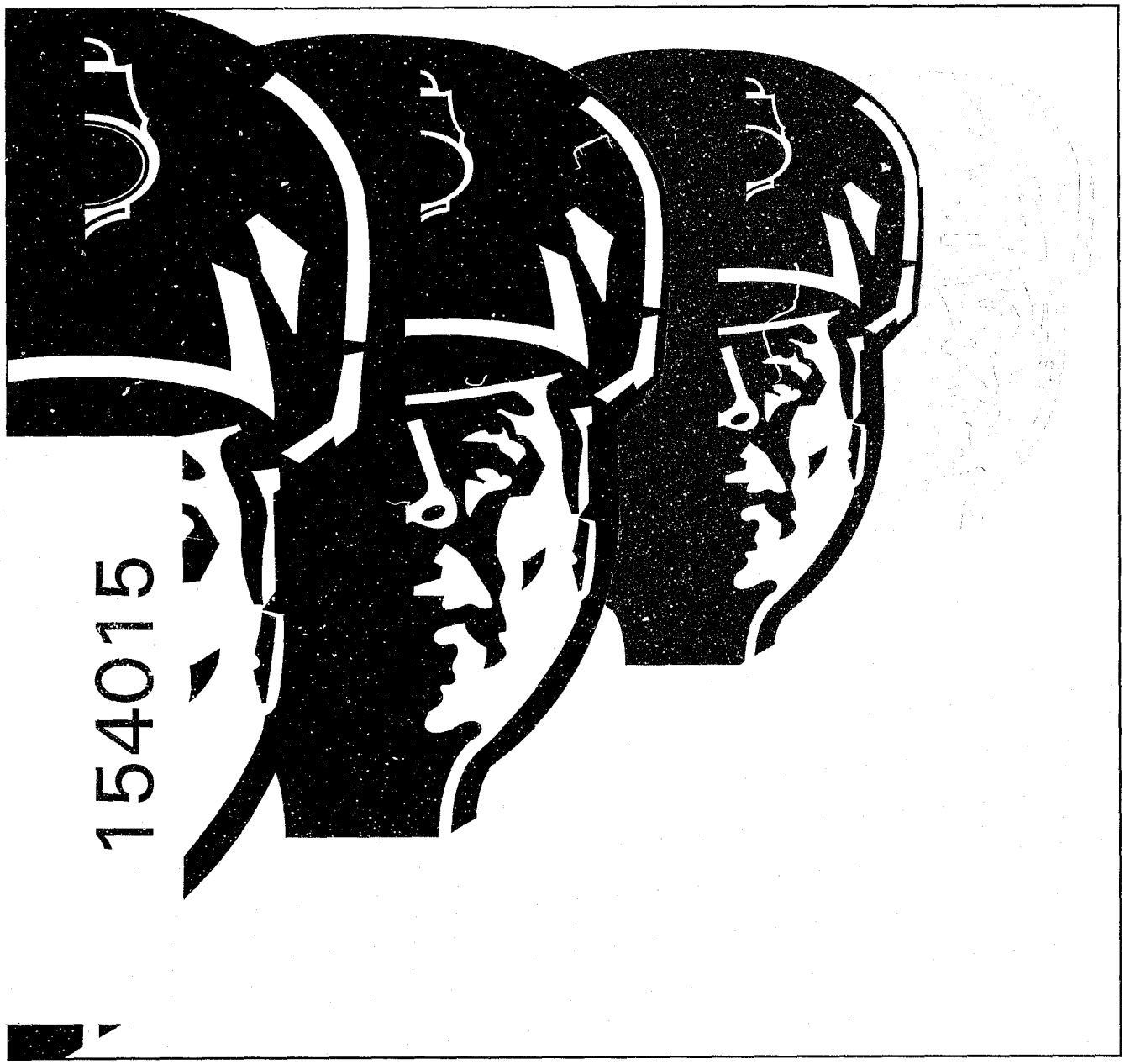
U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

Police Personnel Allocation Manual

State-Wide Agencies



POLICE ALLOCATION MANUAL

Determination of the Number and Allocation of Personnel for
Police Traffic Services for State-Wide Agencies

- PAM Version 4.0 -
July 1991

Prepared by
THE TRAFFIC INSTITUTE
Northwestern University

for
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
U. S. Department of Transportation

Contract No. DTNH22-88-C-05016

FOREWORD

The Police Allocation Manual (PAM) and the Police Allocation Manual User's Guide were developed and field tested by The Traffic Institute of Northwestern University under a contract (No. DTNH22-88-C-05016) issued by the Office of Traffic Safety of the National Highway Traffic Safety Administration, U.S. Department of Transportation. Principal Investigator and author for the study was Dr. William Stenzel. Dr. Stenzel was assisted by Mr. Roy Lucke who had prime responsibility for the design, implementation, and coordination of the field test program. The Contracting Officer's Technical Representative for the project was Mr. David Seiler (The Office of Traffic Safety).

The PAM project was initiated in June 1988 and Phase I was completed in February 1990. The Phase I field test was conducted during the summer and fall of 1989. Phase II of the project was completed in July 1991. Several versions or "editions" of the Manual were produced during the project. Version 1.0 was completed in March 1989. Version 2.0 was completed in June 1989 and was used for the Phase I field test. Version 3.0 was completed at the end Phase I (February 1990), Version 3.5 was submitted to NHTSA in January 1991, and Version 4.0 was completed in July 1991.

The project team wishes to thank the following state agencies which served as field test sites for the study. (The project liaison person for each agency is identified with an "*". Ranks and titles reflect those held during the Phase I field test.)

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Completion of the Manual would not have been possible without the cooperation of the 46 state and provincial law enforcement agencies that provided information about their current staffing and deployment procedures to the project. A list of the 46 agencies is presented below:

Alabama Department of Public Safety

Alaska State Troopers

Arizona Highway Patrol	Arkansas State Police
California Highway Patrol	Colorado State Patrol
Connecticut State Police	Delaware State Police
Florida Highway Patrol	Georgia Department of Public Safety
Idaho Department of Law Enforcement	Illinois State Police
Indiana State Police	Iowa State Patrol
Kansas Highway Patrol	Kentucky State Police
Louisiana State Police	Maryland State Police
Massachusetts State Police	Michigan State Police
Minnesota State Patrol	Missouri Highway Patrol
Montana Highway Patrol	Nebraska State Patrol
Nevada Highway Patrol	New Hampshire State Police
New Jersey State Police	New York State Police
North Carolina State Highway Patrol	North Dakota Highway Patrol
Ohio State Highway Patrol	Oklahoma Highway Patrol
Ontario Provincial Police	Oregon State Police
Pennsylvania State Police	Rhode Island State Police
Royal Canadian Mounted Police	South Dakota Highway Patrol
Tennessee Highway Patrol	Texas Highway Patrol
Utah Highway Patrol	Vermont State Police
Virginia State Police	Washington State Patrol
West Virginia State Patrol	Wisconsin State Patrol

The project team also wishes to thank Messrs. Michael Buren and Alex Weiss of The Traffic Institute, Mr. Sid Girling of the Ontario Provincial Police, and Mr. Richard Raub of the Illinois

State Police (ISP) all of whom reviewed initial drafts of the Manual and provided many valuable suggestions.

A special acknowledgment is extended to Mr. Raub of the ISP. Many of the ideas used in the Manual reflect concepts developed and documented by Mr. Raub and his colleagues in a series of ISP reports beginning in 1981. Mr. Raub's outstanding work into the identification and estimation of the major elements of staffing and allocation of state-wide police agency resources provided many of the basic components for the PAM model.

A special note of thanks is extended to Ms. Darry Ware whose diligence and persistence helped to insure that a steady stream of project materials were sent to the field test agencies in a timely manner.

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CHAPTER 1: Introduction

Purpose of the Manual

The Police Allocation Manual (PAM) is designed to be used by state and provincial law enforcement agencies, or divisions within those agencies, whose mission includes the delivery of police traffic services. The Manual is designed to help such agencies address two key resource allocation questions:

1. What is the total number of officers (i.e., troopers, field supervisors, and staff and command personnel) that are required to provide an acceptable level of service? and

2. How should a specified total number of officers be allocated by geographic regions or time periods to maximize agency productivity?

The staffing and allocation methods described within the Manual are based on a review of procedures currently used by state and provincial agencies throughout the United States and Canada (see the Foreword for a list of agencies which provided information for the project). The framework and rationale presented in the Manual are the result of a distillation process that identified the "best" procedures, and then modified and blended those procedures into a comprehensive model for determining appropriate staffing levels and deployment patterns for state-wide agencies.

It is anticipated that the Manual will provide both immediate and long-range benefits. The procedures in PAM will provide agencies with a logical and explicit format in which to frame requests for additional staff and/or staff deployment. In addition, it is anticipated that the Manual will serve as a catalyst for stimulating further discussion and research in the area of staffing and allocation for law enforcement agencies with state-wide responsibilities.

How To Use the Manual

Version 4.0 of the Police Allocation Manual consists of four chapters and one appendix. Chapter 1 provides a brief introduction to the purposes and use of the Manual and Chapter 2 describes the staffing and allocation model. Chapter 3 contains

eight worksheets, each with instructions, which provide a step-by-step process for determining staffing levels. Chapter 4 contains one worksheet for determining staff allocation over several geographic areas or time periods. Appendix A contains a supplemental worksheet that can be used to expand on the material presented in Worksheet 5 in Chapter 3.

Additional information about the PAM procedures can also be found in the companion document, Police Allocation Manual User's Guide. The Guide presents implementation, data definition, and collection strategies utilized by the field test agencies and additional reference material that were contained in earlier versions of the Manual. The appendix material in the Guide identify all of the input data required to use the PAM model (Appendix A), present a glossary of key terms and a list of all of the notation used in the Manual (Appendix B), include a detailed example showing all nine worksheets in completed form (Appendix C), and illustrate the derivation of all formulas that are used in the model (Appendix D).

For the first-time user of the Manual, the following procedure is recommended:

1. Read Chapter 2 - Chapter 2 can be used to gain an initial understanding of the overall logic of the model and its major components. (The reader may also want to refer to the material that is presented in Appendix D in the Guide.) It is not imperative for the user to understand every detail at first reading. The primary objective of this chapter is to provide sufficient understanding to permit readers to assess how the model can best be used to assist their agency.

2. Review Appendix A in the User's Guide - Appendix A provides an overview of the types of data that are required to use the PAM model.

3. Review Chapters 3 and 4 - Chapters 3 and 4 contain all of the worksheets and instructions for the PAM model. Appendixes B and C in the Guide can be used as references as needed. The purpose of this review is to enhance understanding of the model, to resolve questions about the procedures that are used, and to help the user assess the effort required to use the model.

4. Determine the Data Collection Effort - After reading chapters 2, 3, and 4 (and referring to appendixes A, B, C, and D in the Guide as needed), the user should determine the data collection effort that will be required to use the model. The following steps are recommended for this assessment:

- Review the sections in the Guide entitled "General Implementation Strategies" (Section 2) and "Recommended Data Collection and Implementation Procedure" (Section 4).

- Review the worksheets in chapters 3 and 4 to identify which model options will be used. (Section 3 in the Guide may also be useful for this step.)

- Compile a list of the input data requirements for the agency. This list will include all of the data items in Worksheet 1 plus additional data items from worksheets 2 - 9 as required by the options to be used. The user may find it more convenient to use Appendix A in the Guide to compile this list.

- For each data item on the list, determine its availability and accessibility, and estimate the effort that will be required to obtain it. It is important to recognize that no agency is likely to have available all of the data required; that is, it is probable that every agency will have to estimate some of the data items, at least initially. (Section 3 in the Guide provides specific guidelines and recommendations for defining, collecting, and using a number of input data items.)

5. Assess the Benefits of the Model to the Agency - Before proceeding further, the user should weigh the benefits to be gained from using the model versus the data collection effort that will be required. This tradeoff can be used to help decide whether to use the model or not.

6. Collect the Required Data - If a decision is made to use the model, initial activities should focus on data collection. The actual time required for this effort will vary considerably by agency and will depend on the size of the agency, the degree of automation within the records section, and the scope of existing records. Initial data collection efforts may require time that will not be necessary for later uses of the model because some input data items are not likely to change (e.g., highway miles, patrol areas, etc.).

7. Complete the Worksheets - Once the input data items have been collected, the nine worksheets in chapters 3 and 4 can be used to determine the staffing and allocation levels required for each patrol area. Once the data are available, actual completion of the worksheets themselves will require relatively little time (i.e., only a few hours) compared to the days or weeks that may be required to collect the data.

8. Review and Adjust the Results - After the model has been used to determine staffing and allocation levels, the worksheets and results should be reviewed. The purpose of this review is to:

- explicitly identify the rationale for each model option that is used,

- o explicitly identify the rationale for each performance objective value that is used,
- o verify that the agency data used is both comprehensive (e.g., all agency workload is accounted for) and consistent with model data definitions, and
- o identify and understand differences between current staffing levels and those specified by the model.

The Role of Resource Allocation Models

It is important for the PAM user to remember that the Manual is based on a "model" of staffing and deployment. All models are limited by the assumptions on which they are built and by the data that are used. (See Chapter 2 for additional discussion concerning the limitations of the PAM model.) The user must guard against the temptation to believe that the model provides "the answer." All models, including the one described in the Manual, use a variety of assumptions about the "real" world to assemble data into rational patterns that can be used by decision-makers. (Police administrators do not suffer from a lack of data; but rather from a scarcity of tools for effectively using that data.) The decision-maker, in turn, must weigh the merits of the recommendations of the model against other factors (e.g., political, economic, operational, etc.) in arriving at a final course of action. Perhaps John Schuiteman said it best when he wrote:

> "Adequate police protection, like beauty, lies in the eye of the beholder. The optimal or appropriate ratio of troopers to population, traffic volumes, reported crimes or accidents, etc., is not a matter of mathematics or statistics. It is a matter of human judgment and community resources."
>
> "Allocating State Troopers: The Virginia Experience," The Police Chief, July 1985.

CHAPTER 2: Overview of the Police Allocation Manual Methodology

Time-Based Model

The procedures that are used in the PAM model to determine the total staff requirements for the delivery of state-wide police traffic services are based on an analysis of workload requirements and performance objectives, measured in time, associated with major field activities. The PAM model divides all trooper activities into four time components:

1. Reactive time (calls-for-service),
2. Proactive (self-initiated) time,
3. Proactive (patrol) time, and
4. Administrative time.

Reactive Time

Reactive time refers to trooper time spent on activities that can be described as service-on-demand. These are usually calls for service (CFS) that are assigned by radio dispatch. For many state agencies, the most important CFS activities are requests for police assistance at traffic accidents. Since most agencies also provide services beyond traffic-related activities, the PAM model classifies all CFS as either "accidents" or "other CFS." The total time spent answering CFS is referred to as "obligated time."

Proactive (Self-Initiated) Time

Proactive (self-initiated) time refers to the time spent by troopers on non-CFS activities. In the PAM model, self-initiated activities include the issuance of citations and warnings for driving violations, assisting motorists, providing traffic direction and control, and conducting field interrogations.

Proactive (Patrol) Time

Proactive (patrol) time refers to the time spent by troopers

patrolling the highway system within the jurisdiction. The patrol function provides two benefits: "visibility" for the general deterrence of traffic and criminal violators, and "availability" for self-initiated activities and for the timely response to CFS. Patrol time includes time spent on both moving and stationary patrol.

Administrative Time

Administrative time refers to trooper activities that do not fall into the reactive, self-initiated, or patrol time categories. Typical administrative activities include on-duty court time, personal time (e.g., for meals), patrol car maintenance, training, and agency administrative duties. (Non-permanent special assignments such as long-term training and duty at the state fair are accounted for in the "shift relief factor" for the agency that is computed as part of the PAM procedures.)

Autonomous Patrol Areas

The PAM procedures are designed to determine total staffing requirements for "autonomous patrol areas"; that is, geographic areas which exhibit the following characteristics:

- virtually all of the CFS that originate in the area are handled by troopers assigned to the area (or conversely, few CFS are handled by troopers assigned to other areas);
- troopers assigned to the area are rarely assigned to CFS outside of the area; and
- although troopers may be assigned to specific geographic subdivisions within the area for patrol, a trooper may be dispatched, if required, to a CFS anywhere within the area.

In some state agencies, each police district or trooper zone operates as an autonomous patrol area (APA). In other states, with larger geographic areas, one district may consist of several counties with each county serving as an APA.

Total Staff Requirements

To determine the total staff requirement for a state-wide agency, the PAM model is used in the following way:

1. The entire state is subdivided into a number of autonomous patrol areas (APAs). The APAs should cover

the entire state and should not overlap.

2. The PAM procedures are used to determine the total staffing requirement for each APA.

3. The total staffing requirement for the entire state is obtained by adding the staffing numbers for all of the APAs. (The resulting total may need to be supplemented with additional personnel assigned to the central or regional headquarters of the agency.)

The PAM model uses the following steps to determine the total staffing requirements within each APA:

1. Determine the average daily on-duty police services staff requirement (i.e., the number of troopers required to meet the administrative, reactive, self-initiated, and patrol requirements). The resulting number of troopers is then adjusted for the use of two- officer patrol units, specialized units, and, if applicable, minimum staffing requirements.

2. Determine the average number of on-duty field supervisors required to support the average daily on-duty trooper requirement. The number of troopers may be adjusted to account for patrol workload performed by field supervisors.

3. Determine the total staff requirement (i.e., the total number of personnel needed, both on and off-duty, to provide the required on-duty patrol presence) for the APA. The total staff requirement will include troopers, field supervisors, and staff and command personnel.

Average Daily On-Duty Trooper Requirement

The PAM model determines the average number of on-duty troopers that will be required each day (i.e., within each 24-hour period) based on the following formula (see Appendix D in the Guide for a derivation of this formula):

$$N = \frac{N_r + N_p}{1 - \frac{m_a}{60} - \frac{m_s}{60}}$$

where:

N - the average number of on-duty troopers required per day (i.e., per 24-hour period),

N_r - the average number of on-duty troopers required per day to service all CFS and accidents in the APA,

N_p - the average number of on-duty troopers required per day to provide the specified level of patrol in the APA,

1 - a constant,

m_a - the average number of minutes per hour spent on administrative activities by each on-duty trooper,

m_s - the average number of minutes per hour spent on self-initiated activities by each on-duty trooper, and

60 - a constant.

Much of the effort required to use the PAM model is spent determining appropriate values for N_r, N_p, m_s, and m_a based on the workload level, operational policies, and highway and traffic characteristics of the agency and patrol area. The basis for deriving each of these values is outlined below.

Number of troopers for reactive time workload (N_r). The average number of troopers required per day to provide service to all accidents and other CFS in the patrol area is based on the average total obligated time per day required for all accidents and other CFS and the agency shift length.

Number of troopers for patrol time (N_p). The average number of troopers required per day to provide patrol is based on two factors:

- the number of troopers required to provide an adequate level of patrol visibility as measured by the "patrol interval" (i.e., the average time between trips past any given point on the highway); and
- the number of troopers required to insure a timely response to CFS.

The number of troopers required for visibility is based on the miles of highway to be patrolled, the hours of coverage per week, the average patrol speed, the shift length, and the desired patrol interval by highway type. As an example, a patrol interval of eight hours indicates that a trooper will be observed on

patrol on a given highway segment about once every eight hours or three times per day.

Two criteria are available in the PAM model for determining the number of troopers required for a timely response to CFS. The number can be determined based on either:

- the percentage of CFS for which a trooper is immediately "available" (i.e., a trooper not currently involved in a CFS, self-initiated, or administrative activity), or
- the average travel time to each CFS.

The number of troopers required for immediate response is based on the average number of troopers required per shift for reactive time activities, the hours of coverage per week, and the immediate response percentage set by the agency. Travel time values are based on the area of the patrol area (or highway miles for line patrol), the hours of coverage per week, the average response speed, the shift length, and the average travel time objective set by the agency.

Self-initiated time per hour per trooper (m_s). The PAM model does not attempt to directly determine the total number of troopers that are necessary for all self-initiated activities. To produce such a value would require an accurate measure of the total self-initiated workload for the agency (i.e., the total time that an agency should spend on these activities within the patrol area.) To avoid the difficulties associated with determining this value, the PAM model focuses on the self-initiated effort of each trooper as measured by the historical or specified number of minutes per hour spent on self-initiated activities (m_s). The PAM model allows the user to either directly specify a value for m_s or to derive a value based on self-initiated statistics from previous years.

Administrative time per hour per trooper (m_a). Paralleling the rationale for determining m_s given above, the PAM model does not attempt to determine the total administrative workload of the patrol force, but rather focuses on the amount of administrative time required per hour per trooper (m_a). The PAM model permits the user to either directly specify a value for m_a or to base it on agency experience.

Adjustments to the Average Daily Number of On-Duty Troopers

The initial value for the average number of on-duty troopers required per day is examined to determine whether additional or fewer troopers are needed because of:

- the use of two-trooper patrol units,

- o patrol provided by troopers assigned to specialized units, and
- o minimum staffing levels.

Average Daily Number of On-Duty Field Supervisors

The average number of on-duty troopers required per day serves as the basis for determining the number of on-duty field supervisors that will be required. Two factors are used to determine the final number of on-duty troopers and supervisors: (1) the average number of troopers supervised by each field supervisor (set by agency policy), and (2) the fraction of each field supervisor's time that is spent on patrol (or non-supervisory) activities.

Total Staff Requirements

Worksheet 8 of the PAM model is used to determine the total number of personnel, both on- and off-duty, required to support the average number of on-duty troopers and field supervisors required per day. The total number of personnel consists of troopers, field supervisors, and staff and command personnel. The total number of troopers and field supervisors is based on the shift relief factor for the agency. This factor indicates the average number of persons required to staff one shift position every day, and is based on the shift length of the agency and the average number of on-duty patrol hours that can be expected from each officer per year.

The number of staff and command personnel required is determined in one of two ways: either the user specifies the number of personnel required directly, or determines the number required based on the current rank and staffing distribution of the agency.

Total Staff Allocation

The final worksheet in the Manual (Worksheet 9 in Chapter 4) is used to determine staff allocation over several geographic areas based on the PAM staffing estimates for each APA and the actual total number of staff personnel available for the deployment. Although the discussion in this section and Chapter 4 refers only to the allocation of staff over several APAs (i.e., over geographic "areas"), the logic of the allocation procedures can be applied equally well for staff allocation over time periods or domains (e.g., over shifts or days of the week). However, to use Worksheet 9 for different time areas requires that PAM staffing estimates must be determined for each time period of interest within each APA.

Worksheet 9 can be used to determine two kinds of allocations.

Unconstrained Allocation

Unconstrained allocation refers to a redistribution of all available staff among several APAs according to the relative percentage of staff in each APA based on the staff estimates determined by the PAM model. Such an allocation is called "unconstrained" because it is possible that a reallocation of the total staff may produce a deployment in which some APAs gain staff and other APAs lose staff.

Constrained Allocation

Constrained allocation refers to a reallocation of staff under the following limitations:

- o if the total staff is to be increased, no APA will lose staff because of the reallocation, or
- o if the total staff is to be decreased, no APA will gain staff because of the reallocation.

The process for determining the allocation under these limitations consists of the following steps:

1. The results of the unconstrained allocation are used to identify each APA as either over or understaffed.

2a. If the total staff is to be increased, the additional staff (i.e., the difference between the current total staff and the final total staff) is allocated, based on the PAM staffing estimates for each APA, only to those APAs that are currently understaffed; (Staffing levels for overstaffed APAs remain unchanged.) or

2b. If the total staff is to be decreased, the staff reduction (i.e., the difference between the current total staff and the final reduced total staff) is allocated, based on the PAM staffing estimates for each APA, only to those APAs that are currently overstaffed. (Staffing levels for understaffed APAs remain unchanged.)

It is possible under the limitations of constrained allocation that, even after reallocation, some APAs may still be over or understaffed.

Limitations of the PAM Model

The PAM model, as presented in this document, should be viewed as a generic procedure which must be adapted to fit the mission, physical environment, highway system, and operational idiosyncrasies of each state agency. The missions of state-wide law enforcement departments in the United States range from full-service state police agencies to highway patrols limited almost exclusively to traffic responsibilities. The varieties of agency missions, in turn, exist within a wide range of environmental and highway settings.

In addition, there are a number of issues which, although addressed in a general sense in the PAM model, represent relationships and circumstances for which additional research and operational experience are needed. Some of these areas include:

- the impact of local law enforcement agencies upon the mission and resource requirements of state agencies;
- the relationship between the amount of self-initiated work and various highway and traffic characteristics;
- the determination of travel time for large non-urban areas with sparse highway systems; and
- the determination of staffing requirements for high-volume, high-density, urban interstate and expressway systems.

CHAPTER 3: PAM Instructions and Worksheets for Determining Total Staff Requirements

Introduction

This chapter provides a systematic format and process for determining the total staff requirements for state-wide agencies providing police traffic services in autonomous patrol areas. The process is presented in a series of eight worksheets entitled:

Worksheet 1: Operations, Workload, and Highway Data

Worksheet 2: Administrative Time

Worksheet 3: Reactive Time

Worksheet 4: Proactive Time - Self-initiated

Worksheet 5: Proactive Time - Patrol

Worksheet 6: Average Daily Number of On-Duty Troopers

Worksheet 7: Special Assignments and Field Supervision

Worksheet 8: Total Staff Requirement

Worksheet Format

The same format for data entry and calculation is utilized within each worksheet. The beginning and end of each section or procedure in the worksheet is identified with a double line. Each section, in turn, consists of a series of individual steps. For each step, a numeric value is obtained and recorded in a box on the right-hand side of the worksheet. Each box is labeled with a numeric identifier to facilitate reference to values that are used in later steps or worksheets. The numeric value that is recorded for each step is obtained in one of four ways:

- data collection,
- policy decision,
- referenced from an earlier step, or

- o calculated using the method or formula given in the worksheet based on numeric quantities from previous steps.

Two methods are used to highlight important results:

1. The box is drawn with double lines, and/or

2. A letter notation, shown in parentheses to the right of the box, is used to identify the result.

Preceding each worksheet is a brief description of its purpose followed by instructions for individual steps and the anticipated source of required data items; that is: data collection (D); policy decision or current agency practice (P), referenced value (R), or calculation (C).

For some procedures, more than one method is available for obtaining a particular data item. When two or more options are presented, they are separated by a pair of horizontal lines with the word "OR" between them.

Terminology, Notation, and Key Assumptions

Appendix B in the Guide presents definitions for key terms that are used in the PAM instructions and worksheets. The appendix also lists and identifies all notations that are used in the worksheet formulas.

Within the Manual, the term "patrol" is defined and used in two ways. The specific or narrow definition of patrol refers to one of the four time categories used in the PAM model. (See discussion in Chapter 2.) The "patrol" time category includes time spent in the field while not engaged in reactive, self-initiated, or administrative activities. This definition of patrol is sometimes referred to as "preventive patrol" or "uncommitted time" by other authors. The total patrol time per hour equals the time left over when the average number of minutes per hour that are spent on reactive, self-initiated, and administrative activities are subtracted from 60 minutes. When the generic or more traditional definition of patrol is used, it refers to all field activities; that is, this definition of "patrol" includes some of the activities associated with the reactive, self-initiated, administrative, and patrol activities used in the PAM model. The appropriate meaning of "patrol" in the Manual is indicated by the context in which it is used.

The PAM model is based on a number of assumptions that are identified in the instructions preceding each worksheet. Two key assumptions that should be kept in mind are:

1. The total staff requirement determined with the worksheets is only applicable to autonomous patrol

areas (APA). If a district or zone consists of more than one APA, the total staffing requirement for the district or zone is obtained by determining the staffing requirement for each APA and then adding the results together.

2. The procedures used in worksheets 1-5 and Section 6.1 of Worksheet 6 assume the use of only one trooper for each patrol unit. As a result, the phrases "number of troopers" and "number of patrol units" are used interchangeably. An adjustment for the use of two-trooper patrol units is presented in Section 6.2 in Worksheet 6.

Instructions for Worksheet 1: Operations, Workload, and Highway Data

Worksheet 1 is used to identify most of the data items that will be used in worksheets 2-8. Worksheet 1 is not a complete list of all of the data items that may be needed since several of the worksheets permit the use of optional procedures, each requiring a slightly different set of data items, to obtain a particular result. (A complete list of all input data items is presented in Appendix A in the Guide.)

Some of the procedures permit the user to provide data for three categories of highways within an APA: controlled-access, primary, and secondary. Federal definitions for each highway type are provided in Appendix B in the Guide. Some users may prefer to modify these definitions to make better use of data sources within their agency or jurisdiction which rely on different highway type definitions. It is not necessary to use all three highway types and, if needed, additional highway types can be added with slight modifications to the model.

Instructions for Individual Steps

1.1 Name of the autonomous patrol area (usually a district, zone, or county) (D).

1.2 Operations Data for the APA

1.2.1 Shift length is the number of hours each trooper is on duty for one tour or watch or shift (P). If shift length varies by trooper or assignment, an average value should be used.

1.2.2 The average number of "on-duty" hours per year per trooper refers to the actual number of hours that a trooper appears for regular duty each year (D). This number should include both regularly scheduled on-duty time and paid overtime. (See discussion below about "off-duty" time.)

The average number of actual on-duty hours may be determined in a number of ways. The agency may have a system that keeps track of the number of on-duty patrol hours for each trooper. The average number of hours is obtained by adding all of the on-duty patrol hours and dividing by the number of troopers. In some agencies, it may be easier to determine the average

on-duty hours per year per trooper by assuming that each trooper works one shift on patrol every day and then subtracting the average number of off-duty hours per year per trooper. If this method is used, paid overtime hours must be added to the total number of on-duty hours.

"Off-duty" time consists of:

(1) regular days off (e.g., two days off per week),

(2) benefit days off (i.e., time off for vacations, holidays, illness, compensatory time, etc.) Note: only compensatory time off in excess of straight time is counted as time off (e.g., if a trooper works two days of overtime at time and a half, the trooper receives a total of three days of compensatory time. Only the excess or "benefit" time of one day is counted as time off in computing the average time off per year.), and

(3) special assignments which remove the trooper from field operations (e.g., training that lasts for more than one day). Roll-call training is included in administrative time (m_a).

1.2.3 Average number of troopers to be supervised by one field supervisor (P).

1.2.4 Percentage of field supervisor on-duty time spent on patrol activities (D).

"Patrol activity" refers to any activity that would be performed by a trooper if the field supervisor was not present. Alternatively, patrol activities for field supervisors can be thought of as all non-supervisory activities. The percentage is a number between 0 and 100. A value of 0 indicates that each field supervisor spends no (zero) time on patrol activities. A value of 50 indicates that each field supervisor spend an average of 50% of his/her time on patrol activities.

1.2.5 Patrol operations - controlled-access highways

1.2.5.1 Coverage per week (P)(D).

The number of hours that controlled-access highways in the patrol area are covered per week. A highway is considered "covered" during a shift if at least one trooper has patrol

responsibility for the highway. Note that a "covered" highway does not imply that the patrol level is adequate; merely that at least one unit has patrol responsibility for it whether it can provide adequate coverage or not.

Coverage is expressed in hours per week (i.e., a number between 0 hours (no coverage) and 168 hours (coverage 24 hours per day, seven days a week). Coverage in shifts per week can be easily converted to hours; e.g.,

Patrol Coverage, Number of 8-Hours Shifts per Week	Patrol Coverage, Number of Hours Per Week
21	168
14	112
5	40

If coverage varies by highway location, determine an overall average level of coverage based on the following formula (assumes three coverage levels):

$$\text{Average Coverage (hrs/wk)} = \frac{H_1 \times M_1 + H_2 \times M_2 + H_3 \times M_3}{M_1 + M_2 + M_3}$$

where:

H_1, H_2, H_3 - Hours of coverage for segments 1, 2, and 3.

M_1, M_2, M_3 - Miles of segments 1, 2, and 3.

1.2.5.2 Average patrol speed (D).

The average speed (MPH) of units while on "patrol" only (i.e., it does not include the average speed during travel to an accident or other CFS or travel while performing administrative or self-initiated activities). This value can

be determined by dividing the miles driven per shift (excluding miles driven for reactive, self-initiated, and administrative activities) by the time spent on patrol during the shift. Patrol time equals the shift length minus time spent on accidents, other CFS, self-initiated, and administrative activities. Note that patrol time includes time spent on stationary patrol and time spent on moving patrol even when speeds are reduced because of traffic volumes or control devices.

1.2.5.3 Patrol interval performance objective (P).

The patrol interval indicates the frequency with which a trooper will pass a given point on a highway. Measured in hours, it is the average length of time a stranded motorist would have to wait for a trooper to come by on patrol. As the patrol interval objective is lowered, the number of troopers required increases. As examples, consider the table below (based on 8-hour shifts):

Patrol Interval (hours)	Patrol Frequency (times past fixed location)
2	4 times per shift
4	2 times per shift
8	once a shift
24	once per day
168	once per week

Note that "patrol interval" and "patrol coverage" are not directly related. Patrol coverage merely indicates responsibility for patrolling a highway segment. The patrol interval determines the extent or intensity of the coverage.

1.2.6 Patrol operations - primary highways

See instructions for steps 1.2.5.1 - 1.2.5.3.

1.2.7 Patrol operations - secondary highways

See instructions for steps 1.2.5.1 - 1.2.5.3.

1.3 Workload Data for the APA

1.3.1 Total number of days in the sample period (D).

Collect accident and other CFS data for the previous 1, 2, or 3 years.

1.3.2 Total number of accidents during the sample period (D).

Total number of accidents serviced or investigated by the agency during the sample period. Includes accidents in which the agency provides backup services.

1.3.3 Average service time (hours) per accident (D).

The average time required to handle one accident. The average time can be determined on the basis of a sample of 100 or more accidents. The average service time for an accident includes:

- travel time to the accident,
- on-scene time,
- report writing time,
- follow-up investigation time, and
- time charged by all agency units assigned to the accident.

Note that the average service time for accidents does <u>not</u> include dispatching time.

1.3.4 Total number of other CFS during the sample period (D).

Total number of other CFS handled by the agency during the sample period. Includes CFS for which the agency provides backup support.

1.3.5 Average service time (hours) per other CFS (D).

The average time required to process one CFS. The average time can be determined on the basis of a sample of 100 or more other CFS. The average service time for a CFS includes:

- travel time to the CFS,
- on-scene time,
- report writing time,
- follow-up investigation time, and

- time charged by all agency units assigned to the CFS.

Note that the average service time for other CFS does not include dispatching time.

1.4 Roadway Data for the APA

For steps 1.4.1 - 1.4.3, enter the number of miles in the patrol area for controlled-access, primary, and secondary highways using either the highway type definitions provided in Appendix B in the Guide or an alternate set of definitions provided by the user.

The total miles determined should be based on highways in the jurisdiction of the agency that are routinely patrolled by agency personnel. Highway miles within a municipality that are considered within the jurisdiction of the state-wide agency, but are not usually patrolled by state agency personnel would not be included.

Note that if visibility or access to opposing lanes is limited (e.g., on some interstate highways and urban expressways), each direction of travel can be considered as a separate highway in determining total length.

WORKSHEET 1: Operations, Workload, and Highway Data

Objective: Identify data items to be used for determining the number of state-wide traffic services personnel within an APA.

Method: Data is identified as either operations, workload, or highway.

1.1 Autonomous Patrol Area Name . . [ ] (1.1)

1.2 Operations Data for the APA

1.2.1 Shift length (hours) . . . . . [ ] (1.2.1)

1.2.2 Average number of on-duty hours per year per trooper . . . . [ ] (1.2.2)

1.2.3 Average number of troopers to be supervised by each field supervisor . . . . . [ ] (1.2.3)

1.2.4 Percentage of field supervisor on-duty time spent on patrol, reactive, and self-initiated activities . . . . . [ ] (1.2.4)

1.2.5 Patrol operations - controlled-access highways

1.2.5.1 Coverage per week (hours), (maximum value = 168) . . . [ ] (1.2.5.1)

1.2.5.2 Average patrol speed (MPH) . . . . . [ ] (1.2.5.2)

1.2.5.3 Patrol interval performance objective (hours) . . . . . [ ] (1.2.5.3)

1.2.6 Patrol operations - primary highways

1.2.6.1 Coverage per week (hours), (maximum value = 168) . . . [ ] (1.2.6.1)

1.2.6.2 Average patrol speed (MPH) . . . . . [ ] (1.2.6.2)

1.2.6.3 Patrol interval performance objective (hours) . . . . . [ ] (1.2.6.3)

1.2.7 Patrol operations - secondary highways

1.2.7.1 Coverage per week (hours), (maximum value = 168) . . . [ ] (1.2.7.1)

1.2.7.2 Average patrol speed (MPH) . . . . . [ ] (1.2.7.2)

1.2.7.3 Patrol interval performance objective (hours) . . . . . [ ] (1.2.7.3)

1.3 Workload Data for the APA

1.3.1 Total number of days in the sample period . . . . . [ ] (1.3.1)

1.3.2 Total number of accidents handled by the agency during the sample period . . . . . [ ] (1.3.2)

1.3.3 Average service time (hours) per accident . . . . . [ ] (1.3.3)

1.3.4 Total number of other CFS handled by the agency during the sample period . . . . . [ ] (1.3.4)

1.3.5 Average service time (hours) per CFS . . . . . [ ] (1.3.5)

1.4 Highway Data for the APA

1.4.1 Controlled-access highways (miles) . . . . . [ ] (1.4.1)

1.4.2 Primary highways (miles) . . . . . [ ] (1.4.2)

1.4.3 Secondary highways (miles) . . . . [ ] (1.4.3)

Instructions for Worksheet 2: Administrative Time

Worksheet 2 is used to determine the average number of minutes per hour per trooper spent on administrative activities (e.g., on-duty court time, range training, etc.). Either of two procedures can be used to obtain a value for the administrative time (m_a). In Section 2.1, the user specifies the value directly. In Section 2.2, the user determines the value based on agency administrative workload information for the APA. Care must be taken in defining what agency activities will be included as administrative time to insure that all non-patrol time is included and that no activities are counted more than once. (See Section 3 in the Guide.)

Instruction for Individual Steps

2.1 User specifies average number of minutes per hour per trooper spent on administrative time (P).

2.2 Determine m_a based on the historical experience of the agency within the APA (D).

2.2.1 Select a sample period (e.g., one year) and collect data that indicates the total amount of time (hours) spent by the patrol force on administrative activities during the sample period within the APA.

2.2.2 Determine the number of on-duty hours provided by the patrol force within the APA during the sample period used for Step 2.2.1.

2.3 Administrative Time

User selects a value for m_a based on either section 2.1 or 2.2.

Note that the value selected for m_a (Step 2.3) must satisfy the following condition:

$$0 \leq m_a < 60.$$

This condition requires that the total administrative time per hour for administrative activities must be greater than or equal to zero minutes and less than 60 minutes. In practice, administrative time per trooper is usually less than 20 minutes per hour.

WORKSHEET 2: Administrative Time

Objective: Determine the average number of minutes per hour per trooper to be spent on administrative activities within the APA (m_a).

Method: Based either on policy decision or historical experience.

OPTION: Complete Section 2.1 or Section 2.2.

2.1 Average Number of Minutes Per Hour Per Trooper - Policy Decision

Select administrative time performance objective in minutes per hour per trooper . . . . . [ ] (2.1)

Continue with Section 2.3.

OR

2.2 Average Number of Minutes Per Hour Per Trooper - Historical Experience

2.2.1 Total time (hours) spent on administrative activities within the APA during the sample period . [ ] (2.2.1)

2.2.2 Total on-duty hours by patrol troopers within the APA during the sample period . . . . . [ ] (2.2.2)

2.2.3 Fraction of time spent on administrative activities, divide: (2.2.1) ÷ (2.2.2) . . . . [ ] (2.2.3)

2.2.4 Average number of minutes per hour per trooper, multiply: (2.2.3) x 60 . . . . . [ ] (2.2.4)

2.3 Administrative Time

Minutes per hour per trooper, select either (2.1) or (2.2.4) . . . . . [ ] (m_a) (2.3)
(note: $0 \leq m_a < 60$)

Instructions for Worksheet 3: Reactive Time

Worksheet 3 is used to determine the average number of on-duty troopers (N_r) that are needed each day to handle accidents and other CFS within an APA. The average number of on-duty troopers required per day is determined with the formula:

$$N_r = \frac{\text{Average Total Obligated Time (hours) Per Day For Accidents and Other CFS}}{\text{Shift Length (hours)}}$$

Derivation of this formula is presented in Section D.1 in Appendix D in the Guide.

Sections 3.1 and 3.2 are used to determine the average obligated time per day for accidents and other CFS respectively. If desired, the "other CFS" category can be divided into subcategories (e.g., other agency assists, criminal calls, etc.) for informational purposes. The total average obligated time per day is obtained in Step 3.3.1, and the number of on-duty troopers is calculated in Step 3.3.3.

Agencies that are using computer-aided dispatching (CAD) systems may be able to obtain the total obligated time data required for steps 3.1.3 and 3.2.3 directly. Agencies that use this approach should insure that the total time reported by the CAD system includes all of the elements of obligated time; i.e.,

- travel time to the scene,
- on-scene time,
- report writing time,
- follow-up investigation time, and
- time consumed by all units involved with the incident.

WORKSHEET 3: Reactive Time

Objective: Determine the number of troopers required to handle accidents and other CFS within an APA (N_r).

Method: Based on the total time required to handle all accidents and other CFS, and the shift length.

3.1 Daily Service Time Requirement for Accidents

3.1.1 Total number of accidents within the APA during the sample period, use (1.3.2) . . . . (3.1.1)

3.1.2 Average service time (hours) for each accident, use (1.3.3) . . (3.1.2)

3.1.3 Total obligated time for accidents within the APA during the sample period, multiply: (3.1.1) x (3.1.2) . . . (or enter directly from CAD system) (3.1.3)

3.1.4 Total number of days in the sample period, use (1.3.1) . . . . (3.1.4)

3.1.5 Average workload per day for accidents (hours), divide: (3.1.3) ÷ (3.1.4) . . . . . (3.1.5)

3.2 Daily Service Time Requirement for Other CFS

3.2.1 Total number of other CFS within the APA during the sample period, use (1.3.4) . . . . (3.2.1)

3.2.2 Average service time (hours) for each CFS, use (1.3.5) . . . . (3.2.2)

3.2.3 Total obligated time for other CFS within the APA during the sample period, multiply: (3.2.1) x (3.2.2) . . . (or enter directly from CAD system) (3.2.3)

3.2.4 Total number of days in the sample period, use (1.3.1) . . . . (3.2.4)

3.2.5 Average workload per day for other CFS (hours), divide: (3.2.3) ÷ (3.2.4) . . . . . (3.2.5)

3.3 Total Number of Troopers Required per Day for Reactive Time

3.3.1 Total average workload per day within the APA (hours), add: (3.1.5) + (3.2.5) . . . . . (3.3.1)

3.3.2 Shift length (hours), use (1.2.1) . . . . . (3.3.2)

3.3.3 Average number of on-duty troopers required per day within the APA to meet the average daily workload, divide: (3.3.1) ÷ (3.3.2) . . . . . (3.3.3) (N_r)

Instructions for Worksheet 4: Proactive Time - Self-initiated

Worksheet 4 is used to determine the average number of minutes per hour (m_s) each trooper spends on self-initiated activities within the APA. Three alternative procedures are available to determine m_s. The user can either:

(1) select the value directly based on agency policy (Section 4.1),

(2) select the value indirectly by specifying a number of self-initiated contacts per shift per trooper, the shift length of the agency, and the average time per contact (based on agency experience within the APA) (Section 4.2), or

(3) determine the value based on agency workload experience within the APA (Section 4.3).

Instructions for Individual Steps

4.1 User selects the average number of minutes per hour per trooper to be spent on self-initiated activities within the APA (P).

4.2 User selects m_s based a performance objective of the average number of self-initiated contacts (i.e., warnings, citations, assists, etc.) per shift, the agency shift length, and the average time per contact within the APA (P) (D).

4.2.1 Collect data to determine the total number of self-initiated contacts within the APA during a specified sample period (e.g., one year).

4.2.2 Determine the total time (hours) spent on self-initiated activities by the patrol force within the APA during the same sample period used for Step 4.2.1.

4.3 Determine m_s based on agency experience within the APA (D).

4.3.1 Determine the total time (hours) spent on self-initiated activities within the APA during a sample period (e.g., one year). Note: the total hours indicate the time actually spent handling self-initiated activites; i.e., issuing violations, assisting disabled motor-

ists, etc. It does not include the time spent in looking for these activities.

4.3.2 Determine the total on-duty hours by the patrol force within the APA during the sample period used for Step 4.3.1.

4.4 Proactive Time (Self-initiated)

User selects a value for m_s based on either section 4.1, 4.2, or 4.3.

Note that the values selected for m_a (Section 2.3) and m_s (Section 4.4) must satisfy the following conditions:

$$0 \leq m_a < 60,$$

$$0 \leq m_s < 60, \text{ and}$$

$$0 \leq m_a + m_s < 60.$$

These conditions require that the total time per hour for administrative activities, self-initiated activities, and for administrative and self-initiated activities combined must be greater than or equal to zero minutes and must be less than 60 minutes. In practice, self-initiated time per hour is usually less than 15 minutes.

The PAM field test results suggest that the combined times for administrative and self-initiated activities (i.e., $m_a + m_s$) for most agencies falls into the range 15 - 30 minutes per hour; i.e.,

$$15 \leq m_a + m_s \leq 30.$$

It should be noted that the general structure of the PAM model is predicated on the assumption that the combination of administrative and self-initiated activities does not consume a majority of available patrol time (i.e, that $m_a + m_s \leq 30$ minutes). The use of combined times for administrative and self-initiated activities greater than 30 minutes is not recommended.

WORKSHEET 4: Proactive Time - Self-initiated

Objective: Determine the average number of minutes per hour per trooper to be spent on self-initiated activities within the APA (m_s).

Method: Based either on policy decision or historical experience within the APA.

OPTION: Complete Section 4.1 or Section 4.2 or Section 4.3.

4.1 Average Number of Minutes Per Hour Per Trooper - Policy Decision (Direct)

Select self-initiated performance objective for the APA, minutes per hour per trooper . . . . . [ ] (4.1)

Continue with Section 4.4

OR

4.2 Average Number of Minutes Per Hour Per Trooper - Policy Decision (Indirect)

4.2.1 Total number of self-initiated contacts within the APA during the sample period . . . . . [ ] (4.2.1)

4.2.2 Total time (hours) spent on self-initiated contacts within the APA by all troopers on patrol during the sample period . [ ] (4.2.2)

4.2.3 Average time (hours) per self-initiated contact within the APA during the sample period, divide: (4.2.2) ÷ (4.2.1) . . . . [ ] (4.2.3)

4.2.4 Select number of self-initiated contacts <u>per shift</u> per trooper performance objective . . . . . [ ] (4.2.4)

4.2.5 Shift length (hours), use (1.2.1) . . . . . [ ] (4.2.5)

4.2.6 Number of self-initiated contacts per hour per trooper, divide: (4.2.4) ÷ (4.2.5) . . . . [ ] (4.2.6)

4.2.7 Self-initiated performance objective for the APA in minutes per hour per trooper, multiply: 60 x (4.2.3) x (4.2.6) . . . . . [ ] (4.2.7)

Continue with Section 4.4

OR

4.3 Average Number of Minutes Per Hour Per Trooper - Historical Experience

4.3.1 Total time (hours) spent on self-initiated contacts within the APA by all troopers on patrol during the sample period, (same as (4.2.2)) . . . . . [ ] (4.3.1)

4.3.2 Total on-duty hours by troopers on patrol within the APA during the sample period, (same as (2.2.2)) . . . . . [ ] (4.3.2)

4.3.3 Fraction of time spent on self-initiated activities within the APA during the sample period, divide: (4.3.1) ÷ (4.3.2) . . . . . [ ] (4.3.3)

4.3.4 Average number of minutes per hour per trooper to be spent on self-initiated activities within the APA, multiply: 60 x (4.3.3) . . [ ] (4.3.4)

4.4 Proactive Time (Self-initiated)

Minutes per hour per trooper, select either (4.1) or (4.2.7) or (4.3.4) (note: $0 \leq m_s < 60$) . . . . . [ ] (m_s) (4.4)

Instructions for Worksheet 5: Proactive Time - Patrol

Worksheet 5 is used to determine the number of troopers (N_p) that are required for an adequate level of patrol to provide visibility for general deterrence and availability for the timely response to accidents and other CFS within the APA.

Section 5.1 is used to determine the number of troopers that are required to meet the patrol interval level specified by the user for each highway type within the APA. The formula for the number of troopers (used in steps 5.1.2.5, 5.1.3.5, and 5.1.4.5) is based on:

- the number of highway miles,
- the hours of patrol coverage per week,
- the average patrol speed (MPH),
- the shift length (hours), and
- the patrol interval (hours) set by agency policy.

The total number of troopers required for patrol equals the sum of the number of troopers needed for each highway type (Step 5.1.5). The derivation of the formula used in steps 5.1.2.5, 5.1.3.5, and 5.1.4.5 is presented in Section D.2 in Appendix D in the Guide.

The number of troopers required for timely response is determined using either steps 5.2, 5.3, or 5.4. Section 5.2 determines the number of troopers that must be available to insure that at least one trooper will be available in the APA during the hours of coverage for immediate dispatch or action for a user-specified percentage of all accidents, CFS, and self-initiated activities. The number of required troopers is based on the number of troopers required for reactive activities, the immediate response percentage set by the agency, the hours of patrol coverage per week, and the values determined for m_a and m_s in worksheets 2 and 4.

Two procedures are available for determining the number of troopers. A simplified procedure based on Table 3-1 is presented in Section 5.2. If the simplifying assumptions used in Section 5.2 are not valid, a supplemental worksheet in Appendix A can be used. For either procedure, the final number of patrol officers required is obtained from a table (either Table 3-1 for Section 5.2 or one of several tables in Appendix A) based on a queuing theory model that assumes that accidents, other CFS, and self-

initiated activities occur randomly and that service times are distributed exponentially. The derivations of the formulas and procedures used in Section 5.2 and in the Supplemental Worksheet are presented in Section D.3 in Appendix D in the Guide.

Sections 5.3 and 5.4 determine the number of troopers that must be available in the APA to provide a specified average travel time. Section 5.3 is used when patrol is provided over a designated geographic area and Section 5.4 is used when a trooper is assigned to a line or linear patrol consisting of a highway segment only.

The formula for the number of troopers required for area patrol (Step 5.3.6) is based on the:

- shift length (hours),
- area (square miles) of the APA,
- patrol coverage per week (hours),
- average response speed (MPH), and
- average travel time specified by the agency.

The derivation of the formula for travel time for area patrol is presented in Section D.4 in Appendix D in the Guide.

The formula for the number of troopers required for line patrol (Step 5.4.6) is based on the:

- shift length (hours),
- number of highway miles,
- patrol coverage per week (hours),
- average response speed (MPH), and
- average travel time specified by the agency.

The derivation of the formula for travel time for line patrol is presented in Section D.5 in Appendix D in the Guide.

Whether response time is based on area or line patrol, the average response speed that is used should be equal to or greater than the average patrol speed used in Section 5.1.

The average number of troopers per day for patrol (N_p) is determined by calculating the number of troopers required for visibility (Step 5.1.5) and the number of troopers required for timely response (Step 5.5) and using the larger of the two values (Step 5.6).

Instructions for Individual Steps

5.1 Patrol Visibility

5.1.2.3 In Worksheet 1, the average patrol speed (MPH) is defined as the average speed while on "patrol" only. Patrol is defined as total shift time minus time spent on reactive (i.e., accidents and CFS), self-initiated, and administrative activities. Some agencies make a distinction between "moving" and "stationary" patrol. The PAM model does not make this distinction and the average patrol speed used in the PAM model should be based on both moving and stationary patrol time. If the average patrol speed is known for moving patrol time only, it is possible to estimate the overall patrol speed with the formula given below.

Average Patrol Speed (MPH)	=	Average Patrol Speed (moving) (MPH)	x	Fraction of Time on Moving Patrol

As an example, if the average speed during moving patrol is estimated to be 40 MPH and moving patrol time represents approximately 50% of total patrol time, then the average patrol speed that should be used in the PAM model is 20 MPH (i.e., 20 = 40 x .50). The fraction of time on moving patrol (a number between 0 and 1) is obtained by dividing the percent of time by 100. Notice that if all patrol time is spent on moving patrol, the average speed patrol for the PAM model equals the average speed for moving patrol.

5.1.3.3 See discussion above for Step 5.1.2.3.

5.1.4.3 See discussion above for Step 5.1.2.3.

5.2 Patrol Availability - Immediate Response

Determination of the number of troopers needed for immediate response in Section 5.2 is based on three simplifying assumptions:

1. staffing is uniform over all shifts,

2. the values for m_a (Step 2.3) and m_s (Step 4.4) are approximately 15 and 9 minutes per hour per trooper respectively, and

3. the same user-specified immediate response performance objective is used for each shift.

If any of these assumptions are not valid, the user should use the Supplemental Worksheet in Appendix A to determine the number of troopers needed to satisfy the immediate response performance objective. As a rule of thumb, shift staffing can be considered uniform if the proportion of staff on each shift is within 10% of exact uniform staffing level for each shift. The table below indicates the range of staffing for operations with 2, 3, and 4 shifts.

Number of Shifts	Uniform Staffing — Percent of Staffing on Each Shift: Exact	Range
2	50.0	45.0 - 55.0
3	33.3	30.0 - 36.7
4	25.0	22.5 - 27.5

5.2.6 Specify the percentage of calls for which at least one trooper will be available for immediate dispatch (P). Select a percentage value that corresponds to one of the columns in Table 3-1. The lowest value is 50% and the highest is 99%.

5.2.7 Determine the number of troopers needed with Table 3-1.

Using Table 3-1:

- Examine the left-hand column of the table and select the row that is closest to the average daily number of troopers per shift (Step 5.2.5) that are needed to handle the obligated time workload (N_r).

- Read across the row until the percentage at the top of the column equals or exceeds the agency performance objective percentage (Step 5.2.6).

- The table entry indicates the average number of troopers that are needed on each shift to meet the agency specified percentage. Enter the table value in (5.2.7).

5.3 Patrol Availability - Travel Time for Area Patrol

This section is used to determine the average number of troopers required for patrol within the APA during hours of coverage to provide a user-specified average travel time response to CFS for area patrol (i.e, patrol activities not restricted to a highway segment).

5.3.4 Average response speed (MPH) (D).

The average speed of a patrol unit while responding to a CFS. The average speed is usually lower than anticipated due to factors that may delay or impede a responding unit (e.g., heavy traffic, cornering, etc.)

5.3.5 Average travel time performance objective (minutes) (P).

The average travel time performance objective required to respond to all accidents and other CFS within the APA specified by the agency. It is important to note that this procedure is based on the average travel time, not the maximum time. The number of troopers determined in Step 5.3.6 will provide a level of trooper availability that will yield average travel times that will equal the performance objective value; that is, some travel times will be lower and some will be higher. The number of troopers obtained does not guarantee that the travel time will always be less than the agency-specified performance objective value.

5.4 Patrol Availability - Travel Time for Line Patrol

This section is used to determine the average number of troopers required for patrol within the APA during hours of coverage to provide a user-specified average travel time response to CFS for line patrol (i.e, patrol activities restricted to a highway segment). This step should only be used when troopers are assigned to specific highway segments with no responsibilities other than police services on the highway.

5.4.3 The total number of highway miles for line patrol depends on the access between opposite direction lanes. If complete access is available, the number of highway miles to be patrolled will equal the length of the segment. If, however, no access is available between the opposing direction lanes except at each end of the segment and at a limited number of cross-over points, the "effective" number of highway miles to be patrolled will be greater than the length of the segment. The chart below can be used to estimate the "effective" number of miles for line patrol that should be used for Step 5.4.3. To use the chart, find

the row that best corresponds to the number and location of crossover points along the highway segment. The entry for Step (5.4.3) is obtained by multiplying the length of the highway segment in miles by the value listed in the righthand column (Adjustment Factor) of the row.

Number of Access Points	Location of Access Points	Adjustment Factor
2	Each end of the segment . . .	3.000
3	Each end of the segment and middle of the segment . . .	2.250
4	Each end of the segment and two crossovers dividing the segment into thirds . .	1.889
5	Each end of the segment and three crossovers dividing the segment into fourths . .	1.689
6	Each end of the segment and four crossovers dividing the segment into fifths . .	1.560
Unlimited	Everywhere	1.000

5.4.4 See discussion for Step 5.3.4.

5.4.5 See discussion for Step 5.3.5.

WORKSHEET 5: Proactive Time - Patrol

Objective: Determine the number of troopers required within the APA to provide an adequate level of visibility and availability.

Method: Based on: (1) the patrol interval, and (2) the probability of immediate response to accidents and other CFS or the average travel time to accidents and other CFS.

5.1 Patrol Visibility

5.1.1 Shift length (hours), use (1.2.1) . . . . . [ ] (5.1.1)

5.1.2 Number of troopers needed per day for patrol on controlled-access highways in the APA

5.1.2.1 Miles of highway, use (1.4.1) . . . . . [ ] (5.1.2.1)

5.1.2.2 Hours of coverage per week, use (1.2.5.1) . . . . [ ] (5.1.2.2)

5.1.2.3 Average patrol speed (MPH), use (1.2.5.2) . . . [ ] (5.1.2.3)

5.1.2.4 Performance objective patrol interval (hours), use (1.2.5.3) . . . . . [ ] (5.1.2.4)

5.1.2.5 Number of troopers required per day to meet patrol interval performance objective for controlled-access highways with the APA, use the formula below . . . [ ] (5.1.2.5)

$$\text{Number of Troopers (5.1.2.5)} = \frac{\text{Highway Miles (5.1.2.1)} \times \text{Hours of Coverage Per Week (5.1.2.2)}}{7 \times \text{Average Patrol Speed (5.1.2.3)} \times \text{Shift Length (5.1.1)} \times \text{Perf. Obj. Patrol Interval (5.1.2.4)}}$$

5.1.3 Number of troopers needed per day for patrol on primary highways in the APA

5.1.3.1 Miles of highway, use (1.4.2) . . . . . [ ] (5.1.3.1)

5.1.3.2 Hours of coverage per week, use (1.2.6.1) . . . . [ ] (5.1.3.2)

5.1.3.3 Average patrol speed (MPH), use (1.2.6.2) . . . [ ] (5.1.3.3)

5.1.3.4 Performance objective patrol interval (hours), use (1.2.6.3) . . . . . [ ] (5.1.3.4)

5.1.3.5 Number of troopers required per day to meet patrol interval performance objective for primary highways within the APA, use the formula below . . . [ ] (5.1.3.5)

$$\text{Number of Troopers (5.1.3.5)} = \frac{\text{Highway Miles (5.1.3.1)} \times \text{Hours of Coverage Per Week (5.1.3.2)}}{7 \times \text{Average Patrol Speed (5.1.3.3)} \times \text{Shift Length (5.1.1)} \times \text{Perf. Obj. Patrol Interval (5.1.3.4)}}$$

5.1.4 Number of troopers needed per day for patrol on secondary highways in the APA

5.1.4.1 Miles of highway, use (1.4.3) . . . . . [ ] (5.1.4.1)

5.1.4.2 Hours of coverage per week, use (1.2.7.1) . . . . [ ] (5.1.4.2)

5.1.4.3 Average patrol speed (MPH), use (1.2.7.2) . . . [ ] (5.1.4.3)

5.1.4.4 Performance objective patrol interval (hours), use (1.2.7.3) . . [ ] (5.1.4.4)

5.1.4.5 Number of troopers required per day to meet patrol interval performance objective for secondary highways within the APA, use the formula below . . . . . [ ] (5.1.4.5)

$$\text{Number of Troopers (5.1.4.5)} = \frac{\text{Highway Miles (5.1.4.1)} \times \text{Hours of Coverage Per Week (5.1.4.2)}}{7 \times \text{Average Patrol Speed (5.1.4.3)} \times \text{Shift Length (5.1.1)} \times \text{Perf. Obj. Patrol Interval (5.1.4.4)}}$$

5.1.5 Total number of troopers required per day to meet patrol interval performance objective within the APA, add: (5.1.2.5) + (5.1.3.5) + (5.1.4.5) . [ ] (5.1.5)

OPTION: Complete Section 5.2 or Section 5.3 or Section 5.4 or the Supplemental Worksheet in Appendix A.

5.2 Patrol Availability - Immediate Response

5.2.1 Shift length (hours), use (1,2,1) . . . . . [ ] (5.2.1)

5.2.2 Coverage per week (hours), (maximum value = 168) . . . . . [ ] (5.2.2)

5.2.3 Calculate the effective number of shifts per day based on the formula below . . . . [ ] (5.2.3)

$$\text{Effective Number of Shifts Per Day (5.2.3)} = \frac{\text{Coverage Per Week (hours) (5.2.2)}}{7 \times \text{Shift Length (hours) (5.2.1)}}$$

5.2.4 Average daily number of on-duty troopers for reactive time, use (3.3.3) . . . . [ ] (N_r) (5.2.4)

5.2.5 Average daily number of on-duty troopers per shift (N_{rs}), divide: (5.2.4) ÷ (5.2.3) . . . . [ ] (N_{rs}) (5.2.5)

5.2.6 Performance objective, percentage of accidents, CFS, and self-initiated activities, immediate response (a number between 50 and 99) . . . . . [ ] (PIR%) (5.2.6)

5.2.7 Number of troopers required per shift, use (5.2.5), (5.2.6), and Table 3-1 . . . . . [ ] (5.2.7)

5.2.8 Total number of patrol troopers required per day within the APA to provide immediate response to the performance objective percentage of accidents and CFS, either multiply: (5.2.3) x (5.2.7) or enter value from Step (A.7) . . . [ ] (5.2.8)

Table 3-1

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.25)

Number of Reactive Troopers (N_{rs}) (5.2.5)	----- Performance Objective Immediate Response Percentage (PIR%) (5.2.6) -----										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.3	0.4	0.6	0.8	0.9	1.1	1.4	2.0	2.4	2.7	3.3
.10	0.3	0.5	0.7	0.8	1.0	1.2	1.5	2.1	2.5	2.8	3.4
.15	0.3	0.5	0.8	0.9	1.1	1.3	1.6	2.2	2.6	2.9	3.5
.20	0.4	0.6	0.8	1.0	1.1	1.3	1.7	2.2	2.7	3.0	3.6
.25	0.4	0.6	0.9	1.0	1.2	1.4	1.7	2.3	2.8	3.1	3.7
.30	0.5	0.7	0.9	1.0	1.2	1.5	1.8	2.4	2.8	3.2	3.8
.40	0.5	0.7	1.0	1.1	1.3	1.6	1.9	2.5	3.0	3.4	4.0
.50	0.6	0.8	1.0	1.2	1.4	1.7	2.0	2.7	3.1	3.5	4.2
.60	0.6	0.8	1.1	1.3	1.5	1.7	2.1	2.8	3.3	3.6	4.3
.80	0.6	0.9	1.2	1.4	1.6	1.9	2.3	3.0	3.5	3.9	4.6
1.00	0.8	1.0	1.3	1.5	1.7	2.0	2.5	3.2	3.7	4.1	4.8
1.20	0.8	1.1	1.4	1.6	1.8	2.2	2.6	3.4	3.9	4.3	5.1
1.60	0.9	1.2	1.5	1.8	2.0	2.4	2.9	3.7	4.3	4.7	5.5
2.00	1.0	1.3	1.7	1.9	2.2	2.6	3.1	4.0	4.6	5.0	5.9
2.50	1.1	1.4	1.8	2.1	2.4	2.8	3.4	4.3	4.9	5.4	6.3
3.00	1.2	1.5	2.0	2.3	2.6	3.0	3.6	4.6	5.2	5.8	6.7
4.00	1.3	1.7	2.2	2.5	2.9	3.4	4.0	5.1	5.8	6.4	7.4
5.00	1.5	1.9	2.4	2.8	3.2	3.7	4.4	5.5	6.3	6.9	8.0

Continue with Section 5.5.

OR

5.3 Patrol Availability - Travel Time for Area Patrol

5.3.1 Shift length (hours), use (1.2.1) . . . . . [ ] (5.3.1)

5.3.2 Coverage per week (hours) (maximum value = 168) . . . . . [ ] (5.3.2)

5.3.3 Area (square miles) of the APA . . . . . [ ] (5.3.3)

5.3.4 Average response speed (MPH) (equal to or greater than average patrol speed) . . . . . [ ] (5.3.4)

5.3.5 Average travel time performance objective (minutes) . . . . . [ ] (5.3.5)

5.3.6 Number of troopers required within the APA to meet the average travel time performance objective

5.3.6.1 Calculate K based on formula below . . . . . [ ] (5.3.6.1) **(K)**

$$K = \frac{40}{\text{Speed (MPH) (5.3.4)} \times \text{Time (min) (5.3.5)}}$$

5.3.6.2 Calculate K x K, multiply: (5.3.6.1) x (5.3.6.1) . . . [ ] (K^2)
(5.3.6.2)

5.3.6.3 Number of troopers required, use the formula below . . . . . [ ]
(5.3.6.3)

$$\text{No. of On-Duty Troopers, Area Patrol (5.3.6.3)} = \frac{K^2\ (5.3.6.2) \times \text{Area}\ (5.3.3) \times \text{Coverage Per Week (Hours)}\ (5.3.2)}{7 \times \text{Shift Length (hours)}\ (5.3.1)}$$

Continue with Section 5.5.

OR

5.4 Patrol Availability - Travel Time for Line Patrol

5.4.1 Shift length (hours), use (1.2.1) . . . . . [ ]
(5.4.1)

5.4.2 Coverage per week (hours), (maximum value = 168) . . . . . [ ]
(5.4.2)

5.4.3 Total highway miles to be patrolled within the APA . . . . . [ ]
(5.4.3)

5.4.4 Average response speed (MPH) (equal to or greater than average patrol speed) . . . . . [ ] (5.4.4)

5.4.5 Average travel time performance objective (minutes) . . . . . [ ] (5.4.5)

5.4.6 Number of troopers required within the APA to meet the average time travel performance objective, use formula given below . . . . . [ ] (5.4.6)

$$\text{No. of On-Duty Troopers, Line Patrol (5.4.6)} = \frac{20 \times \text{Highway Miles (5.4.3)} \times \text{Coverage Per Week (Hours) (5.4.2)}}{7 \times \text{Speed (MPH) (5.4.4)} \times \text{Time (min) (5.4.5)} \times \text{Shift Length (hours) (5.4.1)}}$$

5.5 Patrol Availability

Total troopers required within the APA, select either (5.2.8) or (5.3.6.3) or (5.4.6) . . . . . [ ] (5.5)

5.6 Total Number of Troopers Required for Patrol

Average number of troopers (N_p) required per day for patrol within the APA, select the larger of (5.1.5) and (5.5) . . . . . [ ] (N_p) (5.6)

Instructions for Worksheet 6: Average Daily Number of On-Duty Troopers

Worksheet 6 uses information from worksheets 2, 3, 4, and 5 to determine the average number of on-duty troopers that are needed per day within the APA. The formula for the average number of on-duty troopers (Step 6.1.5) is based on:

- the average number of on-duty troopers needed for reactive activities (N_r),
- the average number of on-duty troopers needed for patrol (N_p),
- the average number of minutes per hour per trooper spent on administrative activities (m_a), and
- the average number of minutes per hour per trooper spent on self-initiated activities (m_s).

The derivation of the formula for Step (6.1.5) is presented in Section D.6 in Appendix D in the Guide.

Sections 6.2 and 6.3 are used to add troopers to account for the use of two-trooper patrol units and the presence of minimum staffing requirements set by the agency. The derivation of the formula for adjusting the number of on-duty troopers for two-trooper units is presented in Section D.7 in Appendix D in the Guide.

Instructions for Individual Steps

6.1 Number of On-Duty Troopers per Day - All One-Trooper Patrols (C)

With the completion of Step 6.1.5, it is possible to determine how much time each trooper, on the average, will spend on each of the four work categories: reactive, self-initiated, patrol, and administrative. The four times are given by:

Administrative Time (min/hr) = m_a (Step 2.3),

Self-Initiated Time (min/hr) = m_s (Step 4.4),

$$\text{Reactive Activities Time } (m_r) \text{ (min/hr)} = \frac{N_r \text{ (3.3.3) x 60}}{N_o \text{ (6.1.5)}} \text{ , and}$$

$$\text{Patrol Activities Time (min/hr)} = 60 - m_a - m_s - m_r \text{ .}$$

The four times will sum to 60 minutes. The time (in hours) spent on each activity for an entire shift can be determined by dividing each time by 60 and multiplying by the shift length (in hours).

6.2 Adjustment for Two-Trooper Patrol Units (P).

6.2.1 The percentage of time that patrol units are staffed with two troopers. A value of 0 indicates that no patrol units within the APA are staffed with two troopers while a value of 100 indicates that every patrol unit has two troopers.

6.2.3 The adjustment factor is a number between 1 and 2 that is derived from the percentage entered for (6.2.1). The factor indicates the average number of troopers per unit. A value of 1 indicates an average of one trooper per unit (i.e., no two-trooper units are used). A value of 2 indicates that every unit has two troopers.

6.3 Minimum Staffing Level

The minimum number of on-duty troopers that must be available each day in the APA as determined by agency policy.

WORKSHEET 6: Average Daily Number of On-Duty Troopers

Objective: Determine the average total number of troopers required per day within the APA.

Method: Combine the total number of troopers required for reactive (N_r) and patrol activities (N_p) with the per trooper time requirements for self-initiated (m_s) and administrative (m_a) activities. Adjust the required number of troopers based on the percentage of two-trooper patrols and, if applicable, minimum daily staffing levels.

6.1 Number of On-Duty Troopers per Day - All One-Trooper Patrols

6.1.1 Administrative time - minutes per hour per trooper, use (2.3) . . . . . [ ] (m_a)
(6.1.1)

6.1.2 Average number of troopers required per day to meet reactive time workload, use (3.3.3) . . . . . [ ] (N_r)
(6.1.2)

6.1.3 Self-initiated time - minutes per hour per trooper, use (4.4) . . . . . [ ] (m_s)
(6.1.3)

6.1.4 Average number of troopers required per day to meet patrol time requirements, use (5.6) . . . [ ] (N_p)
(6.1.4)

6.1.5 Average total number of on-duty troopers required per day for all patrol activities within the APA, one trooper per unit, use the formula below . . . . . [ ]
(6.1.5)

$$\text{Average Total Number of On-Duty Troopers Per Day (6.1.5)} = \frac{N_r\ (6.1.2) + N_p\ (6.1.4)}{1 - \frac{m_a\ (6.1.1)}{60} - \frac{m_s\ (6.1.3)}{60}}$$

6.2 Adjustment for Two-Trooper Patrols

NOTE: If two-trooper patrols are not used, enter (6.1.5) into (6.2.4) and continue with Section 6.3.

6.2.1 Percentage of time patrol units within the APA are staffed with two troopers . . . . [ ] (6.2.1)

6.2.2 Fraction of time patrol units within the APA are staffed with two troopers, divide: (6.2.1) ÷ 100 . . . . . [ ] (6.2.2)

6.2.3 Adjustment factor: average number of troopers per unit, add: 1 + (6.2.2) . . . . . [ ] (6.2.3)

6.2.4 Average total number of on-duty troopers required per day for all patrol activities, multiply: (6.1.5) x (6.2.3) . . . . . [ ] (6.2.4)

6.3 Adjustment for Minimum Staffing Levels

Note: If minimum staffing levels are not used, enter (6.2.4) into (6.3.2) and continue with Worksheet 7.

6.3.1 Average minimum number of on-duty troopers required per day for all patrol activities, based on agency policy . . . . . [ ] (N_{min})
(6.3.1)

6.3.2 Average daily number of on-duty troopers required for all patrol activities (N_o), select the larger of (6.2.4) and (6.3.1) . . [ ] (N_o)
(6.3.2)

Instructions for Worksheet 7: Special Assignments and Field Supervision

Worksheet 7 is used to determine the impact of special assignment units (e.g., inspections, weights, accident investigation, etc.) on total patrol staffing and the number of field supervisors required in the APA.

The impact of special assignment personnel is based on the number of on-duty troopers required for the specialized unit (specified by the agency) and the percentage of patrol work, if any, performed by the specialists. The procedure assumes that special assignments are permanent (i.e., that they will continue for an indefinite period of time). Staffing for non-permanent or temporary assignments such as traffic and crowd control at special events (e.g., a state fair) is usually dependent on local characteristics that are beyond the scope of the PAM model.

The number of field supervisors is based on the span of supervision (i.e., the average number of troopers that report to each field supervisor) set by agency policy and the amount of patrol work done by each field supervisor.

The derivations of the formulas used for steps 7.1.6, 7.2.1.6, 7.2.2.6, 7.2.3.6, 7.2.4, and 7.3.1 are presented in Section D.8 of Appendix D in the Guide.

Instructions for Individual Steps

Since field supervisors, and troopers assigned to special assignments, may spend part of their time performing patrol activities, the addition of field supervisors and special assignment personnel to the patrol force may reduce the number of full-time (i.e., non-supervisory and non-special assignment) troopers that are needed. The number of on-duty troopers determined in sections 7.1 and 7.2 consists of an adjusted number of full-time troopers and the number of troopers used for special assignments.

7.1 Number of full-time, on-duty troopers required per day, adjusted for field supervisors (P,D,C)

The adjusted number of full-time, on-duty troopers (N_{ao}) is based on the number of troopers (N_o) derived in Step 6.3.2, the average number of troopers supervised by each field supervisor (Step 7.1.1), and the percentage of on-duty time field supervisors spend on patrol activities (i.e., time spent on reactive, self-initiated, patrol, and non-supervisory administrative work) (Step 7.1.2). If field supervisors

spend no time on patrol activities, then the adjusted number of full-time, on-duty troopers required is unchanged (i.e, $N_{ao} = N_o$).

7.2 Number of on-duty troopers required per day, adjusted for special assignment personnel (D,C)

If special assignment personnel are used, Section 7.2 can be used for up to three types of special assignments and can easily modified by the user if more than three are needed. The adjustment is based on the adjusted number of full-time, on-duty troopers (N_{ao}) derived in Step 7.1.6, the number of on-duty troopers required for special assignments (i.e., N_{s1}, N_{s2}, and N_{s3} from steps 7.2.1.1, 7.2.2.1, and 7.2.3.1), and the percentage of time special assignment personnel spent on patrol activities (i.e., time spent on reactive, self-initiated, patrol, and patrol-related administrative work) (steps 7.2.1.2, 7.2.2.2, and 7.2.3.2). The final adjusted value for the number of on-duty troopers required per day (N_{ot}) is determined in Step 7.2.4 and includes both full-time patrol troopers and troopers on special assignment.

Note that the number of full-time, on-duty troopers per day (N_{ft}) is given by:

$$N_{ft} = \underset{(7.2.4)}{N_{ot}} - \underset{(7.2.1.1)}{N_{s1}} - \underset{(7.2.2.1)}{N_{s2}} - \underset{(7.2.3.1)}{N_{s3}}$$

7.3 Total number of on-duty field supervisors (N_{os}) required per day for the adjusted number of on-duty troopers (N_{ot}) (C)

The number of on-duty field supervisors (N_{os}) is based on the adjusted number of on-duty troopers (N_{ot}) from Step 7.2.4 and the number of troopers assigned to each field supervisor (Step 7.1.1). The value determined for N_{os} in Step 7.3.1 includes supervisors for both full-time patrol troopers and troopers assigned to special units.

WORKSHEET 7: Special Assignments and Field Supervision

Objective: Determine the revised on-duty troopers required per day because of the availability of special assignment troopers for patrol and the number of field supervisors required per day.

Method: The number of troopers for special assignments is based on the number of specialists assigned by the agency and the percentage of time each spends on field patrol activities. The number of field supervisors is based on the span of supervision (set by agency policy) and the percentage of field supervisor on-duty time spent on patrol activities.

7.1 Number of Full-Time, On-Duty Troopers Required per Day, Adjusted for Field Supervisors

7.1.1 Average number of troopers to be supervised by each field supervisor, use (1.2.3) . . . . . [ ] (7.1.1)

7.1.2 Percentage of field supervisor on-duty time spent on patrol activities (a number between 0 and 100), use (1.2.4) . . . . . [ ] (7.1.2)

7.1.3 Fraction of field supervisor on-duty time spent on patrol activities, divide: (7.1.2) ÷ 100 . . . . . [ ] (7.1.3)

7.1.4 Total number of on-duty troopers required per day within the APA (N_o) for all patrol activities, use (6.3.2) . . . . . [ ] (N_o) (7.1.4)

7.1.5 Adjustment factor (K_f), use formula below . . . . . [ ] (K_f)
(7.1.5)

$$\text{Adjustment Factor } (K_f) \text{ (7.1.5)} = \frac{\text{Troopers Per Field Super. (7.1.1)}}{\text{Troopers Per Field Super. (7.1.1)} + \text{Fraction of Field Super. Time on Patrol (7.1.3)}}$$

7.1.6 Adjusted daily number of full-time, on-duty troopers (N_{ao}) required per day, use formula below . . . . . [ ] (N_{ao})
(7.1.6)

$$\text{Adjusted Number of Full-Time, On-Duty Troopers Per Day } (N_{ao}) \text{ (7.1.6)} = K_f \times \text{No. of On-Duty Troopers Per Day } (N_o) \text{ (7.1.4)}$$

NOTE: If no special assignment personnel are to be included, enter (7.1.6) into (7.2.4) and continue with Section 7.3. If special assignment personnel are to be included, continue with Section 7.2.

7.2 Number of On-Duty Troopers Required Per Day, Adjusted for Special Assignment Personnel

7.2.1 Special Assignment 1

7.2.1.1 Assign. 1 name . [ ]
(7.2.1.1)

7.2.1.2 Average number of <u>on-duty</u> troopers per day on specialized assignment 1 . . . . . [ ] (N_{s1})
(7.2.1.2)

7.2.1.3 Percentage of on-duty time spent on patrol activities by troopers assigned to special assignment 1 (a number between 0 and 100) . . . . [ ]
(7.2.1.3)

7.2.1.4 Percentage of on-duty time spent on non-patrol activities by troopers assigned to special assignment 1, subtract: 100 - (7.2.1.3) . . . . . [ ]
(7.2.1.4)

7.2.1.5 Fraction of on-duty time spent on non-patrol activities by troopers assigned to special assignment 1, divide: (7.2.1.4) ÷ 100 . . . . . [ ] (f_{s1})
(7.2.1.5)

7.2.1.6 Adjusted daily number of on-duty troopers assigned to special assignment 1, use formula below . . . . . [ ] (N_{as1})
(7.2.1.6)

Adjusted Number On-Duty Troopers, Special Assignment 1 (N_{as1}) (7.2.1.6) = Number On-Duty Troopers S.A. 1 (N_{s1}) (7.2.1.2) x Fraction Time On Non-Patrol Activities (f_{s1}) (7.2.1.5) x Adjustment Factor (K_f) (7.1.5)

NOTE: If personnel for a second special assignment are to be included, complete steps (7.2.2.1) through (7.2.2.6). If not, enter zeros for steps (7.2.2.6) and (7.2.3.6) and continue with Step 7.2.4.

7.2.2 Special Assignment 2

7.2.2.1 Assign. 2 name . _____ (7.2.1.1)

7.2.2.2 Average number of <u>on-duty</u> troopers per day on specialized assignment 2 . . . . . _____ (N_{s2}) (7.2.2.2)

7.2.2.3 Percentage of on-duty time spent on patrol activities by troopers assigned to special assignment 2 (a number between 0 and 100) . . . . _____ (7.2.2.3)

7.2.2.4 Percentage of on-duty time spent on non-patrol activities by troopers assigned to special assignment 2, subtract: 100 - (7.2.2.3) . . . . . _____ (7.2.2.4)

7.2.2.5 Fraction of on-duty time spent on non-patrol activities by troopers assigned to special assignment 2, divide: (7.2.2.4) ÷ 100 . . . . . _____ (f_{s2}) (7.2.2.5)

7.2.2.6 Adjusted daily number of on-duty troopers assigned to special assignment 2, use formula below . . . . . _____ (N_{as2}) (7.2.2.6)

Adjusted Number On-Duty Troopers, Special Assignment 2 (N_{as2}) (7.2.2.6)	=	Number On-Duty Troopers S.A. 2 (N_{s2}) (7.2.2.2)	x	Fraction Time On Non-Patrol Activities (f_{s2}) (7.2.2.5)	x	Adjustment Factor (K_f) (7.1.5)

NOTE: If personnel for a third special assignment are to be included, complete steps (7.2.3.1) through (7.2.3.6). If not, enter zero for step (7.2.3.6) and continue with Step 7.2.4.

7.2.3 Special Assignment 3

7.2.3.1 Assign. 3 name . _____ (7.2.3.1)

7.2.3.2 Average number of <u>on-duty</u> troopers per day on specialized assignment 3 . . . . . _____ (N_{s3}) (7.2.3.2)

7.2.3.3 Percentage of on-duty time spent on patrol activities by troopers assigned to special assignment 3 (a number between 0 and 100) . . . . _____ (7.2.3.3)

7.2.3.4 Percentage of on-duty time spent on non-patrol activities by troopers assigned to special assignment 3, subtract: 100 - (7.2.3.3) . . . . . _____ (7.2.3.4)

7.2.3.5 Fraction of on-duty time spent on non-patrol activities by troopers assigned to special assignment 3, divide: (7.2.3.4) ÷ 100 . . . . . [ ] (f_{s3})
(7.2.3.5)

7.2.3.6 Adjusted daily number of on-duty troopers assigned to special assignment 3, use formula below . . . . . [ ] (N_{as3})
(7.2.3.6)

Adjusted Number On-Duty Troopers, Special Assignment 3 (N_{as3}) (7.2.3.6) = Number On-Duty Troopers S.A. 3 (N_{s3}) (7.2.3.2) x Fraction Time On Non-Patrol Activities (f_{s3}) (7.2.3.5) x Adjustment Factor (K_f) (7.1.5)

7.2.4 Adjusted total daily number of on-duty troopers required per day, use formula below . . . . . [ ] (N_{ot})
(7.2.4)

Adjusted Total Number of On-Duty Troopers Per Day (N_{ot}) (7.2.4) = N_{ao} (7.1.6) + N_{as1} (7.2.1.6) + N_{as2} (7.2.2.6) + N_{as3} (7.2.3.6)

7.3 Total Number of On-Duty Field Supervisors Required Per Day for the Adjusted Number of On-Duty Troopers

7.3.1 Total number of on-duty field supervisors (N_{OS}) required per day, day, divide: (7.2.4) ÷ (7.1.1) . . [ ] (N_{OS})

(7.3.1)

Instructions for Worksheet 8: Total Staff Requirements

Worksheet 8 is used to determine the total staff needed to support the on-duty trooper and field supervisor requirements determined in worksheets 6 and 7. The total staff requirements for the APA are derived using the following procedure:

- Sections 8.1, 8.2, and 8.3 are used to determine the total number of troopers and field supervisors, both on and off- duty, that are needed.
- Section 8.4 or 8.5 and Section 8.6 are used to determine the total number of staff and command personnel that are required.
- Section 8.7 is used to collect the results into a final tabulation of the total staff requirements for the APA.

The total number of troopers and field supervisors required is determined based on the shift relief factor for the APA. The shift relief factor is defined as the average number of persons required to staff one shift position per day, 365 days a year. The shift relief factor for an APA is calculated with the following formula:

$$\text{Shift Relief Factor} = \frac{\text{Total Number of Hours To Cover One Shift Position Per Day, 365 Days Per Year}}{\text{Average Number of Actual On-Duty Hours Per Person Per Year}}$$

The average number of actual on-duty hours per person per year is determined by the on- and off-duty pattern of the work schedule, the shift length, the benefit time policies (i.e., vacation time, holiday leave, sick leave, etc.) of the agency, and the extent to which troopers are used for non-patrol activities. For agencies with eight-hour shifts, shift relief factors usually fall between 1.60 and 1.90. Derivation of the shift relief factor formula is presented in Section D.9 in Appendix D in the Guide.

Two options are available to determine the number of staff and command personnel. The user can either specify the number directly (Section 8.4) or the number can be obtained by determining the average number of staff and command personnel for each trooper and field supervisor based on the current staffing practices of the agency (Section 8.5).

Instructions for Individual Steps

8.4 The Number of Staff and Command Personnel - Agency Policy (P).

This category should include all command personnel (e.g., lieutenants, captains, majors, etc.) and other staff personnel (i.e., administrative, technical, etc.) that are needed for the supervision and support of the patrol force within the APA. The specific kinds of personnel included in this category will vary from agency to agency.

8.5 The Number of Staff and Command Personnel - Historical Experience (D).

See discussion for Step 8.4.

WORKSHEET 8: Total Staff Requirements

Objective: Determine total staff needed to support the required daily on-duty field personnel.

Method: Use the shift relief factor, daily on-duty staff requirements, and the number of staff and command positions based on either historical data or agency policy.

8.1 On-Duty Troopers and Field Supervisors Required per Day

8.1.1 Total number of on-duty troopers per day within the APA, use (7.2.4) . . . . . [ ] (N_{ot})
(8.1.1)

8.1.2 Total number of on-duty field supervisors per day within the APA, use (7.3.1) . . . . . [ ] (N_{os})
(8.1.2)

8.2 Shift Relief Factor

8.2.1 Shift length (hours), use (1.2.1) . . . . . [ ]
(8.2.1)

8.2.2 Total hours on one shift during one year, multiply: 365 x (8.2.1) . . . . . [ ]
(8.2.2)

8.2.3 Average number of actual on-duty hours per year per trooper and field supervisor, use (1.2.2) . . . . . [ ] (8.2.3)

8.2.4 Shift relief factor, divide: (8.2.2) ÷ (8.2.3) . . . . [ ] (8.2.4) (SRF)

8.3 Total Number of Required Troopers and Field Supervisors Within the APA

8.3.1 Total number of troopers, multiply: (8.1.1) x (8.2.4) . . . [ ] (8.3.1) (N_t)

8.3.2 Total number of field supervisors, multiply: (8.1.2) x (8.2.4) . . . . . [ ] (8.3.2) (N_s)

8.3.3 Total number of troopers and field supervisors, add: (8.3.1) + (8.3.2) . . . . . [ ] (8.3.3)

OPTION: Complete Section 8.4 or Section 8.5.

8.4 Number of Staff and Command Personnel - Agency Policy

Select number of staff and command personnel required for the number of troopers and field supervisors given in (8.3.3) . . . . . [ ] (8.4)

Continue with Section 8.6

OR

8.5 Number of Staff and Command Personnel - Historical Experience

8.5.1 Current number of troopers and field supervisors within the APA

(8.5.1)

8.5.2 Current number of staff and command personnel within the APA . . . . . .

(8.5.2)

8.5.3 Average number of staff and command personnel for each trooper and field supervisor, divide: (8.5.2) ÷ (8.5.1) . . . .

(8.5.3)

8.5.4 Required number of troopers and field supervisors within the APA, use (8.3.3) . . . . . .

(8.5.4)

8.5.5 Required number of staff and command personnel within the APA, multiply: (8.5.4) x (8.5.3) . . . . . .

(8.5.5)

8.6 Total Number of Staff and Command Personnel for the APA

Select either (8.4) or (8.5.5) . . . . . (N_h)

(8.6)

8.7 Total Staff Requirements for the APA

8.7.1 Number of troopers within the APA, use (8.3.1) . . . . . [ ] (N_t)
(8.7.1)

8.7.2 Number of field supervisors within the APA, use (8.3.2) . . . [ ] (N_s)
(8.7.2)

8.7.3 Number of staff and command personnel within the APA, use (8.6) . . . . . [ ] (N_h)
(8.7.3)

8.7.4 Total required staff for the APA, add: (8.7.1) + (8.7.2) + (8.7.3) . . . . [ ] (N_{tot})
(8.7.4)

Chapter 4: PAM Instructions and Worksheet for Allocating Personnel Among Several APAs

Introduction

This chapter describes a systematic procedure for allocating personnel for police traffic services over several APAs based on staffing estimates obtained from the procedures described in the eight worksheets in Chapter 3. The allocation procedure is presented in Worksheet 9 which uses the same format as the worksheets in Chapter 3.

Throughout this chapter, the terms "personnel" and "staff" are used generically to refer to troopers, field supervisors, and support and command staff who are to be added or subtracted from current staffing levels or reallocated among the APAs.

To facilitate the allocation procedure, the data items and calculations for each step in Worksheet 9 can be recorded in the worksheet at the end of this chapter (Table 4-1). The worksheet provides for up to six APAs, but the format of the table can be expanded or reduced to accommodate any number of patrol areas. Each step in Worksheet 9 indicates where the entry should be placed in Table 4-1.

To use Worksheet 9 and Table 4-1, the user must provide the following information:

- the total number of personnel that will be added to the current staff assigned to the APAs (or the number of personnel that will be subtracted from the current total) (Step 9.1.1),
- the number of personnel currently assigned to each APA (Step 9.1.3), and
- the number of personnel estimated by the PAM model for each APA (Step 9.1.5).

The total number of personnel included in the reallocation consists of the total current number of staff (**TC**) plus the number to be added or subtracted (**TA**). If personnel are to be subtracted (noted in Worksheet 9 as **-TA**), then the total number to be allocated will be equal to **TC** minus **TA**. Worksheet 9 and Table 4-1 are used to derive two allocations for the total personnel:

- Unconstrained (Section 9.1) - The values recorded in Column 3 of Table 4-1 indicate the reallocation of all personnel based on the PAM estimates. This allocation is "unconstrained" because:

  - there are no limitations on the final number of personnel that can be assigned to each APA (i.e., each APA may gain or lose personnel), and

  - all personnel, both current and new, are eligible for reassignment.

- Constrained (Section 9.2) - The values recorded in Column 8 of Table 4-1 indicate a reallocation of personnel by APA based on the limitation that none of the personnel currently assigned to an APA can be reassigned. Application of this limitation produces the following effects:

  - Only personnel being added to the current staff are considered for allocation. As a result, no APA will lose personnel because of the reallocation. (New personnel are only added to APAs that are understaffed and no personnel are added to APAs that are overstaffed.) Under this limitation, however, it is possible that some APAs that were understaffed prior to the reallocation will continue be understaffed even after the staff additions.

  - If a reduction in the total number of current personnel is considered, no reassignment of the remaining personnel is permitted. As a result, no APA will gain personnel because of the reallocation. (Personnel are only taken from APAs that are overstaffed and no personnel are taken from APAs that are understaffed.) It is possible, however, that some APAs that were overstaffed prior to the personnel reductions will continue to be overstaffed even after the reallocation.

The derivation of the formulas for both unconstrained and constrained allocation are presented in Section D.10 in Appendix D in the User's Guide.

Although Worksheet 9 and Table 4-1 are designed for the allocation of staff over geographic areas (i.e., over several APAs), the procedure described in Worksheet 9 can also be used to allocate staff over several time periods (e.g., shifts or days of the week). Such allocations, however, require that PAM staffing estimates be determined for each time period (e.g., for each of three shifts) for each APA.

Instructions for Individual Steps

9.1 Unconstrained Allocation

9.1.1 Indicate either the total number of personnel that is to be added to the APAs or the total number of personnel to be subtracted. Typically, the number of new personnel is determined by the number of graduates from the training academy. The number of personnel to be added is entered as a positive number in 9.1.1. If personnel reductions are planned, the total size of the staff reduction is entered as a negative number in 9.1.1.

The value entered in 9.1.1 (TA) should also be entered in Table 4-1 in following locations: at the top of the page in the box labeled (TA), in the Sum Check row for columns 6 and 7, and, after being multiplied by minus one, in the Sum Check row for Column 4.

9.1.2 Determine the total number of current personnel in the APAs. The value is entered in 9.1.2 and in the Sum Check row for column 1 in Table 4-1.

The sum of (9.1.1) and (9.1.2) is entered in the Sum Check row for columns 3 and 8.

9.1.3 Determine the current number of personnel in each APA and enter the values in column 1 in Table 4-1.

9.1.4 The sum of column 1 should equal the Sum Check amount (9.1.2).

9.1.5 Determine the number of personnel estimated by the PAM model for each APA and enter the values in column 2 in Table 4-1.

9.1.7 The unconstrained allocation results for each APA are recorded in column 3 in Table 4-1.

Note: If a value of zero is entered for (9.1.1) (i.e., TA = 0), then the results in column 3 will indicate the unconstrained allocation of the current number of personnel assigned to the APAs.

9.1.8 The sum of column 3 must equal the Sum Check amount given by (9.1.1) + (9.1.2).

9.2 Constrained Allocation

9.2.1 The values in column 4 are computed by taking the

difference between the current number of personnel (column 1) and the unconstrained allocation of personnel (column 3) for each APA. A positive value indicates that the APA is overstaffed when compared to the reallocation based the adjusted number of personnel (TC + TA). A negative value indicates that the APA is understaffed.

9.2.2 The sum of the values in column 4 must equal the number of personnel, multiplied by minus one (-1), to be added or reduced (i.e. -1 x (9.1.1)). As an example, if the number of personnel to be added is 10, then the sum of column 4 must equal -10.

9.2.3 Additional Personnel (TA(9.1.1) ≥ 0)

9.2.3.1 Based on the values in column 4, identify which APAs are overstaffed (a positive value in column 4) and which APAs are understaffed (a negative value in column 4). If an APA is overstaffed, a zero is entered in column 5. If an APA is understaffed, the negative value in column 4 is entered in column 5. When completed, every entry in column 5 should either be zero or a negative number.

9.2.3.3 Based on the formula given in Step 9.2.3.3, determine the number of personnel to be added to each APA and enter the values in column 6.

9.2.4 Personnel Reduction (TA(9.1.1) < 0)

9.2.4.1 Based on the values in column 4, identify which APAs are overstaffed (a positive value in column 4) and which APAs are understaffed (a negative value in column 4). If an APA is overstaffed, the positive value in column 4 is entered in column 5. If an APA is understaffed, a zero is entered in column 5. When completed, every entry in column 5 should either be zero or a positive number.

9.2.4.3 Based on the formula given in Step 9.2.4.3, determine the number of personnel to be subtracted from each APA and enter the values in column 6.

9.2.5 The sum of column 6 must equal the Sum Check amount (9.1.1) TA.

9.2.6 Determine an adjusted number of personnel to be added or subtracted from each APA by rounding each value in column 6 to a whole number and entering the result in

column 7.

9.2.7 The sum of the values in column 7 must equal the Sum Check amount (9.1.1) (**TA**). If the sum of the adjusted values does not equal (9.1.1), then one or more the rounded values must be changed.

9.2.8 Determine the number of personnel in each APA for the constrained allocation by adding together the values in columns 1 and 7 and entering the result in column 8.

9.2.9 The sum of the values in column 8 must equal the number of current personnel plus the number of persons to be added or subtracted.

WORKSHEET 9: Allocation of Patrol Personnel Among Several APAs

Objective: Determine the appropriate number of personnel to be assigned to each APA based on the estimated PAM staffing levels for each APA.

Method: Based on the number of personnel estimated for each APA by PAM, two reallocations of current and new personnel are determined. The unconstrained allocation redistributes all personnel, both current and new, among the APAs in the same proportion as the PAM estimates. The constrained allocation restricts the allocation to only new (or reduced) personnel insuring that no APA loses staffing when new personnel are added (or that no APA gains staffing when personnel reductions are applied).

9.1 Unconstrained Allocation

9.1.1 Total number of new personnel for all APAs, (enter zero if none or a negative value for personnel reductions) . . . . . Table 4-1 (9.1.1) **(TA)**

Enter (9.1.1) in Table 4-1 at four locations: in the box labeled (**TA**), in the Sum Check row for columns 6 and 7, and multiplied by -1 in the Sum Check row for column 5.

9.1.2 Total number of current personnel for all APAs . . . . . Column 1 (9.1.2) **(TC)**

Enter (9.1.2) in the Sum Check row for column 1 in Table 4-1.

9.1.3 Number of current personnel for each APA, enter in column 1 in Table 4-1 . . . . . Column 1 (9.1.3)

9.1.4 Sum the values in column 1 and enter in the Col. Sum row . . . . Column 1 (9.1.4)

Compare (9.1.4) with the Sum Check value (9.1.2) in column 1. If values agree, continue with Step 9.1.5.

9.1.5 Number of personnel estimated by PAM for each APA, enter in column 2 in Table 4-1 . . . . Column 2 (9.1.5)

9.1.6 Sum the values in column 2 and enter in the Col. Sum row . . . . Column 2 (9.1.6) **(TE)**

9.1.7 The unconstrained reallocation for each APA, use the formula below and enter in column 3 in Table 4-1 . . . . . Column 3 (9.1.7)

$$\text{Column 3 Entry (9.1.7)} = \frac{\text{TA (9.1.1)} + \text{TC (9.1.2)}}{\text{TE (9.1.6)}} \times \text{PAM APA Est. Column 2 (9.1.5)}$$

9.1.8 Sum the values in column 3 and enter in the Col. Sum row . . . . Column 3 (9.1.8)

Compare (9.1.8) with the Sum Check value in column 3. If the values agree, continue with Section 9.2.

9.2 Constrained Allocation

9.2.1 Difference in personnel between the current staffing and the unconstrained allocation for each APA, subtract: Col 1. (9.1.3) - Col 3. (9.1.5) and enter in column 4 . . . . . | Column 4 | (9.2.1)

9.2.2 Sum the values in column 4 and enter in the Col. Sum row . . . . | Column 4 | (9.2.2)

Compare (9.2.2) with the Sum Check value in column 4. If the values agree, continue with Step 9.2.3 or Step 9.2.4.

NOTE: Complete Section 9.2.3 or Section 9.2.4. If TA (9.1.1) is greater than or equal to zero, continue with Step 9.2.3. If TA (9.1.1) is less than zero, continue with Step 9.2.4.

9.2.3 Additional Personnel (TA(9.1.1) ≥ 0)

9.2.3.1 Understaffing indicator for each APA, use rules below and enter in column 5 . . . . . | Column 5 | (9.2.3.1)

If column 4 entry is:

- greater than or equal to zero, enter 0 in column 5.
- less than zero, enter column 4 value in column 5.

9.2.3.2 Sum the values in column 5 and enter in the Col. Sum row . . . . . Column 5 (9.2.3.2) **(TN)**

9.2.3.3 Number of personnel to be added to each APA, use the formula below and enter in column 6 . . Column 6 (9.2.3.3)

$$\text{Column 6 Entry (9.2.3.3)} = \frac{\text{TA (9.1.1)} \times \text{Column 5 (9.2.3.1)}}{\text{TN (9.2.3.2)}}$$

Continue with Step 9.2.5.

OR

9.2.4 Personnel Reduction (TA(9.1.1) < 0)

9.2.4.1 Overstaffing indicator for each APA, use rules below and enter in column 5 . . . . . Column 5 (9.2.4.1)

If column 4 entry is:

- greater than zero, enter column 4 value in column 5.
- less than or equal to zero, enter 0 in column 5.

9.2.4.2 Sum the values in column 5 and enter in the Col. Sum row . . . . . Column 5 (9.2.4.2) **(TN)**

9.2.4.3 Number of personnel to be added to each APA, use the formula below and enter in column 6 . . | Column 6 (9.2.4.3)

$$\text{Column 6 Entry (9.2.4.3)} = \frac{\text{TA (9.1.1)} \times \text{Column 5 (9.2.4.1)}}{\text{TN (9.2.4.2)}}$$

9.2.5 Sum the values in column 6 and enter in the Col. Sum row . . . . | Column 6 (9.2.5)

Compare (9.2.5) with the Sum Check value in column 6. If the values agree, continue with Step 9.2.6.

9.2.6 Adjust the value for each APA in column 6 to a whole number and enter in column 7 . . | Column 7 (9.2.6)

9.2.7 Sum the values in column 7 and enter in the Col. Sum row . . . . | Column 7 (9.2.7)

Compare (9.2.7) with the Sum Check value in column 7. If the values agree, continue with Step 9.2.8.

9.2.8 Constrained reallocation for each APA, add: Col 1. (9.1.3) + Col 7. (9.2.6) and enter in column 8 . . . . . | Column 8 (9.2.8)

9.2.9	Sum the values in column 8 and enter in the Col. Sum row	Column 8 (9.2.9)

Compare (9.2.9) with the Sum Check value in column 8. If the values agree, Worksheet 9 is completed.

Table 4 - 1

Worksheet for the Allocation of Patrol Personnel Among Several APAs Based on PAM Staff Estimates

Total Number of Additional (or Reduced) Personnel for All APAs (9.1.1) . . . . . [ ] **(TA)**

APA	Current Staff (9.1.3) Col. 1	PAM Staff Est. (9.1.5) Col. 2	**Unconst Reallo.** (9.1.7) Col. 3	Diff. Col. 1 -Col. 3 (9.2.1) Col. 4	(9.2.3.1) or (9.2.4.1) Col. 5	To Be Added (9.2.3.3) or Reduced (9.2.4.3) Col. 6	Rounded (9.2.6) Col. 7	**Constr. Reallo.** Col. 1 +Col. 7 (9.2.8) Col. 8
1								
2								
3								
4								
5								
6								
Col. Sum	(9.1.4) **(TC)**	(9.1.6) **(TE)**	(9.1.8)	(9.2.2)	(9.2.3.2) or (9.2.4.2) **(TN)**	(9.2.5)	(9.2.7)	(9.2.9)
Sum Check	(9.1.2) **(TC)**		(9.1.1) + (9.1.2) **(TA+TC)**	-1 x (9.1.1) **(-TA)**		(9.1.1) **(TA)**	(9.1.1) **(TA)**	(9.1.1) + (9.1.2) **(TA+TC)**

APPENDIX A: Supplemental Worksheet for Chapter 3, Section 5.2

Instructions for Supplemental Worksheet: Patrol Availability - Immediate Response

The Supplemental Worksheet for Section 5.2 can be used to determine the number of patrol troopers (N_p) that will be required to insure that the probability that at least one trooper will be available for immediate response to an accident, CFS, or self-initiated activity that meets or exceeds the user-specified performance requirement.

The number of patrol troopers (N_p) is based on the number of on-duty troopers required per day for reactive activities (N_r) determined in Worksheet 3, the average number of administrative minutes per hour per trooper (m_a) determined in Worksheet 2, the average number of minutes per hour per trooper spent on self-initiated activities (m_s) determined in Worksheet 4, and the estimated staffing distribution by time of day (i.e., by shift). The number of patrol troopers is determined by using this information in a queuing model that assumes randomly occurring accidents, CFS, and self-initiated activities with exponentially-distributed service times.

The procedure for determining N_p in Section 5.2 in Worksheet 5 relies on the following assumptions:

- the agency has uniform staffing over all shifts,
- the values for m_a and m_s are approximately equal to 15 and 9 minutes per hour per trooper respectively, and
- the same user-specified immediate response performance requirement applies to each shift.

These assumptions, valid for a wide range of agencies and operations, simplify the determination of N_p (i.e., Table 3-1 can be used to determine N_p for every shift).

If any of the assumptions cited above are not valid or applicable, the Supplement Worksheet presented below can be used in place of Section 5.2. The Supplement Worksheet determines the number of patrol troopers per day by estimating the number required for each shift and adding the results together. The

number of patrol troopers required for each shift (N_{p1}, N_{p2}, and N_{p3}) is determined with a table look-up based on the estimated number of on-duty troopers required for reactive activities on each shift (N_r). The appropriate table to be used is based on the values for m_a and m_s determined in worksheets 2 and 4 respectively.

The derivations of the formulas and procedures used in Section 5.2 and in the Supplemental Worksheet are presented in Section D.3 in Appendix D in the Guide.

Instructions for Individual Steps

A.2 Staffing Level By Shift

The values entered for (A.2.1), (A.2.2), and (A.2.3) represent the user's estimate of the percentage of staff that will be on duty on each shift for the APA. The sum of the percents over all shifts must equal 100. (Equal percents for each shift are assumed in Section 5.2.)

A.5 Determine Appropriate Table

A.5.1 K_s values are always positive and usually fall in the range of 0.15 to 0.35. Higher K_s values produce larger N_p values.

A.6 Number of Patrol Troopers Required for Each Shift

A.6.1 Number of Patrol Troopers Required for Shift 1

A.6.1.1 The Supplemental Worksheet permits the user to select, if desired, a different immediate response performance objective percent for each shift. (Section 5.2 uses the same performance objective value for all shifts.)

A.6.1.2 The expected number of daily on-duty troopers for reactive activities for shift 1 (N_{r1}) is based on the user-specified staffing percent for shift 1 recorded in (A.2.1).

A.6.1.3 The table look-up process consists of the following steps:

- Locate the table identified in Step A.5.2.
- Examine the left-hand column of the table and select the row that is closest to the average daily number of reactive troopers for shift 1 (A.6.1.2).

- Read across the row until the percentage at the top of the column equals or exceeds the performance objective percent for shift 1 (A.6.1.1).

- The table entry indicates the average number of patrol troopers that are needed on shift 1 to meet the performance objective. Enter the table value in (A.6.1.3).

A.6.2 Number of Patrol Troopers Required for Shift 2

Read A.6.1.1, A.6.1.2, and A.6.1.3 above.

A.6.3 Number of Patrol Troopers Required for Shift 3

Read A.6.1.1, A.6.1.2, and A.6.1.3 above.

SUPPLEMENTAL WORKSHEET: Patrol Availability - Immediate Response

Objective: Determine the number of troopers required within the APA to provide an immediate response to a user-specified percent of all accidents, CFS, and self-initiated activities.

Method: A queuing model formulation for each shift based on randomly-occurring accidents, CFS, and self-initiated activities with exponentially-distributed service times. Input data includes the number of on-duty troopers required per day for reactive activities, the estimated staffing by shift, the average number of minutes per hour per trooper spent on administrative and self-initiated activities, and user-specified performance objectives for each shift.

A.1 Average daily number of on-duty troopers for reactive activities, use (3.3.3) . . . . . [ ] (N_r)
(A.1)

A.2 Staffing level by shift

A.2.1 Estimated percent of on-duty staff on shift 1, (a number between 0 and 100) . . . . . [ ]
(A.2.1)

A.2.2 Estimated percent of on-duty staff on shift 2, (a number between 0 and 100) . . . . . [ ]
(A.2.2)

A.2.3 Estimated percent of on-duty staff on shift 3, (a number between 0 and 100) . . . . . [ ]
(A.2.3)

NOTE: The sum of the percents for (A.2.1), (A.2.2), and (A.2.3) must equal 100.

A.3 Administrative time - minutes per hour per trooper (m_a), use (2.3) . . . . [ ] (m_a)
(A.3)

A.4 Self-initiated time - minutes per hour per trooper (m_s), use (4.4) . . . . [ ] (m_s)
(A.4)

A.5 Determine appropriate table

A.5.1 Determine adjustment factor based on m_a and m_s, use formula below . . . . . [ ] (K_s)
(A.5.1)

$$K_s \text{ (A.5.1)} = \frac{\text{Self-Initiated Time } (m_s) \text{ (A.4)}}{60 - \text{Administrative Time } (m_a) \text{ (A.3)} - \text{Self-Initiated Time } (m_s) \text{ (A.4)}}$$

A.5.2 Select table based on K_s (A.5.1) from chart below . . . . [Table -]
(A.5.2)

If K_s (A.5.1) is in the range	Use Table (A.5.2)
0 - .099	A-1
.1 - .199	A-2
.2 - .249	3-1
.25 - .299	A-3
.3 - .399	A-4
.4 - .499	A-5
.5 - .599	A-6
.6 - .699	A-7
.7 - .799	A-8
.8 - .899	A-9
.9 or larger	A-10

A.6 Number of patrol troopers required for each shift

A.6.1 Number of patrol troopers required for shift 1

A.6.1.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . [ ] (A.6.1.1)

A.6.1.2 Expected number of daily on-duty troopers for reactive activities on shift 1, use formula below . . . . . [ ] (N_{r1}) (A.6.1.2)

Expected Number of On-Duty Troopers Per Per Day for Reactive Activities on Shift 1, (N_{r1}) (A.6.1.2) = $\frac{\text{Percent of Staff on Shift 1 (A.2.1)} \times \text{Total Number of On-Duty Troopers Per Day } (N_r) \text{ (A.1)}}{100}$

A.6.1.3 Number of troopers required for shift 1: use (A.6.1.1), (A.6.1.2), and the table specified in (A.5.2) . . . . . [ ] (N_{p1})

(A.6.1.3)

A.6.2 Number of patrol troopers required for shift 2

A.6.2.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . [ ]

(A.6.2.1)

A.6.2.2 Expected number of daily on-duty troopers for reactive activities on shift 2, use formula below . . . . . [ ] (N_{r2})

(A.6.2.2)

$$\text{Expected Number of On-Duty Troopers Per Per Day for Reactive Activities on Shift 2, } (N_{r2}) \text{ (A.6.2.2)} = \frac{\text{Percent of Staff on Shift 2 (A.2.2)} \times \text{Total Number of On-Duty Troopers Per Day } (N_r) \text{ (A.1)}}{100}$$

A.6.2.3 Number of troopers required for shift 2: use (A.6.2.1), (A.6.2.2), and the table specified in (A.5.2) . . . . . [ ] (N_{p2})

(A.6.2.3)

A.6.3 Number of patrol troopers required for shift 3

A.6.3.1 Performance objective, percent of accidents and CFS, immediate response (a number between 50 and and 99) . . . . . [ ] (A.6.3.1)

A.6.3.2 Expected number of daily on-duty troopers for reactive activities on shift 3, use formula below . . . . . [ ] (N_{r3}) (A.6.3.2)

Expected Number of On-Duty Troopers Per Per Day for Reactive Activities on Shift 3, (N_{r3}) (A.6.3.2) = $\frac{\text{Percent of Staff on Shift 3 (A.2.3)} \times \text{Total Number of On-Duty Troopers Per Day } (N_r) \text{ (A.1)}}{100}$

A.6.3.3 Number of troopers required for shift 3: use (A.6.3.1), (A.6.3.2), and the table specified in (A.5.2) . . . . . [ ] (N_{p3}) (A.6.3.3)

A.7 Total number of patrol troopers required per day within the APA to provide immediate response at the performance objective percents for each shift, add (A.6.1.3) + (A.6.2.3) + (A.6.3.3) . . . . . [ ] (A.7)

Enter (A.7) in (5.2.7) in Worksheet 5 and continue with Section 5.5.

Table A-1

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.10)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.4	1.7	1.9	2.3
.10	0.2	0.3	0.5	0.6	0.8	0.9	1.2	1.5	1.8	2.0	2.4
.15	0.2	0.4	0.6	0.7	0.9	1.0	1.2	1.6	1.9	2.2	2.6
.20	0.3	0.4	0.7	0.8	0.9	1.1	1.3	1.7	2.0	2.3	2.7
.25	0.3	0.5	0.7	0.8	1.0	1.2	1.4	1.8	2.1	2.4	2.8
.30	0.4	0.6	0.8	0.9	1.0	1.2	1.5	1.9	2.2	2.5	2.9
.40	0.5	0.7	0.9	1.0	1.1	1.3	1.6	2.1	2.4	2.7	3.1
.50	0.5	0.7	0.9	1.0	1.2	1.4	1.7	2.2	2.5	2.8	3.3
.60	0.6	0.7	1.0	1.1	1.3	1.5	1.8	2.3	2.7	3.0	3.4
.80	0.6	0.8	1.1	1.2	1.4	1.7	2.0	2.5	2.9	3.2	3.7
1.00	0.6	0.9	1.2	1.3	1.5	1.8	2.1	2.7	3.1	3.5	4.0
1.20	0.7	1.0	1.3	1.4	1.6	1.9	2.3	2.9	3.3	3.7	4.2
1.60	0.8	1.1	1.4	1.6	1.8	2.1	2.5	3.2	3.7	4.0	4.6
2.00	0.9	1.2	1.5	1.7	2.0	2.3	2.8	3.5	4.0	4.4	5.0
2.50	1.0	1.3	1.7	1.9	2.2	2.5	3.0	3.8	4.3	4.7	5.4
3.00	1.1	1.4	1.8	2.1	2.4	2.7	3.2	4.0	4.6	5.1	5.8
4.00	1.2	1.6	2.0	2.3	2.7	3.1	3.6	4.5	5.2	5.7	6.5
5.00	1.4	1.8	2.3	2.6	2.9	3.4	4.0	5.0	5.7	6.2	7.0

Table A-2

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.20)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.2	0.4	0.6	0.7	0.8	1.0	1.3	1.8	2.1	2.4	3.0
.10	0.3	0.4	0.6	0.8	0.9	1.1	1.4	1.9	2.3	2.6	3.1
.15	0.3	0.5	0.7	0.8	1.0	1.2	1.5	2.0	2.4	2.7	3.2
.20	0.3	0.5	0.8	0.9	1.1	1.3	1.6	2.1	2.5	2.8	3.3
.25	0.4	0.6	0.8	1.0	1.1	1.3	1.6	2.2	2.6	2.9	3.4
.30	0.5	0.6	0.9	1.0	1.2	1.4	1.7	2.2	2.6	3.0	3.5
.40	0.5	0.7	0.9	1.1	1.3	1.5	1.8	2.4	2.8	3.1	3.7
.50	0.6	0.8	1.0	1.2	1.3	1.6	1.9	2.5	2.9	3.3	3.9
.60	0.6	0.8	1.1	1.2	1.4	1.7	2.0	2.6	3.1	3.4	4.0
.80	0.7	0.9	1.2	1.3	1.5	1.8	2.2	2.8	3.3	3.7	4.3
1.00	0.7	1.0	1.3	1.4	1.7	2.0	2.4	3.0	3.5	3.9	4.5
1.20	0.8	1.0	1.3	1.5	1.8	2.1	2.5	3.2	3.7	4.1	4.8
1.60	0.9	1.2	1.5	1.7	2.0	2.3	2.8	3.5	4.1	4.5	5.2
2.00	1.0	1.3	1.6	1.9	2.1	2.5	3.0	3.8	4.4	4.8	5.6
2.50	1.1	1.4	1.8	2.0	2.3	2.7	3.2	4.1	4.7	5.2	6.0
3.00	1.1	1.5	1.9	2.2	2.5	2.9	3.5	4.4	5.0	5.5	6.4
4.00	1.3	1.7	2.2	2.5	2.8	3.3	3.9	4.9	5.6	6.1	7.1
5.00	1.4	1.8	2.4	2.7	3.1	3.6	4.3	5.3	6.1	6.7	7.7

Table A-3

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.30)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.3	0.4	0.7	0.8	1.0	1.2	1.5	2.1	2.6	3.0	3.6
.10	0.3	0.5	0.7	0.9	1.1	1.3	1.6	2.2	2.7	3.1	3.7
.15	0.4	0.6	0.8	0.9	1.1	1.4	1.7	2.3	2.8	3.2	3.8
.20	0.4	0.6	0.9	1.0	1.2	1.4	1.8	2.4	2.9	3.3	3.9
.25	0.5	0.7	0.9	1.0	1.2	1.5	1.8	2.5	3.0	3.4	4.0
.30	0.5	0.7	0.9	1.1	1.3	1.5	1.9	2.6	3.0	3.4	4.1
.40	0.6	0.8	1.0	1.2	1.4	1.6	2.0	2.7	3.2	3.6	4.3
.50	0.6	0.8	1.1	1.2	1.5	1.7	2.1	2.8	3.3	3.7	4.4
.60	0.6	0.9	1.1	1.3	1.5	1.8	2.2	2.9	3.5	3.9	4.6
.80	0.7	0.9	1.2	1.4	1.7	2.0	2.4	3.1	3.7	4.1	4.9
1.00	0.8	1.0	1.3	1.5	1.8	2.1	2.6	3.3	3.9	4.3	5.1
1.20	0.8	1.1	1.4	1.6	1.9	2.2	2.7	3.5	4.1	4.6	5.3
1.60	0.9	1.2	1.6	1.8	2.1	2.5	3.0	3.8	4.4	4.9	5.8
2.00	1.0	1.3	1.7	2.0	2.3	2.7	3.2	4.1	4.8	5.3	6.1
2.50	1.1	1.5	1.9	2.2	2.5	2.9	3.5	4.4	5.1	5.7	6.6
3.00	1.2	1.6	2.0	2.3	2.7	3.1	3.7	4.7	5.4	6.0	7.0
4.00	1.3	1.8	2.3	2.6	3.0	3.5	4.1	5.2	6.0	6.6	7.6
5.00	1.5	1.9	2.5	2.9	3.3	3.8	4.5	5.7	6.5	7.2	8.3

Table A-4

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.40)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.3	0.5	0.8	0.9	1.1	1.4	1.8	2.5	3.0	3.5	4.3
.10	0.4	0.6	0.8	1.0	1.2	1.4	1.8	2.6	3.1	3.6	4.4
.15	0.4	0.6	0.9	1.0	1.2	1.5	1.9	2.6	3.2	3.7	4.5
.20	0.5	0.7	0.9	1.1	1.3	1.6	2.0	2.7	3.3	3.7	4.5
.25	0.5	0.7	1.0	1.1	1.4	1.6	2.1	2.8	3.4	3.8	4.6
.30	0.6	0.7	1.0	1.2	1.4	1.7	2.1	2.9	3.4	3.9	4.7
.40	0.6	0.8	1.1	1.3	1.5	1.8	2.2	3.0	3.6	4.1	4.9
.50	0.6	0.9	1.2	1.3	1.6	1.9	2.3	3.1	3.7	4.2	5.0
.60	0.7	0.9	1.2	1.4	1.7	2.0	2.4	3.2	3.8	4.3	5.2
.80	0.8	1.0	1.3	1.5	1.8	2.1	2.6	3.5	4.1	4.6	5.4
1.00	0.8	1.1	1.4	1.6	1.9	2.3	2.8	3.6	4.3	4.8	5.7
1.20	0.9	1.2	1.5	1.8	2.0	2.4	2.9	3.8	4.5	5.0	5.9
1.60	1.0	1.3	1.7	1.9	2.2	2.6	3.2	4.1	4.8	5.4	6.3
2.00	1.1	1.4	1.8	2.1	2.4	2.8	3.4	4.4	5.2	5.7	6.7
2.50	1.2	1.5	2.0	2.3	2.6	3.1	3.7	4.8	5.5	6.1	7.1
3.00	1.2	1.6	2.1	2.4	2.8	3.3	4.0	5.1	5.9	6.5	7.5
4.00	1.4	1.8	2.4	2.7	3.1	3.7	4.4	5.6	6.4	7.1	8.2
5.00	1.5	2.0	2.6	3.0	3.4	4.0	4.8	6.1	7.0	7.7	8.9

Table A-5

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.50)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.4	0.6	0.8	1.0	1.2	1.5	2.0	2.8	3.4	4.0	4.9
.10	0.4	0.6	0.9	1.1	1.3	1.6	2.1	2.9	3.5	4.1	5.0
.15	0.5	0.7	1.0	1.1	1.4	1.7	2.1	3.0	3.6	4.1	5.1
.20	0.5	0.7	1.0	1.2	1.4	1.7	2.2	3.0	3.7	4.2	5.1
.25	0.6	0.8	1.0	1.2	1.5	1.8	2.3	3.1	3.8	4.3	5.2
.30	0.6	0.8	1.1	1.3	1.5	1.8	2.3	3.2	3.8	4.4	5.3
.40	0.6	0.9	1.2	1.4	1.6	2.0	2.4	3.3	4.0	4.5	5.5
.50	0.7	0.9	1.2	1.4	1.7	2.0	2.5	3.4	4.1	4.7	5.6
.60	0.7	1.0	1.3	1.5	1.8	2.1	2.6	3.5	4.2	4.8	5.7
.80	0.8	1.1	1.4	1.6	1.9	2.3	2.8	3.8	4.5	5.0	6.0
1.00	0.9	1.1	1.5	1.8	2.0	2.4	3.0	4.0	4.7	5.2	6.2
1.20	0.9	1.2	1.6	1.9	2.2	2.6	3.1	4.1	4.9	5.5	6.5
1.60	1.0	1.3	1.8	2.0	2.4	2.8	3.4	4.5	5.2	5.8	6.9
2.00	1.1	1.5	1.9	2.2	2.6	3.0	3.7	4.7	5.5	6.2	7.3
2.50	1.2	1.6	2.1	2.4	2.8	3.3	3.9	5.1	5.9	6.6	7.7
3.00	1.3	1.7	2.2	2.6	3.0	3.5	4.2	5.4	6.3	6.9	8.1
4.00	1.5	1.9	2.5	2.9	3.3	3.9	4.6	5.9	6.9	7.6	8.8
5.00	1.6	2.1	2.7	3.1	3.6	4.2	5.0	6.4	7.4	8.2	9.5

Table A-6

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.60)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.4	0.6	0.9	1.1	1.4	1.7	2.2	3.1	3.9	4.4	5.5
.10	0.5	0.7	1.0	1.2	1.4	1.8	2.3	3.2	3.9	4.5	5.6
.15	0.5	0.7	1.0	1.2	1.5	1.8	2.3	3.3	4.0	4.6	5.7
.20	0.6	0.8	1.1	1.3	1.5	1.9	2.4	3.4	4.1	4.7	5.7
.25	0.6	0.8	1.1	1.3	1.6	2.0	2.5	3.4	4.2	4.8	5.8
.30	0.6	0.8	1.2	1.4	1.6	2.0	2.5	3.5	4.2	4.8	5.9
.40	0.7	0.9	1.2	1.5	1.7	2.1	2.6	3.6	4.4	5.0	6.0
.50	0.7	1.0	1.3	1.5	1.8	2.2	2.8	3.7	4.5	5.1	6.2
.60	0.7	1.0	1.4	1.6	1.9	2.3	2.9	3.9	4.6	5.2	6.3
.80	0.8	1.1	1.5	1.7	2.0	2.4	3.0	4.1	4.8	5.5	6.6
1.00	0.9	1.2	1.6	1.9	2.2	2.6	3.2	4.3	5.1	5.7	6.8
1.20	0.9	1.3	1.7	2.0	2.3	2.7	3.4	4.4	5.3	5.9	7.0
1.60	1.1	1.4	1.9	2.1	2.5	3.0	3.6	4.8	5.6	6.3	7.4
2.00	1.1	1.5	2.0	2.3	2.7	3.2	3.9	5.1	5.9	6.6	7.8
2.50	1.3	1.7	2.2	2.5	2.9	3.4	4.2	5.4	6.3	7.0	8.3
3.00	1.3	1.8	2.3	2.7	3.1	3.7	4.4	5.7	6.7	7.4	8.7
4.00	1.5	2.0	2.6	3.0	3.5	4.1	4.9	6.3	7.3	8.1	9.4
5.00	1.7	2.2	2.9	3.3	3.8	4.4	5.3	6.8	7.8	8.7	10.1

Table A-7

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.70)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.4	0.7	1.0	1.2	1.5	1.9	2.4	3.5	4.3	4.9	6.1
.10	0.5	0.7	1.0	1.3	1.5	1.9	2.5	3.5	4.3	5.0	6.2
.15	0.6	0.8	1.1	1.3	1.6	2.0	2.6	3.6	4.4	5.1	6.2
.20	0.6	0.8	1.1	1.4	1.7	2.0	2.6	3.7	4.5	5.2	6.3
.25	0.6	0.9	1.2	1.4	1.7	2.1	2.7	3.7	4.6	5.2	6.4
.30	0.6	0.9	1.2	1.5	1.8	2.2	2.7	3.8	4.6	5.3	6.5
.40	0.7	1.0	1.3	1.6	1.9	2.3	2.9	3.9	4.8	5.4	6.6
.50	0.7	1.0	1.4	1.6	1.9	2.4	3.0	4.0	4.9	5.6	6.7
.60	0.8	1.1	1.4	1.7	2.0	2.4	3.1	4.2	5.0	5.7	6.9
.80	0.9	1.2	1.6	1.8	2.2	2.6	3.2	4.4	5.2	5.9	7.1
1.00	0.9	1.2	1.7	1.9	2.3	2.7	3.4	4.6	5.4	6.1	7.4
1.20	1.0	1.3	1.8	2.1	2.4	2.9	3.6	4.7	5.6	6.4	7.6
1.60	1.1	1.5	1.9	2.3	2.6	3.1	3.8	5.1	6.0	6.7	8.0
2.00	1.2	1.6	2.1	2.4	2.8	3.4	4.1	5.4	6.3	7.1	8.4
2.50	1.3	1.7	2.3	2.6	3.1	3.6	4.4	5.7	6.7	7.5	8.8
3.00	1.4	1.9	2.4	2.8	3.3	3.8	4.6	6.0	7.1	7.9	9.2
4.00	1.6	2.1	2.7	3.1	3.[illegible]	4.2	5.1	6.6	7.7	8.5	10.0
5.00	1.7	2.3	3.0	3.4	3.9	4.6	5.5	7.1	8.3	9.1	10.7

Table A-8

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.80)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.5	0.7	1.1	1.3	1.6	2.0	2.6	3.8	4.7	5.4	6.7
.10	0.5	0.8	1.1	1.4	1.7	2.1	2.7	3.8	4.7	5.5	6.8
.15	0.6	0.8	1.2	1.4	1.7	2.1	2.8	3.9	4.8	5.5	6.8
.20	0.6	0.9	1.2	1.5	1.8	2.2	2.8	4.0	4.9	5.6	6.9
.25	0.6	0.9	1.3	1.5	1.8	2.3	2.9	4.1	5.0	5.7	7.0
.30	0.7	0.9	1.3	1.6	1.9	2.3	2.9	4.1	5.0	5.8	7.0
.40	0.7	1.0	1.4	1.6	2.0	2.4	3.1	4.2	5.1	5.9	7.2
.50	0.8	1.1	1.5	1.7	2.1	2.5	3.2	4.4	5.3	6.0	7.3
.60	0.8	1.1	1.5	1.8	2.1	2.6	3.3	4.5	5.4	6.1	7.4
.80	0.9	1.2	1.6	1.9	2.3	2.8	3.4	4.7	5.6	6.4	7.7
1.00	1.0	1.3	1.7	2.0	2.4	2.9	3.6	4.9	5.8	6.6	7.9
1.20	1.0	1.4	1.8	2.2	2.5	3.0	3.8	5.1	6.0	6.8	8.2
1.60	1.1	1.5	2.0	2.4	2.8	3.3	4.1	5.4	6.4	7.2	8.6
2.00	1.2	1.6	2.2	2.5	3.0	3.5	4.3	5.7	6.7	7.5	8.9
2.50	1.3	1.8	2.4	2.7	3.2	3.8	4.6	6.0	7.1	7.9	9.4
3.00	1.4	1.9	2.5	2.9	3.4	4.0	4.9	6.4	7.5	8.3	9.8
4.00	1.6	2.1	2.8	3.2	3.8	4.4	5.4	6.9	8.1	9.0	10.6
5.00	1.8	2.4	3.1	3.5	4.1	4.8	5.8	7.5	8.7	9.6	11.2

Table A-9

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 0.90)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.5	0.8	1.1	1.4	1.7	2.2	2.8	4.1	5.1	5.9	7.3
.10	0.6	0.8	1.2	1.4	1.8	2.2	2.9	4.2	5.1	5.9	7.3
.15	0.6	0.9	1.2	1.5	1.8	2.3	3.0	4.2	5.2	6.0	7.4
.20	0.6	0.9	1.3	1.6	1.9	2.4	3.0	4.3	5.3	6.1	7.5
.25	0.7	0.9	1.3	1.6	1.9	2.4	3.1	4.4	5.3	6.1	7.6
.30	0.7	1.0	1.4	1.6	2.0	2.5	3.2	4.4	5.4	6.2	7.6
.40	0.8	1.0	1.5	1.7	2.1	2.6	3.3	4.5	5.5	6.3	7.8
.50	0.8	1.1	1.5	1.8	2.2	2.7	3.4	4.7	5.7	6.5	7.9
.60	0.8	1.2	1.6	1.9	2.3	2.7	3.5	4.8	5.8	6.6	8.0
.80	0.9	1.3	1.7	2.0	2.4	2.9	3.7	5.0	6.0	6.8	8.3
1.00	1.0	1.4	1.8	2.1	2.5	3.1	3.8	5.2	6.2	7.0	8.5
1.20	1.1	1.4	1.9	2.3	2.7	3.2	4.0	5.4	6.4	7.2	8.7
1.60	1.2	1.6	2.1	2.5	2.9	3.5	4.3	5.7	6.8	7.6	9.1
2.00	1.3	1.7	2.3	2.6	3.1	3.7	4.5	6.0	7.1	8.0	9.5
2.50	1.4	1.9	2.5	2.8	3.3	3.9	4.8	6.4	7.5	8.4	10.0
3.00	1.5	2.0	2.6	3.0	3.5	4.2	5.1	6.7	7.9	8.8	10.4
4.00	1.7	2.2	2.9	3.4	3.9	4.6	5.6	7.3	8.5	9.5	11.1
5.00	1.8	2.4	3.2	3.7	4.2	5.0	6.0	7.8	9.1	10.1	11.8

Table A-10

Number of Patrol Troopers Required To Provide Immediate Response Capability Based On the Average Number of Reactive Troopers Required and the Selected Response Percentage (K_s = 1.00)

Number of Reactive Troopers (N_{ri}) (A.6.x.2)	Performance Objective Immediate Response Percentage (A.6.x.1)										
	50	60	70	75	80	85	90	95	97	98	99
.05	0.6	0.8	1.2	1.5	1.8	2.3	3.1	4.4	5.5	6.3	7.8
.10	0.6	0.9	1.3	1.5	1.9	2.4	3.1	4.5	5.5	6.4	7.9
.15	0.6	0.9	1.3	1.6	2.0	2.4	3.2	4.5	5.6	6.5	8.0
.20	0.7	1.0	1.4	1.6	2.0	2.5	3.2	4.6	5.7	6.5	8.1
.25	0.7	1.0	1.4	1.7	2.1	2.6	3.3	4.7	5.7	6.6	8.1
.30	0.7	1.0	1.5	1.7	2.1	2.6	3.4	4.7	5.8	6.7	8.2
.40	0.8	1.1	1.5	1.8	2.2	2.7	3.5	4.9	5.9	6.8	8.3
.50	0.8	1.2	1.6	1.9	2.3	2.8	3.6	5.0	6.0	6.9	8.5
.60	0.9	1.2	1.7	2.0	2.4	2.9	3.7	5.1	6.2	7.0	8.6
.80	1.0	1.3	1.8	2.1	2.5	3.1	3.9	5.3	6.4	7.3	8.8
1.00	1.0	1.4	1.9	2.2	2.7	3.2	4.0	5.5	6.6	7.5	9.1
1.20	1.1	1.5	2.0	2.4	2.8	3.4	4.2	5.7	6.8	7.7	9.3
1.60	1.2	1.6	2.2	2.6	3.0	3.6	4.5	6.0	7.2	8.1	9.7
2.00	1.3	1.8	2.4	2.7	3.2	3.8	4.7	6.3	7.5	8.4	10.1
2.50	1.4	1.9	2.5	3.0	3.5	4.1	5.0	6.7	7.9	8.9	10.5
3.00	1.5	2.1	2.7	3.1	3.7	4.4	5.3	7.0	8.2	9.2	10.9
4.00	1.7	2.3	3.0	3.5	4.1	4.8	5.8	7.6	8.9	9.9	11.7
5.00	1.9	2.5	3.3	3.8	4.4	5.2	6.3	8.1	9.5	10.6	12.4

* U.S. G.P.O.:1993-343-273:80055

DOT HS 807 792
December 1991