7	1
5	35	5	STR EXC ABT STG 1	4	9	17	22	13
5	65	20	APPROACH FILLS WIDENING ITEMS	4	24	28	48	24
5	71	41	PROCURE 3RD AVE SIGNAL	4	45	4	45	*
5	80	10	DETOUR STG 1 REMOVALS & CHANNILIZ	4	14	58	68	54
5	148	30	ILLUM & SIGNALS STG 2	4	34	68	98	64
32	35	0	DUMMY #1	6	6	22	22	16
32	40	15	P-2 FTG & COL STG 1	6	21	7	22	1
10	15	1	FILTER FENCE	9	10	9	10	*
35	55	30	FORM & POUR P-1 & P-3 STG 1	9	39	22	52	13
15	16	10	FR LINE UNSUITABLE	10	20	25	35	15
15	17	25	FR LINE DRAINAGE	10	35	10	35	*
6	65	0	DUMMY #8	19	19	48	48	29
6	135	15	DRAINAGE DETPOND & STG 2 PR & RMPS	19	34	73	88	54
16	17	0	DUMMY #2	20	20	35	35	15
40	45	19	FORM & POUR BOX STG 1	21	40	22	41	1
65	85	20	SURF PR & RAMPS,CURB GUTTER SW	24	44	48	68	24
148	150	0	DUMMY #5	34	34	98	98	64
148	210	30	COMPLETE ILLUM,SIGNALS,SIGNING	34	64	179	209	145
17	18	10	GRADE & SURF FR LINE	35	45	35	45	*
45	50	8	CURE BOX GIRDER STG 1	40	48	41	49	1
18	70	10	CURB GUTTER & WALK	45	55	45	55	*
71	75	20	INSTALL 3RD AVE SIGNAL	45	65	45	65	*
50	55	3	POST TENSION BOX STG 1	48	51	49	52	1
55	85	0	DUMMY #3	51	51	68	68	17
55	90	3	SET GIRDERS STG 1	51	54	52	55	1
90	95	10	FORM & POUR DECK & DIA STG 1	54	64	55	65	1
70	75	10	PAVE & STRIPE FR LINE	55	65	55	65	*
95	100	8	CURE DECK	64	72	65	73	1
75	80	3	FINISH 3RD AVE SIGNAL	65	68	65	68	*
80	85	0	DUMMY #6	68	68	68	68	*
80	110	2	OPEN FR CLOSE MP	68	70	70	72	2
85	135	20	COMPLETE PR & RAMP WIDENING	68	88	68	88	*
110	115	8	REMOVE MP LINE	70	78	72	80	2
100	101	10	POUR & CURE HINGES	72	82	73	83	1
115	120	8	SE DET POND & DITCH	78	86	80	88	2
101	102	2	POST TENSION GIRDERS STG 1	82	84	83	85	1
102	130	4	FORM & POUR BARRIER STG 1	84	88	85	89	1
102	135	0	DUMMY #4	84	84	88	88	4
120	125	5	COMPLETE FR LINE DRAINAGE	86	91	88	93	2
130	140	3	FORM & POUR APPROACH SLABS	88	91	89	92	1
135	145	10	COMP ABUT FILLS PAVE STG 2 DETOUR	88	98	88	98	*
125	145	5	COMPLETE MISC FR & MP WORK	91	96	93	98	2
140	150	6	PLACE TEMP BARRIER PAVE MARKINGS	91	97	92	98	1
145	150	0	DUMMY #7	98	98	98	98	*

Figure 14. DOT Mainframe CPM Example

DATE 02/24/86 CRITICAL PATH ENGR.

:S NO. 3112 SR NO. 005 PROJ-NO. 3058 128TH SW I C

TAIL	HEAD	TIME	DESCRIPTION	ES	EF	LS	LF	TF
145	210	20	SEED LNDSCAPE FINISH GR & DRAIN	98	118	189	209	91
150	155	7	OPEN TRAFFIC STG 2 ,DEMOLISH BRG	98	105	98	105	*
155	160	17	P-2 FTG & COL STG 2	105	122	105	122	*
155	175	40	FORM & POUR P-1 & P-3 STG 2	105	145	111	151	6
160	165	13	FORM & POUR BOX GIRDER STG 2	122	140	122	140	*
165	170	8	CURE BOX STG 2	140	148	140	148	*
170	175	3	POST TENSION BOX STG 2	148	151	148	151	*
175	180	3	SET GIRDERS STG 2	151	154	151	154	*
180	185	10	FORM & POUR DECK & DIA STG 2	154	164	154	164	*
185	190	8	CURE DECK STG 2	164	172	164	172	*
190	195	10	POUR & CURE HINGE STG 2	172	182	172	182	*
195	200	2	POST TENSION DECK GIRDERS STG 2	182	184	182	184	*
200	205	15	REMTMPBARR-CLOPR-APPRSLB-BARPR-3DWK	184	199	184	199	*
205	210	10	CURB GUTTER & PAVING STG 2	199	209	199	209	*
210	215	6	SWITCH TRAFFIC TO ULTIMATE DEMOB	209	215	209	215	*
			PROJECT COMPLETION	215				

Figure 14. DOT Mainframe CPM Example (Continued)

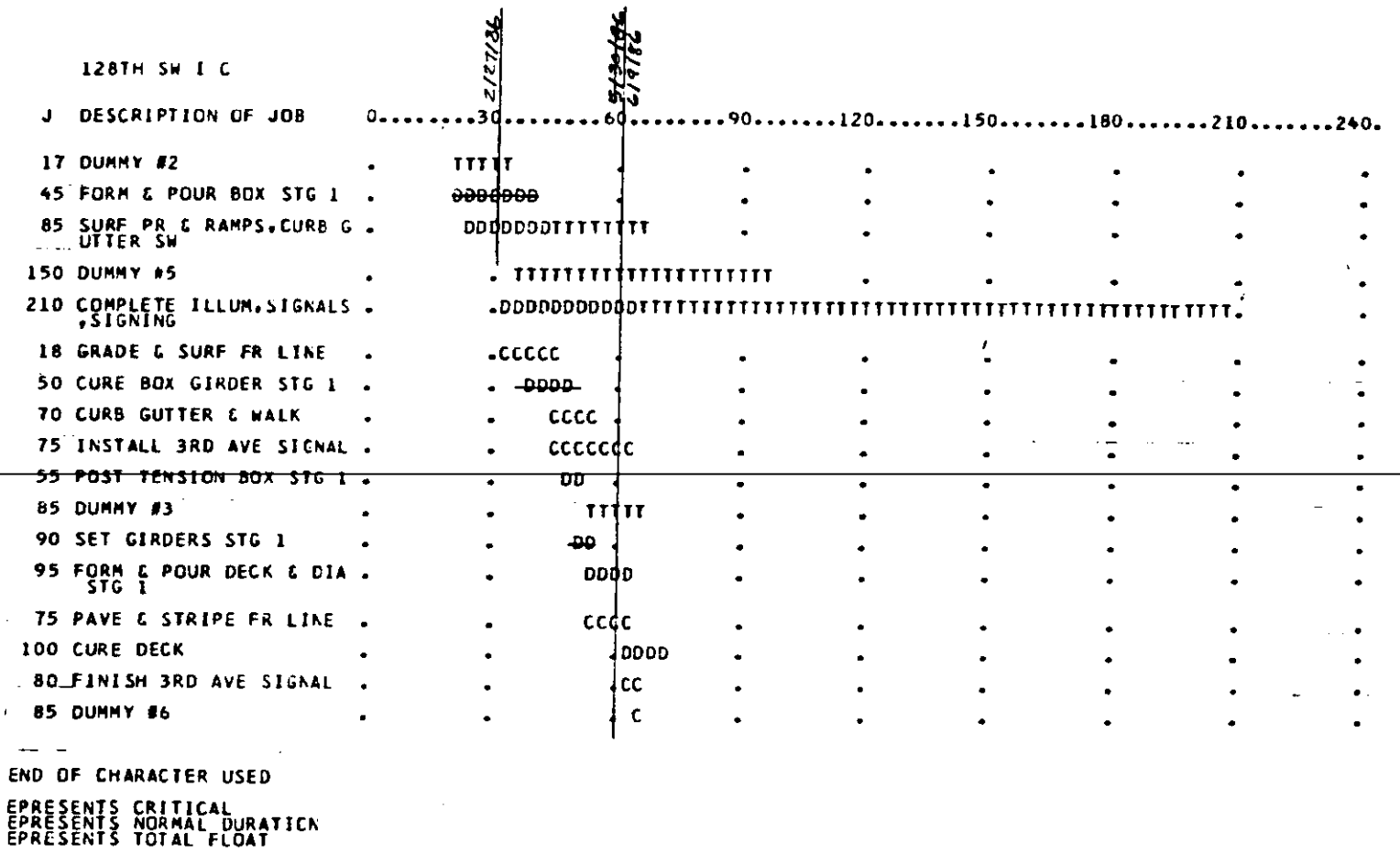


Figure 14. DOT Mainframe CPM Example (Continued)

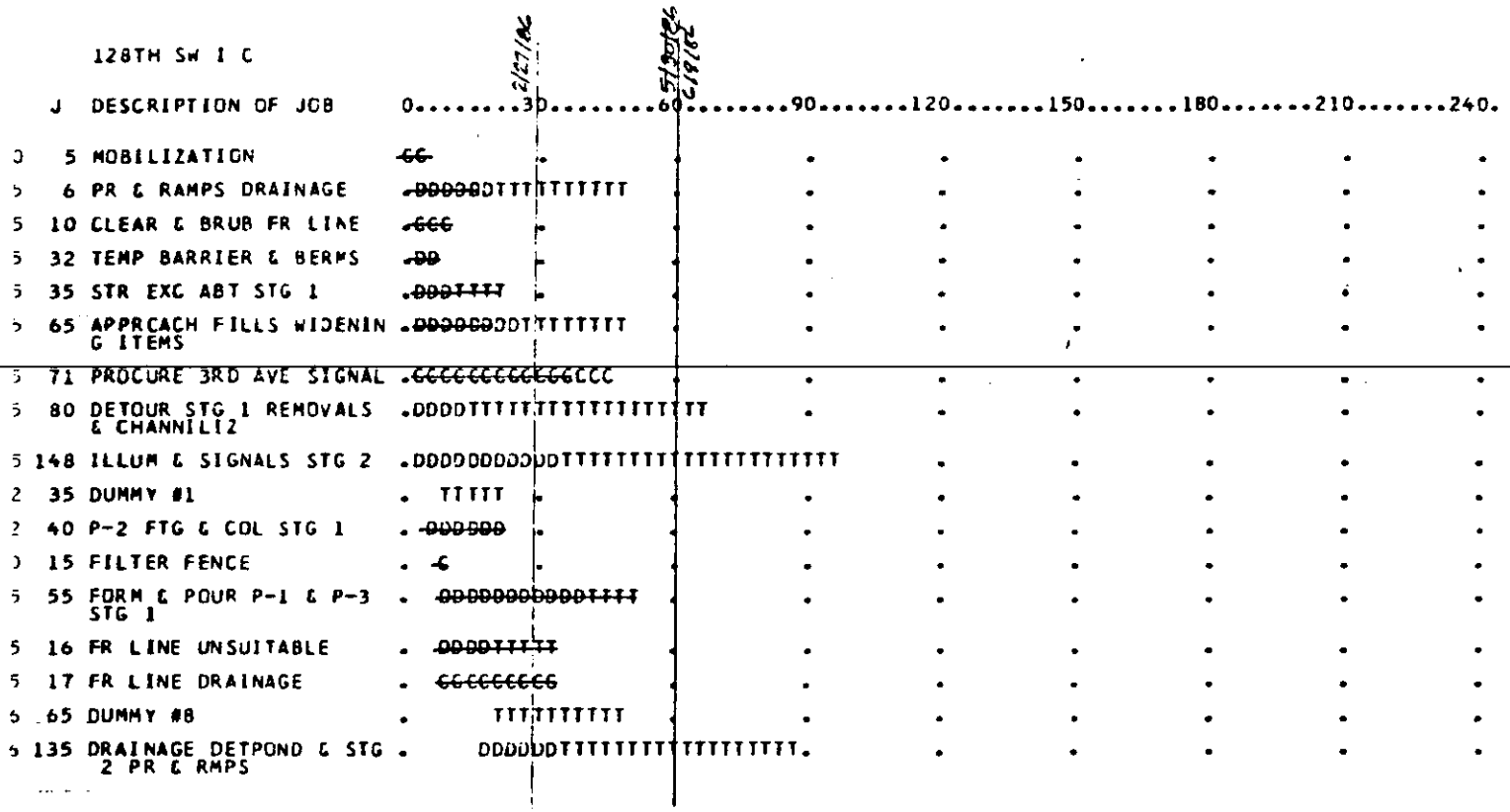


Figure 14. DOT Mainframe CPM Example (Continued)

change. Restrictions are recognized, but they cause more tailored procedures rather than a calm despair.

The advantages of bar charts include the ability to do resource leveling, either manually or using computer generated histograms. Figures 11 and 12 are examples of histograms that can help Project Engineers balance their personnel schedules. This is an important aspect of scheduling and is discussed further under scheduling limitations. Other advantages include a more realistic attitude toward planning, the addition of missing elements (personnel are noticeably scheduled with projects over time) and the ease of incorporating the computer as a scheduling aide.

The major disadvantage of bar charts is the lack of time for updating. This is expected because the bar charts track detailed information, and the input must be gathered from several places. Information may also be missing. In the case of the manual bar chart user, updating itself can be slow, because the entire chart must be redrawn. To set up the system is relatively time consuming as well.

One aspect of bar charts that bears mentioning is that some seem to resemble "to do" lists. There is an element missing from the bar chart, but it is not one of the three dimensions of scheduling. This time, it is a detail level. Figure 15 is a bar chart, but the personnel dimension is lacking so much detail that individuals are difficult to schedule to projects over time. This aspect, the lack of sufficient detail in at least one of the dimensions, could cause the bar chart (or any other level's graphic, for that matter) to not be a schedule.

Networks

Used by 6 percent of the Project Engineers, all from the same district, networks are the most complex of all the personnel scheduling management systems. Planning is considered one of the more useful tools for operations, projects are broken down into task levels important to the field office, updating is constant, historic information is kept for better future scheduling, and engineering funds are tracked. The typical features of the system that follow apply to all the systems because the offices using them developed the system together.

Typical System Features

Planning and Operations. To these Project Engineers, planning is essential and the key to operations scheduling. Seldom are they separated. Though projects are listed and planned for a

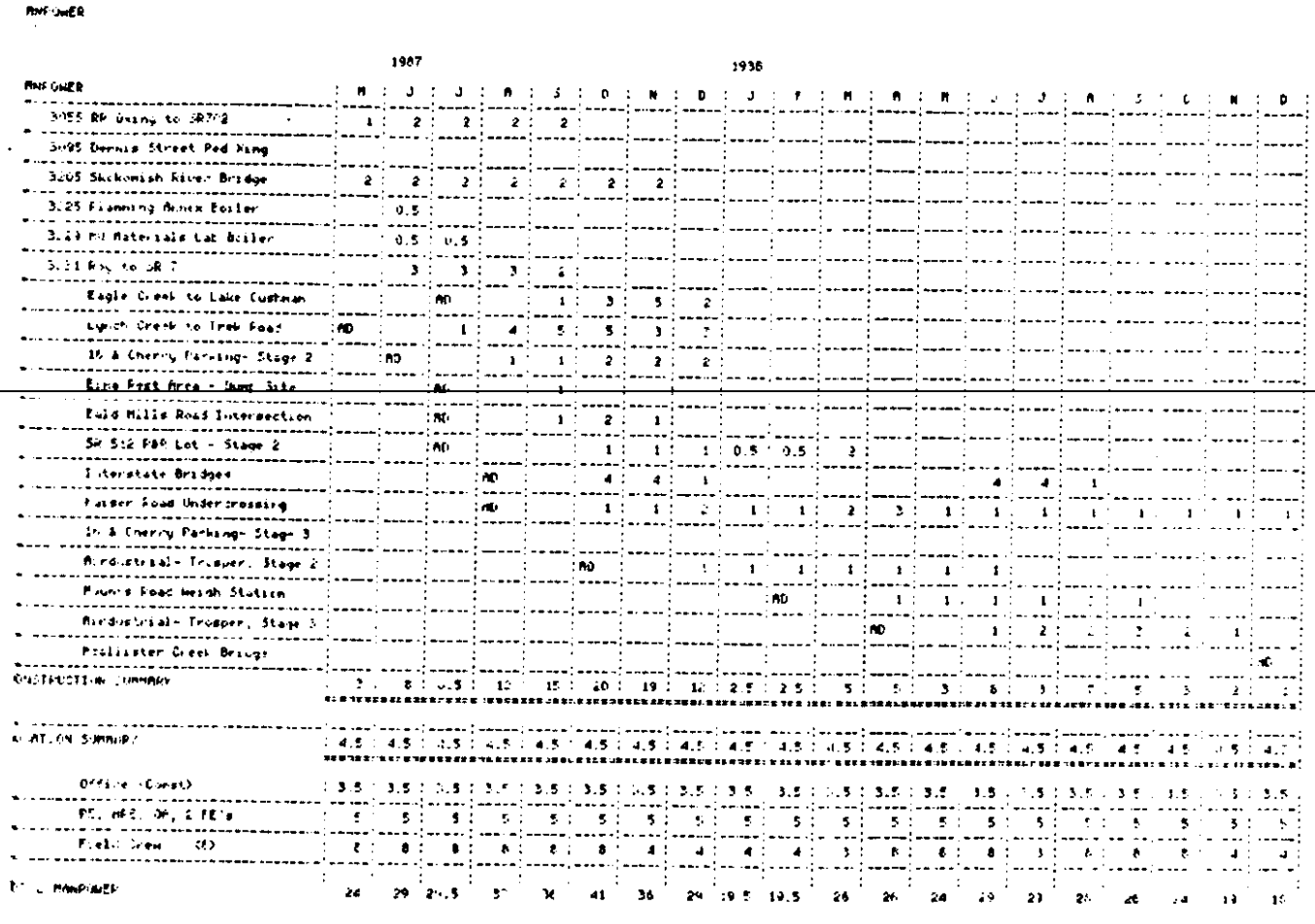


Figure 15. Simple Bar Chart Example

calendar year ahead, as in most other offices, the typical progression begins when the PS&E comes into the office, about two months ahead of the ad date. The PS&E has fixed tasks, so the Project Engineer knows the scope, duration and proposed ad date. He creates a preliminary schedule based on the PS&E and assigns the project inspector (name) and specialty crews (surveying, paving). He makes assumptions about how the contractor will work: single shift, steady progression, few change orders. This becomes the preliminary schedule.

The schedules for all projects are then put together. Three different programs are used. SPF, a computer system facility for creating, editing and running files, is used to create a master file of personnel names and project assignments (Figure 16). This is a weekly assignment list with the individual staff names along the left side with their classifications. Several columns contain bits of static information: vehicle assigned, duty (such as "drainage inspector," "survey crew," etc.), contract or location project number or "final records," hours of work, and general remarks (such as annual leave notes or scheduled training). This schedule, updated as required, matches with the second document (Figure 17) through the names of the staff, to give a complete report of which staff are scheduled for what projects.

LOTUS 1-2-3 is used to create the chart that is a daily schedule delineating one month (Figure 17). The names of all the staff are listed down the left side, and across the top is a month's calendar divided into days, including weekends. Inside the chart are hand drawn arrows that delineate what the person is assigned to do. For office staff, who work on all projects (the Project Engineer, his assistant, the office assistant and the office engineer and his staff), only leave days are delineated. Borrowed and lent crew members are marked by an asterisk, along with a listing of where they came from or have gone. No project identification is included on this document.

Microsoft PROJECT creates total project bar charts and tracks engineering costs and personnel use (Figures 18 and 19). The projects, broken down into inspection tasks (sometimes labeled by a person's name, indicating a specialty) and per diem, are put into separate files, one for each project. Figure 18 lists the resources, which include names of personnel (TT-3s and above), tasks reserved for temporary employees or lower level technicians (scalemen, etc.) and per diem. The last resource, JUNECOST, is what has actually been spent to date on the project's inspection, as taken

WORK SCHEDULE FOR JUNE 22 TO JUNE 26, 1987

NAME	RIG	DUTY	CONTRACT	HOURS	REMARKS
TE5	1B1-56	PROJECT ENGINEER	ALL	8:00-5:00	
TE4	1B1-50	ASSIST. PROJ.ENGR.	ALL	8:00-5:00	
		F.O.A.	ALL	8:00-5:00	A/L FRIDAY
TE3		OFFICE ENGINEER	ALL	8:00-4:30	
TE2		OFFICE	FINAL RECORDS	8:00-4:30	A/L FRIDAY
TT2		OFFICE	FINAL RECORDS	8:00-4:30	TT3 EXAM MONDAY
TE2		P.I. & OFFICE	C-3261	8:00-4:30	LOTUS TRNG WED 24th
TT3	5B10-39	CRUSHER	C-3263 FI RECORDS	8:00-4:30	MONDAY ON C-3263
TE3		OFFICE	L-8771 C-3263	8:00-4:30	
TE3		OFFICE	L-7948	8:00-4:30	A/L WED, THURS & FRI
TE2	5B10-23	OFFICE	C-3275 L-8771	8:00-4:30	LOTUS TRNG WED 24th
TE2	5B2-30	PROJECT INSPECTOR	C-3263	7:00-3:30	
TT3	5B10-6	DRAINAGE INSPECTOR	C-3263	7:00-3:30	
TT2	5B10-12	CRUSHER INSPECTOR	C-3263	7:00-3:30	
TE2	5B2-33	PARTY CHIEF	L-8771	8:00-4:30	
TT3	5B2-33	INSTRUMENT MAN	L-8771	8:00-4:30	
TT3	5B6-4 TUNE-UP	SURVEY CREW	L-8771	8:00-4:30	
TT3		SURVEY CREW	L-8771	8:00-4:30	
TT2		SURVEY CREW	L-8771	8:00-4:30	TT3 EXAM MONDAY
TT2		SURVEY CREW	L-8771	8:00-4:30	

MONDAY-----

TUESDAY----

WEDNESDAY--

THURSDAY---

FRIDAY-----

EXTRA RIGS
5B6-10
5B13-23
5B10-9
5B 3-22

C-3263 WEST FOSTER CREEK BRIDGE TO EAST FOSTER CREEK
C-3275 PESHASTIN CREEK BRIDGE TO MONITOR
XE-2624 DISTRICT 2 - ASBESTOS ABATEMENT

Figure 16. Network Example Report 1

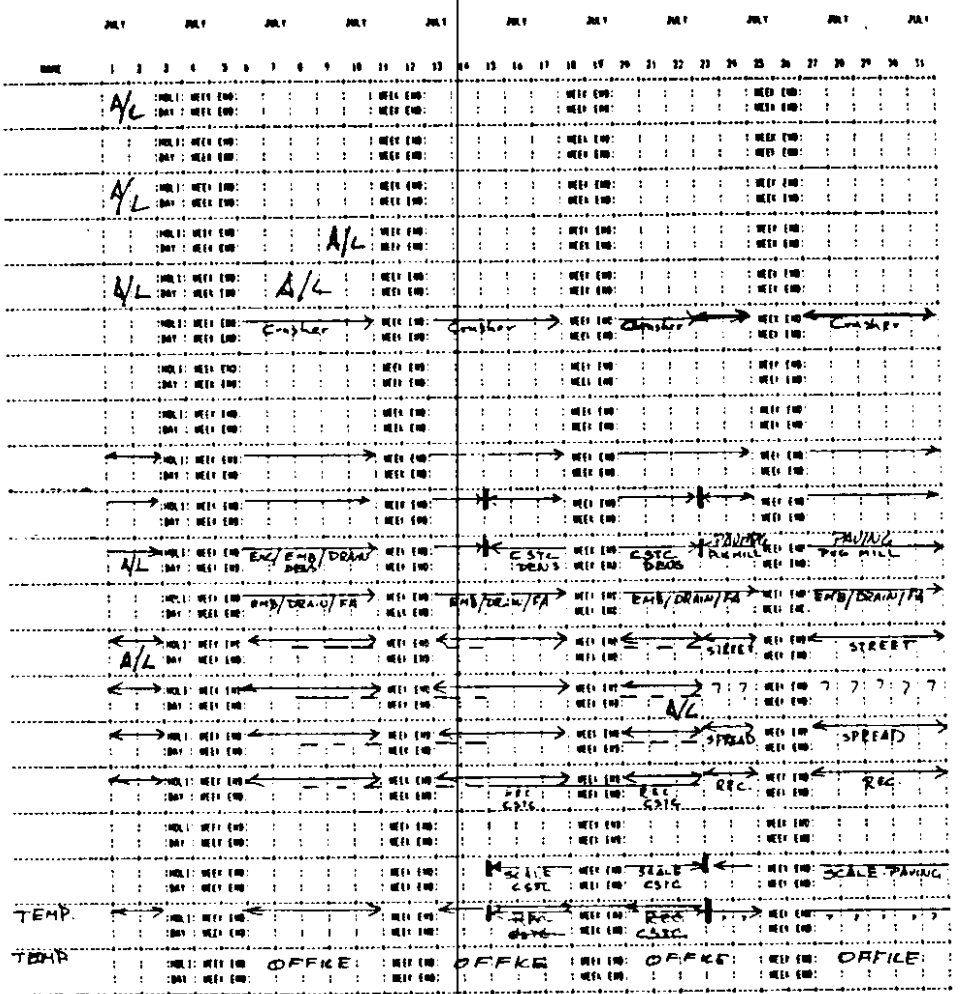


Figure 17. Network Example Report 2

E. FOSTER CR. TO W. FOSTER CR.
EXPENDITURE REPORT FOR
CONSTRUCTION ACTIVITIES

Project: FOSTCOST | Date: Jul 22, 1987 11:01 AM

# Resource		Unit Cost	For	Days to Complete	Cost to Complete
1	1.0	$18.51	Hour	48.6	$7200.08
2	1.0	$16.92	Hour	22.6	$4418.44
3	1.0	$14.57	Hour	6.6	$771.96
4 SCALEMAN	1.0	$14.57	Hour	25.0	$2914.00
5 RECEIVER	1.0	$14.57	Hour	25.0	$2914.00
6	0.2	$26.71	Hour	9.7	$2077.94
7	0.2	$22.21	Hour	9.7	$1727.86
8	1.0	$20.27	Hour	19.0	$3081.04
9	0.2	$24.32	Hour	9.7	$1894.34
10	1.0	$18.51	Hour	7.0	$1036.56
11	1.0	$18.09	Hour	7.0	$1013.04
12	1.0	$16.57	Hour	7.0	$927.92
13	0.1	$15.95	Hour	4.8	$542.63
14	1.0	$22.21	Hour	4.0	$710.72
15 BSG PER DIEM	1.0	$224.64	Week	29.6	$1330.89
16 MP PER DIEM	1.0	$224.64	Week	29.6	$1330.89
17 VP PER DIEM	1.0	$224.64	Week	29.6	$1330.89
18 SCALE/RECV PD	2.0	$449.28	Week	25.0	$2246.39
19 JN PER DIEM	1.0	$224.64	Week	0.0	$0.00
20 TH PER DIEM	1.0	$224.64	Week	0.0	$0.00
21 DBB PER DIEM	1.0	$224.64	Week	0.0	$0.00
22 JOBCOST	1.0	$50800.31	Fixed	0.0	$0.00

Cost to complete: $37469.59 Total cost of project: $100507.91

Total Const Engr. $108,664.00 (65% = 70,625)
and 7/1/87 "Project" projects July expenditures Con. Labor/Per Diem
at (~~52,664 ... 20,664~~)
100,807 − 50,000 − 37,469 = $12,338
(projected(actual)) (actual) (projected) (projected(spent))

12,238
+ 37,469
49,707

49,707
− 37,605
$12,102 → Projected Overrun

Projected Cost & 65% for Labor/Per Diem
C.E. Cost remain 7/1/87: 37,859
65% S remain = 37,605

Figure 18. Network Example Report 3

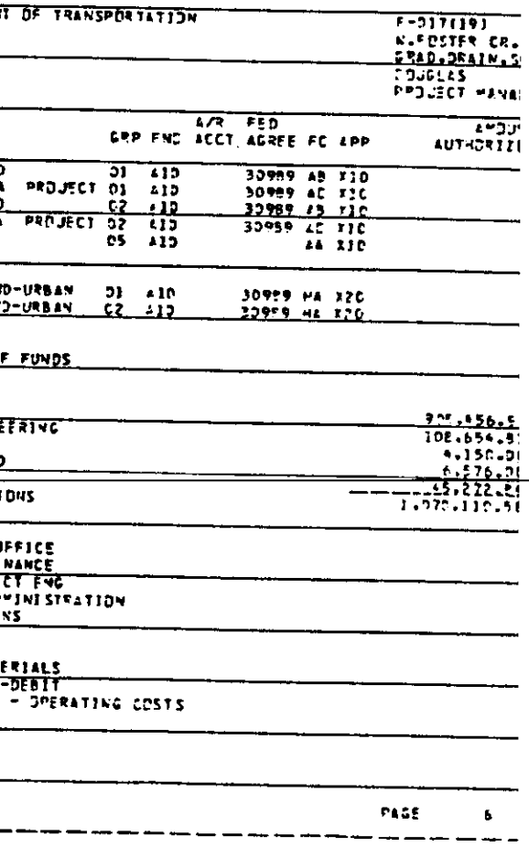


Figure 20. Monthly Headquarters Rep

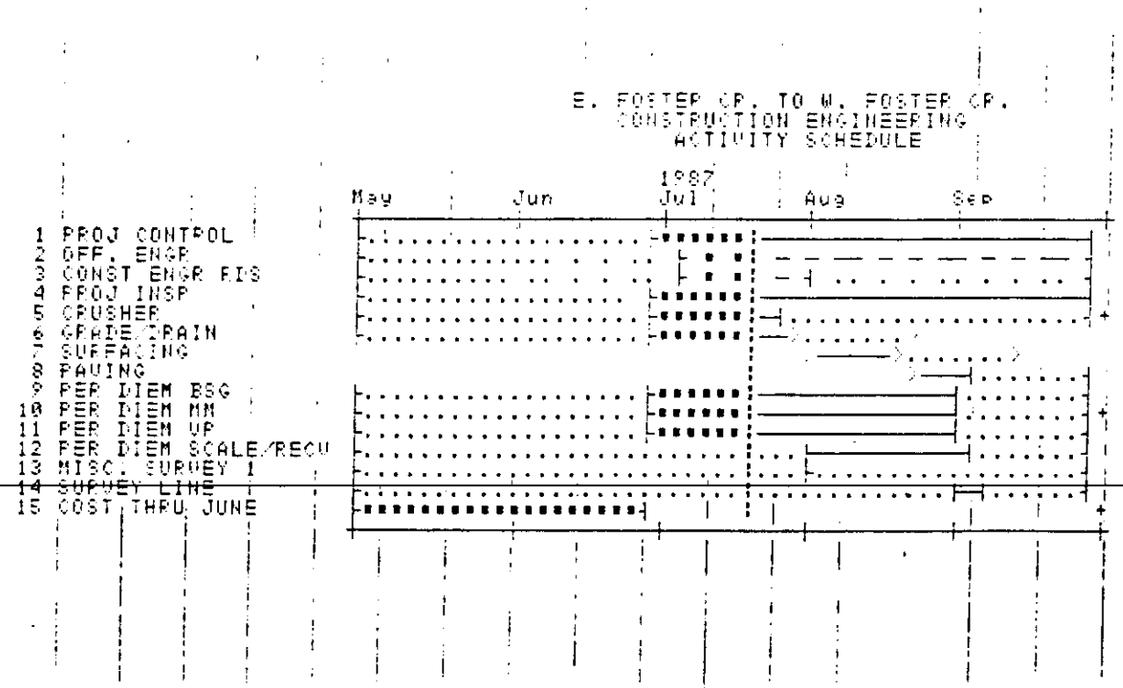


Figure 19. Network Example Report 4

progress, so that he knows whether the contractor is on time. Both schedules can be printed out, resulting in back up documentation for project records. System additions are relatively simple and the system can be altered to include more information and reports as needed. Also, any of the staff can and do use the system in some form within the field office. Updates come from many different sources, the schedules are available for anyone to see, the schedules are understandable at all levels, and the ability to return to the project files after the project is completed for any reason is enhanced.

Two disadvantages to this system are notable. The first is the time needed to set it up and work out the bugs, similar to the problem with bar chart systems. While the ultimate system is useful to the field office, the time and expense may cause the Project Engineers to hesitate to do the required set up. The other disadvantage is that the level of detail and the update are affected by the uncertainty of activity starting dates. This was recognized as an important problem by these Project Engineers. This is most likely due to the greater level of detail and required immediacy of the schedules, and has been partially alleviated by the use of the informal updates.

THE LIMITATIONS OF THE CURRENT PERSONNEL SCHEDULING MANAGEMENT SYSTEMS

Two major restrictions limit the Project Engineer's ability to do personnel scheduling management. The first, and most important, restriction is that the Project Engineer is severely limited in his ability to balance his system. With a minor exception, he cannot take advantage of the entire left side of the scheduling model, as illustrated by Figure 21. The minor exception was briefly mentioned in Chapter 3: under certain limited conditions, the Project Engineer can request that whole projects be reassigned to another field office or ask to be assigned additional projects. Control of the schedules used by the Project Engineer for planning and operations is in the hands of the design section of the Department (which may get the project done early, on-time or late) and the contractor. The result is that the project schedules cannot be adjusted because the capacity to do resource leveling is unable to be done normally, lack of communications commonly occurs and unreliable contractors' progress schedules are frequently turned into the office. The second restriction, affecting the resource pool, consists of difficulties in communication and perceptions about departmental policies. Weather, an

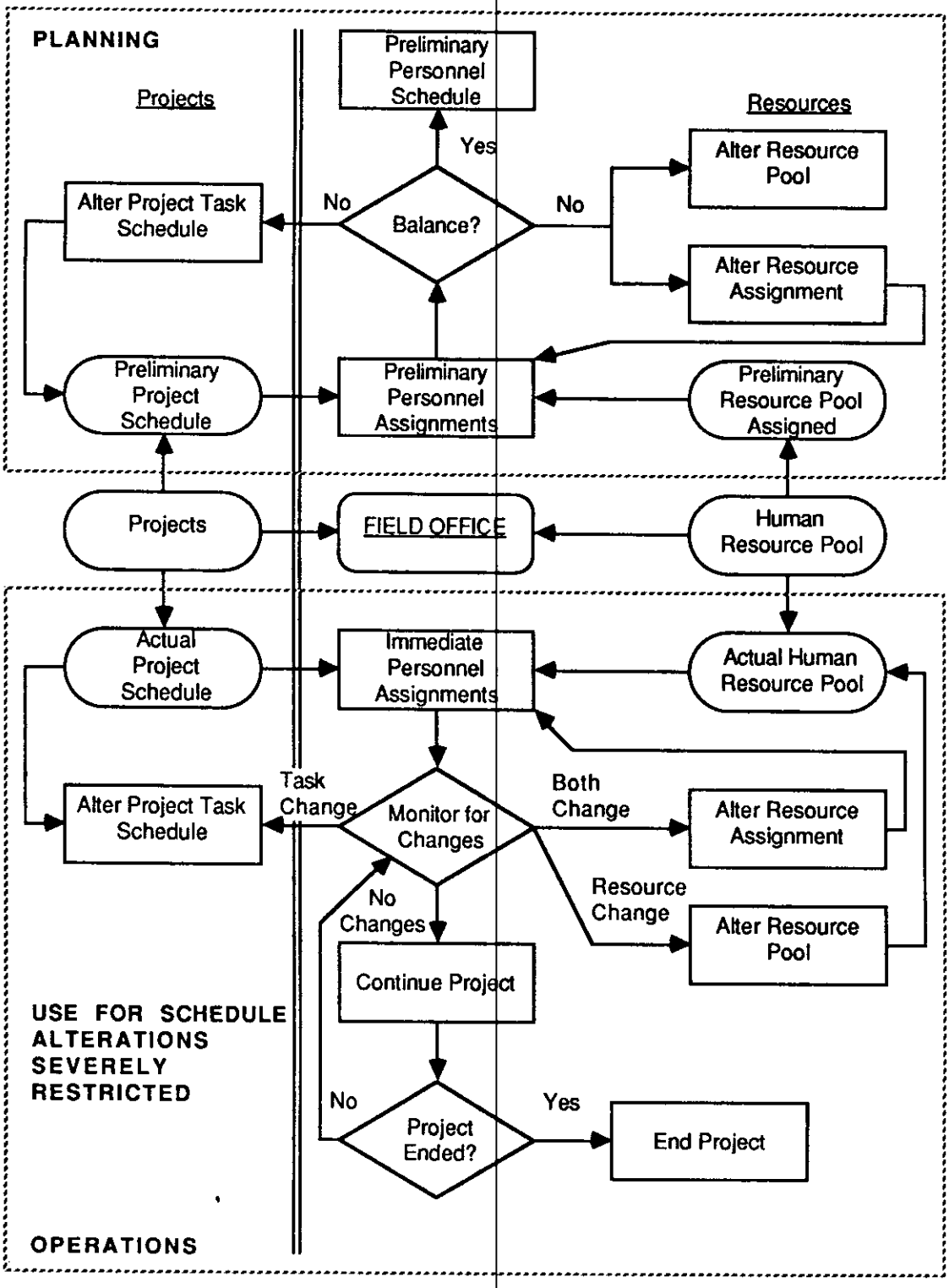


Figure 21. Model of Scheduling: Limitations on the Construction Field Office

important though neglected element in scheduling, affects but does not limit the total scheduling process. Each of these limitations is described in more detail in the following section.

Project Schedule Limitations

Resource Leveling

As mentioned, resource leveling and the graphic representation of personnel use, histograms, are an important aspect of scheduling. For the DOT, resource leveling, especially in the construction field offices, is essential for two reasons. The first is that highs and lows of personnel needs are part of scheduling and caused by the seasonality of the construction process. The second is that the Department limits each field office to a certain level of permanent staff somewhere between the peaks and valleys.

An important part of resource leveling is the process used to do it. The normal procedure is to examine a project schedule or series of project schedules closely, usually in network diagrams, and shift the non-critical items around so that the resources (personnel) are evened out (the histogram is made level). This works well with specialty crews that cannot be on all projects simultaneously.

Unfortunately, major limitations affecting resource leveling are operating within the Department of Transportation. Because of the way the construction field offices are currently set up, a project cannot be closely examined for resource leveling for three reasons:

- the construction field office does not know for certain about a project's assignment until two months (maximum, frequently less) before the ad date, leaving little time for the leveling, which begins to be required at least a year in advance;
- the field office does not control the date, which changes frequently, quickly and with little prior notice, making resource leveling for more than in-house projects a futile exercise; and
- Project Engineers cannot and do not control contractors' progress schedules and so can only guess the task schedule for resource leveling.

The potential solution to this lies in a slightly altered focus. Two obvious imbalances occur in many construction field offices: peak construction periods when everyone is used, and winter shutdown when no one is needed for construction. Therefore, the focus becomes the resource pool rather than

the project schedule. Instead of altering the timing of project tasks, new positions, temporary employees, lending/borrowing crew and other alterations are available. Furthermore, the Project Engineer can establish a secondary task list consisting of items that need to be done but that can wait for slow periods when the inspectors and crews need something to do while waiting on a contractor. This requires careful judgment so that people are not added with nothing to do and subtracted at the peak period.

Lack of Communications

The lack of communications primarily affects the planning of preliminary schedules in the construction field office. One communications lack occurs between the design and construction offices during the Design Report and PS&E stages. The construction field office is seldom fully informed about the project it will be inspecting until approximately two months before the ad date; many times, the amount of time is even less. Furthermore, the ad dates can change forward or back at any time, and the construction field office is not always notified of the change. Figure 3, in Chapter 2, indicates more than project cycles; it also indicates communication lines (or lack thereof).

An example of this type of communication problem was given in the interviews. The DOT, through State Aid, accepts the responsibility, when requested, for inspecting the construction of city or county projects. The project frequently is not assigned to the DOT field office until just before construction (i.e., after the award date). With such little notification for these projects, the Project Engineer must scramble for inspection crew, which can impose hardships on his schedule.

This lack of notice about projects and ad date changes tends to limit the project office's planning to notifying the district office of what the field office feels (guesses) it needs in the way of personnel and equipment for the next season, with a high level of inaccuracy built in. One engineer stated that "the need for quarterly personnel reports seems to be the controlling factor behind updates" of preliminary schedules. Many of the Project Engineers limit their view of planning deliberately to avoid having to deal with as many changes as are expected.

The Contractor's Progress Schedule

Project schedules for operations within the field office are often based, or partially based, on the contractor's progress schedule. A contractor's progress schedule is required for all projects

awarded by WSDOT [Standard Specifications, Section 1-08.3] and varies from a simplistic bar chart to a formal, complex and exceedingly detailed network (or CPM). The most frequent type is the simple bar chart, as in Figure 13; Figure 22 shows two CPMs, the first a small corner of a complex network diagram used on a multi-million dollar project, and the second used for a much simpler and less time consuming project.

The purpose of the contractor's progress schedule is to tell the state what the contractor intends to do, approximately when in work days and what the critical work items are. The Project Engineer must approve the schedule before the start of construction. Unless the contract's Special Provisions specifically requires it, the Project Engineer does not request a CPM, though the bar chart is to be based on a CPM or equivalent [Standard Specifications, Section 1-08.3].

The major limitation of construction field office scheduling from the contractor's progress schedule is directly related to the problems encountered by the Project Engineers: the lack of reliable, detailed and updated contractors' schedules. Though the Project Engineer may assume, from the poor contractors' schedules that he must work with, that the contractor does not know how to schedule, this may not always be the true situation. Some contractors are reluctant to give accurate schedules because of working day charges. Until contractors' progress schedules are examined in more depth, this assumption must remain unverified. The inaccurate schedules affect the project office in two ways: it limits the reliability of the construction field office's schedule and limits the techniques available for adjusting the personnel schedule.

Limitations on the Construction Field Office Schedule. Many Project Engineers attempt to use the contractor's progress schedule to help them schedule their own crews. The interviews revealed that several problems inherent in the contractor's progress schedule limit the use of that schedule for the construction field office. One problem is that often the schedule submitted has no relationship to the project other than as a list of major tasks and predicted project duration. All the contractor needs to show is how long a major task will take. He does not need to break down the tasks into categories useful to the Project Engineer. Another problem is that often the contractor's schedule will fill all of the time allotted for the project, with as many tasks as possible delineated as critical. In actual field practice, these schedules are not realistic.

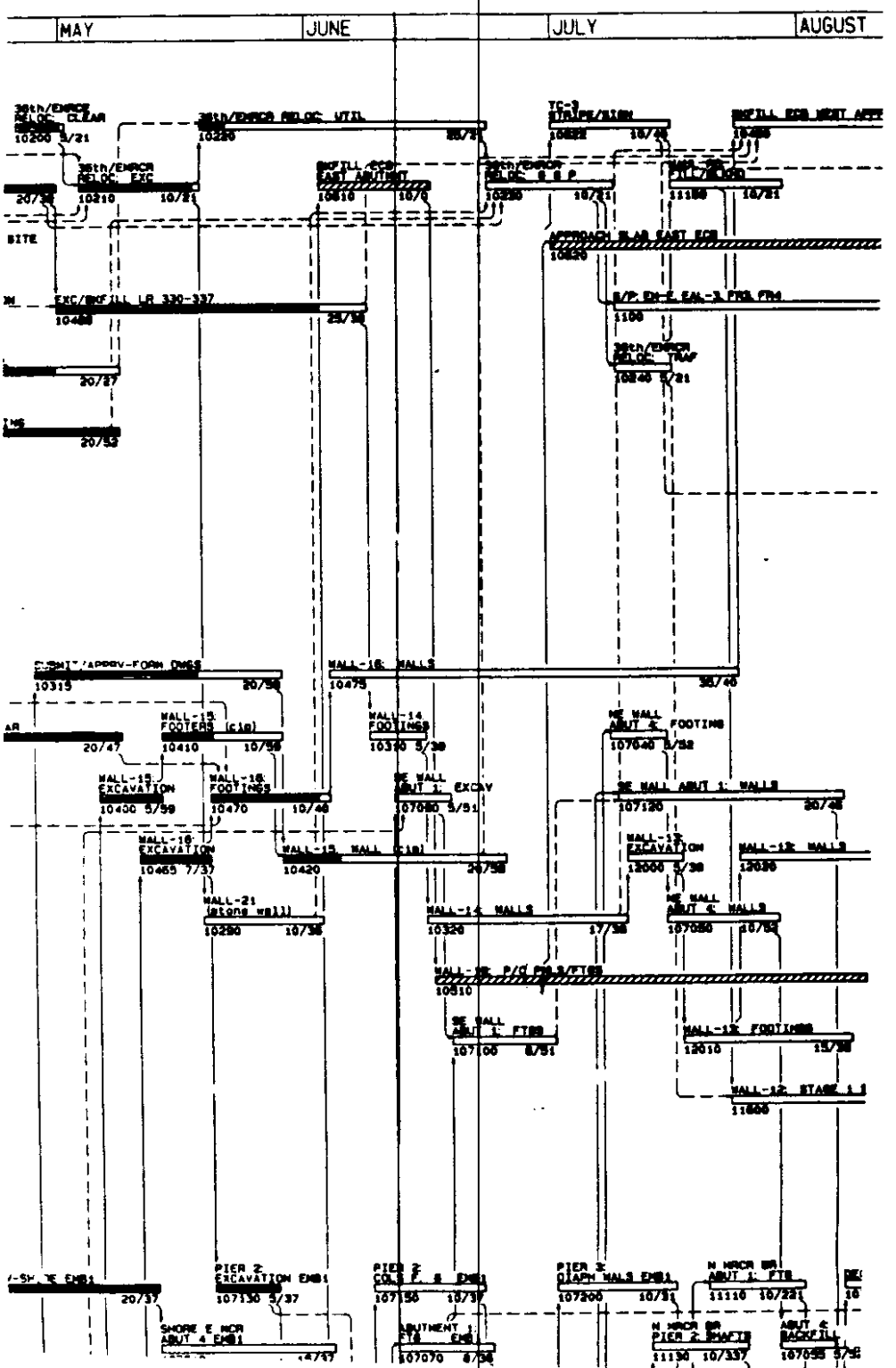


Figure 22. Contractor's Progress Schedule: Network Example

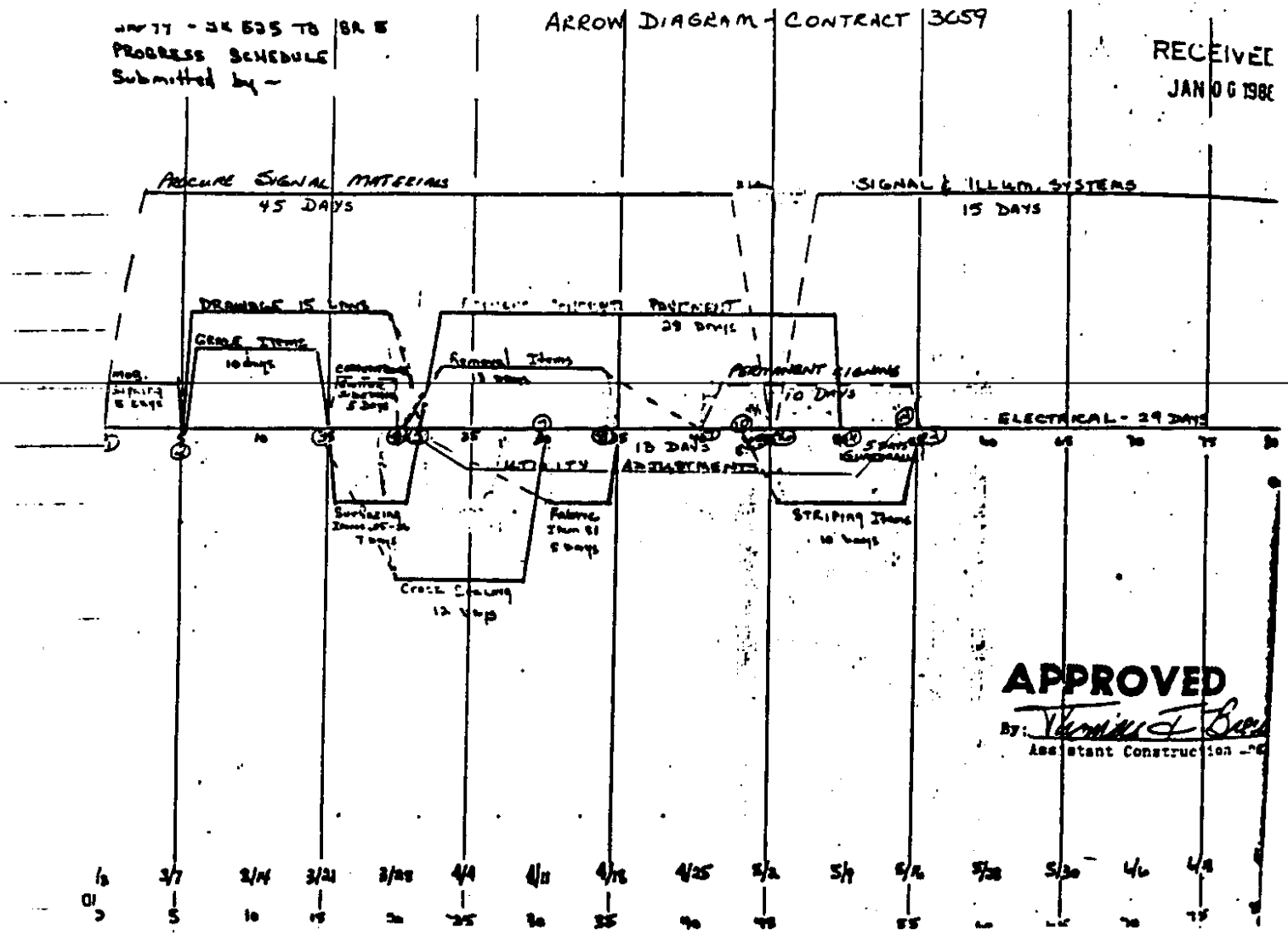


Figure 22. Contractor's Progress Schedule: Network Example (Continued)

The experience of the Project Engineers has been that updates are inadequate (one contractor, when asked for weekly updates, handed in the original schedule without changes over and over again until he absolutely had to change it), hard to get (the Project Engineers mentioned that it took more work to get some contractors to update than to get the project completed), and untrustworthy (the contractor does not bother to follow the update). Most Project Engineers respond in two ways: they rely on the conferences with their project and chief inspectors, and they make their own assessment of the situation and compare the reality with the contractor's schedule.

Updating the contractor's progress schedule (the master schedule) is very difficult. The Standard Specifications state as follows:

> The Contractor shall submit supplementary progress schedules to accurately reflect the times of construction and any delays which may have been encountered in the performance of the work.
>
> The progress schedule and supplementary progress schedules shall be consistent with the time and order of work requirements of the contract. [Section 1-08.3]

If a contractor is behind or his work progress differs radically from the original schedule, the Project Engineer formally requests an updated schedule. Unfortunately, interviews with the Project Engineer established that most contractors are reluctant to furnish the updated schedule; the process may become time consuming and result in inadequate and/or dated information for the Project Engineer.

Limitations on Adjusting the Construction Field Office Personnel Schedule. The limitation caused by the contractor's progress schedule on the technique of balancing the personnel schedule is based mostly on the reluctance of the construction field office Project Engineer to do anything that might cause a construction delay.[17] Over half of the Project Engineers do not ask the contractor to alter his or her schedule at all (Table 17, Chapter 3), and the rest are reluctant to do so unless pressed, even though the Standard Specifications, some contract specials and other rules require certain notification procedures.

---

[17]A delay caused by anything that the DOT does, whether in the field or office, is basis for claims against the state by the contractor and can cause increases in actual contract costs, whether the claim goes to court or not.

For example, construction staking requires three days' notice [Standard Specifications 1-05.5], and shift work requires seven days' notice [union rules], neither of which are always given. Updated schedules (weekly plans for construction) are also required in certain contracts. District 2 writes into every contract:

> In addition to the requirements of section 1-08.3 of the standard specifications, the Contractor shall submit a weekly schedule to the Engineer.
>
> The schedule shall indicate the Contractor's proposed activities for the forthcoming week, along with the hours of work to permit the Engineer to more effectively provide the contract engineering and inspection for the Contractor's operations.
>
> The written weekly activity schedule shall be submitted to the Engineer before the end of the last shift on the next to last working day of the week preceding the indicated activities, or other mutually agreeable time.
>
> If the Contractor proceeds with work not indicated on his weekly activity schedule or in a sequence differing from that which he has shown on his schedule, the Engineer may require the Contractor to delay unscheduled activities until they are included on a subsequent weekly activity schedule.

Other districts, depending on the contract, may or may not have similar special provisions.

The problem of reliability surfaces again when such updates are handed in to the Project Engineer. On simpler, more straightforward projects, the updates probably are not necessary. On larger projects, if the Project Engineer gets an update, he is often reluctant to hold the contractor to it even when the contractor does not follow it. These unreliable updates and the reluctance of the Project Engineer to enforce the schedule points out again that the Project Engineers have no control over the contractors' schedules and thus cannot alter the task schedule to balance the crews' assignments.

Resource Pool Limitation

The resource pool can be limited by communications difficulties and the Project Engineer's perceptions about departmental policies. The communications gap is between the district construction section organizations themselves, while the departmental policies may or may not be the way they are perceived.

Communications. Several districts experience communications difficulties among the various construction section organizations, and these difficulties directly affect the resource pool. The severity of this communication gap varies from district to district, from almost non-existent to severely limiting.

One way to solve the problems of both too many and too few crew members for the work available is to adjust the resource pool by adding or subtracting personnel. Because the Department limits the number of permanent personnel in each field office, and because temporary positions are not always available, theoretically the pool can be adjusted by borrowing or lending of crew members. Both are done frequently, though the geographic locations of the construction field offices and the intensity of the district rivalries, egocentricities and position protection can affect the solutions.

The geographic spread of field offices imposes the requirement that any construction field office located away from other field offices (as is the case in several districts) must pay per diem costs to borrowed crew members unless the project to be inspected is close to the other construction field office. This can cause engineering cost overruns and is not done unless necessary. This problem is, however, more easy to solve than the second.

The rivalries, egocentricities and position protection problem mentioned can engender at least three related responses. By most district policies, when a Project Engineer understands that he has too many or too few staff, he is to let the district construction office know. The district construction office then finds a way to help the Project Engineer with his resource pool problem by finding another office (either design or construction) that can lend crew or use more personnel. This is not considered a permanent transfer on the part of any personnel.

The first response that the problem causes is fear in many Project Engineers that another Project Engineer or organization is going to try to hold on to the absent crew member for longer than the problem exists. The borrowed crew member is given a specific time frame, based on the project schedules of the office, by which he or she knows when he or she will return to the original office. However, sometimes the best people, when lent, have not been returned in good time or when needed, and the original construction field office has been stuck.

Related to the first response are two other reactions, also based on the personalities of the Project Engineers. One of the ways that the Project Engineers have reacted to this is by first offering

problem[18] employees and less able or less experienced employees for movement between offices. A second reaction has been to not let the district know about the field office's scheduling problems (deliberate isolation).

Some districts do have excellent communication patterns. These districts are marked by easy lending of good crew when necessary, high morale, better communication between design and construction and fewer rivalries, egocentricities and position preservation. Information flow is open. With more open communication, project scheduling is easier, especially in the matter of crew shifting. Problems that come up are discussed rather than ignored, and solutions from other engineers are acceptable rather than perceived as take over attempts.

Perceptions. The resource pool is also affected by how the construction field office Project Engineers perceive headquarters and district policies and how they interpret these policies. Districts, at headquarters behest, are making an effort to enhance productivity while cutting costs, especially personnel costs; the Project Engineers perceive this negatively.

One of the ways the Department has been expecting to enhance productivity is through design centralization, as mentioned earlier. The Project Engineers have perceived this policy as affecting their resource pool, as well as their project schedules, negatively. In the summary of the topic "Centralized Location" in the proceedings from the 1986 statewide Project Engineers' meeting, it states, in part,

> The discussion then swung to the question -- is centralized location a positive influence on the department? It was felt that people in a centralized location become too specialized and pigeonholed, that they become stagnant and stop growing in their development, and possibly even careers . . . . It was felt that location jobs need to be in all field offices for employee development and training. Employees need to be well rounded, motivated to perform varying tasks and given a feeling of accomplishment in new areas. With smaller jobs coming out in many of the districts, the need to balance manpower with a winter workload of location work seems to be a necessity . . . . [O]nce the location and construction people are in separate offices, besides the obvious lack of cross training, there is no mix of the location and construction people on an informal basis that is utilized in many cases to communicate and solve problems . . . . It is felt that a lot of improvements that are made to jobs come strictly from knowledge gained during construction while keeping up with design standards obviously helps the quality of all work . . . . A well balanced mix of construction and design work is, from the project engineer's standpoint, the most desirable working environment [Vandehey, p. 21-24].

---

[18]Problem employees are permanent crew members who seem unable to handle normal job stresses and are constantly on leave with or without permission or unable to complete a project either correctly or on time. Every Department organization seems to have at least one problem employee.

Certain districts are attempting to avoid this problem by interpreting design centralization in such a way that the construction field office still does the majority of the design work, allowing as many of the employees as possible broadly based experiences. The central district office, especially if it is located close to one or more construction field offices, assigns most of the design work to the field office and only concerns itself with directing the design process for each project or designing specialty projects.

The second way that perceptions affect the resource pool is based on the reduction in number of permanent staff within the construction field office. The Department has cut the number of permanent field office staff to a minimum based on project assignments because fluctuations in staff needs are so great within the construction field offices, especially since design centralization has removed one of the basic resource leveling techniques available. The intent is to employ temporary, seasonal and project employees as "fillers," hiring and releasing them as warranted. This has given rise to a concern about quality control in inspection. Fewer experienced personnel are on the inspection crews; more on-the-job training is required; and more field errors and lawsuits may occur.

A third type of perception affecting the resource pool more indirectly surfaced during the interviews with the Project Engineers. Many of the Project Engineers mentioned that they perceived the primary purpose of the construction field office was to ensure that the contractor was not delayed in fulfilling contractural obligations. In response, the Project Engineers aim toward accommodating the contractors' needs first, straining the resource pool to its limits and beyond. This perception may be one reason for the emphasis of the Project Engineers on reactive management rather than longer range planning.

Weather

Weather is largely ignored because it can be taken into account automatically. Weather affects much of what happens in construction and must never be minimized. Though the state has two basic weather patterns, caused by location on the east or west side of the Cascades, the effects are somewhat similar.

Most contracts contain several tasks that are weather sensitive. This limits the construction season of most contracts to about April, when the weather begins to improve, through October, when

schedules. Operations scheduling must include a way to see clearly the complete day-to-day office tasks and available personnel projected over the short term. Ideally, the system should also include longer range planning aspects that allow assessment of the impacts of schedule changes, although unreliable project schedules do limit detailed personnel scheduling to a period of a few weeks.

To maintain efficient use of resources, specifically of human resources, means to upgrade the resource scheduling so that unnecessary peaks and valleys do not occur. Currently, much of the scheduling done is "hit or miss guesstimation" that can easily result in extremes: periods of excessive work demands on available personnel intermixed with periods of excess personnel. The personnel schedules must be able to deal with the peaks so that project delays due to unavailable or unqualified people are avoided, and with the valleys so that unnecessary non-productivity does not occur.

Documentation is the maintenance of records that chronicle the relationship between project progress and personnel assignments and utilization. Currently, much of the documentation is haphazard, used mainly to fulfill departmental requirements. A secondary use, not often found, is to document where personnel have been assigned. Consistent and formalized record keeping can substantiate personnel requests made to district and headquarters, track office staff scheduling trends, provide all staff with reasonable schedules, and be used as historic data for future forecasting and balancing.

Ease of use underlies the entire system as an objective. The system will not be helpful if it is not easily usable. The data collection and processing necessary for the system must be easy to carry out. This includes the original compilation of a schedule as well as the maintenance of it on an on-going basis. Furthermore, the documents that result must be clearly understandable by anyone in the construction field office.

ESSENTIAL SYSTEM REQUIREMENTS

System requirements can be defined in terms of three basic components: inputs, processes and outputs. The inputs are the data that must be collected for the system to function. The processes are manipulations of the data that create products. The outputs, or products, are how the system supplies useful information, fulfilling its purpose.

The discussion that follows presents an overview of these components. Products most clearly indicate the purpose of the system and thus significantly define the other components. Consequently, outputs are presented first. Processes are presented next to provide a step-by-step analysis of what the system must incorporate to function. These products and processes sections are divided into planning and operations which, though interrelated, have specific purposes to fulfill and maintain.

System Products

The basic system objectives could be met through the production of three standard reports:

- a Personnel Projections Schedule,
- a Quarterly Personnel Summary, and
- a Daily Personnel Assignments Schedule.

The first two would be specifically planning reports and the last would be an operational report. While the Personnel Projections Schedule and Daily Personnel Assignments Schedule would be similar, each would serve a very different purpose. The planning schedule would focus on gross projections of resource demand for long-term scheduling while the operations schedule would address assignments of specific personnel for short-term scheduling.

None of these reports would be specifically aimed toward providing historic records. However, if they were maintained, they could furnish historic information upon which future planning and operations scheduling judgments might be based. This is important for two reasons. First, the Project Engineer could substantiate any requests for personnel with office history, especially if the same contractors were repeatedly awarded contracts. Second, the history would furnish a basis from which new Project Engineers could make scheduling judgments.

Planning Products

Personnel Projections Schedule. Figure 23 illustrates the general format of this report. The scales would be at a low level of detail: time in weeks (or quarter-months) over a two-year period, personnel in crews and classification levels, and projects at gross level of tasks. The two-year term has been chosen to represent the biennium unit used for much of the Department's planning. Each of the four sections of the report would offer different information important to the Project Engineer.

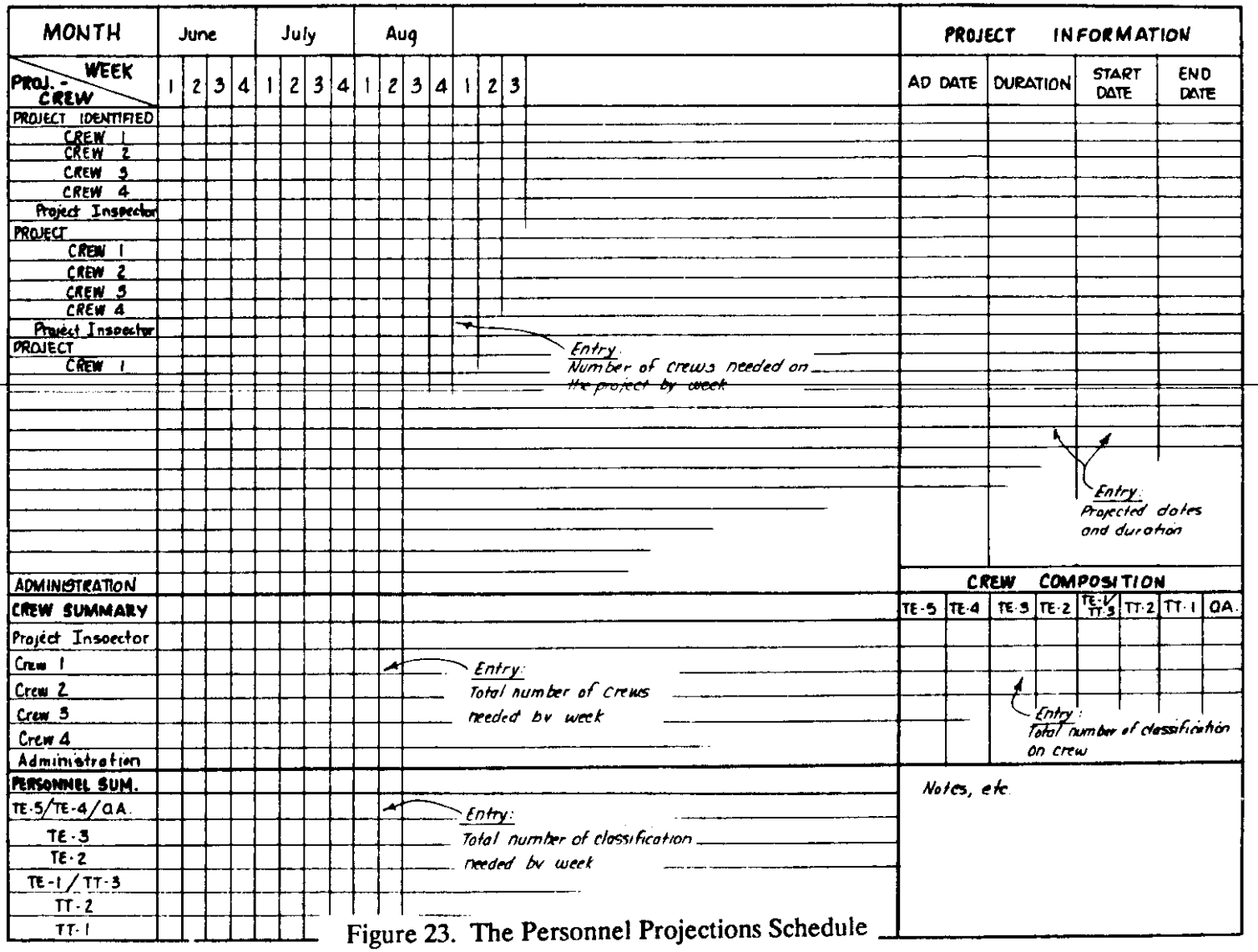


Figure 23. The Personnel Projections Schedule

The first section, the bar chart on the top left of Figure 23, would be the main schedule overview. It would illustrate crew requirements by week for each project. At a glance, the bar chart would provide an overall picture of project activity for the entire two-year period. Information displayed on the chart would include when work on each project would be needed and the crew type required.

The second section on this report, below the bar chart and labeled "Crew Summary" on Figure 23, would provide a summary of how many crews would be required for each time period. Coupling this with a table of the classification levels that make up each crew (the "Crew Composition" on the mid-right side of Figure 23), which is static information that would be located in the third section, a projection of the number of personnel needed in each classification level could be generated, as shown in the bottom section (labeled "Personnel Summary"). This information could be directly summarized for the Quarterly Personnel Summary, below.

Quarterly Personnel Summary. Quarterly Personnel Summary reports, similar to Figure 24, which indicate the projected person-months needed in the field office for construction, location and administration, would be sent to the district and headquarters every three months to help them plan future personnel needs. As noted above, this report could be compiled directly from the classification demand figures maintained in the Personnel Projections Schedule.

Operations Product

Daily Personnel Assignments Schedule. Figure 25 illustrates this report's general format, a bar chart showing how each person is scheduled over four weeks. The scales would be at a fine level: time in days covering a four-week period, personnel by individual names and classification level, and projects broken into tasks at each point where the size or type of crew changes. Below the bar chart would be the project summary, which would list each project's tasks and total the number of personnel assigned daily to each task.

The Daily Personnel Assignments Schedule would cover a time period of only four weeks. This would minimize the work required to create and maintain the schedule. If left as is, the reliability of the operations schedule after two weeks is reduced, but usable; by four weeks, without alterations, it

QUARTERLY PERSONNEL SUMMARY

PROJECT ENGINEER

	REPORT PERIOD _____												
MAN MONTHS REQUIRED	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
LOCATION													
CONSTRUCTION													
ADMINISTRATION P.E. Assist. Office Engr. Secretary													
OFFICE TOTAL													

EMPLOYEE ROSTER

_____ PERMANENT

_____ ON LOAN TO

_____ BORROWED FROM

_____ IN TRAINING

_____ TEMPORARY

_____ TOTAL

NOTE: REQUIRED PERSONNEL SHOULD INCLUDE 10% TO COVER ANNUAL AND SICK LEAVE

SURVEY & MATERIALS INSPECTION TO BE INCLUDED IN LOCATION OR CONSTRUCTION

Figure 24. Quarterly Personnel Summary (Example from District 1)

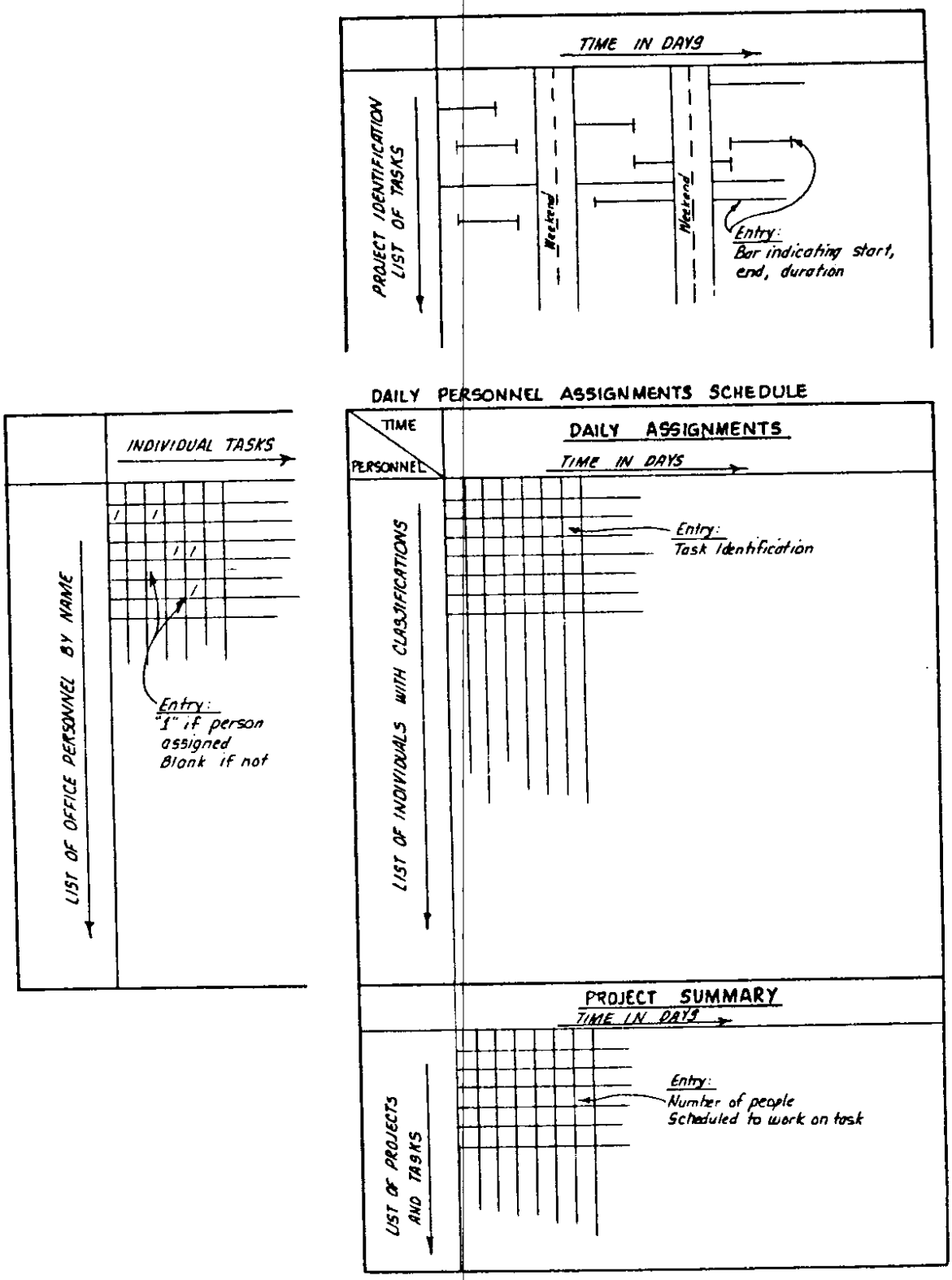


Figure 25. The Daily Personnel Assignment Schedule

usually is drastically reduced, though some of the schedule is still operational. This schedule is not intended to forecast longer term future personnel use; rather, it is to provide a dynamic window reflecting the constant changes to enable the immediate scheduling problems to be anticipated. Four weeks has been chosen as the outside limit for maintaining a reasonable operations schedule.

The other scales are more self-explanatory. This schedule is intended to assign individuals to specific daily tasks; adequate scales to do this are required. As a result of the use of these three scales, this report would show, at a glance, to which project each individual was assigned daily. It would also highlight what projects were lacking assignments and who could or could not be reassigned to another project's task. Blanks in a person's schedule would highlight imbalances between available personnel and work load demand. Similarly, project summaries showing too few personnel assigned to a task would indicate the need for additional or reassigned personnel.

Summary

All of the information in the proposed products for this system is currently being produced in some configuration by one or more of the Project Engineers. As indicated in Chapter 3, however, its presentation and use is not uniform throughout the construction field offices. The design challenge is to offer a systematic method of capturing and processing data to generate these products as easily, quickly and accurately as possible, given the limitations within which the project offices are operating.

System Processing Overview

The system process is specified here as a series of steps necessary to generate the products previously described. The steps required to incorporate the project into the construction field office's schedule are presented along with descriptions of the information needed to accomplish the step.

Steps to Create the Personnel Projections Schedule

The process would be initiated by the assignment of a project to the field office. As soon as the project assignment was known, the project would be related to a calendar, it would be broken into tasks based on crews and crew demand would be determined. Figure 26 is a flow chart that illustrates the process required to achieve both the Personnel Projections Schedule and the Quarterly Personnel Summary.

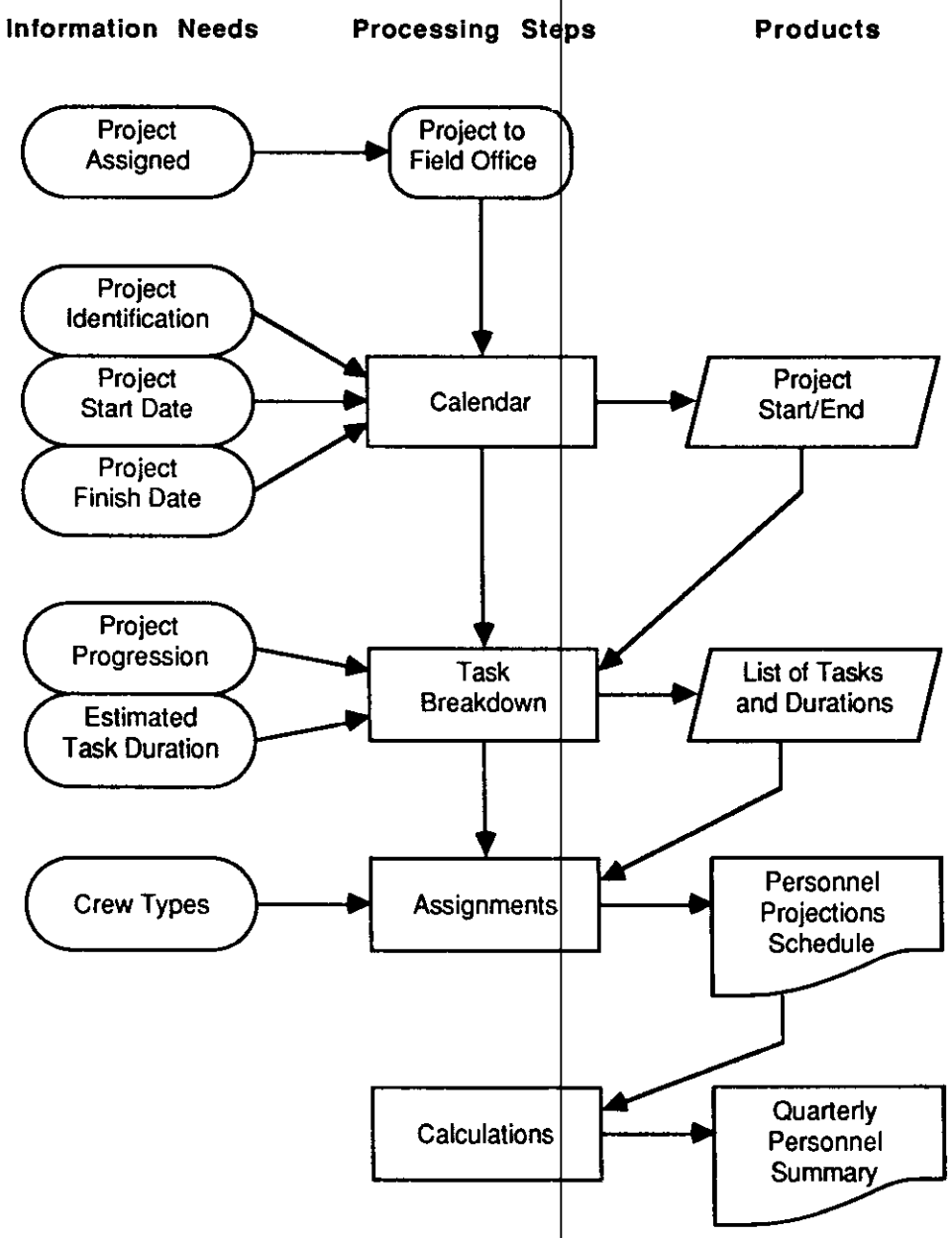


Figure 26. Flow Chart for Personnel Projections Schedule and Quarterly Personnel Summary

The Calendar Step. The first step in the planning process would be to place the project onto a master calendar. This would be essential for estimating the time periods over which the project was expected to be completed. Three pieces of information would be required for this step: a project identifier (the L or C number,[19] other number or unique name), the first date anyone in the office was expected to begin work on it, and a date for the project's completion.

Though seemingly simple, establishing meaningful beginning and ending dates would not be easily done. For example, it is difficult to determine a reliable beginning date. Several districts publish lists of projects that include an ad date. Figure 27 is an example sheet from such a list. The ad date could be used to approximate PS&E arrival, when an inspector might be assigned to review the project and when preliminary staking might be done. Other dates might be estimated from the ad date as well. Therefore, the major concern would be whether the ad date, the basis for all other dates, was reliable. The system must be able to accommodate the fluctuating ad date and adjust beginning dates easily.

The end date would be theoretically determined by adding the project's duration (not available on the list above), or number of work days, to the start of construction date, with time added for final records completion. The translation of a project's duration in work days into calendar tasks must reflect possible delays, such as weather. The use of either Table 18 or 19 would be one way to estimate weather delays on workable days and relate them to the calendar.

These tables project the average number of construction working days available in each month of the year, based on whether certain contract elements can be done in winter. Though not specific to any location, these tables could be used to establish a rough estimate of a project's calendar duration.

Depending on the status of the Design Report or PS&E, duration might be available through the design office. Another source that might help determine both start and end dates would be the Capital Program Management System (CPMS).[20] Though the system is not fully functional at present,

---

[19]Location (L) and contract (C) numbers are internal accounting numbers used to identify projects. L numbers are for the Design Report and PS&E and are assigned at project conception, while C numbers are for construction and assigned at the ad date.

[20]CPMS is a program being developed to incorporate a number of separate programs, including MMIS, into one large system for better management of the entire Department of Transportation's personnel and budget. At this time (early 1988), installation is expected to be completed by the end of 1988.

DISTRICT NO. 3
LOCATION ENGINEERING SCHEDULE BY STATE ROUTE

	PROJ TO PE	PRE EST TO D O	HR DATA TO D O	HR DATA TO D O	R/W PLAN TO PLANS	ENV DOC TO H Q	DES RPT TO H Q	R/W PLAN TO H Q	R/W ENVS APPROVAL	PS & E COMPLETE	PS & E TO H Q	AD DATE
ORG. SCH:	08/16/83	09/14/83	03/84	N/A	N/A	07/02ECS	04/84	N/A	N/A	08/84	09/84	11/84 SH
CUR. SCH:	08/16/83	09/14/83	01/20/84	N/A	N/A	07/02ECS	03/30/84	N/A	N/A	07/86	08/86	07/87 *

SR# - 117 MP 060.13 TO MP 061.25
JOB# - L-7713 PROJ# - 33089A SUB-PGM (A1) FUNDING (SF $) 1036
DESC. - ELWAH RIVER TO SR101
LOC. ENGR. - GINTER/SHANAFELT CONST. ENGR. - GINTER

	PE	R/W	CONSTRUCTION	TOTAL
ORIGINAL EST:			178,000	178,000
CURRENT EST:				

CPMS MILESTONES: ENVIRONMENTAL ACT. COMP. 07/00/82 — R/W PLAN APPROVED — BRIDGE PS&E COMPLETE
GOILS REPORT COMPLETE — AGREEMENTS COMPLETE — BRIDGE DATA TO H. Q.
DESIGN REPORT APPROVED 07/23/84 — R/W CERTIFIED

REMARKS: PAT CONSTRUCTION SEASON JULY 1 TO AUGUST 15. SUPPLEMENT DESIGN REPORT AND RESURFACING REPORT REQUIRED. * FUNDED BY UV RICN.

****

ORG. SCH:	09/85	10/85	12/85	N/A	N/A	01/86ECS	04/86	N/A	N/A	08/86	09/86	11/86
CUR. SCH:	07/26/85	11/18/85	12/13/85	N/A	N/A	01/86ECS	04/86	N/A	N/A	08/86	09/86	11/86

SR# - 115 MP 000.00 TO MP 002.20
JOB# - L-8425 PROJ# - 33013D SUB-PGM (A1) FUNDING (SF $) 2034
DESC. - OCEAN SHORES TO SR 109
LOC. ENGR. - HART/BRASCHER/SHANAFELT CONST. ENGR. - HART

	PE	R/W	CONSTRUCTION	TOTAL
ORIGINAL EST:	24,831		320,155	344,986
CURRENT EST:			372,000	372,000

CPMS MILESTONES: ENVIRONMENTAL ACT. COMP. 01/29/86 — R/W PLAN APPROVED — BRIDGE PS&E COMPLETE
GOILS REPORT COMPLETE — AGREEMENTS COMPLETE — BRIDGE DATA TO H. Q.
DESIGN REPORT APPROVED — R/W CERTIFIED

REMARKS: PROJECT INCLUDES PRELIMINARY ENGINEERING AND CONSTRUCTION FOR A PLANNED 0.06 ACP OVERLAY AND 0.02 PRELEVEL INCLUDING, DIGOUTS, CRACK SEALING, STRIPING, SIGNING AND OTHER SAFETY WORK AS ADDRESSED IN THE DESIGN REPORT.

****

ORG. SCH:	02/85	03/85	04/85	N/A	04/85	03/85ECS	05/85	05/85	07/85	11/85	12/85	02/86
CUR. SCH:	02/15/85	04/03/85	07/17/85	N/A	N/A	03/85ECS	07/17/85	N/A	N/A	01/15/86	02/06/86	04/14/86

SR# - 121 MP 000.18 TO MP 000.32
JOB# - L-8248 PROJ# - 33158J SUB-PGM (A2) FUNDING (FA $) 1170
DESC. - BN XING AT ROCHESTER DOT 925746
LOC. ENGR. - BERRY/HRASCHER/SHANAFELT CONST. ENGR. - BERRY

	PE	R/W	CONSTRUCTION	TOTAL
ORIGINAL EST:	15,400	5,000	87,000	107,400
CURRENT EST:			141,000	141,000

CPMS MILESTONES: ENVIRONMENTAL ACT. COMP. 03/27/85 — R/W PLAN APPROVED — N/A — BRIDGE PS&E COMPLETE
GOILS REPORT COMPLETE — AGREEMENTS COMPLETE — BRIDGE DATA TO H. Q.
DESIGN REPORT APPROVED 08/26/85 — R/W CERTIFIED — N/A

REMARKS: REVISE RR CROSSROAD PROFILE.
UNPROGRAMED PROJECT REQUEST

****

Figure 27. District Project Listing Example

Table 18. 130 Workable Days With Winter Shutdown

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	13	15	17	20	20	19	16	10	0

Table 19. 185 Workable Days Without Winter Shutdown

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	10	12	13	15	20	20	20	20	20	15	10

Both tables are from: Washington State Department of Highways. Manpower Management Information System, Volume 1: Procedures. No date. Manual Number M11-01, Page 5A-22. In this manual, the tables are Table 2 and Table 3, dated January 1986.

the Department expects the CPMS data bank to provide personnel and project information for construction planning. Information for CPMS is based on methods of inspection from actual construction projects, which have been broken down into a gross schedule of tasks. This information has been used to create a base average for per-day progress on tasks. These averages, generated from quantities and not dollar amounts, are compared to quantities expected on a new project to estimate the amount of time it will take to complete construction. The reports generated from CPMS also allow time for potential delays. The result is a preliminary schedule for the project. However, as projects increase in complexity and uniqueness, the ability of the program to estimate personnel needs decreases.

Figures 28 and 29 illustrate two forms of CPMS information. Figure 28 is a single project's gross task breakdown, with estimated beginning and ending dates. The ending date includes a short amount of time for final records. While this may not be exactly the form needed, it would still be useful as a basis for projecting task breakdowns and limitations. Figure 29 lists all the projects expected to be assigned to the field office and gives a general idea (by person-months assigned) of when the project is expected to start and end. Using either or both of these reports would ease the work and shorten the time required to do this step and the next. However, at this time, reports similar to those illustrated are only available on a monthly basis, and information on them is not necessarily up to date.

The Task Breakdown Step. This step would involve breaking the project into tasks that different crews would perform. The task breakdown would be necessary to match crews to projects. Two pieces of information would be required to break down the tasks: the probable project progression and the estimated duration of the tasks.

Two sources might be available for this information. The first would be the design office, which prepares the Design Report and the PS&E, if the design is far enough along. The second would be the CPMS information mentioned under the previous step, especially the report in Figure 28. Enough project information must be available to the construction field office to permit tasks and task durations to be generated, resulting in projects listed with tasks over time.

REPORT # R02203-21 — WASHINGTON STATE DEPARTMENT OF TRANSPORTATION — PAGE 01

PROJ-MGR = 444304 — PROJECT SCHEDULE AND MANPOWER PLAN — RUN DATE 12/01/87

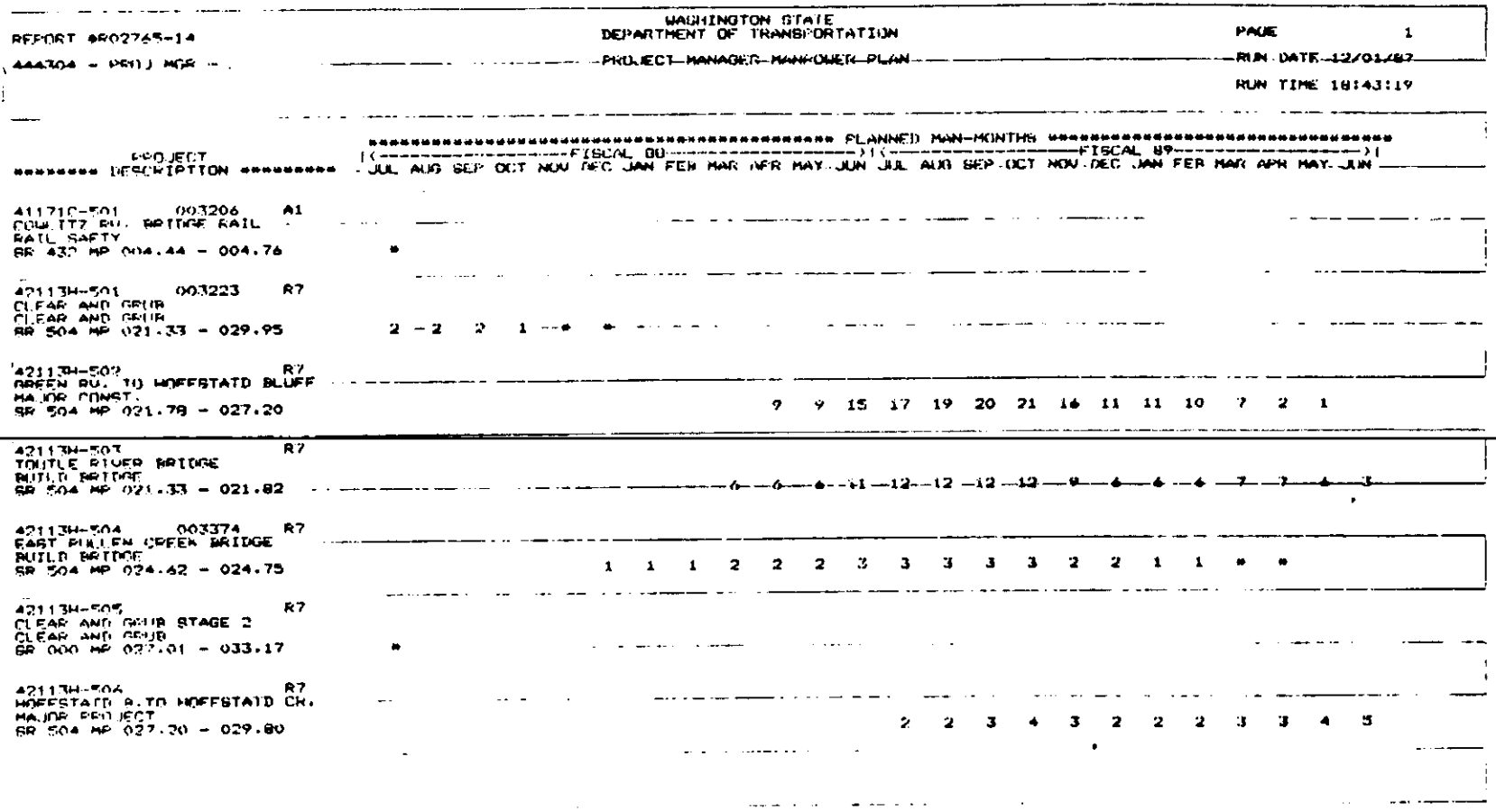
PROJECT # 41075C-501 A1
HAGERUP RD. TO SR 4
SR 401 MP 003.00 - 012.13
SR 401 SR 300 TO 1213

CONTRACT AMOUNT = $2970000
CONTRACT WORKING DAYS 80

****** ACTIVITY TITLE ******	*** PLANNED *** START	COMPLETE	SUPPORT ORG	*** MAN-HOURS *** HOUR SUPPT	DIST SUPPT	PROJ MGR	**** MAN-HOURS BY SKILL LEVEL **** ENGR AU	LEVEL 5	LEVEL 4	LEVEL 3	LEVEL 2	LEVEL 1
PROJECT ADVERTISEMENT	05-01-91	07-01-91	304020	0								
			303042	20								
SURVEY	07-01-91	11-01-91				1042			244	244	266	266
INSPECT	07-01-91	11-01-91				1409			578	911	620	
TEST	07-01-91	11-01-91				397					155	242
WEIGH, DISPATCH, RECEIVE	07-01-91	11-01-91				666						666
OFFICE ENGINEERING	05-01-91	12-01-91				665		144		333	166	
CLERICAL	05-01-91	12-01-91				294						
PROJECT MANAGEMENT	05-01-91	12-01-91				378	378					
GENERAL	05-01-91	12-01-91				168						
DISTRICT SUPPORT	05-01-91	12-01-91	444001		126							
HEADQUARTERS SUPPORT	05-01-91	12-01-91	303022	4								
			303020	4								
			304010	42								
TRAVEL TIME	05-01-91	12-01-91				840						
	********* DIRECT MAN-HOURS *********			20		4199		144	844	810	1207	1174
	******** INDIRECT MAN-HOURS ********			50	126	1680	378					
	********* TOTAL MAN-HOURS *********			78	126	5879						

* INDICATES MILESTONE
() INDICATES WORK DAYS OVERRIDDEN

Figure 28. Single Project Report from CPMS



REPORT #R02765-14 — WASHINGTON STATE DEPARTMENT OF TRANSPORTATION — PAGE 1

444304 - PSNJ MGR = . — PROJECT MANAGER MANPOWER PLAN — RUN DATE 12/01/87

RUN TIME 10:43:19

PROJECT ******** DESCRIPTION *********			PLANNED MAN-MONTHS FISCAL 88 JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	FISCAL 89 JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
41171C-501 COWLITZ RV. BRIDGE RAIL RAIL SAFTY SR 432 MP 004.44 - 004.76	003206	A1	*																							
42113H-501 CLEAR AND GRUB CLEAR AND GRUB SR 504 MP 021.33 - 029.95	003223	R7	2	2	2	1	*	*																		
42113H-502 GREEN RV. TO MOFFSTATD BLUFF MAJOR CONST. SR 504 MP 021.78 - 027.20		R7											9	9	15	17	19	20	21	16	11	11	10	7	2	1
42113H-503 TOUTLE RIVER BRIDGE BUILD BRIDGE SR 504 MP 021.33 - 021.82		R7									6	6	6	11	12	12	12	12	9	6	6	6	7	7	6	5
42113H-504 EAST FULLEN CREEK BRIDGE BUILD BRIDGE SR 504 MP 024.62 - 024.75	003374	R7						1	1	1	2	2	2	3	3	3	3	3	2	2	1	1	*	*		
42113H-505 CLEAR AND GRUB STAGE 2 CLEAR AND GRUB SR 000 MP 027.01 - 033.17		R7	*																							
42113H-506 MOFFSTATD R.TO MOFFSTATD CK. MAJOR PROJECT SR 504 MP 027.20 - 029.80		R7													2	2	3	4	3	2	2	2	3	3	4	5

Figure 29. All Projects Report for Single Field Office from CPMS

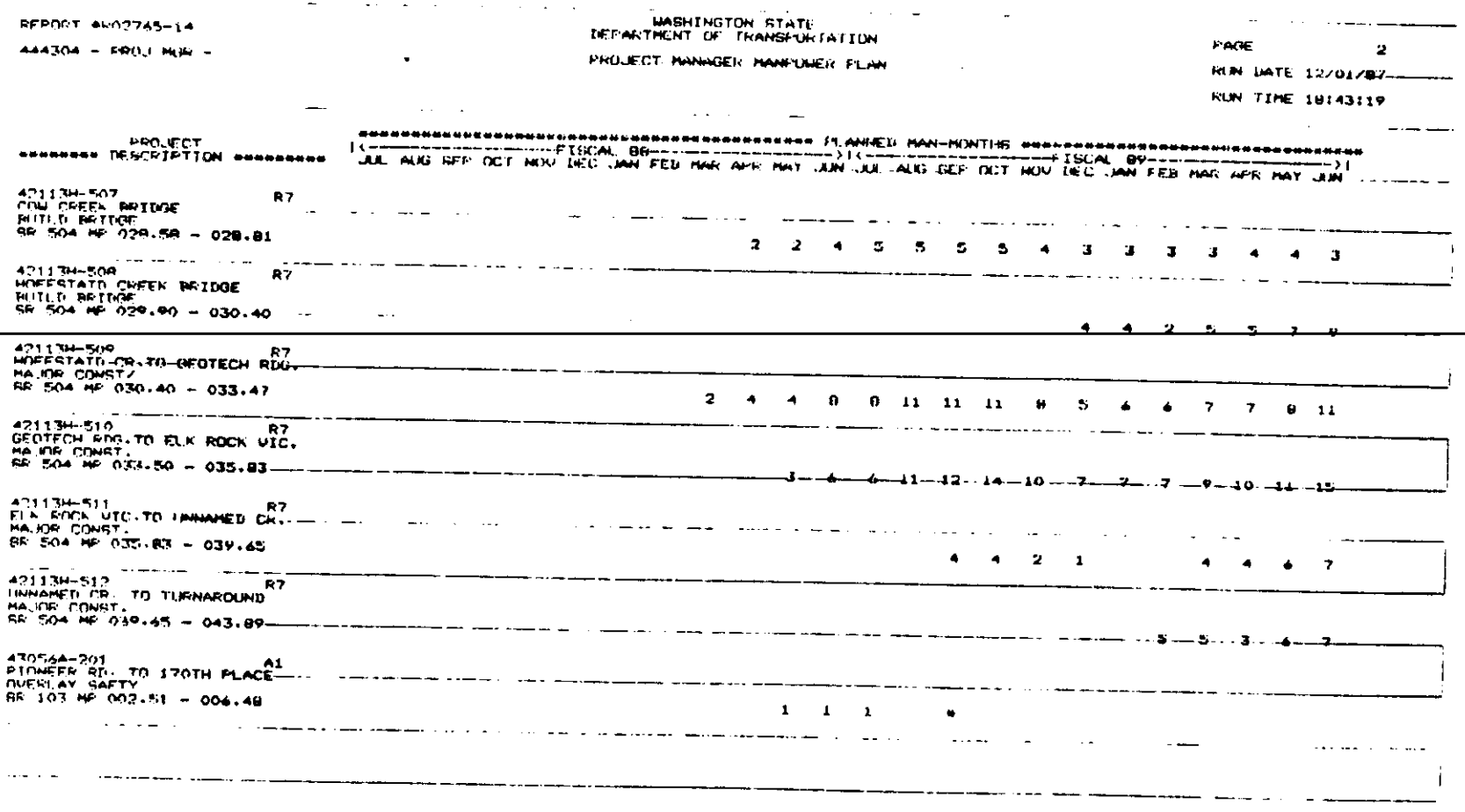


Figure 29. All Projects Report for Single Field Office from CPMS (Continued)

REPORT #R02265-14 WASHINGTON STATE DEPARTMENT OF TRANSPORTATION PAGE 3

444304 - PROJ MGR - PROJECT MANAGER MANPOWER PLAN RUN DATE 12/01/87

RUN TIME 18:43:19

PROJECT ******** DESCRIPTION **********		PLANNED MAN-MONTHS FISCAL 88 JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	FISCAL 89 JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
430544-301 PIONEER RD. TO 170TH PLACE OVERLAY SAFTY SR 103 MP 002.51 - 006.48	A1													1	1	2	2	1	*	*					
430544-501 PIONEER RD. TO 170TH PLACE OVERLAY SAFTY SR 103 MP 002.51 - 006.48	A1																						*	*	
430494-501 R/R-XING-BNSO-1491-200E-204S REPLACESIGNALS AT 3 PLACES SR 142 MP 999.99 - 999.99	A1				1	1	1	1	1	1	1	1	1	*											
43127H-201 CREEK BRIDGE 508/25 REPLACE BRIDGE SR 508 MP 024.00 - 024.18	H1																				*	*	1	*	*
43127H-301 CREEK BRIDGE 508/25 REPLACE BRIDGE SR 508 MP 024.00 - 024.18	H1																		1	1	*	*	*	*	

Figure 29. All Projects Report for Single Field Office from CPMS (Continued)

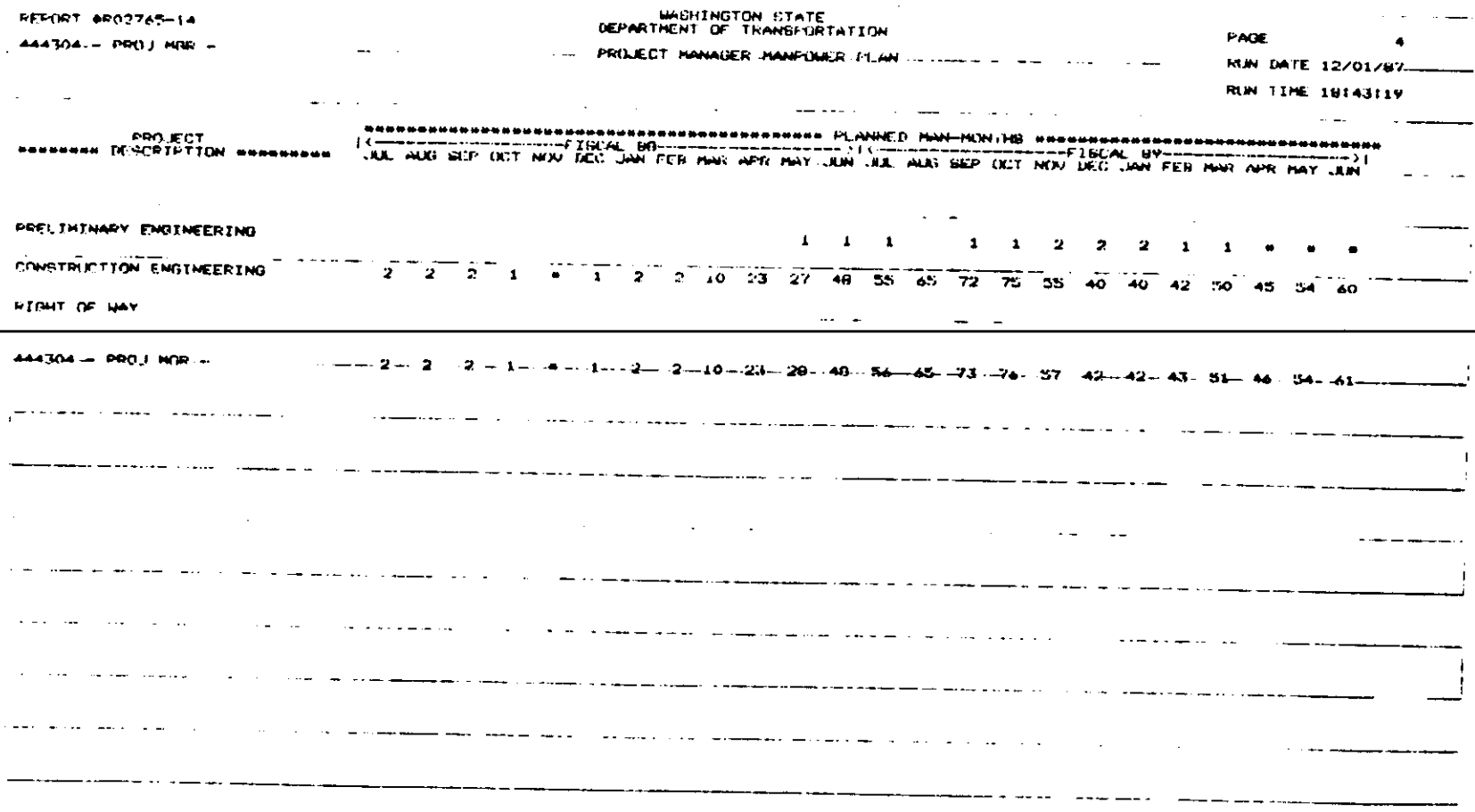


Figure 29. All Projects Report for Single Field Office from CPMS (Continued)

The Assignments Step. This step would bring together the information from the first two steps and determine crew demand by project. To do this, crew types would be assigned to projects. For each project task listed on the calendar, the number of each kind of crew required to carry out the task would be noted for each week. This number would not have to be limited to whole numbers; partial weeks or multiple crews by week could be indicated using decimals. For example, .5 would indicate a crew needed for a half week; 1.5 would indicate that more than one crew was needed for the week.

The Reports Step. After the assignments had been made, calculations would fill in the remainder of the Personnel Planning Schedule and the Quarterly Personnel Summary. Generation of the demand by time period by crew type, the crew summary of Figure 23, would be done first. Extending the crew type out by the number of persons per crew would lead to person demand by week, termed the personnel summary.

The Quarterly Personnel Summary would be generated from information located on the Personnel Projections Schedule. The personnel summary section would be an estimate of the number of personnel by classification by week (or quarter-month) required in the field office. The monthly average of personnel by classification could be calculated and added together for the office totals required on the Quarterly Personnel Summary.

Planning Steps Summary. The process to produce the Personnel Projections Schedule and the Quarterly Personnel Summary generally builds on informal patterns currently used by the Project Engineers. The proposed system is not intended to cover specific individuals or highly detailed project tasks. It must allow for two types of flexibility. The first is easily adjustable start and end dates that incorporate new information as it becomes available. The second is flexibility in producing the two reports, of which the second report is dependent on the first. Furthermore, the system must recognize variations in types of data available and permit the Project Engineers to use their own judgment in assessing future total crew needs for project tasks. While only required on a quarterly basis, the Personnel Projections Schedule can be updated more frequently in the event of significant, near-term project changes.

Steps to Create the Daily Personnel Assignments Schedule

The operations schedule process, while similar to the planning process, would be more complex and would have to be more immediately available. Figure 30 is a flow chart that illustrates the process that would be required to create and maintain the Daily Personnel Assignments Schedule. The arrival of the completed plans for construction, the PS&E, would confirm that the field office was being assigned responsibility for the construction of the project. Preliminary scheduling of crews to tasks might have to begin earlier in anticipation of receiving the PS&E; however, once the PS&E was "in house," specific individuals would have to be scheduled to specific project tasks.

The Project Task Schedule Step. The first step would be to convert the project into crew related tasks and associate these with a daily calendar. As indicated earlier, the daily calendar would cover a maximum period of four weeks, allowing the detailed task breakdown to be for the next four weeks rather than for the entire project. Each task's duration would depend on where a crew size or type changed. Information required to do the task breakdown would include the project identification, the project plans, the ad and/or construction start date and total project duration.

Sources for this information would include the project task breakdown previously done for the planning schedule, the PS&E and the Department's CPM. The information from the planning schedule would include a basic outline of the project, which could then be refined with the PS&E and the Design CPM, if it was done. Plan quantities, found on the PS&E, could be used to estimate the amount of time tasks would take, giving a preliminary estimated duration for inspection. The estimate of task duration would also include an assessment of potential delays and accelerations brought about by design problems, contractor delays, weather or other reasons. In completing this step, however, the operations schedule must retain the flexibility of the dates found in the planning scheduling process, while refining the level of detail.

The Individual Assignments Step. Here individuals would be assigned by name to each defined project task. The information required for this matching would be a list of all members of the office staff and their classification levels, and the list of tasks and durations developed above. A preliminary determination would have to be made at this time about whether the tasks would require the crew to be on overtime or per diem. The result would be a table with columns listing project tasks

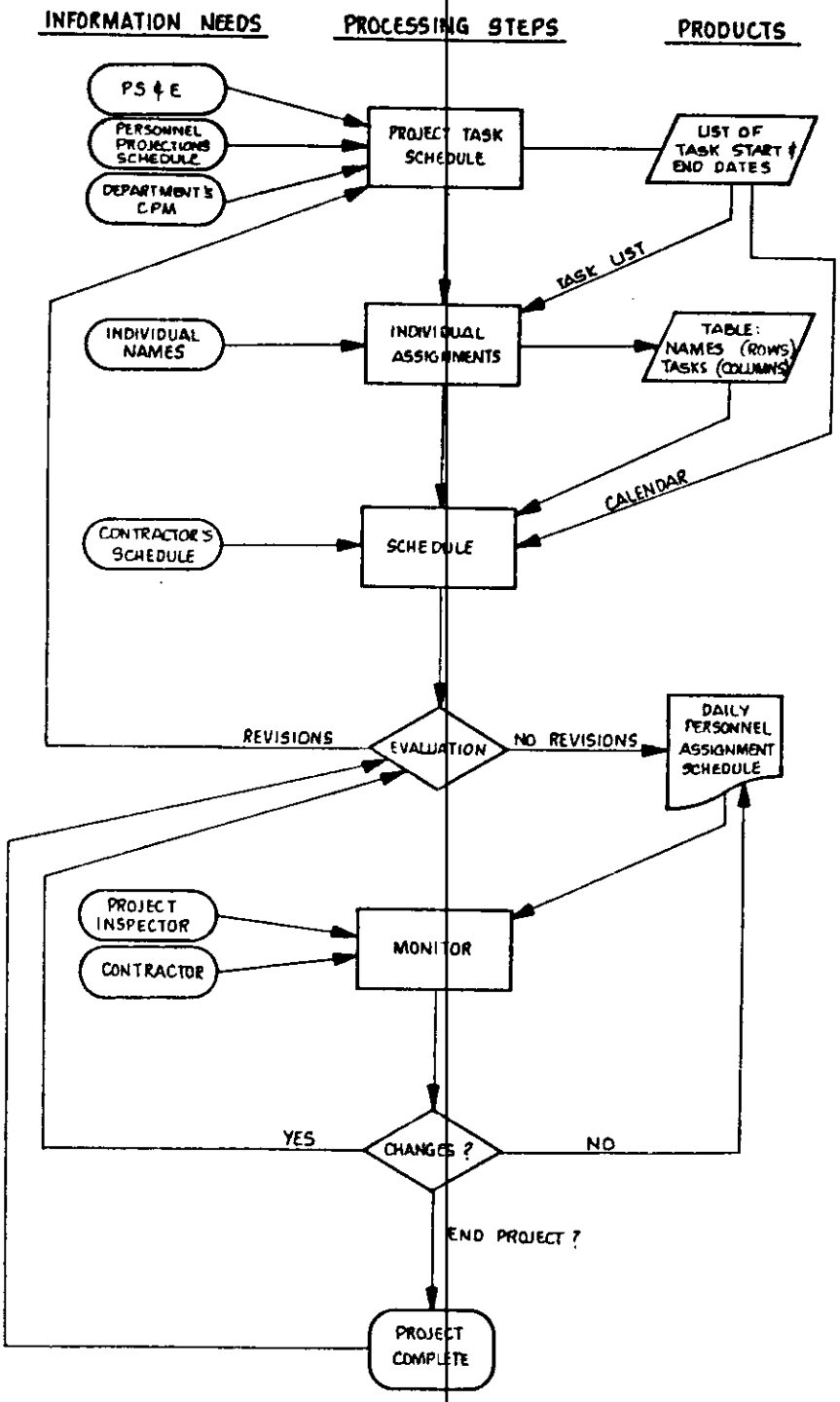


Figure 30. Flow Chart for the Daily Personnel Assignments Schedule

and rows listing individuals; entries at the junction of the columns and rows would indicate when the individual was assigned to a task.

The Schedule Step. Combining the information from the first two steps would create the proposed operations schedule. The daily tasks that each person was assigned would be noted for the next four weeks. As in the case with crews on the planning schedule, individuals might be assigned to tasks on a less than full day basis using decimals to indicate partial days. The result of this step would be the ability to summarize on a daily basis the allocation of individuals to project tasks. Any days on which a person was not scheduled to any task or was scheduled to too many tasks would appear.

The project summary would also be created during this step. In the project summary portion of the schedule, each task would be outlined and the number of individuals assigned to that task would be totaled. The completion of this table would indicate when too few or too many people were assigned to a task.

The Evaluation Step. After the schedule had been created, it would have to be evaluated to determine its acceptability. The two criteria of concern would be whether all project tasks were adequately staffed and whether all personnel were committed at, or close to, 100 percent time throughout the period. If adjustments were not necessary, a usable schedule would exist. If adjustments were required, revisions would have to be made.

As noted in earlier chapters, three alternatives for balancing the schedule are usually possible: adjusting the project task schedule, adjusting the resource pool and adjusting the resource assignments. Adjusting the project tasks schedule would require that the task start and end dates be altered arbitrarily to fit, which is not generally considered a realistic alternative. To do the second or third adjustments would require reassessing the individual assignments and either adding or deleting personnel or altering the assignments in the table created earlier. Once these revisions were completed, the result would be the Daily Personnel Assignments Schedule. The system must permit these changes to be made easily so that various alternative assignments can be tested if necessary.

The Monitoring Step. To keep the Daily Personnel Assignments Schedule current would require collection of the best information available on task start and end changes and personnel adjustments possible over the next four weeks. The intent is to update the schedule at least weekly; if

more time passed before an update, the schedule's usefulness would be reduced greatly. Two basic sources, the project inspector and the contractor, would be available for this information.

The project inspector could furnish information about project task progress either through formal, written weekly updates of the schedule, or through informal weekly crew meetings. The formal update could be an arrangement in which the Project Engineer handed the inspector a list of scheduled tasks for the next four weeks and the inspector noted whether the tasks were likely to occur or finish and added any not on the list. The crew meetings would review the progress of all the assigned tasks, estimate whether they were continuing or were expected to finish in the next time period and note any new tasks expected to begin in that time period.

Tasks that had been projected to occur over the next four weeks could also be reviewed with the contractor in weekly meetings. The contractor would be expected to provide verbal comments on the reasonableness of the schedule rather than written updates, unless the contract required the written form.

After current data about the project tasks and upcoming personnel availability had been collected, the Daily Personnel Assignments Schedule would have to be reviewed to identify any changes. If changes had occurred, the project task schedule and individual assignment steps would have to be reiterated. The result would be an updated and current Daily Personnel Assignments Schedule every week covering the next four weeks.

Operations Steps Summary. The process to produce the Daily Personnel Assignments Schedule would be similar to the planning process and would be based on similar informal patterns already established in the field offices. The proposed system is expected to cover specific individuals in daily detail over short time periods. It must also be flexible enough to allow constant adjustment of individual assignments as new information becomes available, while maintaining a slightly longer view on upcoming changes. This schedule is also expected to be updated at least weekly, to maintain as high a level of accuracy as possible.

Component Interactions

The planning and operations components of the system are expected to interact in two ways. First, the planning schedule could be used as the initial project task schedule for operations. The

planning schedule, if available, would be refined as necessary to meet the detail requirements of operations. Second, current operations information on projects in progress would be periodically incorporated into the Personnel Projections Schedule. Remaining tasks and their projected start and end dates would have to be used to update that project in the planning system. This process would be done at least quarterly, and ought to have been done whenever the operations project schedule indicated a very different progress from the original planned schedule. The interacting processes would result in easier scheduling methods and better foresight into potential scheduling problems.

SUMMARY

The system design concepts presented above, which include the system objectives and essential requirements for meeting the objectives, are a series of steps based deliberately on informal processes already used in the DOT field offices. The proposed process would use available information to produce three reports, the Personnel Projections Schedule, the Quarterly Personnel Summary and the Daily Personnel Assignments Schedule. Besides offering a unified method of personnel scheduling management, these reports might be maintained for historic records. These records would offer the advantages of future projections based on past performance and requirements and easier office management changeovers when necessary. The next chapter describes three possible approaches to further design and implementation of the personnel scheduling management system.

CHAPTER 6
SYSTEM DESIGN APPROACHES

INTRODUCTION

Three approaches to the concepts of the personnel scheduling management system are presented in this chapter, one manual and two computer based. Each approach has its own advantages and disadvantages, which are noted. The availability of two departmentally supported microcomputer programs, LOTUS 1-2-3 and Microsoft PROJECT, has been the reason for selecting the two computer based approaches, the spreadsheet and the network. Other approaches may also be possible as long as the system objectives and requirements can be fulfilled.

THE MANUAL SYSTEM APPROACH

In physical looks, the manual implementation of these procedures would closely resemble the lists, tables and charts used to describe the conceptual system. Each of the reports, the Personnel Projections Schedule, the Quarterly Personnel Summary and the Daily Personnel Assignments Schedule, would become a form to fill in. Tables and charts, used to create the final reports, would also be fill-in forms. The steps outlined in Chapter 5, done manually, would be the process by which the information would be transformed into the reports.

The only advantage to this approach would be that a standardized procedure for scheduling would be available. For field offices lacking formal scheduling capabilities, these procedures would result in documented personnel schedules.

The manual approach would have the major disadvantage of being very time consuming to use. Consequently, this system is not recommended for implementation except in limited circumstances. Because of the time limitations imposed by the dynamic nature of the schedules, three of the original system objectives would be severely compromised.

First, the system would be required to be flexible and easy to use in adjusting dates and other information. The manual schedule would require constant recalculation and redrawing and thus would not encourage this ease of use. Second, the monitoring aspect, which would allow the system to

minimize reactive management, would require swift responses. Continual updates demanded by the schedule at the detail level suggested would require major time commitments to maintain accuracy. Third, when creating a schedule becomes so time consuming, the effective use of personnel fails. The information required would not be available in a timely manner, and more time would be committed to the scheduling process than with the simpler systems that have already evolved.

THE SPREADSHEET SYSTEM APPROACH

Implementing the outlined system on a spreadsheet program is a reasonable alternative. All field offices currently have access to at least one spreadsheet program, LOTUS 1-2-3. Programs like LOTUS 1-2-3 would allow the direct implementation of the proposed reports and procedures. The degree to which the overall system was automated could vary, depending upon the extent to which the designer wished to use various program capabilities. Planning and operations schedules would be completed separately in a spreadsheet system.

The Planning Component

Implementation of the Personnel Planning Schedule and the Quarterly Personnel Summary would closely parallel the procedures outlined in Chapter 5 and would produce the final form of the reports as described. To obtain the desired results, the planning spreadsheet could be separated into six sections. The first could be a table from which other information was entered into the two reports; the next four sections would be the four sections of the Personnel Planning Schedule, as in Figure 23 of Chapter 5; and the sixth would be the Quarterly Personnel Summary, Figure 24 of Chapter 5.

The first section could be a table that would list projects in one column, start and end dates in two more columns and required crew types in the remaining columns. This table would be used to modify the second section automatically whenever start and end dates changed, simplifying that process. Specific start and end dates would need to be determined before spreadsheet entry.

This table would be optional. If the Engineer so desired, the second section, the top left section of the Personnel Planning Schedule, containing the main schedule, could be developed with direct entry of start and end dates. This section would include the list of projects and crews assigned to each project as rows, and weeks within the two-year period as columns. Each row would be limited to

either the project identification or one crew type. For each crew type, the assignment to project tasks would be indicated by the number of crews required for that week (e.g., .2 for one crew needed only one day, or 1.5 for more than one crew of the same type). Zero crews would not be entered.

The third section, the Crew Summary on Figure 23, would include a list of all crew types, one per row, including one row for an administrative crew type. Within each row the number of crews required across all projects for each week would be presented. This number could be calculated from information contained in the first section through entry of appropriate cell formulas or macros. The values for these cells would simply be a sum of entries for corresponding crews within the project list of the second section.

Each crew's composition in classification levels (number of crew by classification), which is usually a static list, would be provided in the fourth section, the Crew Composition section of Figure 23. This information would be multiplied by the number of crews needed each week. The results would be presented in the fifth section of the report, which would indicate the number of personnel required by classification by week. The weekly values of the fifth section, the Personnel Summary of Figure 23, would be automatically calculated based on appropriate formulae entered into each cell.

The information of the Personnel Summary could then be summarized, again through the use of cell formulae, into an estimate of the number of person-months required in the field office. The Personnel Planning Schedule, in the spreadsheet design, would indicate location and administration as well as construction. Once the calculations were complete, this information could be directly entered into the Quarterly Personnel Summary report.

The Operations Component

Production of the proposed Daily Personnel Assignments Schedule would be similar. Five sections would be required, though only the four presented in Figure 25 of Chapter 5 would make up the final report. The steps described in Chapter 5 would be used to produce the results.

The first section, the top chart of Figure 25, would include a projected schedule of projects by tasks by day for the upcoming four-week period. Each row would represent an individual project task and each column would be a specific day, including weekend days. For each day that a particular task would be worked on, an indicator (e.g., 1) would be entered into the appropriate row and column. This

could be done manually or, preferably, could be accomplished through the use of a separate table, in the second section (not on Figure 25), indicating the projected start and end dates of each task. This second section would be similar to the planning spreadsheet's first section, but simpler in that only the dates would be required.

The third section, the chart on the left side of Figure 25, would consist of a table relating project tasks and personnel. Each column would be a project task and each row an individual. The assignment of an individual to a task would be noted with the placement of a 1 in the cell at the intersection of the individual's row and the task's column. If the individual was assigned to the task other than full time, a value different than 1 could be indicated (e.g., .5 for half day, or 1.25 for a ten-hour day).

The information in these three sections would be used to produce the report itself, titled the Daily Personnel Assignments Schedule on Figure 25, which would show the tasks to which each individual was scheduled on a daily basis. The first three sections, once completed, would be the basis for macros and/or cell formulae that would automatically calculate the entries onto the Daily Assignments bar chart section of Figure 25, the fourth spreadsheet section. The Project Summary of Figure 25, the fifth section, would then be developed with macros which used the Daily Assignments information to calculate the number of individuals assigned to each task. Completion of the Project Summary would finish the operations schedule.

Advantages and Disadvantages

The first advantage to the spreadsheet is that, with the cell formulae and macros, many of the manual calculations would be removed from the production of the reports. All the reports could be prepared by entering as little information as the project and/or task start and end dates and the personnel assignments to tasks. This approach would allow easy updating of the dates and assignments, giving the system approach the required flexibility.

A second advantage would be that, when the spreadsheet sections were completed, the sections pertinent to each final report could be printed directly from the spreadsheet. The final forms of the reports would be similar to the products described in Chapter 5, with all the information required on only a few pages.

A third advantage would be the graphics extension capability. Bar graphs, similar to the ones in Figures 12 and 13 of Chapter 4, could be created as additional reports. They would be used to visualize resource distribution by illustrating where the resource peaks and valleys were expected to occur. Periods when adjustments were likely to be needed would be clearly shown.

The major disadvantage would be that the set up of this system would require time for the design and testing of all the spreadsheets and macros. Each report section would need to allow for the addition and deletion of projects, project tasks and personnel, and recalculation of the summaries. Familiarity with spreadsheet programs and the macro programming language would be necessary for the designer to accomplish the task. However, once the master spreadsheets had been created and were working, the advantages for the construction field office would far outweigh this disadvantage. The Daily Personnel Assignments Schedule alone, with automatic recalculations available, could be as dynamic as required to keep up with the changes, provided that the data were collected in a timely manner and were of reasonable accuracy.

THE NETWORK SYSTEM APPROACH

The third approach would incorporate the use of network based project management software. Programs such as Microsoft PROJECT, which is supported by the DOT, are thought to fit naturally into the context of any type of project management environment. Though they use a different method of input and report production, these programs still encompass scheduling and use of resources in a process much the same as the steps presented earlier in the description of the required system procedures. The projects are broken into tasks, start and end dates (or duration) are established, a resource pool is defined and assignments are made to tasks. Reports can be produced showing resource demand by time unit and project assignments for individual resources. Planning and operations schedules, because of differences in purpose, are done separately. Reports are described under each component portion. Note that Microsoft has recently upgraded PROJECT to Version 4.0. This newer version, and the program enhancements that are included, is the basis for the following discussion.

The Planning Component

Processing

The planning component would involve the creation of at least three and probably four master files: a master resource file, at least one master calendar file, and a master project file for the office. This method of saving information in three interconnected files is one of the differences between this approach and the other two, so a more detailed description of the entire program follows.

The PROJECT program, when entered, allows the creation of three interconnected files for any project. One of these is the resource file. The information in this file can be specified for each project, or a master can be created that is later connected with each new project file. For the planning component, the master resource file could be set up in one of two ways. The first would list each classification level available in the field office. The classification level would be used to designate an assignment to a task, and the Project Engineer would establish crews by assigning as many of each classification level required to the task. The second set up method would be to list as a single resource each crew that would be required for all assigned projects. Non-crew personnel, such as project inspectors and chief inspectors, would be listed separately. This would allow for less initial entry when the project is set up in the activities screen resource section because only one or two resources would need to be listed rather than every crew member separately.

The calendar file could be created either as a master file or individually with each project file. To save work, two master files could be created, filling two separate needs. One would be the master workable days file and the other would be the master standard calendar file. The workable days calendar file would take into account potential project delays, perhaps by using Table 18 or 19 from Chapter 5 and turning random days in a month "off" or "on" to correspond. Other anticipated delays might also be added. This calendar would be used to calculate project and task calendar durations and end dates using the program. To do this, the project and/or task breakdown would be entered into the activities screen of the program. The estimated start date would be entered, as would be the project and/or task duration. The program, using the workable days calendar, would calculate end dates automatically. To ensure that a task's duration in relation to other tasks was calculated properly,

preceding tasks, start-to-start, finish-to-finish and lead or lag time dependencies would also be entered. The result would be a more realistic series of task start and end dates.

After the start and end dates have been calculated, the date information for each activity would be edited. Dependencies would not be changed, but durations would have to be deleted and end dates specifically entered.[21] Then, the standard calendar, which would only show holidays and weekends as non-work days (the calendar by which state employees would actually be working), would be used to establish the final schedule. The start and end dates would be used to calculate duration in terms of standard calendar days when the standard calendar file was attached. At this point, the resources would be assigned and a realistic project inspection schedule based on state employee scheduled time would result.

The project master file could be set up in one of two ways. If the combined number of tasks on all projects was too great to allow entry of all of the information into a single master file (the first option), then separate project files could be created that would then be linked into a master schedule file (the second option). The first option, in which all tasks would be listed with each project in a single file, would allow the user to see the entire schedule in all detail required at all times. Microsoft PROJECT does allow several hundred tasks to be individually entered into one file, but this may be awkward to work with in a total office scheduling system.

The linked master file, the second option, would not allow all the tasks to be visible; it has only a single line designating the name of the reference file where the remaining information is located. The second option would still allow, however, the same master calendar to show project start and end dates and the individual resource information for all projects.

Following a project through the process illustrates how this might work. A project would be assigned to the construction field office and broken into tasks, each task defined so that crews and/or classifications could be assigned. The workable days calendar would be used to establish realistic start and end dates. These dates would be noted on the activities screen for each task, after which the

---

[21]Though end dates would seem to be entered already when the editing has begun, this is not the case with Microsoft PROJECT. End dates at this stage are calculated and disappear when durations are deleted. To keep the proper end dates when the standard calendar was attached, they would have to be physically re-entered at this time.

standard calendar file would be substituted for the workable days calendar file. As each project file was completed, it would be linked to the master project file, where the entire office schedule (at only a project level of detail) would be represented in a bar chart. The resource assignments could be checked in the master file for over- or under-use of particular crews or classifications with the use of the available reports and histograms featured in the resource section. Once necessary adjustments were noted, the individual project files or section in the master file would be recalled and updated.

Planning Reports

The two reports required of planning, in the conceptual system, are the Personnel Planning Schedule and the Quarterly Personnel Summary. Neither of these reports is directly available in Microsoft PROJECT. However, several types of standardized and custom reports are accessible either on the printer or the computer screen that gather pieces of each of the required reports together and give a complete scheduling picture.

For example, Figure 31 is a typical bar chart showing tasks with calendar durations. This bar chart can be varied in time scale, so that any level of detail from half-days to years is available to the user. This furnishes the project task/time relationship. In conjunction with this, an Activity Table Report (Figure 32) can be accessed that lists each activity (or task) separately with start and end dates, predecessors and successors for the task, and resources. A third summary, the Resource Histogram, is a view of how one resource is scheduled over a calendar period. Using all three of these together, the top left section, the Project Summary and the Crew Summary of Figure 23 could be filled in. Crew Composition would be manually filled in, as would the Personnel Summary, assuming that the Master Resource File consisted of crews only. If the Master Resource File consisted of classifications, then most of the Personnel Planning Schedule information (except the Crew Summary) could be accessed using these three PROJECT reports and views.

The Quarterly Personnel Summary, similar to Figure 24, Chapter 5, would be extracted manually from the information in Microsoft PROJECT. Using the Period Demand Report (Figure 33), person-months by classification would be available. Further calculations, including combining the classifications into "Location," "Construction," and "Administration" categories, would provide the remaining information required by the report.

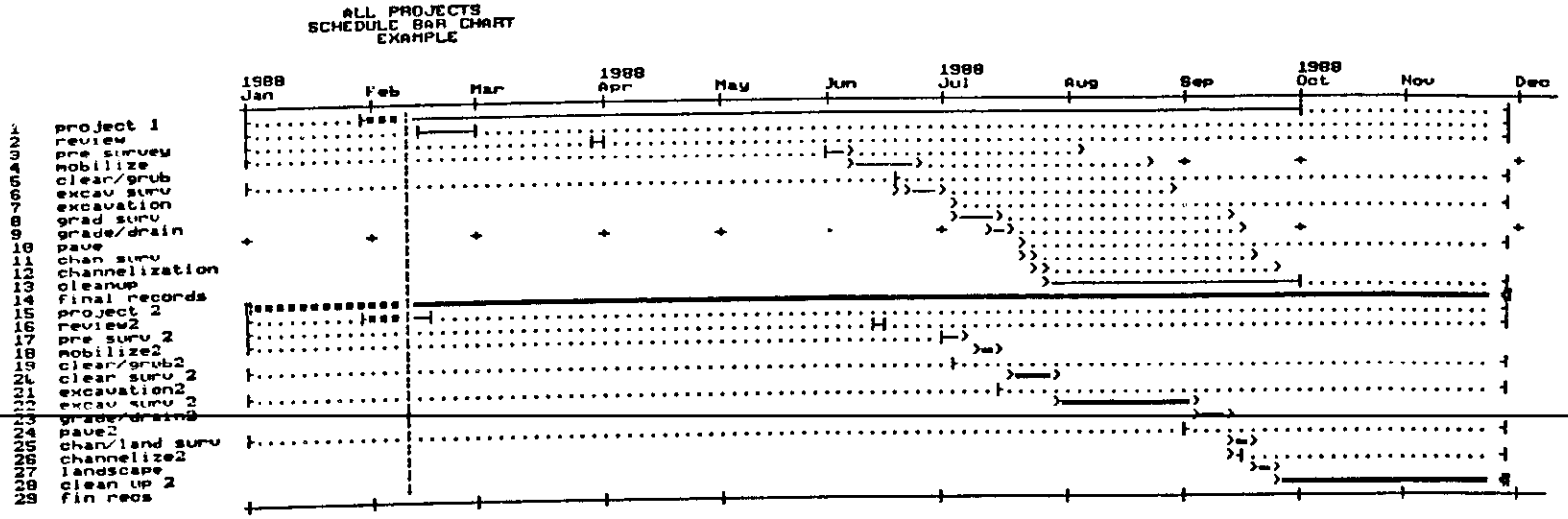


Figure 31. Schedule Bar Chart from Microsoft PROJECT

ALL PROJECTS, PERSONNEL
ACTIVITIES TABLE REPORT
EXAMPLE

Project: MPROJ Date: Feb 29, 1988 1:07 PM

---

1 project 1

Early Start: Jan 1, 1988 8:00 AM Early Finish: Sep 1, 1988 5:00 PM
Late Start: Mar 28, 1988 8:00 AM Late Finish: Nov 30, 1988 5:00 PM
Sched Start: Feb 1, 1988 8:00 AM Sched Finish: Oct 3, 1988 5:00 PM

Duration: 172.00 Days Slack: 61.00 Days
Predecessors: None
Successors: None

Resource: bane,e2

---

2 review

Early Start: Jan 1, 1988 8:00 AM Early Finish: Jan 20, 1988 5:00 PM
Late Start: Nov 9, 1988 8:00 AM Late Finish: Nov 30, 1988 5:00 PM
Sched Start: Feb 15, 1988 8:00 AM Sched Finish: Mar 3, 1988 5:00 PM

Duration: 14.00 Days Slack: 219.00 Days
Predecessors: None
Successors: None

Resource: bane,e2

---

3 pre survey

Early Start: Jan 1, 1988 8:00 AM Early Finish: Jan 4, 1988 5:00 PM
Late Start: Nov 29, 1988 8:00 AM Late Finish: Nov 30, 1988 5:00 PM
Sched Start: Apr 1, 1988 8:00 AM Sched Finish: Apr 4, 1988 5:00 PM

Duration: 2.00 Days Slack: 231.00 Days
Predecessors: None
Successors: None

Resource: mccauley,e1, shaver,t3, jones,e2, te-2, te-1/tt-3, tt-2

Figure 32. Activities Table Report from Microsoft PROJECT

SURVEY CREW
PERIOD DEMAND REPORT
EXAMPLE

Project: MPROJ
Time scale: Month

Date: Feb 29, 1988 1:05 PM
Demand scale: Day

Period ending	May 1, 1988	Jun 1, 1988	Jul 1, 1988
1 te-3	0	0	0
2 te-2	2.00	0	5.00
3 te-1/tt-3	2.00	0	5.00
4 tt-2	4.00	0	10.00
5 tt-1	0	0	0
Total:	8.00	0	20.00

Figure 33. Period Demand Report from Microsoft PROJECT

The Operations Component

Processing

Creation of the operations files would be similar to the creation of the planning files. However, the master files would be set up slightly differently. This time, the master resource file would list each individual's name and classification level, one per line. A helpful addition if filtering were planned would be to include a resource identification tag.

The master calendar would be the standard calendar for the next four weeks because the operations schedule would be based on what happened to state employees' schedules. For the operations schedule, use of another option for calendars, individual calendars for each resource, might be helpful when each resource was working with a different schedule because of overtime, per diem, or other reasons. Calendar file choice would depend on need and might vary over a year.

Depending on how the planning files were set up, the operations schedule would be done in one of two ways. If the planning schedule was set up as a single master file with tasks for all projects broken out, then the operations schedule could be based on it. Updating would entail only adjusting task detail levels, start and end dates, and resource pool and assignments based on weekly monitoring.

If the planning schedule was set up using linked files, or if it seemed more expedient, a new operations project file could be created with only the next four weeks detailed. For this second option, new tasks would be added and finished ones deleted every week. Updating would be based on weekly monitoring, and adjustments of tasks, dependencies, dates and resources would be done as required.

Operations Reports

In the conceptual system, the operations report consisted of the Daily Personnel Assignments Schedule. This report is not available directly in Microsoft PROJECT. As in the planning section, several standardized and custom reports and views would be accessible to provide the information for the Daily Personnel Assignments Schedule.

The bar chart of Figure 31 is available at a daily level. More to the point would be Figure 34, the Calendar Report.[22] Combined with the Calendar Activities Report (Figure 35) and the Period Demand Report (Figure 36), both of which could be filtered for a crew or an individual using resource identification tags, specific information about each person's assignments could be gathered. When examined closely, the imbalances would show. Using other information such as in Figure 37, a custom report which would compare actual (A) schedules with forecast (F) schedules could be created. Though Figure 37 does not show forecast schedule information, the information can be accessed for a custom report.

It would be easier to use these reports as on-screen views if the first option, basing the operations schedule files on the planning schedule files, were used. Though some of the reports, such as the Calendar Report, can be "windowed" and printed for specific time periods, other reports would be printed out for the entire file, which could be both time- and paper-consuming. The choice of options for creating the operations component files would depend on what reports were required as printed reports.

Specifically, then, the bar chart would be equivalent to the top portion of Figure 25. The Calendar Report, Calendar Activities Report and Period Demand Report together would be the Daily Personnel Assignments Schedule. The table to the left of Figure 25 would be incorporated into these reports. Therefore, all the information required would be available, just in different forms. Imbalances would show up just as on the conceptualized report form, only on the Microsoft PROJECT reports. When imbalances occur, they would be corrected interactively, using the program directly. Monitoring information would also be entered and updating of all tasks affected would occur through the program's ability to recalculate.

Advantages and Disadvantages

One advantage to using a network program is that all calculations that are necessary to scheduling are already built in and no system development is required. Another advantage is that

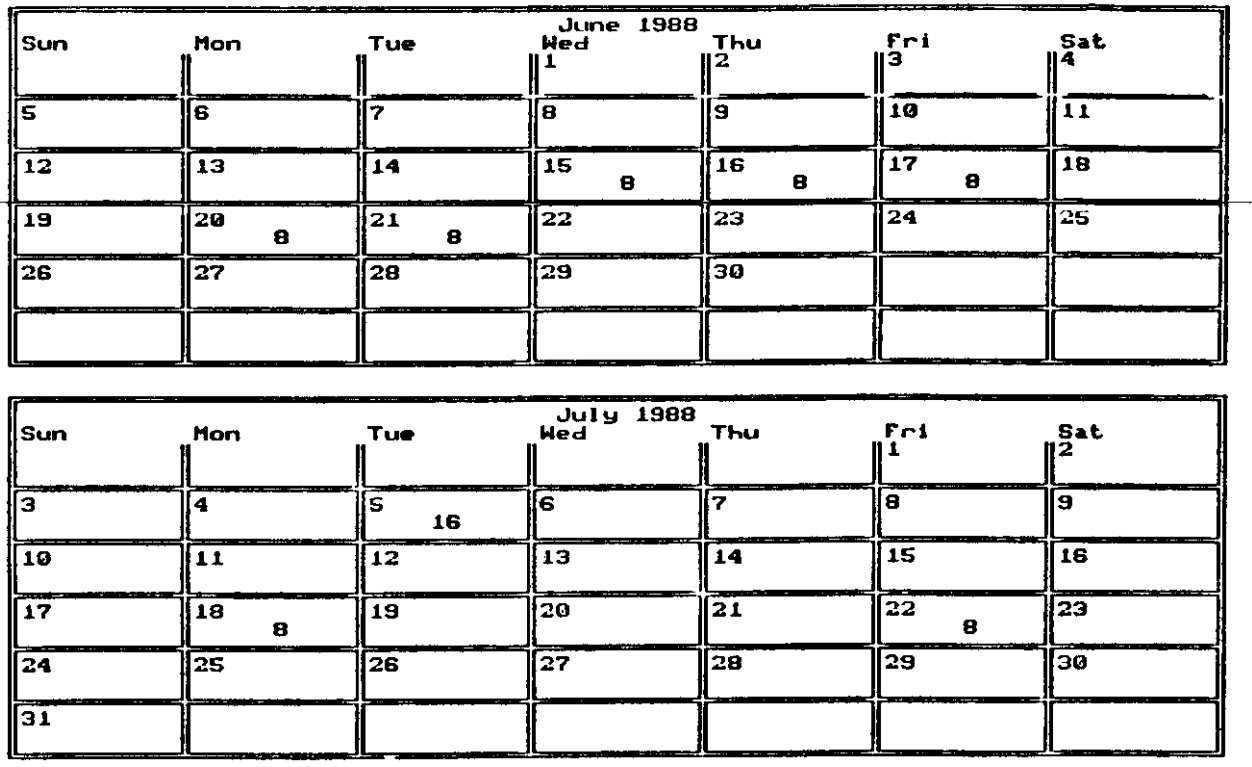
---

[22]The resource is labeled Jones, E2. The calendar report will either schedule all resources or one resource; Jones is on the survey crew, and represents all assigned crew members. Filtering is not available for this report.

ALL PROJECTS
CALENDAR REPORT
EXAMPLE

Project: MSTAND
Resource: jones,e2

Date: Feb 14, 1988 1:50 PM
Report type: ALL



June 1988

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15 8	16 8	17 8	18
19	20 8	21 8	22	23	24	25
26	27	28	29	30		

July 1988

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5 16	6	7	8	9
10	11	12	13	14	15	16
17	18 8	19	20	21	22 8	23
24	25	26	27	28	29	30
31						

Figure 34. Calendar Report for Survey Crew

SURVEY CREW
CALENDAR ACTIVITIES REPORT
EXAMPLE

Project: MPROJ
Resource: jones,e2

Date: Feb 16, 1988 7:53 AM

July 1988		Hours
5		
	20 clear surv 2	8.00
	8 grad surv	8.00
18		
	22 excav surv 2	8.00
22		
	11 chan surv	8.00
Total:		32.00

Figure 35. Calendar Activities Report – Survey Crew

ALL PROJECTS, SURVEY CREW ONLY
PERIOD DEMAND REPORT
EXAMPLE

Project: MPROJ
Time scale: Week

Date: Feb 15, 1988 10:01 AM
Demand scale: Day

Period ending	Jun 24, 1988	Jul 1, 1988	Jul 8, 1988
1 jones,e2	3.00	0	2.00
2 mccauley,e1	3.00	0	2.00
3 shaver,t3	3.00	0	2.00
4 temp,t2	0	0	0
5 temp,t1	0	0	0
Total:	9.00	0	6.00

Figure 36. Period Demand Report for Survey Crews

ALL PROJECTS
REPORT TO ANALYZE PROJECTS
EXAMPLE

Project: TEMP Date: Feb 15, 1988 9:53 AM

Activity Number	Duration to Date (A)	Total Duration (A)	Start Date (A)	Predecessors
1	10.17 Days	172.00 Days	Feb 1, 1988 8:00 AM	
2	0.17 Days	14.00 Days	Feb 15, 1988 8:00 AM	
3	0.00 Days	2.00 Days	Apr 1, 1988 8:00 AM	
4	0.00 Days	6.00 Days	Jun 1, 1988 8:00 AM	
5	0.00 Days	13.00 Days	Jun 9, 1988 8:00 AM	mobilize
6	0.00 Days	2.00 Days	Jun 20, 1988 8:00 AM	
7	0.00 Days	7.00 Days	Jun 23, 1988 8:00 AM	clear/grub
8	0.00 Days	1.00 Day	Jul 5, 1988 8:00 AM	excavation
9	0.00 Days	10.00 Days	Jul 5, 1988 8:00 AM	excavation
10	0.00 Days	6.00 Days	Jul 14, 1988 8:00 AM	grade/drain
11	0.00 Days	1.00 Day	Jul 22, 1988 8:00 AM	pave
12	0.00 Days	3.00 Days	Jul 22, 1988 8:00 AM	pave
13	0.00 Days	2.00 Days	Jul 27, 1988 8:00 AM	channelization
14	0.00 Days	45.00 Days	Jul 29, 1988 8:00 AM	cleanup
* 15	31.17 Days	233.00 Days	Jan 1, 1988 8:00 AM	
16	10.17 Days	14.00 Days	Feb 1, 1988 8:00 AM	
17	0.00 Days	3.00 Days	Jun 15, 1988 8:00 AM	
18	0.00 Days	5.00 Days	Jul 1, 1988 8:00 AM	
* 19	0.00 Days	6.00 Days	Jul 11, 1988 8:00 AM	mobilize2
20	0.00 Days	1.00 Day	Jul 5, 1988 8:00 AM	
* 21	0.00 Days	10.00 Days	Jul 19, 1988 8:00 AM	clear/grub2
22	0.00 Days	1.00 Day	Jul 18, 1988 8:00 AM	
* 23	0.00 Days	24.00 Days	Aug 2, 1988 8:00 AM	excavation2
* 24	0.00 Days	6.00 Days	Sep 7, 1988 8:00 AM	grade/drain2
25	0.00 Days	0.50 Days	Sep 2, 1988 8:00 AM	
* 26	0.00 Days	4.00 Days	Sep 15, 1988 8:00 AM	pave2
27	0.00 Days	2.00 Days	Sep 16, 1988 8:00 AM	channelize2
* 28	0.00 Days	4.00 Days	Sep 21, 1988 8:00 AM	channelize2
* 29	0.00 Days	45.00 Days	Sep 27, 1988 8:00 AM	clean up 2

Figure 37. Customized Report Example

updating is easy for both task start and end dates and classification/crew and individual resource files. Creation of master files for calendars that cover several years and resources that are relatively static makes scheduling simpler by allowing the focus to be the activities section of the program, where the main adjustments are made. The ability to designate task dependencies uses the program's strength in updating subsequent tasks based on one change, allowing greater ease in updating the entire schedule. Another advantage is that planned schedules can be compared easily with actual schedules, allowing tasks to be tracked. Through some of the views available (such as the Comparison View, which contrasts two resources, or the Resource View Activities, which shows the schedule and a resource histogram together), resource distributions can be evaluated and altered interactively as required.

There are several disadvantages to network programs. One is that some time is required to understand completely the advantageous use of the program. Application guidelines would need to be fully defined to allow the Project Engineer to precisely apply the chosen program. Another disadvantage is that the reports are not in the same format as the conceptual system has envisioned. Network programs will furnish the same information, but the reports would need to be carefully scrutinized and customized for the required information to be accessed.

The third disadvantage is that the network programs base their systems on traditional resource leveling methodology, i.e., adjusting project tasks over time to level the use of limited resources. This algorithm is not applicable to the construction field offices, in that shifting activities is not an option. Microsoft PROJECT, for example, features the ability to do automatic resource leveling; this is useless for the DOT field offices. However, adjustment of the resource pool and assignments is still available as a schedule balancing solution.

The fourth disadvantage is that the data for the Quarterly Personnel Summary, as shown in Figure 24, are not able to be extracted automatically from at least Microsoft PROJECT. Methods to obtain the required information would include manual extraction from data provided in Microsoft PROJECT, and entry of the data from Microsoft PROJECT into LOTUS 1-2-3 for automatic Quarterly Personnel Summary calculations.

The fifth disadvantage depends on the choice made for operations schedules. These could be done either by constant detailed update of the planning schedule, or by creation of a totally new

operations schedule file. Unless few printouts are desired, and those printouts consist only of the reports that can be windowed, the first option is useful only for interactive viewing and updating and historic records. Too much time and paper would be required for constant reprinting of the schedules from the first option.

APPROACH ASSESSMENTS

Three approaches to implementing the personnel scheduling management system have been suggested. The debate now becomes which one to implement. Though the manual system, because of the time constraints that limit its effective full implementation, is not recommended for use in the construction field offices, it still might be useful. There seems to be merit in suggesting at least partial implementation of the manual form, perhaps simplified or in conjunction with some already in use and discussed in Chapter 4, because field offices that do not have any documented system might desire to begin with a manual system. Each field office would have the option of proceeding to more detailed systems as it became (or needed to become) more sophisticated in its personnel scheduling methods. There is also merit in adding features from the proposed manual system to existing manual systems that would make true schedules out of levels of scheduling that are missing certain essential elements.

The two computer based systems each have different foci and strengths that could be advantageous to a field office, depending on the focus of the personnel scheduling system manager. The spreadsheet system is focused on the end products, or the reports. The process is defined in terms of what the output should be like, and the system would be established to furnish the products. System design would be more difficult to do initially, but the end product would offer more flexibility, especially because the information could be presented in the proposed conceptual forms.

The network approach is focused on the process involved, the dynamics of the system. The system is already defined, and the user would employ the system to access the outputs that met the personnel scheduling needs. There would be less work in programming, but more in establishing the best way to access the system for the information required.

Both computer based systems would require some manual operations. The spreadsheet would require at least manual entry and updating of start and end dates and resource assignments, as well as

initial spreadsheet set up information, which would be office-specific. Depending on the amount of automation through macros and cell formulae, more manual operations might be required. The network system would require that at least start dates and durations, task breakdowns and resources be manually entered. Once the network was operating, updating would be performed manually. The Quarterly Personnel Summary would also have to be extracted manually from data provided by the program or sent to the spreadsheet for automatic calculations.

It is also possible that use of one or the other would not be the answer to a field office's needs. Using both in a system together has been advantageous to one project office, as the network example in Chapter 4 illustrates. However, each of the approaches can stand alone. The decision about which system or combination of systems would be most useful to a particular construction field office must finally be left to the Project Engineer.

SUMMARY

This chapter has described three different approaches to implementing the personnel scheduling management system outlined in Chapter 5. The manual approach has difficulties meeting three of the five system objectives (ease of use, minimizing reactive management and efficient use of resources) because of time constraints. The two computer based systems meet all the objectives, though meeting the ease of use objective is different for each. The spreadsheet would take time to design and implement, but would be easy to use once implemented. The network would not need programming design, but would take more time for familiarization; over time, it would become easy to use. The next chapter summarizes and concludes the report and makes further recommendations for implementation of the system, future studies and possible enhancements.

CHAPTER 7
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter has been divided into four sections. The first section summarizes the findings and proposals of the first five chapters. The second section draws conclusions from the completed study. The third section, split into two parts, makes recommendations for the implementation of the proposed personnel scheduling management system and future studies that could arise from this work. The fourth section briefly explores potential system enhancements which, though not essential to the system, would upgrade the capabilities of it.

SUMMARY

This report has focused on the current state of personnel scheduling management systems in Washington State Department of Transportation construction field offices. Behind this focus has been the assumption that, though all of the field offices use some level of scheduling, there could be more effective, systematic and less reactive ways of doing personnel scheduling at this level. The study found that the Project Engineers are scheduling under a variety of constraints and concerns that directly impact their ability to do long-range planning and respond quickly to short-range schedule changes. In response to the findings, a unified personnel scheduling management system has been conceived, with three suggested approaches for design and implementation that would fit into many of the project offices.

To develop the final personnel scheduling management system concept, an investigation was completed to understand how personnel scheduling is done currently. As part of the investigation, the structural placement of projects, personnel and the construction field office itself within the Department was established and a model of scheduling for the construction field offices was developed. A data collection methodology that included a questionnaire sent to the Project Engineers and interviews of Project Engineers was used.

The majority of the information from the questionnaires and interviews has shown that the Project Engineers are doing restricted scheduling under numerous constraints. These constraints have been identified and are generally categorized as

- current notification procedures of project assignment and scope to the field office;
- limitations on project management based solutions;
- inaccurate contractors' progress schedules and contractors' updates during construction;
- limitations on numbers of personnel available to the construction field office; and
- attitudes and perceptions of the Project Engineers themselves about the construction field office, its position, the Department and their ability to deal with the problems they encounter.

The first three of these constraints directly affect the project side of scheduling. The first four originate from outside the construction field office and are not under the Project Engineer's control to change.

The effect of this series of constraints is that, when the model of scheduling is applied to the actual field office situation, the Project Engineers find themselves unable to make use of a major portion of the solutions that would normally be available to balance their personnel schedules. The model indicated that three areas of scheduling adjustment, adjusting the resource pool, adjusting the resource assignments and adjusting the task schedules, would be available to the project manager on any project. With the constraints, the Project Engineer is not able to adjust the project task schedules at all because they come from outside the field office, while the resource pool and resource assignments are partially limited by communications difficulties and perceptions.

The response to the constraints has been a variety of levels of personnel scheduling, developed in an attempt to focus on projects while adjusting personnel. Four basic scheduling level categories have been identified in the project offices: informal, `to do' lists, bar charts and networks, with variations on each. Some of the techniques used, while they eventually respond by putting people with projects over time, are missing elements or detail levels that cause them not to be true schedules. Other techniques are highly crafted examples of what can be done in spite of the constraints.

One of the findings, suspected but not assumed, was that planning is generally not considered a useful tool at the field office level of personnel scheduling. Planning, or long-term scheduling, in the construction field offices is characterized by detachment from operations, or short-term, scheduling

and by a focus isolated to fulfilling a departmental requirement. Frequently, the planning scheduling has been guesstimation, with little more than past experience to justify the guess.

From these investigations, a unified personnel scheduling management system has been outlined. This system would include the ability to do both planning and operations scheduling, interconnecting the two scheduling methods. Three approaches to further design and implement this system have been proposed, one manual and two computerized. All of the approaches utilize the steps to scheduling found in the conceptual exploration of the system, many of which are already in place in the construction field offices. Recommendations regarding each approach follow the conclusions.

CONCLUSIONS

Given the findings summarized above, the following conclusions are drawn:

(1) The constraints that are operating will continue to restrict any personnel scheduling management system in the construction field offices.

(2) The system proposed here in conceptual form is expected, when implemented, to improve personnel scheduling management and decisions by standardizing and, in some cases, automating procedures, thus alleviating some of the stresses associated with reactive management.

(3) The three approaches fulfill the system objectives to varying degrees. The manual system can be implemented without requiring extra help, but, because of time constraints, is severely limited in its ability to be easy to use, to minimize reactive management and to effectively use personnel. The spreadsheet system minimizes the manual calculations required in scheduling and has less time constraints, but requires a greater set up time and more expertise for the designer. The network system requires little physical system development and offers the easiest updating methods, but the programs can be time consuming in learning applications especially because the reports from this system are conceptually different than the proposed approach.

RECOMMENDATIONS

The recommendations that follow are divided into two sections: those that can be implemented by the construction field office directly and those that are dependent on outside actions for implementation. The two sets of recommendations are intended to dovetail so that the best system design, implementation and use can result.

Inside the Construction Field Office

The first recommendation is that one or more construction field offices do a more detailed system design and test it by limited implementation. The manual approach, as noted above, is difficult to justify in terms of the time it would require and the objectives that would remain unfulfilled as a result. If a Project Engineer does desire to implement a manual system, the recommendation is that he explore one of the simpler versions described in Chapters 3 and 4, enhancing one of those systems with the concepts and details he needs from the proposed system. Many of the systems in place are adequate to do the personnel scheduling; with some additions, they will work in more situations and be strengthened.

For either of the computer based systems, the recommendation is that implementation be done in coordination with the technical support personnel available at DOT. The detailed design of the spreadsheet system requires people knowledgeable about the technical aspects of spreadsheet programming as well as field office people knowledgeable in their specific scheduling needs. The detailed network system's use requires technical knowledge of how to accommodate some of the features (and quirks) of Microsoft PROJECT or other programs to accomplish the field office requirements.

After the various system approaches have been designed and tested, full scale training and implementation can begin. The recommendation is that construction field office personnel experienced in the use of either or both systems work out formal training sessions that would teach both the concepts that are the basis of the system and offer hands-on experience in system implementation and use. A major objective of the training would be to increase the skills of all concerned in the art of scheduling personnel, including how to personalize the system used for specific

information needs. Depending on the system chosen by the field office, basic LOTUS 1-2-3 and/or Microsoft PROJECT training would be included.

Outside the Construction Field Office

Several recommendations to help the construction field office realize a personnel scheduling management system must be instituted outside the field office itself. The first recommendation is that a study be made of whether exclusive assignment of a micro to the Project Engineers for use in scheduling would be the best way to encourage implementation of either system. Several Project Engineers mentioned that the lack of an exclusive use computer caused them to do less scheduling of the type they wanted (for example, using Microsoft PROJECT).

The second recommendation is that steps be taken to alleviate some or all of the following problems related to the project cycle. Construction field office Project Engineers have mentioned that input directed to Design from the construction side much earlier in the design process would be important to their scheduling for the following reasons.

- Currently, when the PS&E arrives at the construction field office, little time remains before the ad date to review the project for constructability. Redesign at this stage has caused ad date changes and, consequently, considerably altered the office's personnel schedules.
- The engineers and technicians obtain valuable training, versatility and capability in helping to develop the project's design as well as inspecting the construction, offering both the field office and the Department more benefits in scheduling versatility.
- The construction field office would be able to offer the headquarters planning staff a more realistic projection of what personnel and equipment would be required for inspection at an earlier stage in the total project process because of the more accurate input into their own planning system. Therefore, from the district and headquarters level, procedures could be inaugurated that allow construction personnel to input their expertise earlier in the design process, including (but not limited to)
  - inviting construction inspectors with some experience to design team meetings when project scope and/or design is being discussed,

- inviting input from the tentatively assigned construction field office when alternatives have been chosen for constructability of the designs,
- inviting construction field office input into special designs for constructability and understandability of the plans.

The third recommendation is that training in CPMS, which has developed a way to estimate project time lines, be more widely available to the entire field office system. Plans have been made to this end already. Any required training might include helping the field offices understand the advantages and disadvantages of CPMS in relation to the proposed personnel scheduling management system. Further development of CPMS could include consideration of methods by which the construction field office can directly access the CPMS information at any time needed and enter it easily and automatically into its scheduling process.

The fourth recommendation is that headquarters and district management encourage and support the Project Engineers in their enforcement of the Standard Specifications and Special Provisions regarding contractors' schedules. As part of this enforcement, an exploration of how contractors' progress schedules could be altered to be more useful to the construction field office's personnel scheduling management needs to be done. Though the information on contractors' progress schedules can be acquired (albeit with greater difficulty) from other sources, the contractors' progress schedules are important for confirming the project inspector's scheduling guesses and giving a longer-range view of the project from the contractor's perspective.

The fifth recommendation concerns engineering costs and is less directly related to scheduling, though there is an impact to scheduling from them. Engineering costs are frequently overrun on certain types of projects, while other projects become catchalls for funding of non-project related activities. The inability to relate personnel schedules to realistic project costs can cause both scheduling and accounting difficulties that could be alleviated by the design of a different method of estimating these costs.

FUTURE SYSTEM ENHANCEMENTS

What has been described in this report are the essential features of the system. This does not mean that they are the only features that can be included; in fact, several Project Engineers during the interviews recommended that some of the following enhancements be part of the original system. At a later date, when initial installation and assessment of the system is complete, additional features such as these could be added.

Engineering Costs Enhancement

Engineering costs, which are directly related to field office inspection of a contract, have been mentioned frequently. The Department, because of the increasing demand for monetary accountability from the taxpayers, is pressuring the Project Engineers to keep these inspection costs down. Adding the ability to track project costs would be helpful, and would offer earlier warning of overruns. This enhancement would require additional work with the technical support staff.

Tracking Training and Skills Enhancement

A second enhancement would be the ability to track employee skills and training. Many Project Engineers need versatile crews, capable of inspecting any project. Project inspectors and their crews are required, therefore, to be skilled in more than one area of construction inspection. Training in many of the inspection skills would most likely occur on the job, with a skilled project inspector training another project inspector. The enhancement to the system would consist of listing the skills and training needs with the individual's name. Then, when a project is given its basic tasks, a match can be made that allows the Project Engineer to assign personnel with training in mind: a skilled project inspector may be scheduled to train another project inspector (if there are enough staff available) or may be assigned to a project alone (if staff is short).

Equipment Pool Enhancement

Another enhancement mentioned concerns the equipment pool. Each field office is assigned a certain number of inspection vehicles and other surveying and testing equipment. Each of these has upkeep needs, and some require special training before their use. The enhancement here would consist of adding the equipment, listed individually as resources. Tracking of the equipment would include the calculation of "next service due" as part of the total schedule, notation of equipment

assignment to particular staff members, skills required to use it and those personnel who have been trained to use it.

Weather Enhancement

At the beginning, it was assumed that weather related delays would be important to personnel scheduling and would require the incorporation of a way to estimate these delays. Tables 18 and 19 are not very accurate for estimating weather related delays in many regions of Washington. However, with the noted constraints and restrictions causing other problems, weather has become of minor significance. For the long range, after more pressing problems have been remedied, a weather enhancement could be explored.

As envisioned, this could take the form of a weather database developed from sources within the National Weather Service. The weather database would be able to provide system inputs in four forms, each to be used when appropriate:

- the average number of work days by month that work may be performed;
- the average number of calendar days (i.e., weekends included) by month that work may be performed;
- the average number of work days by month that bridge, concrete and other more weather-insensitive work may be performed; and
- the average number of calendar days by month that weather insensitive work may be performed.

The weather database would also divide the state into at least seven main regions (Olympic Peninsula, Puget Sound, Southwestern Washington, Northern and Southern Central Washington, Northeastern and Southeastern Washington), with subregions as necessary, to allow more accurate estimates of potential delays.

BIBLIOGRAPHY

I.A. WASHINGTON STATE DEPARTMENT OF TRANSPORTATION LITERATURE

Anderson, Donald R. and Gerald E. Goetz. "Engineering Resource Planning and Use in the State of Washington." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 68-77.

Bockstruck, Ron. "Keep Your Eyes on the Mark." All in One. October/November 1987, page 2.

Fiedler, Fred E. and Susan E. Murphy. "Investigation of Job Attitudes for Journey-Level Engineering Technicians and Transportation Engineers." Draft report for the Washington State Department of Transportation and Washington State Transportation Center, April 1987.

Intra-Departmental Communication. From A.D. Andreas, to District Administrators. Construction Project Engineer Study. March 10, 1986. Report attached: Report to the Secretary of Transportation on the Construction Project Engineer Study, January 1986.

Intra-Departmental Communication. From R. A. Mattila, to District 1 Design Engineers. Productivity Improvement Meeting. January 30, 1987. Attachments: 1. Productivity Actions List. 2. Commitments List.

Intra-Departmental Communication. From R. A. Mattila. "Strategic Management Plan (Draft)." October 28, 1987. Attachment: R. E. Bockstruck, A Strategic Management Plan for District 1, 1987-1989 Biennium.

Intra-Departmental Communication. From Robert C. Schuster, to V.W. Korf. Training. January 12, 1979.

Intra-Departmental Communication. From Tom McLain to District Administrators. Report of Program Managers' Meeting. June 2, 1987. Work Session Notes attached: Keeping Projects Within Scope and On Schedule.

Jones, Charles R. "Productivity Improvement: District 1 - Preliminary Engineering." May 14, 1987. Attachments with this include a series of IDCs from Ron Mattila dated January 6, 1987 through May 12, 1987. This series of IDCs culminated in this document by Jones and the Bockstruck document, "Strategic Management Plan."

Lund, Donald L. "Preconstruction Engineering Management in Washington: Manpower Management Information System." (abridgement) Transportation Research Record 742: Program Planning, Finance and Preconstruction Management. Commission on Sociotechnical Systems, Transportation Research Board, National Research Council, Washington DC, 1980, pages 34-36.

Shawcroft, Robert G. and Charles E. Barb. Critical Path Method Scheduling: Basic. Course notebook prepared for Washington State Department of Transportation. Seattle, Washington, 1986.

Vandehey, Del J., editor. Second Annual Statewide Project Engineer's Meeting. Proceedings, Washington State Department of Transportation, Union Washington, October 28-29, 1986.

Washington State Department of Highways. Manpower Management and Information System. Volume 1: Procedures. Volume 2: Planning Standards. No date. Manual Number M 11-01.

Washington State Department of Transportation and Association of Public Works (Washington State Chapter). 1984 Standard Specifications for Road, Bridge and Municipal Construction.

Washington State Department of Transportation, Management Services Division. Training Program Study. October 1985.

Washington State Department of Transportation. Construction Manual 1984. Olympia, 1984 edition, with revisions up through June 1987.

Washington State Department of Transportation. "CPMS Debut is Set to Go After Delays." Interchange. September, 1987, page 3.

Washington State Department of Transportation. "Managers Set Strategic Objectives." Interchange. September 1987, page 2.

Washington State Department of Transportation. 1987 Standard Specifications, Draft, Section 1-08, subject to revision, due in October 1987.

Washington State Department of Transportation. Project Engineer's PS&E Checklist. No date, internal checklist.

I.B. OTHER DEPARTMENTS OF TRANSPORTATION LITERATURE

Kutz, Scott A. "Programmed Project Management in Pennsylvania: Statewide Data Access." Transportation Research Record 826: Transportation Programming, User Benefit Analysis, and Vehicle Licensing. Transportation Research Board, Commission on Sociotechnical Systems, National Research Council, Washington DC, 1981, pages 1-4.

McLoughlin, William J. "Matrix Management in Transportation: New York State Experience." Transportation Research Record 742: Program Planning, Finance and Preconstruction Management. Commission on Sociotechnical Systems, Transportation Research Board, National Research Council, Washington DC, 1980, pages 11-14.

McManus, J. F., presenter. Automating California's Capital Delivery Program: ASCP/PYPSCAN - Unit 1. WASHTO Workshop on Management of Resources During Turbulent Times, Phoenix, Arizona, April 30, 1981.

McManus, James F. "California's Engineered Systems Approach to Project Delivery and Capital Resource Management." Transportation Research Record 867: Transportation Programming Process. Transportation Research Board, National Research Council, Washington DC, 1982, pages 33-43.

Michigan Department of Transportation. 1984 Standard Specifications for Construction. Section 1.02, 1.03, 1.08, pages 10-15, 52-59.

Michigan Department of Transportation. Michigan Plan on Staffing, Pay and Training. Paper presented to Transportation Research Board, January 1982, Washington DC.

Michigan Department of Transportation. Procedure Manual for the Construction Manpower Management System. Construction Division, February 1980.

Michigan Department of Transportation. Work Element Certification Procedures and Personnel Classification Plan for Transportation Construction Technicians. Construction Division, May 1981.

North Dakota State Highway Department. Construction Manpower Planning: Staffing and Standards. No date.

Tracy, Frank E. "Preconstruction Engineering Management in Virginia." (abridgement) Transportation Research Record 742: Program Planning, Finance and Preconstruction Management. Commission on Sociotechnical Systems, Transportation Research Board, National Research Council, Washington DC, 1980, pages 37-40.

Turner, O. D. "Management By Objective Program of the Florida Department of Transportation." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 60-67.

Wisconsin Department of Transportation. Construction Manual. Chapter 1 only. No date.

Wisconsin Department of Transportation. Optimum Construction Staffing Study - Staffing Criteria. Report attached: C. E. Aten, "Highway Construction Operations: Central and District Office Staffing Needs - Work Load Data", April 26, 1976.

Wisconsin Department of Transportation. Standard Specifications for Road and Bridge Construction. 1981.

II. PROJECT MANAGEMENT LITERATURE.

Ahuja, Hira N. Project Management: Techniques in Planning and Controlling Construction Projects. John Wiley and Sons, New York, 1984.

Bernard, Prosper M. "Information Systems for Project Management." Proceedings of the Canadian Computer Conference. Canadian Information Processing Society, Edmonton, Alberta, May 23-25, 1978, pages 154-157.

Gower, D. N. "Productivity in Project Management - Has it any Relevance?" M. C. Grool, Co Visser, Willem J. Vriethoff and Gert Wijnen, editors. Project Management in Progress: Tools and Strategies for the 90s. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1986, pages 45-48.

Graham, Robert. "The Role of Network Techniques in Team Building for Project Management." Burton V. Dean, editor. Studies in Management Science and Systems: Volume II: Project Management: Methods and Studies. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1985.

Gupta, Sushil and Larry R. Taube. "A State of the Art Survey on Project Management (1976-1983)." Burton V. Dean, editor. Studies in Management Science and Systems: Volume II: Project Management: Methods and Studies. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1985, pages 293-313.

Heightchew, Robert E., Jr. and William E. Baumgaertner. "A Manual Project Management System." Journal of Civil Engineering Design. Volume 1, Number 3, 1979, pages 207-229.

Kerzner, Harold. Project Management: A Systems Approach to Planning, Scheduling and Controlling. Second edition. Van Nostrand Reinhold Company, New York, 1984.

Kirby, Edward. "Project Management for a Change." Journal of Information Systems Management. Volume 1, Number 2, Spring 1984, pages 85-88.

Kliem, Ralph L. with Alexander Hamilton Institute. The Secrets of Successful Project Management. John Wiley and Sons, New York, 1986.

Kunz, John C., Thomas Bonura, Raymond E. Levitt and Marilyn J. Stelzner. "Contingent Analysis for Project Management Using Multiple Worlds." Paper presented to the First International Conference on Applications of Artificial Intelligence to Engineering Problems, Southampton, UK, April 1986.

Larson, Thomas D. "Innovations in Transportation Management." Transportation Quarterly. Volume XXXVIII, Number 3, July 1984.

Malcolm, D. G., J. H. Rosenboom, C. G. Clark, and W. Fazar. "Application of a Technique for Research and Development Program Management." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 2-13.

Martino, R. L. Project Management and Control. American Management Association, New York, 1964. Volume I: Finding the Critical Path. Volume II: Applied Operational Planning. Volume III: Allocating and Scheduling Resources.

National Cooperative Highway Research Program. Synthesis of Highway Practice 6: Principles of Project Scheduling and Monitoring. Highway Research Board, Division of Engineering, National Research Council, Washington DC, 1970.

Rosenau, Milton D., Jr. Project Management for Engineers. Lifetime Learning Publications, Belmont California, 1984.

Smith, Larry A. and Joan Mills. "Concurrent and Sequential Networks - Implications for Project Management." Engineering Management International. Volume 3, 1986, pages 279-282.

Stewart, J. M. "Making Project Management Work." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 197-211.

Wiest, Jerome D. and Ferdinand K. Levy. A Management Guide to PERT/CPM: With GERT/PDM/DCPM and Other Networks. Second edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1977.

III. CONSTRUCTION MANAGEMENT LITERATURE

"Let's Redefine Responsibility." Editorial. ENR (Engineering News-Record). Volume 219, Number 15, October 8, 1987, page 56.

"MDC Creates a Discipline for Construction Management." Engineering News-Record. Volume 191, Number 8, August 23, 1973, pages 17-20.

Caspe, Marc S. "Developing a Management Support System for Performing Design and/or Construction Management Services." Project Management Quarterly. Volume VIII, Number 4, December 1977, pages 41-51.

Copas, Thomas L. and Herbert A. Pennock, principal investigators. Synthesis of Highway Practice 51: Construction Contract Staffing. National Cooperative Highway Research Program, Transportation Research Council, National Research Council, Washington DC, 1978.

Creighton, Roger. Synthesis of Highway Practice 95: Statewide Transportation Planning. National Cooperative Highway Research Program, Transportation Research Board, National Research Council, 1982.

Forbes, C. E. and Robert R. Womack. "A New Direction for the Highway Program." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 1-16.

Froemming, A. P. and S. J. Fenves. "Data Structures for a Construction Company Management System." Highway Research Record 278: Highway Equipment Studies, Construction Management, Noise and Air Pollution Bibliography. Highway Research Board, Division of Engineering, National Research Council, Washington DC, 1969, pages 22-34.

Fryer, Barry. The Practice of Construction Management. Collins Professional and Technical Books, London, 1985.

Gabriel, Eric and E. G. Trimble. "Construction Planning by Participation." M. C. Grool, Co Visser, Willem J. Vriethoff and Gert Wijnen, editors. Project Management in Progress: Tools and Strategies for the 90s. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1986, pages 99-105.

Goff, K. A. and H. W. Meier. "Construction Management for the Next Decade - A Need for Project Organization and Training." Cost Engineering Magazine. Volume 22, Number 2, March/April 1980, pages 83-91.

Hoffeditz, Don C. and Neal X. Jones. "Systems Approach to Increasing Preconstruction Engineering Productivity." Transportation Research Record 742: Program Planning, Finance and Preconstruction Management. Commission on Sociotechnical Systems, Transportation Research Board, National Research Council, Washington DC, 1980, pages 28-33.

Institute of Mechanical Engineers. Proceedings of the Discussion on Critical Path Analysis Planning Techniques for Engineering Management. Institute of Mechanical Engineers, London, April 23, 1963.

Kleever, James. "Recognize Claim Situations to Preserve Rights." Pacific Builder and Engineer. Volume 93, Number 18, September 21, 1987, page 13.

Kosiba, Richard J. "Syntonic Management Approaches in Large Engineering Operations." Journal of Management in Engineering. Volume 3, Number 2, April 1987, pages 138-149.

Levy, Sidney M. Project Management in Construction. McGraw-Hill Book Company, New York, 1987.

Mundt, Barry M. "Multiproject Scheduling for Transportation Construction Programs." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 17-24.

Newman, Robert B. and Fred D. Hejl. Development of a Construction Engineering Manpower Management: System Design Manual. Prepared by Roy Jorgensen Associates, Inc., for U.S. Department of Transportation/Federal Highway Administration and other sponsoring state agencies. Maryland, April 1978.

Noel, Errol C. "Information Systems in Highway Construction: the State of the Art." Transportation Research Record 745: Computer Aids and Statistics in Quality Assurance. Commission on Sociotechnical Systems, Transportation Research Board, National Research Council, Washington DC, 1980, pages 28-32.

Public Technology Inc., preparers. Transportation Construction Management. Secretariat to the Urban Consortium for Technology Initiatives, supported by U.S. Department of Transportation, Washington DC, September 1980.

Sajani, Jarir S. "Systems Analysis: Implications for Construction Management." American Association of Cost Engineers. 1972 Transactions of the American Association of Cost Engineers. 16th National Meeting, June 24, 1972, pages 156-163.

Schaffer, Robert J. "Manpower Planning - Make a Moral Contract." David C. Johnston, editor. Planning Engineering and Construction Projects. Proceedings of a symposium sponsored by the Engineering Management Division of the American Society of Civil Engineers in conjunction with the American Society of Civil Engineers convention in Seattle, Washington, April 8, 1986, pages 15-18.

Schuster, Robert C. "Manpower Planning for Construction Administration." David C. Johnston, editor. Planning Engineering and Construction Projects. Proceedings of a symposium sponsored by the Engineering Management Division of the American Society of Civil Engineers in conjunction with the American Society of Civil Engineers convention in Seattle, Washington, April 8, 1986, pages 19-24.

Wright, Jeff R., Steven C. Egly and Hugh W. Gallivan. "A Multi-objective Model for Seasonal Personnel Reassignment." Civil Engineering Systems. Volume 3, Number 1, March 1986, pages 16-21.

IV. GENERAL SCHEDULING LITERATURE

Bryan, Shawn. "A Plan For All Reasons." PC Products. Volume II, Number 1, January 1985, pages 41-58.

Dar-el, E. M. A. Behmoaram and Y. Tur. "SCREAM - Scarce Resource Allocation to Multi-Projects." John R. Adams and Nicki S. Kirchof, editors. A Decade of Project Management: Selected Readings from the Project Management Quarterly, 1970 through 1980. Project Management Institute, 1981, pages 225-232.

Davis, Edward W. "CPM Use in Top 400 Construction Firms." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 94-99.

Davis, Edward W. "Networks: Resource Allocation." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 117-127.

Harris, Robert B. Precedence and Arrow Networking Techniques for Construction. John Wiley and Sons, New York, 1978.

Iannone, Anthony L. and Andrew M. Civitello, Jr. Construction Scheduling Simplified. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1985.

Kelley, James E., Jr. and Morgan R. Walker. "Critical Path Planning and Scheduling." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 14-27.

Oien, Eric S. and Douglas L. Jonas. "CPM-Based System for Scheduling and Allocating Resources to Project Design." Transportation Research Record 480: Allocating and Managing Manpower Resources. Transportation Research Board, National Research Council, Washington DC, 1974, pages 1-11.

Patrascu, Anghel. "How We Streamlined Our CPM." American Association of Cost Engineers. 1972 Transactions of the American Association of Cost Engineers. 16th National Meeting, June 24, 1972, pages 12-17.

Schimpeler, Charles C., Joseph C Corradino, John J. Davis, V. Ed Unger and Robert W. Stout. "Optimum Staging of Projects in a Highway Plan." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 25-34.

Talbot, F. Brian and James H. Patterson. "Optimal Methods for Scheduling Projects Under Resource Constraints." John R. Adams and Nicki S. Kirchof, editors. A Decade of Project Management: Selected Readings from the Project Management Quarterly, 1970 through 1980. Project Management Institute, 1981, pages 225-232.

Thomas, H. Randolf, Jr., John R. Jones, Jr., Jack H. Willenbrock, Weston T. Hester and Paul A. Logan. Analysis of Time and Schedule Performance on Selected Highway Projects. Federal Highway Administration, July 1985.

Thomas, H. Randolf, Jr., John R. Jones, Jr., Jack H. Willenbrock, Weston T. Hester and Paul A. Logan. Highway Construction Contract Claims: Causes and Resolution Practices. Federal Highway Administration, July 1985.

Van Hessen, Thomas. "A Combination of Network and Resource Planning: Difficult, Unpractical or Both?" M. C. Grool, Co Visser, Willem J. Vriethoff and Gert Wijnen, editors. Project Management in Progress: Tools and Strategies for the 90s. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1986, pages 255-264.

Wiest, Jerome D. "A Heuristic Model for Scheduling Large Projects with Limited Resources." Edward W. Davis, editor. Project Management: Techniques, Applications and Managerial Issues. American Institute of Industrial Engineers, Norcross, Georgia, 1976, pages 128-137.

V. PERSONNEL MANAGEMENT LITERATURE

Alpander, Guvenc G. Human Resources Management Planning. American Management Associations, New York, 1982.

Babcock, Daniel L., editor. American Society for Engineering Management: Engineering Management Through People. proceedings of the Third Annual Meeting, October 17-19, 1982. American Society for Engineering Management, 1982.

Burack, Elmer H. and Robert D. Smith. Personnel Management: A Human Resource System Approach. John Wiley and Sons, New York, 1982. Especially chapters 14 and 16, pages 436-461 and 510-540.

Cascio, Wane F. and Elias M. Awad. Human Resources Management: An Information Systems Approach. Reston Publishing Company (Prentice-Hall), Reston, Virginia, 1981. Especially chapters 3 and 4, pages 40-93.

DeMaagd, Gerald R. "Management Information Systems - The Psychology of Project Organization." Management Accounting. Volume 65, Number 3, September 1983, pages 10, 71.

Eno, Eric J. "The Administrative Generalist and MIS." Public Administration Review. Volume 39, Number 5, September/October 1979, pages 485-488.

Haire, Mason. "Managing Management Manpower." Elmer H. Burack and James W. Walker. Manpower Planning and Programming. Allyn and Bacon, Inc., Boston, 1972, pages 122-130.

Lee, Sang M. and Cary D. Thorp, Jr. Personnel Management: A Computer-Based System. Petrocelli Books, Inc., New York, 1978.

Martino, R. L. PMS - Personnel Management System. MDI Publications, Wayne, Pennsylvania, 1969.

McGraw-Hill. Case of the Missing Person. Video.

McNamara, R. T. "Identifying and Solving Corporate Manpower Problems." Elmer H. Burack and James W. Walker. Manpower Planning and Programming. Allyn and Bacon, Inc., Boston, 1972, pages 160-174.

Meister, D., D. J. Sullivan and W. G. Askren. The Impact of Manpower Requirements and Personnel Resources Data on System Design. Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio.

Poirot, James W. "Current Trends in Engineering Training for Management in the United States." Journal of Management in Engineering. Volume 3, Number 2, April 1987, pages 127-132.

Verheyen, Leland G. "The Employee Development System." Transportation Research Record 480: Allocating and Managing Manpower Resources. Transportation Research Board,National Research Council, Washington DC, 1974, pages 31-41.

Walker, James W. "Problems in Managing Manpower Change." Elmer H. Burack and James W. Walker. Manpower Planning and Programming. Allyn and Bacon, Inc., Boston, 1972, pages 76-85.

White, Kathy B. "A Diverse, Balanced Team Approach Generates Vital Management Strategy." Data Management. Volume 22, Number 9, September 1984, pages 34-36.

Wilcox, John L. "Management Renaissance." Transportation Research Record 480: Allocating and Managing Manpower Resources. Transportation Research Board,National Research Council, Washington DC, 1974, pages 25-30.

VI. COMPUTER PROGRAMS LITERATURE (ALL TYPES OF COMPUTERS)

"Choosing Software: The most Critical Computer Problem." Better Roads Magazine. Volume 57, Number 3, March 1987, pages 26-35.

"How the Project Managers Rate." Business Software. Volume 3, Number 7, July 1985, pages 44-45.

"Manufacturing Resource Planning: MRPII - Managing Company Resources." Small Business Report. August 1985, pages 37-40.

"Project Panning Programs Put to the Test." Business Software. Volume 3, Number 3, March 1985, pages 21-23.

"Return of the Project Managers." Business Software. Volume 3, Number 7, July 1985, pages 30-31.

"They Considered Mainframes: But ETA SYstems Uses PCs for Project Management." Software News. VOlume 6, Number 8, August 1986, page 46.

"Which Scheduler for You?" Business Software. Volume 3, Number 3, March 1985, page 53.

Adams, Russ. "Project Planning Solves Three Problems." Business Software. Volume 3, Number 3, March 1985, pages 26-28.

Alter, Steven and Michael Ginzberg. "Managing Uncertainty in MIS Implementation." Sloan Management Review. Volume 20, Number 1, Fall 1978, pages 23-31.

Baras, Edward M. The Osborne McGraw-Hill Guide to Using LOTUS 1-2-3. Second edition. Osborne McGraw-Hill, Berkeley, California, 1986.

Berry, Timothy. "Pursuing the Well-Managed Project" Business Software. Volume 3, Number 1, January 1985, pages 26-27.

Box, George. "Engineering Management and Administration of Documents." Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 52-56.

Deitzler, Richard P. "A Computer-Aided Management Tool to Aid Resource Allocation by the Job Shop Manager." Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 11-14.

Dries, William C. "Comparison of Computer Programs for Network Management." M. C. Grool, Co Visser, Willem J. Vriethoff and Gert Wijnen, editors. Project Management in Progress: Tools and Strategies for the 90s. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1986, pages 291-297.

Edwards, Ken. "Project Management with the PC." PC Magazine. In three parts: October 30, 1984, pages 109-156; November 13, 1984, pages 211-268; December 11, 1984, pages 193-277.

Foshay, Laird. "Straightforward Scheduler With No Flair." Business Software. Volume 3, Number 3, March 1985, pages 42-44.

Frantz, William E. "Project Management in Wisconsin." W. Tracy Lenocker, editor. Computing in Civil Engineering: Proceedings of the Fourth Conference. American Society of Civil Engineers, New York, 1986, pages 424-437.

Goldstein, Larry Joel. IBM-PC: An Introduction to the Operating System, BASIC Programming, and Applications (College Edition). Prentice-Hall Press, New York, 1986.

Hayes-Roth, Frederick. "Knowledge-Based Expert Systems." Computer. October 1984, pages 263-273.

Highway Research Board. Special Report 128: Automation Systems for Highway Organizations. Proceedings of the Western Summer Meeting Sponsored by the Highway Research Board and co-sponsored by the Texas Highway Department and the College of Engineering, University of Texas at Austin, August 16-18, 1971, Austin Texas. National Research Council.

Hogan, Thom. "A Capable, Easy-to-Learn Schedule." Business Software. Volume 3, Number 3, March 1985, pages 30-33.

Hogan, Thom. "Super SuperProject." Business Software. Volume 3, Number 3, March 1985, pages 49-52.

Kroep, Leon H. "Comparing Resource Scheduling in Project Management Packages." M. C. Grool, Co Visser, Willem J. Vriethoff and Gert Wijnen, editors. Project Management in Progress: Tools and Strategies for the 90s. North-Holland-Elsevier Science Publishers BV, New York/Amsterdam, 1986, pages 279-289.

LeBlond, Geoffrey and Douglas Ford Cobb. Using 1-2-3. Second edition. Revised for Release 2 by Thomas W. Carlton. Que Corporation, Indianapolis, Indiana, 1986.

Mak, King K. and Paul S. Jones. "Priority Analysis Procedure for Ranking Highway Improvement Projects." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 35-48.

Markevicius, V. and Nagui M. Rouphail. "An Interactive Model for Project Planning and Scheduling." W. Tracy Lenocker, editor. Computing in Civil Engineering: Proceedings of the Fourth Conference. American Society of Civil Engineers, New York, 1986, pages 913-926.

Morrison, Edward J. Developing Computer-Based Employee Information Systems. American Management Association, Research Study 99. 1969.

Noah, Lisa. "LOTUS-Like Program Provides Painless Project Scheduling." Business Software. Volume 3, Number 3, March 1985, pages 34-37.

Oppenheimer, Henry N. "Managing Information and People: The Engineering Manager in the Computer Age." Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 95-99.

Poor, Alfred and Bruce Brown. "Project Management Software: The Best Sellers." PC Magazine. Volume 5, Number 3, February 11, 1986, pages 155-164.

Raidma, J. K. "Project Management - The Computer as a tool for Managing a Major Construction or Repair Project." American Society of Mechanical Engineers. No date.

Samaras, Thomas T. and Kim Yensuang. Computerized Project Management Techniques for Manufacturing and Construction Industries. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1979.

Satpute, Sharad N. "Optimal Manpower Allocation Using Computer-Aided Linear Programming Techniques." Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 38-41.

Sheldon, Thomas. Introducing PC-DOS and MS-DOS: A Guide for Beginning and Advanced Techniques. McGraw-Hill Book Company, New York, 1985.

Spencer, Cheryl. "An Alternative Approach: Simple, Fun and Competent." Business Software. Volume 3, Number 7, July 1985, pages 32-35.

Spencer, Cheryl. "For Serious Project Managers Only." Business Software. Volume 3, Number 7, July 1985, pages 36-39.

Spencer, Cheryl. "The Simple Approach Works!" Business Software. Volume 3, Number 3, March 1985, pages 46-48.

Spencer, Cheryl. "Where, Oh Where Did the Data Go?" Business Software. Volume 3, Number 3, March 1985, pages 39-41.

Stang, David J. "GCN Focus Report: A Guide to Project Management Software." Government Computer News. March 27, 1987, pages 73-79.

Tarlson, Nick and Chris Yalonis. "Convenience or Functionality? Hard Choices for PM Users." Software News. Volume 6, Number 8, August 1986, pages 39-49.

Thamhain, Hans J. "Skills Requirements of Engineering Program Managers." Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 100-104.

Wylie, Connie. "Beware the Thundering Herd: More Than 400 Software Products on the Market." Computing Canada. January, 1986, page 7.

Zadeh, Lofti A. "Making Computers Think Like People." IEEE Spectrum. August 1984, pages 26-32.

Zagursky, George P. "Management Information System: An Engineer's Friend or Foe?" Engineering Management in the Computer Age. Joint Engineering Management Conference, Denver Colorado, October 16-18, 1978, pages 165-168.

Zuckerman, Maria, Anne Dyrud and John Posner. The LOTUS Guide to 1-2-3 Advanced Macro Commands: Programming Techniques. LOTUS Books, Addison-Wesley Publishing Company, Reading, Massachusetts, 1986.

VII. INFORMATION SYSTEMS LITERATURE

Clark, William G. "Management Systems - The Client's Organization." 1979 Transactions of the American Association of Cost Engineers, Cincinnati, Ohio.

Fuller, Jack A. and Daryl Fortin. "Management Information Systems: A Vehicle for Operations Management." International Journal of Operations and Product Management. Volume 5, Number 2, 1985, pages 58-62.

Gobeli, D. H. and E. W. Larson. "Matrix management: More than a Fad." Engineering Management International. Volume 4, Number 1, October 1986, pages 71-76.

Harmon, Paul and David King. Expert Systems: Artificial Intelligence in Business. John Wiley and Sons, New York, 1985.

Hayes-Roth, Frederick, Donald A. Waterman and Douglas B. Lenat. Building Expert Systems. Addison-Wesley Publishing Company, Reading Massachusetts, 1983.

Kibler, Bruce E. "The Perfect Plan." Cost Engineering: The Journal of Cost Estimating, Cost Control and Project Management. American Association of Cost Engineers, Volume 27, Number 7, July 1985, pages 8-13.

Kutz, Scott A. and Warren W. Zeiss. "Improved Highway Program Management Through Use of Integrated Information Systems." Transportation Research Record 867: Transportation Programming Process. Transportation Research Board, National Research Council, Washington DC, 1982, pages 1-6.

Lawson, James W. "A Quick Look at Matrix Organization from the Perspective of the Practicing Manager." Engineering Management International. Volume 4, Number 1, October 1986, pages 61-70.

Miller, N. Craig and Charles C. Barrett, Jr. "Management Information System Implementation Theory and Practice." Transportation Research Record 480: Allocating and Managing Manpower Resources. Transportation Research Board,National Research Council, Washington DC, 1974, pages 12-24.

VIII. OTHER LITERATURE

Goshen, Charles E. "(Mis)Management of Communications." Engineering Management International. Volume 3, Number 2, February 1985, pages 139-145.

Hirten, John E. "Managing Capital Projects." Transportation Quarterly. Volume 38, Number 3, July 1984.

National Cooperative Highway Research Program. Synthesis of Highway Practice 47: Effect of Weather on Highway Construction. Sponsored by American Association of State Highway and Transportation Officials in cooperation with Federal Highway Administration. Transportation Research Board, National Research Council, Washington DC, 1978.

Peters, Thomas J. and Robert H. Waterman, Jr. In Search of Excellence: Lessons From America's Best Run Companies. Warner Books, New York, 1984.

Pigman, J. G., K. R. Agent, J. G. Mayes and C. V. Zegeer. "Optimal Highway Safety Improvement Investments by Dynamic Programming." Transportation Research Record 585: Transportation Programming and Management. Transportation Research Board, National Research Council, Washington DC, 1976, pages 49-59.

The Effect Of Temperature on Productivity: Test Report. National Electrical Contractors Association, Washington DC, 1974.

Wolf, Carl. "Behavioral Aspects of Cost Engineering." in American Association of Cost Engineers. 1972 Transactions of the American Association of Cost Engineers. 16th National Meeting, June 24, 1972, pages 199-202.

APPENDIX A

QUESTIONNAIRE

TRAC

WASHINGTON STATE **TRA**NSPORTATION **C**ENTER

June 5, 1987

Dear :

The Washington State Department of Transportation (WSDOT), in cooperation with the Washington State Transportation Center (TRAC) and the University of Washington (UW), currently is conducting research into project scheduling for WSDOT construction field office personnel. The aim of the research is to help project engineers in construction field offices schedule their workloads so that they can effectively use their personnel. Funding for this research is through a grant from WSDOT and the WSDOT fellowship program. The chief investigator is a WSDOT employee and UW graduate student in civil engineering.

The enclosed questionnaire has been developed to understand more clearly the current workload scheduling procedures of construction field offices. After the questionnaires are returned, between one quarter and one half of the project engineers across Washington State will be requested to participate in in-depth interviews to explore more completely these procedures. Anonymity is assured in any published or presented forms of the research, though your name, address and telephone number are necessary for potential followup. Calls to set up interviews will be made two or three days after the questionnaires are returned.

Please fill out the questionnaire and return it in the enclosed envelope by June 12, 1987. Your help and cooperation are very much appreciated. If you have any questions or comments, please call the investigator, Meg Blau, at (206) 527-2013.

Sincerely,

Margaret E. Blau (Meg)
Project Manager

MEB:rdp

Enclosure

121 More Hall, FX-10, University of Washington, Seattle, Washington 98195, Telephone (206) 543-8690

University of Washington | Washington State University | Washington State Department of Transportation

QUESTIONNAIRE

The objective of this questionnaire is to determine what workload scheduling is being done for the construction office staff at the field office level. The purpose of the research is to design ways to assist PEs in handling workload scheduling needs and problems so that your construction staff is used effectively. Your help in this effort is appreciated. Please take the hour or so needed to fill out this form and return it in the envelope provided by June 12, 1987.

1. General Information

The following is requested for follow up purposes only. Anonymity is assured, both for published and presented forms of the results.

Project engineer's name _____

Field office address _____

_____

_____

_____

Field office telephone - SCAN _____

non-SCAN _____

Who filled this form out:

Name: _____

Position: _____

Type of Office (check one):

_____ Design only

_____ Construction only

_____ Design and Construction combined (please estimate split below)

_____ % Design

_____ % Construction

Field office data:

Size of staff at this time:

Max. staff size during construction season _____

Max. staff size during non-construction season _____

Average number of construction projects in field office _____

Avg. no. of design projects in field office (if applicable) _____

Current number of construction projects at the following size levels:

Project Size	Jobs Complete Final Records Still Open	Active Projects	Scheduled For Work This Season
Under $50,000			
$50,000 to $100,000			
$100,000 to $500,000			
$500,000 to $1 million			
$1 million to $5 million			
Over $5 million			

II. Planning

The questions in this section are designed to find out if you do any advanced planning of workload for your construction staff. Advanced planning is considered, in this context, as planning done for staff and projects prior to actual project award dates. Please read through the questions and answer all that apply. If you have any comments that you want to make on any particular question, feel free to use the additional space under the question or the back of the sheet.

1. Do you attempt to plan your manpower schedule for your project office personnel for the coming year (or biennium) by making personnel assignments to projects?

_____ Yes (answer A and B below) _____ No (skip to question 10)

A. If you do this, why? Check all that apply.

_____ To determine adequacy of available personnel
_____ To determine adequacy of available equipment
_____ To determine project costs
_____ To make assignments of personnel to projects
_____ To determine when the project should begin
_____ Other (describe:

B. What determines which projects have manpower planning done for them? Check all that apply.

_____ Done for all projects
_____ Complexity of the project
_____ Duration of the project
_____ Dollar value of the project
_____ Project geographic location with respect to the office
_____ The requirement of specialized knowledge
_____ The requirement of specialized equipment
_____ Project funding
_____ Other (describe:

2. At what level of detail are the personnel assignments made? Check one.

_____ Number of employees needed by job classification
_____ Employees assigned to project by individual names
_____ Both (describe under what circumstances each is used:

3. When making assignments to a project, what level of project detail is typically considered? Check one.

_____ Project as a whole only
_____ Gross schedule of tasks that comprise the project (e.g., project described by major tasks only and/or tasks with duration in months)
_____ Detailed project task level (e.g., project described by specific tasks and/or tasks with durations in weeks)
_____ Other (describe:

4. What written products are generated from this process? Check all that apply.

_____ No written products are generated
_____ List of projects with all personnel assigned to each
_____ List of projects with key personnel assigned to each
_____ List of project tasks with all personnel assignments
_____ Schedule of personnel workloads by time periods (e.g., specific months, weeks and/or days, etc.)
Describe:

_____ Other (describe:

5. Outline the steps that you take to do this advance workload scheduling process. Note any project schedules, diagrams, computer software and other information used in the process. (Include examples of any lists or schedules produced.)

6. Who within the office is typically involved in the assignment of personnel to projects? Check all that apply.

_____ Project engineer (TE-5)
_____ Assistant project engineer (TE-4)
_____ Office engineer (TE-3)
_____ Construction engineer (TE-3)
_____ Others (list title with classification:

7. The following lists potential problems in longer range planning which could be encountered or which could limit the planning effectiveness. Use the following scale to indicate each problem's importance. Also indicate how often these problems might occur in manpower planning:

   1 -- unimportant (is not a problem)
   2 -- somewhat unimportant
   3 -- important
   4 -- very important
   5 -- extremely important (is a major problem)

Scale	Frequency	Potential Problem
_____	_____	Lack of detailed project schedules
_____	_____	Lack of adequate personnel information
_____	_____	Lack of adequate equipment information
_____	_____	Uncertainty of project start dates
_____	_____	Uncertainty in when project activities will actually occur (e.g., due to weather, changes, etc.)
_____	_____	Lack of time of analyze task level assignments
_____	_____	Lack of time to make project level assignments
_____	_____	Lack of procedures or methods to do workload scheduling

Others (describe and indicate importance:

_____	_____	_____
_____	_____	_____
_____	_____	_____

8. Do you update your manpower plan, either prior to or during construction season?

   _____ Yes _____ No

   If yes, describe:
   -- how you update it
   -- what the update is used for
   -- if it turns out to be useful in some way

9. Do you do anything else with advanced scheduling that has not already been covered? Please describe fairly specifically what you do.

SKIP TO OPERATIONS SECTION, PAGE 6

10. For each of the following, indicate its importance as a reason for <u>not</u> doing advanced scheduling of personnel. Use the following scale:

1 -- unimportant (is not a reason)
2 -- somewhat unimportant
3 -- important
4 -- very important
5 -- extremely important (is a major reason for not doing scheduling)

_____ No need to do it
_____ Advance scheduling too unreliable to be of use
_____ Lack of time
_____ The capability of doing it (e.g., software and/or methodology) is not available
_____ The information on projects is not available soon enough
_____ Lack of other necessary information (list:

Other (describe and indicate importance:

_____ _____

_____ _____

_____ _____

_____ _____

CONTINUE ON TO OPERATIONS SECTION, PAGE 6

III. Operations

The following questions relate to specific scheduling of staff members to projects which have been awarded and are in progress, or soon will be. Even if you believe that you balance staff with projects by intuition alone, please answer the questions. Your answers will help clarify the process a construction field office uses in scheduling. Note that, even if your office has a design section, the questions are related to the scheduling of personnel with construction projects.

1. At the beginning of the project, are specific personnel assigned to the project?

   _____ No specific assignments are made (skip to question 8)
   _____ Only key personnel assignments are made at the project beginning
   _____ All project personnel assignments are made at the project beginning
   _____ Other (describe:

2. Are personnel assignments made at the beginning of the project to specific activities within the project?

   _____ No, assignments are based only on projects as a whole
   _____ Yes, on some projects
   _____ Yes, on all projects

   If yes, what source of project activities is used? Check all that apply.

   _____ Contractor supplied
   _____ WSDOT supplied from design
   _____ Other (describe:

3. Are personnel schedules examined in relation to specific calendar days (or weeks) for the life of the project?

   _____ No, only to work days (answer A below)
   _____ Yes, on some projects (answer B and C below)
   _____ Yes, on all projects (answer B and C below)

   A. If no, do you ever try to relate work days to calendar days?

   _____ Yes _____ No

   If yes, describe how you tie them together.

   B. If yes, are schedules made using individuals or job classifications?

   _____ Individual names
   _____ Job classifications

C. If yes, what determines whether a schedule is made? Check all that apply.

_____ Done for all projects
_____ Complexity of the project
_____ Duration of the project
_____ Dollar value of the project
_____ Project geographic location with respect to the office
_____ The requirement of specialized knowledge
_____ The requirement of specialized equipment
_____ Project funding
_____ Other (describe:

4. Is a schedule generated showing all project assignments (workload) of individuals for each day (or week or month) of the construction season?

_____ Yes _____ No

If yes, what time period is used?

_____ Day _____ Week _____ Month

5. Outline the steps followed in making the assignments described in questions 1 through 4, above. Note any:
-- specific methods (whether manual or automated)
-- software packages (names and what has been done with them)
-- any software designed specifically for your office
-- other information used in the process as well as the products generated (include examples of any lists or schedules produced)

6. Who within the office is typically involved in the assignment of personnel to projects? Check all that apply.

_____ Project engineer (TE-5)
_____ Assistant project engineer (TE-4)
_____ Office engineer (TE-3)
_____ Construction engineer (TE-3)
_____ Others (list title with classification:

7. Are changes in the construction project schedules evaluated to determine the impacts on field office personnel workloads?

_____ No
_____ Yes, for some of the projects
_____ Yes for all of the projects

If yes, then
-- outline the procedures used,
-- how frequently workload evaluation is done (every day, every week, every two weeks, etc.),
-- what determined which project will be evaluated (duration, complexity, dollar value, etc.)

8. What steps do you take if demand for field office personnel exceeds that assigned to the project? Next to the steps listed, indicate the number of times each step would be taken in a typical construction season.

Number of Times	Possible Steps
_____	Assign office staff not normally assigned to the field
_____	Request more permanent staff positions
_____	Add temporary personnel
_____	Add overtime to workload
_____	Give inspectors responsibility for more projects
_____	Shift personnel from one project to another
_____	Transfer in help from other WSDOT offices
_____	Ask the contractors to adjust their schedules
_____	Change inspection methods to accommodate fewer people
_____	Change the assignments for better personnel balance

Others (describe:

_____ _____

_____ _____

9. When construction has slowed or stopped, what options for rescheduling do you make use of? Use the scale below to note how frequently you would use the options listed.

1 -- Never use this option
2 -- Seldom use this option
3 -- Usually use this option
4 -- Often use this option

_____ Use our office's design function (answer A below)
_____ For our office, construction goes on all the time; personnel are always working.
_____ The paperwork backlog from previous construction season(s) keep personnel busy in off and slow seasons.
_____ Personnel are temporarily placed in another office.
_____ Personnel are permanently placed in another office.
_____ Personnel are sent to training classes.
_____ Personnel are assigned odd jobs in the office.
_____ Other (describe:

A. Does the design function allow you to reschedule construction personnel in the off season fairly effectively? Check one.

_____ Yes, the construction staff fit into the design function reasonably well
_____ No, the non-construction season is too short for construction staff to fit into the design section
_____ No, the construction staff do not fit into the design section well; they have trouble adjusting
_____ No, the construction stoppages are almost always temporary, so there is no time to get the construction staff familiar with design projects

10

10. How long prior to actually needing to change your manpower schedules do you find out about changes in the work schedules? Use the following chart to indicate the number of times and how far in advance you would have prior knowledge of changes that would come up in a typical construction season.

Lead Time / Cause of Delays	At start of Project	One Month	Two Weeks	One Week	One Day
EXAMPLE:					
Weather	---	---	5	10	60
Weather					
Altered Work Methods (contr)					
Altered Work Methods (WSDOT)					
DOT Staff Not Avail					
Contractor No Show					
Changed Conditions					
Late Start on Project					
Late Start on Task					
Material Source Change					
WSDOT Budget Problems					
Environmental Delays					
Others:					

11. The following is a list of potential problems which could limit the even use of personnel over a typical calendar year. Use the following scale to indicate the relative importance of each as a problem or limit. Also indicate how often these occur over a typical calendar year.

1 -- unimportant (is not a problem or limit)
2 -- somewhat unimportant
3 -- important
4 -- very important
5 -- extremely important (is a major problem or limit)

Scale	Frequency	Potential Problem or Limit
_____	_____	Lack of procedures or methods to do workload scheduling
_____	_____	Lack of time to analyze task level assignments
_____	_____	Lack of detailed project schedule from WSDOT
_____	_____	Lack of detailed project schedule from contractor
_____	_____	Lack of reliable project schedule from contractor
_____	_____	Poor project design
_____	_____	Lack of updated project schedule from contractor
_____	_____	Lack of time to respond to schedule and/or personnel changes
_____	_____	Lack of procedures or methods to identify and respond to changes
_____	_____	Uncertainty of what secondary tasks could be done if primary ones cannot be done as scheduled
_____	_____	Uncertainty in when project activities will actually occur (e.g., due to weather, changes, early completion incentives, etc.)
_____	_____	Lack of adequate personnel information
_____	_____	Lack of interest of inspectors in projects
_____	_____	Lack of capability in field office staff to do work
_____	_____	Absenteeism of staff
_____	_____	Lack of team work in staff
_____	_____	Lack of adequate equipment information
_____	_____	Lack of alternatives for keeping personnel in house in off season
_____	_____	Lack of communications with outside WSDOT offices regarding personnel

Others (describe and indicate importance:

_____ _____ _____

_____ _____ _____

_____ _____ _____

12. Is there anything else about scheduling personnel with projects and updating schedules that you do or think about doing not already mentioned? Please describe fairly specifically what you do and your ideas.

NOTE:
If you answered question number 1 in this section (Section III, Operations) "NO", answer question 13. If you answered question 1 "YES", do not answer question 13.

13. For each of the following, indicate its importance as a reason for not assigning specific personnel to projects or project tasks. Use the following scale:

1 -- unimportant (is not a reason)
2 -- somewhat unimportant
3 -- important
4 -- very important
5 -- extremely important (is a major reason for not doing scheduling)

_____ No need to do it
_____ Contracts are too small to bother with this
_____ Assigning specific people to projects is too unreliable to be of use
_____ Lack of time
_____ The capability of doing it (e.g., software and/or methodology) is not available
_____ The information on projects is not available soon enough
_____ Contractor's schedule is not clear or accurate enough to enable me to do this
_____ Contractor does not update schedule, so that I cannot update my people
_____ Lack of other necessary information (list:

Other (describe and indicate importance:

_____ ----------
_____ ----------
_____ ----------
_____ ----------

END OF QUESTIONNAIRE

APPENDIX B

PROJECT ENGINEER INTERVIEWS -- GENERAL OUTLINE

APPENDIX B
PROJECT ENGINEER INTERVIEWS - GENERAL OUTLINE

I. Please show/tell me about the steps you take to do your personnel scheduling, both in planning for manpower needs and in operations for short-term scheduling.

- How do you deal with projects and assigning people to them?
- What kind of time span are you comfortable using?
- Do you monitor and update your schedules?
- How frequently do you update?

II. How do you estimate project durations?

- Do you take into account any project delays?

III. What kinds of solutions do you use to deal with the peaks and valleys of personnel use over a calendar year?

IV. What kinds of difficulties do you encounter in your present personnel scheduling technique?

- What are you doing to solve these problems?
- Do they have solutions?
- Would anything you don't have now help you?
- Do you know where to get it from?

V. Do you use your microcomputers to help you schedule?

- How, or why not?
- Would you like to?

VI. Do you have written examples of your scheduling method? May I have a copy?

VII. Is there any information you are not getting for scheduling now that you would like to have?

- Do you know where the information can be found?
- Do you have access to it?
- Do you use any information from MMIS (future CPMS)? Do you want to?

VIII. Are there any suggestions you have of things that you would like to see in a personnel scheduling system?

IX. How do you see current departmental procedures and policies?

- Have they affected you in any way?

X. Is there anything you can think of regarding personnel scheduling that we have not talked about?

APPENDIX C

OTHER STATES' PERSONNEL MANAGEMENT SYSTEMS

APPENDIX C
OTHER STATES' PERSONNEL MANAGEMENT SYSTEMS

INTRODUCTION

In Chapter 3, the method used to collect data from five other states was described. Briefly, the purposes behind the collection of the data were:

- to determine their existing personnel scheduling management practices;
- to identify problems and constraints within their systems;
- to discover if any of them had developed a construction field office level personnel scheduling management system; and
- to obtain suggestions any of them could make regarding personnel scheduling management that potentially could be applied to the Washington State Department of Transportation.

The five states chosen were Michigan, Louisiana, Ohio, North Dakota, and Wisconsin. Following are brief descriptions of each state's construction inspection and personnel scheduling techniques and an assessment of potential relevance to Washington.

Note that, of the five states interviewed, only Michigan is using computers to schedule personnel. Several states use temporary on-site field offices set up by contractors, which can create difficulties for computer set ups; other states do not have the funds or staff to incorporate the new technology. Though the FHWA (Federal Highway Administration) is encouraging the states to begin incorporating micros into their scheduling and engineering practices, this is not always considered feasible.

Michigan

The Michigan Department of Transportation is headquartered at Lansing and has nine districts. Much of the organization of Michigan Department of Transportation is similar to that of the Washington State Department of Transportation in that there are 53 permanent construction field

offices with similar staffing levels, classifications and procedures. In dealing with the peaks and valleys of work load, the methods are similar: adding temporary employees, lending and borrowing crew, reassigning project inspectors and other crew members to work in design offices with the regional design teams. The construction season is about April through November, with no contracts progressing in winter due to extreme cold and snow. Contractors' schedules control field office personnel use, and the construction field offices do all the required staking.

In the construction field office, the Project Engineer uses the let schedule and carry over projects to determine the required personnel needs for the office; these are submitted to the district, which then submits them to headquarters. Headquarters analyzes the estimate using its computer program, which is based on contract quantities, the let schedule and the civil service classification system, adjusting the Project Engineer's estimates. The result is estimated person-hours for each $1000 of construction.

Michigan is in the process of putting micros into the construction field offices in a system combining micro capabilities with mainframe programs intended to help the Project Engineer and his or her staff do personnel scheduling. The contractor, once the project is awarded, submits a brief schedule that lists procurement and critical dates (begin paving, open to traffic, completion). The Project Engineer develops an estimated construction CPM and enters it into the micro, uploading it eventually into the mainframe program. Daily construction reports are fed into the micros and uploaded to the mainframe as construction progresses. These daily reports, combined with the estimated CPM and critical dates, become the basis for contractor payments, project tracking and field office personnel use estimates.

The anticipated advantages of this system, which is not yet out of the pilot study stage, include

- less record keeping time and errors;
- automatic calculations of costs and quantities;
- an earlier awareness of overages and schedule lags;
- immediate access to information regarding project status for any project; and

- payment controls on the system that do not pay over 100 percent of the contract until any problems and overages are cleared up.

The major problem Michigan DOT encounters in scheduling is that the let schedule is unreliable. Of all the contracts let, approximately 25 percent slip. Headquarters, aware of this, tries to adjust for it, basing the budget and the hiring and placement of temporary employees on the estimated let schedule. Reasons for letting slippage are similar to WSDOT's: problems in design, right of way acquisition, switching funds from one project to another, political urgency.

Michigan's experience is somewhat relevant in the way it has connected its most general personnel scheduling levels to its most detailed levels through the newly developed computer systems. Headquarters maintains direct control over many personnel scheduling issues by having the field offices enter construction progress and field office personnel use data into the mainframe program directly. The Project Engineer's involvement in personnel scheduling is focused, then, mainly on operations scheduling within his or her field office using personally developed project CPMs as the basis for assignments.

Louisiana

The Louisiana Department of Transportation is headquartered at Baton Rouge and has nine districts. Headquarters administers the majority of the design functions, which are mainly let to private consultants. Each district has an administrator with four assistants, one each for maintenance, public works/design, accounting and construction.

In construction, 53 Project Engineers cover all nine districts. Under these Project Engineers are the project inspectors, who are certified in several areas of expertise (materials, testing, surveying, etc.). Construction is year-round. Louisiana's weather is usually rain from November to February or March. With little cold weather, everything except rain sensitive tasks are done, resulting in slowing rather than seasonal project shutdowns. Because of this, construction personnel do not go into design, nor do design personnel do construction inspection.

Contractors are responsible for all the construction surveying; project inspectors check the field books after each survey and do on-site checks if there are enough people available. To get the work done, the project inspectors will work overtime, and the Project Engineer will hire temporary employees as necessary.

The major constraint operating in Louisiana is that, as in Washington, the let schedule is infirm, with projects delayed due to a variety of problems, including right of way acquisition, utility relocation agreements negotiations, and consultants doing design. The latter frequently causes delays during design as well as creating plans that have errors not discovered until after construction begins.

In two areas, Louisiana may have techniques within its system that are relevant to Washington. First, Louisiana seems to have had little trouble with the contractors doing their own surveying. The contractor surveying may, in fact, help in the area of stakes loss. The WSDOT surveyors are constantly restaking areas where contractors have not been careful to preserve stakes; penalties invoked do not seem to have much effect. In Louisiana the contractor is responsible for maintaining the stakes.

Louisiana also has a variation on the use of comp time. Louisiana requires all overtime to be recorded as comp time. The accumulated comp time must be taken as leave within six months of earning it, and Project Engineers are actively involved in encouraging their crews to take that leave. Comp time is used primarily to schedule inspectors in off-peak times. While construction does not stop, there is still a winter slowdown. All inspectors with accumulated comp leave are encouraged to take the leave time. Inspection funding thus is spread more evenly over the year. Using leave within six months also gives the Project Engineer a time frame for personnel scheduling using leave.

Ohio

The Ohio Department of Transportation is headquartered at Columbus and has eight districts. Headquarters is responsible for various pre-construction approvals, letting contracts and approval of the contractors' schedules. Districts are responsible for design/location, surveying, testing and everything to do with direct construction inspection.

The responsibility for what happens during construction inspection in each district rests on the District Construction Engineer. Depending on the district, about four Project Engineers work under him or her (that is, a total of about 32 Project Engineers statewide), with eight to ten project inspectors under each Project Engineer. Ohio has no fixed field offices. Project Engineers and project inspectors live and are sent to projects anywhere in the district. Often, the project inspector is the only person on the project. Off-season assignments for project inspectors include final records, design and maintenance work.

The contractor is responsible for two areas: project surveying (except for setting monuments), and establishing an on-site field office for the project inspector. A centrally located project, or large or complex project is usually where the Project Engineer has his or her office. Project Engineers are responsible for all projects in their sections of the district, so must travel to all of them frequently; a centralized location is ideal for this.

Constraints on personnel scheduling include personnel system rules and practices, training and funding. For example, one personnel rule requires that travel distance in time over 20 miles away from where the project inspector lives is paid time. Therefore, the project inspector living closest to a project is assigned to it, which requires skillful personnel scheduling to minimize cost. Almost in opposition to this rule, a condition of employment is that any project inspector can be moved to any place in the state that needs a project inspector. Thus, the Project Engineers cannot be certain that the project inspectors for this season will be the same next season. Added to the chronic shortage of project inspectors in Ohio, these conditions alone cause personnel scheduling headaches.

In training, the constraint is that the Project Engineer is not free to hire as many temporary employees as might be required. Instead, Ohio trains maintenance personnel in construction inspection techniques and project inspectors in maintenance. This allows reciprocal reassignment of permanent employees that may be short on work during various season. However, this does not always fulfill the need for inspection personnel.

Funding is another constraint, though not in the expected fashion. Ohio frequently inspects projects in which the funds are matched by a municipality. The municipalities do not feel they should pay for charges on projects that are not actually being inspected in the field. Ohio's Department of Transportation is protective of its relationship with the municipalities, so the department absorbs much of the non-construction inspection costs (final records, office engineering, management, etc.). Instead, other projects are overcharged to cover these additional costs, causing overruns.

In general, the Ohio Department of Transportation is less well organized than Washington in terms of personnel scheduling management. However, in the area of training maintenance personnel in lieu of hiring temporary employees, Ohio may have a relevant idea. The ability to switch people between these two divisions may alleviate some training problems (less training needed for permanent employees year to year) and fill spots where crews are required quickly.

North Dakota

The North Dakota Department of Transportation is headquartered at Bismarck and has eight districts. Headquarters maintains a close relationship with construction inspection by setting inspection standards and assigning inspection personnel.

The process used to schedule construction inspection has several steps. First, headquarters sets up the main divisions (such as surveying) for the contracts. The number of crews required are set by the number of contracts both let that season and continuing from the previous season. Based on the contracts, headquarters assigns each district a number of hours that can be filled by temporary personnel.

Each district has a Project Coordinator with approximately twenty construction employees. Project inspectors, called project managers, are responsible for direct on-site project inspection and must be either state certified (non-licensed) or licensed engineers. Senior project managers are responsible for multiple and complex projects. Each project manager is assigned an inspection crew.

Construction staff are considered part of a statewide "pool." The project managers and their crews may be assigned to projects anywhere in the state by the District Construction Coordinator in

headquarters. Assignments are as close to the project manager's home as possible, and crews are kept together, when possible. For a project, first consideration is for the pool employees living within the district where the project is.

Project managers, their crews and equipment necessary are scheduled manually using the schedule sheet in Figure C-1. One sheet is completed for each district, then a master is completed for statewide totals. Let dates are also entered on this form. Scheduling is done up to three years in advance for budgeting and personnel projections, with exact crew assignments made after the form is completed.

Contractors are required to establish a field office on the construction site for the use of the project manager and his or her crew. The project manager assigns people to inspection tasks, hires any temporary personnel required, and makes certain that all the personnel are not overworked. Inspection has a peak season of about six weeks, where everyone is stretched thin. During a season, over two hundred temporary employees may be hired statewide, and survey crews are put together as needed rather than permanently assigned.

Contractors' schedules are submitted to the project manager, usually in the form of a bar chart delineating major tasks. The completion date controls priorities for both the project manager and the contractor; as is true in Washington, the timing of tasks depends on the other contracts held by the contractor. More complex projects have weekly progress meetings, and, as required, weekly progress reports distributed to all concerned parties, including area business people. Telephone communications report changes to all parties if progress schedules are unavailable.

Rainy weather in North Dakota can interfere with construction. If bad enough, the rain can cause early season shutdowns. Winter, which is harsh with low temperatures and snow, also closes down projects. These factors restrict the construction season greatly.

When projects are shut down, permanent employees are reassigned to design, bridge division, planning and final records. Weather permitting, preliminary construction surveying, design surveying, roadway crack surveys and bridge inventories are done off season by both permanent crews assigned to

P=PERMANENT EMPLOYEE
T=TEMPORARY EMPLOYEE
V=VEHICLE

DATE	PROJECT	LOCATION	TYPE	MILES	MAY			JUNE			JULY			AUG			SEPT			OCT		
					P	T	V	P	T	V	P	T	V	P	T	V	P	T	V	P	T	V

Figure C-1. Manual Schedule Sheet: North Dakota

this work and construction inspection crews. Maintenance people are called on to help meet peak inspection needs, and some inspection crew members staff the snow plows in winter.

Assignments, except for temporary employees, are handled by headquarters. This means that the District Project Coordinator and his or her staff do little planning. Input is asked of the project manager and Project Coordinator regarding personnel needed for particular projects. Operations (day to day) assignments are the project manager's responsibility.

This state does not have very much that recommends itself to Washington except for the manual personnel scheduling technique for planning. The form used for projecting needs is a simple bar chart that could be used by the Project Engineer for planning,m either in manual form or on LOTUS 1-2-3.

Wisconsin

The Wisconsin Department of Transportation is headquartered in Madison and has eight districts. Headquarters sets guidelines for everything connected with inspection (materials, surveying, etc.). Districts are autonomous, with construction staff assigned at district level. The total number of district construction staff is dependent on "program size, type of projects, size of projects, starting time and time span of projects, available staff, and their recent experiences with personnel allocation."[1] Specific assignments are made by considering the entire district a "pool" of employees.

Each district's hierarchy consists of the District Chief Construction Engineer with the Area Construction Supervisor for an assistant. The Area Construction Supervisor is responsible for all contracts let in the district and directs several Project Engineers in construction inspection. The Project Engineers ensure that the inspectors assigned to them properly oversee the contracts. In Wisconsin, construction inspection is separate from materials testing in that the materials inspectors work directly out of the district office on all projects in the district.

---

[1]Quotations are from a letter dated July 30, 1987, from David A. Jensen, Specifications Engineer. It was written in response to the telephone interview of a few days earlier.

Consultants are used to do construction management tasks, including inspection, surveying, testing and administration. This allows the state to hire only a minimum number of permanent staff. According to Mr. Jensen, private consultants have been retained to do construction management on 74 contracts let between 1982 and 1986. This represents about 4 percent of the total contracts per year. In 1987, this percentage rose to about 20 percent, and for fiscal 1988, this percentage is planned to be between 25 and 50 percent of the contracts let. The Area Construction Supervisor oversees the consultants' work and gives the consultant guidance to ensure the projects are constructed properly, just as is done for the departmental inspectors.

Contracts managed by state personnel must be furnished an on-site field office and materials laboratory by the contractor. The Project Engineer operates out of this temporary construction field office and is in charge of several proximate projects. His or her support personnel are assigned from the district "pool." The Project Engineer, with a chronic staff shortage, must schedule staff wisely.

Contractors are pre-qualified before being allowed to bid on a project. This helps ensure that contracts will not go into default or be delayed by a contractor's inability to perform the work. The pre-qualification rates each contractor by past performance and limits the maximum dollar amounts of contracts on which he or she can bid. The pre-qualification is renewed yearly.

Since the districts are autonomous, staff can be scheduled according to need. In large districts, there is a permanent design section; the smaller districts use the same people for both construction and design. Mr. Jensen writes:

> The "pool" concept in staffing construction projects has several variations among our districts. Some consider all designers available for field assignment, others rotate staff between field and office to gain experience, others designate full-time design staff. Most construction personnel in from the field are expected to (1) finish construction project paperwork (2) do assigned design tasks until the start of the next construction season (3) prepare in-office for their next construction assignment to the extent possible after letting and (4) participate in training.

Snow, ice and cold temperatures cause winter shutdowns between November 1 and April 15.

The legislature has a direct say in how many staff can be hired by allocating funds, approving projects and setting the number of temporary employees that may be hired. These temporary

employees can be hired for as long as 11 months and are frequently civil engineering students on summer break.

The relationship between private consultants and the state has been strained by the practice (until recently) of "raiding" the state inspectors for consultant construction superintendents. This has mainly been stopped by mutual consent.

Because of the chronic staff shortages, several staff reduction techniques have been instituted. All are accepted by the FHWA. These techniques include spot checking truck weights rather than checking all of the weights all the time; automatic plant operations for paving with pay weights recorded and printed electronically; paying the contractor by plan quantities, not on field surveying on smaller straightforward projects; and establishing expert "floating" crews that do only certain types of inspection either districtwide or statewide. These techniques have enabled Wisconsin DOT to keep staff needs to a minimum.

Wisconsin does not require the Project Engineer to be responsible for all the construction funds. The information for payment to both contractors and state staff is sent to headquarters via district offices, and headquarters attends to the payments. This removes some of the pressure from the construction field office for cost control, and allows the Project Engineer a little more scheduling freedom.