

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

120



**PROFESSIONAL RESOURCE
MANAGEMENT AND
FORECASTING**

TRANSPORTATION RESEARCH BOARD
National Research Council

TRANSPORTATION RESEARCH BOARD EXECUTIVE COMMITTEE 1985

Officers

Chairman

JOHN A. CLEMENTS, *President, Highway Users Federation for Safety and Mobility*

Vice Chairman

LESTER A. HOEL, *Hamilton Professor and Chairman, Department of Civil Engineering, University of Virginia*

Secretary

THOMAS B. DEEN, *Executive Director, Transportation Research Board*

Members

RAY A. BARNHART, *Federal Highway Administrator, U.S. Department of Transportation (ex officio)*

JOSEPH M. CLAPP, *Vice Chairman, Corporate Services, Roadway Express, Inc. (ex officio, Past Chairman, 1984)*

LAWRENCE D. DAHMS, *Executive Director, Metropolitan Transportation Commission, Berkeley, California (ex officio, Past Chairman, 1983)*

DONALD D. ENGEN, *Federal Aviation Administrator, U.S. Department of Transportation (ex officio)*

FRANCIS B. FRANCOIS, *Executive Director, American Association of State Highway and Transportation Officials (ex officio)*

WILLIAM J. HARRIS, JR., *Vice President for Research and Test Department, Association of American Railroads (ex officio)*

RALPH STANLEY, *Urban Mass Transportation Administrator, U.S. Department of Transportation (ex officio)*

DIANE STEED, *National Highway Safety Administrator, U.S. Department of Transportation (ex officio)*

ALAN A. ALTSHULER, *Dean, Graduate School of Public Administration, New York University*

DUANE BERENTSON, *Secretary, Washington State Department of Transportation*

JOHN R. BORCHERT, *Regents Professor, Department of Geography, University of Minnesota*

ROBERT D. BUGHER, *Executive Director, American Public Works Association, Chicago*

ERNEST E. DEAN, *Executive Director, Dallas/Fort Worth Airport*

MORTIMER L. DOWNEY, *Deputy Executive Director for Capital Programs, Metropolitan Transportation Authority, New York*

JACK R. GILSTRAP, *Executive Vice President, American Public Transit Association, Washington, D.C.*

MARK G. GOODE, *Engineer-Director, Texas State Department of Highways and Public Transportation*

WILLIAM K. HELLMAN, *Secretary, Maryland Department of Transportation*

LOWELL B. JACKSON, *Secretary, Wisconsin Department of Transportation*

JOHN B. KEMP, *Secretary, Kansas Department of Transportation*

ALAN F. KIEPPER, *General Manager, Metropolitan Transit Authority, Houston*

HAROLD C. KING, *Commissioner, Virginia Department of Highways and Transportation*

DARRELL V. MANNING, *Adjutant General, Idaho National Guard*

JAMES E. MARTIN, *President and Chief Operating Officer, Illinois Central Gulf Railroad*

FUJIO MATSUDA, *Executive Director, Research Corporation of the University of Hawaii*

JAMES K. MITCHELL, *Professor, Department of Civil Engineering, University of California, Berkeley*

H. CARL MUNSON, JR., *Vice President for Strategic Planning, The Boeing Commercial Airplane Company*

MILTON PIKARSKY, *Distinguished Professor of Civil Engineering, City College of New York*

WALTER W. SIMPSON, *Vice President-Engineering, Norfolk Southern Corporation*

LEO J. TROMBATORE, *Director, California Department of Transportation*

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Transportation Research Board Executive Committee Subcommittee for the NCHRP

JOHN A. CLEMENTS, *Highway Users Federation for Safety and Mobility (Chairman)*

RAY A. BARNHART, *Federal Highway Administration*

JOSEPH M. CLAPP, *Roadway Express, Inc.*

FRANCIS B. FRANCOIS, *Amer. Assoc. of State Hwy. & Transp. Officials*

LESTER A. HOEL, *University of Virginia*

THOMAS B. DEEN, *Transportation Research Board*

Field of Special Projects

Project Committee SP 20-5

RAY R. BIEGE, JR., *Consultant (Chairman)*

VERDI ADAM, *Louisiana Dept. of Transp. and Development*

ROBERT N. BOTHMAN, *Oregon Dept. of Transportation*

E. DEAN CARLSON, *Federal Highway Administration*

JACK FREIDENRICH, *New Jersey Dept. of Transportation*

DAVID GEDNEY, *De Leuw, Cather and Company*

SANFORD P. LAHUE, *American Concrete Pavement Association*

BRYANT MATHER, *USAE Waterways Experiment Station*

THOMAS H. MAY, *Pennsylvania Dept. of Transportation*

THEODORE F. MORF, *Consultant*

EDWARD A. MUELLER, *Morales and Shumer Engineers, Inc.*

ROBERT J. BETSOLD, *Federal Highway Administration (Liaison)*

K. B. JOHNS, *Transportation Research Board (Liaison)*

Program Staff

ROBERT J. REILLY, *Director, Cooperative Research Programs*

ROBERT E. SPICHER, *Deputy Director, Cooperative Research Programs*

LOUIS M. MacGREGOR, *Administrative Engineer*

IAN M. FRIEDLAND, *Projects Engineer*

CRAWFORD F. JENCKS, *Projects Engineer*

R. IAN KINGHAM, *Projects Engineer*

HARRY A. SMITH, *Projects Engineer*

HELEN MACK, *Editor*

TRB Staff for NCHRP Project 20-5

DAMIAN J. KULASH, *Assistant Director for Special Projects*

THOMAS L. COPAS, *Special Projects Engineer*

HERBERT A. PENNOCK, *Special Projects Engineer*

ANNE S. BRENNAN, *Editor*

EMMA LITTLEJOHN, *Secretary*

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

120

PROFESSIONAL RESOURCE MANAGEMENT AND FORECASTING

BEATRICE B. COLLINS
Southbury, Connecticut

Top Panel

RAYMOND J. COLANDUONI, *New Jersey State Department of Transportation*

KENNETH E. COOK, *Transportation Research Board*

PAUL CRAIG, *Illinois Department of Transportation*

WILLIAM W. MILLER, *Florida Department of Transportation*

ESTHER M. SWANKER, *Schenectady, New York*

THOMAS W. MYERS, *Federal Highway Administration (Liaison)*

RESEARCH SPONSORED BY THE AMERICAN
ASSOCIATION OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS IN COOPERATION
WITH THE FEDERAL HIGHWAY ADMINISTRATION

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C.

DECEMBER 1985

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an assurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

NCHRP SYNTHESIS 120

Project 20-5 FY 1983 (Topic 15-08)
ISSN 0547-5570
ISBN 0-309-04004-3
Library of Congress Catalog Card No. 85-51726

Price: \$6.80

Subject Areas
Administration

Mode
Highway Transportation

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the Federal Government. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

*By Staff
Transportation
Research Board*

This synthesis will be of interest to administrators, personnel managers, and others concerned with recruiting, promoting, training, and retaining engineers and other professional staff in highway agencies. Information is presented on planning for professional staff needs and on the elements of a professional resource program, including examples of practice in several states.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

Changes in highway programs and the likely retirement of many professionals in the near future mean that there is a need to carefully manage the professional staff resources of a highway agency. This report of the Transportation Research Board gives information on how highway agencies can plan for professional staff needs, including use of a professional resource management program that enables management to ensure that the right numbers and kinds of employees are in the right places at the right times.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

1	SUMMARY
3	CHAPTER ONE INTRODUCTION The Need for Professional Resource Management, 3 Changes in Highway Programs—Is the Personnel Supply Adequate?, 3
4	CHAPTER TWO PLANNING FOR PROFESSIONAL STAFF NEEDS Factors That Affect Professional Resource Planning, 4 Attracting and Retaining Professional Staff, 8
9	CHAPTER THREE PROFESSIONAL RESOURCE MANAGEMENT PRACTICES IN HIGHWAY AGENCIES Elements for a Successful Program, 9 Representative Programs, 9 Personnel Planning as a Part of Capital Programs, 12
14	REFERENCES
15	BIBLIOGRAPHY

ACKNOWLEDGMENTS

This synthesis was completed by the Transportation Research Board under the supervision of Damian J. Kulash, Assistant Director for Special Projects. The Principal Investigators responsible for conduct of the synthesis were Thomas L. Copas and Herbert A. Pennock, Special Projects Engineers. This synthesis was edited by Anne S. Brennan.

Special appreciation is expressed to Beatrice B. Collins, Southbury, Connecticut, who was responsible for the collection of the data and the preparation of the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Raymond J. Colanduoni, Director, Employee and Support Services, New Jersey State Department of Transportation; Paul Craig, Manager, Personnel Administration, Illinois Department of Transportation; William W. Miller, State Transportation Engineer, Florida Department of Transportation; Esther M. Swanker, Schenectady, New York; and Liaison Member Thomas W. Myers, Highway Engineer, Program Review & Technical Support Branch, Federal Highway Administration.

Kenneth E. Cook, Transportation Economist, Transportation Research Board, assisted the NCHRP Project 20-5 Staff and the Topic Panel.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

PROFESSIONAL RESOURCE MANAGEMENT AND FORECASTING

SUMMARY

As changes in highway programs occur, effective management of professional staff will be required to accommodate changes in the work force and to respond to internal and external changes. Professional resource management is a management tool that can help determine professional recruitment and promotion requirements; determine the kind of training, retraining, and career development programs an agency needs; and forecast professional supply in terms of changing organizational needs.

The major factor that will affect professional resource planning in the near future is the likely retirement of large numbers of management-level and other professional engineers. Many organizations will not have sufficient competent professionals to move directly into those positions. On the other hand, this may present an opportunity to force the pace of development of younger professionals to fill the void.

Other factors that will affect professional resource planning include civil service and merit system regulations, which may emphasize quantity rather than quality of experience; use of consultants, which affects costs, uniformity of work, and morale of employees; collective bargaining agreements, which will affect working conditions; affirmative action requirements, which affect recruiting, training, and promotion activities; and technology advances, which will change not only the numbers of professionals needed but also the types of skills required.

Attracting and retaining professionals can be improved through (a) good relations with colleges and universities, (b) recruitment programs that look toward future management responsibilities, (c) professional training programs that produce multi-qualified staff, and (d) adequate compensation.

A professional resource management program is a continuing activity that will enable management to ensure that the right numbers and kinds of employees are in the right place at the right time, thus enabling the agency to meet its goal of building better roads in more effective ways with the best use of the talent available.

A professional resource plan includes an organizational analysis to determine professional needs, an analysis of needed skills, recruitment policies, projections of shortages in professional categories, and training and promotion plans.

Successful programs are organization-wide and have the support of both management and employees. The programs are based on information that enables management to identify important background data about employees, and the data are updated annually. A professional resource planning system will give management the tools to judge the recruiting, training, and development needs of the department.

INTRODUCTION

As changes in the size and availability of resources occur and program emphases shift, state highway administrators are developing appropriate responses to the challenges of the decade ahead. One of these responses is more effective management of professional resources to accommodate changes in the size and composition of the work force. A comprehensive professional resource program can result in positive and timely reactions to internal organizational changes (caused by such factors as hiring freezes and enhanced retirements) as well as to external (economic and political) changes.

The purpose of this synthesis is to examine the factors that affect professional resource management, to determine what the elements of professional resource management are, and to describe a few of the programs now in operation in state agencies.

To determine which state highway and transportation agencies actually do professional resource planning and forecasting, the extent of these plans, and the importance each agency attaches to this kind of planning, the 50 states were offered an opportunity (through a survey) to present their current practices. Twenty states responded. The information they supplied was supplemented by interviews with agency officials in several states and a review of the literature.

The synthesis discusses the major issues identified by the agencies as key elements in professional resource management, and describes some of the programs now in process. This report is concerned only with the professional/technical staff of highway agencies. Examples of professional/technical personnel are engineers, accountants, planners, and others requiring special education, experiences, and, in some cases, license or registration.

THE NEED FOR PROFESSIONAL RESOURCE MANAGEMENT

It is paradoxical that in an era where planning activities occupy so much of our attention and extend to so many elements of our social and economic structure, so little is being done to plan the supply of our most valuable resource of all, manpower (1).

Why should the skillful management of professional resources be of such immediate concern to highway and transportation officials? Certainly professional resource planning is not a new concept nor has it been ignored in the past. Indeed, it has been done over the years with varying degrees of success in most public and private organizations. Today, however, important changes have occurred that influence how administrators are forced to manage. Consider the following:

- Retirement and attrition policies that push out senior employees before subordinates have sufficient experience to take their place.
- Requirements of civil service and merit systems as to how personnel are selected, employed, retained, and promoted.
- Use of consultants in place of full-time agency employees.

- The impact of technological advances on personnel planning.

- Changes and uncertainties in the character of highway program (e.g., construction and expansion versus reconstruction and preservation). Will this signify a change in the type of professional need by highway agencies and if so, is the personnel supply adequate to meet current needs?

- Uncertain financing of highway programs in the recent past with little assurance that the "feast and famine" pattern of public moneys will change.

- Equal employment opportunity and affirmative action requirements.

- The influence of government employee unions.

The decrease in the number of state highway employees that was evident in the 1970s has carried into the 1980s (Table 1). This has taken place during a period of growth in state government outside of highway agencies (2). A substantial number of the personnel lost were professionals. Recent increases in the taxes on motor vehicle fuels should provide funds for some stable programs in most states and for a continuing need for professional services by highway agencies.

CHANGES IN HIGHWAY PROGRAMS—IS THE PERSONNEL SUPPLY ADEQUATE?

Although emphasis in highway projects has shifted in recent years from construction to reconstruction and preservation, highway officials are in general agreement that the engineering and technical skills required for reconstruction, preservation, and maintenance are not substantively different from those used in construction.

Several agencies (California, Kansas, Massachusetts, New York, and Oregon, for example) do foresee some shortages in managerial, professional engineering, and engineering technician categories over the next five years. But these shortages are attributed to retirement, attrition, and reductions in force, not to a shortage of entry-level engineers. There is also an expectation that computer literacy, management, and supervisory skills may be in short supply, although agency training programs may be able to rectify these problems.

Some agencies may find it necessary to solve their shortage problems by recruiting out of state or by hiring more foreign-born professionals than in previous years. Highway departments may no longer be able to afford professionals who are competent in only one field. The development of a multiquified professional staff through cross-training programs is an increasingly important solution to skill shortages, budgetary restraints, and hiring freezes.

A recent report of the Transportation Research Board concludes that despite an expected decline in the number of civil engineering graduates in the late 1980s, state highway agencies are not likely to experience a shortage of civil engineers (3).

TABLE 1
STATE EMPLOYMENT BY MAJOR FUNCTION (2)

Function	Total Employment			Average Annual Rate of Change (%)	
	1970	1980	1982	1970-1980	1980-1982
Higher education	1,093,637	1,474,326	1,496,349	3.0	0.7
Hospitals	450,382	577,721	570,173	2.5	-0.7
Highways	301,896	258,377	244,339	-1.6	-2.8
Natural resources ^a	150,817	191,948	186,618	2.4	-1.4
Correction	91,505	153,086	185,477	5.3	3.9
Public welfare	99,489	173,909	174,456	5.7	0.1
Financial and general government administration ^b	145,429	237,225	163,321	5.0	17.0
All other functions	370,416	573,871	609,296	4.5	1.2

^aIncludes state parks and recreation.

^bIncludes courts and legislatures.

CHAPTER TWO

PLANNING FOR PROFESSIONAL STAFF NEEDS

FACTORS THAT AFFECT PROFESSIONAL RESOURCE PLANNING

Retirement

The factor most frequently mentioned as a major problem in professional resource management today is the unbalanced age structure of the professional job category. Professional staff hired during the period between 1946 and 1966 is the largest group in most highway organizations and is, by and large, the group closest to retirement. "Sadly for many organizations, there is no horizontal lens of competent professionals of adequate number ready to move into these positions when their current incumbents retire" (Paul Craig, Illinois DOT, personal communication).

A 1978 National Science Foundation report projected that for all engineering fields, the number of engineers retiring between 1984 and 1988 (assuming a retirement age of 65) will be almost 62 percent greater than the number retiring between 1979 and 1983 (4). The retirement rate is highest for civil, electrical, and mechanical engineers. The TRB report on transportation professionals (3) indicated that more than 60 percent of management-level engineers in state agencies will be eligible to retire in the 1985-1989 period and that 13.5 percent of them will leave as well as 18.4 percent of other professional engineers. The average annual attrition rate of these engineers (3.1 percent) is substantially higher than in the past and nearly $\frac{1}{3}$ higher than that for civil engineers generally (3). A New York State report

concludes that nationwide "it would appear that a greater number of job vacancies in most engineering fields will be creative by retirement in the coming decade than in the preceding one—half again as many, as a conservative estimate" (5). Tables 2 and 3 show the percentages by age of engineers and a projection of engineers retiring up to 1993.

Several states either already have been seriously affected by retirement policies or face problems in the near future. For example:

In Michigan, a new law will allow the state to replace only one in four of the 6,000 employees projected to leave under the state's "rule of 80," which is age plus service. The law provides a monetary sweetener until the employee is eligible for social security. To deal with this eventuality, the Michigan DOT has established an Organizational Evaluation Review Team to develop the manpower utilization and planning necessary to meet an eight percent net reduction of employees over a nine-month period.

In 1983 the New York State DOT was faced with a similar situation as a result of an enhanced retirement plan used as an incentive by the state to reduce its work force. As a result, the agency lost 688 people, many of whom were key professional employees. The situation was further compounded because vacant positions were earmarked so that the agency could not fill any positions without a protracted analysis and clearance by the Governor's Budget Division.

An Engineering Process Study Group in Maine found that as of July 1980, 40 percent of management-level engineers and

TABLE 2
ENGINEERS IN 1978 (Percentages by Age in Selected Fields) (4)

Field	Total	24 & under	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70 & over
Aeronautics/astronautics	48,700	2.5	17.2	11.5	11.7	12.5	12.9	12.7	11.3	5.1	1.2	1.2
Chemical	67,900	8.7	18.3	14.4	11.9	9.9	8.1	9.6	10.0	6.3	2.1	1.0
Civil	183,500	4.5	15.5	11.4	12.9	11.7	11.4	12.4	7.3	5.3	3.9	3.7
Electrical/electronic	243,000	5.9	15.5	15.0	13.5	13.3	12.4	10.5	6.9	3.8	1.8	1.4
Mechanical	233,700	5.2	13.3	14.1	12.2	11.6	11.4	13.4	10.1	5.2	2.4	1.2
Other	619,500	4.1	12.6	12.9	11.8	11.3	11.4	12.5	9.5	6.4	4.5	3.0
Total all fields	1,396,300	4.8	14.0	13.3	12.3	11.7	11.5	12.1	8.9	5.5	3.4	2.4

7.5 percent of the remaining engineers and technicians were potential retirees within the next 5 years. Officials noted that even "if all attrition is replaced by new hires, maintaining the current staffing level, the percentage of potential retirees will increase to 54 percent for management level engineers and 22 percent for remaining engineers and technicians by 1992" (6). Maine officials concluded that these data indicate the importance of a hiring program that can develop a core of experienced employees able to move into positions vacated by retirees. However, they caution that funding policies, which are basically controlled by four-year cycles of elected officials, may have "a profound limiting effect on the agency's ability to hire in accordance with a long-term hiring plan" (6). For example, a departmental request to hire a crop of new graduates to provide a supply of trained and experienced engineers in six years could be easily denied because there is no immediate threat to public services.

California reports that the average age of retirees is now 62, but is decreasing. Employees may retire at age 50 with 5 years of service. Although there is no mandatory retirement age, there is a self-certification of ability to perform at age 70.

Caltrans will have 2,057 professionals eligible to retire in 5 years. (This includes managers, associate and senior professional engineers, engineering technicians, and assistant technical engineers.) Professional engineers and assistant technical engineers are the two job categories with the largest number of eligible retirees. California was particularly hard hit as the result of a 1975 layoff when a large number of young engineers were lost

to the department. This was followed by a five-year hiring freeze creating an age gap in the professional force. To make up for this situation, the department has now begun to hire aggressively and will continue this practice, funds permitting, over the next five years.

In Oregon, the department reports that its major problem will be to compensate for the results of a 1976 layoff. Approximately 25 percent of the employees will be eligible to retire within the next 5 years. The 1976 layoff caused some gaps in technical expertise in the middle range but the department is now hiring younger engineers who are well trained; however, they may not receive adequate supervision or challenges for their professional development.

The Wisconsin Department of Transportation reports that as a result of the lack of a regular program of bringing in new engineers over the past 10 years, a large percentage of the agency's management group is 55 years old or older. WISDOT concludes that "the retirement of this large group of employees age 55 and older over the next 10 years will have both a positive and negative effect in the department" (7). Positively, it will present an unprecedented opportunity for middle-level engineers to move up; negatively, the effect will be to deplete the ranks of these middle-level engineers. The solution recommended is to bring in a limited number of engineers on a regularly scheduled basis. If this is not done, department officials fear that by the end of 1991 there will be a shortage of professionals.

Although the gap in age distribution is viewed as a major problem, it can also be seen as opportunity to free many

TABLE 3
RETIREMENTS OF ENGINEERS (4)

Field	Retirements			Percent Change	
	1979-83	1984-88	1989-93	1979-83 to 1984-88	1979-83 to 1989-93
Aeronautics/astronautics	2,500	5,500	6,200	+120	+148
Chemical	4,300	6,800	6,500	+58	+51
Civil	9,800	13,400	22,800	+37	+133
Electrical/electronic	9,200	16,800	25,500	+83	+177
Mechanical	12,100	23,500	31,200	+94	+158
Other	39,400	58,900	77,200	+49	+96
Total all fields	77,300	124,900	169,300	+62	+119

agencies from the view that older necessarily means better. Indeed, it is quite possible that departments could benefit by forcing the pace of developing younger professionals to fill the void left by retiring engineers.

Attrition

There are two forms of attrition: the first can be termed "normal," where management can plan for it; and the second can be termed "forced," which is not manageable. In general, the problem of the use of attrition to reduce the size of the work force is that it is employee selective rather than management selective. The junior talented employee with good, saleable skills in the marketplace sees that there is no place to go in the organization, looks for a new job, finds one, and leaves.

Attrition is a sure way of emptying an organization of its young talent. It does not disturb the employee with some seniority and a retirement stake in staying. As long as seniority and not productivity is the criterion for retention of employees, attrition will continue to be the most widely used method of reducing the size of an organization.

In Virginia, it has been recommended that reductions in one division or another be achieved, where possible, through cross-training of employees and moving individuals from one classification to another, or from field offices to the central office. The method could be used to correct imbalances in the agency's structure.

Civil Service and Merit System Regulations

All of the states commenting on employment practices agreed that civil service and merit system regulations can adversely affect professional resource management. One official noted that Civil Service selection practices frequently impede his ability to hire and promote people on the basis of ability and potential. He stated that these systems tend to place more emphasis on amounts of experience rather than quality of experience.

In Arizona, agencies must interview a minimum of seven people for each position, which delays hiring and makes planning difficult. In addition, appeal procedures for terminations and adverse actions are lengthy and involve considerable administrative time. In Oklahoma, personnel limits are currently prescribed by the state legislature. These are in the form of statutory limits on the number of full-time equivalent employees the agency can have on a payroll at any given time. A legislative mandate in Vermont puts a ceiling on the number of positions in the agency and prohibits reallocation of a vacant position to a higher level classification.

Although these regulations may have a negative impact, many states report that a civil service system is frequently considered a plus in attracting employees; civil service regulations mean job stability, particularly in times of economic recession.

One reform in the civil service system that should be noted is a recent trend toward so-called "broad banding." Under this system there are fewer job classifications, thus making way for multiqualfified professionals.

Use of Consultants

The use of consultants is an important factor in professional resource management and one that causes mixed reactions among highway officials.

In many cases consultants are preferred because they can be hired quickly on a project-by-project basis without having to go through time-consuming civil service hiring requirements. Also, at a time of restricted state financing, consultants can be used for new highway and bridge projects, as well as for construction management when it may not be possible to expand departmental staffs. (Note that Federal Highway Administration regulations require a state employee to supervise all consultant work.)

Conversely, a few departments note that the cost of consultants is increasingly prohibitive. They also point out that extensive use of consultants can result in a lack of uniformity in project work. Another problem is that the morale of permanent employees can be damaged when agency salaries are compared to consultant fees.

Several states, however, have started to use consultants in areas formerly reserved for agency employees (Kansas, Maryland, Massachusetts, and Texas, to name a few). New York State, which is a heavy user of consultants, will be hiring even larger numbers of consultants for projects to be completed with funds made available from its recently passed bond issue as well as increased federal funding.

Labor Relations

State highway and transportation agencies are subject to the growing influence of public employee unions. Some overall facts concerning public employee unions are important here.

By 1980, 40 states had a labor management policy covering all or part of their work force (8). (The usual exemptions from union membership are: elected and appointed officials, agency heads, and designated managerial and confidential employees.) Thirty-three of these 40 states had provision for collective bargaining with employee groups (8).

Forty percent of all full-time state workers, or 1,163,000 full-time equivalent state employees, belong to employee organizations. The state function with the highest proportion of full-time employees who are members of employee unions or organizations is highways (52.9 percent), followed by police (51.8) and hospitals (49.8 percent) (8).

Labor management contracts between state governments and employee organizations exist in 29 of the 33 states having collective bargaining provisions. These 29 states had a total of 728 contractual agreements covering 837,628 employees or 22 percent of all state employees.

These facts suggest that the influence of public employee unions is growing and will have an impact on how professional resources are managed. The reasons in support of this are:

- Public employee unions are growing in strength. The American Federation of State, County, and Municipal Employees (AFSCME), the largest of the unions, has grown on an average of 800 members per week since 1964. It now represents 1.75 million employees. This growth was achieved while the rest of

the labor movement lost membership, from 30 percent to 20 percent of the work force in the 1970s (9).

- The states that recognize the bargaining rights of public employee unions usually limit the scope of bargaining to wages, hours, and terms and conditions of employment.

- Most states allowing collective bargaining prohibit strikes by public employees. This prohibition does not, however, threaten the strength of public employee unions.

- Public employee unions have entered the political arena. In 1982, AFSCME alone spent \$2.5 million to support candidates favoring its views.

What does all this mean to managers in states developing and using professional resource planning?

First, in those agencies with unions it will be incumbent on administrators to deal openly and fairly with union representatives. There is a growing trend, particularly in the private sector, toward participatory management (quality circles, employee involvement, quality-of-work-life committees, etc.). The unions particularly are anxious to move this idea to the public sector; some states, and other political subdivisions, are moving toward production schedules, training, and other issues that are not related to wages, salaries, or hours.

Second, managers should listen to and encourage professional employee participation at all levels of professional resource planning.

In California, the department's new management philosophy is to be "people oriented." As one part of this, Caltrans has begun a proficiency pay policy, which is part of collective bargaining. Employees who have been at the top of the grade for three years can now be given a one-time bonus to compensate for what would otherwise be a dead-end position.

Overall, transportation managers should encourage professional participation in the development of training and cross-training programs to further career development opportunities. Professional employees have knowledge of the specific requirements for the agency work tasks and the training and experience needed for each position.

Affirmative Action Requirements

Affirmative action programs affect professional resource management as organizations must make a special effort to recruit, retain, and promote women and minority groups.

Some areas that require particular attention to ensure compliance include ensuring an equitable distribution of minorities and nonminorities in temporary and permanent positions; selecting a representative mix of white men, minorities, and women for training courses; and ensuring that program managers interview all qualified personnel for vacant professional positions. Table 4 gives data on bachelors degrees awarded to women and minorities in recent years.

Several states have made special efforts to recruit minorities and women. Recruiting out of state is a possibility if there is a shortage of women or minorities in the home state.

To help ensure equal career opportunities for foreign-born professionals, special programs can be provided to help them overcome language and cultural differences. One Illinois official pointed out that advanced education and technology are meaningless unless the cultural differences of foreign-born employees are given special attention.

TABLE 4

BACHELORS DEGREES IN ENGINEERING AWARDED TO WOMEN AND MINORITIES, 1976-1984 (10)

Year	Women				Minorities ^a	
	All Engineers		Civil Engineers		All Engineers	
	No.	% of total	No.	% of total	No.	% of total
1976	1,376	3.6	-	-	2,176	5.7
1977	1,961	4.9	-	-	2,248	5.6
1978	3,280	7.1	-	-	2,003	4.3
1979	4,716	9.0	-	-	2,380	4.5
1980	5,680	9.8	931	9.1	2,712	4.7
1981	6,557	10.4	1,065	10.1	2,952	4.7
1982	8,140	12.2	1,144	11.1	3,345	5.0
1983	9,566	13.2	1,315	12.5	3,842	5.3
1984	10,761	13.9	-	-	4,172	5.4

^aBlacks, Hispanics, American Indians.

Technological Advances

Although the full impact of new technology on professional resource management is not yet known, it is apparent that the use of computers can offer a wide range of benefits—from managerial tools to improving productivity in the field.

For example, to forecast and plan for professional needs on both a short-range and long-range basis, managers must have a complete knowledge of their existing staff. This should include job qualifications, age, career plans, education, on-the-job training, and participation in training and continuing education programs. A total data system enables management to merge employee qualification and availability with information on funding and project personnel requirements to develop a workable manpower plan.

The New Jersey Department of Transportation, for example, uses computer-stored personnel data to access a variety of information on its employees. The accompanying employee profile is maintained by the Division of Personnel. In addition to this basic personal data file, the computer can be queried for such up-to-date information as an employee's promotional history, tuition-aid courses completed, and management development programs taken. This information is updated when an action is completed. New Jersey officials report that these files are useful aids in determining which employees are eligible for promotion and, once promoted, what additional training might be useful for the employee to have to meet new responsibilities.

The use of computer systems has affected the need for and the use of professionals in several areas. Some of these systems are: the application of computerized data in computer-aided design; the development of pavement management systems to minimize long-term highway maintenance and rehabilitation costs; satellite survey control systems for highway location and mapping; on-line project management and scheduling systems; and construction engineering management systems that provide ready information on the status of highway improvements and the professional personnel needs.

ATTRACTING AND RETAINING PROFESSIONAL STAFF

Recruitment, Training, and Career Development

Attracting and retaining professionals are very much the responsibilities of each agency and directly affect its professional resource management. There are several ways to attract and retain professionals.

Good Relations with Colleges and Universities

This includes contact with faculty, participation in school activities, providing field trips for students to view agency projects, and summer hiring. It also means developing cooperative programs for students and an agency policy that ensures preferential hiring for those students completing the program.

The role of universities in preparing their graduates for the type of highway programs that will be prevalent in the future is extremely important and cannot be accomplished without increased interaction between educators and practitioners (11). Highway department officials should make every effort to meet regularly with university faculty and administrators to ensure that the curricula being offered meet the needs of current and future highway programs. There is general agreement among state agencies that there is a need for a broader curriculum that includes transportation management and environmental studies, as well as traditional engineering subjects.

Forward-looking Recruitment Programs

In several states, departments are planning to meet future professional needs. For example, the Oregon DOT is considering requesting legislation that would allow it to hire 200 engineers who will be needed in a few years' time. The California Department of Transportation is recruiting as many junior civil engineers a year as it can to create a backlog of professionals who will be trained for supervisory and managerial positions that will become available as attrition and retirement take their toll. The Illinois Department of Transportation has hired 130 junior civil engineers since January 1, 1984.

Professional Training, Retraining, and Career Development Programs

The importance of retraining and cross-training professionals to produce a multiqualfied staff cannot be overemphasized, particularly at a time when hiring freezes, attrition, and early retirements are depleting the forces of key senior employees.

Some of the measures taken by several states (Kansas, Massachusetts, Oregon, and Texas) to increase productivity and minimize staffing problems include: expansion of in-house management training courses; where funds permit, sending professionals to management training courses outside the agency; expanded technical training and retraining courses; paid tuition for supplementary education; and partial payment of professional registration and licensing fees.

In Minnesota, professional development focuses on the agency's existing work force through internal training, man-

agement evaluation and seminars, tuition reimbursement, and a few sponsored educational sabbaticals. In 1981, the Minnesota Department of Transportation developed a three-part program of formal training, participative management, and coaching about the tools and techniques to help supervisors "work smarter, not harder." This program is reported to have directly increased the effectiveness of first-level supervisors and improved productivity in the department.

Maryland DOT requires all newly hired graduate engineers to attend a four-year training program in which they visit all principal areas of the agency, are given a short "hands-on" experience, and are instructed in all facets of the department.

The California Transportation Department management believes that there is a need to stimulate engineers and motivate them toward creativity. Accordingly, Caltrans has recently reinstated mid-level management training conferences at which legislators, representatives from private industry, and staff from other state agencies are brought in to give transportation managers a new perspective.

In addition, California has started a new program for supervisory management that includes: (a) an annual needs assessment that compares the existing skills and knowledge of managers with required skills (this provides managers and supervisors with a list of managerial competencies to strive for and results in an annual training and development plan), (b) a network of trained management mentors to review and consult with managerial supervisory employees, and (c) a management information program.

As part of its overall engineer-development program, Caltrans has a rotational training program. Participation is mandatory for entry-level engineers and for junior civil engineers and assistant-level graduate engineers who have no prior department engineering experience. Each district office and the headquarters office has a manager responsible for implementing the engineer-development program. The rotational training program has four parts: orientation, job rotation, training, career counseling, and evaluation.

The rotation period is for not less than 18 months and no more than 36 months. Participants must be assigned two core functions, project development and construction, and must also be allowed one elective. On completion of the rotation program, the participant's work is evaluated by a front-line supervisor. The employee is also required to evaluate the program in terms of its contribution to his or her career development. Feedback on the program has been positive and it has also been regarded as a strong recruiting tool for the department. Structure, control, and management commitment are the necessary ingredients for making such programs successful.

Although there is general agreement that innovative training programs are important, some managers caution that if trainees are not used in the jobs for which they are trained, such programs can turn out to be destructive rather than positive forces in an agency.

The Role of Compensation

Salaries offered by highway agencies to either graduate or experienced engineers are frequently lower than those offered by other employers (3). However, such data do not reflect differences in employee benefits, average seniority, working con-

ditions, or regional cost of living. Among state highway agencies there is a wide range of salary levels for similar positions. For example, in July 1984 the maximum monthly salary for a project engineer ranged from \$1972 to \$3739 and there were often differences of several hundred dollars between adjacent states (12). According to the TRB study of transportation professionals (3), most state DOTs have been able to hire qualified profes-

sionals in all areas because of an abundant supply; however, this trend will not remain permanent.

Thus, state administrators should regularly review their recruitment practices, training and other professional development programs, and salary structures so that they remain successful in attracting high-quality professionals as job market conditions change (3).

CHAPTER THREE

PROFESSIONAL RESOURCE MANAGEMENT PRACTICES IN HIGHWAY AGENCIES

ELEMENTS FOR A SUCCESSFUL PROGRAM

In its proposed program for professional resource planning, the Minnesota Department of Transportation describes professional resource management as a future-oriented concept that deals with policies, plans, analysis, systems, and methods that are used to establish and implement programs that will bring about an effective work force. From the employees' viewpoint, a professional resource plan has been described as an attempt to reconcile an individual's needs for the future with those needs of the organization.

One of the desirable elements in successful professional resource management is that it be a continuing activity; updated regularly to take into consideration new technology, the overall economy, and the changing needs of an organization (13). Another ingredient for success is that a professional resource plan be organization-wide and given the continuous support and participation of senior management.

The importance of professional resource planning is recognized by administrators in both public and private organizations. At a time of rapid advances in technical and managerial knowledge, spiraling labor and material costs, and changes in public funding policies, management must be able to ensure that the right number and kind of employee is in the right place at the right time (14).

A still broader view, as one state official has pointed out, is that the only real purpose in considering employees as resources is to accomplish the agency's goal: that is, to build better roads in more effective ways with the best use of the talent available. The only way to accomplish this is through a dynamic human resource plan that has management's total commitment.

Professional resource management, then, can be viewed as a management tool that can: (a) help determine professional recruitment and promotion requirements; (b) determine the kind of training, retraining, and career development programs the agency needs to meet its program requirements; and (c) forecast professional supply in terms of changing organizational needs.

A professional resource plan should include the following components:

1. An overall organization analysis that attempts to identify the professionals needed to achieve the agency's goal (this could include projected changes in work load, labor mix, and departmental policies);
2. An analysis that determines the behavior and skills necessary to perform specific tasks;
3. Person analysis that seeks to identify the skills and abilities an individual needs to perform specific tasks;
4. Recruitment policies and programs, including the number and level of recruits;
5. Projected shortages in specific professional categories that can be determined by analysis of data on external labor demand and supply, as well as internal departmental data on the age structure and projected retirement of employees; and
6. Training and promotion plans for various professional categories.

REPRESENTATIVE PROGRAMS

The following are descriptions of agency-wide professional resource programs in various stages of operation in three states. These programs are described in detail because they seem to include all the elements necessary for successful professional resource management and because they address some of the problems highway agencies face today and will face in the near future.

Minnesota

The Minnesota Department of Transportation (Mn/DOT) has done operational and tactical human resource planning for several years. Two systems are used: the Construction Engineering Manpower Management System for short-range projections (6 to 18 months), and the Project Management Scheduling System for project design staffing projects (1 to 5 years). These systems are used for programmed projects and are more for management of existing personnel (staffing and assigning people,

adding temporary help for construction) than for justifying changes in the number and skills of employees.

In 1980, a demonstration project for an overall human resource plan was initiated involving five percent of the Mn/DOT employees. The target date for completion was June 30, 1984.

In devising its human resource plan, Mn/DOT concluded that the most important benefits of the program would be (a) to routinely provide human resource planning information for use by management, (b) to stimulate employee motivation by letting employees know where they stand in the organization, (c) to provide a long-lasting program that crosses functional lines and remains compatible with future changes in component subsystems, and (d) to provide improved credibility with the public and the state legislature.

Priorities for the Minnesota plan were identified as:

1. Developing a human resource planning policy that demonstrates management's commitment to a program that meets management's needs while ensuring that it is also good for the employees.

2. Establishing a human resource inventory that would contain position requirements, skills, demographics, and employment history.

3. Developing a process for work-force planning that would include forecast modeling and coordination with existing systems. The expected output would be (a) demand forecasts of work-force needs at prescribed budgetary levels that have been identified by strategic and tactical planning efforts; (b) supply forecasts of available personnel and skills obtained from the human resources inventory; and (c) environmental scanning to identify factors outside the department's control that could affect future hiring activities, transfers, promotions, etc.

In its proposal, Mn/DOT noted that one of the critical elements required for successful planning is the availability of real time information—the better the information, the better the output that is possible. Accordingly, it was decided that the ultimate goal would be a computerized data bank primarily for human resource planning that would include the following elements:

1. Attrition data, record of promotions, lateral and other transfers, leaves, and temporary assignments.
2. Academic accomplishments and experience records.
3. Training and development records.
4. Technical and management skills inventories, measurable attributes (optional to employee).
5. Reporting relationships.
6. Vacancies.
7. Position requirements (technical and management).
8. Employee preferences regarding location, position.
9. Employee target positions (career paths).
10. Performance evaluation (future inclusion).
11. Estimated year of retirement (age 65 unless otherwise noted).

From this data, management could expect reports on attrition rates, anticipated retirements by location and position, education, experience and training, affirmative action information, and employee lists by authority levels. All of this information would form the base for the agency's human resource planning.

Another element of the Minnesota plan is work-force planning, which consists of demand and supply forecasting, matching supply against demand, and overlaying influences identified from external environmental scanning. For purposes of demand forecasting a task force was established and charged with relating program levels to personnel requirements for all major activities in the department and developing a technique for applying these criteria to forecasting.

The goal of supply forecasting is to identify the skills (training and experience of current employees listed in the data bank) and to determine the availability of particular employees at given times in the future.

The goal of external environmental scanning is to stay up-to-date on possible changes outside the department (such as economic, social, political, and technological changes) competition for labor supply, demographic changes, and legislative changes affecting interagency rules. To achieve this goal it would be necessary for the agency to routinely survey information sources and regularly communicate with other agencies and with industry.

In a November 1983 interim report, Minnesota's Human Resource Planning Steering Committee reported that the overall policy for the plan was approved. A data bank for approximately 240 employees was developed for five types of data—demographic reports, current positions, employment history in the department, other employment history, and education. These files were reviewed and corrected by participating employees.

Management reports have been designed and programmed in preliminary form. These include employees by bargaining unit, list of actual supervisors, vacancy reports, retirement eligibility, and working locations of employees. Additional reports will include information on position changes, attrition over defined periods, and employee resumes for promotional exams.

The demonstration project was completed at the end of June 1984. Since that time efforts have been directed toward continuing development of demand forecasting activities and toward including the balance of the total Mn/DOT complement in the human resource information system (data bank).

North Dakota

The North Dakota Highway Department in January of 1984 made a major commitment to implement a human resource planning program. In instructing its managers how to proceed in developing such a program, agency administrators emphasized that projections of human resource requirements would be influenced by technological changes, planned efficiency steps, and changing priorities (e.g., changing program emphasis from construction to rehabilitation of highways).

Managers were told to consider the following factors:

1. Division needs including expansion of activities, new technologies, or applications and changes in operating methods, and/or productivity improvements.
2. External factors with human resource implications, such as government regulations.
3. Internal analysis having human resource implications, such as: areas of technical competency or potential shortcomings; age patterns that could suggest future attrition or career path block-

age; and determination of the balance between managerial, professional/technical, and support personnel.

4. Management implications of human resource issues including analysis of managerial skills, technical competence, and management structure to meet changing demands of the department.

The outline of the human resource planning program includes:

- Work force planning based on division/district goals and objectives. Managers were instructed to analyze and project human resource needs for a two-year period for specific projects and a three-year period for a general program. Skills needed and not needed were to be identified. A general agreement would be reached by top management on department-wide projections.

- A current skills inventory would be developed based on personal interviews with each employee. Present skills, career interests, and targeted positions would be identified and a data bank developed.

- A task force would be organized to review projected department needs with the present skills inventory. A preliminary department-wide plan would be drafted and training guidelines developed.

Finally, division and district director approval would be sought and a human resource plan implemented.

The Department's follow-up on October 1, 1985 provided the following information:

1. The human resource plans developed by each division and district for two years specific and three years general were reviewed by top management. Because of legislative constraints (i.e., budget and employee authorization), the department was unable to implement the majority of the suggestions.

2. The skills inventory has not been utilized as the Department has not made any major operational changes.

3. The training plan has been developed. Because the majority of the training requested is specialized and only affects one or two employees, they have greatly increased the budgeted amount for tuition reimbursement.

Virginia

The Virginia Department of Highways and Transportation has an on-going work-force planning process, the Human Resource Planning System (HRPS), that is automated and has been operational since July 1983. The system consists of two elements:

1. A Workload Assessment System, which is part of the foundation of the HRPS and determines demand for personnel. Components of this system were designed with sufficient flexibility to allow adaptation to the needs of the various disciplines in the agency.

2. A Forecasting, Analyzing, Controlling, Tracking System (FACTS), which monitors changes in personnel supply.

Virginia's plan is the result of a 17-month, full-time study by the Department's Management Advisory Group, which has been made a permanent part of the Department's Personnel Division,

now known as the Human Resource Planning Group. Originally the advisory group was made up of representatives from personnel, design, administration, and industrial engineering disciplines. A computer analyst and a statistician were added to the group later. All department managers participated in the study and the plan was a result of continuous interaction between the advisory group and field and central office management.

In devising its human resource plan, Virginia officials identified six essential components:

1. Assess environmental (legislative, executive, and public interest) and organization conditions that will influence future staffing requirements. Once this assessment is made, consideration should be given to changes in supply and demand of personnel.

2. Collect information on current human resource requirements by job class and compare staffing to manning guides and staffing ceilings.

3. Calculate future staffing needs by modeling the conditions identified above and by extrapolating the relationships between current staffing and work-load indicators.

4. Provide an inventory of available staff, noting potential surpluses or deficits by class of employee.

5. Calculate a projected supply of employees based on past patterns of change (attrition, mobility) and on assumptions about future changes.

6. Match projected staffing demand for each condition identified in No. 1 (above) with projected staffing supply. The results of this final component represent the recruiting, retraining/cross-training, and career development needs of the department.

The foundation of the plan is the work-load assessment system. This system consists of several components: mission, goals, and objectives; scheduling; measurable work units; work standards; and the annual budget.

The mission, goals, and objectives are identified by the district or division manager. These statements then justify dedicating human resources to specific activities performed by each work group and then incorporating these activities into the overall system.

Budgets for human resources are prepared annually to coincide with the program budget cycle. Preconstruction and construction divisions prepare work-load budgets based on the department's Six-Year Improvement Program. Maintenance and support divisions base their work load on division activities for the specific time period budgeted. Work-load projections are sent to the commissioner for review and establishment of organizational priority and projected activity levels.

When the work-load budget is completed, short-term staffing adjustments are made by cross-training, transfers, overtime, temporary or part-time help, transfer of functions or the use of consultants. A layoff plan and selective hiring ceilings are used as long-term methods for adjusting surplus staff.

The second element in the Virginia system is FACTS, which ensures effective utilization of personnel under controlled growth or cut-back conditions. FACTS has three components: a position status program, an available time program, and employee movement programs.

The position status program monitors, plans, and controls

organizational size. It is designed to identify in advance positions that cannot be refilled when vacated.

The available time program is capable of comparing available time for a work group with the average for the agency as a whole. A second program under this component monitors compensated and uncompensated overtime. A third program will monitor the hours contributed to the work effort by temporary employees and is designed to compare actual and projected utilization rates for each work group so that budgeted time will not be exceeded and individual work groups can plan their work loads.

The third component tracks and forecasts attrition and turnover. The attrition program can track retirements, resignations, deaths, and dismissals. The turnover program can track promotions, demotions, and lateral transfers. The model for this component will be used to project total agency turnover by age, class, location, sex, and race.

In addition to the Workload Assessment System and FACTS, the department's program will have the capability of evaluating the impact of environmental and organization situations to forecast human resource needs. Forecasting for staffing needs will be based on revenue projections for the engineering divisions that will then be translated into projects. Work-load projections will be multiplied by the most typical value for each element and then converted to work hours, using the Workload Assessment System.

Maintenance work-load forecasts will be based on an extension of the growth trend over past years to a planning horizon. The department assumes that greater amounts of maintenance will continue to be needed each year.

To forecast staffing supply, a model was developed based on three years of personnel transactions. The model will be used to forecast turnover and attrition, the number of employees needed to maintain staffing at desired levels, and surplus positions.

PERSONNEL PLANNING AS A PART OF CAPITAL PROGRAMS

Several of the states contacted (California, Maine, Pennsylvania, and New York) have personnel planning programs as part of their capital scheduling plans, but have not yet attempted organization-wide human resource management. This type of personnel projection, however, is a logical first step in overall planning for an agency's human resources.

California

California's systems approach to transportation management recognizes the need for a comprehensive system, with all resource needs tied together, that can respond to changing processes as they occur, and provide managers with complete, timely, and comprehensive information and options to enable them to make informed decisions.

Caltrans found that because design, construction, and right-of-way management systems had always been kept separate for purposes of project planning, programming, and budgeting, it was difficult to develop an overall consistent personnel management policy. In 1979, the department decided to plan a total resource management package for all divisions involved in the

project-related sphere; the result was PYPSCAN (Person Year, Project Scheduling, and Cost Analysis), an automated capital scheduling plan. The system came on-line in mid-1980 and incorporates the following policies: all then-existing separate functional systems were eliminated; all approved capital outlay projects are included in the system; agreed upon target dates are considered contracts; the system provides the basis for the support budget; headquarters and district office involvement is required; and the system is used to develop and update the State Transportation Improvement Program.

PYPSCAN was designed to automate multiyear scheduling of all resources (money, time, and people) for the department's capital related program. Variables involved in projecting these resources are many and include environmental studies, project size, project concept, construction type, weather zones, construction working days, and location (e.g., rural, urban, or metropolitan areas) considerations. All of these variables and others, plus dollars, provide factors that help calculate the time and personnel necessary to deliver each project.

The system now also produces a series of management reports for use in resource planning, programming, tracking, budgeting, and evaluating planned progress against accomplished progress. Reports have proved useful to a variety of staff, from the project engineer to the department's director and can range in detail from personnel analysis and production reports to a multiyear statewide program.

Department officials estimated that from its implementation in 1980 through 1982, PYPSCAN saved the agency approximately \$875,000. At that time, it was estimated that a continued savings of about \$450,000 per year would be realized in the future. Most of the savings are realized by the consolidation and automating of previous personnel-intensive separate approaches to resource projecting and management.

On the question of establishing an agency-wide personnel inventory that would include skills as well as employee background and educational data and retirement information, opinion among Caltrans management was mixed. However, a top management task force, the Management Development Strategic Planning Group (MDSPG), has developed such a computerized management skills bank that will be in use in early 1986. In addition, a listing of desirable qualifications for all management levels at Caltrans has been developed and will be the basis for future individual management development plans.

This computerized personnel inventory covers about 300 designated managers. It contains extensive data about each manager including current assignment, prior experience, special assignments, education, professional status, job-related awards, prior training and outside activities, career goals, development/training goals, and mobility.

The data is systemized to provide common terms and codes to give flexibility in selecting and combining specific data about groups of managers. The data can be electronically organized, maintained, retrieved, manipulated, sorted, displayed, or printed through direct commands on a timeshare terminal. The inventory is security controlled by several primary and secondary procedures.

Maine

The Maine Department of Transportation's Bureau of Project Development, which is responsible for preconstruction engi-

neering, forecasts work-force needs based on availability of federal and state funds. Forecasts are based on: (a) all projects being advertised for bid during a two-year period for which construction is funded, (b) obligation of all federal funds, and (c) a long-range goal of catching up on projects to a point where there is a six-month inventory ready for advertising as funds become available.

Recently, a preliminary engineering work-force estimating model was developed for the department and was tested and applied to highway and bridge projects in the 1984–1985 Transportation Investment Program.

The model considered several options to deal with a peak in work load. These were:

1. Add staff—Under this option it was concluded that if staff is added, it takes time for new employees to reach full productivity. Conversely, it takes time for attrition to reduce the staff to the level of on-going need. Layoffs were considered undesirable. The best method was thought to be holding increases to a minimum.
2. Use consultants—This was considered an effective way of dealing with work-load problems. It was noted, however, that there are constraints (such as staff time to administer consultant work and the high cost of consultant fees).
3. Defer some projects—This was considered viable if combined with other options that result in catching up on deferred work.
4. Minimize nonpreconstruction engineering work.
5. Increase use of new technologies.
6. Increase use of off-season construction personnel with additional cross-training between design and construction.
7. Increase use of seasonal employees.

The recommendations resulting from this analysis were: replace all losses caused by attrition and retirement, but not necessarily in the same positions; add staff for projected on-going program levels; and increase use of consultants with supplements by additional seasonal and off-season personnel. Finally, it was recommended that personnel analysis be repeated every two years when a new program is developed.

Pennsylvania

Currently, Pennsylvania maintains an automated personnel plan in response to work load in its field offices. Each engineering district personnel officer is responsible for developing a work-force plan based on work load, turnover, new programs, and new technology. A computer system projects seasonal construction needs based on lettings, and a project management system and contract management system monitor and control all projects, including staffing needs.

On a departmental basis, staffing levels are set in conjunction with the Motor License Fund budget for each district and central office organization. The department is using a four-year planning process on a task force basis to determine design/building programs and the staffing required for them.

Pennsylvania is evaluating each section of the agency as part of a business group contributing to the group mission and objectives. Information will be developed to demonstrate how functions are utilized to meet objectives through: (a) linking missions

to objectives; (b) examining functions at organization levels and linking them to objectives and to key managers; (c) determining the cost out of functions; (d) evaluating what is “critical” as opposed to what is “nice” to have, and linking this to federal and state legislation; (e) defining key issues, both external and internal to the organization; and (f) identifying risks associated with altering organizational functions.

New York

In the spring of 1984, the New York State Department of Transportation management decided to proceed with the installation and development of a project monitoring and personnel resource management scheduling system. At that time a special task force was established from the various functional areas to implement a system. Following an evaluation of the commercial software packages available, it was decided that the department would proceed with PAC II, a copyright product of AGS Management Systems.

It is expected that PAC II will provide the department with a management tool that will produce a system necessary to plan, monitor, and manage multiple projects based on the availability of personnel resources within a scheduled period. The PAC II system is expected to provide the project, regional, and main office manager with more current data on project and program status as to meeting the manager’s goals and objectives while providing for the optimum use of personnel resources resulting in an increased ability to program and meet targets.

During the fall and winter of 1984/1985, the PAC II software was placed on the Burroughs mainframe and subject to a series of tests to assure the department that the software would perform and produce the necessary reports.

In the spring of 1985, the PAC II Task Force ran a test implementation of PAC II in Regions 1 and 9. This test implementation has provided data for an evaluation of the ability of PAC II to be adjusted to the needs and process used by the department. The overall goal to be achieved in the test is to develop a computerized system that will be used by the staff to plan, schedule, monitor, and provide for a basic personnel resource management system. It is recognized that the initial testing does not utilize anywhere near the full potentials of PAC II. At the present time, the New York DOT believes it has achieved a successful test and is evaluating the results to better define its future course of action.

The New York DOT expects to implement PAC II in the remaining nine regions and the main office. It will then proceed to more fully develop the capabilities of PAC II and other possible supportive software. The long-term goals are for the development of a computer-aided management system in which PAC II will become the core of a more all-encompassing series of subsystems.

In September of 1984, an effort was initiated by the New York State DOT to acquire and test the New York State Education Department’s computerized (Burroughs 7700) payroll and personnel data system with the objective of coordinating and automating similar processes at DOT.

In addition to automating manual processes and increasing the efficiency of these activities, this system will increase DOT’s capabilities in the area of Human Resource Management. Improving the availability and accuracy of human resource data

will improve the consistency of employee-related policies and practices throughout the department. DOT will now be able to monitor trends in policy implementation (i.e., discipline and grievance procedures) and provide feedback to specific program areas and/or regional offices. Staffing problems will be more readily anticipated and solutions can be identified before they require crisis management decisions. Positions where most of the incumbents are approaching retirement age can be identified and the necessary transitional recruitment processes can be initiated, and positions experiencing a high turnover rate can be analyzed to determine corrective action. Senior managers will be better able to review program goals, modify objectives, and hold program managers more accountable when they receive work-force data that is current, broad based, and presented in a manner that lends itself to analysis.

The system, which clearly increases capabilities as well as efficiency, will provide the following benefits:

- Management of the internal Affirmative Action program will be facilitated. The New York DOT will have access to current data on protected class employees for its own internal planning and tracking purposes and for use in responding to external reporting requirements. By analyzing the current work force, positions could be targeted for special Affirmative Action efforts and data trends could be used to plan for special recruitment activities.

- The New York DOT will now have the ability to routinely issue accurate and timely position/personnel reports. This will allow the department to accurately project the status of its work force for budgetary purposes. Its data will be more current and accurate than that which is available from either Civil Service or Audit and Control.

- Both routinely generated reports and specially requested reports from the Human Resources Data Base will provide management with information that is not now available except through a laborious and inefficient, manual data-gathering and analysis effort. These efforts are currently extremely time-consuming, disruptive to other processes as staff must be temporarily misassigned, and do not produce benefits commensurate with the costs.

- Special reports could be tailored to meet individual program needs (e.g., data could be analyzed to project future requirements for professionally licensed engineers based on the age of the current work force).

The proposed system will capture and store data points that are not currently available to management (i.e., licenses, training, accident history, etc.). All the information that is manually generated under the existing process will be inputted into the computer along with these new data points. It is anticipated that program managers, who are currently frustrated in their attempts to secure accurate and timely work-force information, will increase their demands for reports and data analysis using the data stored in the system.

A six-month pilot phase in DOT's main office and Region 8 was scheduled to begin in the fall of 1985. As discussed above, the proposed system will provide management with a tool that can be used to better manage the department's human resources and to monitor and evaluate DOT's progress toward achieving Affirmative Action objectives. The usefulness of an up-to-date, on-line Human Resources Data Base will depend on the availability of skilled paraprofessionals to input data at each personnel/payroll point.

REFERENCES

1. Haas, R. C. D., "Skilled Manpower Requirements for the Canadian Transportation Industry," Department of Civil Engineering, University of Waterloo, Waterloo, Ontario (December 1972).
2. "Book of the States 1984-85," Council of State Governments (1985).
3. TRB, *Transportation Research Board Special Report 207: Transportation Professionals—Future Needs and Opportunities*, Transportation Research Board, National Research Council, Washington, D.C. (1985) 299 pp.
4. National Science Foundation, "U. S. Scientists and Engineers 1978: Detailed Statistical Tables," Report #80-304, Washington, D.C. (1978).
5. New York State Education Department, *Engineering Manpower and Engineering Education in New York State, A Report and Recommendations*, University of the State of New York, Albany, N.Y. (July 15, 1982).
6. Maine Department of Transportation, "Project Development Manpower Needs, Summary Report," Engineering Process Study Group (September 1983).
7. Wisconsin Division of Highways and Transportation Facilities, "The Aging WISDOT," Age Analyses, Permanent Employees, Division of Districts, Wisconsin DOT (July 1981).
8. Council of State Governments, *Book of the States 1980-81*, Lexington, Kentucky (1982).
9. *California Journal* (December 1983) p. 165.
10. *Engineering Education* (April issues, 1977-1985).
11. Hoel, L. A. and M. D. Meyer, "Training and Education in Transportation: Future Directions," in *Transportation Research Record 748: New Directions in Transportation Education*, Transportation Research Board, National Research Council, Washington, D.C. (1980) pp. 15-21.
12. Transportation Research Board, *Transportation Research*

- Circular No. 287: Progress Report on Maintenance and Operations Personnel*, National Research Council, Washington, D.C. (December 1984) 35 pp.
13. Donnelly, E. L., "An Initial Approach to Manpower Planning in Highway Departments: Some Practical Considerations," in *Highway Management '74*, Planning and Transport Research and Computation, PYRC/P/106, International Company Limited (July 1974) pp. 19-32.
14. Alpander, G. G., "Human Resource Planning in U.S. Corporations," *California Management Review* (Spring 1980) pp. 24-31.

BIBLIOGRAPHY

- American Association of State Highway Transportation Officials, Response to October 13, 1982 AASHTO Survey of Chief Administrative Offices, Washington, D.C. (1982).
- Briscoe, D. R., "Organizational Design: Dealing with the Human Constraint," *California Management Review*, Vol. 23, No. 1 (Fall 1980) pp. 71-79.
- California Department of Transportation, 'PYPSCAN,' *The Departments' Management and Information System as a Resource Management Tool*, Caltrans Supervisory/Management Development Program (March 1984).
- Management Transportation Associate, Inc., *Project Synthesis of the Indiana State Highway Commission Construction Supervision Manpower Planning Program*, State of Indiana (not dated) 41 pp.
- Michigan Department of Transportation, "Retirement Impact and Contingency Personnel Planning," Ann Arbor, Michigan (1983) 46 pp.
- Minnesota Department of Transportation, "Managing the Transportation Infrastructure," St. Paul, Minnesota (1982).
- National Science Foundation and U.S. Department of Education, *Science and Engineering Education for the 1980s and Beyond*, Washington, D.C. (October 1980).
- New York State Department of Civil Service, Program Evaluation and Development, "Management Skills Inventory," Albany, New York (1982).
- Peters, T. J. and R. H. Waterman, Jr., *In Search of Excellence: Lessons from America's Best Run Companies*, Harper & Row, New York (1982) 360 pp.
- Transportation Research Board, *NCHRP Synthesis of Highway Practice 51: Construction Contract Staffing*, National Research Council, Washington, D.C. (1978) 62 pp.
- Virginia Department of Highways and Transportation, "Human Resource Planning in the Virginia Department of Highways and Transportation," Richmond, Virginia (November 1983) 80 pp.

THE TRANSPORTATION RESEARCH BOARD is an agency of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the Federal Government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine.

The National Academy of Sciences was established in 1863 by Act of Congress as a private, nonprofit, self-governing membership corporation for the furtherance of science and technology, required to advise the Federal Government upon request within its fields of competence. Under its corporate charter the Academy established the National Research Council in 1916, the National Academy of Engineering in 1964, and the Institute of Medicine in 1970.

TRANSPORTATION RESEARCH BOARD

National Research Council

2101 Constitution Avenue, N.W.

Washington, D.C. 20418

ADDRESS CORRECTION REQUESTED