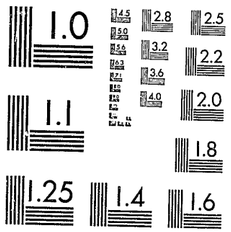

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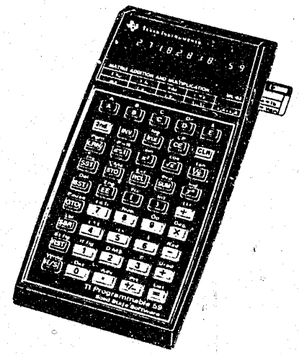
POLICE / PLAN — AN EASY-TO-USE RESOURCE ALLOCATION SYSTEM:

User's Manual and Training Materials For PATROL / PLAN Software on TI Programmable 59 Calculator



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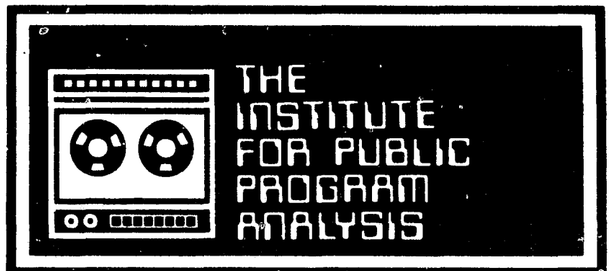

POLICE / PLAN — AN EASY-TO-USE RESOURCE ALLOCATION SYSTEM:

User's Manual and Training Materials for PATROL / PLAN Software on TI Programmable 59 Calculator

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October 1979

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ABSTRACT

This report describes in detail the procedures for using POLICE/PLAN, an easy-to-use police resource allocation planning system developed for the Texas Instruments Programmable 59 calculator. PATROL/PLAN--the principal component of the system--is a planning tool used for evaluating and improving the deployment of police field operations units by time and geographic area. With PATROL/PLAN, a planner can assess the effects of varying the number of in-service patrol units, the call-for-service rate, the amount of non-CFS activity, the dispatching policy, etc. on such field performance characteristics as unit workload, average travel time, the percent of time that all units are busy, and patrol interval. The procedures described are illustrated through the solution to a typical resource allocation problem confronting small and medium-sized police departments which represent the intended audience for the POLICE/PLAN system. Training exercises and solutions are included to further demonstrate the capabilities of POLICE/PLAN.

This report is one of the products of the project "Easy-to-Use Police Resource Allocation Planning Tools--Practical Derivatives of Sophisticated Computer-Based Planning Models." The project was conducted by The Institute for Public Program Analysis, with funding from the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration (grant #78NI-AX-0015). POLICE/PLAN has been field tested in three police departments, and prototype versions have been obtained by 29 additional agencies. Field experience has shown that POLICE/PLAN can be used by persons with no prior data processing experience and can bring sophisticated planning capabilities within the reach of small and medium-sized police departments.

PREFACE

This report is one of the products of the project "Easy-to-Use Police Resource Allocation Planning Tools--Practical Derivatives of Sophisticated Computer-Based Planning Models." The project was conducted by The Institute for Public Program Analysis, a private non-profit research firm located in St. Louis, Missouri. The project was funded by the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration (grant #78NI-AX-0015).

The primary product of the project is POLICE/PLAN, a police resource allocation planning system used with low cost ($300-$3800) microcomputers or programmable calculators. The findings and products of the study are presented in five reports:

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: Executive Summary, Richard A. Kolde, William W. Stenzel, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN software on TI Programmable 59 Calculator, Richard A. Kolde, Nelson B. Heller, William W. Stenzel, and Allen D. Gill, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN Software on TRS-80 Microcomputer, William W. Stenzel, Richard A. Kolde, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual for PATROL/PLAN, BEAT/PLAN, and DATA/PLAN Software on Apple II Microcomputer, Richard A. Kolde, William W. Stenzel, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979; and

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: Training Materials for PATROL/PLAN, BEAT/PLAN, and DATA/PLAN Software on Apple II Microcomputer,

William W. Stenzel, Richard A. Kolde, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Programming Analysis, October 1979.

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Finally, a special note of thanks is extended to Mrs. Vicki O'Dell and Mrs. Nancy McCloud, who typed most of the material contained in the project's reports and ably supervised the typing of the remainder.

Information about how to obtain the POLICE/PLAN software and documentation is available from:

- Executive Director
  The Institute for Public Program Analysis
  1328 Baur Boulevard
  St. Louis, Missouri 63132

or

- Director
  Police Division
  National Institute of Law Enforcement
  and Criminal Justice
  Washington, D.C. 20531

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CHAPTER I

INTRODUCTION

This chapter describes the purpose and use of PATROL/PLAN with a Texas Instruments Programmable 59 Calculator*, and summarizes the input data items required and the outputs produced. Chapters II through VI discuss the capabilities of each of the five programs which comprise the PATROL/PLAN system. A sample exercise and solution is included in each chapter to illustrate the features of the programs. Appendix A contains a glossary of the terminology used, Appendix B contains a summary of PATROL/PLAN inputs and outputs, and Appendix C contains a training exercise and solution.

A. Purpose and Use of PATROL/PLAN

PATROL/PLAN is an easy-to-use patrol car allocation model used chiefly for evaluating and improving the deployment of police field operations units by time and geographic area. The program uses basic operations data supplied by the user to produce estimates of several field operations performance characteristics including:

- average service time spent by each unit on a CFS;
- total service time spent by all units dispatched to each CFS;
- average amount of time spent per hour by each patrol unit on CFS work and non-CFS activities;
- average number of free units available to respond to incoming calls;
- minimum patrol interval;
- percent of incoming CFS that must be "stacked" (i.e., calls delayed by the dispatcher) because all units are busy; and
- average travel time.

These performance estimates can be used for many planning functions: to assess the effectiveness of an existing deployment plan, to compare plans for different time blocks or geographic regions, or to investigate the effects of changes in workload (e.g., the

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*As described in Section B, versions of PATROL/PLAN are available for use with or without the Texas Instruments PC-100A or PC-100C print unit.

number of calls-for-service received per hour), operations (e.g., the number of units fielded), or geographic configuration (e.g., the area serviced).

In addition to assessing or comparing existing deployment plans, PATROL/PLAN can be used to determine the minimum number of units needed to satisfy user-specified performance standards. This capability allows the user to set standards for one or more of the following performance measures:

- actual CFS work per unit (minutes per hour);
- percent of time that all units are busy;
- travel time (minutes); and
- patrol interval.

The PATROL/PLAN programs are designed to be used by persons who are not familiar with data processing. Field operations data are entered interactively into the calculator. If a print unit is available, the program requests each input data item in a tutorial manner using easy-to-understand English language commands. Otherwise, numerically codes messages are used. Field data needed to run the PATROL/PLAN programs include:

- number of patrol units fielded;
- average number of CFS per hour;
- fraction of calls that require exactly 1,2,..., units;
- average number of minutes spent on non-CFS activities per hour by each unit;
- dispatching policy used when a CFS is received and all units are busy;
- area of the region;
- average response speed;
- number of miles of patrolled streets; and
- average patrol speed.

B. Selecting a Program to Use

This section identifies the programs available and the capabilities of each. If you are using a version of the PATROL/PLAN system designed for use with the Texas Instruments Programmable 59 calculator and the PC-100A or PC-100C print unit, together called

the "Calculator/Print system," you will use programs having index numbers terminating with the letter P, such as PATROL/PLAN-10P. If you are using a version designed for use with the TI-59 calculator alone, called "Calculator/Display system," you will use programs having index numbers terminating with the letter D, such as PATROL/PLAN-10D. The functions of each PATROL/PLAN program are described below and summarized in Table 1-1.

1. PATROL/PLAN-10P or 10D is the first program used in any analysis. It is used to specify the number of calls for service per hour, service time, and number of patrol cars. In addition, this program is used to account for:

   a. non-called-for-service (non-CFS) and self-initiated work; or
   b. the dispatching of more than one patrol car to some incidents.

2. PATROL/PLAN-20P or 20D is used if calls for service that arrive when all patrol cars are simultaneously busy are held by the dispatcher (queued) until a patrol car becomes available, and you want to compute:

   a. the work per car for patrol cars assigned to the region of interest;
   b. the percent of time all patrol cars are simultaneously busy handling calls for service;
   c. the minimum number of patrol cars needed so that the work per car is less than a specified value;
   d. the minimum number of patrol cars needed so that the percent of time all patrol cars are simultaneously busy is less than a specified value.

3. PATROL/PLAN-25P or 25D is used if calls for service that arrive when all patrol cars are simultaneously busy are immediately transferred to other cars, and you want to compute:

   a. the incoming work per car for patrol cars assigned to the region of interest;
   b. the actual work per car for patrol cars;
   c. the percent of time all patrol cars are simultaneously busy handling calls for service;
   d. the minimum number of patrol cars needed so that the actual work per car is less than a specified value; or
   e. the minimum number of patrol cars needed so that the percent of time all patrol cars are simultaneously busy is less than a specified value.

4. PATROL/PLAN-30P or 30D is used if you want to compute:

   a. the average travel time for response to calls for service; or
   b. the minimum number of patrol cars needed so that average travel time is less than a specified value.

Table 1-1

SUMMARY OF FUNCTIONS OF PATROL/PLAN PROGRAMS

Program*	Function
10P, 10D	Used to input: • Number of calls for service per hour • Service times • Number of units and account for: • Multiple car dispatching • Non-CFS work
20P, 20D, 25P, 25D	Used to calculate: • Incoming work per car • Actual work per car • Minimum number of cars to meet standard on actual work • Percent of time all cars are busy • Minimum number of cars to meet standard on percent of time all cars are busy
30P, 30D	Used to calculate: • Average travel time • Minimum number of cars to meet standard on travel time
40P, 40D	Used to calculate: • Average number of free cars • Patrol interval • Minimum number of cars to meet standard on patrol interval
50P, 50D	Used to review values previously input or calculated

*The notation used to identify PATROL/PLAN programs is discussed in Section B.

5. PATROL/PLAN-40P or 40D is used if you want to compute:

   a. the average number of free patrol cars;
   b. the patrol interval (i.e., the average time, in hours, between passings of any given point in the region by a patrol car on free patrol); or
   c. the minimum number of patrol cars needed so that the patrol interval is less than a specified value.

6. PATROL/PLAN-50P or 50D is used if you want to list or display the values previously input or calculated for:

   a. number of CFS cars;
   b. number of minutes of non-CFS work per hour per car;
   c. number of calls per hour;
   d. service time per call (reflecting the impact of multiple car dispatching);
   e. area of the region;
   f. response speed;
   g. number of patrolled street miles; and
   h. patrol speed.

C. Entering Programs into the Calculator

In order to use the programs of the PATROL/PLAN system they must first be entered into the calculator as follows:

1. Before using the program selected, reserve the correct number of storage registers required by programs of the PATROL/PLAN system by keying in the sequence of instructions shown in Table 1-2.

2. The program of interest is read into the calculator by reading in two to four sides of the magnetic cards containing the program. The number of card sides to be read for each program is indicated in Table 1-2. For programs in the Calculator/Print system, four card sides are read if the program is the first used in an analysis. (The first program used in an analysis is normally PATROL/PLAN-10P.) Otherwise, three card sides are read.

If a patrol car deployment analysis requires the use of more than one of PATROL/PLAN's programs, the system is designed so that values for the number of patrol cars, call rate, service time, number of minutes of non-CFS work per hour per car, area of the region, number of patrolled street miles, and response and patrol speeds are entered or computed only once: these values are then automatically saved by the calculator for reuse by other PATROL/PLAN programs providing that the calculator is not switched off and that no programs from any other software package are run during the intervening period.

Table 1-2

SEQUENCE OF INSTRUCTIONS REQUIRED PRIOR TO ENTERING PATROL/PLAN PROGRAMS

Using program PATROL/PLAN		First key in:	Then key in:	Display should read:	Number of Card Sides to Read In:
PRINT	10P	6	2ND CP	479.59	3-4
	20P or 25P	6		479.59	3-4
	30P	6		479.59	3-4
	40P	7		399.69	3-4
	50P	8		319.79	3-4
DISPLAY	10D	3	OP 17	719.29	2
	20D or 25D	3		719.29	2
	30D	3		719.29	2
	40D	3		719.29	2
	50D	3		719.29	2

To enter side 1 of a program into the calculator, key in 1 and insert side 1 of the selected program into the card reader (lower slot on right-hand side of the calculator). After the card has been read, the display should read -1. If the display is flashing, key in CE and repeat the process (i.e., key in 1 and reinsert side 1 of the program).

Repeat this step for sides 2, 3, and 4, if necessary. In each case, the number of the side being read should be keyed in before the card is inserted into the reader. After each side has been successfully read, the side number (-2, -3, or -4) should be displayed without flashing.

Complete the program entry process by keying in CLR to clear the display.

D. Interpreting the Display When Using the Calculator/Display System

Unlike the Calculator/Print version of the PATROL/PLAN system, which employs easily understood messages using the alpha-numeric capabilities of the print unit to request input data, send messages to the user, and label program output, the Calculator/Display version communicates this information using coded numeric messages. The system of code numbers employed enables the user to determine what information is being requested and to identify the name of each output prior to display of the computed value.

All messages have the following format:

X.YYY ZZ

(Note that message numbers are easily distinguished from input data and computed output values by the two "ZZ" digits which are placed separately to the right of the other numbers in the display.) In this format, "X" specifies the tens digit of the program number for the program(s) with which the message is associated. For example, for program PATROL/PLAN-10D the value of "X" is always 1. "YYY" identifies the applicable message in a message list given in each program's documentation. "ZZ" tells the user how to respond:

"01" identifies an output message or names a forthcoming computed output value. The user must key in R/S after interpretting the message, and, if an output value is next displayed, key in R/S again after recording the value, in order to continue processing.

"02" indicates that the user should enter the data item being requested, and then key in R/S to continue processing.

For example, the message numbers for PATROL/PLAN-10D are shown in Table 1-3. Message number 1.103 02 is interpretted as follows:

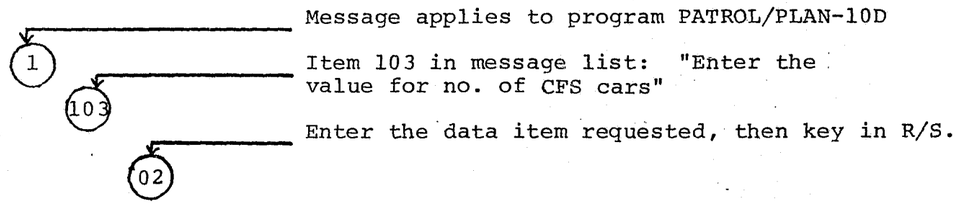

Table 1-3

SAMPLE CODED MESSAGES GENERATED BY PATROL/PLAN PROGRAMS

The following messages are read, "The next number displayed is the":

1.401 01	Adjusted calls per hour
1.402 01	Service time per call
1.403 01	Service time per dispatch

The following messages are read, "Enter the value for":

1.101 02	Calls per hour
1.102 02	Service time per call
1.103 02	No. of CFS cars
1.104 02	Non-CFS min/hr/car
1.201 02	Percent of calls that require exactly 1 car
1.202 02	Percent of calls that require exactly 2 cars
:	:
1.299 02	Percent of calls that require exactly 99 cars
1.301 02	Service time of 1st CFS car dispatched (min.)
1.302 02	Service time of 2nd CFS car dispatched (min.)
:	:
1.399 02	Service time of 99th CFS car dispatched (min.)

The following message is read:

1.999 01	End of operation (another routine may be selected, or another program may be read into the calculator after first keying in R/S)

CHAPTER II

PATROL/PLAN-10P AND 10D

A. Introduction

PATROL/PLAN-10P or 10D is used to specify the number of calls per hour, service time, and number of patrol cars at the start of any PATROL/PLAN analysis. They can also be used to compute the following:

- average service time per call--the average total of service times, in minutes, worked by all cars dispatched to a single incident (thereby accounting for multiple car dispatching);
- average service time per dispatch--the average of service times, in minutes, recorded for individual cars, regardless of the number of other cars dispatched to each incident;
- adjusted calls per hour--the scaled-up value of calls for service per hour which allows PATROL/PLAN to account for non-CFS work.

B. Procedure for Using PATROL/PLAN-10P or 10D

To calculate the average service times per call and dispatch, you will need to specify:

- the percent of calls for service that require exactly N cars to be dispatched, separately indicated for values of N from 1 up to (if necessary) 99; and
- the average service time, in minutes of the Nth car to be dispatched to calls for service, for values of N from 1 up to (if necessary) 99.

The user must supply this information for one car, two cars, etc. until the sum of the percentages is equal to or greater than 100 percent, at which point the program automatically stops the input process (it stops asking the user for information regarding simultanious dispatching of any greater number of cars).

To account for non-CFS work, you must also specify:

- the number of calls for service per hour arriving in the region of interest;
- the number of CFS (patrol) cars in the region of interest; and
- the number of minutes per hour required by each patrol car to perform its non-CFS work.

If acceptable values for the number of calls for service arriving per hour or the number of patrol cars have been previously specified, they need not be reinput, assuming that the calculator has not been switched off and that programs from software packages other than PATROL/PLAN have not been used since the values were entered.

PATROL/PLAN 10P and 10D routines allow the user to select the patrol operations characteristics to be computed, and to input needed data items. The programs guide the user in performing these analyses using printed messages or coded message numbers (see Table 2-1 for a description of the message numbers used by PATROL/PLAN-10D).

The program's routines are initiated by entering one or two keys, as described in the following list, and following the instructions given.

ROUTINE	KEY SEQUENCE FIRST	SECOND (if any)
Initialization	2ND	E
Input calls per hour, number of CFS cars, percent of calls requiring exactly 1, 2, ... cars, service time of 1st, 2nd ... car dispatched, and non-CFS min/hr/car, and then compute average service times per call and dispatch	A	
Compute average service times per call and dispatch using previously entered data	B	
Print or display the adjusted number of calls per hour (adjusted to account for non-CFS work)	C	
Input or modify the percent of calls requiring exactly 1,2,... cars, and the service time of the 1st, 2nd,... car dispatched	D	
Input or modify the number of non-CFS minutes per hour per car	E	
Input or modify the number of calls per hour	2ND	A
Input or modify the average service time per call	2ND	B

Table 2-1

CODED MESSAGES GENERATED BY PATROL/PLAN-10D

The following messages are read, "The next number displayed is the":

1.401 01 Adjusted calls per hour
1.402 01 Service time per call
1.403 01 Service time per dispatch

The following messages are read, "Enter the value for":

1.101 02 Calls per hour
1.102 02 Service time per call
1.103 02 No. of CFS cars
1.104 02 Non-CFS min/hr/car
1.201 02 Percent of calls that require exactly 1 car
1.202 02 Percent of calls that require exactly 2 cars
: :
1.299 02 Percent of calls that require exactly 99 cars
1.301 02 Service time of 1st CFS car dispatched (min.)
1.302 02 Service time of 2nd CFS car dispatched (min.)
: :
1.399 02 Service time of 99th CFS car dispatched (min.)

The following message is read:

1.999 01 End of operation (another routine may be selected, or another program may be read into the calculator after first keying in R/S)

Input or modify the number of patrol cars	2ND	C
Input or modify the number of calls per hour, average service time per call, and number of patrol cars	2ND	D

Note that initialization (2ND E) must be the first routine used after PATROL/PLAN-10P or 10D is read into the calculator.

C. Example

Suppose that the number of calls per hour is 8, the number of patrol cars is 11, the number of non-CFS minutes per hour per car is 10, and that the percent of calls requiring 1, 2, and 3 cars, and service times of the 1st, 2nd, and 3rd car dispatched are as follows:

number of cars, N	percent of calls requiring exactly N cars	service time of Nth car dispatched (min)
1	50	30
2	25	20
3	25	10

Compute the service times per call and dispatch, and the adjusted number of calls per hour (taking into account non-CFS work).

The solution obtained from the Calculator/Print system is shown in Figure 2-1, and from the Calculator/Display system, in Figure 2-2.


```
2ND
 E
 A ──→ CALLS PER HOUR?

          8.

       NO. OF CFS CARS?

          11.

    % OF CALLS REQUIRING
    EXACTLY  1 CARS?

          50.

    SERVICE TIME OF CAR
     1 (MIN.)?

          30.

    % OF CALLS REQUIRING
    EXACTLY  2 CARS?

          25.

    SERVICE TIME OF CAR
     2 (MIN.)?

          20.

    % OF CALLS REQUIRING
    EXACTLY  3 CARS?

          25.

    SERVICE TIME OF CAR
     3 (MIN.)?

          10.

    NON-CFS MIN/HR/CAR?

          10.

    SERVICE MIN. PER
    DSP.=

          24.29

    SERVICE MIN. PER
    CALL=

          42.50

C ──→ ADJ. CALLS PER HOUR=

          10.59
```

Figure 2-1

PROBLEM SOLUTION USING PATROL/PLAN-10P

KEY SEQUENCE FIRST	SECOND	CALCULATOR DISPLAY	INTERPRETATION
2ND	E	1.999 01	End of operation (initialization)
R/S		0	
A		1.101 02	Input calls per hour
8	R/S	1.103 02	Input number of CFS cars
11	R/S	1.201 02	Input percent of calls that require exactly 1 car
50	R/S	1.301 02	Input service time of 1st CFS car dispatched (minutes)
30	R/S	1.202 02	Input percent of calls that require exactly 2 cars
25	R/S	1.302 02	Input service time of 2nd CFS car dispatched (minutes)
20	R/S	1.203 02	Input percent of calls that require exactly 3 cars
25	R/S	1.303 02	Input service time of 3rd CFS car dispatched
10	R/S	1.104 02	Input non-CFS minutes/hour/car
10	R/S	1.403 01	Service time per dispatch (minutes) equals
R/S		24.29	
R/S		1.402 01	Service time per call (minutes) equals
R/S		42.50	
R/S		1.999 01	End of operation
R/S		0	
C		1.401 01	Adjusted calls per hour equals
R/S		10.59	
R/S		1.999 01	End of operation
R/S		0	

Figure 2-2

PROBLEM SOLUTION USING PATROL/PLAN-10D

CHAPTER III

PATROL/PLAN-20P, 20D, 25P, and 25D

A. Introduction

PATROL/PLAN-20P, 20D, 25P, or 25D is used to compute the following:

- the incoming work per car, in minutes per hour, for patrol cars assigned to the region of interest;
- the actual work per car, in minutes per hour, for patrol cars;
- the percent of time all patrol cars are simultaneously busy handling calls for service or non-CFS work;
- the minimum number of cars needed so that the actual work per car is less than a specified value; or
- the minimum number of cars needed so that the percent of time all patrol cars are simultaneously busy is less than a specified value.

PATROL/PLAN-20P or 20D is used if calls that arrive when all patrol cars are busy, are queued until a patrol car becomes available.* PATROL/PLAN-25P or 25D is used if such calls are transferred to non-patrol cars (e.g., detective, canine, supervisory, or cars from another command).

B. Procedure for Using PATROL/PLAN-20P, 20D, 25P, or 25D

Before using PATROL/PLAN-20P, 20D, 25P, or 25D, the number of patrol cars, calls per hour, service time, and non-CFS minutes per hour per car must be entered or computed using PATROL/PLAN 10P or 10D.**

If values for these factors have been previously specified, they need not be reinput, assuming that the calculator has not been switched off and that programs from software packages other than PATROL/PLAN have not been used since the values were entered.

---

*In this case, the incoming and actual work are the same.

**Note that although 20P, 20D, 25P and 25D have routines for specifying calls per hour, service time, and number of cars, these routines may only be used when the value of non-CFS minutes per hour per car is zero (otherwise, non-CFS work will be ignored).

PATROL/PLAN-20P, 20D, 25P, and 25D's routines allow the user to select the patrol operations characteristics to be computed. The programs guide the user in performing the analyses using printed messages or coded message numbers (see Table 3-1 for a description of the message numbers used by PATROL/PLAN-20D and 25D).

The program's routines are initiated by entering one or two keys, as described in the following list, and following the instructions given.

ROUTINE	KEY SEQUENCE FIRST	SECOND
Initialization	2ND	E
Compute incoming work per car (PATROL/PLAN-25P and 25D only)	A	
Compute actual work per car	B	
Compute the percent of time all patrol cars are simultaneously busy	C	
Compute the minimum number of cars needed so that the actual work per car is less than a specified number of minutes per hour	D	
Compute the minimum number of cars needed so that the percent of time that all patrol cars are simultaneously busy is less than a specified value	E	
Input or modify the number of calls per hour*	2ND	A
Input or modify the average service time per call*	2ND	B
Input or modify the number of patrol cars*	2ND	C
Input or modify the number of calls per hour, service time, and number of patrol cars*	2ND	D

Note that initialization (2ND E) must be the first routine used after the program has been read into the calculator.

---

*These routine should not be used unless the value for non-CFS minutes per hour per car is zero.

Table 3-1

CODED MESSAGES GENERATED BY PATROL/PLAN-20D AND 25D

The following messages are read, "The next number displayed is the":

2.201	01	Incoming work per car (minutes per hour)
2.202	01	Actual work per car (minutes per hour)
2.203	01	Percent of time all patrol cars are simultaneously busy
2.204	01	Minimum number of cars needed so that the actual work per car is less than the specified number of minutes per hour
2.205	01	Minimum number of cars needed so that the percent of time all patrol cars are simultaneously busy is less than the specified value

The following messages are read, "Enter the value for":

2.101	02	Calls per hour
2.102	02	Service time per call (minutes)
2.103	02	Number of patrol cars
2.104	02	Maximum acceptable value for actual work per car
2.105	02	Maximum acceptable value for percent of time all cars are simultaneously busy

The following message is read:

2.999	01	End of operation (another routine may be selected, or another program may be read into the calculator, after first keying in R/S)

C. Example

Suppose that calls per hour, service times, non-CFS minutes per hour per car, and number of cars are as described in the example in Chapter II, and that calls arriving when all patrol cars are busy are queued. Compute the actual work per car and the percent of time that all cars are simultaneously busy. Also, determine the minimum number of cars needed so that (1) the actual work per car is less than 20 minutes per hour, and (2) the percent of time all cars are simultaneously busy is less than 5 percent.

The solution obtained from the Calculator/Print system is shown in Figure 3-1, and from the Calculator/Display system, in Figure 3-2.


```
2ND
E
B→ ACTUAL WORK PER CAR
   (MIN./HOUR)=

      40.91

C→ % OF TIME ALL CARS
   ARE BUSY=

      17.5807

D→ MAXIMUM ALLOWED
   ACTUAL WORK PER CAR
   (MIN./HOUR)?

      20.

   MINIMUM NO. OF CARS=

      34.

   ACTUAL WORK PER CAR
   (MIN./HOUR)=

      20.00

E→ MAXIMUM ALLOWED
   % OF TIME ALL CARS
   ARE BUSY?

      5.

   MINIMUM NO. OF CARS=

      14.

   % OF TIME ALL CARS
   ARE BUSY=

      3.9280
```

Figure 3-1

PROBLEM SOLUTION USING PATROL/PLAN-20P

KEY SEQUENCE FIRST	SECOND	CALCULATOR DISPLAY	INTERPRETATION
2ND	E	2.999 01	End of operation (initialization)
R/S		0	
B		2.202 01	Actual work per car (minutes per hour) equals
R/S		40.91	
R/S		2.999 01	End of operation
R/S		0	
C		2.203 01	Percent of time all patrol cars are simultaneously busy equals
R/S		17.5807	
R/S		2.999 01	End of operation
R/S		0	
D		2.104 02	Input maximum acceptable value for actual work per car (minutes per hour)
20	R/S	2.204 01	Maximum number of cars needed such that actual work per car is less than specified value equals
R/S		34	
R/S		2.202 01	Actual work per car (minutes per hour) equals
R/S		20.00	
R/S		2.999 01	End of operation
R/S		0	
E		2.105 02	Input maximum acceptable value for percent of time all cars are busy
5	R/S	2.205 01	Minimum number of cars needed such that percent of time all cars are busy is less than specified value equals
R/S		14	
R/S		2.203 01	Percent of time all cars are busy equals
R/S		3.9280	
R/S		2.999 01	End of operation
R/S		0	

Figure 3-2

PROBLEM SOLUTION USING PATROL/PLAN-20D

CHAPTER IV

PATROL/PLAN-30P AND 30D

A. Introduction

PATROL/PLAN-30P or 30D is used to compute the following:

- average travel time--the average time, in minutes, from the dispatch of a patrol car until its arrival at the scene of the assigned incident; and
- minimum number of patrol cars needed so that the average travel time is less than a specified number of minutes.*

B. Procedure for Using PATROL/PLAN-30P or 30D

Before using PATROL/PLAN-30P or 30D, the number of patrol cars, calls per hour, service time, and non-CFS minute per hour per car must be entered or computed using PATROL/PLAN-10P or 10D,** and the actual work per car must be computed using PATROL/PLAN-20P, 20D, 25P, or 25D. You will also need to specify:

- the area of the region of interest, in square miles; and,
- the average response speed, in miles per hour.

If values for these factors have been previously specified, they need not be reinput, assuming that the calculator has not been switched off and that programs from software packages other than PATROL/PLAN have not been used since the values were entered.

PATROL/PLAN-30P and 30D's routines allow the user to select the patrol operations characteristics to be computed, and to input needed data items. The programs guide the user in performing these analyses using printed messages or coded message numbers (see Table 4-1 for a description of the message numbers used by PATROL/PLAN-30D).

---

*Assuming that calls which arrive when all patrol cars are busy are held "in queue" by the dispatcher until a patrol car becomes available.

**Note that PATROL/PLAN-30P and 30D have routines for specifying calls per hour, service time, and number of cars. However, these routines may only be used when the value of non-CFS minutes per hour per car is zero (otherwise, non-CFS work will be ignored).

Table 4-1

CODED MESSAGES GENERATED BY PATROL/PLAN-30D

The following messages are read, "The next number displayed is the":

3.101	01	Average travel time (minutes)
3.102	01	Minimum number of cars such that the average travel time is less than the specified number of minutes

The following messages are read, "Enter the value for":

3.201	02	Calls per hour
3.202	02	Service time per call (minutes)
3.203	02	Number of patrol cars
3.204	02	Area of the region (square miles)
3.205	02	Response speed (m.p.h.)
3.206	02	Maximum acceptable average travel time (minutes)

The following messages are read:

3.100	01	Compute actual work per car first
3.999	01	End of operation (another routine may be selected, or another program may be read into the calculator after first keying in R/S)

The program's routines are initiated by entering one or two keys, as described in the following list, and following the instructions given.

ROUTINE	KEY SEQUENCE FIRST	KEY SEQUENCE SECOND (if any)
Initialization	2ND	E
Specify or modify the area of the region and response speed, and then compute average travel time.	B	
Compute average travel time using previously specified area and response speed.	C	
Determine the minimum number of cars needed so that average travel time is less than a specified number of minutes*	D	
Input or modify the number of calls per hour**	2ND	A
Input or modify the average service time per call**	2ND	B
Input or modify the number of patrol cars**	2ND	C
Input or modify calls per hour, service time, and number of patrol cars**	2ND	D

Note that initialization (2ND E) must be the first routine used after PATROL/PLAN-30P or 30D is read into the calculator.

---

*This routine assumes that calls for service which arrive when all patrol cars are simultaneously busy are queued until a patrol car becomes available. If, in fact, such calls are transferred to other cars, fewer cars may be required to meet the travel time constraint.

**These routines should not be used unless the value for non-CFS minutes per hour per car is zero.

C. Example

Suppose that calls per hour, service times, non-CFS minutes per hour per car, and number of cars are as described in the example in Chapter II, and that calls arriving when all patrol cars are busy are queued, the area of the region is 76 square miles, and the response speed is 24.4 m.p.h. Compute the average travel time, and the minimum number of cars needed to reduce the average travel time to four minutes or less.

The solution obtained from the Calculator/Print system is shown in Figures 4-1, and from the Calculator/Display system, in Figure 4-2.


```
2ND
 E
 B ----------> RESPONSE SPEED(MPH)?

               24.4

               AREA(SQ. MILES)=

               76.


               TRAVEL TIME(MIN.)=

               8.15

 D ----------> MAX. TRAVEL MINUTES
               ALLOWED?

               4.


               MINIMUM NO. OF CARS=

               25.

               TRAVEL TIME(MIN.)=

               3.91
```

Figure 4-1

PROBLEM SOLUTION USING PATROL/PLAN-30P

KEY SEQUENCE FIRST	KEY SEQUENCE SECOND	CALCULATOR DISPLAY	INTERPRETATION
2ND	E	3.999 01	End of operation (initialization)
R/S		0	
B		3.205 02	Input response speed (M.P.H.)
24.4	R/S	3.204 02	Input area of the region (square miles)
76	R/S	3.101 01	Average travel time (minutes) equals
R/S		8.15	
R/S		3.999 01	End of operation
R/S		0	
D		3.206 02	Input maximum acceptable travel time (minutes)
4	R/S	3.102 01	Minimum number of cars needed such that travel time is less than specified value equals
R/S		25	
R/S		3.101 01	Average travel time (minutes) equals
R/S		3.91	
R/S		3.999 01	End of operation
R/S		0	

Figure 4-2

PROBLEM SOLUTION USING PATROL/PLAN-30D

CHAPTER V

PATROL/PLAN-40P AND 40D

A. Introduction

PATROL/PLAN-40P or 40D is used to compute the following:

- number of free patrol cars--the average number of patrol cars free to respond to incoming calls;
- patrol interval--the average time in hours between passings of any given point in the region by a car on free patrol; and
- minimum number of patrol cars needed so that the patrol interval is less than a specified number of hours.*

B. Procedure for Using PATROL/PLAN-40P or 40D

Before using PATROL/PLAN-40P or 40D, the number of patrol cars, calls per hour, service time, and non-CFS minutes per hour per car must be entered or computed using PATROL/PLAN-10P or 10D** and the actual work per car must be computed using PATROL/PLAN-20P, 20D, 25P, or 25D. If you want to calculate the patrol interval, you will also need to specify:

- the number of patrolled street miles (a good estimate for many cities is 35 times the area of the region in square miles); and,
- the average patrol speed, in miles per hour.

If values for these factors have been previously specified they need not be reinput, assuming that the calculator has not been switched off and that programs from software packages other than PATROL/PLAN have not been used since the values were entered.

PATROL/PLAN-40P and 40D's routines allow the user to select the patrol operations characteristics to be computed, and to input needed data items. The programs guide the user in performing these analyses using printed messages or coded message numbers (see Table 5-1 for a description of the message numbers used by PATROL/PLAN-40D).

---

*Assuming that calls which arrive when all patrol cars are busy are held "in queue" by the dispatcher until a patrol car becomes available.

**Note that PATROL/PLAN-40P and 40D have routines for specifying calls per hour, service time, and number of cars. However, theses routines may only be used when the value of non-CFS minutes per hour per car is zero (otherwise non-CFS work will be ignored).

Table 5-1

CODED MESSAGES GENERATED BY PATROL/PLAN-40D

The following messages are read, "The next number displayed is the":

4.101 01	Number of free cars
4.102 01	Patrol interval (hours)
4.103 01	Minimum number of cars such that the patrol interval is less than the specified number of hours

The following messages are read, "Enter the value for":

4.201 02	Calls per hour
4.202 02	Service time per call (minutes)
4.203 02	Number of patrol cars
4.204 02	Patrolled street miles
4.205 02	Patrol speed (m.p.h.)
4.206 02	Maximum acceptable patrol interval (hours)

The following messages are read:

4.100 01	Compute actual work per car first
4.999 01	End of operation (another routine may be selected, or another program may be read into the calculator after first keying in R/S)

The program's routines are initiated by entering one or two keys, as described in the following list, and following the instructions given.

ROUTINE	KEY SEQUENCE FIRST	SECOND (if any)
Initialization	2ND	E
Compute average number of free cars	A	
Specify or modify the number of patrolled street miles and patrol speed, and then compute the patrol interval	B	
Compute patrol interval using previously specified street miles and patrol speed	C	
Determine the minimum number of cars needed so that the patrol interval is less than a specified number of hours*	D	
Input or modify the number of calls per hour**	2ND	A
Input or modify the average service time per call**	2ND	B
Input or modify the number of patrol cars**	2ND	C

Note that the initialization (2ND E) must be the first routine used after PATROL/PLAN-40P or 40D is read into the calculator.

---

*This routine assumes that calls for service which arrive when all patrol cars are simultaneously busy are queued until a patrol car becomes available. If, in fact, such calls are transferred to other cars, fewer cars may be required to meet the patrol interval constraint.

**These routines should not be used unless the value for non-CFS minutes per hour per car is zero.

C. Example

Suppose that calls per hour, service times, non-CFS minutes per hour per car, and number of cars are as described in the example in Chapter II and that calls arriving when all patrol cars are busy are queued, the number of patrolled street miles is 633, and the patrol speed is 15 m.p.h. Compute the average number of free cars, the patrol interval, and the minimum number of cars needed to reduce the patrol interval to two hours or less.

The solution obtained from the Calculator/Print system is shown in Figure 5-1, and from the Calculator/Display system, in Figure 5-2.


```
2ND
 E
 A ------> NO. OF FREE CARS=

              3.50

 B ------> PATROL SPEED(MPH)?

              15.

          PATROLLED STREET
          MILES?

              633.

          PATROL INTERVAL
          (HOURS)=

              12.06

 D ------> MAX. PATROL INTERVAL
          ALLOWED(HOURS)?

              2.

          MINIMUM NO. OF CARS=

              33.

          PATROL INTERVAL
          (HOURS)=

              1.93
```

Figure 5-1

PROBLEM SOLUTION USING PATROL/PLAN-40P

KEY SEQUENCE FIRST	SECOND	CALCULATOR DISPLAY	INTERPRETATION
2ND	E	4.999 01	End of operation (initialization)
R/S			
A		4.101 01	Average number of free cars equals
R/S		3.50	
R/S		4.999 01	End of operation
R/S		0	
B		4.205 02	Input patrol speed (M.P.H.)
15	R/S	4.204 02	Input number of patrolled street miles
633	R/S	4.102 01	Patrol interval (hours) equals
R/S		12.06	
R/S		4.999 01	End of operation
R/S		0	
D		4.206 02	Input maximum acceptable patrol interval (hours)
2	R/S	4.103 01	Minimum number of cars needed such that patrol interval is less than specified value equals
R/S		33	
R/S		4.102 01	Patrol interval (hours) equals
R/S		1.93	
R/S		4.999 01	End of operation
R/S		0	

Figure 5-2

PROBLEM SOLUTION USING PATROL/PLAN-40D

CHAPTER VI

PATROL/PLAN-50P AND 50D

A. Introduction

PATROL/PLAN-50P or 50D is used to list or display the current value (i.e., the previously entered value or, if affected by subsequent computations, the most recently computed value) for the following input variables:

- number of CFS cars--the number of patrol cars in the region of interest;
- number of non-CFS minutes per hour per car--the average number of minutes per hour that a patrol car spends on non-CFS assignments;
- calls per hour--the average number of calls for service per hour in the region of interest;
- service time per call--the average number of minutes expended by all cars dispatched to a single incident (computed from previously input data specifying the frequency with which one or more cars are dispatched, and the average service time for each such car; note that only the result of the computation is stored--the details on multiple car dispatches are not);
- area of the region in square miles;
- response speed--the average travel speed, in miles per hour, for patrol cars responding to calls for service;
- number of street miles--the total number of miles of streets patrolled in the region of interest; and
- patrol speed--the average travel speed, in miles per hour, for cars on free patrol.

B. Procedure for Using PATROL/PLAN-50P or 50D

The routines of PATROL/PLAN-50P and 50D allow the user to specify which input variables are to be printed or displayed. The set of message numbers used by PATROL/PLAN-50D to identify the variables prior to their being displayed is shown in Table 6-1.

The program's routines are initiated by entering one or two keys as follows:

Table 6-1

CODED MESSAGES GENERATED BY PATROL/PLAN-50D

The following messages are read, "The next number displayed is the":

5.101 01	Number of CFS cars
5.102 01	Number of non-CFS minutes per hour per car
5.103 01	Number of calls per hour
5.104 01	Service time per call (minutes)
5.105 01	Area of the region (square miles)
5.106 01	Response speed (M.P.H.)
5.107 01	Number of patrolled street miles
5.108 01	Patrol speed (M.P.H.)

The following messages are read,

5.100 01	Value not yet specified
5.999 01	End of operation (another routine may be selected, or another program may be read into the calculator, after first keying in R/S)

ROUTINE	KEY SEQUENCE FIRST	SECOND (if any)
Initialization	2ND	E
List the current value for:		
all input variables	A	
number of CFS cars	B	
non-CFS minutes per hour per car	C	
calls per hour	D	
service time	E	
area of the region	2ND	A
response speed	2ND	B
patrolled street miles	2ND	C
patrol speed	2ND	D

Note that initialization (2ND E) must be the first routine used after PATROL/PLAN-50P or 50D is read into the calculator.

C. Example

Use programs PATROL/PLAN-10P and 30P or PATROL/PLAN-10D and 30D to input the following values:

number of CFS cars	8 cars
calls per hour	9.5 calls
service time*	32.25 minutes
non-CFS minutes per hour per car	5 minutes
area of region	76 square miles
response speed	24.4 m.p.h.

Then, use PATROL/PLAN-50P or 50D to verify the values entered for all input variables.

The solution obtained from the Calculator/Print system is shown in Figure 6-1, and from the Calculator/Display system, in Figure 6-2.

*Assume that only one car is dispatched to all calls for service.

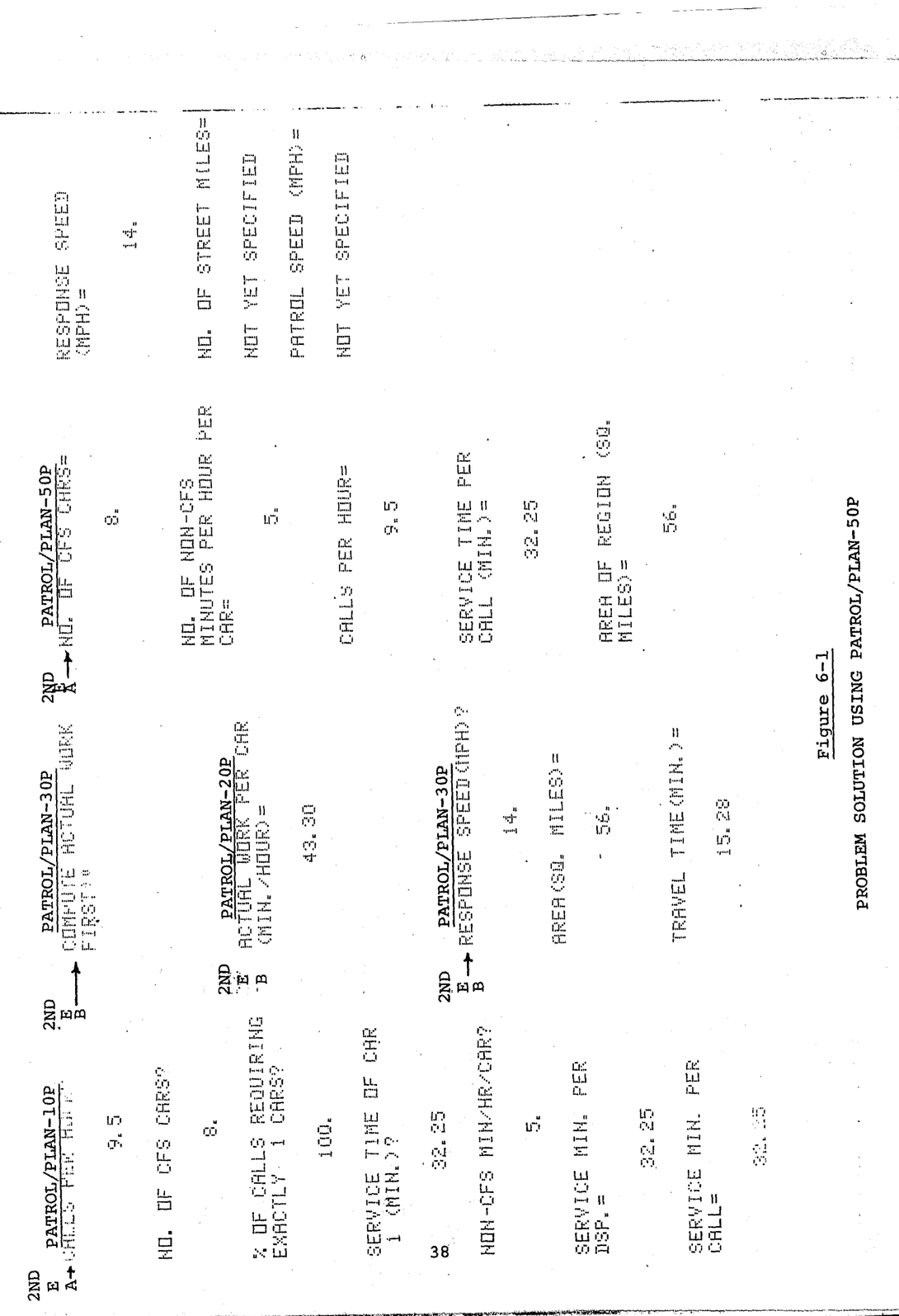

Figure 6-1

PROBLEM SOLUTION USING PATROL/PLAN-50P

KEY SEQUENCE FIRST	SECOND	CALCULATOR DISPLAY	INTERPRETATION
2ND	E	5.999 01	End of operation (initialization)
R/S		0	
A		5.101 01	Number of CFS cars equals
R/S		8	
R/S		5.102 01	Number of non-CFS minutes per hour per car equals
R/S		5	
R/S		5.103 01	Number of calls per hour equals
R/S		9.5	
R/S		5.104 01	Service time per call (minutes) equals
R/S		32.25	
R/S		5.105 01	Area of the region (square miles) equals
R/S		56	
R/S		5.106 01	Response speed (M.P.H.) equals
R/S		14	
R/S		5.107 01	Number of patrolled street miles equals
R/S		5.100 01	Value not yet specified
R/S		5.108 01	Patrol speed (M.P.H.) equals
R/S		5.100 01	Value not yet specified
R/S		5.999 01	End of operation
R/S		0	

Figure 6-2

PROBLEM SOLUTION USING PATROL/PLAN-50D

APPENDIX A

GLOSSARY OF PATROL/PLAN TERMINOLOGY

Actual Work Per Car: The average number of minutes of work per hour that each CFS car in a region experiences due to CFS and non-CFS work. If all arriving calls for service are handled by the region's CFS cars with no backup service from supervisory or other cars, then the actual and incoming work per car are equal. However, if calls for service arriving when all CFS units are busy are handled by supervisory or other cars, the actual work per (CFS) car will be less than the incoming work per car (because some of the incoming work is shunted off to the other cars).

Adjusted Call Rate: A scaled-up value of calls per hour which allows PATROL/PLAN to account for non-CFS work.

Average Number of Free Cars: The average number of CFS cars which are engaged in preventive patrol work and are free to accept dispatch assignments to CFS incidents, for the region and time block of interest. While the number of free cars will usually vary considerably during any time block, the average number of free cars is a useful aggregate measure of field operations activity.

Average Patrol Interval: A measure of the ability of a region's CFS cars to provide preventive patrol of the patrolled streets. Expressed in hours, it may be interpreted as either (1) the average time between passings of any given point in the region by a free car, or (2) the amount of time needed for the region's CFS cars to travel a distance equal to the length of the patrolled streets at the patrol speed during free patrol. For example, when the patrol interval for a region is five hours and the shift length is eight hours, then on the average a CFS car will pass any patrolled point in the region while on preventive patrol slightly less than twice each shift; alternatively, the total distance covered by all CFS cars during the time available for free patrol in a five hour period will, on the average, equal the length of the region's patrolled streets.

Average Service Time for Car (N): The average total "off the air" or "out of service" time per call for service experienced by the (Nth) car dispatched to the incident, for the time block and region of interest. Included are travel time, on-scene time, and subsequent off-scene time until the car becomes available to accept a new dispatch assignment. Averages are expressed in minutes per call. Thus, the average service time for car one refers to first car dispatched to an incident; for car two, refers to the second car dispatched to an incident; and so on. (Often, the second car dispatched spends less time at an incident than does the first.)

Average Service Time Per Call: The average total of service times, in minutes, worked by all cars dispatched to a single incident (thereby accounting for multiple car dispatching). This represents the average total work, counting all cars involved, arising from a single incident.

Average Service Time Per Dispatch: The average of service times, in minutes, recorded for individual cars, regardless of the number of other cars dispatched to each incident. This represents the average time any single car is busy as a result of being dispatched to a CFS incident. Sometimes called "service minutes per dispatch."

Average Travel Time Per Car: The average time, in minutes, from the dispatch of a patrol car until its arrival at the scene of the assigned incident, for the region and time block of interest. Not included is "dispatch delay," the time interval from the receipt of the call for service by the police until the assignment of the call to a CFS car. Average travel time per car is sometimes abbreviated as "travel time."

Call For Service: A communication to the police originating from a citizen, an alarm system, a police officer, or other detector, reporting an incident that requires on-scene police assistance (i.e., dispatch of a CFS car), and for which pertinent information is usually recorded on a dispatch card or ticket. The abbreviation CFS is sometimes used.

Calls Per Hour: The average number of calls per hour for the region and time block of interest. Ideally, the average should be based on a year's data, but sampling procedures may be used to allow estimation of the average from examination of a small fraction of the call records. Sometimes called "CFS rate," or "calls for service (CFS)/hr."

CFS Car: A patrol car, scooter, or van and its assigned police officer(s), which serves as a primary response unit for calls for service. When not handling CFS work, these cars are normally engaged in either non-CFS work or preventive patrol. A supervisor's car is not normally considered to be a CFS car itself unless it routinely serves as a primary response unit.

CFS Work: The time devoted by a CFS car to responding to CFS incidents, measured in minutes per hour per car. PATROL/PLAN assumes that when engaged in CFS work, a car may not be interrupted for reassignment to another CFS incident. Also used to refer to the component of actual work per car which arises from CFS work, averaged for the region and time block of interest.

Free Car: A term used to describe the status of a CFS car when it is available to accept dispatch assignments. For PATROL/PLAN, a CFS car is free if engaged in preventive patrol, which can be interrupted by a dispatch assignment, and is busy if engaged in CFS or non-CFS work. PATROL/PLAN uses the average number of free cars as one measure of the ability of a region's CFS cars to respond to incoming calls and to engage in preventive patrol.

Incoming Work Per Car: The average number of minutes per hour each CFS car in a region would be occupied by CFS and non-CFS work if all arriving calls for service were handled only by the region's CFS cars (with no backup service from supervisory or other cars). When the CFS and non-CFS work are large enough, or the number of CFS cars too few, the incoming work can be greater than 60 minutes per hour per car (meaning that not enough cars are available to meet the demand for service and cover the time unavoidably lost to non-CFS work). See also "actual work per car."

Minimum Number of Cars: The smallest number of CFS cars for which a user-specified performance level (for travel time, percent of time all cars are busy, workload per car, or patrol interval) can be achieved for the region and time block of interest. When the user selects the performance factor of interest and indicates a desired performance level, PATROL/PLAN computes the minimum number of cars.

Non-CFS Minutes Per Hour Per Car: The average amount of non-CFS work, expressed in minutes per hour per car, for the region and time period of interest. One method for estimating this input item is to compute the average total non-CFS work per shift per car, and then divide the result by the number of hours in the shift (e.g., if time for meals, vehicle maintenance, etc. averages 80 minutes per car in an 8-hour shift, non-CFS work is 10 minutes per hour per car).

Non-CFS Work: Any activity in which a CFS car may engage, other than response to a call for service, which causes it to be unavailable for dispatching. Normally included are meals, personal activities, processing of notifications or warrants, vehicle maintenance, processing of arrestees, and meetings with a supervisor. Also used to refer to the component of actual work per car which arises from non-CFS work averaged for the region and time block of interest.

Number of CFS Cars: The number of CFS cars assigned to the region and time block of interest. PATROL/PLAN's formulas are valid only when this is a whole number. If the number of cars actually fielded varies from time to time (e.g., due to absences), and the average number of cars fielded is not a whole number, each performance characteristic of interest can be computed separately for each number of cars fielded and the results combined using a weighted average. For example,

if seven cars are fielded 90 percent of the time and six cars are fielded the other 10 percent, the user can compute average travel time as: 0.9 x (average travel time for seven cars) + 0.1 x (average travel time for six cars). However, if the user desires a simpler procedure and will settle for slightly less accurate results, the analysis can be carried out assuming that seven cars are always fielded.

Patrol Speed: The average speed, in miles per hour, travelled by CFS units when engaged in preventive patrol. Since this average may include periods when a car is stationary, accelerating, or decelerating, its value tends to be considerably less than the peak speed experienced during these activities.

Patrolled Street Miles: The total length of the streets, alleys, and other routes in a region which are patrolled by CFS cars on preventive patrol, measured in miles. If it is necessary to estimate this length, an approximation may be obtained by marking a few mile square blocks on a street map of the region, measuring and averaging the number of street miles in each block, and multiplying the resulting average by the area of the region. Sometimes called "street miles."

Patrolled Streets: The streets, alleys, and other routes in a region which are patrolled by CFS cars when on preventive patrol.

Percent of Calls That Require (N) Car(s): The percent of calls for service for which the dispatcher assigns N car(s) to respond. Thus, when N is one, this is the percent of calls to which only a single car is dispatched; when N is two, this is the percent of calls to which only a primary car and a single backup car are dispatched; and so on. The percentages for calls requiring one, two, ..., (largest number of cars normally dispatched) should add to 100. Cars engaged in "roll by" or self-initiated backup of a dispatched vehicle are not themselves counted as dispatched vehicles unless they are unavailable to accept other dispatches during this period. Ideally, the percentages used should pertain to the region and time block of interest.

Percent of Time Entire Patrol Force is Busy: The average percent of time when all CFS cars in a region are simultaneously busy (i.e., engaged in CFS or non-CFS work), for the region and time block of interest. For example, a value of 15 percent indicates that all cars are simultaneously busy an average of 0.15 x 60 = 9 minutes each hour. Over an extended period of time, the percent of time the entire patrol force is busy also indicates the percent of incoming calls for service for which no CFS car is immediately available (i.e., calls for which assignment of a car is delayed).

Preventive Patrol: The activities in which a CFS car engages when not handling calls for service or involved in non-CFS work, and during which the car is available to accept dispatch assignments. Preventive patrol activities include routine surveillance of patrolled streets, meeting citizens, certain types of traffic enforcement, and other proactive activities aimed at crime reduction.

Region: The geographic territory or jurisdiction served by the CFS cars represented in a PATROL/PLAN analysis. Normally the region is an autonomous field operations territory whose CFS cars have prime responsibility for responding to CFS incidents arising within it. In some departments a region would consist of all the patrol cars supervised by one sergeant; in others, all the cars supervised by several sergeants.

Region Area (Square Miles): The area of the region of interest, measured in square miles. If it is necessary to estimate this area, one simple method involves superimposing a detailed grid over a map of the region, counting the number of grid squares falling in the region, and multiplying this number by the area, in square miles, of each square.

Response Speed: The average speed, in miles per hour, travelled by CFS units when en route to the scene of a CFS incident. Since this average includes periods of acceleration and deceleration arising from traffic conditions, turns, and traffic signals, its value tends to be considerably less than the peak speed experienced en route.

Shift: A period of consecutive duty hours used for scheduling officers' on-duty assignments, sometimes called a watch or tour. In law enforcement, work shifts are commonly eight or ten hours in length.

Time Block: A period of time over which the number of CFS cars on duty does not change. Usually a shift, but time blocks may be shorter if shifts overlap, or longer if the number of CFS cars on duty remains constant for more than one shift. To use PATROL/PLAN, the time blocks of interest must first be identified. Then an analysis is made for each block, either assessing the effectiveness of fielding a given number of cars, or finding the number of cars needed to meet a specified performance criterion. Time blocks are also the periods over which data on factors such as calls per hour, service time, and non-CFS work are normally averaged for use as input to PATROL/PLAN.

APPENDIX B

SUMMARY OF PATROL/PLAN INPUTS AND OUTPUTS

Summary of Inputs and Outputs

PATROL/PLAN-10

1. User Inputs: Calls per hour, number of CFS cars, fraction of calls requiring exactly N cars, service time of the Nth car dispatched, number of non-CFS minutes per hour per car

2. Other Inputs: None

3. Program Outputs: Service time per dispatch, service time per call, adjusted calls per hour

PATROL/PLAN-20 and 25

1. User Inputs: Maximum acceptable actual work per car, maximum acceptable percent of time all cars are busy

2. Other Inputs: Number of CFS cars, number of non-CFS minutes per hour per car, service time per call, adjusted calls per hour

3. Program Outputs: Incoming work per car, actual work per car, percent of time all cars are busy, minimum number of cars based on actual work per car, and minimum number of cars based on percent of time all cars are busy

PATROL/PLAN-30

1. User Inputs: Area, response speed, maximum acceptable travel time

2. Other Inputs: Actual work per car, number of CFS cars, number of non-CFS minutes per hour per car, service time per call, adjusted calls per hour

3. Program Outputs: Travel time, minimum number of cars based on travel time (assuming calls are queued when all cars are busy)

PATROL/PLAN-40

1. User Inputs: Street miles, patrol speed, maximum acceptable patrol interval

2. Other Inputs: Actual work per car, number of CFS cars, number of non-CFS minutes per hour per car, service time per call, adjusted calls per hour

3. Program Outputs: Number of free cars, patrol interval, minimum number of cars based on patrol interval (assuming calls are queued when all cars are busy)

PATROL/PLAN-50

1. User Inputs: None

2. Other Inputs: None

3. Program Outputs: Number of CFS cars, number of non-CFS minutes per hour per car, service time per call, calls per hour, area, response speed, street miles, patrol speed

APPENDIX C

PATROL/PLAN TRAINING EXERCISE AND SOLUTION

EXERCISE

The following information has been compiled by a police planner regarding called-for-service and patrol operations in his department:

area patrolled = 80 square miles
street miles patrolled = 217

Shift	Calls/ hour	Cars Sent 1	2	3	Service Time 1st	2nd	3rd	Cars Now	Speed Resp.	Patrol
1 (day)	5.7	70%	20%	10%	30	20	10	10	12	8
2 (aft)	7.8	60%	30%	10%	35	15	5	13	15	10
3 (nite)	4.1	50%	30%	20%	20	10	5	8	20	15

The planner has also found that non-CFS work presently totals 10 minutes per hour per car, and that calls are queued when all CFS cars are busy.

1. For the present allocation of cars to shifts, compute for each shift the incoming work per car, actual work per car, average travel time, average number of free cars, patrol interval, and percent of time when all cars are simultaneously busy.

2. Suppose that the numbers of cars fielded on each shift is to be modified in such a way that:

   a. actual work per car is less than or equal to 30 minutes per hour on all shifts;

   b. average travel time is less than or equal to 10 minutes on all shifts;

   c. patrol interval is less than or equal to 2 hours on shift 3; and

   d. the percent of time that all cars are simultaneously busy is less than or equal to 5 percent.

   Determine the minimum number of cars required on each shift in order to meet all of the above conditions.

3. Recompute the incoming and actual work per car, average travel time, average number of free cars, average patrol interval, and percent of time when all cars are busy for this new allocation of cars to shifts.

4. Determine the minimum number of cars required on each shift so that the percent of time that all cars are busy is less than 50%, and compute the actual work per car. First assume that calls are queued when all CFS cars are busy. Repeat the analysis, assuming that calls arriving when all CFS cars are busy are transferred to other cars.

SOLUTION TO PATROL/PLAN EXERCISE
SHIFT 1

2ND E
A→CALLS PER HOUR? . . . . .

5.7

NO. OF CFS CARS?

10.

% OF CALLS REQUIRING EXACTLY 1 CARS?

70.

SERVICE TIME OF CAR 1 (MIN.)?

30.

% OF CALLS REQUIRING EXACTLY 2 CARS?

20.

SERVICE TIME OF CAR 2 (MIN.)?

20.

% OF CALLS REQUIRING EXACTLY 3 CARS?

10.

SERVICE TIME OF CAR 3 (MIN.)?

10.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER DSP.=

26.43

SERVICE MIN. PER CALL=

37.00

2ND E PATROL/PLAN-20P

B→ACTUAL WORK PER CAR (MIN./HOUR)=

31.09

C→% OF TIME ALL CARS ARE BUSY=

4.4575

2ND E PATROL/PLAN-30P

B→RESPONSE SPEED(MPH)?

12.

AREA(SQ. MILES)=

80.

TRAVEL TIME(MIN.)=

14.49

2ND E PATROL/PLAN-40P

A→NO. OF FREE CARS=

4.82

B→PATROL SPEED(MPH)?

8.

PATROLLED STREET MILES?

217.

PATROL INTERVAL (HOURS)=

5.63

2ND E PATROL/PLAN-50P

A→NO. OF CFS CARS=

10.

NO. OF NON-CFS MINUTES PER HOUR PER CAR=

10.

CALLS PER HOUR=

5.7

SERVICE TIME PER CALL (MIN.)=

37.

AREA OF REGION (SQ. MILES)=

80.

RESPONSE SPEED (MPH)=

12.

NO. OF STREET MILES=

217.

PATROL SPEED (MPH)=

8.

2ND PATROL/PLAN-20P
E
D→MAXIMUM ALLOWED
ACTUAL WORK PER CAR
(MIN./HOUR)?

30.

MINIMUM NO. OF CARS=

11.

ACTUAL WORK PER CAR
(MIN./HOUR)=

29.17

E→MAXIMUM ALLOWED
% OF TIME ALL CARS
ARE BUSY?

5.

MINIMUM NO. OF CARS=

10.

% OF TIME ALL CARS
ARE BUSY=

4.4575

2ND PATROL/PLAN-30P
E
D→MAX. TRAVEL MINUTES
ALLOWED?

10.

MINIMUM NO. OF CARS=

17.

TRAVEL TIME(MIN.)=

9.74

2ND PATROL/PLAN-10P
E
A→CALLS PER HOUR?

5.7

NO. OF CFS CARS?

17.

% OF CALLS REQUIRING
EXACTLY 1 CARS?

70.

SERVICE TIME OF CAR
1 (MIN.)?

30.

% OF CALLS REQUIRING
EXACTLY 2 CARS?

20.

SERVICE TIME OF CAR
2 (MIN.)?

20.

% OF CALLS REQUIRING
EXACTLY 3 CARS?

10.

SERVICE TIME OF CAR
3 (MIN.)?

10.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER
DSP.=

26.43

SERVICE MIN. PER
CALL=

37.00

2ND PATROL/PLAN-20P
E
B→ACTUAL WORK PER CAR
(MIN./HOUR)=

22.41

% OF TIME ALL CARS
ARE BUSY=

0.0347

2ND PATROL/PLAN-30P
E
C→TRAVEL TIME(MIN.)=

9.74

2ND PATROL/PLAN-40P
E
C→PATROL INTERVAL
(HOURS)=

2.55

SHIFT 2

2ND PATROL/PLAN-10P
E
A→ CALLS PER HOUR?

7.8

NO. OF CFS CARS?

13.

% OF CALLS REQUIRING EXACTLY 1 CARS?

60.

SERVICE TIME OF CAR 1 (MIN.)?

35.

% OF CALLS REQUIRING EXACTLY 2 CARS?

30.

SERVICE TIME OF CAR 2 (MIN.)?

15.

% OF CALLS REQUIRING EXACTLY 3 CARS?

10.

SERVICE TIME OF CAR 3 (MIN.)?

5.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER DSP. =

27.67

SERVICE MIN. PER CALL=

41.50

2ND PATROL/PLAN-20P
E
B→ ACTUAL WORK PER CAR (MIN./HOUR) =

34.90

C→ % OF TIME ALL CARS ARE BUSY=

5.2344

2ND PATROL/PLAN-30P
E
B→ RESPONSE SPEED (MPH)?

15.

AREA (SQ. MILES) =

80.

TRAVEL TIME (MIN.) =

10.91

2ND PATROL/PLAN-40P
E
A→ NO. OF FREE CARS=

5.44

B→ PATROL SPEED (MPH)?

10.

PATROLLED STREET MILES?

217.

PATROL INTERVAL (HOURS) =

3.99

2ND PATROL/PLAN-50P
E
A→ NO. OF CFS CARS=

13.

NO. OF NON-CFS MINUTES PER HOUR PER CAR=

10.

CALLS PER HOUR=

7.8

SERVICE TIME PER CALL (MIN.) =

41.5

AREA OF REGION (SQ. MILES) =

80.

RESPONSE SPEED (MPH) =

15.

NO. OF STREET MILES=

217.

PATROL SPEED (MPH) =

10.

2ND E D → PATROL/PLAN-20P

MAXIMUM ALLOWED ACTUAL WORK PER CAR (MIN./HOUR)?

30.

MINIMUM NO. OF CARS=

17.

ACTUAL WORK PER CAR (MIN./HOUR)=

29.04

E → MAXIMUM ALLOWED % OF TIME ALL CARS ARE BUSY?

5.

MINIMUM NO. OF CARS=

14.

% OF TIME ALL CARS ARE BUSY=

3.0446

2ND E D → PATROL/PLAN-30P

MAX. TRAVEL MINUTES ALLOWED?

10.

MINIMUM NO. OF CARS=

15.

TRAVEL TIME(MIN.)=

9.54

2ND E A → PATROL/PLAN-10P

CALLS PER HOUR?

7.8

NO. OF CFS CARS?

17.

% OF CALLS REQUIRING EXACTLY 1 CARS?

60.

SERVICE TIME OF CAR 1 (MIN.)?

35.

% OF CALLS REQUIRING EXACTLY 2 CARS?

30.

SERVICE TIME OF CAR 2 (MIN.)?

15.

% OF CALLS REQUIRING EXACTLY 3 CARS?

10.

SERVICE TIME OF CAR 3 (MIN.)?

5.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER DSP.=

27.67

SERVICE MIN. PER CALL=

41.50

2ND E B → PATROL/PLAN-20P

ACTUAL WORK PER CAR (MIN./HOUR)=

29.04

C → % OF TIME ALL CARS ARE BUSY=

0.5283

2ND E C → PATROL/PLAN-30P

TRAVEL TIME(MIN.)=

8.59

2ND E C → PATROL/PLAN-40P

PATROL INTERVAL (HOURS)=

2.47

A → NO. OF FREE CARS=

8.77

SHIFT 3

2ND E
A→ PATROL/PLAN-10P

CALLS PER HOUR?

4.1

NO. OF CFS CARS?

8.

% OF CALLS REQUIRING EXACTLY 1 CARS?

50.

SERVICE TIME OF CAR 1 (MIN.)?

20.

% OF CALLS REQUIRING EXACTLY 2 CARS?

30.

SERVICE TIME OF CAR 2 (MIN.)?

10.

% OF CALLS REQUIRING EXACTLY 3 CARS?

20.

SERVICE TIME OF CAR 3 (MIN.)?

5.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER DSP. =

15.29

SERVICE MIN. PER CALL=

26.00

2ND E
B→ PATROL/PLAN-20P

ACTUAL WORK PER CAR (MIN./HOUR) =

23.32

C→ % OF TIME ALL CARS ARE BUSY=

1.5816

2ND E
B→ PATROL/PLAN-30P

RESPONSE SPEED (MPH)?

20.

AREA (SQ. MILES) =

80.

TRAVEL TIME (MIN.) =

8.63

2ND E
A→ PATROL/PLAN-40P

NO. OF FREE CARS=

4.89

B→ PATROL SPEED (MPH)?

15.

PATROLLED STREET MILES?

217.

PATROL INTERVAL (HOURS) =

2.96

2ND E
A→ PATROL/PLAN-50P

NO. OF CFS CARS=

8.

NO. OF NON-CFS MINUTES PER HOUR PER CAR=

10.

CALLS PER HOUR=

4.1

SERVICE TIME PER CALL (MIN.) =

26.

AREA OF REGION (SQ. MILES) =

80.

RESPONSE SPEED (MPH) =

20.

NO. OF STREET MILES=

217.

PATROL SPEED (MPH) =

15.

2ND E D → **PATROL/PLAN-20P**

MAXIMUM ALLOWED ACTUAL WORK PER CAR (MIN./HOUR)?

30.

MINIMUM NO. OF CARS=

6.

ACTUAL WORK PER CAR (MIN./HOUR)=

27.77

E → MAXIMUM ALLOWED % OF TIME ALL CARS ARE BUSY?

5.

MINIMUM NO. OF CARS=

7.

% OF TIME ALL CARS ARE BUSY=

3.4392

2ND E D → **PATROL/PLAN-30P**

MAX. TRAVEL MINUTES ALLOWED?

10.

MINIMUM NO. OF CARS=

7.

TRAVEL TIME(MIN.)=

9.47

PATROL/PLAN-40P

D → MAX. PATROL INTERVAL ALLOWED(HOURS)?

2.

MINIMUM NO. OF CARS=

11.

PATROL INTERVAL (HOURS)=

1.96

2ND E A → **PATROL/PLAN-10P**

CALLS PER HOUR?

4.1

NO. OF CFS CARS?

11.

% OF CALLS REQUIRING EXACTLY 1 CARS?

50.

SERVICE TIME OF CAR 1 (MIN.)?

20.

% OF CALLS REQUIRING EXACTLY 2 CARS?

30.

SERVICE TIME OF CAR 2 (MIN.)?

10.

% OF CALLS REQUIRING EXACTLY 3 CARS?

20.

SERVICE TIME OF CAR 3 (MIN.)?

5.

NON-CFS MIN/HR/CAR?

10.

SERVICE MIN. PER DSP.=

15.29

SERVICE MIN. PER CALL=

26.00

2ND E B → **PATROL/PLAN-20P**

ACTUAL WORK PER CAR (MIN./HOUR)=

19.69

C → % OF TIME ALL CARS ARE BUSY=

0.1369

2ND E C → **PATROL/PLAN-30P**

TRAVEL TIME(MIN.)=

7.02

2ND PATROL/PLAN-40P
E
A → NO. OF FREE CARS=

7.39

C → PATROL INTERVAL (HOURS)=

1.96

2ND PATROL/PLAN-50P
E
A → NO. OF CFS CARS=

11.

NO. OF NON-CFS MINUTES PER HOUR PER CAR=

10.

CALLS PER HOUR=

4.1

SERVICE TIME PER CALL (MIN.)=

20.

AREA OF REGION (SQ. MILES)=

80.

RESPONSE SPEED (MPH)=

20.

NO. OF STREET MILES=

217.

PATROL SPEED (MPH)=

15.

END