DIRECTED PATROL EXPERIMENTATION USING AN AUTOMATIC VEHICLE MONITORING SYSTEM

FINAL REPORT

Public Systems Evaluation, Inc.

Public Systems Evaluation (PSE) was founded in March 1974 for the purpose of conducting evaluations of innovative concepts and methods that are being developed and implemented in the public sector. As a non-profit organization, PSE is dedicated to the improvement and increased effectiveness of urban service systems through the conduct of objective and technically sound evaluations of experimental and on-going programs. In the course of undertaking evaluations in such areas as law enforcement, transportation, housing, health and electronic funds transfer, PSE has also advanced the state of the art in evaluation methodology. In particular, PSE believes in an interdisciplinary approach to evaluation, as reflected in the PSE staff members, who have expertise in operations research, survey research, communications engineering, systems engineering, electronic data processing, economics, management, urban planning, law, sociology and criminology.

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DIRECTED PATROL EXPERIMENTATION USING AN AUTOMATIC VEHICLE MONITORING SYSTEM

FINAL REPORT

By

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December 1982

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This document was prepared for the National Institute of Justice, U.S. Department of Justice, by Public Systems Evaluation, Inc., and was supported by Grant Number 79-NI-AX-0112. Points of view or opinions stated herein are those of the authors and do not necessarily represent the official position or policies of the U.S Department of Justice.

FOREWARD

Police patrol represents the major "front line" activity of nearly every city and municipal police department. General attitudes toward police, of both law-abiding citizens and potential criminals alike, are often shaped by the effectiveness of police patrol. Police budgets, too, usually have their largest single share allocated to the patrol force.

Proposals for improving patrol operations have usually been based on theories which have gone untested. In this report we see a first scholarly attempt to use a new and potentially revolutionary technology--automatic vehicle location (AVL) systems--as a tool to undertake valid police patrol research studies. The report demonstrates how AVL can be used to study patrolling patterns and locations, to monitor experiments, and to conduct pathbreaking research in policing.

The main contents of this report should be incorporated in any academic program focusing on police administration. This study takes several giant steps toward the further rational planning of police patrol. Undoubtedly, as the AVL technology becomes more widely implemented, we will see more police patrol research utilizing this unique tool.

Col. Eugene J. Camp
Chief of Police (Retired)
St. Louis Metropolitan Police Department

ABSTRACT

This report summarizes the first police research study to use an automatic vehicle monitoring (AVM) system as a research tool. An AVM system provides to the police dispatcher or researcher up-to-the-second vehicle location information. This information was used in undertaking patrol experimentation in the St. Louis Metropolitan Police Department.

Our major study focused on the interrelationships between the locations of street-visible serious crimes and the locations of nearby police cars. By using AVM information to measure the distance from such a crime in progress to the nearest police car, and by developing a related set of statistical models, we tentatively found that individuals who commit street-visible assaultive-type crimes do so independently of the locations of police cars. On the other hand, individuals who commit street-visible property type crimes exhibit a slight tendency to avoid police. Our results are the first to suggest that police patrol may have a positive effect on deterring or at least displacing up to 30 percent of street-visible property crimes.

Our other major study was a 6-month AVM-monitored directed patrol experiment (DPE) whose design was aided by mathematical models of patrol operation. Many earlier police patrol experiments have been criticized for not keeping patrol cars in their designated experimental areas. The AVM-monitored DPE revealed the utility of the AVM capability in detecting and correcting violations of experimental conditions. This demonstration suggests that any future major patrol experiments could benefit greatly from the monitoring capability afforded by AVM systems.

PREFACE

Historians may label the 1970's as the decade of police patrol experimentation in the United States. Prompted in part by the 1967 Report of the President's Commission on Law Enforcement and the Administration of Justice and in part by the creation of the Law Enforcement Assistance Administration in 1968, several preliminary efforts were already underway by 1970. Early substantial efforts occurred in such cities as Los Angeles, Boston, Chicago, Syracuse, and New York City. The most visible early study took place in 1972 and 1973 in Kansas City, Missouri, a study which came to be known as the Kansas City Preventive Patrol Experiment. This experiment created much enthusiasm and debate in police circles, among practitioners and researchers alike. As a result, numerous studies were conducted in other cities, building on the preliminary results and recommendations of the Kansas City Police Preventive Patrol Experiment. These studies took place in Wilmington, Delaware; Worcester, Massachusetts; again in Kansas City, Missouri; again in New York City; San Diego; St. Louis; Newark, New Jersey; Los Angeles; Seattle; Minneapolis; and numerous smaller cities.

The impressive substantive results of these studies, when viewed collectively, have provided important new knowledge in the area of urban policing. They have revised our thinking about such standard topics as police response time, police "preventive patrol," one officer vs. two officer police cars, police dispatching procedures, the dependence of crime on patrolling levels, the use of crime statistics in patrolling, officers' attitudes toward their work, and citizens' attitudes toward the police and public safety. Yet the decade of the seventies was not without growing pains. Unlike a more mature area of social science research, police experimenters often wanted, it seems, to jump to significantly new conclusions based on a single first study done in a single police department. It wasn't until about 1980 or so that the idea of experimental replication, an idea standard in the more mature substantive areas of social science research, became as popular in police research circles. Without replication and verification of earlier studies, one runs the risk of creating a "house of cards" of research results--the falling of any given card creating a risk for the entire structure.

The research of the 1970's, too, was hampered to some extent by a lack of appropriate technical tools to assist the experimental designers. Among these were mathematical models of police patrol force operations which if used carefully and appropriately, could provide great guidance to the experimental designers in predicting the likely operational consequences of alternative patrol experimental designs. We are aware of only one or two studies that occurred during the 1970's which used such mathematical models before the study or experiment was implemented. Now, a wide range of such models exist, and there is no reason why subsequent researchers cannot use these models in the pre-implementation phase.

Another more fundamental problem hampered police patrol researchers prior to this time, and that is the lack of knowledge of the whereabouts and activities of police patrol cars in the experimental areas. Nationally, police patrol forces have been called one of the largest labor forces in the country in which supervisors cannot monitor the activities of the people whom they are to supervise. Likewise, police patrol researchers, when attempting to implement a spatial redeployment of patrol resources in order to achieve experimental conditions, were never certain that the experimental conditions were in fact maintained. Participant observers could ride along in the back seats of police cars for a fraction of time during the experiment, but use of such participant observers was costly and obtrusive; their presence could certainly alter the usual behavior of police officers in a car. Another means was necessary to monitor and maintain the integrity of the experimental design. That capability is now potentially available with Automatic Vehicle Monitoring (AVM) systems. The St. Louis Metropolitan Police Department is the only major police department in the United States that has a citywide, accurate AVM system. That system, when properly maintained and supervised, provides a potential for police researchers heretofore unavailable.

In the spirit of experimental replication and verification and of enhanced experimental capabilities, the National Institute of Justice (NIJ) of the U.S. Department of Justice awarded to Public Systems Evaluation, Inc. (PSE) a grant (No. 79-NI-AX-0112) to study the feasibility and desirability of using AVM in a police patrol experimental context. The project was not meant to be replication of any previous police patrol experiment, in that resources were to be directed at pilot test questions, not at definitve research results per se. Our work reported in this final report builds on the theme of using AVM in police patrol experimentation. It is not limited to obtrusive experimentation, in which police patrol resources are deliberately redeployed over some spatial area, but includes unobtrusive experimentation as well, in which some basic research questions can be articulated and addressed for the first time. In the course of our work, we have found that AVM is a potentially valuable research tool to aid the police patrol researcher. The high cost of existing AVM systems has deterred other police departments from implementing them during the past decade or so. It is likely that one or more "technological breakthroughs" will have to occur before the cost of AVM is within a range acceptable to currently financially strapped urban police departments.

In addition to demonstrating the feasability of AVM in police patrol experimental settings, we have found some substantive results of independent interest. These include questions of the dependence or lack of dependence of crime locations on nearby police patrol locations, officers' attitudes toward technology and police patrol in general, characteristics of directed patrol, and statistical characteristics of preventive patrol.

We feel that this work would be of interest to police researchers and practitioners alike, as well as to others interested in (particularly urban) research. More broadly, social scientists might find interesting our analyses of officer attitudes; operations researchers might find interesting our use of mathematical modelling in the experimental design process and the testing for dependence of crime locations on police patrol locations.

Hopefully historians will label the 1970s as the <u>first</u> major decade police patrol research, and that subsequent decades followed building on experimental replication and enhanced technical capabilities for designing and monitoring experiments.

ACKNOWLEDGMENTS

This project could not have been undertaken without the substantial support that we have received from numerous individuals. First, for supporting the underlying motivations for monitored patrol experimentation, we thank many individuals at the National Institute of Justice (NIJ) of the U.S. Department of Justice. In particular, we thank our grant monitor, Mr. George Shollenberger for providing feedback and suggestions throughout the entire project. We also thank Mr. Robert A. Burkhart, Director of Research for NIJ, for his continuing support. We would also like to thank Mr. David Farmer, formerly Head of NIJ's Police Division, for his encouragement in designing and carrying out this project.

The project also could not have occurred without the strong support of many individuals within the St. Louis Metropolitan Police Department (SLMPD). We can only name a few here, because the project touched on literally hundreds of individuals in the SLMPD, ranging from patrol officers on up through the ranks. First, we are extremely indebted to Colonel Eugene J. Camp, Chief of Police (now retired), for his continued wholehearted enthusiasm for our work in St. Louis: not only for this project, but for our earlier evaluations of the Automatic Vehicle Monitoring program in St. Louis. Chief Camp's willingness to innovate and experiment is truly noteworthy; we thank him sincerely. We would also like to thank the following people, listed in alphabetical order, for their strong contributions to this project: Lieutenant Lawrence Akley (Executive Aide to the Chief of Police), Lieutenant Eugene Broaders (Manager of the FLAIR Program), Lieutenant Colonel William E. Brown (Assistant to the Chief of Police), Mr. Herbert Bosch (Communications Specialist for the FLAIR Program), Lieutenant Jay Canada (in charge of the Communications Division), Lieutenant Arthur R. Coffey (Executive Secretary to the Board of Police Commissioners), Sergeant Kenneth E. Gabel (in charge of crime data analysis), and Colonel Adolph Jacobsmeyer (formerly in charge of the ICAP Program). In addition there are numerous other individuals, both at police headquarters and at Districts 3 and 9, who we sincerely thank for their cooperation in this program.

We at PSE received cooperation from the Boeing Company, manufacturers of the FLAIR Automatic Vehicle Monitoring system. In particular, we would like to thank Mr. Joe Hanson, formerly the FLAIR Program Manager at Boeing.

We also thank Dr. Jan Chaiken (Rand Corporation), Professor Kenneth Chelst (Wayne State University) and three anonymous references for providing detailed comments on an earlier draft of this report.

While the focus of this report is on the SLMPD, PSE also monitored—on a considerably smaller scale—Directed Patrol programs of the Minneapolis Police Department. With regard to this effort, we would particularly like to thank Chief Anthony V. Bouza for his enthusiastic support of our work, Captain Jack Jenson for directing a police command using innovative directed patrol activities, and Deputy Chief Patrick Farrell for assisting us in the data collection efforts.

At PSE the initial phases of this program benefited immensely from the design guidance of Mr. Gilbert C. Larson. Much of the on-scene data collection work in St. Louis was completed under the direction of Ms. Ann E. Crepin and

Mr. Robert Thomas. We sincerely thank these individuals. Finally, we thank Mrs. Jo Ann W. Bohmfalk for her diligence and excellence in typing and producing this final report.

PROJECT IMPACT LETTER

BOARD OF POLICE COMMISSIONERS
1200 CLARK AVENUE
CITY OF ST. LOUIS
MISSOURI 63103

March 19, 1982

Mr. Richard Larson
Public Systems Evaluation, Inc.
929 Massachusetts Ave.
Cambridge, Mass. 02139

Dear Mr. Larson:

This is in reference to the "Controlled Preventive Patrol* Experiment" which was conducted by Public Systems Evaluation, Inc., in conjunction with the St. Louis Police Department, during 1981. After the completion of on-site experimentation, the St. Louis Police Department instituted a new city-wide patrol plan.

While some of the components of the new patrol plan did not relate to the experiment, I think you will find it of interest that one primary element was directly derived from the experiment. That element, which is now an important factor in the new patrol plan, is directed patrol.

Each of our nine police districts may utilize up to two patrol units, on any watch, for directed patrol.

We feel that the concept of directed patrol is a more effective and efficient use of resources, as it provides flexibility in addressing crime and other problems which are not constant.

I wanted to share this information with you as it certainly relates to the work and cooperation we received from Public Systems Evaluation, Inc.

Enclosed you will find a copy of our new patrol plan.

Sincerely,

Arthur R. Coffey

Ltn. Arthur R. Coffey
Secretary to the Board

ARC/jah

*Retitled Directed Patrol Experimentation Using an Automatic Vehicle Monitoring System in this report.

EXECUTIVE SUMMARY

Controlled experimentation with urban patrol forces is now possible. No longer must the researcher either "hope" that experimental conditions are being maintained or risk the disruption of participant observers in ride-alongs. The principal new technical capability tested in our research was an Automatic Vehicle Monitoring (AVM) system. This technical capability was augmented by computer-based mathematical models of police patrol operations to explore the operational consequences of alternative experimental configurations prior to implementation. It was also augmented by crime data and other more usual police research statistics. A major aspect of our work also included the essential elements of a comprehensive evaluation — analyzing project inputs, processes, and outcomes (in a Directed Patrol Experiment or DPE).

Our work in St. Louis concentrated on the potential use of AVM as an aid to the police patrol experimenter. In addition to arriving at various conclusions in this area of work, we have obtained several substantive results that are of interest in their own right. In this executive summary, we first summarize our findings with regard to AVM in police patrol experimentation and then our substantive findings. We conclude with recommendations for further research.

AVM AND POLICE PATROL EXPERIMENTATION

Automatic vehicle monitoring location systems can be used in two basic ways for police patrol experimentation. First, they can monitor the integrity and measure certain performance characteristics of patrol field experiments that involve spatial manipulation of police patrol vehicles. This new instrumentation capability has the potential for vastly increasing the reliability of police patrol research findings. For the short term at least, the potential may have to remain just that, primarily because only one city—St. Louis, Missouri—has implemented a citywide AVM system. Other cities throughout the U.S. are awaiting subtantial cost reductions in these systems. The second major use of AVM systems in police patrol experimentation is in the conduct of unobtrusive experiments, that is, experiments in which there is no deliberate spatial manipulation of police patrol vehicles.

AVM As Part of Experimental Instrumentation

In the instrumentation mode, we found AVM useful in the following areas:

1. In the monitoring of detailed patrol-car-specific patrol patterns and locations. Thus, any experiment that attempts to modify the patrolling patterns of the vehicles or their location, can be visually monitored so as to maintain the integrity of the experimental conditions via the AVM device. Particularly, excursions of a patrol car into areas in which it does not belong (according to the experimental design) can be quickly determined, and corrective feedback can be provided to the officers in question.

2. In the accurate measurement of patrol intensity or frequency. The use of AVM signposts, either hardware or software, allow precise measurement over prespecified times of day of the number of passings of patrol cars. Thus, for the first time, the police patrol researcher has an instrumentation capability for precisely measuring patrol intensities at pre-specified points throughout the experimental area.

3. Monitoring Dispatch Patterns. Although not a focus of our work in St. Louis, any police patrol experiment in which dispatch patterns were a crucial part of the experiment could be monitored by AVM. For instance, if only one patrol car was to respond to a particular call for service, and two or three responded instead, such violations of dispatching policies could be noted quickly and feedback provided.

AVM As A Basic Research Tool

AVM is somewhat analogous to a biologist's microscope. For example, just as a biologist studies the spatial relationships between mutant and normal cells, the police researcher can now study interrelationships between crimes and police patrol cars. This is but one example of how AVM can be used in

unobtrusive experimentation to explore various basic research topics which heretofore have been totally beyond the grasp of the police patrol researcher.

The following is an illustative set of questions that could be explored unobtrusively via AVM:

1. Testing for the spatial and temporal relationships, if any, between the locations and times of crimes and the locations and patrolling patterns of police cars. An illustration of this kind of testing is described in Chapter 5, and a more comprehensive test is outlined at the end of Chapter 5.

2. Analyzing patrolling patterns of individual cars. For instance, it may be anticipated that a certain degree of randomness in patrol patterns is to be preferred over "predictability." The idea of randomness and predictability could be precisely defined with one or more performance measures, and these could be studied via the AVM technology.

3. Testing for correlations and other statistical relationships between the locations of crimes on one day and the patrolling intensity of police patrol cars on subsequent days. Namely, one could address the question as to whether police patrols are responsive to near term changes in crime activity.

4. Undertaking research on the effectiveness of various "hot pursuit" strategies for apprehending offenders. For instance, the Philadelphia Police Department has a procedure called "Operation Find" in which an entire area of a city can be cordoned off with 20 to 30 police cars in an attempt to apprehend the perpetrators of a bank robbery or a serious felony. One could perform basic research on the effectiveness of alternative ways of doing things like hot pursuits or "Operation Finds" to improve the effectiveness of the police patrol force under periods of emergency conditions.

Problems Of AVM In St. Louis

Our research in St. Louis was not without problems. The AVM system implemented there, FLAIR, was designed more than a decade ago. It has undergone approximately six years of test, evaluation, and technological revision in an attempt to achieve optimal system performance. During this time, police officers' attitudes toward the system deteriorated because system performance was not up to expectations. In addition, the officers felt that their ideas regarding an AVM system were not included in the installation the system. How much of this attitude is self serving, or the officers not wanting their supervisors to know their whereabouts, and how much of the attitude is valid on other grounds, one can only speculate.

Technically, FLAIR's accuracy was never greater than during the period of our experimentation in St. Louis. This was due in large part to the installation of approximately 100 signposts throughout the city, a technological change motivated in part by PSE's earlier recommendations and its earlier evaluations of the FLAIR implementation in St. Louis. Also, during the research period, the SLMPD recognized the need for a diligent preventive maintenance program to ensure the workability of the FLAIR units in each of the FLAIR-equipped vehicles.

Despite the technical workings of the FLAIR system, however, the system was not designed for police patrol researchers. The largest shortcoming from our perspective was the lack of an "automatic playback capability." Such a capability is discussed in detail in Chapter 2. To capture incidents we were forced to use the standard videotape recorders one might have at home. This resulted in somewhat awkward measurement practices which were also extremely labor intensive. Had automatic playback been available, it would have allowed sample sizes at least two orders of magnitude greater than the sample sizes we were able to achieve in our unobstrusive experimentation.

Another research limitation of FLAIR, as currently designed, is the lack of portable signposts throughout the city. Portable signposts would allow the researcher to cordon off certain sensitive areas, such as the "reactive beats" of the Kansas City Preventive Patrol Experiment (KCPPE) and to readily detect any incursions into the designated zone or zones. Of course, a well programmed automatic playback capability could provide "software signposts" in which the

passage of a car at a particular point on a street could be monitored by the software system, and counts of such passages could be automatically maintained.

Finally, there were cars from other jurisdictions and from citywide jurisdictions that were not visible via the FLAIR console. Any major police patrol experimentation would have to maximize the fraction of these vehicles that were AVM monitorable and develop procedures as we did in St. Louis, for monitoring the general presence of non-AVM equipped cars in the experimental zone.

OUR SUBSTANTIVE FINDINGS

In this section we report on our research findings which we think are of independent interest for police researchers and practitioners. We discuss first those basic research findings resulting from our unobtrusive experimentation with the AVM system, secondly those from the DPE, and third those from our survey of officer attitudes.

AVM Related Basic Research Findings

We undertook a range of unobtrusive experiments in the attempt to study the characteristics of police patrolling and the relationships between police patrols and crimes. Several mini-analyses were conducted to test the DPE procedures and are described in Chapter 2.

In an analysis of the fraction of time spent in the patrol areas in a district we found that the allocation of patrol efforts is highly nonuniform through a typical district. Even within a particular neighborhood, the time spent on the patrol varies greatly on a day-to-day basis. There was no simple relationship between the amount of patrol activity dedicated to a particular area and the statistically-known characteristics of the area such as the crime rates, rates of calls for service, etc.

In an analysis of the dynamics of police patrolling patterns, we measured the probablity of a patrolling vehicle making a right turn, a left turn, a u-turn, or going straight through a randomly entered intersection. We found that typically the mean number of blocks traveled in a straight line between turns is between three and four. We found that there was no measurable serial correlation between the turning probablities from one turn to the next. Thus, it appears that a rather meandering patrol pattern is in place, suggesting that to an outside observer, a patrolling police vehicle is not predictable in its future locations.

Our major unobtrusive experiment focused on the distance between a crime reported in progress and the nearest police patrol car. This analysis, described in Chapter 5, focused on two competing hypotheses:

H_0: the locations of crimes are chosen independently of the locations of nearby police vehicles.

H_1: criminals, when choosing locations of their crimes tend, to some extent, to deliberately avoid nearby police vehicles.

The two hypotheses may be summarized as one of "independence" and one of "avoidance." In a carefully screened and monitored process, we gathered a sample of 117 verified crimes in progress reported from District 3 in St. Louis and potentially visible from the street. The sample was split roughly 50/50 between "property" crimes and "assaultive" crimes. The former were conjectured to be crimes of the rational criminal, whereas the latter were conjectured to be crimes of the irrational criminal. The rational person is risk averse, whereas the irrational individual is the risk prone.

If the crime locations are selected independently of patrol car locations, then the distribution of distance from the crime to the nearest patrol car would be determined by "random chance" alone. In our analysis of this problem,

we generated three alternative and independent mechanisms for computing the probability law of the distance from a crime to the nearest patrol car under the independence assumption. The first was based on the simple theory of spatial Poisson processes, yielding a probability law known as the Rayleigh probability distribution function. The second was based on a detailed Monte Carlo computer simulation model of the District 3 patrol operations, utilizing 1,000 random incidents generated within the computer. On the third procedure we utilized 1,000 "pseudo incidents," the times and locations of which were generated in the computer by Monte Carlo techniques but the distances were measured directly from the FLAIR console. For the distances of interest, all three methods for generating the null hypothesis probability laws yielded approximately equivalent results.

The alternative hypothesis of avoidance H_1 was modeled in fact as a family of hypotheses, parameterized by a non-avoidance term in the probability law equation. The essence of the argument generating the H_1 probabiity law was that potential crimes occur independently of police presence, but that potential crimes result in actual crimes with a probability directly dependent on the distance to the closest police car.

In analyzing the results, we found that the distance from an assaultive crime to the closest police car follows a distribution which is almost identical to the H_0 distribution. Thus, for assaultive crimes, we tentatively have reached the following conclusion:

> Individuals who commit assaultive crimes do so with nearly total disregard for the whereabouts of motorized police patrol cars. This conclusion is consistent with the conjecture that assaultive crimes are irrational and would be committed by risk-prone individuals.

In further analyzing the data we conjectured that the property crimes would be more likely to indicate some measure of risk avoidance. Initial analyses tended to dispel the conjecture, and almost led us to conclude that property crimes too occur independently of the locations of patrol cars. But further scrutiny of the analysis method indicated that one parameter in the equation, namely the police patrol car density, is a known physical parameter which should be estimated independently from a least squares curve fit to the empirical data. Upon implementing this observation, we did find a measurable level of avoidance between the locations of the property crimes that actually occur and the location of the nearest patrol car. Assuming the accuracy of the postulated causal model, the extent of avoidance is such that roughly 25 percent of crime opportunities of the type of property crimes in the sample would not result immediately in actual crimes occurring. The 25 percent of crimes that do not immediately occur could be attributed to the presence of nearby police patrol cars. However, the 25 percent could not be said to be deterred crimes because the lack of immediate occurrence of a crime could also imply temporal or spatial displacement of the crime opportunity. The temporal displacement is referred to as deferrence, whereas the spatial displacement is referred to as simply as displacement. Thus, for the property crimes, we have tentatively concluded the following:

> Individuals who commit property crimes that are potentially visible from the street do so with at least a limited awareness of police patrol cars. They tend to commit their crimes at a distance further from patrol cars than could be explained by random chance alone.

If the causal model that we tested is correct (an assumption that needs extensive additional research), then roughly 25 percent of property crime opportunities that occur in District 3 and that are potentially visible from the street are either deferred, displaced, or deterred because of nearby police patrol vehicles.

Our results regarding the dependence or independence of crime locations and police car locations has potential consequences in the debate of the rational vs. the irrational criminal. The results if validated in further work, also would give rise to the need for more sophisticated patrol models for crime interception; the earlier models always assumed a statistical independence between police car location and crime location. The results, if validated, tend to support the findings of the KCPPE in the area of assaultive crimes, where the findings relate to the lack of dependence of criminal activity on patrolling levels. However, the avoidance that we measured for the property crimes bears further scrutiny, and is somewhat at odds with the findings of the KCPPE. In the text, we have briefly sketched the outline for a more detailed test which could be the core for a more comprehensive study.

Directed Patrol

The principal obtrusive experiment conducted in our work with the SLMPD was a six-month Directed Patrol Experiment in District 3. This work is described in Chapter 3. Not only did we test the utility of the AVM monitoring device in carrying out this obtrusive experiment, but we found limited substantive findings regarding directed patrol of interest in their own right:

1. Police patrol cars on directed patrol do not stay in their assigned areas unless corrective feedback is provided to the officer involved. This finding suggests that earlier patrol experiments that attempted to deliberately change the spatial allocation of police patrol units may not have been as successful in that regard as had been hoped or anticipated.

2. The district patrol commanders, when given wide discretion and flexibility in selecting numbers of directed patrol units and their patrolling locations, choose areas for directed patrol based on more information than that provided by the Crime Analysis section alone. Thus, it appears that "street knowledge" at the district level is equally or more important in selecting directed patrol areas than headquarter's derived crime data.

3. Directed patrol was no less efficient than regular patrol in terms of arrests per car hour, especially when the pro-active nature and the quality of the arrests were considered.

4. The location of the greatest patrol intensity in the entire district was, not surprisingly, the police district station house. Patrol cars tended to pass by the district's station house at least three to five times as frequently as any other monitored point within the district (monitored points were AVM signposts).

5. Directed patrol, and in fact, regular patrol, tended to be greatly diminished in magnitude one half hour before and one half hour following the change of watches. Three such watch changes occurred during each 24 hour period.

6. In a DPE giving great discretion to the district commander, a number of different patrol configurations were selected by the various commanders when implementing directed patrol. The most popular strategy was to assign a regular beat car to directed patrol in his ordinary beat. Calls for services from that beat would be handled by cars in two contiguous beats. The second most popular strategy was to assign a regular patrol car to an entire precinct or sergeant's area, comprising typically three or four regular beats. The remaining cars in that precinct would handle call-for-service activities from the depleted beat. The third most popular strategy was to reassign a regular patrol car from its ordinary beat to another beat for directed patrol activities; in this configuration, the directed patrol beat would be staffed with two cars, one for directed patrol and one for ordinary call for service activities; as before, calls for service from the depleted beat would be handled by cars in contiguous beats.

7. In a DPE giving great discretion to the district commanders, 60 percent of the directed patrol assignments were for single target crimes, whereas 40 percent of the assignments were for multiple target crimes. Of the single target crime assignments, 47 percent were for residential burglary, 23 percent were for auto larceny, 20 percent were for street robberies and purse snatchings, and the remaining 10 percent were for business burglaries.

8. The dispatch procedures implemented to remove directed patrol cars from answering calls for service were successful. Directed patrol cars were sent on fewer than one dispatched call per watch.

9. The chief and other SLMPD commanders viewed the directed patrol concept sufficiently positively following our six-month study that they implemented the concept, together with other compatible provisions, on a citywide basis. (See Project Impact Letter, page vii and Appendix I).

<u>About Officers' Attitudes</u>

In order to make our evaluation in St. Louis comprehensive, it was necessary to spend a great deal of time with the officers at the district level. Information, opinions, and feedback were solicited from officers and their supervisors in both Districts 3 and 9 in St. Louis. The information gathering mechanisms included formal questionnaires, extensive structured interviews, unstructured discussions, and ride alongs. The following represent the major findings from our survey of officer attitudes:

Technology and Progress

1. For a variety of reasons, police officers in St. Louis no longer feel the FLAIR system is a good idea. In fact, there has been a steady decrease in officer confidence since FLAIR was introduced.

2. The only area in which a large number of police officers feel FLAIR has improved departmental performance is in "keeping track of the patrol force."

3. Police officers feel strongly that their opinions were not considered when the FLAIR system was designed.

4. Despite negative attitudes toward FLAIR , officers generally do not oppose new technologies and procedures in police work.

Directed and Preventive Patrol

1. A great majority of the police officers did not feel directed patrol is effective in either preventing or deterring crime.

2. Two-officer cars and the questioning of suspicious persons are seen as the most effective tactics for directed patrol.

3. Increased use of crime information, the use of two-officer teams and the elimination of non-critical calls for service were suggestions offered for improving patrol.

4. Police officers feel that traditional tactics are the best to apply in directed patrol but are willing to try others.

5. Assignment to directed patrol is seen as either a punishment or as a reward.

6. The importance of communication between all personnel involved in directed patrol cannot be overstated.

Police Patrol and Crime

1. Police, in general, do not feel criminals pay a great deal of attention to the presence of police.

2. For certain crimes, police believe perpetrators pay somewhat greater attention to police presence than they do in others.

3. Police officers who believe in the effectiveness of directed patrol are less likely to think criminals observe police activities.

4. The use of crime statistics to combat crime would seem to be a function of command attitude rather than officer willingness.

6.3 RECOMMENDATIONS FOR FURTHER WORK

We believe that the entire field of police patrol experimentation could be somewhat revolutionized by the tremendous new instrumentation capabilities of automatic vehicle monitoring or automatic vehicle location systems. Before extensive additional research can be done with this capability, however, AVM systems should be modified to facilitate the task of the police patrol researcher. Most critical in this area would be the installation of playback capabilities which would allow sample sizes of at least two orders of magnitude greater than we were able to obtain in our study. In addition, automatic playback capability could be used in conjunction with an entire interrelated set of patrol and crime performance variables to study a potentially rich set of interactions. A second research related feature of AVM would be to have movable signposts for detecting the passing of a police car at a particular street location; such movable signposts would also record the identity of the car, the time of day, and the direction of travel. Of course, a playback system with sophisticated analytical software could provide for "software

signposts" within the computer programming itself. In that way, for instance, incursions into depleted zones or other deviations from desired patrol patterns could be quickly detected and corrected. Finally, to extend the potential work beyond the SLMPD, we apparently await one or more technological breakthroughs, which would reduce the cost of AVM systems significantly so that police administrators in most major cities would choose to implement them in their own cities.

With regard to further substantive work on police patrol experimentation, virtually any future police patrol experiment which includes deliberate manipulation of patrolling patterns and locations could be criticized if it did not utilize the AVM monitoring capability to assure the integrity of experimental conditions. Thus, we can only hope that additional police departments in the not too distant future will implement such capability (perhaps based on the aforementioned technological breakthrough) in order to enlarge the number of potential "urban police patrol laboratories" available for further experimentation.

With regard to unobtrusive experimentation, it may be that this aspect of the AVM capability is the most far reaching from a basic police patrol research point of view. Many issues regarding deterrence, displacement, and general patrol effectiveness have gone unanswered or ambiguously answered in the past, in large part due to limitations of the aggregate data that were available for analysis. With the AVM capability, one can now study the microstructure of various processes, hopefully shedding more light on these issues.

Building on our own work in St. Louis, we urge its replication with a larger sample size and more comprehensive study of the analysis of the dependence or lack thereof of crime locations upon nearby patrol car locations. A definitive finding based on a larger sample size that assaultive crimes occur independently of patrol cars could have far reaching consequences. A similiar finding about the deliberate avoidance by property criminals of nearby patrol cars could have also significant consequences. Any further study of this issue, in addition to containing a vastly increased sample size, should include a number of different variables associated with each crime in progress that is included in the sample. This set of variables could include among other things, distance to the five closest police cars, a flag variable indicating whether or not the closest car is visible from the crime scene, the elapsed time between the last passing of a patrol car at the scene of the crime and the time of the crime, a flag variable indicating whether or not the car assigned to patrol the area is busy or available at the time of the crime, and the average empirically measured patrol frequency past the crime scene during the previous 24 hours. All of these and more variables are now easily measured from an AVM system, particularly one that has an automatic playback capability.

Future experiments in police patrol should occur in an environment of replication, innovation, and enhanced instrumentation. AVM is one element of enhanced instrumentation. There are others, too, including computer aided dispatch (CAD) systems, mobile digital communications, and statistical crime analyses. Experimental design in the future can be further enhanced by mathematical models of the spatially distributed patrol police force which allow the researcher to anticipate the operational consequences of alternative experimental design prior to implementation. These new techniques, when coupled with proven methods of comprehensive evaluation should lead to significant and operationally useful research results in the police research studies of the 1980s and 1990s.

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Exhibit

1 INTRODUCTION

Innovation, experimentation, and police patrol—these are the themes of the research we describe herein. We report on a number of related research activities carried out in conjunction with the St. Louis Metropolitan Police Department (SLMPD) during the period 1979 through 1981.

From the standpoint of police patrol research, the SLMPD is unique. It is the only major police department in the United States that has an accurate, citywide Automatic Vehicle Monitoring (AVM) system. This system, called FLAIR,[1] provides each police dispatcher, via a color television screen, second-by-second position estimates and status readings for each of the police patrol cars in his/her area of dispatch responsibility. The locations and movements of each car can be viewed at one of several map magnification levels on the television screen. The status of each car (e.g., busy on high priority call, busy on low priority call, or on preventive patrol) is also indicated. Originally installed to decrease police response time and to enhance officer safety, the AVM system has provided only marginal benefits in these areas.[2] However, the AVM system offers another potential benefit that has been—up to this time—virtually unexplored. It provides an accurate patrol monitoring capability heretofore unavailable to the police researcher. This monitoring capability can be useful for carrying out both "obtrusive" and "unobtrusive" experiments.

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[1]FLAIR, is an acronym which stands for Fleet Location And Information Reporting and is a trademark of the Boeing Company.

[2]R.C. Larson, K.W. Colton, and G.C. Larson, Evaluation of a Police-Implemented AVM System: Phase I With Recommendations for Other Cities (Washington, DC: Government Printing Office, 1977); G.C. Larson and J.W. Simon, Evaluation of a Police Automatic Vehicle Monitoring System: A Study of the St. Louis Experience 1976-1977 (Washington, DC: Government Printing Office, 1979).

1.1 THE NEED FOR MONITORING PATROL EXPERIMENTS

By obtrusive experiments, we refer to those experiments that involve a deliberate redeployment of police patrol forces over some area of the city. Perhaps the most famous obtrusive police patrol experiment is the well-known Kansas City Preventive Patrol Experiment (KCPPE).[3] Carried out in the early 1970s, the Kansas City researchers (associated with the Police Foundation) attempted to explore the dependence of crime rates, citizen attitudes, and other indicators on the level of police patrol presence in their areas. In one 15-beat region of Kansas City, Missouri, the experimenters devised three different treatments. Treatment 1 was a control treatment, in which five of the 15 beats were assigned the standard single patrol car to patrol the area and answer nearby calls for service. In treatment 2, five patrol beats were designated "proactive" beats, in which a second car was added in an attempt to at least double the level of police patrol coverage in those beats. In the third and perhaps most controversial treatment, the researchers designated the remaining five beats as "reactive" beats, in which the usually assigned police patrol car was removed. That patrol car, when on preventive patrol, was to patrol a common boundary between its usual beat (now the reactive beat) and a contiguous proactive beat, in a sense adding at least a fraction of a car to the proactive beat which already had two cars assigned to it. The reactive beat was to remain uncovered by regular police patrol cars, except for answering calls for service, serving warrants, pursuing offenders, and other such situations.

The Kansas City researchers, when analyzing the results of their year-long study, found primarily negative results. That is, neither actual nor perceived

[3]G.L. Kelling, et. al., The Kansas City Preventive Patrol Experiment (Washington, DC: Police Foundation, 1974).

crime rates or levels of safety seemed to depend on experimental treatment, either control, proactive, or reactive. The Kansas City researchers concluded, among other things, that crime rates, citizen attitudes, and related performance measures do not seem to depend strongly on levels of preventive patrol coverage. These findings generated considerable interest, activity, and debate in police circles, both among practitioners and researchers.[4] It is not the purpose of this introduction to review the long history following the KCPPE. The enthusiasm generated by the experiment prompted others throughout the country to conduct experiments in numerous different police departments. Thus began the decade of police patrol experimentation in the United States.

The experiments that followed the KCPPE, many building on its themes and tentative recommendations, included the Wilmington, Delaware "Split-Force" experiment; the San Diego "One-Man, Two-Man Car" study; the Wilmington "Management of Demand" Study, the Newark, New Jersey "Foot Patrol" study; the Worcester, Massachusetts "Police Service Aide" study; the Kansas City "Response Time" studies; the Seattle "Response Time" studies; and the experiments on police patrol done in Syracuse, New York.[5] The great majority of these studies,

[4]R.C. Larson, "What Happened to Patrol Operations In Kansas City? A Review of the Kansas City Preventive Patrol Experiment," Journal of Criminal Justice 3(1975):267-297; S.E. Fienberg, K. Larntz, A. J. Reiss, Jr. "Redesigning the Kansas City Preventive Patrol Experiment," Evaluation Review 3(1976); T. Pate, G.L. Kelling, C.E. Brown, "A Response to 'What Happened to Patrol Operations in Kansas City?'" Journal of Criminal Justice 3(1975); B.J. Risman, "The Kansas City Preventive Patrol Experiment: A Continuing Debate," Evaluation Review 4(1980):802-808; R.C. Larson, "Critiquing Critiques: Another Word on the Kansas City Preventive Patrol Experiment," Evaluation Review 6(1982).

[5]J.M. Tien, R.C. Larson, et al., An Evaluation Report: Wilmington Split-Force Patrol Program (Cambridge, MA: Public Systems Evaluation, Inc., 1976); J.E. Boydstun, M.E. Sherry, and N.P. Moelter, Patrol Staffing in San Diego: One- or Two-officer Units (Washington, DC: Police Foundation, 1977); M.F. Cahn and J.M. Tien, An Alternative Approach In Police Response: The Wilmington Management of Demand Program (Cambridge, MA: Public Systems Evaluation, Inc., 1981); G. Kelling, A. Pate, et al., The Newark Foot Patrol Experiment (Washington, DC: Police Foundation, 1981); Tien, et. al., An Evaluation Report of the Worcester Crime Impact Program (Cambridge, MA: Public Systems Evaluation, Inc., 1975); M.L. Van Kirk, Kansas City Response Time Analysis

including the original KCPPE, included as a primary input into their study or experiment the deliberate spatial manipulation of police patrol cars. This led to one big problem in all of these studies: the inability of the researchers to monitor unobtrusively the locations and [illegible]ities of the police patrol cars. The only way in which continuous monitoring of the patrol cars could occur was by "backseat ride-alongs," in which a researcher would virtually sit in the rear seat of a police patrol car and maintain a record of the activities of the car during the period of monitoring. This technique, which was utilized by a number of researchers, is open to the criticism that the intrusion of the researcher will affect the manner in which the patrol officers carry out their activities during the period of the obtrusive monitoring. Thus, in fact, there was no feasible procedure for assuring that experimental conditions were maintained—that is, for insuring the integrity of the patrol experiment.

With the KCPPE, there is ample evidence that the integrity of the experiment was not maintained, particularly in the reactive beats. For example, the number of patrol self-initiated activities in the reactive beats during the year of the study actually increased compared to the year before the study, a year in which a regular police patrol car had been assigned to those beats. Such an increase in self-initiated activities suggests a not insignificant level of patrol presence in those beats during the year of the study, a year in which virtually no preventive patrol was to occur in the reactive beats. Also, dispatching procedures were violated during the KCPPE, in that approximately 1.6 patrol cars acknowledged responding to an average call for service within the reactive beats. The average in the other beats was 1.2 patrol cars per dispatch or less. The extra cars that went in were discouraged from doing so by the experimental design. And there is no knowledge of how many cars went in that did not acknowledge their response to the police dispatcher. Thus, had it been possible to monitor locations while on patrol and dispatch response patterns, the integrity of the KCPPE could have been improved. One major purpose of our study in the SLMPD was to test the feasibility using AVM to monitor the integrity of patrol experiments.

Final Report (Kansas City, MO: Kansas City Police Department, 1977); C. Clawson and S. Chang, "Relationship of Response Delays and Arrest Rates," Journal of Police Science and Administration 5(1977); D.P. Tarr, "An Analysis of Response Delays and Arrest Rates," Journal of Police Science and Administration 6(1978); J. Elliot and T. Sardino, Crime Control Team: An Experiment in Municipal Police Department Management and Operation (Springfield, IL: Charles C Thomas, 1971).

1.2 AVM AS A BASIC RESEARCH TOOL

A second potential use of AVM in police research is in the area of unobtrusive experimentation. By this we mean experimentation in which the AVM system is used to gather data regarding police patrols and crimes during periods in which the police patrol force is operating in a standard nonexperimental mode. Potentially, this experimental capability of AVM could be as far reaching as the monitoring capability for obtrusive experimentation. Particularly with regard to the subject of dependence of crime and police patrols, all earlier studies of necessity focused on macroscopic questions. These dealt with such issues as the aggregate crime rate for various types of crimes over subareas of the city for certain time periods as a function, say, of the aggregate number of police patrol cars deployed to that area. The KCPPE was in this category, as was the 20th Precinct Study in New York City.[6] Most of these studies have found little dependence of a policy significance of crime rates on police patrol numbers at the aggregate level. But an AVM system presents a very disaggregate picture of police patrolling and criminal activity, especially for activities reported while in progress. In a sense, AVM provides

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[6] S.J. Press, Some Effects of an Increase In Manpower In the 20th Precinct of New York City (New York: New York City Rand Institute, 1971).

to the police researcher what a microscope provides to the biologist in his laboratory. Just as the biologist studies the interaction of, say, mutant vs. nonmutant cells on the slide of his microscope, now the police researcher can study the interaction (via AVM) of crimes vs. police patrol cars. Any spatial dependence of criminal activity upon local police patrol presence should be detectable with this new measurement capability. We are quite excited to be the first police patrol researchers to be able to take advantage of this potentially far reaching police research capability.

1.3 OVERVIEW OF OUR WORK IN ST. LOUIS

During the course of our experimentation in the SLMPD, we carried out both obtrusive and unobtrusive studies. We emphasize that all of these studies were of a pilot nature, with a primary purpose to study the feasibility and desirability of using AVM in an experimental context. As a by-product, we have developed some preliminary research results of substantive interest in themselves, which seem to require additional follow-up work with larger sample sizes. The primary obtrusive experiment with the SLMPD was a "directed patrol" study conducted in the police district with the largest number of calls for service, District 3. The concept of directed patrol, in which police officers on preventive patrol would have specific target crimes which they focus their patrol activities on, has evolved from the sequence of studies during the 1970s that started with the KCPPE. Directed patrol has been and remains an "idea in good currency" in the police field, thus we chose a particular directed patrol format for the use of AVM in an obtrusive experimental setting.

As implemented in St. Louis, upon any given tour of duty, zero, one, two, or three patrol cars could be designated as directed patrol (DP) cars. These cars were to focus on specific target crimes in one or more assigned beats. The remaining regular patrol cars in District 3 were to assume the call-for-

service responsibilities formally assigned to the DP cars, although the DP cars could be assigned to high priority calls for service if necessary. The Directed Patrol Experiment (DPE) contained elements of patrolling within given areas and limited dispatch responsibilities, both of which could be monitored via AVM. Early on, we found out through AVM monitoring that the guidelines were often violated, and thus corrective feedback had to be given to the appropriate police patrol officers. If similiar violations of experimental integrity had occurred in earlier police preventive patrol experiments, the results of those experiments may be brought to question. In addition to indicating the feasibility of using AVM as an experimental monitoring device, the District 3 DPE was sufficiently encouraging to the senior officers of the SLMPD to motivate them to implement a similiar program city-wide. This implementation is described in a letter on page vii and in Appendix I.

In experimentation of the unobtrusive type, we carried out a number of different activities. These included statistical descriptions of patrolling patterns, the amount of patrol coverage given to various areas of a police district, and--most significantly--the dependence of crime locations upon nearby police patrol car locations. This latter study in particular has generated certain tentative substantive findings regarding the independence or dependence of criminal activity upon police patrol car locations; further research is warranted in this area.

The work carried out herein extends beyond mere use of AVM as a technological tool. The evaluation methodology utilized in the DPE is comprehensive, simultaneously analyzing relevant aspects of program inputs, processes, and outcomes. In this regard, extensive in-the-field interviewing and questioning of patrol officers occurred in District 3 and a related district, District 9. We have extensive results on officer attitudes toward directed patrol, policing in general, technology and policing, and related issues which are of independent interest in themselves. Among other things, we now have a time series dating from 1974 related to District 3 officer attitudes on the FLAIR system. The results of this time series would seem to be crucial for any public emergency agency attempting to implement a very visible and untested technology such as AVM into their standard operating procedures.

The DPE in District 3 was also a "model-based experiment." By this we mean that alternative deployments of police patrol forces within District 3 were analyzed via a mathematical, computer-based model prior to the selection and implementation of a particular experimental design. Since the District 3 DPE permitted a good deal of discretion on the part of the district commanding officer on any given tour, a number of different and somewhat typical directed patrol deployments were studied. The model, known as the "Hypercube Model,"[7] takes as inputs the spatial distributions of calls for service and police patrol efforts, and the travel time characteristics of the region; it produces as outputs a range of performance measures including area-averaged and point-specific travel times, workloads of the various police patrol units, frequency of interarea dispatching, etc. Being an analytical or "equation-based model" (not a Monte Carlo Simulation Model), the model produced accurate results with a relatively small expenditure of computer time. The various runs provided general guidelines that we communicated to district commanders regarding appropriate selection or nonselection of directed patrol configurations. We have observed that with a large fraction of earlier police patrol experiments, the experimental design was selected without such a pre-analysis of its operational impact. Our hope is that future obtrusive police patrol experiments will benefit by such model-based analysis prior to actual experimentation. Such a

[7] R.C. Larson, "A Hypercube Queueing Model for Facility Location and Redistricting in Urban Emergency Services," Computers and Operations Research 1(1974).

pre-analysis would seem to greatly increase the probability that the desired system performance will resemble the measured system performance.

1.4 OUTLINE OF REPORT

The purpose of this section is to provide a quick overview of the contents of the report. Chapter 2 contains an introduction to the city of St. Louis and District 9, which for the past several years has been an area of innovation and experimentation. In particular, District 9 operated with an "open beat concept," where police officers were encouraged to patrol an area larger than the usual single patrol sector, the larger area being equal to at least three or four patrol sectors and sometimes the entire district. The officers in District 9 were used to participating in alternative modes of operation, and thus we initially felt that it would be the appropriate district for the study. However for several reasons, including the relatively small size of District 9, we decided to shift our main experimental efforts to a larger area, namely District 3. Before that shift was carried out, we pretested many of our data gathering methods in District 9, and these are described in Chapter 2. These included analyses of patrolling patterns, with emphasis on the fraction of time spent in various patrol areas, randomness of the patrolling pattern as reflected by turning probabilities, and other related issues. We also pretested our procedures for investigating the statistical dependence or independence between crime locations and patrol car locations.

Chapter 3 describes District 3 and the design and conduct of the DPE. It discusses use of the Hypercube model in studying the effects of alternative directed patrol deployments, techniques for FLAIR-based and other data collection, and the results from monitoring and measuring directed patrol.

Chapter 4 contains an intensive analysis of police officer attitudes toward technology and patrol practices. The analyses are derived from responses to questionnaires (in which the response rate was nearly 100 percent), in-depth field interviews, participant observation, and related information-gathering techniques carried out in District 3 and 9. Of particular interest with regard to other police patrol studies, we asked the officers a sequence of questions regarding their perceptions of the effectiveness of preventive patrol and directed patrol for reducing or deterring various crimes. We believe that it is the first time that such a sequence of questions has been directed to police officers. Also, as mentioned earlier, we asked questions regarding officers' attitudes about the FLAIR system, and when combined with earlier PSE studies, their responses provide a time series over a seven-year period of officer attitudes toward AVM technology.

Chapter 5 represents our most extensive unobtrusive analysis with AVM. Here we examine the question of the dependence or lack thereof of crime locations on nearby police patrol car locations. We tested the following null hypothesis: H_0: the times and locations of crimes occur independently of the locations of police patrol cars. The alternative hypothesis we considered, was the following: H_1: the locations and times of crimes occur in a way which to some extent deliberately avoids nearby police patrol cars. Thus the two hypotheses were <u>independence</u> and <u>avoidance</u>, the first representing a potential criminal who is a "risk taker" and the second criminal who is a "risk minimizer." The result of the analyses, based on an admittedly small sample size of 117 confirmed crimes in progress, should be of independent interest. To some extent, the results confirm some of the "police level independence" interpretations of the KCPPE, but to a limited extent a subset of the results suggest a measurable police avoidance phenomenon.

The appendices include a description of the new St. Louis District Patrol Plan that has been implemented subsequent to our study (Appendix I), a sample copy of the eight-hour FLAIR output (Appendix II), the questionnaire

administered to District 3 officers (Appendix III), and the full mathematical developments related to the testing of H_0 and H_1 in Chapter 5 (Appendix IV).

2 ST. LOUIS AND THE DISTRICT 9 PRETEST

St. Louis has been, and will continue to be, an important hub of commerce in both east-west and north-south shipping. It is situated on the Mississippi River approximately halfway between the northern and southern termini of the river. It is approximately 61.4 square miles in size. In 1980, the Census Bureau counted 448,640 residents in St. Louis, 27.9 percent fewer than in 1970. At the same time, there were 1.8 million people in the city and its surrounding counties. Thus, while the city itself ranks 25th in population among U.S. cities in the U.S., the metropolitan area ranks 12th.[1]

The St. Louis Metropolitan Police Department (SLMPD) has approximately 1,950 sworn personnel—a ratio of 4.3 police officers per thousand residents, one of the highest in the country. The city is divided into nine police districts, based more on tradition than equal workload, population or area. As shown in Exhibit 2.1, District 3 is in terms of reported crimes, the "busiest" in the city. Until 1980, District 9 was the second busiest. That year, however, District 7 had the second highest number of reported crimes, and the largest number of crimes against persons.[2]

Our police patrol experiments were undertaken here for a number of reasons. Most importantly, St. Louis is the only large city that has an AVM system. The capacity to monitor and track patrol cars was essential to the study. It also has a progressive police management team, willing to try new ideas and willing to allow these new ideas to be objectively evaluated. Finally, St. Louis has a complement of professional police officers who are

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[1]Robert Levey, "It's Goodby St. Louis, Goodby," Boston Globe, 22 Jan. 1981.

[2]Crime rates (i.e., crimes per 1000 persons) have not been computed because (1) census data have been released slowly due to court challenges, and (2) the available data can only be approximately aggregated by police district.

Exhibit 2.1

Total Crimes And Arrests in 1980, by Police District

District	Crimes Against: Person	Property	Total	Rank	Arrests: Total	As a % of Total Crimes	Rank Based on %
1	383	4668	5051	9	1292	25.6	1
2	316	4874	5190	8	912	17.6	8
3	1660	9711	11371	1	2170	19.1	6
4	932	5741	6673	5	1403	21.0	2
5	1418	5298	6716	4	1392	20.7	3
6	1236	5360	6596	6	1311	19.9	4
7	2143	6519	8662	2	1660	19.2	5
8	1589	4446	6035	7	941	15.6	9
9	1306	7031	8337	3	1473	17.7	7

Source: SLMPD, unpublished statistics, nd.

willing to try new approaches to policing and to allow outside researchers the opportunity to test these ideas.

Based on discussions with the SLMPD command staff, it was decided to begin the initial stages of our experimentation in District 9. Numerous tests of hypotheses and FLAIR recording methods were conducted there during the summer and early fall of 1980. The results of these tests are discussed in this chapter. At the end of this pretest phase, it was decided that the major obtrusive experiment, the six-month directed patrol experiment (DPE), should be conducted in another district. The presence of the SLMPD's main garage in District 9 was the primary reason for this move. The associated traffic tended to confound some of the early AVM-derived results and make the drawing of firm conclusions difficult. Attempting to measure "police presence" was impossible in District 9 because police cars of all types continually entered and left the garage area. While many cars were monitored by FLAIR, untold numbers could not be. It was the presence of an unknown (and unmonitored) number of police vehicles which contributed to the relocation of the remainder of our work. District 3 was chosen—in part because of its large size and crime volume. The results of the DPE are discussed in Chapter 3.

2.1 THE FLAIR SYSTEM

The FLAIR system was developed by the Boeing Company in conjunction with the Law Enforcement Assistance Administration, the National Institute of Justice and the SLMPD. The system, also known as an Automatic Vehicle Monitoring (AVM) system, is of the "dead-reckoning" type. Dead-reckoning systems depend upon equipment within the vehicle to generate locational movement information, in a manner similar to that of inertial guidance systems used in missiles, aircraft, submarines, etc. For these systems to work, the initial vehicle location must be known, after which the instruments within the vehicle monitor its movement through distance and direction sensors.[3]

Accuracy in position tracking is necessary in dead-reckoning systems to avoid cumulative errors which eventually could lead to the vehicle becoming "lost" to the system. The FLAIR system has a rather unique means to track vehicles using rather low-cost distance sensors (odometers) and heading sensors (magnetic compasses). This tracking technique is called "map matching"—the computer-based visual display keeps the vehicles on a street even though the relatively inaccurate heading sensors might otherwise indicate that it has wandered off. In a similar manner, inaccuracies in the odometer can be overcome when a vehicle turns a corner as the computer will correct the location to the nearest cross street, even though the indicated location is short of, or beyond, the intersection. If the computer should pick the wrong intersection, it is likely that the vehicle will eventually encounter routes not on the map, and thus the computer can no longer track it. Under these conditions, the computer will search the map to find the location that corresponds to the vehicle route, and if successful, will relocate the vehicle.

If a vehicle does become "lost" (because the computer can no longer track it), a "V" is displayed on the video screen identifying its number. To verify the location, the dispatcher asks the particular officer to stop and identify the next convenient intersection. If the location is not correct, the dispatcher places a cursor at the correct location on the screen, and the car is reinitialized. Occasional lost cars do not substantially diminish the

[3]The Boeing FLAIR System not only operates on the dead-reckoning principle, but also uses the computer to reduce the possibility of accumulated errors. The FLAIR system should therefore more appropriately be called a computer-tracked dead-reckoning system, or, because it uses more than one location technology, a hybrid system.

effectiveness of the system, but too many lost cars could obviously negate the benefits intended.

After FLAIR was installed it became apparent that a larger than expected proportion of vehicles were lost. To correct for the high volume the Boeing Company agreed to install a number of automatic reinitialization points, or signposts on busy thoroughfares throughout the city. Every time a vehicle passes a fixed signpost its exact location is automatically transmitted to the FLAIR computer which in turn corrects for any accumulated errors which may have caused the computer to assume an incorrect location for the car. It is not unusual to see a car "jump" from one location to another as the FLAIR computer relocates a car to its correct spot upon receipt of information from the signpost. Of the slightly more than 100 fixed signposts installed in the city, ten were in District 9 and sixteen in or on the borders of District 3.

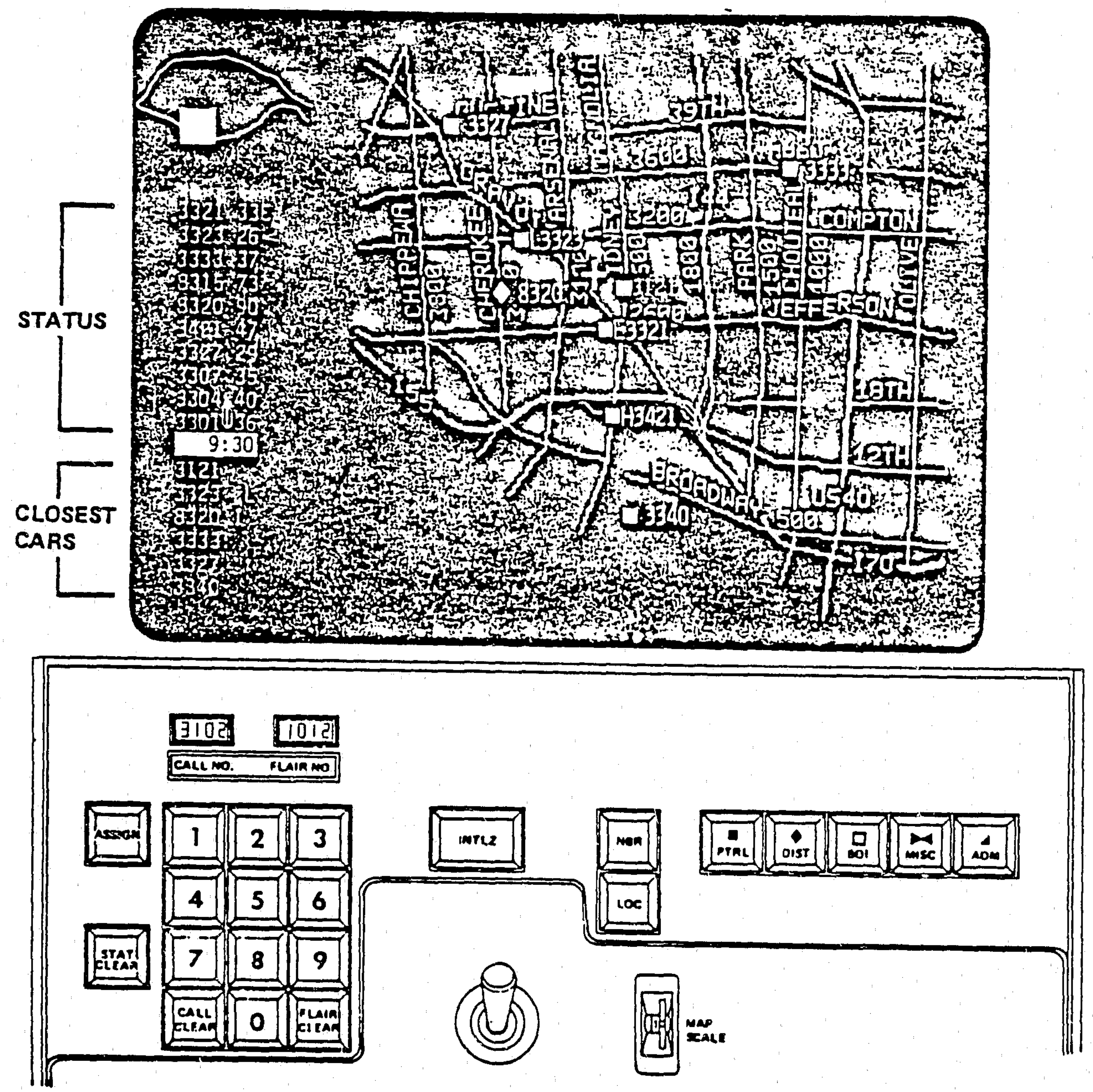
As seen by a dispatcher or observer, the FLAIR video display (see Exhibit 2.2) updates the location of each car every second giving a real-time view of the continuous movement of all vehicles. The real-time view of patrol movements makes it easier for a dispatcher to relate to the work of the police officer (compared to other AVM systems in which vehicles may appear to wander through buildings); verifies the location of the computer-selected closest cars—which could be on one-way streets or across a natural or man-made barrier (e.g., a river or expressway); assists the dispatcher in command and control operations (e.g., sealing off an area); and assists in identifying the location of a car that has activated its emergency alarm.[4]

The FLAIR system also has a capacity of 99 "canned" messages which provide digital communications from mobile units to headquarters. The mobile

[4]The emergency alarm is a button on the radio console which, when activated, sends a signal that places an "E" next to the vehicle number on the FLAIR screen, and sets off an audible alarm in the communications center.

Exhibit 2.2

FLAIR Display and Operator's Console



operator transmits a selected message by keying in the appropriate numbers. These codes are used for general messages, which the dispatcher must acknowledge by voice; messages of another type perform an automatic function on the display (e.g., identifying one- versus two-man cars, leaving for incident scene, etc.) requiring no dispatcher acknowledgement; and a third class automatically initializes the car at given locations when the operator keys in the appropriate number.[5]

For the police researcher the ability to monitor all cars at one time was a substantial breakthrough. Unfortunately, the FLAIR system has—from the researcher's point of view—a number of disadvantages. Perhaps the most important disadvantage is that the system, as installed, cannot retain or play back material. In other words, as changes occur in the spatial locations of patrol cars, old locations are discarded. Since much of the analysis planned for this study required the ability to replay patrol and deployment situations, we were forced to use videotape recorders (VTRs) to capture and retain the data.

Much of our data were gathered through the use of two VTRs attached to the FLAIR computer system. The VTRs were wired in such a way that an observer could record activities as shown on the FLAIR console with one VTR while the other was used to (1) make copies of incidents from the first VTR or (2) analyze one tape of incidents while another was being compiled in real time.

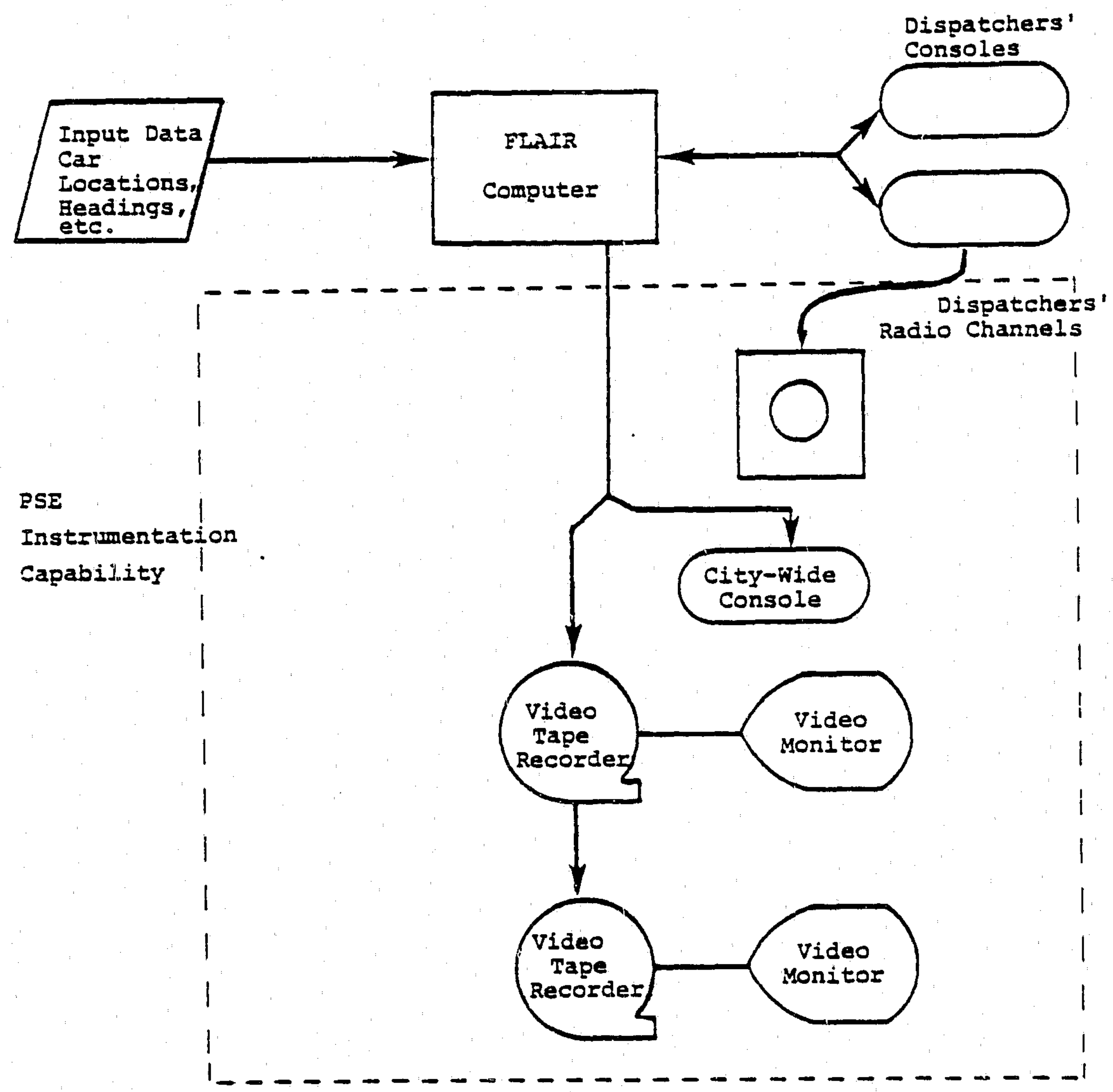
As shown in Exhibit 2.3, this rather unwieldly arrangement meant that a PSE staff member had to monitor visually the FLAIR console in order to determine if items of interest were occurring. Although the equipment could be left to record data automatically, in later portions of the experiment (see

[5] For a more detailed explanation of the FLAIR system as well as other AVM technologies, see: G.C. Larson, "Alternative Vehicle Monitoring Technologies," Appendix A in G.C. Larson and J.W. Simon, Evaluation of A Police Automatic Vehicle Monitoring (AVM) System: A Study of the St. Louis Experience (Washington, DC: Government Printing Office, 1979).

Exhibit 2.3

Schematic Representation of FLAIR System and

VTR Attachments for Gathering/Recording Data



Chapter 5), 24-hour monitoring of the system was mandatory. Further, once the FLAIR information was recorded on the VTR it still had to be analyzed. The analysis of individual incidents often required playing a portion of the tape repeatedly before some of the more subtle aspects of the patrol cars' movements were discerned. In addition, the FLAIR records were reconciled with radio dispatch logs and crime analysis information generated by the police department. Finally, specially written computer programs were used to analyze the data.

In the pages that follow, the results of our initial analyses are presented. These include analyses of the fraction of time spent by patrol cars in an area, turning probabilities of patrol cars, and the responsiveness of patrol efforts to crime patterns, as well as a first cut assessment of the relationship between crime and patrol.

2.2 THE DISTRICT 9 PRETEST

District 9, covering 4.0 square miles, abuts downtown St. Louis and contains an extremely diverse population. For example, the southwest area contains hospitals, medical centers, and expensive shops and housing. The northeast area, however, is blighted; it contains many shells of buildings, a few respectable dwellings, some stores and a great many rubble-filled lots. The district is also home to "the Stroll," an approximately 24-block area of rundown hotels and vacant lots where prostitutes and their customers mingle. Recently installed traffic barriers and more intense police presence have made contacts between the parties more difficult but the "problem" persists.

During our initial research the police in District 9 utilized an open-beat concept on specified watches. Under this approach, the district was divided into three supervisory areas with one sergeant and up to three patrol cars in each area. Patrol officers had responsibility for an entire supervisory area and generally could respond to any call within that area. It would appear, also, that there was some informal sub-area responsibility; if officers felt they knew one portion of the patrol area better than another they would most probably take responsibility.

2.2.1 Patrol Patterns: Fraction of Time Spent in Patrol Areas

The purpose of this analysis was to demonstrate that AVM could be used to determine the spatial distribution of patrol effort at various points in time. To facilitate the analysis, District 9 was divided into the ten zones depicted in Exhibit 2.4. The zones reflect neighborhoods within the district and the boundaries were determined with the assistance of the district's patrol and supervisory officers. These divisions were created to allow us to test the instrumentation capabilities of FLAIR. The areas represented what would be beats under a more traditional patrol plan and allowed limited testing of hypotheses and extensive testing of measurement methodologies.

By analyzing the data from the FLAIR system it was possible to determine the <u>fraction of time</u> spent by patrol cars in each of the "patrol zones."[6] Of interest was the degree to which these zones receive equivalent levels of patrol over time and across zones. From July 7-11, 1980, a 24-hour watch was maintained on the positions of FLAIR-observable patrol cars by video recording the FLAIR monitor.

As can be seen in Exhibit 2.5, the different patrol zones in District 9 received significantly different patrol efforts (a conclusion reached by obser-

[6] The information presented here represents analyses of the activities of only those vehicles which are capable of being monitored by the FLAIR system. Some cars are without FLAIR equipment while, occasionally, one or two FLAIR cars may have malfunctioning equipment. We can say nothing about the movements of such cars in District 9 during this period.

Exhibit 2.4

Patrol Zones in District 9

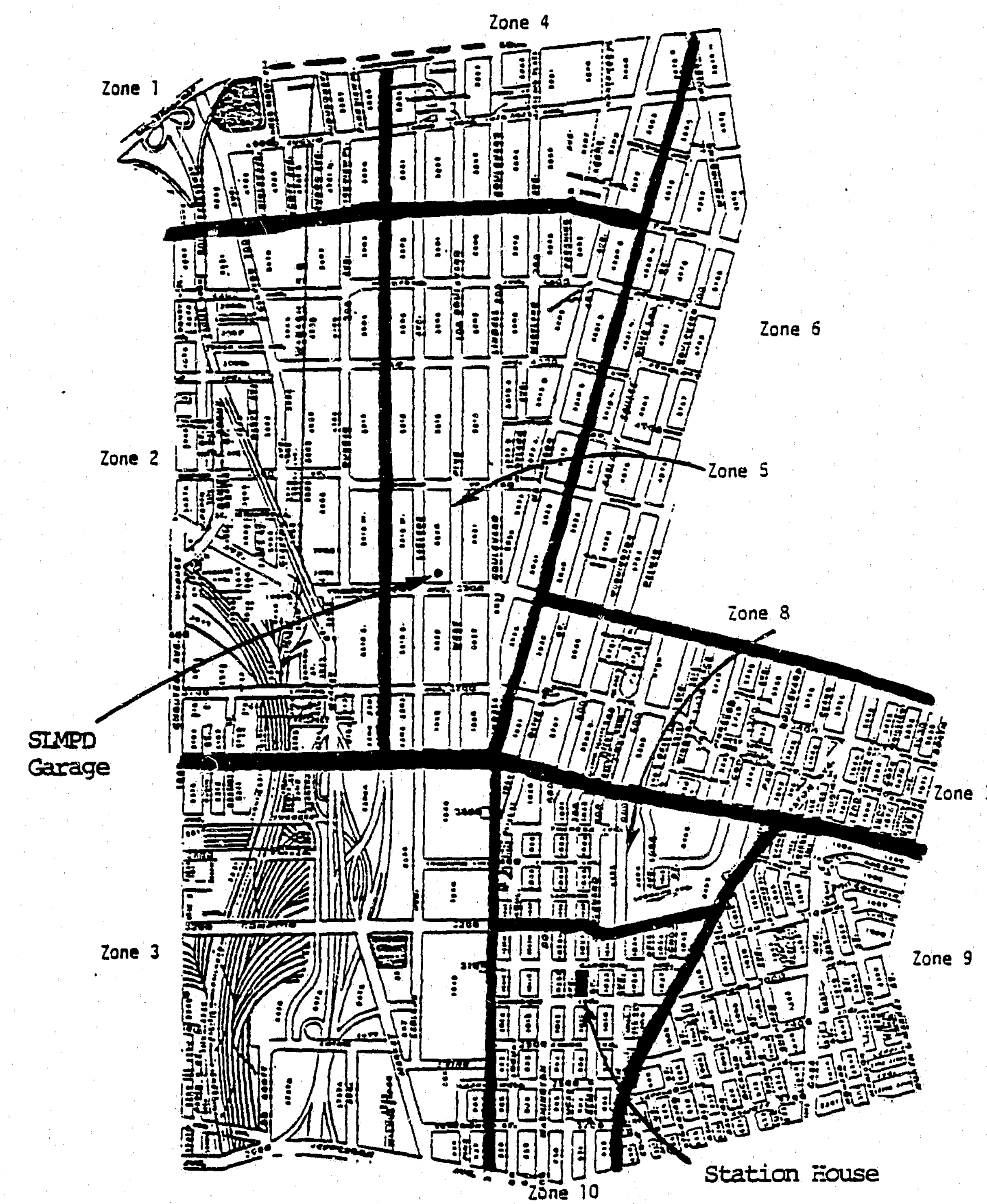


Exhibit 2.5

Percent of Time Spent by all FLAIR-Observable Patrol Cars In the Zones of District 9, July 7-11, 1980

Zone	Type of Use	Percent of Time Spent in Zone
1	Hospitals, Upper-Middle Class Housing and Shops	1.82%
2	Factories, Warehouses, Some Houses	5.81
3	Shipping and Transportation	8.04
4	Middle and Upper Class Housing and Shops	8.36
5	The "Heart" of the District—varying uses	17.87
6	The "Stroll"	7.61
7	Lower Socioeconomic Class Housing	6.93
8	Small Businesses, Symphony Hall	5.49
9	The "Hole"—Lower Socio-economic Class Housing and Shops	4.60
10	The Zone Containing the District Station House (but excluding the facility)	10.83
—	Station House	22.64
	TOTAL	100.00%

vation and verified by use of the chi-square test).[7] The exhibit shows the total patrol effort during the five-day, 24-hour-a-day monitoring period patrol officers spend a great deal of their time (up to 23 percent) at the station while some zones (such as Zone 1) receive almost no patrol. Zones that are consistently patrolled at less than average intensity include Zone 1 and Zone 9. Zones that are consistently patrolled intensely include Zone 10 (the area around the district station house) and Zone 5 (the zone in which the police garage is located).

As a means for extending the test of instrumentation, 22 four-hour periods were sampled. Using the VTR playback capacity described above, each neighborhood was studied, for each time period, to determine the amount of time the FLAIR-observable cars spent in that area. Exhibit 2.6 shows a series of box plots of the fraction of patrol effort in each zone. The end points of each line represent the maximum and minimum effort measured within a zone, the line at the center of the box represents the median amount of patrol effort in a zone, and the upper and lower ends represent the 75th and 25th percentiles, respectively. For example, the data indicate that even the small amount of patrol effort Zone 1 received was not consistent across the five-day period. It is interesting that the spatial distribution of effort across zones is clearly uneven, as is the temporal distribution of effort within zones.

In an attempt to examine the differential patrol effort somewhat more closely, PSE examined the data by time of day. As shown in Exhibit 2.7, the patrol effort within District 9 is most "uniform" during the late evening and night shifts. Such a finding is not surprising given the fact that fewer calls-for-service occur during these hours, resulting in officers having more time available for patrol duties.

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[7]Patrol effort refers to the total number of hours a car was in (whether on general patrol or responding to a call for service) that zone.

Exhibit 2.6

Distribution of Fraction of Time Spent In

Patrol Zones by FLAIR-Observable Patrol Cars

(Sample = 22 4-hours time blocks)

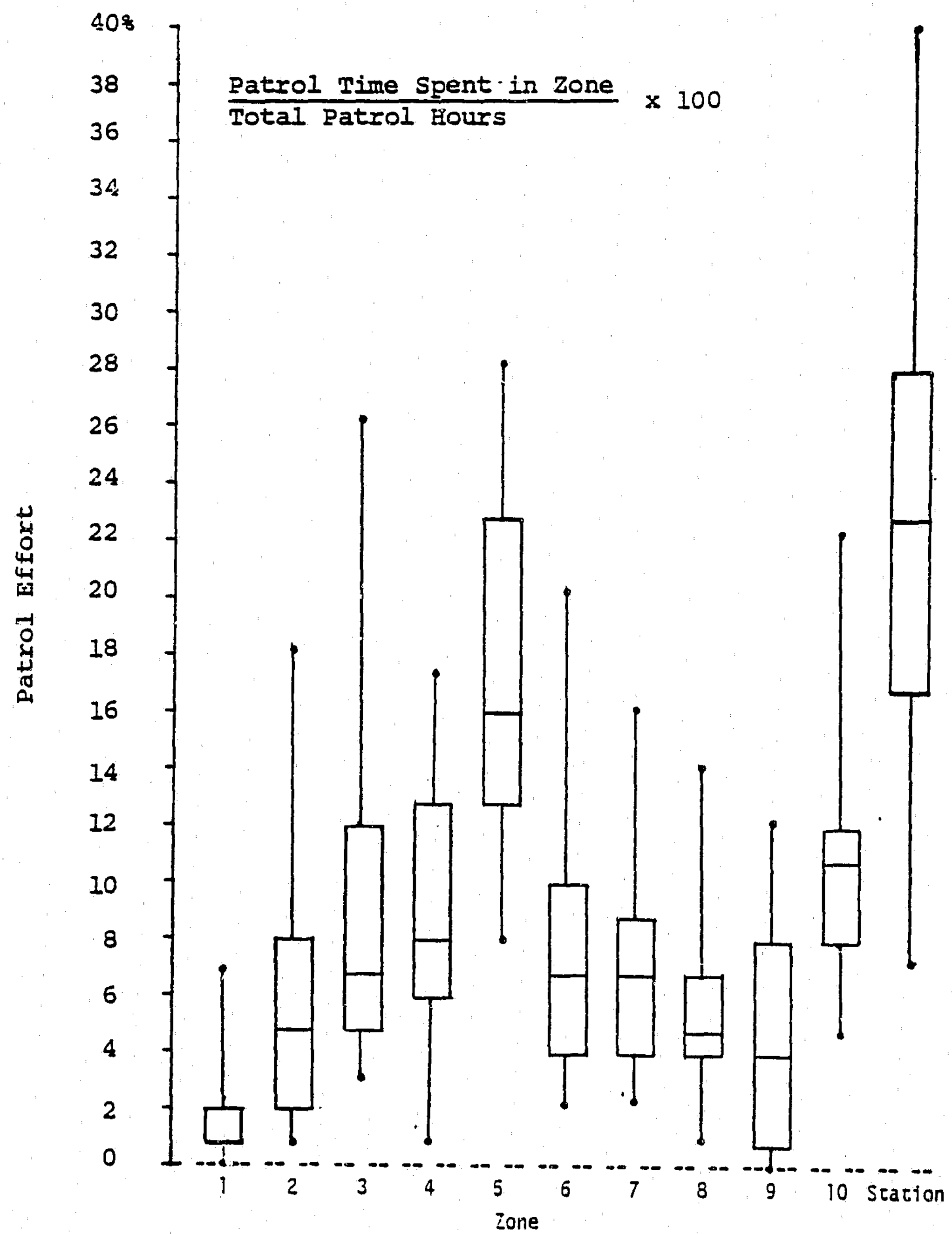


Exhibit 2.7

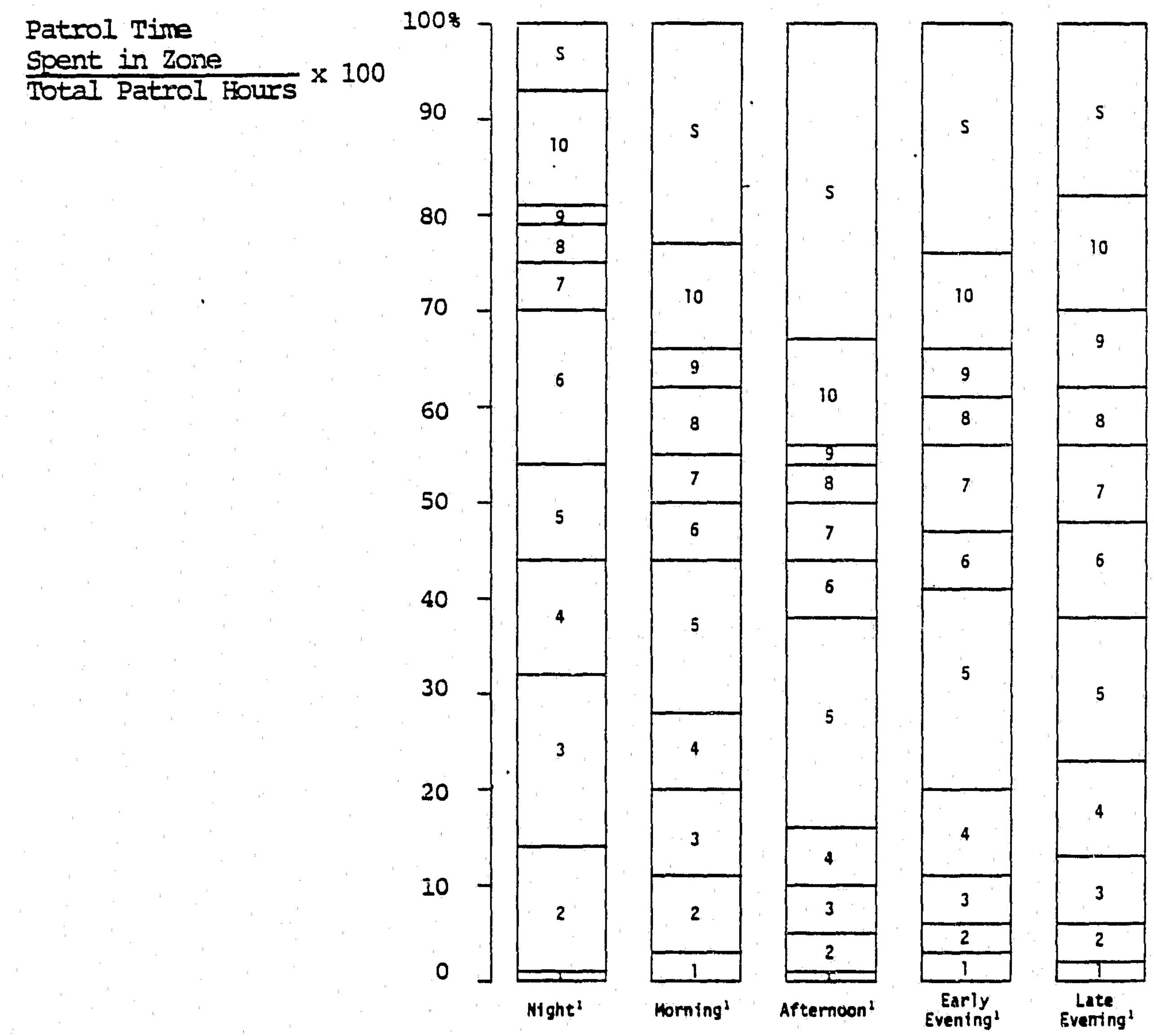
Patrol Effort of FLAIR-Observable

Cars By Zone and Time Block

(Sample = 22 4-hour timeblocks)

Zones 1-10 Shown on Map

S = Station House



[1]Times in these categories are approximate due to overlap of tapes and other monitoring problems.

The information analyzed allows two conclusions: one substantive, the other methodological. First, for this period of monitoring, patrol efforts were far from uniform throughout the district.[8] Second, the FLAIR system, while imperfect, allows for a level of detail never before available to the police patrol researcher. An AVM system such as the FLAIR system can, in other words, provide better data more accurately than any other previous research technique used in police patrol research.

2.2.2 Patrol Patterns: Turning Probabilities

In addition to providing area-averaged data regarding patrol car presence and activities, AVM allows the police researcher to examine the microscopic level, or fine structure, of police patrol. Using the tracking option on the FLAIR system, which allows the computer to "lock-in" and follow a specified patrol car, individual cars were followed for sizeable periods of time (e.g., 4 hours). Illustrative measures of patrolling behavior for both busy and overall time periods were constructed through computer-based analysis.[9] The statistics considered include the average number of blocks traveled between turns, the serial correlation of blocks traveled, overall and conditional turning probabilities, and the frequency distribution of blocks traveled between turns.

Possibly the most accurate information recorded over the period was the turning probabilities of patrol cars. As shown in Exhibit 2.8, cars were tracked on different dates and at different times. We note that the results from different days were generally consistent. The computer output for a

---

[8] This is not to suggest that patrol levels should have been uniform.

[9] By "busy" we mean the time when a patrol car was unavailable for answering calls for service (and thus, was also not available to perform preventive patrol).

Exhibit 2.8

Turning Probabilities By Car and Time

Patrol Car	Time	Number Of Turns In The Sample	Average Number Of Blocks Between Turns	Probability Of Right Turn*	Probability Of Left Turn*	Probability Of U-Turn*
1	5:37pm- 9:56pm	89	3.00	.607	.348	.045
2	3:00pm- 7:00pm	88	2.73	.455	.465	.080
3	7:00pm-11:00pm	60	4.05	.534	.333	.133
4	7:00am-11:00am	33	3.85	.484	.455	.061
5	11:00am- 3:00pm	55	3.38	.527	.400	.073
6	11:00pm- 7:00am	157	2.85	.433	.452	.115

*Given that a turn occurs.

Exhibit 2.8

Turning Probabilities By Car and Time

Patrol Car	Time	Number Of Turns In The Sample	Average Number Of Blocks Between Turns	Probability Of Right Turn*	Probability Of Left Turn*	Probability Of U-Turn*
1	5:37pm- 9:56pm	89	3.00	.607	.348	.045
2	3:00pm- 7:00pm	88	2.73	.455	.465	.080
3	7:00pm-11:00pm	60	4.05	.534	.333	.133
4	7:00am-11:00am	33	3.85	.484	.455	.061
5	11:00am- 3:00pm	55	3.38	.527	.400	.073
6	11:00pm- 7:00am	157	2.85	.433	.452	.115

*Given that a turn occurs.

single patrol car tracked over a four-hour period is represented in Exhibit 2.9.[10] Note that the average number of blocks traveled between turns is approximately three for both the busy and overall time periods. Of particular interest is that this car made twice as many right turns as left turns. This result also appears to hold when turning probabilities are conditioned by type of previous turn. Thus, the probability of a right turn following a left turn equals the probability of a right following a right turn, and both of these equal the overall probability of making a right turn. Finally, the serial correlations of numbers of blocks traveled between turns does not differ appreciably from zero. Thus, there is no tendency for long "straightaways" to be followed by short "straightaways", and vice versa.

Finally, one can conclude that the distributions of blocks traveled between turns are not geometric. The distributions are typically steeper than geometric near the origin (i.e., at distances of 1 and 2 blocks). Patrol cars are quite likely to travel very short distances between turns, supporting the notion that a rather meandering patrol pattern is in place.

2.2.3 Crime and Patrol: Patrol Effort and Crime Pattern

Returning to the five-day sample of 24-hour patrol patterns, one hypothesis was explored pertaining to the responsiveness of patrol effort to crime pattern. Since patrol effort varies so greatly over time and space, it was postulated that the patrol effort in Zone i on day j (f_{ij}) was a function of the number of crimes in Zone i on day j-1 ($C_{i,j-1}$). In other words, is today's patrol pattern based on yesterday's crime pattern? To check this hypothesis, the number of crimes occurring in each zone was correlated with the patrol effort in each zone at a one-day time lag. The resulting correlation was r=.3667. Although this correlation is positive, it is too weak to conclude

[10] Identical to the format of our patrol pattern analysis program.

Exhibit 2.9

Sample Computer Output of Turning Probabilities For A Single Patrol Car

```
enter number of data points:  178
data has been entered
summary statistics:  turning probabilities
avg. blocks between turns = 3.0000
avg. blocks between turns when busy = 2.8718
serial correlation of blocks traveled = -.0550
serial correlation of blocks traveled when busy = 0.1057
```

turning probabilities

	overall	busy
left	0.3483	0.3250
right	0.6067	0.6000
u-turn	0.0449	0.0750

conditional turning probabilities

	left	right	u-turn
left	0.3333	0.6333	0.0333
right	0.3333	0.6111	0.0556
u-turn	0.7500	0.2500	0.0000

conditional busy turning probabilities

	left	right	u-turn
left	0.1667	0.7500	0.0833
right	0.3750	0.5417	0.0833
u-turn	0.6667	0.3333	0.0000

frequency distribution of blocks traveled between turns

number of blocks	overall	busy
1	38	19
2	10	4
3	13	5
4	12	4
5	3	1
6	4	2
7	4	1
8	0	0
9	2	2
10	0	0
11	0	0
12	2	1
13	1	0

that patrol is responsive to crime patterns, especially given the limitation imposed by the small sample sizes.

2.2.4 Crime and Patrol: Distance to Patrol Cars

In preparation for more complete analyses, a test was performed to examine the spatial relationship between crimes and police patrol by measuring the distances from incidents to patrol cars. It seemed reasonable to assume that if patrol deters criminals from committing crimes, then when crimes are committed, they are not committed in the presence of patrol cars. While this assumption is plausible for any specific point in time (e.g., one would not hold up a liquor store with the knowledge that a manned patrol car is parked across the street), it is not clear that a given patrol car deters crime in areas out of view of that particular unit.

Our interest at this point was to develop a workable methodology for a more complete examination of the spatial relationships between criminals and police which was to be undertaken as part of the DPE. Our analysis of some 35 unverified incidents revealed the problems inherent in the FLAIR-based measurement and forced us to use a very labor-intensive schedule for monitoring the system. Had we later undertaken in-depth analyses without pretesting the measurements, the efforts would have been troublesome.

Essentially, the test procedure involved comparing distances from given locations to patrol cars corresponding to (1) a time when a crime had just occurred at the location; and (2) a randomly chosen point in time. If criminals consider the general pattern of patrol when committing crimes, then one would expect the distance from a location of the nearest patrol car (or second nearest, or in general the k^{th} nearest) to be larger when a crime has just occurred at the location as opposed to some other randomly chosen time. Conversely, taking a null hypothesis, one would argue that crimes occur

regardless of the locations of patrol cars. These issues are considered in detail in Chapter 5.

2.3 SUMMARY AND CONCLUSIONS

The initial analyses reported here, which represented a pretest of the methodologies for the six-month DPE, demonstrated both the advantages and disadvantages of the FLAIR system as a research tool. The pretest also demonstrated the necessity for documenting problem areas as they occur so that appropriate feedback mechanisms could be implemented.

As noted briefly above, a major problem with the use of FLAIR as a research instrument was the degree to which modifications had to be made in data gathering processes due to system limitations. The lack of a computer-supported playback capability meant that alternative instrumentation was necessary before the system could be used as a data gathering tool. Additionally, software constraints programmed into the system required PSE to modify its initial data gathering methodologies. For example, at certain magnification levels, the FLAIR screen was unable to provide a picture of car activities throughout the entire district. Thus, if one wanted to "zero in" on certain cars and locations, other cars and locations could not then be observed. It was only through the judicious switching back and forth from one area to another and by continual adjustment of the magnification level that all cars and locations could be isolated.

However, despite these constraints, it is clear that the FLAIR system provides a tool not available to earlier researchers. For example, had there been an AVM system available in Kansas City, unauthorized incursions[11] into the "depleted beats" could have been monitored, analyzed and corrected.

[11] See R.C. Larson, "What Happened to Patrol Operations in Kansas City? A Review of the Kansas City Preventive Patrol Experiment," Journal of Criminal Justice 3(1975):267-297.

3 THE DIRECTED PATROL EXPERIMENT

From January to July 1981 PSE conducted a directed patrol experiment (DPE) in District 3. Its primary purpose was to assess the use of an automatic vehicle monitoring system (the FLAIR system in St. Louis) for police patrol research in an obtrusive setting. The obtrusive aspect of this investigation was the deliberate spatial redeployment of police officers and cars in a directed patrol (DP) effort. A secondary purpose was to use the data collected to arrive at some substantive conclusions about the effects of a discretionary directed patrol program as implemented in St. Louis. The design of the DPE proceeded interatively. That is, the measurement techniques and DP strategies were based on the results of the pretest, the realities of policing, and interaction with members of a departmental task force designated by the Chief of Police. The following sections discuss characteristics of pre-DPE patrol operations in District 3, techniques used for FLAIR-based and other data collection, and results from monitoring and measuring directed patrol.

3.1 DISTRICT 3

District 3 comprises 9.8 square miles in the center of St. Louis. Its boundaries extend westward from the Mississippi River to Kingshighway Boulevard. The northeast section abuts the downtown area and includes both public housing developments and upper-middle class urban townhouses. The Anheuser-Busch corporate headquarters and numerous manufacturing plants are located in the southeast section. The western boundary of the district, Kingshighway Boulevard, is a strip of fast food outlets and new and used car lots. District 3 has the largest population of the nine police districts, approximately 93,500 residents in 1980. Over the past decade, the population fell by almost 30,000, a decrease of 24 percent from the 1970 total of 123,000.

This trend is not unusual in St. Louis—city-wide the population decreased by 28 percent from 1970 to 1980.[1]

3.1.1 Crime Patterns

District 3 also has the largest numbers of calls for service, crimes and arrests of any district. The incidence of property and personal crimes for the twelve months preceeding and the six months during the DPE is depicted by the graph in Exhibit 3.1. As would be expected, crime patterns in the district are seasonal. That is, the incidence of crime drops in early winter, reaches a high point in mid-summer, and tapers off to another low point the following winter. Thus, the DPE was conducted in an off-peak demand period in District 3. Further, although the trends are similar in 1980 and 1981, the total number of crimes was lower in the latter year. In the first eight months of 1980, 983 personal and 5,716 property crimes were committed in the district. The figures for 1981 are 917 and 5,372 respectively. This decrease is simliar to that experienced city-wide. The number of crimes reported—in both District 3 and the remainder of the city--during the first eight months of 1981 was 6.1 percent lower than the comparable period in 1980.

3.1.2 Existing Patrol Operations

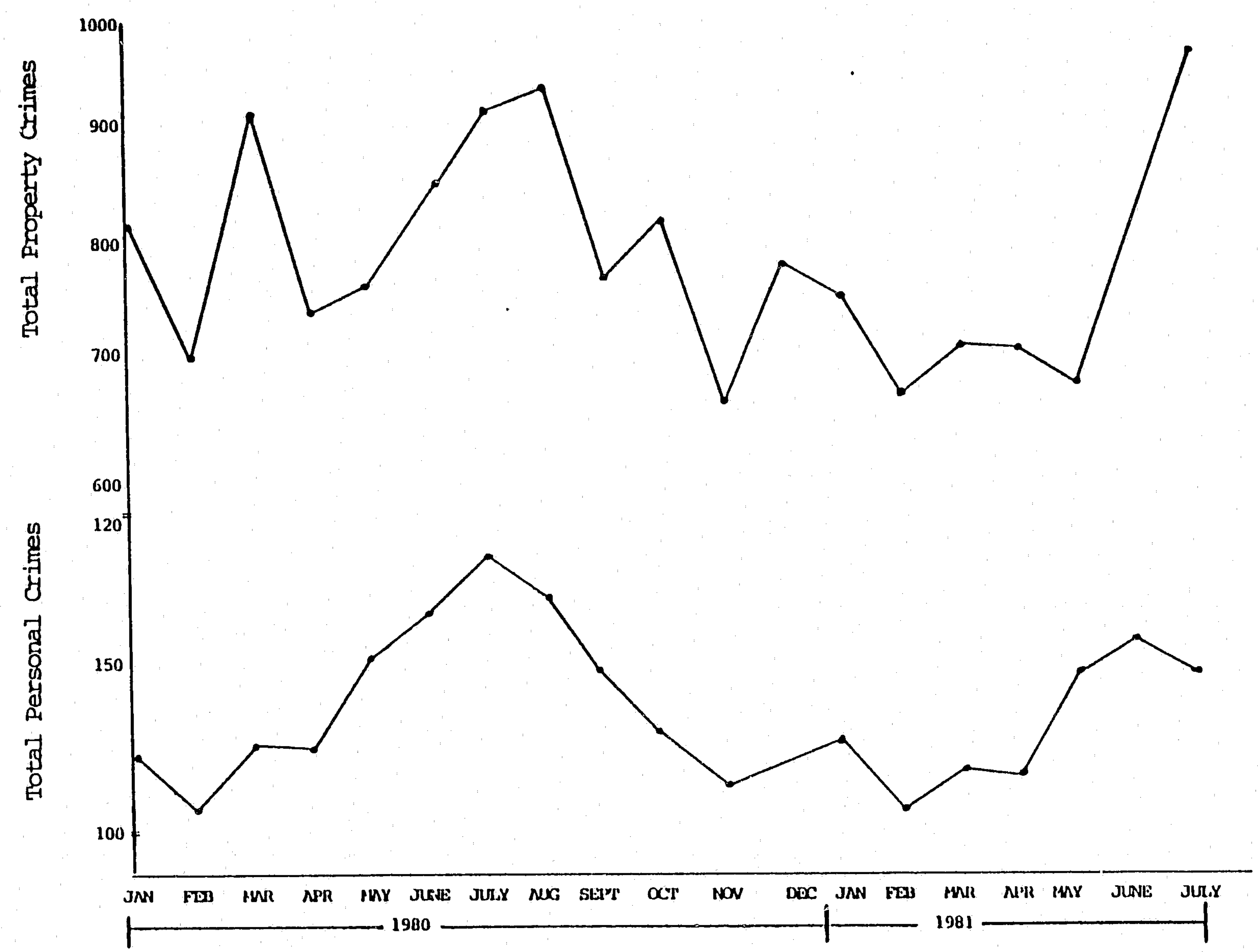
District 3 was divided into five precincts, or sergeant's areas, during the study. Each sergeant was responsible for three or four patrol beats each staffed by a one- or two-officer patrol car; some sergeants were also responsible for district-wide vehicles such as the cruiser (often known as a paddy wagon) and the stack car (a car assigned to handle only low priority

[1]Delay in the release of data from the 1980 Census of Population made it necessary to use estimates of the population rather than the final counts. In addition, as the census tract boundaries do not match the boundaries of the police districts, these estimates must be taken as very rough.

Exhibit 3.1

Personal and Property Crimes

in District 3, January 1980 to July 1981



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calls that could be stacked in a queue and be dealt with at the officer's discretion). This configuration of beats and precincts is shown in Exhibit 3.2.[2] In addition to the patrol cars, there were two walking officers assigned to the low-income housing project in beat 3327, a tri-car (three-wheeled motorcycle) which combined riding and walking assigned to the business districts, and a Patrol With a Purpose (PWP) vehicle. A watch commander was responsible for the activities of all the district cars and officers assigned to his platoon during each watch.

Established in 1974, the PWP car's assignment was to focus on crimes against businesses. It was assigned to a fixed route with a designated number of inspections to make each watch but was under radio control in high priority situations. The assigned duties were outlined in a letter to the Board of Police Commissioners in November 1974 as follows: "Front and rear inspections of doors and windows will be made, as well as looking into premises for evidence of holes chopped through walls and ceilings. Vacant premises adjoining business places must be checked as possible points of entry for burglars. The inspection of construction site tool sheds and storage buildings will be assured."[3]

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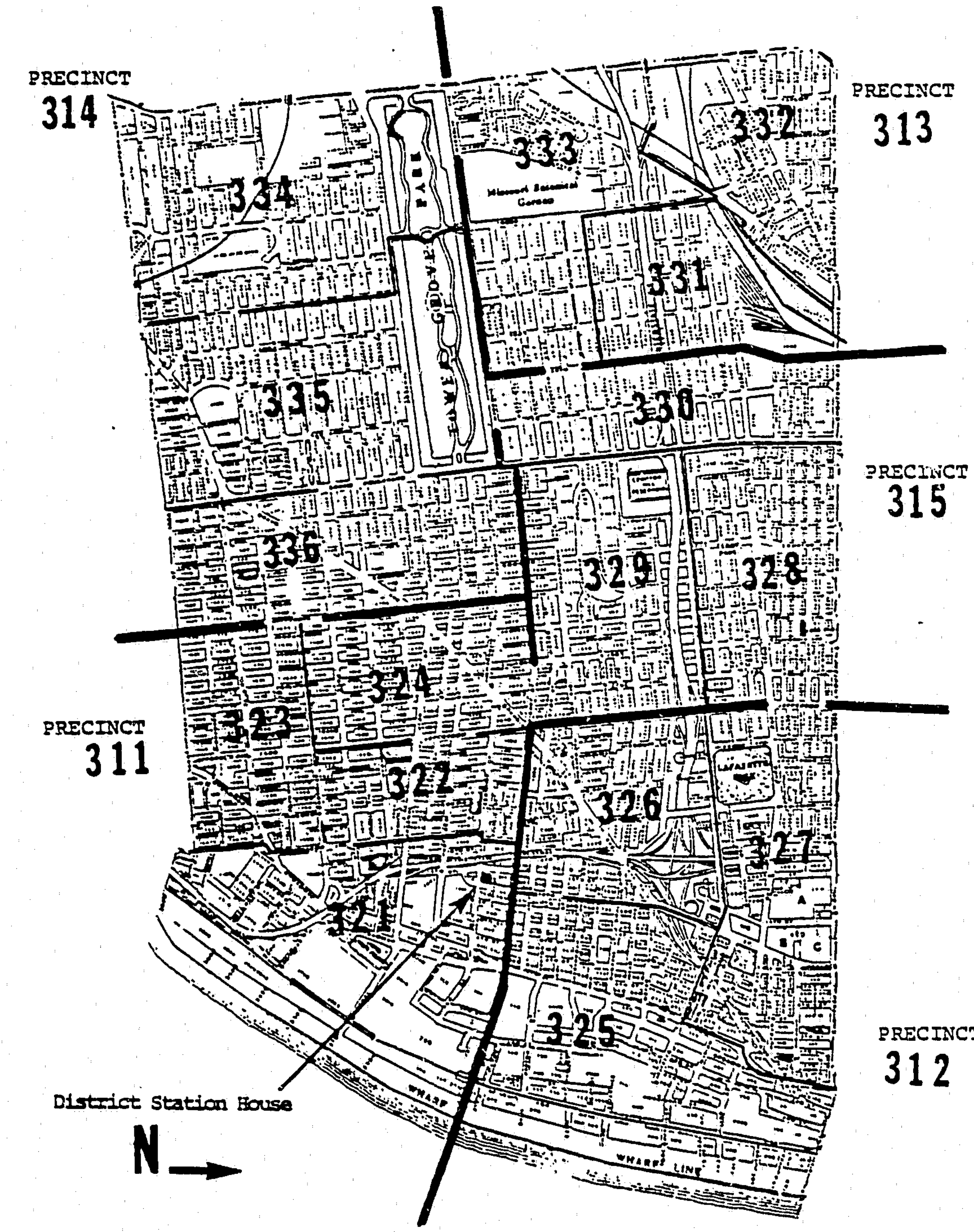
[2]During the study there were three equally-manned watches in District 3 (and the SLMPD): first watch 0700-1500 hours; second watch 1500-2300 hours; and third watch 2300-0700 hours. In January 1982, the district (and department) changed to uneven manning to accomodate differences in demand for police services by time-of-day.

[3]Directed patrol was added to the district's responsibilities over and above the ones required by PWP. In Section 3.2 it will be seen that in contrast to PWP, directed patrol was much larger and broader: it involved more officers, gave officers and watch commanders discretion over strategies, and was aimed at a wider range of incidents. Many police officers initially questioned the utility of a directed patrol, which they perceived as an elaboration of the PWP program, until they understood these differences.

Exhibit 3.2

Beat and Precinct Boundaries in District 3



3.2 DIRECTED PATROL PROCEDURES

To help explain the DPE to SLMPD personnel in District 3 and department headquarters, a statement of expected roles was circulated. The responsibilities of the program participants were outlined as follows:

> Crime Analysis to provide timely and accurate crime data to the district headquarters, and to make recommendations for target crime and target areas;
>
> Communications Division to support patrol through adherence to the deployment plan and assist through additional telephone report taking;
>
> Patrol Officers to follow the deployment plans and to accurately report all activities, particularly locational information;
>
> Police Department Project Manager (PDPM) to make certain the project ran smoothly, to work with all commands, to represent the Office of the Chief in all decision making and to be responsible for interfacing with Public Systems Evaluation; and
>
> Public Systems Evaluation to work as mediator in project-related discussions within the department, and to be evaluator of project results.

The responsibilities of other commands (e.g., traffic, canine, evidence) operating in District 3 were also outlined. The pretest revealed that these cars were not FLAIR-observable, but were in fact frequently operating in District 9. Thus, to monitor their presence in District 3 during the DPE, all local activities of these commands were logged and chronological records by week were forwarded to the PDPM.

3.2.1 Directed Patrol Concept

As implemented in District 3, directed patrol removed regular patrol cars from call-for-service responsibilities and reassigned them to patrol specified areas with the intention of deterring or detecting identified crimes or activities. The basic assumption underlying our obtrusive experimentation was that the number of cars assigned to directed patrol could be varied according to the needs of the district. Thus, from zero to three cars were assigned to

directed patrol depending on the time of day and day of the week. For example, on a Tuesday afternoon with a light call-for-service workload, it might be possible to assign three cars to directed patrol. On a Friday night at ten o'clock in the summertime, all cars might be needed to answer calls for service. Given the fixed number (16) of patrol cars in District 3, the effective number of cars available for regular patrol was reduced by the number of DP cars. Decisions about directed patrol were made by each watch commander based on the overall workload in the district and the assumed need for directed patrol.

A second assumption was that the directed patrol conducted in District 3 was to be highly discretionary. Thus, the choice of assigned officers,[4] target crimes (i.e., the crimes or activities officers were to focus on during directed patrol on a given watch), and target areas (i.e., the specific beats, sub-areas chosen for directed patrol on a given watch), was made by each commander based on information from the Crime Analysis section about the previous day's crimes and his intuitive judgments. These decisions were made on a watch-by-watch or hour-by-hour basis. Thus, a particular beat car might be assigned to conduct directed patrol from 11 a.m. to 3 p.m. in an area where a number of purse snatches or residential burglaries had recently occurred. Similarly, the choice of DP tactics was made by the officers assigned to directed patrol. For example, when purse snatches were the target crime, a DP officer might choose to walk the assigned beats or to survey a vulnerable street or intersection from his patrol car.

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[4]While the ideal may have been to assign all officers to directed patrol on a rotating basis, some were more motivated and effective in conducting directed patrol. Most officers, however, eventually participated in the project.

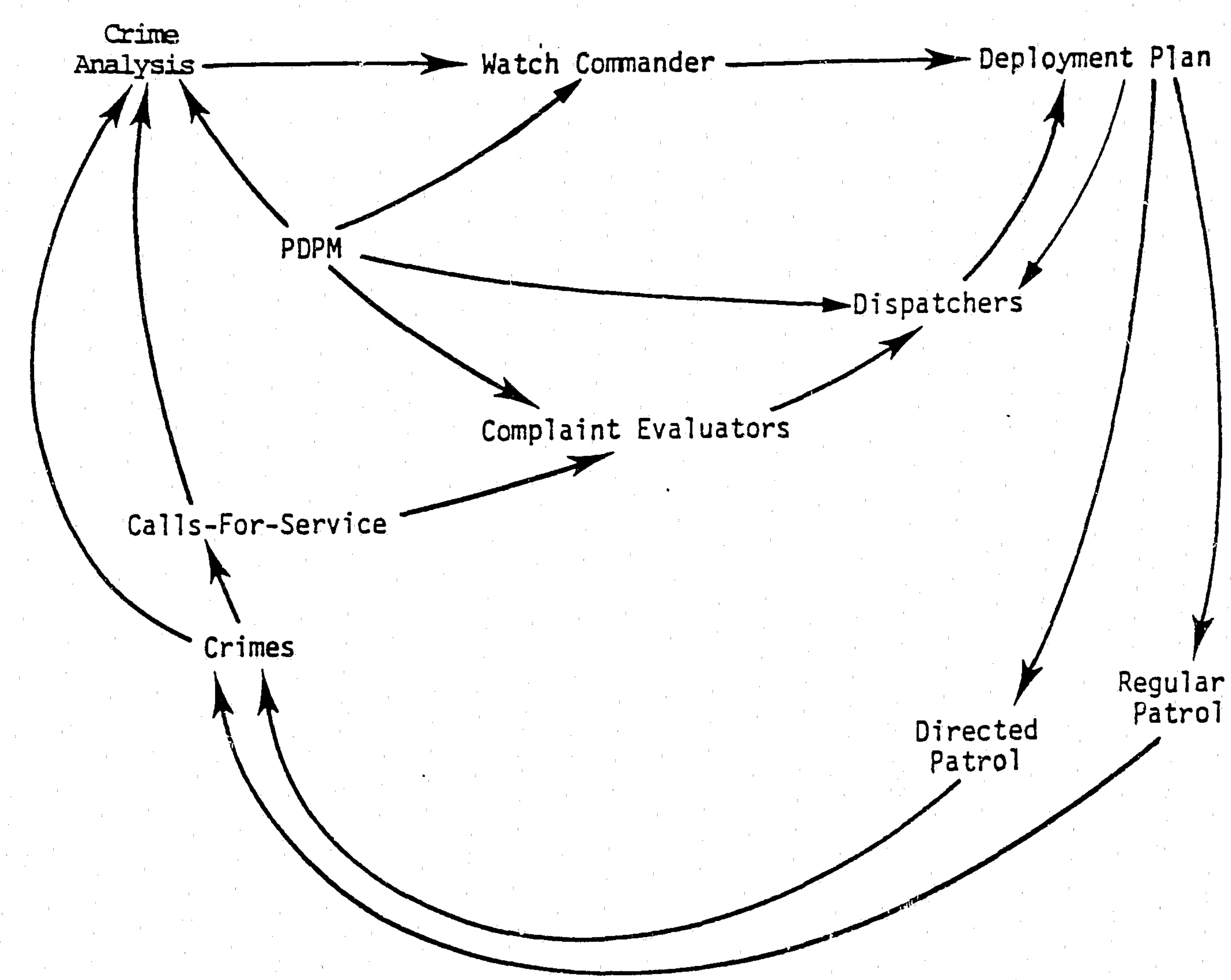
The flow of information and responsibility for implementing the DPE is shown in Exhibit 3.3. Data on calls for service and reported crimes were sent to the Crime Analysis section, which then made recommendations for patrol activities in subsequent watches. Based on these recommendations, the watch commander prepared a deployment plan describing how patrol is to be conducted in each watch (e.g., number of DP cars, assigned officers, target crimes, and target areas). Patrol officers were informed of the deployment plans in briefings at the start of each watch. The deployment plan was also forwarded to the dispatchers as a guide for sending cars in response to the calls for service screened by the call takers. Given this design, communication between the various players was essential to the experiment's success or failure.

Dispatching procedures were an important link in the communications process. Designating a variable number of cars for directed patrol required changes in these procedures. DP cars were not to answer calls for service unless an officer was in need of assistance or a felony was in progress in the immediate vicinity of the car. Under all other circumstances the cars were restricted to conducting directed patrol. Both dispatchers and patrol officers were informed that officers in DP cars were not to answer calls for service.

To accommodate the variable reduction in the number of cars available to answer calls for service, two revisions in call stacking procedures were implemented. First, the number and kinds of reports taken over the phone were increased. In addition to incidents that had traditionally been resolved by complaint evaluators and sworn personnel without dispatching a patrol car, the SLMPD added larceny (up to $1,000) and stolen car reports. Increasing the number of phone reports decreased the call-for-service workload and facilitated

Exhibit 3.3

Communications Channels for the DPE



the transition to fewer cars available for regular patrol. Second, the number of stack cars was increased from one to two. Stack cars answered only those calls for service which could be put in a queue (e.g., after-the-fact burglary or stolen car reports), leaving other cars free to respond to high priority calls. By managing demand in this way District 3 could undertake the DPE with minimum disruption.

3.2.2 Using Operational Models in an Experimental Setting

When resources are reallocated in an existing system, it is useful to know the operational consequences of such an action. Most police patrol experiments involve a reallocation in space (and perhaps in time) of existing police patrol units. Predicting a priori the operational consequences of any anticipated reallocation of police patrol resources can be a very complicated task. A police patrol force constitutes a spatially-distributed set of "servers" in a spatially-distributed "queueing" system. Even without a spatial component, stochastic queueing systems are highly non-linear and often quite counter-intuitive in their behavior. When the spatial nature of an urban police patrol force is added, the complexities become even greater. Thus, one is directed to some means of analytical assistance in order to obtain valid estimates of system behavior under alternative allocations of resources.

The tool used by PSE in its pre-analysis of District 3 operations was the Hypercube Queueing Model.[5] The Hypercube Model requires as input to the

[5] R.C. Larson, "A Hypercube Queueing Model for Facility Location and Redistricting in Urban Emergency Services," Computers and Operations Research, 1(1974):67-95; also see R.C. Larson, "Computer Program for Calculating the Performance of Urban Emergency Service Systems: User's Manual (Batch Processing)" Innovative Resource Planning in Urban Public Safety Systems, Report TR-14-75, Massachusetts Institute of Technology, Cambridge, MA, 1975; and R.C. Larson and A.R. Odoni, Urban Operations Research, (Englewood Cliffs, NJ: Prentice Hall, 1981).

computer a depiction of the map of the region being studied and the deployment of patrol resources on that map. The model produces as output a range of performance measures, including workloads of the various units, system-wide and area-averaged travel times, and numbers of cross-beat dispatches. We thus have a model-based means for predicting the operational consequences of alternative deployments before they are implemented in the field. We believe virtually any experiment in police patrol could be informed and probably improved by the use of such analytical models in the experimental design process. Such models contribute to what could be called model-based evaluations.

In our particular application in District 3 we were concerned with the effect on travel times, patrol car workloads, and other measures, attributable to the reassignment of up to three regular call-answering patrol cars to directed patrol. The watch commanders were encouraged to select, on a day-to-day and a tour-by-tour basis, the individual areas to receive the directed patrol. Thus, the design was to be flexible on a day-to-day basis. To reflect that fact, PSE carried out a number of different Hypercube runs, each corresponding to a different patrol configuration. Thus, we were interested in determining the approximate effects of alternative DP assignments. The model was used with recent call-for-service and crime data in order to provide the realistic assessments required. In addition to studying alternative DP assignments, PSE also used the model to determine the degree to which existing patrol car beat assignments could (or should) be altered in order to prevent unacceptable degradations of service under DPE conditions.

The SLMPD supplied data on the characteristics of dispatched incidents that occurred between January and December 1980; these data were scaled to fit 1981 call-for-service totals. Also supplied were data on multiple car dispatches and time spent out of service on nondirected incidents (such as meals, self-initiated calls, administrative work, etc.) For each configuration considered, PSE conducted a Hybercube analysis for both average call-for-service rates and increased call-for-service rates as would be experienced in District 3 on Friday evenings. To illustrate the usefulness of this type of analysis, we report here the results of Hypercube runs using average call-for-service rates.

The Hybercube methodology will be illustrated here by considering in some detail five of the numerous runs that we conducted:

Run No. 1: Status Quo

The status quo is the spatial allocation of patrol forces in District 3 as of January 1981, just prior to the start of the DPE. In this configuration, District 3 contained 16 regular beat patrol cars, numbered from 3321 through 3336; five area sergeant's cars, numbered 3311 through 3315; two stack cars, numbered 3337 and 3338; and one district-wide cruiser (i.e., paddy wagon), numbered 3306. A summary of this numbering scheme is shown in Exhibit 3.4, and a map of the deployments is shown in Exhibit 3.5. Each sergeant's car patrols an area covering three or four regular patrol car beats, and has administrative responsibility for these beats; each of the two stack cars is assigned to one half of District 3, and has responsibility for low priority calls generated from its area. The average district-wide workload is 18.69 calls for service per hour. Each call requires an average of 35 minutes of total service time. The "dispatch policy" for Run No. 1 is as follows: given a call for service from a particular Pauly Block[6] in District 3,

1. First attempt to dispatch the beat car assigned to the Pauly Block;

2. If the above is busy, dispatch the closest available beat car (with the estimation based on statistically averaged positions of cars and incidents)[7];

3. If all cars are busy, dispatch the area stack car;

4. If all of the above are busy, dispatch the area sergeant's car;

[6]Pauly Blocks are used by the SLMPD to record and analyze crime data. One Pauly Block generally consists of 8 to 10 city blocks.

[7]Technically, this is called "expected strict center of mass" dispatching. See R.C. Larson, Urban Police Patrol Analyusis (Cambridge, MA: MIT Press, 1972), pp. 93-95.

Exhibit 3.4

Standard Car Assignments for District 3

Beat Patrol Cars		Sergeant's Cars	Stack Cars
3321	3329	3311	3337
3322	3330	3312	3338
3323	3331	3313	
3324	3332	3314	
3325	3333	3315	Cruiser
3326	3334		
3327	3335		3306
3328	3336		

Total = 16 Beat Patrol Cars

Total Number of Cars = 24

5. If all of the above are busy, dispatch the district cruiser;

6. If all of the above are busy, dispatch the other stack car;

7. If all of the above are busy, dispatch the available sergeant's car estimated to be closest;

8. If all the above are busy, enter the call in a queue which is depleted in a first come, first serve manner.[8]

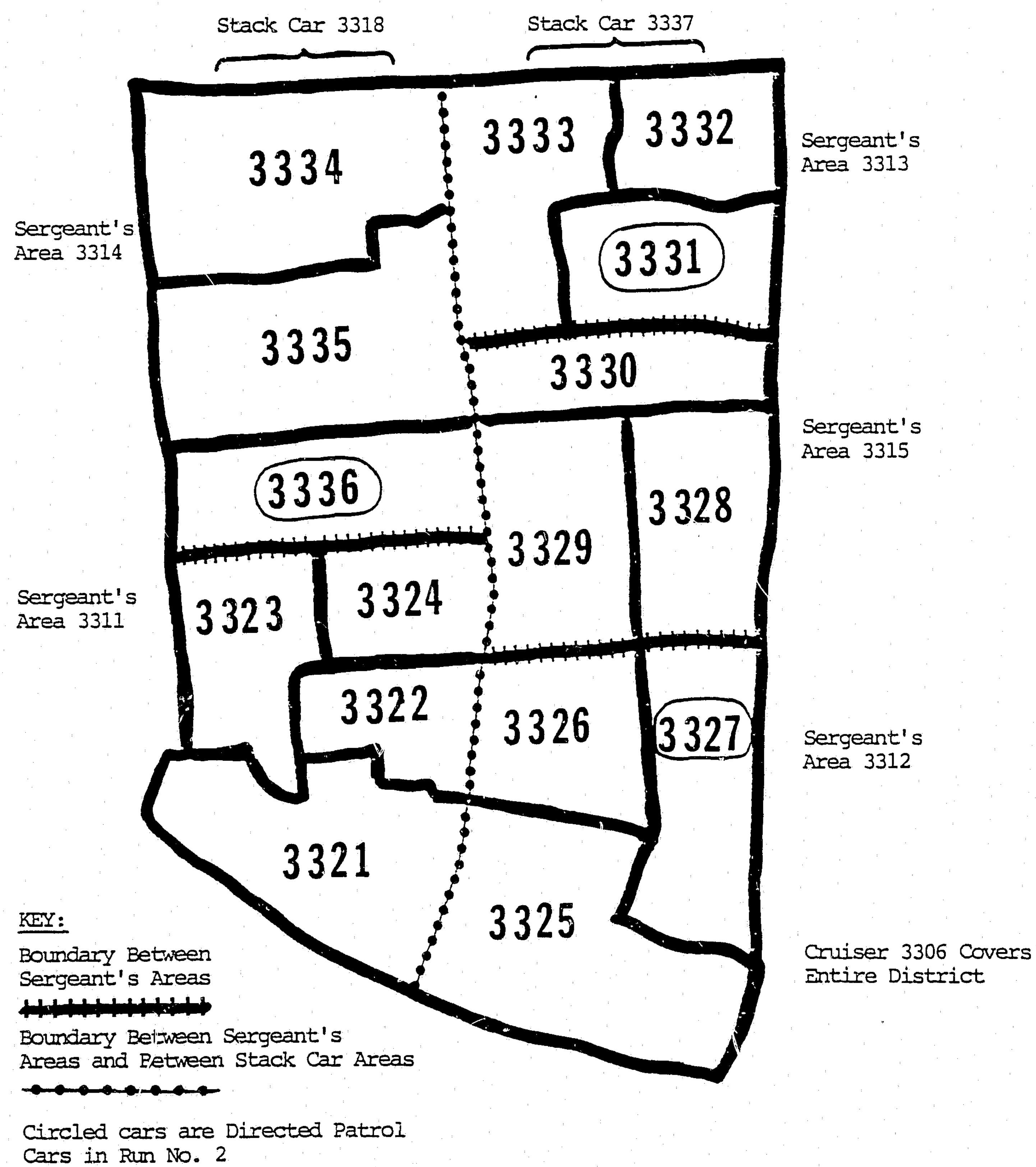
Run No. 2: Directed Patrol Plan No. 1 (Hypothetical)

This configuration is similar to Run No. 1 except that cars 3337, 3331 and 3336 are assigned to directed patrol in their own beats. DP cars are the last cars ever to be assigned to calls for service. Thus, beats 3327, 3331 and 3336 are not covered by regular call-for-service units. The beat map depicting this run is shown in Exhibit 3.5.

[8]While the model requires a mathematically formal dispatch policy as reflected by these steps, the idiosyncrasies of dispatchers in St. Louis yield a rather inexact dispatch policy, particularly when seeking back-up cars which are not regular beat cars. The outlined policy represents PSE's best estimate of what should happen if dispatching were rigourously formalized in District 3 and should yield a good approximation to actual performance.

Exhibit 3.5

District 3 Patrol Beat Map, Run Nos. 1, 2



Run No. 3: Directed Patrol Plan No. 2 (Hypothetical)

This configuration is also similar to Run No. 1 except that: (a) cars 3327 and 3324 are assigned to directed patrol in their own beats, and (b) car 3321 is assigned to directed patrol in beat 3336. Again, DP cars are the last cars to be assigned to calls for service. The beat map depicting this run is shown in Exhibit 3.6.

Run No. 4: Beat Design Modification

The purpose of this configuration was to investigate, independent of the directed patrol experiment, whether the beat design in District 3 could be changed in order to reduce travel times or otherwise improve performance. Run No. 4 is illustrative of a number of runs attempted by PSE analysts to try to discover status quo (i.e., pre-directed patrol) designs which improved performance. In this illustrative run, beats 3324 and 3330, heavy workload beats, are made smaller in size. Adjacent beats are also modified in their designs so that all areas are covered. Otherwise, this run is similar to Run No. 1. The beat map depicting Run No. 4 is shown in Exhibit 3.7.

Run No. 5: Open Beat Concept

This configuration models the effects of an open beat concept in District 3, a procedure that had been utilized in District 9 for over a year (see Chapter 2). With the open beat concept each police car patrols the entire sergeant's area containing the car's usual beat. One of the underlying philosophies of this concept is that patrolmen become bored patrolling a small area and like to follow their hunches regarding where crimes are likely to occur and where patrol is likely to be needed. Except for the spatial reallocation of patrol cars to sergeant's areas, Run No. 5 is similar to Run No. 1.

Several summary statistics of the five runs are shown in Exhibit 3.8. The following performance measures are shown for each run:

- District-wide average travel time (in minutes)
- Maximum beat-averaged travel time (in minutes)
- Maximum workload imbalance, as reflected by the maximum difference in workload (measured in fraction of time busy) between the busiest unit and the least busy unit
- Fraction of dispatches that are cross-beat dispatches.

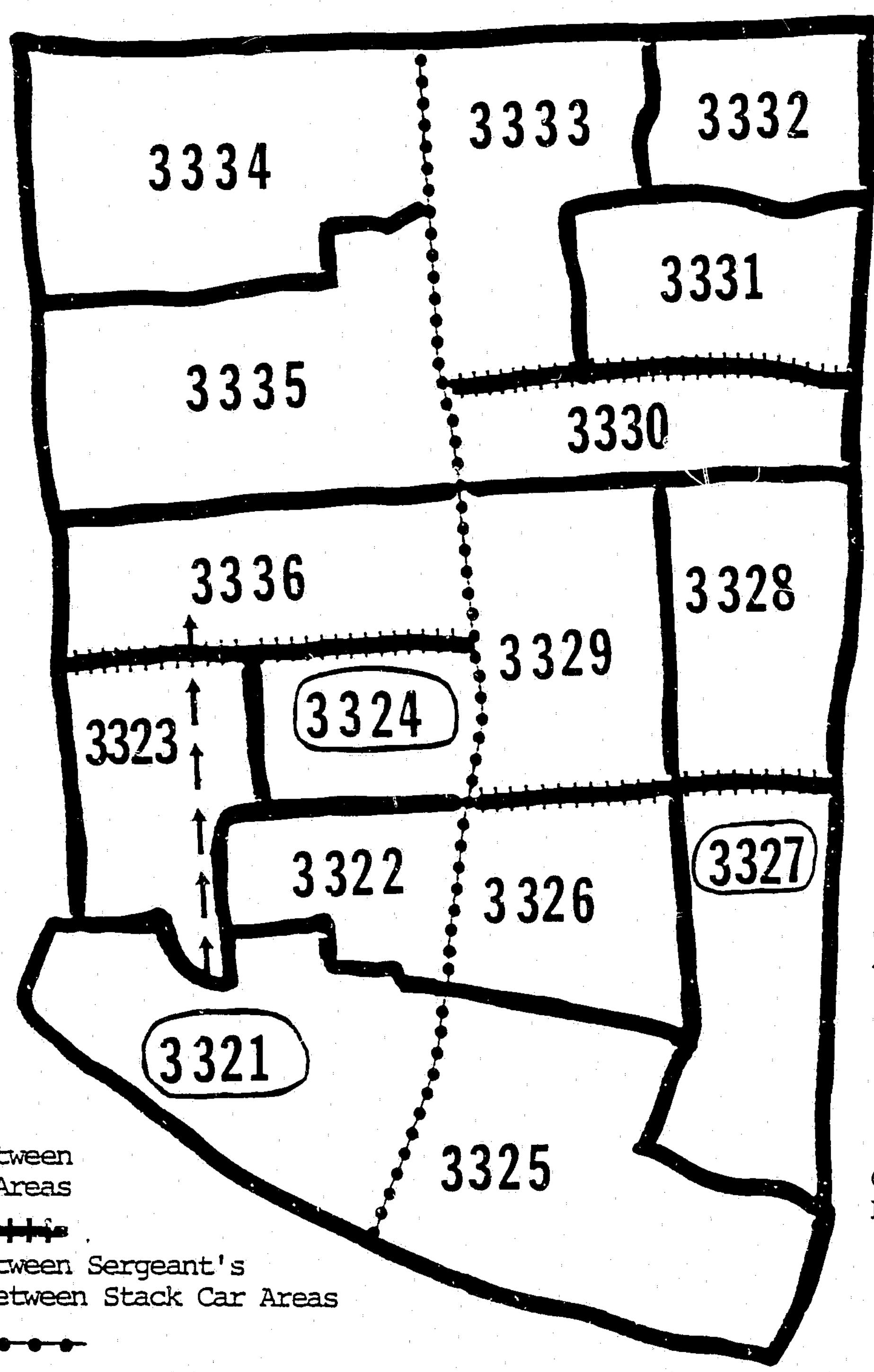
The Hypercube runs revealed the effect of directed patrol on travel times. For example, switching from the Status Quo (Run No. 1) to Directed Patrol Plan No. 1 (Run No. 2), changes the average travel time from 4.62 to 5.57 minutes.

Exhibit 3.6

District 3 Patrol Beat Map, Run No. 3

Sergeant's Area 3314

Sergeant's Area 3313



Sergeant's Area 3315

Sergeant's Area 3311

Sergeant's Area 3312

Cruiser 3306 Covers Entire District

KEY:

Boundary Between Sergeant's Areas

Boundary Between Sergeant's Areas and Between Stack Car Areas

Circles Cars are Directed Patrol Cars in Run No. 3

Exhibit 3.7

District 3 Patrol Sector Map, Run No. 4

Sergeant's cars, Stack Cars, and the Cruisers are assigned as in Run No. 1.

Exhibit 3.8

Summary Statistics for the Five Hypercube Runs

	Run No. 1	Run No. 2	Run No. 3	Run No. 4	Run No. 5
District-wide Average Travel Time (Minutes)	4.62	5.57	5.58	4.90	5.31
Maximum Beat-averaged Travel Time (Minutes)	5.76	6.81	7.21	5.62	5.92
Maximum Workload Imbalance	0.691	0.739	0.742	0.730	0.689
Fraction of Dispatches that are Cross-Beat Dispatches	0.632	0.719	0.698	0.707	0.278*

*Reflects redefinition of beats to sergeant's zones.

The 4.62 minutes was calibrated to travel times experienced in District 3, where the parameter of calibration was the mean response speed (which was set equal to 12.5 miles per hour). The increase to 5.57 minutes represents a 20.6 percent increase in district-wide travel time. Directed Patrol Plan No. 2 (Run No. 3), showed a similar increase in district-wide average travel time. The increase of 20 to 21 percent in district-wide travel time is typical of what we found in several different Hypercube runs in which three of the 16 beat patrol cars were assigned to directed patrol. While we place no value judgments on the increase in district-wide travel time, we do emphasize that it is important for district commanders and experimental designers to know the consequences (both positive and negative) of such proposed operational changes. Based on such analyses, an experimental designer or a patrol administrator can select a patrol configuration that best achieves the desired new performance

characteristics with minimum degradations in regular service. Many previous patrol experiments have been somewhat limited in their experimental design phase by the lack of such use of operational models.

The detailed computer printouts of the Hypercube model for Run Nos. 1, 2, 3, and 4 are shown in Exhibits 3.9 through 3.12.[9] We encourage the reader to examine some of the detailed entries in these exhibits in conjunction with the beat maps and the dispatching strategies, to develop a fuller intuition for status quo operations and the proposed revised operations. As an example of the detailed study of Run No. 1, for instance, we note that units 3321, 3325, 3328 and 3334 all have average travel times exceeding five minutes. All of these units are assigned to beats on the boundary of District 3, and three of them are in relatively large beats. The heaviest workload beats, as read off from Exhibit 3.9, are beats 3323, 3327, 3329, 3331 and 3336. Three of these beats, 3327, 3331 and 3336, are the beats selected for directed patrol in Run No. 2. In Run No. 2 those three beats will have no usual call-for-service car, but virtually all of the calls for service will be handled by other beat cars and by other back-up cars; the three DP cars are cars of last resort, as can be seen by examining the workloads of those cars in Exhibit 3.10. Thus, the experimental designer must be concerned with untoward increases in beat-averaged travel times for the three uncovered beats. Close examination of Exhibit 3.10 in comparison to Exhibit 3.9 illustrates, for instance, that the travel time of beat no. 3327 is increased to 6.826 minutes, up from 5.002 minutes, an increase of 36.5 percent. The other two directed patrol beats experienced increases of 32.2 percent and 18.8 percent, respectively,

[9]We have not reported the detailed computer printout for Run No. 5, because it does not pertain directly to the DPE.

Exhibit 3.9

Run No. 1

```
EXPECTED SCM DISPATCHING
PROBLEM TITLE: St. Louis Jan. 80 Status Quo

    * ITERATIVE APPROXIMATION METHOD USED *
    NUMBER OF ITERATIONS REQUIRED:          12
UNLIMITED CAPACITY QUEUE WITH 1_ST-COME 1_ST-SERVED QUEUE DISCIPLINE
RUN NUMBER:  1
RESPONSE_UNIT          ...TOTAL NUMBER OF = 24
pauly_bk   ...TOTAL NUMBER OF =  85
AVERAGE SERVICE TIME=  35.00 MINUTES
AVERAGE NUMBER PER HOUR OF CALLS FOR SERVICE  =  18.690
AVERAGE NUMBER PER  35.00 MINUTES OF CALLS FOR SERVICE  =  10.902
AVERAGE UTILIZATION FACTOR
   (IN THE CASE OF UNLIMITED LINE CAPACITY)=  0.454

REGION-WIDE AVERAGE TRAVEL TIME=   4.624 MINUTES

AVERAGE TRAVEL TIME FOR QUEUED CALLS=    9.192 MINUTES
PROBABILITY OF SATURATION= 0.00043
REGION-WIDE AVERAGE WORKLOAD (% TIME BUSY)= 0.45427
STANDARD DEVIATION OF WORKLOAD=   0.281
MAXIMUM WORKLOAD IMBALANCE= 0.69115

FRACTION OF DISPATCHES THAT ARE INTER-beat      = 0.63245
```

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH RESPONSE_UNIT

Group	ID OF RESPONSE_UNIT NAME	NO	WORKLOAD OF UNIT	% OF MEAN	FRACTION OF DISPATCHES OUT OF beat	% OF MEAN	AVERAGE TRAVEL TIME
Patrol Cars	UNIT	3321	0.598	131.6	.6722	106.3	5.084
	UNIT	3322	0.680	149.7	.7404	117.1	4.225
	UNIT	3323	0.642	141.3	.5117	80.9	4.345
	UNIT	3324	0.702	154.4	.7419	117.3	4.145
	UNIT	3325	0.602	132.5	.6923	109.5	5.168
	UNIT	3326	0.674	148.4	.7439	117.6	4.248
	UNIT	3327	0.600	132.1	.5036	79.6	4.703
	UNIT	3328	0.626	137.9	.6666	105.4	5.071
	UNIT	3329	0.702	154.4	.6454	102.0	4.334
	UNIT	3330	0.676	148.8	.7783	123.1	4.934
Sergeant's Cars	UNIT	3331	0.680	149.8	.5966	94.3	3.939
	UNIT	3332	0.592	130.2	.4657	73.6	4.186
	UNIT	3333	0.626	137.7	.6930	109.6	4.891
	UNIT	3334	0.580	127.7	.5728	90.6	5.615
	UNIT	3335	0.669	147.2	.5904	93.4	4.467
	UNIT	3336	0.679	149.4	.5945	94.0	4.644
	UNIT	3311	0.025	5.5	.0163	2.6	3.757
	UNIT	3312	0.029	6.4	.0146	2.3	3.860
	UNIT	3313	0.033	7.3	.0123	1.9	3.468
	UNIT	3314	0.025	5.5	.0162	2.6	4.514
Stack Cars	UNIT	3315	0.087	19.2	.8306	131.3	5.128
	UNIT	3337	0.208	45.9	.0011	0.2	7.739
Cruiser	UNIT	3338	0.158	34.8	.0023	0.4	6.104
	UNIT	3306	0.010	2.3	.0000	0.0	8.363

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH beat

ID OF beat NAME	NO	WORKLOAD OF beat	% OF MEAN	FRACTION OF DISPATCHES INTER-beat	% OF MEAN	AVERAGE TRAVEL TIME
beat	3321	0.523	115.1	.4989	78.7	4.340
beat	3322	0.628	138.3	.5612	88.7	3.616
beat	3323	0.891	196.2	.6220	98.3	4.672
beat	3324	0.668	147.1	.6903	109.1	3.645
beat	3325	0.459	101.0	.5826	92.1	5.208
beat	3326	0.571	125.6	.6532	103.3	4.038
beat	3327	0.898	197.6	.6653	105.2	5.002
beat	3328	0.553	121.7	.6065	95.9	4.648
beat	3329	0.921	202.6	.6810	107.7	4.224
beat	3330	0.490	107.9	.6555	103.6	4.497
beat	3331	0.942	207.4	.6590	104.2	4.425
beat	3332	0.738	162.4	.5713	90.3	4.932
beat	3333	0.513	112.8	.6052	95.7	4.746
beat	3334	0.553	121.8	.5612	88.7	5.757
beat	3335	0.888	195.5	.6487	102.6	5.010
beat	3336	0.919	202.2	[illegible]	104.8	4.817

Exhibit 3.10

Run No. 2

```
EXPECTED SCM DISPATCHING
PROBLEM TITLE: St.lou. Jan 80. status quo + dp 327,331,336 own

    * ITERATIVE APPROXIMATION METHOD USED *
    NUMBER OF ITERATIONS REQUIRED:          18
UNLIMITED CAPACITY QUEUE WITH 1_ST-COME 1_ST-SERVED QUEUE DISCIPLINE
RUN NUMBER:  1
RESPONSE_UNIT          ...TOTAL NUMBER OF = 24
ATOM       ...TOTAL NUMBER OF =  85
AVERAGE SERVICE TIME=  35.00 MINUTES
AVERAGE NUMBER PER HOUR OF CALLS FOR SERVICE  =  18.690
AVERAGE NUMBER PER  35.00 MINUTES OF CALLS FOR SERVICE  =  10.902
AVERAGE UTILIZATION FACTOR
   (IN THE CASE OF UNLIMITED LINE CAPACITY)=  0.454

REGION-WIDE AVERAGE TRAVEL TIME=    5.575 MINUTES

AVERAGE TRAVEL TIME FOR QUEUED CALLS=    9.192 MINUTES
PROBABILITY OF SATURATION= 0.00043
REGION-WIDE AVERAGE WORKLOAD (% TIME BUSY)= 0.45427
STANDARD DEVIATION OF WORKLOAD=   0.292
MAXIMUM WORKLOAD IMBALANCE= 0.73884

FRACTION OF DISPATCHES THAT ARE INTER-beat_no  = 0.71938
```

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH RESPONSE_UNIT

Group	ID OF RESPONSE_UNIT NAME	NO	WORKLOAD OF UNIT	% OF MEAN	FRACTION OF DISPATCHES OUT OF beat_no	% OF MEAN	AVERAGE TRAVEL TIME
Patrol Cars	UNIT	3321	0.678	149.2	.7742	107.6	6.072
	UNIT	3322	0.717	157.9	.7969	110.8	5.149
	UNIT	3323	0.704	154.9	.6575	91.4	5.401
	UNIT	3324	0.739	162.7	.8077	112.3	4.795
	UNIT	3325	0.676	148.7	.7835	108.9	6.241
	UNIT	3326	0.723	159.2	.8144	113.2	5.041
	UNIT	3327	0.000	0.1	.9064	126.0	8.939
	UNIT	3328	0.698	153.5	.7781	108.2	5.892
	UNIT	3329	0.734	161.6	.7232	100.5	5.057
	UNIT	3330	0.726	159.7	.8434	117.2	5.557
Sergeant's Cars	UNIT	3331	0.026	5.6	.9991	138.9	7.668
	UNIT	3332	0.687	151.2	.6761	94.0	5.679
	UNIT	3333	0.700	154.1	.7991	111.1	5.607
	UNIT	3334	0.670	147.4	.7210	100.2	6.886
	UNIT	3335	0.714	157.1	.6894	95.8	5.321
	UNIT	3336	0.000	0.1	.9061	126.0	8.738
	UNIT	3311	0.138	30.4	.0580	8.1	3.888
	UNIT	3312	0.140	30.9	.0449	6.2	3.950
	UNIT	3313	0.153	33.6	.0224	3.1	3.476
	UNIT	3314	0.128	28.2	.0467	6.5	4.694
Stack Cars	UNIT	3315	0.220	48.3	.6265	87.1	4.876
	UNIT	3337	0.419	92.2	.0188	2.6	7.805
Cruiser	UNIT	3338	0.350	77.1	.0512	7.1	6.332
	UNIT	3306	0.163	36.0	.0000	0.0	9.111

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH beat_no

ID OF beat_no NAME	NO	WORKLOAD OF beat_no	% OF MEAN	FRACTION OF DISPATCHES INTER-beat_no	% OF MEAN	AVERAGE TRAVEL TIME
beat_no	3321	0.523	115.1	.5390	74.9	5.012
beat_no	3322	0.628	138.3	.5755	80.0	4.183
beat_no	3323	0.891	196.2	.6437	89.5	5.328
beat_no	3324	0.668	147.1	.6970	96.9	4.047
beat_no	3325	0.459	101.0	.6161	85.6	6.350
beat_no	3326	0.571	125.6	.6616	92.0	4.611
beat_no	3327	0.898	197.6	.9401	130.7	6.826
beat_no	3328	0.553	121.7	.6373	88.6	5.471
beat_no	3329	0.921	202.6	.6723	93.5	4.605
beat_no	3330	0.490	107.9	.6643	92.3	5.365
beat_no	3331	0.942	207.4	.9389	130.5	5.849
beat_no	3332	0.738	162.4	.6262	87.0	6.710
beat_no	3333	0.513	112.8	.6389	88.8	5.792
beat_no	3334	0.553	121.8	.6109	84.9	6.809
beat_no	3335	0.888	195.5	.6641	92.3	5.734
beat_no	3336	0.919	202.2	.9479	131.8	5.724

Exhibit 3.11

Run No. 3

```
EXPECTED SCM DISPATCHING
PROBLEM TITLE: Stlou,jan80. as ts+DP327,324(own)/321 in336

    * ITERATIVE APPROXIMATION METHOD USED *
    NUMBER OF ITERATIONS REQUIRED:          21
UNLIMITED CAPACITY QUEUE WITH 1_ST-COME 1_ST-SERVED QUEUE DISCIPLINE
RUN NUMBER:  1
RESPONSE_UNIT         ...TOTAL NUMBER OF = 24
ATOM       ...TOTAL NUMBER OF =  85
AVERAGE SERVICE TIME=  35.00 MINUTES
AVERAGE NUMBER PER HOUR OF CALLS FOR SERVICE  =  18.690
AVERAGE NUMBER PER  35.00 MINUTES OF CALLS FOR SERVICE  =  10.902
AVERAGE UTILIZATION FACTOR
   (IN THE CASE OF UNLIMITED LINE CAPACITY)=  0.454

REGION-WIDE AVERAGE TRAVEL TIME=   5.581 MINUTES

AVERAGE TRAVEL TIME FOR QUEUED CALLS=   9.192 MINUTES
PROBABILITY OF SATURATION= 0.00043
REGION-WIDE AVERAGE WORKLOAD (% TIME BUSY)= 0.45427
STANDARD DEVIATION OF WORKLOAD=   0.293
MAXIMUM WORKLOAD IMBALANCE= 0.74178

FRACTION OF DISPATCHES THAT ARE INTER-beat     = 0.69850
```

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH RESPONSE_UNIT

	ID OF RESPONSE_UNIT NAME	NO	WORKLOAD OF UNIT	% OF MEAN	FRACTION OF DISPATCHES OUT OF beat	% OF MEAN	AVERAGE TRAVEL TIME
Patrol Cars	UNIT	3322	0.740	163.0	.8229	117.8	4.872
	UNIT	3323	0.714	157.2	.6825	97.7	5.395
	UNIT	3324	0.000	0.1	.9370	134.1	9.044
	UNIT	3325	0.679	149.6	.7876	112.8	6.253
	UNIT	3326	0.732	161.2	.8279	118.7	4.861
	UNIT	3327	0.000	0.1	.9183	131.5	9.305
	UNIT	3328	0.700	154.0	.7803	111.7	6.000
	UNIT	3329	0.742	163.4	.7421	106.2	5.020
Sergeant's Cars	UNIT	3330	0.716	157.7	.8298	118.7	5.768
	UNIT	3331	0.711	156.6	.6640	95.1	4.950
	UNIT	3332	0.657	144.7	.5859	83.9	6.037
	UNIT	3333	0.679	149.5	.7612	109.0	5.952
	UNIT	3334	0.653	143.7	.6808	97.5	7.088
	UNIT	3335	0.710	156.4	.6789	97.2	5.429
	UNIT	3336	0.725	159.6	.7027	100.6	5.472
	UNIT	3311	0.140	30.9	.0638	9.1	3.915
	UNIT	3312	0.139	30.7	.0499	7.1	3.976
	UNIT	3313	0.151	33.3	.0244	3.5	3.481
	UNIT	3314	0.137	30.2	.0458	6.6	4.634
	UNIT	3315	0.232	51.0	.6737	96.5	4.958
Stack Cars	UNIT	3337	0.417	91.9	.0208	3.0	7.808
	UNIT	3338	0.356	78.4	.0518	7.4	6.338
Cruiser	UNIT	3306	0.167	36.8	.0000	0.0	9.089
	UNIT	3321	0.000	0.1	.9148	131.0	9.103

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH beat

ID OF beat NAME	NO	WORKLOAD OF beat	% OF MEAN	FRACTION OF DISPATCHES INTER-beat	% OF MEAN	AVERAGE TRAVEL TIME
beat	3322	0.628	138.3	.6812	97.5	5.364
beat	3323	0.891	196.2	.6553	93.8	5.948
beat	3324	0.668	147.1	.9574	137.1	4.963
beat	3325	0.459	101.0	.6217	89.0	7.118
beat	3326	0.571	125.6	.6722	96.2	5.151
beat	3327	0.898	197.6	.9417	134.8	7.213
beat	3328	0.553	121.7	.6393	91.5	5.301
beat	3329	0.921	202.6	.6820	97.6	4.876
beat	3330	0.490	107.9	.6545	93.7	4.792
beat	3331	0.942	207.4	.6490	92.9	4.722
beat	3332	0.738	162.4	.5965	85.4	5.528
beat	3333	0.513	112.8	.6178	88.5	5.049
beat	3334	0.553	121.8	.5976	89.0	6.314
beat	3335	0.888	195.5	[illegible]	93.1	5.388
beat	3336	0.919	[illegible]	.6734	96.4	5.414

Exhibit 3.12

Run No. 4

```
EXPECTED SCM DISPATCHING
PROBLEM TITLE: St. Louis Modification 1

    * ITERATIVE APPROXIMATION METHOD USED *
    NUMBER OF ITERATIONS REQUIRED:          11
UNLIMITED CAPACITY QUEUE WITH 1_ST-COME 1_ST-SERVED QUEUE DISCIPLINE
RUN NUMBER:  1
RESPONSE_UNIT         ...TOTAL NUMBER OF = 24
pauly_bk   ...TOTAL NUMBER OF =  85
AVERAGE SERVICE TIME=  35.00 MINUTES
AVERAGE NUMBER PER HOUR OF CALLS FOR SERVICE  =  18.690
AVERAGE NUMBER PER  35.00 MINUTES OF CALLS FOR SERVICE  =  10.902
AVERAGE UTILIZATION FACTOR
   (IN THE CASE OF UNLIMITED LINE CAPACITY)=  0.454

REGION-WIDE AVERAGE TRAVEL TIME=   4.896 MINUTES

AVERAGE TRAVEL TIME FOR QUEUED CALLS=   9.192 MINUTES
PROBABILITY OF SATURATION= 0.00043
REGION-WIDE AVERAGE WORKLOAD (% TIME BUSY)= 0.45427
STANDARD DEVIATION OF WORKLOAD=   0.283
MAXIMUM WORKLOAD IMBALANCE= 0.73014

FRACTION OF DISPATCHES THAT ARE INTER-beat     = 0.70697
```

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH RESPONSE_UNIT

	ID OF RESPONSE_UNIT NAME	NO	WORKLOAD OF UNIT	% OF MEAN	FRACTION OF DISPATCHES OUT OF beat	% OF MEAN	AVERAGE TRAVEL TIME
Patrol Cars	UNIT	3325	0.599	131.8	.6831	96.6	5.321
	UNIT	3326	0.666	146.5	.7269	102.8	4.538
	UNIT	3327	0.602	132.5	.5084	71.9	4.824
	UNIT	3328	0.644	141.8	.6983	98.8	5.183
	UNIT	3329	0.715	157.4	.6763	95.7	4.560
	UNIT	3332	0.681	150.0	.6936	98.1	4.236
	UNIT	3334	0.574	126.3	.5618	79.5	5.571
	UNIT	3335	0.653	143.7	.5460	77.2	4.445
	UNIT	3336	0.679	149.6	.5950	84.2	4.727
Sergeant's Cars	UNIT	3311	0.025	5.4	.0157	2.2	3.755
	UNIT	3312	0.029	6.4	.0148	2.1	3.861
	UNIT	3313	0.033	7.3	.0115	1.6	3.469
	UNIT	3314	0.025	5.5	.0159	2.2	4.490
	UNIT	3315	0.076	16.7	.7768	109.9	5.072
	UNIT	3337	0.209	45.9	.0011	0.2	7.748
	UNIT	3338	0.158	34.7	.0022	0.3	6.099
	UNIT	3306	0.010	2.2	.0000	0.0	8.930
	UNIT	3321	0.569	125.3	.8966	126.8	6.291
	UNIT	3322	0.687	151.2	.8156	115.4	4.730
Stack Cars	UNIT	3323	0.740	162.9	.7327	103.6	4.267
	UNIT	3324	0.703	154.8	.9090	128.6	4.648
	UNIT	3330	0.601	132.3	.8700	123.1	5.750
Cruisers	UNIT	3331	0.645	141.9	.7839	110.9	4.604
	UNIT	3333	0.581	127.9	.8463	119.7	5.435

PERFORMANCE MEASURES THAT ARE SPECIFIC TO EACH beat

ID OF beat NAME	NO	WORKLOAD OF beat	% OF MEAN	FRACTION OF DISPATCHES INTER-beat	% OF MEAN	AVERAGE TRAVEL TIME
beat	3325	0.459	101.0	.5794	82.0	3.299
beat	3326	0.571	125.6	.6453	91.3	4.064
beat	3327	0.898	197.6	.6655	94.1	5.063
beat	3328	0.553	121.7	.6235	88.2	4.774
beat	3329	0.921	202.6	.6948	98.3	4.232
beat	3332	0.738	162.4	.6591	93.2	5.152
beat	3334	0.553	121.8	.5542	78.4	5.618
beat	3335	0.888	195.5	.6321	89.4	4.847
beat	3336	0.919	202.2	.6636	93.9	4.850
beat	3311	2.459	541.3	.7821	110.6	4.803
beat	3312	1.927	424.2	.6390	90.4	4.823
beat	3313	2.193	482.7	.7589	107.4	5.027
beat	3314	2.360	519.5	.6261	88.6	5.029
beat	3315	1.964	432.3	.7189	101.7	4.774
beat	3337	6.084	339.2	.7080	100.1	4.881
beat	3338	4.319	060.8	.7057	99.3	4.913

CONTINUED

1 OF 4

indicating to the experimental designer or the patrol administrator the magnitudes of the response time increases to be expected by implementing that particular experimental design. In examining Exhibit 3.10 we see that the three DP cars spent very little of their time on calls for service, but when they do go on calls for service their average travel times are considerably larger than those for regular patrol cars; this is because they are called only as a last resort, and therefore are very likely to be sent to distant points throughout the district.

In conducting Run Nos. 2 and 3 and in similar runs not reported here, PSE attempted to develop general guidelines for use by District 3 watch commanders in implementing DP strategies, yet allowing the desired flexibility. Our general guidelines included such things as limiting the number of DP cars during heavy workload periods and assigning DP areas that were spatially separate from each other. The guidelines appeared, for the most part, to be adhered to throughout the six-month experiment.

Run No. 4 was one of several attempts to redesign the beat configuration in District 3 in order to reduce average travel times and improve other performance measures. In large part, we were unsuccessful at doing this. Every strategy that we thought was reasonable actually increased the district-wide average travel time. We thus arrived at the conclusion that beat design as currently implemented in District 3 is perhaps as close to the best beat design as one can find, where the criterion of optimality is district-wide average travel time.

3.2.3 Directed Patrol Strategies

On Monday, January 12, 1981, the directed patrol experiment (DPE) began in District 3 at the start of the first watch. To acquaint patrol officers with the change in operations, a videotape presentation, which outlined the project

and explained the officers' roles and duties, was shown at all roll calls.[10] Other PSE staff were present to answer questions before the start of the DPE and during the first week. More detailed discussions were held with command staff during this period. For the first watch, three patrol cars were assigned to directed patrol: two began at 8:00 am and continued until noon, the third car began at noon and continued until 3:00 pm.

During the study, diverse approaches and activities were subsumed under the title of directed patrol. The diversity occurred largely because decisions about DP deployment were made by each watch commander in accordance with his perception--aided by daily crime analysis bulletins--of the needs of the district, precincts, and beats. Thus, a variety of target areas, target crimes, and the street-level activities were assigned to directed patrol during the six-month period. Contributing also to diversity was the widespread distribution of DP assignments among the district's officers.

In addition, because directed patrol spatially reallocated the district's existing resources, the remaining patrol cars had to respond to calls for service in the DP cars' customary beats. These district-wide rearrangements were also subject to the discretion of the watch commanders. Consequently, a variety of strategic configurations were used during the study to operationalize the directed patrol concept. The three configurations which accounted for 92 percent of the 719 DP assignments are depicted in Exhibit 3.13, and summarized below:

> The most common arrangement, Strategy 1, designated a single beat as the DP target area, and simply shifted responsibility for radio assignments from the beat car to one or two "cover cars" in adjoining beats. The beat car then had 100 percent of its time available for patrol within its accustomed beat. This strategy was used in 36 percent of all the DP assignments.

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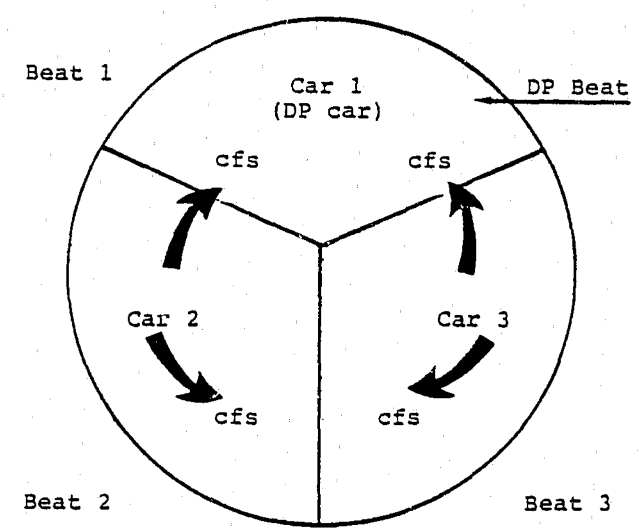
[10] Dr. John F. Runcie prepared the videotape presentation.

Exhibit 3.13

Common Directed Patrol Strategies



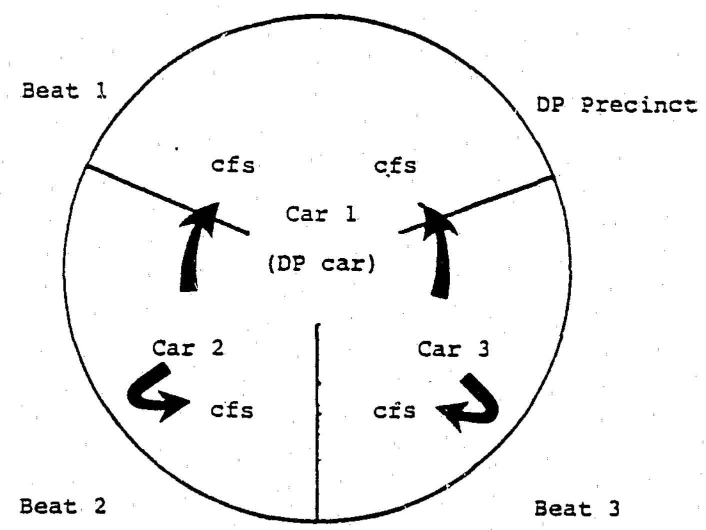
STRATEGY 1

--One beat chosen as Directed Patrol Target Area

--Designated Directed Patrol car is beat' customary radio car

--Calls for Service (CFS) in target area attended to by one or two neighboring beat cars

Frequency of use in CPPE: 36% of all Directed Patrol assignments



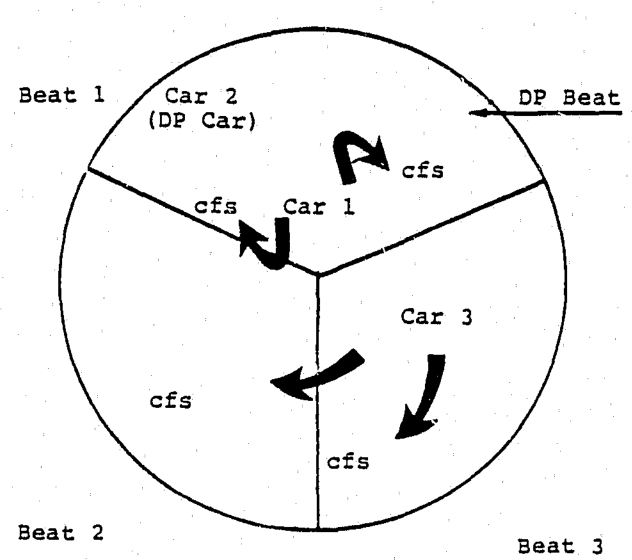
STRATEGY 2

--One 3-4 beat precinct chosen as Directed Patrol target area

--Designated Directed Patrol car is one of the precinct's beat cars

--Calls for Service in depleted beat attended to by one or two of precinct's remaining beat cars

Frequency of use in CPPE: 31% of all Directed Patrol assignments



STRATEGY 3

--One beat chosen as Directed Patrol target area

--Designated Directed Patrol car is reassigned from normal duties in its customary beat

--Calls for Service in depleted beat attended to by car or cars outside the target area

Frequency of use in CPPE: 25% of all Directed Patrol assignments

In Strategy 2, the DP car was assigned to a target area consisting of an entire precinct (i.e., three or four beats). The remaining cars in the precinct were dispatched to radio assignments in the now depleted beat. This strategy was used in 31 percent of all the DP assignments.

The DP target area in Strategy 3 was also a single beat. However, the DP car was reassigned from an outside beat, resulting in one DP car and one regular patrol car in the DP beat. Calls for service in the depleted beat were attended to by one or two of its neighboring beat cars. This strategy was used in 25 percent of all DP assignments.

If more than one DP car was assigned during a watch, different strategies were often used for each.[11]

This pattern of relying primarily on Strategies 1 and 2 tended to keep DP cars in or near their home beats. In approximately 62 percent of the beat-level DP assignments, the DP car was assigned to its home beat, and in another 15 percent to another beat in its home precinct. In approximately 96 percent of the precinct-level DP assignments, the DP car was assigned to its home precinct. Thus, officers conducted directed patrol in the areas they were most familiar with.

The distribution of DP assignments by car and beat is shown in Exhibit 3.14. Two observations about DP strategies are apparent in these figures. First, there was significant variation in the number of times a given beat was chosen for directed patrol. Four beats—321, 322, 326, and 331—accounted for only 7.4 percent of DP assignments, while another four beats—324, 327, 330, and 332—accounted for 55.1 percent. Directed patrol was clearly not distributed evenly across the district. Second, watch commanders tended to assign cars to directed patrol according to the relative frequency of calls for service in their home beats. The four cars most often assigned to directed patrol rank 16, 7, 8 and 15 in terms of call-for-service-volume in their home

[11] Using the Hypercube Queueing Model, PSE analyzed the operational changes when (1) three cars were assigned to Strategy 1, and (2) two cars were assigned to Strategy 1 and one to Strategy 3. See Section 3.2.2 for the results.

Exhibit 3.14

DP Areas by Calls for Service and Car Assigned

Patrol Area	Calls for Service	Rank	Chosen for DP	Rank	Car Used for DP	Rank
321	4.32%	16	1.86%	13	8.38%	1
322	5.55	10	1.86	13	5.49	12
323	7.44	4	4.26	9	6.50	6
324	8.97	1	9.57	4	6.50	6
325	4.40	15	2.93	12	7.37	4
326	5.22	11	1.86	13	4.11	16
327	6.73	7	21.81	1	7.87	2
328	4.57	14	7.71	5	4.30	15
329	7.02	6	4.26	9	6.50	6
330	5.03	12	10.11	3	6.50	6
331	7.33	5	1.86	13	7.19	5
332	5.56	8	13.56	2	7.51	3
333	5.67	9	3.19	11	5.83	11
334	4.94	13	5.59	6	6.18	10
335	7.61	3	4.52	8	4.63	14
336	8.55	2	5.05	7	5.14	13
Total	100.00%		100.00%		100.00%	
(N)	(53,829)		(376)		(582)	

Precinct	Calls for Service	Rank	Chosen for DP	Rank
311	26.28%	1	22.69%	1
312	16.35	5	21.13	2
313	19.65	3	21.13	2
314	21.10	2	15.12	5
315	16.62	4	19.93	4
Total	100.00%		100.00%	
(N)	(53,829)		(206)	

beat. At the other extreme, of the four cars least chosen for directed patrol, the home beats of two—335 and 336—rank 2 and 3 in call-for-service volume. Logic argues then, that they should have been chosen less frequently since they would have been "missed" had they been removed from ordinary dispatching. This consideration of heavy versus light workloads indicates that the watch commar 'ers relied on more than just crime analysis information when making DP assignments.

The choice of one DP strategy over another had important implications for the potential increase in patrol time within the DP target area. Patrol time can be thought of as uncommitted time: that is, the number of hours not spent responding to calls for service, eating meals, writing reports or otherwise "out of service." The total patrol time available in a given beat would then include the patrol time spent by a regular patrol car as well as that spent by an assigned DP car (whose hypothetical patrol time is 100 percent).

Exhibit 3.15 shows the potential improvement in patrol time associated with each of the three most common DP strategies. The exhibit illustrates the effect of a given strategy used in a DP assignment under two hypothetical workload conditions. Under a moderate workload, 50 percent of a watch (for regular patrol cars) is spent responding to calls for service or otherwise out of service. This is a reasonable assumption as the average out-of-service time in District 3 during the study was 4.03 hours, or 50.4 percent of an eight-hour watch. Under a light workload condition, 33 percent of the watch is assumed to be spent out of service. (During periods when CFS volume was high, watch commanders frequently curtailed or cancelled DP assignments.)

Because actual patrol time is affected by several other factors as well, Exhibit 3.15 is useful primarily for comparing strategies, rather than predicting outcomes under any one of them. The exhibit clearly indicates the

Exhibit 3.15

Potential Increases in Patrol Time in DP Target Areas Under Two Workload Assumptions

		Moderate Workload*		Light Workload*	
		Total Hours	Change from Status Quo	Total Hours	Change from Status Quo
Status Quo		4.00	——	5.33	——
Strategy 1 (DP target beat patrolled by customary radio car)		8.00	100.0%	8.00	50.0%
Strategy 2 (DP target precinct patrolled by one of precinct's radio cars)	Beat 1	2.67	-33.3%	2.67	-50.0%
	Beat 2	4.67	16.7%	6.67	25.0%
	Beat 3	4.67	16.7%	6.67	25.0%
Strategy 3 (DP target beat patrolled by radio car from another beat)		12.00	200.0%	13.33	150.0%

*Moderate workload assumes 50 percent of a regular patrol car's watch time is spent out of service. Light workload assumes 33 percent of a regular patrol car's watch time is spent out of service. In both cases, the remainder is considered to be patrol time. DP cars are assumed to spend 100 percent of the watch on patrol time. The total patrol time availabe in a given beat equals the DP car's patrol time plus the regular patrol car's (if one is assigned to the DP beat) patrol time.

superior potential of Strategy 3 to increase patrol time in the DP target area. Under non-busy as well as moderately busy conditions, Strategy 3 at least doubles the increase in patrol time produced by Strategy 1. Strategy 1, in turn, at least doubles the potential increase in patrol time generated under Strategy 2. The potential increase in patrol time from Strategy 2 is minor in both a relative and an absolute sense.

The specific crimes targeted by watch commanders for directed patrol were burglaries (both business and residential), street robbery (including purse snatch), and auto-related crimes (including vehicle theft, auto parts theft, and break-ins). These target crimes were assigned with relative frequencies as follows:

Single Target Crime Assignments:		60%
Residential Burglary	47%	
Auto-Related Larceny	23	
Street Robbery/Purse Snatch	20	
Business Burglary	10	
Multiple Target Crime Assignments:		40
All DP Assignments (n=707, 12 cases missing data)		100%

Directed patrol operations at the precinct level (i.e., Strategy 2) were distinguished by a greater tendency among watch commanders to designate two or three target crimes. Whereas multiple crimes were targeted in 32 percent of all beat-level DP assignments, 46 percent of the precinct-level assignments were deployed against multiple target crimes. Watch commanders specifying precinct-level directed patrol with multiple crime targets may have done so in deference to the judgment of the assigned officers. In these cases the deployment plan may have been intended to set parameters within which assigned DP officers were to exercise discretion in allocating DP time to target crimes.

There appeared to be wide variation in the crime-specific DP tactics chosen by the officers. Study of the DPE at the street level is somewhat hampered by a lack of information available from the officers' DP activity logs. It is not possible to determine the extent to which distinct patterns of officer activity were associated with the various target crimes. However, the logs indicate that at least some of the officers actively engaged in crime-specific patrol tactics in their assignments. Officers targeting auto parts larceny occasionally report having spent a portion of the watch conducting surveillance of parking lots; officers targeting purse snatching and street robbery sometimes report having spent a portion of the watch on foot patrol in certain areas; officers targeting burglary sometimes indicate building security checks as a major activity. As 160 of the district's officers participated in DPE, it may be inferred that the utilization of crime-specific tactics was subject to considerable variation.

These variations in DP strategies and tactics reflect the discretionary nature of the DPE. However, deployment of a DP car throughout a precinct versus a beat, designation of multiple target crimes versus a single target crime, and assignment of one officer versus another, are choices which, taken together, produce extensive variation at the street-level. Evaluation of directed patrol requires thorough and accurate monitoring of this variation in order to identify the conditions under which directed patrol can be expected to operate most effectively. The following section describes FLAIR-based and other techniques used to monitor and measure directed patrol in District 3.

3.3 MONITORING AND MEASURING DIRECTED PATROL

The primary purpose of the DPE was to assess the use of the FLAIR system in an obtrusive police patrol experiment. There are two ways in which FLAIR can be used in this setting: (1) to monitor the activities of patrol cars to

determine the extent to which experimental conditions are maintained, and (2) to measure the effect of directed patrol on district operations. However, not all aspects of experimental integrity can be monitored through FLAIR, nor can all the operational effects of directed patrol be measured automatically. Thus, two main categories of data were collected during the DPE: FLAIR-based data and non-FLAIR data. The eight-hour watch was used as the analytic base for both types of data. This section first reviews the data gathering procedures followed during the DPE, then looks at some results from mini-experiments with FLAIR-based and non-FLAIR monitoring, and concludes with the results from FLAIR-based and non-FLAIR measurements.

3.3.1 FLAIR-Based and Non-FLAIR Data Gathering

One of the primary purposes of the District 9 pretest was to implement procedures to record, and then compile, the volumes of data that would be generated during the DPE. An early decision was made to have all data sent to the PDPM who would act as a clearing house; the PDPM had sufficient authority to ensure that data were delivered on schedule. As each week's data were gathered, the information was categorized and then sent to PSE for review. Missing data items were noted and requests sent to the PDPM for the missing items. In virtually all cases, except where the requested data did not exist, the requests produced the missing data items.

FLAIR-based data were collected in two principal ways. First, as described in Chapter 2, the FLAIR system does not remember or record the movements of patrol cars. Thus, when information was required on the movement of patrol cars during a given watch, the FLAIR display was visually monitored by a PSE staff member. When appropriate, the display was videotaped to allow playback. Second, at the end of each watch, FLAIR produces a written summary of all FLAIR-relevant activity during the preceding eight hours which includes:

(1) number and locations of emergency transmissions (an officer safety feature); (2) the number of automatic initializations by signpost; (3) FLAIR activities by district (i.e., map changes made by dispatchers, number of times cars were lost by FLAIR, number of FLAIR-observable cars, total miles traveled, and number of signpost initializations); (4) a list of the 20 most active cars; and (5) mileage, initializations, and requests to verify location by car. A sample copy of this output is presented in Appendix II.

There were several sources of non-FLAIR data. Officers on directed patrol were required to fill out a log sheet, depicted in Exhibit 3.16, detailing their activities on the assignment. Arrests made by other officers were recorded by the watch commanders on the regular patrol log, depicted in Exhibit 3.17. In addition, a copy of the deployment plan for each watch was forwarded to PSE. Utilizing the log sheets and the deployment plan it was possible to map changes in patrol strategy from one day to the next, to note manpower and vehicle availability, and to note crime and arrest patterns. This information was forwarded weekly to the PDPM.

Several other records and reports were collected by the PDPM for use in the experiment. For example, Chronological Car Activity reports were used to determine the degree to which DP cars had been removed from answering calls for service, as well as to provide a number of district-wide radio analyses. Also forwarded to the PDPM were summaries of other commands operating in the District each week; the activities of FLAIR-observable cars; the incidence of target crime in the district (published at intervals by the Crime Analysis section); and the incidence of district-wide crime and arrests.

3.3.2 FLAIR-Based Monitoring

The FLAIR system proved to be a valuable source of information on directed patrol activities. Throughout the experiment, it was used to (1) maintain

Exhibit 3.16

Directed Patrol Log Sheet

(Completed by Officers on DP Assignment)

DATE______________________ WATCH______________________

VEHICLE No.______________ RADIO CALL LETTERS______________

ONE OFFICER______________ TWO OFFICERS______________

NAME & DSN OF OFFICERS ASSIGNED______________________

____

CRIME TARGET______________________________________

AREA PATROLLED____________________________________

____

TIME PATROLLED____________________________________

ARRESTS: (Type, number, location--be specific: time, complaint number)

FIELD INTELLIGENCE REPORTS: (Location, number at each location, time)

OTHER ACTIVITY OR INFORMATION:

USE A SEPARATE FORM FOR EACH INDIVIDUAL ASSIGNMENT PER WATCH

Exhibit 3.17

Regular Patrol Log Sheet

(Completed by Watch Commanders)

DATE________________ WATCH________________

TYPE ARREST, NUMBER, LOCATION—BE SPECIFIC: TIME, COMPLAINT NUMBER)

(1) CALL LETTERS______ OFFICER(S)________________

RADIO DIRECTED______ SELF INITIATED________________

(2) CALL LETTERS______ OFFICER(S)________________

RADIO DIRECTED______ SELF INITIATED________________

(3) CALL LETTERS______ OFFICER(S)________________

RADIO DIRECTED______ SELF INITIATED________________

A FORM REPORTING ARREST INFORMATION, WHETHER NEGATIVE OR POSITIVE, IS TO BE PREPARED FOR EACH WATCH.

control over the DP cars and activities, (2) monitor unusual occurrences and record the cars' activities for analysis at a later time, and (3) conduct tests of the experimental procedures. Results from this last use provided feedback that identified behaviors, occurring early in the experiment, which were outside the bounds of activities defined as acceptable.

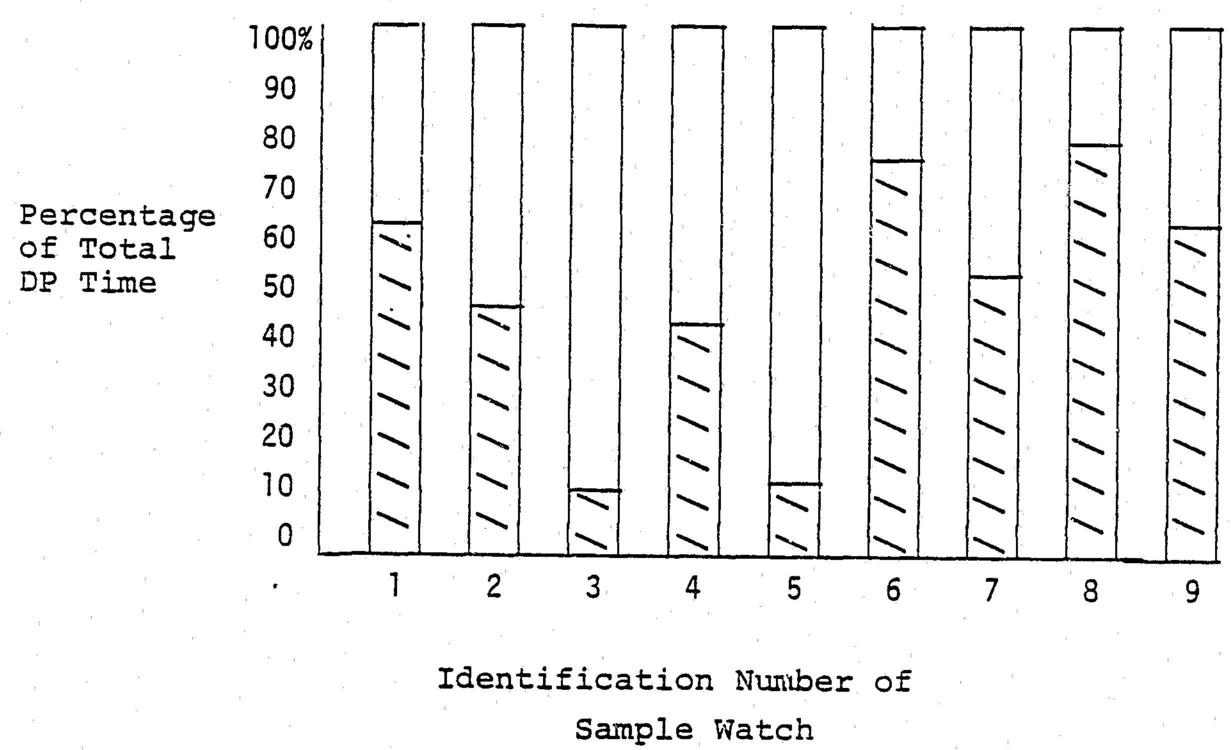
For example, near the start of the DPE it appeared that there was some question as to the integrity of the DP areas. In other words, it seemed as if DP cars were straying from their areas or were being joined in the area by cars not assigned there. To assess these problems, a "mini-experiment" was conducted. For a two-week period PSE randomly sampled DP assignments from 20 percent of all watches. If more than one car was assigned to directed patrol on the chosen watch, one car was chosen at random from those assigned. For each car chosen, the following information was recorded based on observation (and tapes) made from the FLAIR system console:

- time on directed patrol (in minutes)
- time DP car remained in DP area (in minutes)
- time DP car was not in DP area (in minutes)
- number of times DP car left DP area
- number of times DP car's location was uncertain, according to FLAIR
- time DP car's location was uncertain (in minutes)
- rationale, if any, for deviations by a DP car from its assigned area (radio dispatch, self-initiated, no reason, etc.).

Exhibit 3.18 compares the total amount of DP time for the sample vehicles with the total time each car spent in and out of its assigned DP area. The average amount of DP time was 272 minutes per DP car per eight-hour watch, with an average of 133 minutes spent in the assigned DP area and an average of 139 minutes spent outside the area. The exhibit reveals considerable variation among the sampled vehicles in the proportion of time spent out of the assigned

Exhibit 3.18

Percent of Time DP Cars Spent In and Out of Assigned DP Area



KEY: [ ] percentage of total Directed Patrim time spent in designated patrol area.

[\\] percentage of total Directed Patrol time spent out of designated patrol area.

* Data gathered by monitoring the FLAIR console.

DP area. As little as 10 percent and as much as nearly 80 percent of DP time is seen to be directed toward activities outside the DP area boundaries. These excursions flagged the need to instruct officers to pay greater heed to staying within the boundaries of the DP areas.

Another concern to the police researcher using an AVM system is that cars whose locations are uncertain could weaken the integrity of an experiment (the cars could be inside an assigned area or outside). An analysis similar to that for excursions was performed for the times the sampled DP cars locations were uncertain. Again, there was considerable variation: the time a car's location was uncertain ranged from 0.0 percent of the DP tour to 37.0 percent, with a mean of 16.3 percent. These results suggested the need to prompt dispatchers to verify more quickly the locations of "lost" cars.

These examples illustrate just two of the ways in which FLAIR can be used to monitor obtrusive police patrol experiments. Regardless of the factors contributing to this observed variation, the findings strongly support the need for careful and continuous monitoring of DP operations. As noted above, the FLAIR system allowed PSE to monitor all FLAIR-observable cars on all watches throughout the course of the DPE. PSE's approach was to note any deviations from experimental conditions, suggest appropriate corrective actions to be taken and be available to explain the necessary changes. In some cases the changes went into effect with no problems, in some cases, there were heated debates over procedures and in other cases no changes were made for safety reasons.

3.3.3 Other Monitoring

While not relying totally on the FLAIR system, another experimental validity check did begin with FLAIR. At the onset of the DPE, PSE was concerned that DP cars might not be removed from answering calls for service as

Exhibit 3.19

Distribution of Radio Transmissions for Regular and Directed Patrol Cars, Weeks 1-4 of the DPE, by Watch

	First Watch		Second Watch		Third Watch	
	Regular Patrol	Directed Patrol	Regular Patrol	Directed Patrol	Regular Patrol	Directed Patrol
Dispatched Incident	52.4%	16.5%	57.2%	20.8%	47.1%	23.7%
Self-Initiated	32.2	69.8	29.4	58.5	32.0	65.8
Dispatched Assist	7.5	2.2	8.4	11.3	15.3	3.9
Information Received or Requested	7.9	11.5	5.0	9.4	5.6	6.6
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
(N)	(3728)	(139)	(3992)	(53)	(2855)	(76)

the experimental design required. A visual (and aural) monitoring of FLAIR was instituted which suggested that a further assessment should be undertaken. A complete count of all radio calls during the first four weeks of the DPE was made. As can be seen in Exhibit 3.19, the DP cars showed a marked change over regular patrol cars in their radio activity. The percentage of radio-directed incidents is considerably lower for DP cars than regular patrol cars, no matter which watch is concerned. At the same time, the percentage of self-initiated calls engaged in by DP cars is approximately twice as large as those for regular patrol cars, again, regardless of the watch.

A second concern for the integrity of the DPE stemmed from the presence of non-patrol or other command cars (i.e., traffic, canine, evidence) in District 3. These cars were not FLAIR-equipped, yet one wanted to know how often they were in the district. The presence of these other unmonitored (by FLAIR) cars has potential implications both for the present study and for any larger study of police patrol that might be undertaken. Thus, these cars were required to

record their locations each time they entered the district. The average number of incursions by vehicles of these non-patrol command was 16.3 per watch during the DPE. In a larger and more in-depth research project, a greater amount of time would be spent to more precisely record the locations and activities of these commands. If the priority were high enough, the cars could be FLAIR-equipped. Nonetheless, even at the preliminary level of this study it was possible to account for the presence of unmonitored vehicles. As will be described in Chapter 5, knowing unmonitored cars are present means that it is possible to take them into account when constructing statistical models.

3.3.4 FLAIR-Based Measurements

In addition to its monitoring capabilities, FLAIR was used to measure the level of patrolling, or police presence, in the district. There are at least two types of information that FLAIR can provide in this area. First, FLAIR records the total miles traveled by each FLAIR-observable car each watch, and computes averages for each district. While there is always some number of vehicles in which the FLAIR transmitter is inoperable (usually no more than 1 or 2 of the 24 FLAIR-observable cars in the district), these figures do allow for certain rough comparisons among districts and cars. No discussion of miles traveled by DP cars as opposed to regular patrol cars is included here as the standard FLAIR output only displays total mileage for each car by watch. Since virtually all DP assignments extended for less than a full eight-hour tour of duty, comparisons of total miles traveled by DP versus regular patrol cars would be inconclusive. Under the aegis of a larger research project a re-programming of the FLAIR system to provide hour-by-hour mileage readings by car would be extremely useful.

Second, the FLAIR system records patrol cars' passings at signposts. As noted earlier the installation of fixed signposts improved the locational accuracy of FLAIR by automatically recording the locations of cars when they passed a signpost. This decreased the number of times dispatchers had to request car locations over the radio, and reduced the incidence of "lost" cars. This automatic reinitialization capability also means, for any police patrol experiment using an AVM system such as the FLAIR system, that a reasonably close check can be kept on patrol cars at all times and that constant and continuous calibration of the experiment is possible. In addition, the signposts provide an additional tool for the police researcher. Patrol intensity in an area can be examined by noting the frequency with which patrol cars pass signpost locations. Clearly, the greater the number of passings in a given time period the greater the patrol intensity in that area.

Exhibit 3.20 shows the average number of passings per watch during the DPE for each fixed signpost in or on the borders of District 3. Exhibit 3.21 gives the location for each signpost. As might be expected, signpost 27, located in front of the station house, had the highest average number of passings.

Exhibit 3.20

Patrol Intensity In District 3 During the DPE

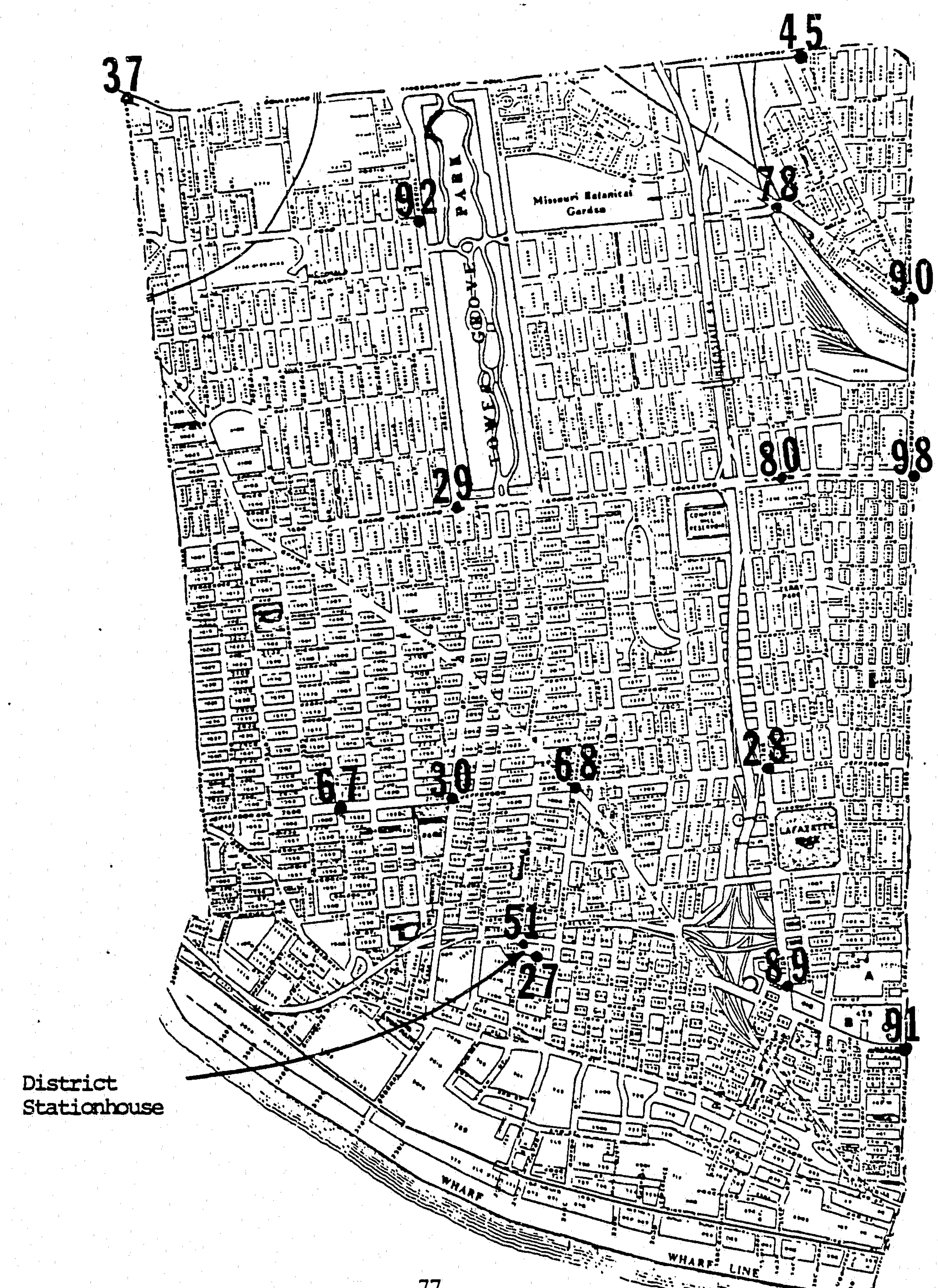
Signpost Number	Average Total Passings Per Watch	Ranking
27	64.6	1
28	7.7	15
29	29.5	3
30	20.0	8
37	19.7	11
45	12.3	12
51	28.1	4
67	40.4	2
68	25.0	5
78	19.8*	10
80	6.5	16
89	21.6*	7
90	22.1	6
91	20.0	8
92	9.1	14
98	11.4	13

Average total for all signposts = 22.4

*Average does not include those watches with no passings recorded under the assumption that the signpost was inoperative.

Exhibit 3.21

Locations and FLAIR Numbers of Fixed Signposts in District 3



Signpost 51 at the side of the station house, while showing a high number of passings, was not consistently high. This is probably explained by the officers tendency to park in front of the station house and use the main street more frequently than the side street. Likewise, signposts located at major intersections within the district, such as 67 and 68, also had a large number of patrol passings.

Signpost data can also be used to measure changes in patrol intensity. As seen in Exhibit 3.22, there was a general decrease in signpost passings during the DPE. In the first week, signposts were passed an average of 425.5 times per watch. The average passings then followed a somewhat random pattern until the highest average was reached in Week 15. From Week 15 to the end of DPE there was a general decline in signpost passings until the lowest point was reached in the last week, an average of 193.7 passings per watch. The FLAIR-based data items in Exhibit 3.23 were examined in an attempt to discover the reason for the large decrease. It would appear that signpost passings can be related most closely to the number of FLAIR-observable vehicles on the street. Clearly, the fewer vehicles there are with operating FLAIR units, the fewer signpost passings that can be recorded. If there were also an increase in the number of radio assignments--as might be expected to accompany warmer weather--one could suggest that the cars were spending a larger amount of time parked, thus reducing the possibility for passing signposts. In the last two weeks of DPE, the radio assignment volume was considerably higher than it was for the first two weeks of the DPE, leading to a conclusion that it is the number of radio assignments coupled with fewer FLAIR-observable cars on the street which resulted in fewer signpost passings.

For a signpost to be most useful in police patrol research, the computerized system should be able to record (and print) not only the actual passing of the signpost by a patrol vehicle but also the identification number

Exhibit 3.22

Average Signpost Passings Per Watch by Week of the DPE

Week	Dates	(N)*	Average Total Passings Per Watch
1	1/12 - 1/18	21	425.5
2	1/19 - 1/25	21	375.3
3	1/26 - 2/01	21	416.2
4	2/02 - 2/08	21	417.4
5	2/09 - 2/15	19	372.3
6	2/16 - 2/22	20	411.7
7	2/23 - 3/01	19	413.3
8	3/02 - 3/08	17	382.9
9	3/09 - 3/15	15	388.8
10	3/16 - 3/22	13	390.2
11	3/23 - 3/29	15	415.1
12	3/30 - 4/05	11	364.7
13	4/06 - 4/12	19	383.6
14	4/13 - 4/19	19	395.4
15	4/20 - 4/26	19	434.0
16	4/27 - 5/03	16	355.2
17	5/04 - 5/10	17	373.3
18	5/11 - 5/17	17	369.4
19	5/18 - 5/24	19	381.1
20	5/25 - 5/31	17	303.7
21	6/01 - 6/07	17	244.8
22	6/08 - 6/14	17	210.9
23	6/15 - 6/21	15	236.8
24	6/22 - 6/28	18	215.7
25	6/29 - 7/05	21	200.4
26	7/06 - 7/12	21	193.7
TOTAL		465	357.8

*Number of tours in the week for which data are available.

Exhibit 3.23

Average Signpost Passings As Related to Other FLAIR-Based Information

	Week of the DPE				
	1	2	15	25	26
Total Miles (FLAIR-Observable Cars)	21,494	17,529	22,152	17,446	18,581
Average Miles/Watch	1023.5	876.5	1107.6	830.8	884.8
Total Cars (FLAIR-Observable)	448	464	508	402	432
Average Cars/Watch	21.3	23.2	25.4	20.1	20.6
Average Miles/Car	48.0	37.8	43.6	41.0	43.0
Average Signpost Passings/Watch	425.5	375.3	434.0	200.4	193.7
Average Number of Radio Assignments/Watch	130.8	130.4	157.3	168.5	160.5

of the vehicle and the direction of travel. Such notations require additional software for the computer system and were not possible in the present research project. Were such additions possible, it would make sense to bracket an area with signposts to monitor patrol cars as they enter and leave. Were this possible in the Kansas City study, for example, corrective actions could have been implemented in order to prevent unjustified incursions into the "depleted" beats by unauthorized patrol vehicles. Unfortunately, FLAIR software was programmed only to record the fact that a FLAIR observable vehicle passed a particular signpost, not which vehicle nor even the vehicle's district identity. Thus, signposts on district borders record passings of vehicles from any district, not just vehicles from District 3.

For future police research it might be well to utilize movable "signposts" in order to check traffic patterns in more detail in areas of interest. In the current research the signposts were stationary and limited to intersections

with a traffic light (as the source of electrical power). Were the signposts movable, however, it would be possible to position them in a number of places within the district to check on patrol intensity in areas which generate both large and small volumes of calls for service and crime. For example, one might position signposts around beat 322 as it receives a large volume of calls for service. As expected, signposts 67, 30 and 68 in beat 332 have a higher than average number of passings.

Should FLAIR be equipped with extensive playback capability, then research signposts that record vehicle passings could be installed in the tracking software. These software signposts could provide detailed and refined data now unavailable from hardware signposts. However, the hardware signposts also correct location estimation errors, which software signposts cannot. The key idea behind signposts and patrol research is, however, the following: patrol intensities at given points can be recorded precisely and unobtrusively with such signposts. Further, hardware or software signposts could record incursions and excursions, eliminating the need for visual monitoring by the researcher. They provide a heretofore unavailable monitoring mechanism for the implementation of any patrol deployment experiment.

3.3.5 Other Measures of Directed Patrol

Exhibit 3.24 presents a profile of police operations in District 3 during the DPE. As can be seen, there was an average of almost six car hours of directed patrol on each watch throughout the course of the experiment. This ranged, however, from no directed patrol on some watches to as high as 21 car hours on others. The second—or afternoon—watch was the busiest: it had the highest average number of radio assignments, the highest average number of crimes committed, the highest average number of minutes out of service, and

Exhibit 3.24

Profile of Police Operations in District 3 During the DPE, by Watch

Average Value:	First Watch	Second Watch	Third Watch	Average
Number of Patrol Cars	16.03	16.06	16.01	16.03
Number of Two-Officer Patrol Cars	6.46	7.31	5.86	6.50
Directed Patrol Hours	6.50	5.48	5.95	5.99
Miles for FLAIR-Observable Vehicles	940.61	1017.25	915.80	958.79
Number of FLAIR-Observable Vehicles	22.36	22.32	22.20	22.30
Minutes Out of Service	4915.38	5474.51	3578.34	4656.08
Radio Log Entries				
Total Calls*	147.56	181.29	123.34	150.73
(watch percent)	(32.6)	(40.1)	(27.3)	
Dispatched Incidents	74.92	105.87	61.79	80.86
(watch percent)	(30.9)	(43.6)	(25.5)	
Self-Initiated	45.12	42.70	30.86	39.56
(watch percent)	(38.1)	(36.0)	(26.0)	
Dispatched Assists	13.70	23.17	22.10	19.66
(watch percent)	(23.2)	(39.3)	(37.5)	
Other Commands				
Total**	14.81	22.30	10.66	16.31
Traffic	8.84	9.81	1.65	6.77
Canine	5.97	10.92	9.01	8.64
Other	—	1.57	—	0.90
Crimes and Arrests				
District-Wide Crimes	14.55	16.69	11.10	14.12
District-Wide Arrests	3.27	7.19	5.46	5.31
DP Area Crimes	0.38	0.36	0.50	0.42
DP Arrests	0.25	0.18	0.19	0.21

*Includes "no dispatch" log entries such as supplementary information requests.
**The number of times city-wide commands entered District 3.

so on. It is not surprising, therefore, that the second watch also averaged the least amount of time spent on directed patrol. Since watch commanders were free to assign directed patrol--both in terms of area and in terms of the number of cars—the second watch priority was clearly responding to the district's call-for-service needs rather than anticipating crime through directed patrol.

Exhibit 3.25 shows the distribution of the average number of hours spent on directed patrol by all the watches for each month of the DPE. As can be clearly seen (and as is discussed in Chapter 4, Police Officer Attitudes) enthusiasm for directed patrol decreased over the course of the DPE and this decreased enthusiasm is mirrored in the amount of DP time assigned by watch commanders. At the start of the DPE, all watches began with a moderate amount of time allotted for directed patrol, increased over the three months and then began a steady decline until at the end of the DPE the monthly averages were fairly low. The third watch is the only one of the three which shows a less extreme trend, suggesting a more consistent approach to the allotting of time to directed patrol. Since the third watch is also the least "busy" of the three watches, a finding such as just noted is not unreasonable. In other words, a watch commander knowing there would (potentially) be fewer radio assignments, fewer minutes out of service, and so on, could more easily assign cars to directed patrol, knowing these assignments would not adversely affect workloads of the remaining patrol cars. A similar concern for considering heavy versus light workloads surfaced in the choice of DP strategies (see Section 3.2.3).

As discussed in Section 3.3.3, one measure of success was the degree to which cars assigned to directed patrol were removed from answering calls for service and the degree to which the DP cars involved themselves in self-initiated activities. As Exhibit 3.26 shows, DP cars were assigned few calls

Exhibit 3.25

Directed Patrol Hours, by Month

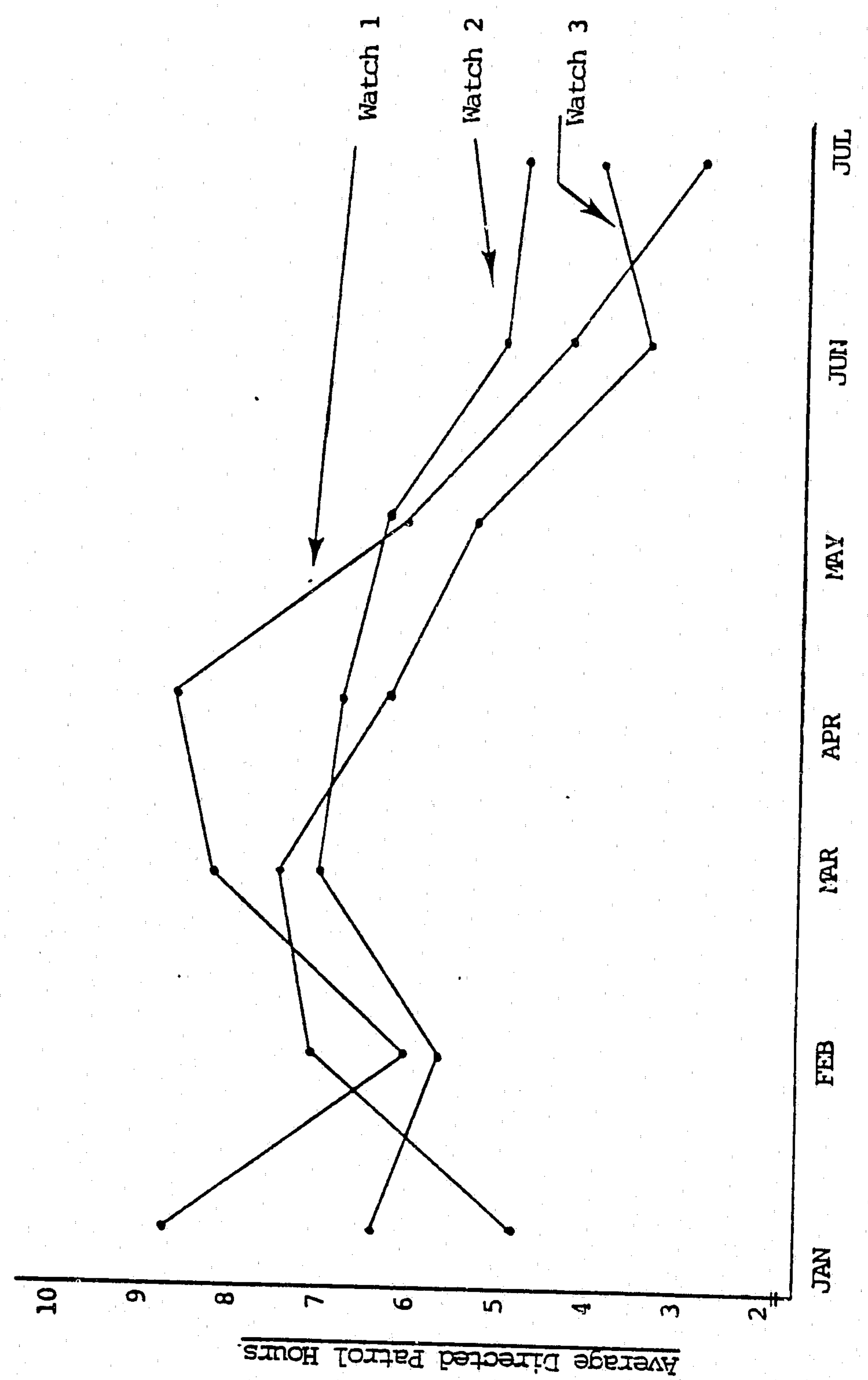


Exhibit 3.26

Average Number and Type of Radio Assignments During the DPE, By Watch

Type of Assignment	First Watch Directed Patrol	First Watch Regular Patrol	Second Watch Directed Patrol	Second Watch Regular Patrol	Third Watch Directed Patrol	Third Watch Regular Patrol
Directed Incident	0.77	74.92	0.65	105.87	1.31	61.79
Self-Initiated Call	1.56	45.12	1.15	42.70	1.14	30.86
Directed Assist	0.11	13.70	0.08	23.17	0.38	22.10
TOTAL	2.44	133.74	1.88	171.74	2.83	114.75

by the dispatchers and, on average, had more self-initiated activities than the regular patrol cars. An examination of the ratio of self-initiated calls to dispatched calls, shows that on two of the three watches, the DP cars' ratios were above unity. It is only on the third watch that the ratio drops below unity, but one could argue that (1) the ratio is still higher than the ratio for the regular patrol cars; and (2) the lower ratio is not due to fewer self-initiated activities, but to more dispatched calls. Whatever the reason, on allthree watches the ratio is greater for the DP cars than it is for the regular patrol cars.

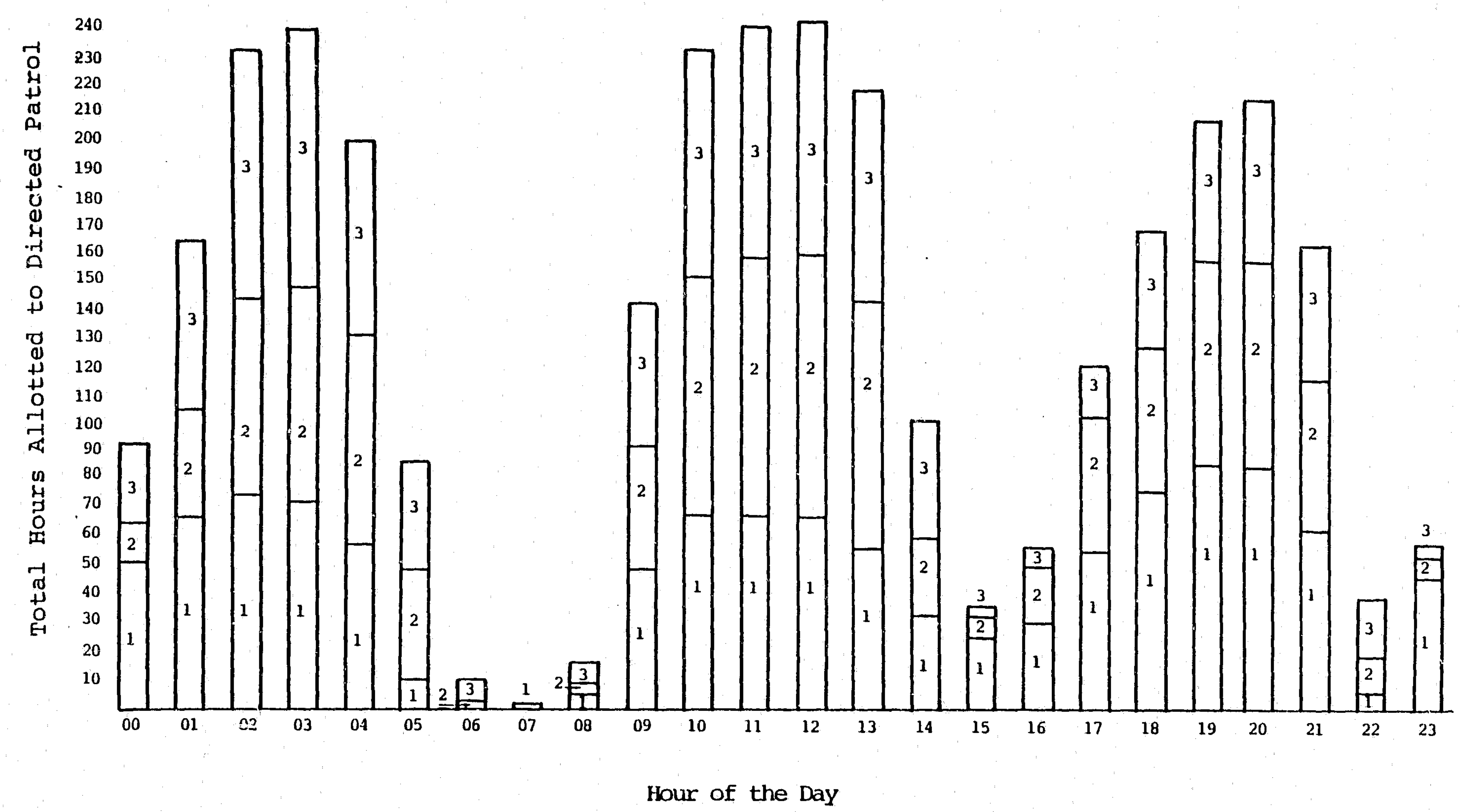
One question raised by PSE early in the research was the potential effect of individual differences among watch commanders in degree of commitment to the concept and operation of directed patrol. Examination of the hours assigned to directed patrol by watch commander could potentially have been obscured had an examination only been made using watch-based statistics. Looking only at the watch-based information would have been problematic since patrol platoons (with their watch commanders) rotated through all three watches, changing every three weeks. That is, one platoon would go from first watch (1700-1500), to night watch (2300-0700), to afternoon watch (1500-2300). Unless an examination followed the platoons and the watches, differences would be obscured. Exhibit 3.27 shows the number of hours dedicated to DP during the course of the DPE by hour of the day and by platoon. While there are some obvious differences in emphasis, in general the amount of time devoted to DP follows the busy times of both day and night. Had particular watch commanders been so inclined they could easily have the same total hours of DP but had them concentrated in the less busy hours. That they did not do so is testimony to the general commitment the watch commanders had to the concept of DP.

One interesting trend to note is the low numbers of hours allotted to DP in the hours preceeding and following the change of watches (at 0700, 1500 and 2300). From the available evidence (from field observations, interviews, radio room observations and FLAIR monitoring) it appears that all patrol coverages tend to decline in the half hour preceeding and following a roll call. Whether criminals take note of these regular periods of reduced patrol coverage is uncertain. However, it is important to note that coverage by patrol vehicles during these hours should be improved under the newly installed patrol plan which (as noted above) includes uneven manning of watches and overlay watches. A more complete discussion of the effect of police patrol on crime will be discussed in Chapter 5.

Another area of interest in the DPE was the effect of the discretionary directed patrol program on crimes and arrests. A number of analyses of the relationships between measures of directed patrol effort and crimes were conducted. None revealed any significant relationships. This was due, in part, to the difficulty of obtaining comparable crime information for subwatch time periods. However, the data do seem to suggest some interesting findings about the efficiencies of directed patrol in terms of arrests.

Exhibit 3.27

Total Hours Allotted to Directed Patrol By Hour of the Day and Platoon*



*Platoon numbers (shown within each bar of the bargraph) are included in random order to maintain anonymity.

Exhibit 3.28

Arrests by Car Hour and Man Hour Expended During the DPE

	Arrests Per Car Hour	Arrests Per Man Hour
Regular Patrol*	.034	.027
Directed Patrol		
Total	.033	.021
For Target Crime	.009	.005
For Other Crime	.024	.015

*Excluding supervisory and command officers who may be on the street.

An examination of the comparable efficiencies of directed patrol versus regular patrol officers entails analysis of arrests during the hours that the officers were "on the street." Directed patrol can be thought of as a pro-active form of police patrol. That is, because the purpose of directed patrol is to seek out potential crimes, DP officers are capable of intervening while a crime is in progress and thus more likely to result in a "good" arrest (in the sense that it would be witnessed by police officers). Regular patrol, on the other hand, can be seen as more reactive in nature, responding after-the-fact.

Exhibit 3.28 presents arrest data for the period of the DPE. The figures have been standardized by car hour and man hour to allow for a more meaningful comparison of arrest productivity between the large number of regular patrol assignments and the small number of directed patrol assignments.[12] As can be seen from the figures, cars assigned to directed patrol are no less efficient in making arrests than regular patrol cars. That is, the number of arrests per car hour is virtually identical for the two groups. (There is a difference between the two groups in terms of arrests per man hour, but it is not substantial.) Thus, removing cars from regular patrol and assigning them to directed patrol did not "hurt" the district's law enforcement capabilities. Indeed, not only do DP officers make proportionately the same number of arrests as regular patrol officers, but they may be arresting offenders who would otherwise be undetected. Regular patrol officers tend to make arrests while responding to calls for service or after the fact for reported crimes, but DP officers presumably are arresting offenders before crimes are reported.

While one might expect that the favorable performance of the DP cars was due to purposeful choice of the better officers to perform directed patrol, such does not seem to be the case. A total of 90 officers participated in the DP arrests, or approximately two out of every five officers assigned to the district, and more than half of the 160 that participated in the DPE. Thus, the comparable arrest rate for the DP cars is not due to the presence of a highly trained special tactical force, nor is it due to spectacular success in combatting a particular type of crime. It is due, simply, to the deployment of a car committed strictly to patrol, without responsibility for a call-for-service workload.

[12]Directed patrol car hours and man hours reflect the total hours officers and cars were assigned to directed patrol each shift as shown on the deployment plan. Regular patrol car hours and man hours reflect the total hours officers and cars were assigned to regular patrol each shift as shown on the deployment plan. These totals were not adjusted for call-for-service time, meal breaks, etc.

3.4 SUMMARY AND CONCLUSIONS

Consistent with the overall design of the DPE, the conclusions to be drawn from this work fall into two categories—those that relate to the capabilities of FLAIR to measure and monitor directed patrol, and those that relate to substantive issues in a discretionary directed patrol program.

Monitoring and Measuring With FLAIR

The FLAIR system can be used to measure and monitor patrol patterns under obtrusive experimental conditions. Specifically, in our work we found:

1. By "locking on" to an area or car, implementation of an obtrusive patrol experiment can be visually monitored. For example, in a directed patrol experiment, excursions by DP cars from assigned areas and incursions by other cars into the DP areas can be quickly determined, and corrective feedback can be provided to the officers in question.

2. Police patrol cars on directed patrol do not always stay in assigned areas unless corrective feedback is provided to the officer involved. This finding suggests that earlier patrol experiments that attempted deliberately to change the spatial allocation of police patrol units may not have been as successful in that regard as had been hoped or anticipated.

3. The use of FLAIR signposts allows precise measurement over prespecified times of day of the number of passings of patrol cars. Thus, for the first time, the police patrol researcher has an instrumentation capability for precisely measuring patrol intensities at prespecified points throughout the experimental area.

4. The location of the greatest patrol intensity in the entire district is, not surprisingly, the police district station house. Patrol cars tended to pass by the district's station house almost four times as frequently as the average for all the monitored points within the district (the monitoring done by FLAIR signposts).

5. It is possible to account for the presence of unmonitored cars--in our study these were primarily non-patrol commands such as canine and traffic--by requesting these officers to log their activities in the experimental areas.

Effect of the DPE

As a secondary focus of the study, we were interested in the effects of the DPE on district operations. The experiment allowed a great deal of discretion to both watch commanders and officers. Among other findings of interest, we found that this policy had a noticeable effect on deployment decisions and officer actions.

1. In a directed patrol experiment giving great discretion to the district commander, a number of different patrol configurations were selected by the various commanders in implementing directed patrol. The most popular was to assign a regular beat car to directed patrol in his ordinary beat. Calls for service from that beat would be handled by cars in two contiguous beats. The second most popular strategy was to assign a regular patrol car to an entire precinct or sergeant's area, comprising typically three or four regular beats. The remaining cars in that precinct would respond to calls for service in the depleted beat. The third most popular strategy was to reassign a regular patrol car from its ordinary beat to another beat for directed patrol activities; in this configuration, the directed patrol beat would be staffed with two cars, one for directed patrol and one with ordinary call-for-service responsibility; as before, calls for service from the depleted beat would be handled by cars in contiguous beats.

2. The district patrol commanders, when given wide discretion and flexibility in selecting numbers of directed patrol units and their patrolling locations, choose areas for directed patrol based on much more information than is provided by crime analysis alone. Thus, it appears that "street knowledge" at the district level is equally or more important in selecting directed patrol areas than is headquarter's derived crime data.

3. In a directed patrol experiment giving great discretion to the district commanders, 60 percent of the directed patrol assignments were for single target crimes, and 40 percent were for multiple target crimes. Of the single target crime assignments, 47 percent were for residential burglary, 23 percent for auto related larceny, 20 percent for street robberies and purse snatchings, and the remaining 10 percent for business burglaries.

4. The dispatching procedures implemented to remove DP cars from call-for-service responsibility were successful. DP cars were sent on fewer than one dispatched call per watch.

5. Directed patrol, and in fact, regular patrol, tended to be greatly diminished in magnitude one half hour before and one half hour following the change of watches. Three such watch changes occurred during each 24 hour period.

6. Directed patrol was no less efficient than regular patrol in terms of arrests per car hour. This is revealing, especially when the pro-active nature and the quality of the arrests are considered.

7. The chief and other commanders of the SLMPD viewed the directed patrol concept sufficiently positively following our six month study that they implemented the concept, together with other compatible provisions, on a city-wide basis.

8. Computer-based models, such as the Hypercube Queueing Model, are important planning aides both for police research and normal deployment planning. In our analysis, we used them to examine increases in area-averaged travel times and changes in operational

operational performance measures that could be expected from changes in patrol deployment practices.

9. Results from the Hypercube runs demonstrated the efficiency of the District 3 beat configuration. None of the runs designed to increase efficiency was able to improve the area-averaged travel times in the district.

4 POLICE OFFICER ATTITUDES

To supplement statistical information obtained from systems operation, PSE recognizes the importance of learning the attitudes of the officers involved in the project toward not only the concept of DP but also toward other aspects of their lives as police officers, such as the FLAIR system, community contacts, and the use of crime statistics to aid patrol.

The interest in understanding officers' attitudes toward the numerous aspects of their jobs is a long-standing one and grew out of earlier evaluations of the FLAIR system in St. Louis. In the current project, questions were asked about the system and its utility, in order to understand current feelings toward FLAIR and to be able to compare those feelings with feelings expressed by officers in previous studies. Asking questions about tactics of regular and directed patrol was an important means for soliciting ideas for future considerations. Finally, it was expected that comparisons of police officers' attitudes about the deterrent effect of directed patrol could be made with the findings from the "Nearest Neighbor Analysis" (Chapter 5). In other words, the degree to which measurements of avoidance/deterrence using videotape monitoring of the FLAIR system corresponded with the officers' attitudes toward their effectiveness would be examined.

4.1 METHODOLOGY

A detailed questionnaire (see Appendix III) was administered to all command and patrol officers on duty during the survey periods in Districts 3 and 9. The questionnaires were administered to District 9 officers in September 1980 and to District 3 officers in September 1981. The time difference is serendipitous in that it allows a comparison of attitudes between officers not involved in a directed patrol effort with those who had recently concluded such an effort.

Questionnaries were administered on an individual basis over four days. At each roll call, the watch commander mentioned that questionnaires were being administered by a PSE staff member who would also be available to answer questions and collect completed questionnaires. The officers were either called in from patrol to complete the instruments or were contacted by a staff member while in the stationhouse.

As shown below, the response rate in both districts, was in excess of sixty percent.

Questionnaire Returns

	Authorized Strength	Number Completed	Response Rate
District 9	126	83	65.9%
District 3	212	132	62.3%

It is important to note that in each district the actual numbers of officers on duty during the survey periods were less than the authorized strength, due to officers who were absent, on recreational days off, on vacation, in court, or on detached duty to other commands. Looked at another way, the response rate among the police officers on duty when the questionnaires were administered approached 100 percent.

In addition to the written survey questionnaire, police officers in District 3 were also interviewed in depth by a team consisting of PSE's subcontractor and a sworn member of the SLMPD's Planning and Development Staff. The interviews were conducted before the questionnaires were administered, but after directed patrol had been operating in the district for about five months. The interviews were open-ended and unstructured and were designed to offer District 3 personnel the opportunity to express their feelings about directed patrol as a concept and as implementated and also to solicit suggestions to improve directed patrol.

A final research approach was used but in a much more subjective and qualitative manner. PSE staff took every opportunity to engage in participant-observation with the officers in Districts 3 and 9. PSE staff rode with patrol officers and command staff but did not involve themselves in actual police activities. During these "ride-alongs" PSE staff informally interviewed the officers and recorded, as completely as possible, their responses.

As can be seen from Exhibit 4.1, the personnel of the two districts in which the research was conducted are similar demographically. Police officers in both districts are overwhelmingly male, white, and relatively educated. The officers in District 3 have served slightly more years on the police force than the officers in District 9. Median years on the police force are 9.8 years for the officers in District 3 compared to 8.5 years for personnel in District 9. Similarly, the median amount of time the officers have been assigned to the district is 5.2 years for the officers in District 3 and 4.6 years for the officers in District 9.

The three techniques used—survey questionnaires, in-depth interviews and participant-observation--allowed triangulation[1] of the results. In other words, the use of these methods of data gathering allowed the assumptions generated in one setting to be tested in another. By analyzing the relationships from a number of "angles" it is possible to make a somewhat stronger case for the conclusions drawn.

4.2 ATTITUDES TOWARD "PROGRESS"

The SLMPD officers were questioned about their attitudes toward progress

[1] See N.K. Denzin, The Research Act, Second Edition, (Chicago: Aldine-Atherton, 1978) pp. 28-29.

Exhibit 4.1

Demographic Characteristics of Police Officers in Districts 3 and 9

	District 3	District 9
SEX		
Male	96.8	97.6
Female	3.2	2.4
(N)	(126)	(82)
RACE		
White	92.7	87.8
Non-White	7.3	12.2
(N)	(123)	(82)
YEARS ON THE FORCE		
0-5	34.6	36.6
6-10	20.5	26.8
11-16	28.3	15.9
16 or more	16.5	20.7
(N)	(127)	(82)
EDUCATION		
High School Graduate	22.2	33.7
Some College	52.4	51.8
College Graduate	16.7	10.8
Other	8.7	3.7
(N)	(127)	(82)

Source: Surveys administered by PSE to District 3 officers on duty in September 1981 and District 9 officers on duty in September 1980. See Chapter 4 for more information on the survey, the methodology and the results.

in general and the FLAIR system in particular. Those questioned clearly feel their ideas were not taken into account when FLAIR was designed. As shown in Exhibit 4.2, approximately nine of every ten officers in both districts felt their opinions were not seriously considered in the design and operation of the FLAIR system. Whether it is because their ideas were not considered in the design stage or for other reasons, it is clear the officers are not currently in favor of the system. Approximately seven out of ten officers questioned said they felt the FLAIR system was not a good idea in St. Louis.

One conclusion to be drawn from this result--and other information--is that the FLAIR system has not lived up to its potential. For example, when the system was initially installed it was touted as the latest means to protect and enhance officer safety. With FLAIR, dispatchers were to be able to locate instantly officers in need of aid and thus be able to send assistance even if the officer was unable to indicate verbally his/her exact position. As noted in an earlier PSE report:

> While the importance of officer safety was strongly and continuously emphasized, the perceptions of FLAIR's performance in this area show a pattern of continuous decrease. Before FLAIR was implemented in Phase I, a large majority (77.9 percent) of the Third District officers who would be using FLAIR felt that the new system would improve officer safety. Their opinions and those of all officers in the city declined until only 21.9 percent felt that FLAIR could improve officer safety by the end of Phase II. In fact, many people felt that FLAIR decreased officer safety by providing false confidence to the officers, which led many of those who were particularly concerned about officer safety to feel that FLAIR had no effect or worsened the situation.[2]

As shown in Exhibit 4.3, the percentage of officers who feel that FLAIR has improved departmental performance in the area of officer safety increased slightly from 22.3 percent in 1976-77 to 29.2 percent in 1980-81. (The interim

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[2]G.C. Larson and J.W. Simon, Evaluation of a Police Automatic Vehicle Monitoring (AVM) System: A Study of the St. Louis Experience 1976-1977 (Washington, DC: U.S. Department of Justice, 1979) pp. 88-89.

Exhibit 4.2

Police Officer Attitudes Toward Design and Presence of the FLAIR System

Question	DISTRICT 3			DISTRICT 9		
	Yes	No	N	Yes	No	N
In designing and operating the FLAIR System do you think suggestions of patrol officers were seriously considered?	7.7%	92.3	(130)	12.1%	87.9	(83)
	Good	Bad	N	Good	Bad	N
In general, do you think it is a good idea or a bad idea to have the FLAIR System in St. Louis?	23.9%	76.1	(130)	35.4%	64.6	(82)

Exhibit 4.3

Perceived Usefulness of FLAIR Objectives

	Percent of Officers Who Felt FLAIR Improved Departmental Performance			
Objective:	AVM Study*	N	DPE	N
Reducing Response Time	19.0%	(493)	25.2%	(214)
Officer Safety	22.3%	(476)	29.2%	(212)
Dispatch Operations	18.0%	(467)	19.2%	(213)
Increasing Radio Access	33.6%	(482)	37.6%	(210)
Command and Control	—		15.7%	(210)

*Larson and Simon, Evaluation of a Police Automatic..., pp. 78-104.

period brought enhancements to the FLAIR system which improved the locational accuracy through the installation of fixed signposts which automatically transmit a car's exact location, as the car passes the signpost). Similarly, for the other objectives noted in the exhibit, there have also been an increase in the percentage of officers who feel FLAIR has improved departmental performance in specific areas.

Exhibit 4.4 shows responses of officers toward the effect of FLAIR on patrol operations. The majority of officers questioned felt that FLAIR had not improved departmental performance in the specific areas of police operations noted. In fact, the only area in which a large percentage of officers thought there had been improvement was in "keeping track of the patrol force." In this instance it was not clear that the ability to keep track of the patrol force was seen positively. Contrary to stated intentions, shortly before the questionnaires were distributed in District 3 a number of officers from another district had been disciplined for congregating too closely together. The patrol cars were "seen" by a command officer using a FLAIR monitor at head-quarters who in turn dispatched a command officer to determine the circumstances. When no valid reason for the meeting was shown, the police officers were disciplined.

When asked how their tasks as patrol officers were affected by FLAIR, officers showed surprisingly little change between 1975 and 1981. The only significant change, as noted in Exhibit 4.5, was a decrease in the percentage of officers who felt FLAIR increased their ability to coordinate operations with fellow officers. Such a decrease is noteworthy because one of the major reasons for FLAIR's presence in the department was to have been its ability to allow dispatchers and commanders to deploy officers as needed and as dictated

Exhibit 4.4

Percent of Officers Who Feel The FLAIR System

Has Improved Police Department Operations

Police Operations	District 3	N	District 9	N
Keeping Track of The Patrol Force	38.6%	(132)	31.3%	(83)
Handling Extraordinary Events Like Pursuits	22.7%	(132)	22.9%	(83)
Effective Resource Utilization	6.8%	(132)	12.1%	(83)
Efficient Use of Available Patrol Time	10.6%	(132)	14.8%	(83)

by circumstances within a district. FLAIR was, in other words, to be used dynamically to allocate officers throughout a district—or even potentially throughout the city—in response to changing conditions. It would appear that the officers questioned do not feel this aspect of FLAIR has been used well.

Exhibit 4.6 summarizes the officers' feelings toward the FLAIR system as these attitudes have evolved over time. Within District 3, where FLAIR was first implemented, there has been a steady and continued decrease in the percentage of officers who feel that FLAIR was a good idea. Before the introduction of the system in 1974, 64.4 percent of the officers felt that FLAIR was a good idea for the police department. By the time of the DPE, approximately seven years later, the percentage of officers who felt FLAIR was a good idea for the department had declined to 23.8 percent of the total. One can only speculate on the reason for the decline but it does not seem unreasonable to suggest, based on discussions with the officers involved, that the primary reason for the change in attitudes was due to the fact that

Exhibit 4.5

Comparison of Police Officer Attitudes Toward Ability to Perform Task As a Result of FLAIR

Statement: As a result of FLAIR, my ability to perform this task has...

District 3

Task	1975*				1981			
	Increased	Stayed the Same	Decreased	N	Increased	Stayed the Same	Decreased	N
Preventive Patrol	8.8	77.0	14.2	(119)	4.6	83.1	12.3	(130)
Flexibility to follow individual hunches	2.6	48.7	48.7	(119)	3.1	48.5	48.5	(130)
Coordinated operations with fellow officers	8.0	62.8	29.2	(119)	0.8	64.6	34.6	(130)

*See R.C. Larson, K. Colton and G. Larson, Evaluation of a Police Implemented AVM System, Phase I, Volume II, Cambridge, MA: Public Systems Evaluation, Inc., 1976, p. 484.

Exhibit 4.6

Attitudes Toward FLAIR Over Time*

Question: In general do you think it is a good idea or not a good idea to have the FLAIR system in St. Louis?

District 3 Officers	Before FLAIR (August 1974)	During Phase I (April 1975)	Before Phase II (July 1976)	During Phase II (Sept. 1977)	During DPE (Sept. 1981)
Good Idea	64.4%	39.8%	35.2%	30.2%	23.8%
Not a Good Idea	35.6	60.2	64.8	69.8	76.2
N	(166)	(119)	(128)	(126)	(130)

*Source for data from previous periods: Larson and Simon, Evaluation of A Police Automatic..., p. 81/

Exhibit 4.7

Median Scores For Officers Describing Feelings

About New Technologies and New Procedures

	Median Scores*			
	District 3	N	District 9	N
New Technologies	3.353	(128)	3.156	(81)
New Procedures	3.825	(129)	3.342	(81)

*The higher the score the more the officers feel the statement is "a bad idea." The scores range from 1 to 7.

FLAIR's abilities were oversold in the early phases of the project. When the system was unable to perform as advertised, the officers became increasingly less inclined to think that it (1) could improve performance in specific areas and (2) was a good idea for the city.

To say that the officers changed their minds about FLAIR and its abilities is not to suggest they are averse to the introduction of new technology and new procedures into the police department. While the distribution of responses is somewhat spread, as shown by the medians in Exhibit 4.7, it is important to note that the modal category for both groups combined is category 1, which represented "a very good idea." Officers questioned, in other words, may well feel that a specific technology or procedure is not a good idea for the department while at the same time indicating that new procedures and new technologies in general are a good idea for the department. The officers seem to be saying that while FLAIR may not have worked out as well as they might have wished, this fact does not mean they are unwilling to try other new ideas which may aid them in their jobs as police officers.

4.3 ATTITUDES TOWARD DIRECTED PATROL

As noted earlier, an important component of the investigation of the effect of directed patrol is the officers' attitudes toward this type of patrol. In the following analysis, the officers from District 9 serve as a "before" group in that they were questioned about their attitudes without having experienced directed patrol as subsequently implemented in the SLMPD. Likewise, the officers of District 3 serve as the "after" group because they were questioned at the conclusion of the project.[3] Additionally, the understandings possessed by the officers of the District 9 were based on their interpretations of the explanations in the questionnaire combined with PSE's limited presentations at their roll calls. The District 3 officers, in addition, were exposed to the concepts of directed patrol in practice, in PSE's participant observation, at roll calls, in the in-depth interviews, and through repeated on-site presence of PSE staff at the station house.

4.3.1 Questionnaire Results

Exhibit 4.8 shows the attitudes of the officers in the two police districts toward specific issues in regular and directed patrol. In every case, District 3 officers--who had participated in the project--were less inclined to see either tactic as very effective than those from District 9 who had not been involved. It is important to note here that officers were asked to respond to a concept in the abstract without having the opportunity to divide the idea into its component parts. An analogy might be to ask persons

[3]The major difference between the two groups occurs because the patrol plan in District 9 involves a limited open beat approach while that in District 3 is a more traditional beat pattern. The open beat approach allows patrol cars within any precinct, on specified watch, to roam that area at will, responding to calls as they became free. All cars have overlapping area responsibility within the precinct.

Exhibit 4.8

Officers' Attitudes Toward Effectiveness of Directed and Regular Patrol

Issue	District 3	N	District 9	N
Percent of Officers Who Feel Directed Patrol Would Be Very Effective				
Preventing Crimes	3.1%	(130)	12.1%	(83)
Deterring Crimes	4.6%	(130)	14.5%	(83)
Increasing Police Visibility in the Street	12.3%	(130)	19.3%	(83)
Percent of Officers Who Feel Regular Patrol Would Be Very Effective				
Preventing Crimes	6.9%	(130)	12.1%	(83)
Deterring Crimes	10.7%	(130)	15.7%	(83)
Increasing Police Visibility in the Street	20.0%	(130)	24.1%	(83)

to rate "the service" at a restaurant as an entity, rather than asking them to rate specific aspects of that service (such as food preparation, cleanliness, promptness, food quality, freshness, etc.).

As shown in Exhibit 4.9, officers were asked to rate specific tactics that could be used in directed patrol and provide their estimates of the effectiveness of each. Except for reversing the rank order of preference, officers in both districts feel that two most effective tactics in directed patrol are: questioning of suspicious persons, and two-officer patrol cars. Further, the top ten tactics for both groups tend to be tactics one might label as aggressive patrol tactics: quicker response times, knowing whereabouts of convicted offenders, knowing the modus operandi of recent crimes and so on. At the other extreme, some of the more innovative approaches to patrol (splitting a force, delaying response to calls, and using civilians) fared poorly, being ranked consistently near the bottom. The officers of both districts agree on

Exhibit 4.9

Officers Feelings Toward Specific Directed Patrol Tactics

PERCENT OF OFFICERS WHO FEEL TACTIC EFFECTIVE AND RANK OF THAT TACTIC

TACTIC	District 3 %	Rank	(N)	District 9 %	Rank	(N)
Aggressive checking of doors and windows	62.6	7	(77)	67.5	12	(52)
Questioning of suspicious persons	77.2	1	(95)	77.9	2	(60)
Splitting the force into a force only answering calls for service and a force only doing patrol	39.8	19	(49)	34.2	18	(26)
Delaying response to low priority calls for service	53.3	15	(65)	52.6	17	(40)
Surveillance	60.2	9	(74)	60.5	15	(46)
Stake-out	57.4	12	(70)	57.9	16	(44)
Marked cars	47.5	16	(58)	73.7	5	(56)
Slow speed patrol	56.7	13	(68)	73.3	6	(55)
One officer cars	18.9	22	(23)	22.4	20	(17)
Off-duty use of patrol cars	47.5	16	(58)	73.7	6	(56)
Civilians to handle noncritical calls for service	43.4	18	(53)	34.2	18	(26)
Foot patrol	58.5	11	(72)	72.0	8	(54)
Quicker response time	60.2	9	(74)	68.4	10	(52)
Knowing the whereabouts of formerly convicted offenders in the community	67.5	3	(83)	69.7	9	(53)
Having one or more patrol cars deliberately follow a lead car (with one or two blocks separating them) so that criminals could not predict times of relative safety to commit crimes	21.7	20	(26)	19.7	22	(15)
Knowing the <u>modus operandi</u> of recently committed crimes	63.1	6	(77)	75.0	4	(57)
Saturation patrol	56.6	14	(69)	76.3	3	(58)
Unmarked cars	65.9	4,5	(81)	68.4	10	(52)
High speed patrol	19.8	21	(24)	21.1	21	(16)
Two officer cars	74.8	2	(92)	85.5	1	(65)
District meetings to discuss critical police issues among officers	60.2	9	(74)	64.5	13	(49)
Knowing the leaders of youth gangs in the community	65.9	4,5	(81)	63.2	14	(48)

the three least effective tactics (although not on the rank order): playing "follow the leader", the use of one-officer cars, and high speed patrol. While it is not possible to draw absolute conclusions about these findings, it would seem to be the case that the officers feel that relying on "tried and true" tactics of police work, if these are applied diligently, will be the best and most productive ways in which to conduct preventive patrol.

It is interesting that the use of unmarked cars received a large percentage of responses as being a tactic which would be effective. If directed patrol—as one would expect—is to be composed of obvious police cars making an effort to deter crime, one would not expect officers who favored the use of unmarked cars for directed patrol. On the other hand, many officers in conversation indicated their interest in using unmarked cars to lull the criminals, making them easier to apprehend. As will be noted below, officers interviewed in-depth about improving directed patrol noted the importance of using a mix of marked and unmarked cars.[4]

When given the opportunity to express their opinions on improving patrol, a large majority (over 75 percent in each district) responded to an open-ended question asking them to describe the best way to improve the effectiveness of patrol. Further, 27.4 percent volunteered a second technique to improve effectiveness and 8.4 percent volunteered more than two techniques. Exhibit 4.10 presents the items most often mentioned by the officers in the two districts as techniques which could be used to increase the effectiveness of patrol (and by implication directed/preventive patrol). Contrary to the approaches suggested in the more general comments about the effectiveness of

[4] The directed patrol experiment expressly denied commanders the use of unmarked cars for directed patrol activities. It was not until the completion of the experiment that unmarked cars could be used in the district for directed patrol. An interesting comparison could be made between the success (i.e., arrest) rates under both conditions.

Exhibit 4.10

Rank Order of Responses to Open-Ended Question Asking Officers

To Suggest Ways To Improve Patrol, First Response Only

	District 3		District 9	
	Rank	(N)	Rank	(N)
Allow More Individual Discretion	1	(20)	6	(5)
Increase Use of Crime Information	2	(14)	5	(6)
General Comments on Improving Patrol	3	(12)	7	(2)
Use More Two-Officer Teams	4	(9)	1	(12)
Eliminate Non-Critical Calls-for-Service	5	(7)	2	(9)
Add More Personnel	6	(6)	4	(7)
Increased Use of Saturation Patrol	7	(4)	3	(8)
Comments Not Elsewhere Classified	-	(7)	-	-

tactics, officers, when given free reign to use their imaginations, see a number of innovations in policing that could improve patrol. It might well be argued that in this question officers were attempting to send a message that they wished to be given more assistance in doing their jobs—either by being relieved of responsibility for non-police-oriented activities or by getting "an edge" over criminals through the increased use of crime statistics.

4.3.2 In-Depth Interviews

As noted above, interviews with officers and commanders of District 3 were undertaken by PSE's on-site sub-contractor and a sworn member of the SLMPD, Planning and Development Staff. The interviews were conducted in the

last two weeks of May 1981, and were completed approximately two weeks before the end of the formal data gathering for the directed patrol portion of study. These interviews were open-ended and unstructured and were designed to offer District 3 personnel an opportunity to express their feelings about directed patrol as a concept, about the implementation of directed patrol and finally, to solicit suggestions for improvement of directed patrol.

The officers' feelings about the concept of directed patrol generally reflected negative impressions derived from other police patrol experiments (particularly the Kansas City Preventive Patrol Experiment [KCPPE][5]) and were expressed in ways which suggested that directed patrol would probably not result in criminal apprehension. Directed patrol was seen as a potential for deterring crimes to another time or another place rather than as a useful technique for apprehension. Officers also felt they had been led to believe—referring to the KCPPE—that directed patrol was to include area saturation by patrol units, rather than using a car free from radio assignments and removed from responsibility for an area. It was the officers' opinion that removing a car from area responsibility did not bolster the directed patrol effort but simply left the area uncovered.

One of the major problem areas uncovered deals with the fact that other patrol officers feel those on DP are "not carrying their weight." Such feelings seem to be expressed more often on busy nights than slow ones, and may well be exacerbated by two practices: (1) requiring DP officers to turn arrests over to other officers, thus returning them to directed patrol more quickly, and (2) not allowing the officers on directed patrol to answer even high priority calls for service. Police officers feel they should have the responsibility for following an arrest through to its conclusion and resent (1)

[5]George L. Kelling, et. al, The Kansas City Preventive Patrol Experiment (Washington, DC: The Police Foundation, 1974)

turning it over to others or (2) having an arrest turned over to them. Not responding to calls for service, especially those of high priority, also frustrates officers and results in a degree of boredom. Finally, some officers feel they are discouraged from making arrests for non-target crimes while on directed patrol. Whether this is a real or perceived problem is not clear at this time.

The officers' feelings about the implementation of directed patrol in District 3 were almost uniformly negative. At the same time, there was no general agreement on the source of these negative feelings. One area in which there was some agreement was stated as the feeling that there did not seem to be adequate direction. Thus, some DP areas were too large and others were too small. Officers felt that they were often assigned to an area they did not know well, if at all. On the other hand, officers assigned to directed patrol in their own areas cited boredom as their major objection to the assignment. Further, changing the target crime by day or watch often obscured, for the officers, the nature of the assignment. Additionally, the frequent change of area and target crime made it difficult--from the officers' point of view--to learn enough about the area and potential perpetrators for the police to have a significant impact on crime. Due to the perceived lack of a clear rationale for assignments, the officers see directed patrol as either a reward or a punishment depending on their own points of view.

As noted above, the majority of the officers interviewed felt that the lack of radio assignments contributed to (1) boredom, (2) animosity by officers on radio assignments and (3) frustration at not being allowed to get involved in "the action." Officers feel territorial toward their usual assignment areas and resent it when another car must answer calls they are forbidden to answer. Finally, a resentment toward the fact that the directed patrol car was not

allowed to handle high priority calls officially (i.e., was not dispatched) but had to handle them somewhat surreptitiously was also noted. The "need" to take matters into their own hands also caused officers to feel resentment toward the directed patrol concept as implemented.

The officers interviewed strongly recommended improving communication between the various units involved in patrol, investigation and data analysis. The interviewees suggested the following types of information, if supplied to the directed patrol units, might aid in performing more "effective" directed patrol: wanted subjects information, arrest register for persons living in the District and suspect information. Further, the interviewees felt that once problems have been identified, directed patrol should only be rotated throughout a sergeant's area rather than the District as a whole. Because officers feel they know their own and immediately adjacent beats best, they feel it advantageous not to be rotated too far. Finally, many officers suggested the addition of a plain clothes task force to augment the uniformed directed patrol activities.

Based on officers' comments, it can be suggested that communications and organizational problems within the District 3 and between District 3 and the main headquarters contributed significantly to the problems noted by the officers. Clearly, without open communication lines between all persons involved, and a full understanding of the reasons for directed patrol and directed patrol assignments, problems were bound to occur. Problems also occurred through the less than rigorous application (and use) of crime analysis and statistics.

4.4 CRIME STATISTICS AND PATROL

One of the major tools used by police in recent years to give them "an edge" against criminals is the use of crime statistics for predictions. As the numbers of computers in police departments has grown, so has the application of crime statistics. Despite this, it appears that the utilization of crime statistics varies not only from one police department to another, but even within a department.

As shown in Exhibit 4.11, many more police officers in District 9 indicate that crime statistics are used to increase their effectiveness than do officers in District 3. One reason for this large discrepancy in the use of statistics may well be the attitudes of the command staff toward their use. In District 9, the captain's aide updated crime maps regularly based on figures from the bulletins prepared by the department's crime analysis section. These crime maps were prominently displayed in the District Captain's office where officers were free to examine them. The crime statistics were also used extensively on the street by supervisors in an attempt to alert patrol officers of to potential trouble spots. In District 3, on the other hand, the crime maps were updated by the night detective sergeant and were kept in the detective squad room. While officers were certainly allowed to examine the crime maps in District 3, this did not appear to be a priority. Likewise at roll call, commanders in District 9 tended to refer to the crime analysis bulletins to alert officers to potential trouble spots. In District 3, even during the

Exhibit 4.11

Officers' Perceptions of the Use of Crime Statistics To Improve Patrol

Crime Statistics:	District 3	District 9
Used	57.7%	80.7%
Not Used	42.3	19.3
TOTAL	100.0%	100.0%
(N)	(130)	(83)

period of the DPE, it was unclear to what use the bulletins were being put by watch commanders. Finally, it was clear that the use of crime statistics on the street was less extensive in District 3 than in the District 9.

Because the crime statistics were used with great frequency in one district and not in the other, it is not surprising to find officers differing about the degree to which their use affects the job. As shown in Exhibit 4.12, three-quarters of the District 9 officers felt that the use of crime statistics improved their job compared to one-half of the District 3 officers. Further, almost one-half of the District 3 officers felt the use of crime statistics would have no effect on their job compared to only one-fifth in District 9. Those who regularly used crime statistics found them to improve the job while those who used them less often were not quite so certain.

4.5 POLICE PATROL AND CRIME

Of particular interest to the DPE project are the officers' attitudes toward the deterrent effects of directed patrol and the degree to which the officers feel criminals take police presence into account when committing a crime. These attitudes are especially important when examined in conjunction with the results of the Nearest Neighbor Analysis (see Chapter 5).

Exhibit 4.12

Officers' Perceptions of How Use of Crime Statistics To Position or Direct Patrol Would Affect Job

Affect Job:	District 3	District 9
Improve Job	50.0%	75.9%
No Effect	45.4	22.9
Worsen Job	4.6	1.2
TOTAL	100.0%	100.0%
(N)	(130)	(83)

As shown in Exhibit 4.13, police officers in both districts do not feel, on the average, that criminals engage in avoidance behavior either generally or when committing a housebreak or robbery. Exhibit 4.14 takes the analysis one step further and inquires whether, in the opinion of police officers, criminals in specific circumstances take police presence into account. As in the previous exhibit, the more likely a crime is to occur on a street or in a public place, the more the police feel their presence has a potential deterrent effect. It is important to note that in no case, except that for rape in a public place, do the police feel that their presence is more than "somewhat effective" in deterring or preventing crime. For the case of rape in a public place, the average response moves toward the "very effective" category.

Exhibit 4.13

Mean Scores* of Officer Attitudes Toward Correctness of Statements About Patrol Effectiveness

	MEAN SCORE*			
Statement	District 3	N	District 9	N
In order to avoid apprehension many criminals time their crimes to be immediately after a patrol car passes.	3.92	(131)	4.94	(81)
Many housebreakers listen to the police radio and time their break-ins to occur when the local beat car is busy on a call for service.	3.78	(129)	3.63	(82)
Many armed robbers choose the location of their robbery without regard to the whereabouts and activities of nearby patrol cars.	5.41	(129)	5.29	(82)

*The higher the score the more the officers feel the statement is correct. The scores range from 0 to 10.

Exhibit 4.14

Mean Scores* of Attitudes Toward Effectiveness of Patrol to Preventing Specific Crimes

	District 3	District 9
First Degree Murder of an Acquaintance	0.65	0.99
Armed Robbery of a Liquor Store	4.98	5.17
Armed Robbery of a Person in the Street	5.11	5.00
Housebreak of a Single Family Home	4.09	3.98
Rape in a Public Place	5.95	5.99
Auto Theft on a Street	4.30	4.83
Street Assault of a Stranger	4.52	4.82
	(N=124)	(N=79)

*The higher the score the more effective is patrol seen as a preventive or deterrent. The scores range from 0 to 10.

The questions related to Exhibit 4.15 asked the police to put themselves in a criminal's "shoes" and assess to what degree criminals take police presence into account when committing the same specific crimes examined in Exhibit 4.14. It is only when committing the most obvious "crime of passion"—murder of an acquaintance—that criminals are not thought to be concerned about police presence. In all other cases, the police believe that the criminals are at least somewhat concerned with police presence. The differences between the two districts in the mean scores are not, however, sufficiently large to draw any meaningful statistical conclusions. What is significant is that contrary to what was noted earlier—that the police believe criminals do not pay attention to police presence--police do believe that in committing certain crimes, criminals note the whereabouts of police and act accordingly.

In order to understand more clearly the officers' feelings toward the effectiveness of directed patrol in preventing and deterring crime, the

Exhibit 4.15

Mean Scores* of Attitudes Toward Degree To Which Criminals Ignore Police Presence When Committing Specific Crimes

	District 3	District 9
First Degree Murder of An Acquaintance	1.35	1.80
Armed Robbery of a Liquor Store	5.87	5.94
Armed Robbery of a Person in the Street	6.15	6.10
Housebreak of a Single Family Home	5.21	5.20
Rape in a Public Place	6.52	6.08
Auto Theft on a Street	5.49	5.66
Street Assault of a Stranger	5.26	5.53
	(N=124)	(N=79)

*The higher the score the more the officers feel criminals observe patrol cars. The scores range from 0 to 10.

relationship between the degree to which criminals pay attention to police presence was examined in terms of the attitudes of officers toward the effectiveness of directed patrol. As shown in the cross-tabulation of Exhibit 4.16, District 3 officers who feel that directed patrol is very effective in preventing crime tend to be more certain about criminals ignoring their presence than do other officers. It is possible that officers who feel directed patrol is effective do not think criminals pay attention to police activity. Conversely, those who think directed patrol is less effective in preventing crime see criminals as effective in evading police patrol. In other words, those police officers who see directed patrol as effective may also be the ones who (1) are more successful at apprehending criminals, (2) work harder at their jobs, and (3) consequently, see criminals as having only limited success at evading the police.

Exhibit 4.16

Mean Scores* For Degree to Which Police Feel Criminals Observe Police by Effectiveness of PREVENTIVE Aspect of Directed Patrol

DISTRICT 3

	Directed Patrol as Prevention		
Statement	Very Effective	Effective	Not Very Effective
In order to avoid apprehension many criminals time their crimes to immediately after a patrol car passes.	4.25	3.90	3.87
Many housebreakers listen to the police radio and time their break-ins to occur when the local beat car is busy on a call for service.	4.75	3.70	3.72
Many armed robbers choose the location of their robbery without regard to the whereabouts and activities of nearby patrol cars.	5.25	4.47	5.66
	(N=4)	(N=30)	(N=88)

*The higher the score the more an officer agreed with the statement. The scores ranged from 0 to 10.

A similar conclusion can be drawn from the cross-tabulated results in Exhibit 4.17. Officers were asked to look at the effectiveness of directed patrol in deterring, as opposed to preventing, crime. As the mean scores for each avoidance question show, officers who see directed patrol as effective in deterring crime, again, are less likely to see criminals as working to evade detection in any rational or meaningful way. These officers tend to think the statements about avoidance are, on the average, less correct than do officers who feel that directed patrol is not effective in deterring crime.

Exhibit 4.17

Mean Scores* For Degree to Which Police Feel Criminals Observe

Police By Effectiveness of DETERRENT Aspect of Directed Patrol

DISTRICT 3

Directed Patrol as Deterrent

Statement	Very Effective	Effective	Not Very Effective
In order to avoid apprehension, many criminals time their crimes to immediately after a patrol car passes.	4.33	4.07	3.84
Many housebreakers listen to the police radio and time their break-ins to occur when the local beat car is busy on a call for service.	5.00	3.80	3.64
Many armed robbers choose the location of their robbery without regard to the whereabouts and activities of nearby patrol cars.	5.00	4.50	5.67
	(N=6)	(N=30)	(N=86)

*The higher a score the more an officer agreed with the statement. Scores ranged from 0 to 10.

4.6 SUMMARY AND CONCLUSIONS

It seems clear that the attitudes of police officers toward themselves and their work are not vastly different from attitudes expressed by people in other occupations--attitudes are somewhat difficult to isolate and are less than clear in many circumstances. The following represent the major points made in this chapter:

Technology and Progress

For a variety of reasons, police officers in St. Louis no longer feel the FLAIR system is a good idea. In fact, there has been a steady and continual decrease in officer support for FLAIR since the system was introduced.

The only area in which a large number of police officers feel FLAIR has improved departmental performance is in "keeping track of the patrol force."

Police officers feel strongly that their opinions were not taken into account in designing the FLAIR system.

Despite negative attitudes toward FLAIR, officers do not generally oppose new technologies and procedures in police work.

Directed and Preventive Patrol

The great majority of police officers do not feel directed patrol would be effective in either preventing or deterring crime.

Two-officer cars and the questioning of suspicious persons are seen as the most effective tactics for directed patrol.

Increased use of crime information, the use of two officer teams and the elimination of non-critical calls-for-service are suggestions offered spontaneously for improving patrol.

Police officers feel that traditional tactics are the best to apply in directed patrol but are willing to try others.

The assignment of police officers to directed patrol is seen by them as either a punishment or as a reward.

The importance of communication between all personnel involved in directed patrol cannot be overstated.

Police Patrol and Crime

Police, in general, do not feel criminals pay a great deal of attention to the presence of police.

For certain crimes, police believe perpetrators note the whereabouts of the police and act accordingly.

Police officers who believe in the effectiveness of directed patrol are less likely to think criminals observe police activities.

The use of crime statistics to combat crime would seem to be a function of command attitude rather than officer willingness.

5 THE DISTANCE BETWEEN CRIMES AND POLICE CARS: TESTING FOR INDEPENDENCE

A major purpose of our work in St. Louis was to demonstrate the feasibility and utility of using a new technology—Automatic Vehicle Monitoring (AVM) systems—as a research tool. In other chapters we have shown how AVM can be used to monitor police patrol car locations. In police patrol experiments that deliberately manipulate the locations and patrolling patterns of police cars, the monitoring capability provides the first feasible control mechanism available to police researchers to maintain the integrity of experimental conditions. Virtually all previous patrol experiments suffer to some extent because of the lack of such experimental monitoring.

In addition to the monitoring function, earlier in this report we have demonstrated how AVM can also be used as a basic research tool. Our reported analyses (in Chapter 2) describe the statistical behavior of patrolling patterns (e.g., the mean and distribution of the number of blocks that are traveled between turns, the serial correlation of the numbers of blocks traveled between turns, etc.). Potentially, it could be this basic research capability of AVM that provides the most far-reaching and exciting opportunities for police researchers.

In this chapter our goal is to indicate by detailed example the type of basic research analysis now possible with AVM. Our focus is on the following question:

> When a criminal is deciding whether or not to commit a crime at a particular time and location, does he/she take into account the locations of nearby police patrol cars?

For crimes reported in progress (or shortly after completion), AVM provides a detailed picture of the locations and patrolling patterns of nearby patrol cars. Given a crime (say a street robbery) at a particular time and location, a police researcher using AVM can measure travel distances to the closest police car (at the time of the crime), to the second closest police car, etc. One might speculate that a "rational" criminal who weighs risks and benefits prior to commiting a criminal act would select the times and locations of his/her crimes to be farther from police patrol cars than one might expect from "random chance." That is, a rational criminal would attempt to avoid police patrols as a means for avoiding police detection and apprehension. On the other hand, one might speculate that at least some criminals are either risk-prone or indifferent to police presence, perhaps believing that the risk of on-site apprehension is so small that it can be ignored.

For the case of the risk-prone individual, the distance between his/her crime location at the time of the crime and the nearest police patrol car is determined solely by random chance. In the case of the risk averse individual, the distance between the crime and the closest police car would tend statistically to be larger than what one would expect from random chance.

AVM allows one to begin to address the types of hypotheses suggested above. In some ways, the AVM capability is analogous to a biologist's microscope, but instead of studying the distances and interactions between, say, mutant and normal cells, we are studying the distances between crimes and police patrol cars. We feel very fortunate to be the first police researchers to utilize this exciting new research tool.

This chapter contains four sections. In Section 1, we define what we mean by "random chance" and thereby develop a predictive theory for the distance from a crime to the closest police car under the null hypothesis of independence between crime locations and police car locations. We develop three alternative procedures for predicting these distances under the null hypothesis, and fortunately for the types of questions we are asking, all three essentially predict the same type of statistical behavior. In Section 2, we

describe a limited sample of 117 crime incidents that were monitored and analyzed for this study. Careful consideration is given to verification and experimental controls. Section 3 contains the results of the statistical analysis, whereas Section 4 contains a discussion of possible policy implications of our results. All of the relevent mathematical modeling theory is developed in Appendix IV.

5.1 PREDICTING DISTANCES BETWEEN CRIMES AND NEARBY POLICE CARS

In this section we derive the statistical behavior of the distance between a crime and the closest police car. These "probability laws" are required to test formally, the two competing hypotheses: H_0 (null hypothesis), crimes occur independently of police car locations; H_1 (alternative hypothesis), crimes occur in a way that depends on police car locations. We will restrict our family of H_1 hypotheses to those for which there is a deliberate avoidance of police cars by criminals.

Under the null hypothesis of independence, we might expect that the probability density function[1] (PDF) for the distance between a crime and the nearest police patrol car might resemble that shown in Exhibit 5.1. Under the alternative hypothesis of avoidance, we would expect the probability density function to be shifted to the right, also as shown in Exhibit 5.1. Another way to display these same models is to use cumulative probability distribution functions (CDFs), as shown in Exhibit 5.2. CDFs have the advantage that one can read intuitively appealing values of probabilities directly from the curve. The value of a CDF at a particular distance, say 1,000 feet, is the probability that for a random crime the closest patrol car will be closer than 1000 feet.

[1] A probability density function is the underlying theoretical curve that gives rise to empirical histograms in data collection procedures. As the sample size of an experiment increases, the histogram approaches in appearance the probability density function that generated the data.

Exhibit 5.1

Two Plausible Probability Density Functions (PDFs)

for Distance from a Crime to the Closest Police Car

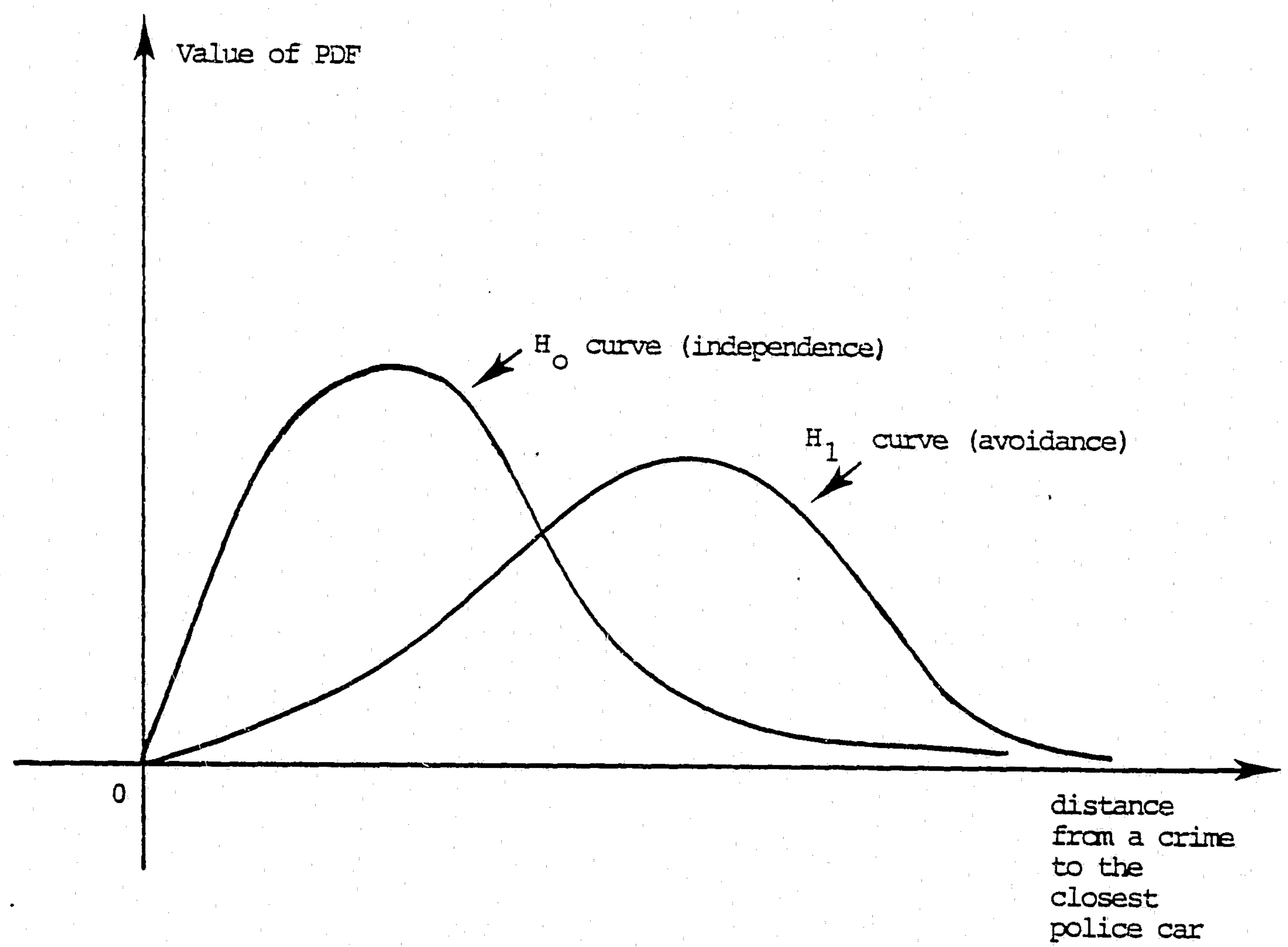
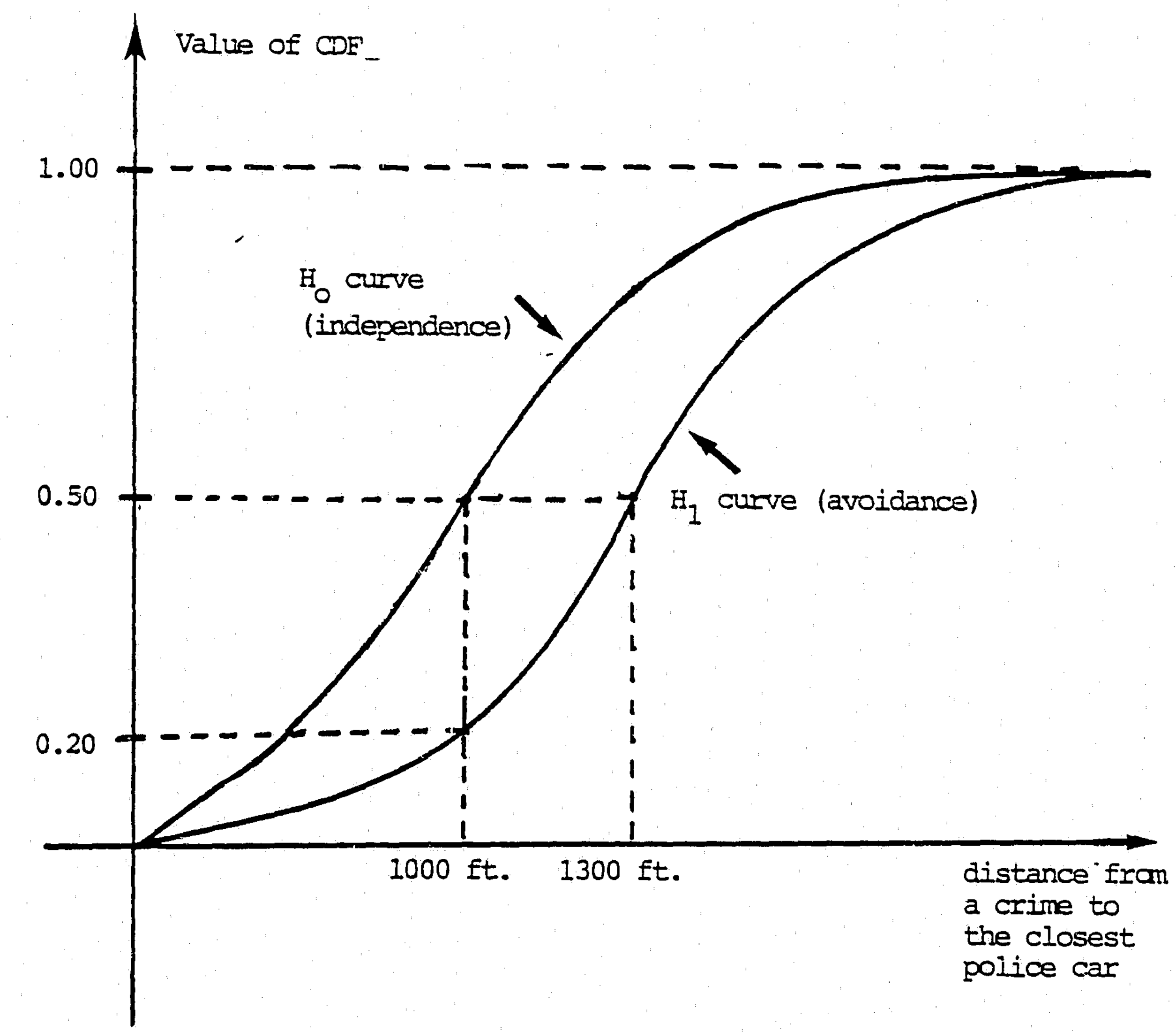


Exhibit 5.2

Two Plausible Cumulative Probability Distribution Functions

(CDFs) for Distance from a Crime to the Closest Police Car



Our CDFs always start at a value equal to zero (at zero feet), climb smoothly and continuously, and eventually reach the value of one (reflecting the fact that eventually the closest police car must be within, say, one million feet of the crime). In Exhibit 5.2, we have shown two CDFs: one for the null hypothesis (H_0) of independence and the other for the competing hypothesis (H_1) of avoidance. As drawn in Exhibit 5.2, there is fully a 50 percent chance that the closest police car will be within 1000 feet of a random crime, given the null hypothesis of independence. Under the alternative hypothesis of avoidance (H_1) there is only a 20 percent chance that the closest police car will be within 1000 feet. Also under H_1, there is a 50 percent chance that the closest police car will be within 1300 feet. A consequence of these numbers is that there is a 30 percent chance that under H_1 the closest police car will be between 1000 and 1300 feet from the crime. Because of the intuitive appeal of CDFs (over PDFs) and because of their proneness to more statistical stability (when compared to PDFs), our derived probability laws and our empirical results will usually be displayed as CDFs.

All of our distance measurements are made assuming the "Manhattan" or "right-angle" distance metric. By this, we mean that cars only have four directions in which to travel, typically east, west, north and south. This metric is more appropriate for describing travel distances in a city than, say, the Euclidean ("as the crow flies") metric. A visual inspection of the street map of District 3 will reveal the desirability of the Manhattan metric as compared to the Euclidean metric. When the Manhattan metric is used, the set of points that are a fixed distance from a given point is a square rotated at a 45° angle to the directions of travel. (For the Euclidean metric, the corresponding figure is a circle.) Templates of such rotated squares were used to measure travel distances from maps in St. Louis.

5.1.1 Spatial Poisson Process

One can generate a simple model for the probability law for the distance between a crime and the closest police car by resorting to the theory of spatial Poisson processes. For such a process operating in two dimensions, one assumes that there are "entities" distributed throughout the two dimensional space, with the average density of such entities being G entities per unit of area. For instance, if G = 2 and the unit of area is a square mile, then we have a process with 2 entities (on average) per square mile. The locations of these entities are "totally random," as if one had determined them by throwing darts blindfolded at a wall.[2] The numbers of entities in nonoverlapping areas are assumed to be independent. The likelihood of an entity being in a particular very small area, say $1/1000^{th}$ of a square mile, is approximately $(1/1000) \cdot G$, or from the example above, $(1/1000) \cdot 2 = 2/1000$.

The name Poisson process derives from the fact the probability law of the number of entities in any prespecified region having area A obeys a Poisson probability law having mean GA.[3] These processes have been utilized before by biologists examining distances between cells in a microscope slide, by astronomers examining distances between stars in galaxies,[4] and by others dealing with probabilities in a spatial environment.

In a police application, the Poisson entities would be patrol cars. Under H_0, one picks a random point in the plane containing G patrol cars per square mile, and one derives the probability law for the distance from the random point to the nearest police car. This derivation is sometimes called

[2] The purpose of our discussion of technical topics in this chapter is to maximize the accessibility of essential points and to develop intuition. Appendix IV contains full technical details.

[3] That is, the probability that there are n entities in a fixed region of area A is $(GA)^n e^{-GA}/n!$ for n=0,1,2,...

[4] A three-dimensional Poisson process in required in this case.

"nearest neighbor" analysis.[5] The result is as follows:

$$PDF = 4\,G\,d\,e^{-2Gd^2} \qquad d \geq 0 \qquad (a)$$
$$(1)$$
$$CDF = 1 - e^{-2Gd^2} \qquad d \geq 0 \qquad (b)$$

This PDF is called a Rayleigh PDF with parameter $\sqrt{4G}$. These curves are displayed in Exhibit 5.3. The mean and variance are

$$\bar{D} = \frac{1}{4}\sqrt{\frac{2\pi}{G}} \qquad (a)$$
$$(2)$$
$$VAR_D = \left(2 - \frac{\pi}{2}\right)\frac{1}{4G} \qquad (b)$$

Equations (1) and (2) above summarize our simplest predictive model for the distance from a crime to the closest police car, under the null hypothesis of independence. We refer to this as the "Rayleigh model."

In police applications, the assumptions underlying the Rayleigh model are violated in the following ways:

1. The two-dimensional space has a finite area (e.g., the area of District 3), not an infinite area.
2. Police patrol cars are distributed over beats and sergeant's zones, thus a certain degree of randomness assumed in the Poisson model is not present in reality.
3. Police patrol cars are not distributed uniformly in space.
4. Crimes, even if they occur independently of police patrol cars, are not distributed uniformly in space.

Because of these violations of the Poisson (or Rayleigh) model in practice, one seeks to derive H_0 probability laws from models having more realistic assumptions. That is the purpose of the next two subsections. We will find, that for distances of interest, the Poisson (or Rayleigh) model is a remarkably robust model, even in the presence of the four complications cited above.

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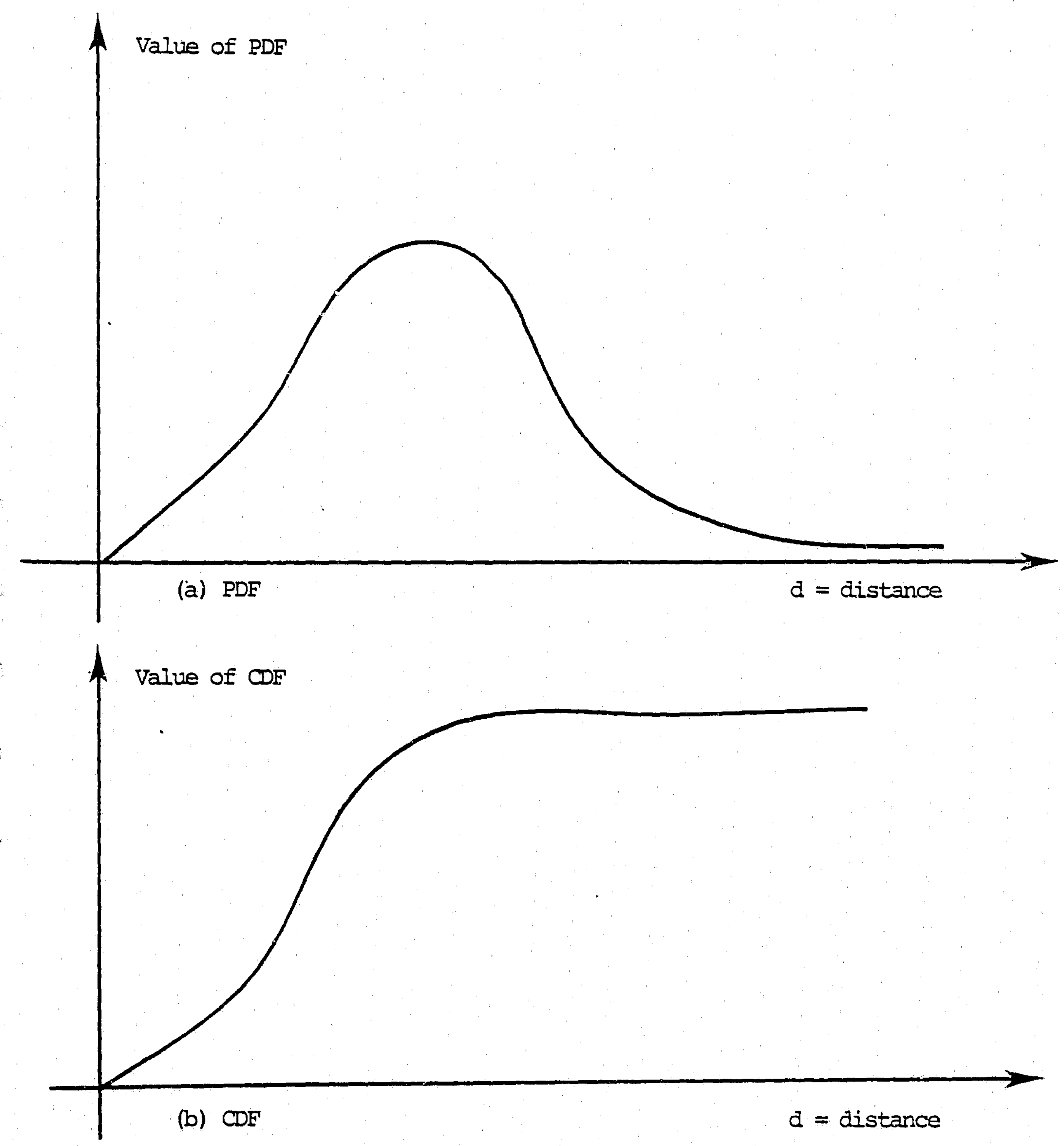
[5] R.C. Larson and A.R. Odoni, Urban Operations Research (Englewood Cliffs, NJ: Prentice Hall, 1981), pp. 150-151.

Exhibit 5.3

Rayleigh Probability Law for Distance from a Crime to the Closest Police Car



5.1.2 Results of a Simulation Model

One way to derive the probability law for the distance between a crime and the nearest police car is to simulate the police patrol force being studied. A simulation model is a computer-based model in which relevant complications of the real world are incorporated in the simulated world. Thus, one need not assume an infinite-area region having uniformly distributed police cars (as is assumed by the spatial Poisson model), but rather all of the spatial heterogeneities and other complications of the real world can be incorporated within the simulation model.

We report here the development and use of a simulation model of the District 3 police patrol force. Within the simulation, 1,000 incidents were generated independently of the location of the (simulated) patrol cars, and an empirical probability law was derived for the distance from the incident to the closest police car. This represents our second method for deriving probability laws under H_O.

In conducting the computer simulation runs, the following assumptions were initially used:

1. District 3 is modeled spatially according to its "Pauly Block" structure. A Pauly Block in St. Louis is the smallest area for which police statistics are maintained.

2. Crimes are distributed over Pauly Blocks in the simulation model in the same way as they are in District 3 (as measured over a two-month period). Thus, the probability that a particular crime occurs in Pauly Block 103, say, is the same probability that one would experience in practice.

3. Simulated crimes occur independently of patrol car locations. Each crime incident is modeled individually, and patrol car locations for crime i are independent of the locations for crime i-1 or any other crime.

4. Patrol cars are always assumed to be in their beats. The district station house is ignored.

5. The proportion of time that a patrol car spends in any given Pauly Block in his beat is assumed to be equal to the proportion of call-for-service workload that is generated from that Pauly Block (compared to the beat-wide total). Given that a particular Pauly Block is selected by the simulation model as the one containing the patrol car, the exact locations of the car within the Pauly Block are chosen from a uniform probability law over the Pauly Block.[6]

6. The model is general, so that different sections of different cities can be modeled.

7. For District 3, the model assumes 24 patrol units, 85 Pauly Blocks, and 1,000 crime incidents.

The major result of this simulation model is shown in Exhibit 5.4, which displays the CDF for the distance to the closest car. In fact, two CDFs are shown: the empirical one, derived by the 1,000 random-points simulation model, and the theoretical Rayleigh CDF whose mean is set equal to the empirical mean derived from the simulation. The simulation results on the figure are shown as a sequence of dots, whereas the theoretical results are shown as a smooth curve. For both situations, the mean distance to the closest car is 1,872 feet.[7] A visual inspection of Exhibit 5.4 reveals how closely the Rayleigh model fits the much more complex simulation model. The empirical variance of the distance to the closest car was found to be 1,202 square feet with the given mean of 1,872 feet, and assuming the true distribution is Rayleigh, the patrol density would then be 0.1120293 cars per 1,000 square

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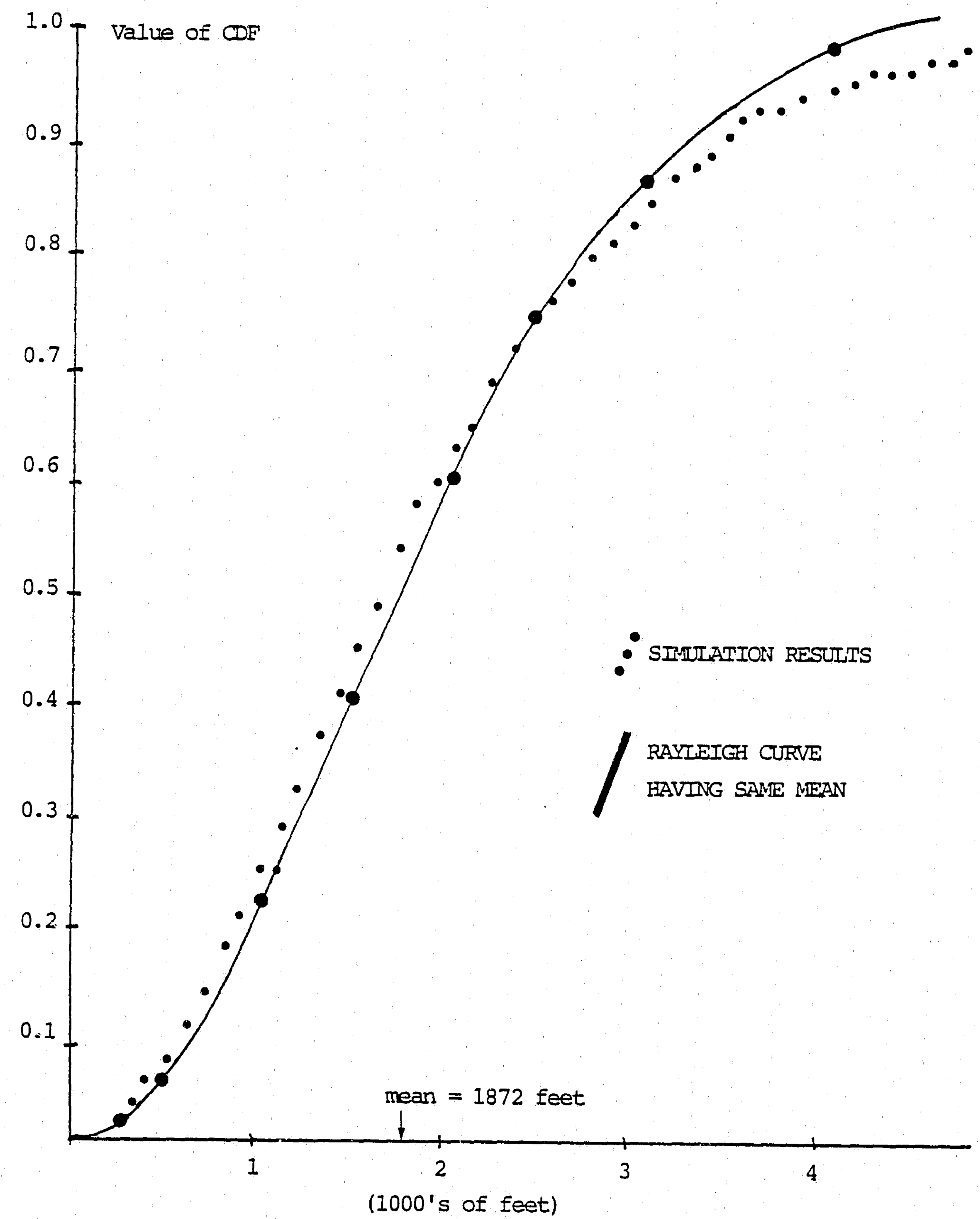
[6] The "point-polygon" method is used. See R.C. Larson, Urban Police Patrol Analysis (Cambridge, MA: MIT Press, 1972) pp. 174-77.

[7] Since District 3 contains approximately 9.8 square miles, with 24 patrol units the patrol car density is $G = 24/9.8 \approx 2.449$ cars per square mile. The Rayleigh model predicts in this case a mean distance [See Eq. 2(a)] of $(1/4)\sqrt{2\pi/2.449} \simeq 0.4004$ mile, or 2,114 feet. The reduction from 2,114 feet to 1,872 feet, or about 11 percent, is due to spatial inhomogeneities in patrol and incident locations and to the constraint that police cars must be located in sectors. To the extent that the district boundary affects the mean value, Chaiken has shown that boundary effects should actually increase the mean travel distance as compared to the value predicted by the spatial Poisson model. [J.M. Chaiken, "Boundary Effects in Square Root Laws for Travel Distance," Research Note, 1973, Rand Corporation, Santa Monica, CA].

Exhibit 5.4

Right-Angle Distance CDF via Simulation

(No Station House)



feet. With such a car density the Rayleigh predicts a variance of the distance to the closest car of 0.957796, about 20 percent less than the variance computed by the simulation model.

The simulation variance seems to be associated with a longer tail than that predicted by the Rayleigh model. Chi-square tests comparing the theoretical and the empirical curves for rather coarse partitionings of the distance axis yielded remarkably good results indicating that the null hypothesis that the Rayleigh curve is the underlying theoretical curve should not be discarded. To test the curve even further, we partitioned the distance sample axis into the smallest intervals $[x_i, x_i + 1]$ such that the expected number of incidents in each interval is greater than or equal to 5. We then obtained a chi-square value of 231 with 165 degrees of freedom, which is approximately the same as 3.36 in the standard normal distribution.[8] If the model is correct, one would obtain such an outlying statistical value less than five times in 10,000 tries. Hence, that application of the chi-square test suggests a plausible rejection of the null hypothesis. Here, we are running into a situation which is quite common in statistics, namely, that if the sample size is large enough virtually any null hypothesis which is even marginally different from the underlying true state of nature, will be rejected.

Upon examining the detailed assumptions of the simulation model, it was felt that one critical aspect of District 3 operations was not included in the model. This related to patrol cars located at the district station house during their eight-hour tour of duty, most likely filling out a crime report, bringing in an arrested person, or other similar activities. We thus modified

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[8]When the number of degrees of freedom in a chi-square test exceeds 100, one treats $2\chi^2 - 2$(No. degrees of freedom) $- 1$ as a standard normal random variable. [See, for instance, P.G. Hoel, S.C. Port and C.J. Stone, Introduction to Statistical Theory (Boston: Houghton Mifflin, 1971), p. 226.]

the simulation model (called SIMBASE) to include the possibility that patrol cars were at the station house. In particular, we designed SIMBASE to have 24 cars patrolling in District 3 in the same way that the Hypercube runs reported in Chapter 3 were configured. Each patrol car, however, is assumed to spend 20 percent of its patrol time at the station house.[9] The station house is modeled in the simulation world as a 100 ft. x 100 ft. Pauly Block in which a 25th car patrols continuously. This means that the proportion of time that car i spends in Pauly Block j, t_{ij}, under this model, is 0.8 t'_{ij}, where t'_{ij} is the proportion of time car i spends in Pauly Block j as calculated by the Hypercube model. Moreover, for each incident, the distance to the nearest car is calculated as the minimum of the distance to the nearest regular patrol car and the distance to the car at the station house. There is a small probability (equal to 0.0005) that an incident will arise at the station house itself.

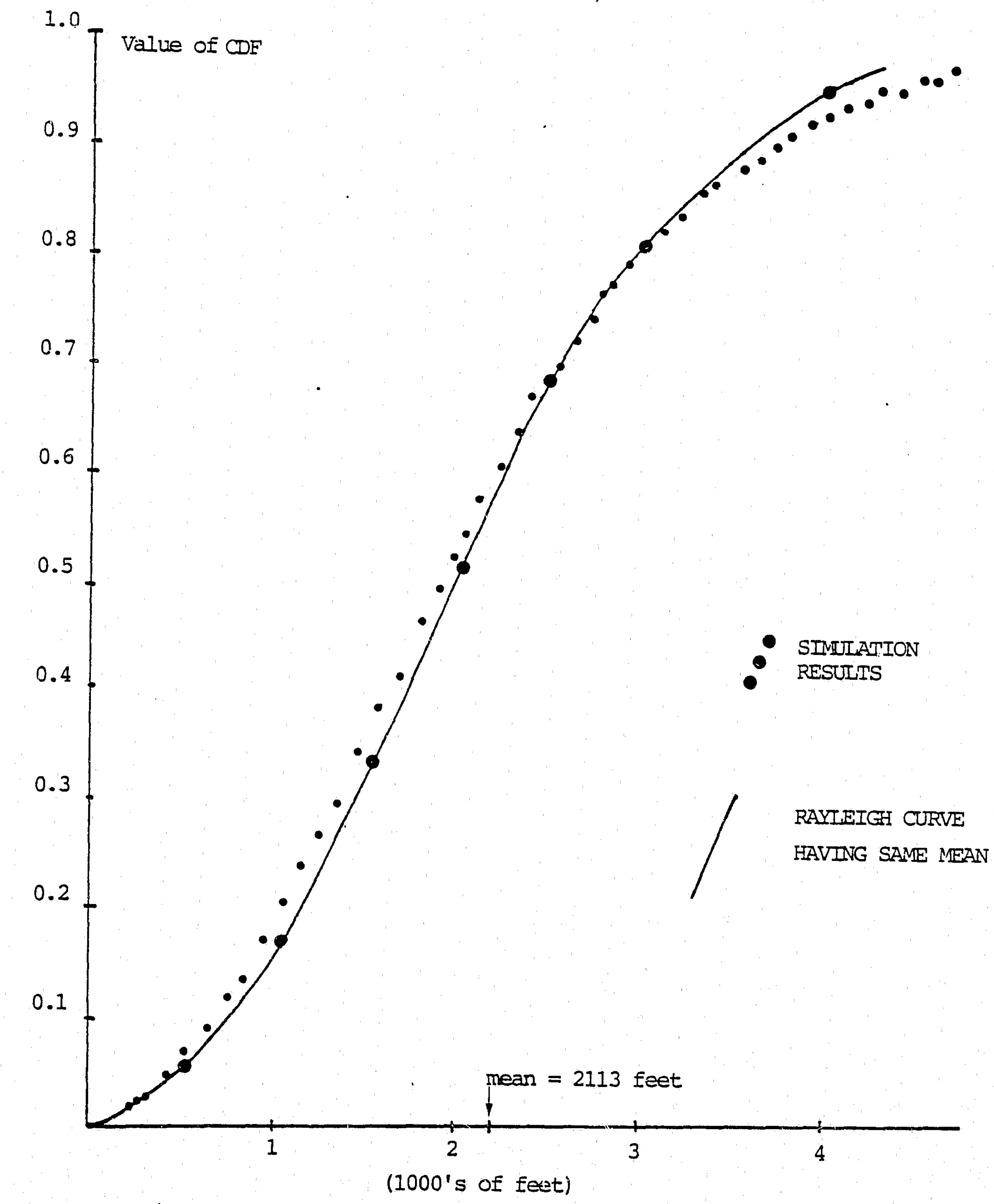
The associated CDFs for the station house simulation are shown in Exhibit 5.5. Here we note that the mean distance has shifted from 1,872 feet to 2,113 feet. The increase, roughly 13 percent, in mean travel distance is predicted crudely by the square root law which states that the mean distance to the closest car varies roughly as (1/patrol car density). In this case, the density was effectively reduced by approximately 20 percent, so we could expect roughly that the mean response distance would be increased by 9 or 10 percent. The fact that the increase is close to 13 percent is due probably to the inhomogeneities and boundary effects found in District 3. A visual inspection of Exhibit 5.5 will indicate that the station house simulation results seem to fit more closely to the Rayleigh CDF having the same mean for moderate and large response distances and it fits roughly the same as the

[9] The 20 percent figure is based on data collected during the summer of 1980 in District 9.

Exhibit 5.5

Right-Angle Distance CDF via Simulation

(With Station House)



earlier simulation for smaller response distances. The empirical variance, calculated from the simulation run is 1,540 square feet. The patrol car density G is given as 0.08796, as derived from the Rayleigh model. With that G value the Rayleigh model predicts a variance of 1,220 square feet. Again, the variance, as predicted by the Rayleigh distribution is approximately 20 percent less than the variance calculated from the simulation model, a result similar to the earlier simulation run.

A series of chi-square tests was done on these results, all indicating relatively good agreement between the simulation curves and the theoretical Rayleigh curve. For instance, in one chi-square test calculated over the interval [0, 9000] feet, each chi-square cell had an expected value greater than 20.0; the step size in determining the cells was 500 feet; for the first 980 points (out the total 1,000 points) the chi-square value was 16.4 with 10 degrees of freedom. The probability that chi-square would be greater than this particular value given the accuracy of the null hypothesis, is approximately 0.1, meaning that the null hypothesis could not be discarded at the 0.05 level of significance. When doing chi-square tests on the interval [0, 8000] feet, the results were even more strongly favorable toward the Rayleigh distribution. For instance, with a step size of 10 feet and requiring that each interval have an expected value greater than 5 incidents, the chi-square value for the first 800 points was 117, having 125 degrees of freedom; the probability that the chi-square statistic would be greater than this value, given the correctness of the null hypothesis, is approximately 0.70; this again confirms the strength of the null hypothesis, particularly for non-extreme values of distance to the closest car.

We have essentially similar results for CDFs computed from the simulation using the <u>Euclidian</u> distance metric, for both the station house and no station house cases. The chi-square results in these cases tended to be less suppor-

tive of the null hypothesis, and most of our tests could be used to reject the null hypothesis at the .05 level of significance.

When comparing the simulation results to the Rayleigh model, we thus conclude that the Rayleigh model is a relatively accurate one for predicting distance to the closest car under the right-angle metric, but somewhat less accurate under the Euclidian metric. The Rayleigh model is particularly accurate for low and moderate values of travel distance. The right-angle model is more relevant for our purposes here, since it is the right-angle metric which is appropriate in a metropolitan or urban setting for predicting travel distances. An examination of the potential response paths in District 3 will reveal that the right-angle metric is a much more accurate depiction of travel paths than the Euclidian metric.

5.1.3 Generating Pseudo-Incidents

So far we have described two alternatives for generating the null hypothesis: the first by the spatial Poisson model yielding a Rayleigh probability law for the distance from a crime to the closest car under the assumption of independence; the second a detailed spatial simulation model which partitioned District 3 into 85 statistical reporting areas and used the simulation model to generate 1,000 incidents independently of patrol car locations. We now describe yet a third procedure for generating the travel distance probability law under the null hypothesis of independence between crimes and police, and that involves so-called pseudo-incidents.

<u>A pseudo-incident is defined to be an imaginary crime whose time and location are selected via computer to match the statistical likelihood of times and locations of crimes in District 3.</u> That is, via computer we sampled the temporal and spatial distribution of District 3 crimes to generate the times and locations of 1,000 pseudo-incidents to occur in District 3.

Suppose that pseudo-incident 113 is in Pauly Block 49 and is to occur at 4:19 pm on a Tuesday afternoon. On that Tuesday, a staff member in St. Louis would hold a clear transparency onto the FLAIR console at 4:19 pm, and via the movable cursor, center the console display on Pauly Block 49. He or she would then encircle, on the transparency, the location of the center of Pauly Block 49 and then place x's at the locations of the five nearest police cars as shown by the FLAIR console. Clearly, the locations of these police cars occur independently of this time and location selected for the pseudo-incident. This procedure was used to generate approximately 1,000 pseudo-incidents in District 3.

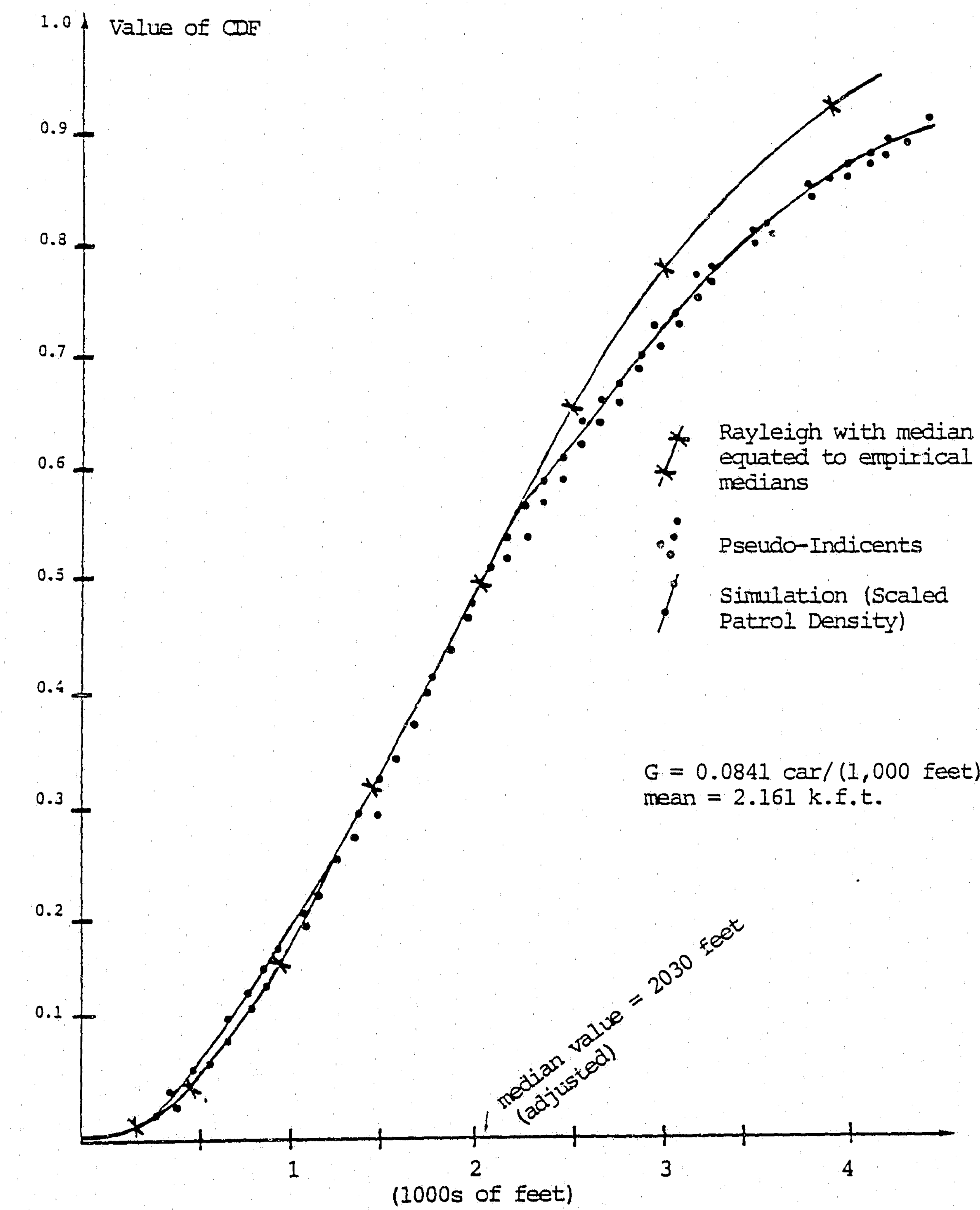
The pseudo-incidents represent a hybrid between pure computer simulation and empirical measurement in the field. The times and locations of the pseudo-incidents were generated by Monte Carlo computer simulation techniques; the locations of the police cars are actual locations as measured in St. Louis at the simulation-generated times and locations.

All of this work is summarized in Exhibit 5.6 which displays the CDF for the distance to the nearest police car (as measured by the Manhattan metric) for three different cases: the new 1,000 pseudo-incidents, the aforementioned 1,000 simulation incidents, and a Rayleigh distribution adjusted so that the median of the Rayleigh equals the medians of the two empirical CDFs. The simulation results which are displayed in Exhibit 5.6 are identical to the simulation results of Exhibit 5.5 (i.e., Monte Carlo simulation with the station house) with a minor adjustment scaling each simulation entry so that the patrol density (in patrol units per square mile) equals the average patrol density experienced in St. Louis. As can be seen from the exhibit, there are no significant differences between the three curves for values of cumulative

Exhibit 5.6

Three Comparative CDFs for

Distance to the Closest Police Car



probabilities ranging from 0 to approximately 0.6. After 0.6 in cumulative probability, the pseudo-incident curve and the simulation curves remain very close; however, the Rayleigh curve tends to be somewhat above the other curve. Thus, the Rayleigh curve--when adjusted at the median value--tends to underestimate distances for responses in the top 40^{th} percentile of responses compared to both the pseudo-incidents and the simulation model. This is somewhat surprising considering the fact that the Rayleigh model assumes an infinite plane having approximately 0.0841 cars per 1,000 square feet, whereas District 3 represents a finite area. Some of these boundary effects have been considered earlier in the aforementioned technical paper by Chaiken.

The major conclusion here is that for response distances ranging from 0 feet up to the number of feet corresponding to the 60^{th} percentile, there appear to be no statistically significant or policy significant differences between an adjusted Rayleigh probability law and the probability laws derived by two much more complex modeling efforts: the Monte Carlo simulation model and the pseudo-incident method. This further justifies the robustness of the spatial Poisson model or the Rayleigh model, especially for small and moderate valued response distances.

5.1.4 Generating a Family of Alternative Hypotheses

Now that we have successfully generated probability laws for the distance from a crime to the closest police car under the null hypothesis of independence, we are confronted with the task of deriving analogous laws under the competing hypothesis of a criminal's deliberate avoidance of police. Building on the robustness of the Rayleigh model, we alter the Rayleigh model to bring in avoidance.

Our first step in modeling avoidance is to assume that potential crimes occur as a homogeneous Poisson process (both in space and time). The key idea

is that, with avoidance, certain potential crimes will never become actual crimes due to the proximity of a patrol car. More precisely, suppose that a potential crime is to occur at a particular point (e.g., an unlocked automobile with the key left in the ignition) and that the nearest marked patrol car is d units of distance away. Then we assume, under the avoidance hypothesis, that the potential crime will become an actual crime with probability a(d). Intuitively, one would expect a(d) to behave as follows:

1. $a(0)=0$; that is, no actual crimes occur "in front of" a police officer.
2. $a(\infty)=1$; that is, if the distance to the closest police car is arbitrarily large, then the potential crime will certainly result in an actual crime.
3. a(d) should be smoothly increasing with d.

For our analysis we will choose

$$a(d) = 1 - e^{-2Ld^2} \qquad L>0 \qquad (3)$$

Here L is an index of nonavoidance, with nonavoidance increasing as L increases. Very large L implies almost no deliberate avoidance of police by the criminal, thus supporting the null hypothesis of independence. Very small L implies considerable avoidance.

With the Manhattan distance metric we recall that the set of points equidistant from a given point is a square rotated 45° to the directions of travel. If the (travel) distance from the given point to a point on the side of the square is d, then the area of the square is $2d^2$. The form of Eq. (3) is suggestive: it implies that avoidance decreases exponentially with the area of the rotated square centered at the criminal's position and having size determined by the closest police vehicle. In a sense, the size of the square may reflect to the potential criminal the chances of successful escape or of lack of police detection, the larger the square, the larger the "police-free zone" centered at the location of the potential illegal act.

Given a degree of nonavoidance L and patrol car density G, using spatial Poisson process ideas, one can show that the probability that a potential crime will result in an actual crime is

$$P\{C\} = \frac{L}{G+L} \tag{4}$$

To the extent that P{C} is less than one, we have a measure of deterrence or displacement or deferrence of crimes due to police presence. The average distance to an <u>actual</u> crime, given values for G and L, is found to be

$$\overline{D}(G,L) = \frac{1}{4}\left\{\left(1 + \frac{G}{L}\right)\sqrt{\frac{2\pi}{G}} - \frac{G}{L}\sqrt{\frac{2\pi}{G+L}}\right\} \tag{5}$$

As one might expect, this average distance is always found to be greater than that which one computes under an assumption of no avoidance.[10] With maximal avoidance (i.e., L=0) we have

$$\overline{D}(G,0) = \frac{3}{8}\sqrt{\frac{2\pi}{G}} \tag{6}$$

Comparing this result with the mean distance found under the independence assumption (Eq. 2(a)), there is (somewhat surprisingly) only a 50 percent range of possible variability beyond the case of no avoidance. Thus, even with marked avoidance, we should not expect drastically differing probability curves for the distance to the closest police car. The plausible family of CDF curves is displayed in Exhibit 5.7.[11]

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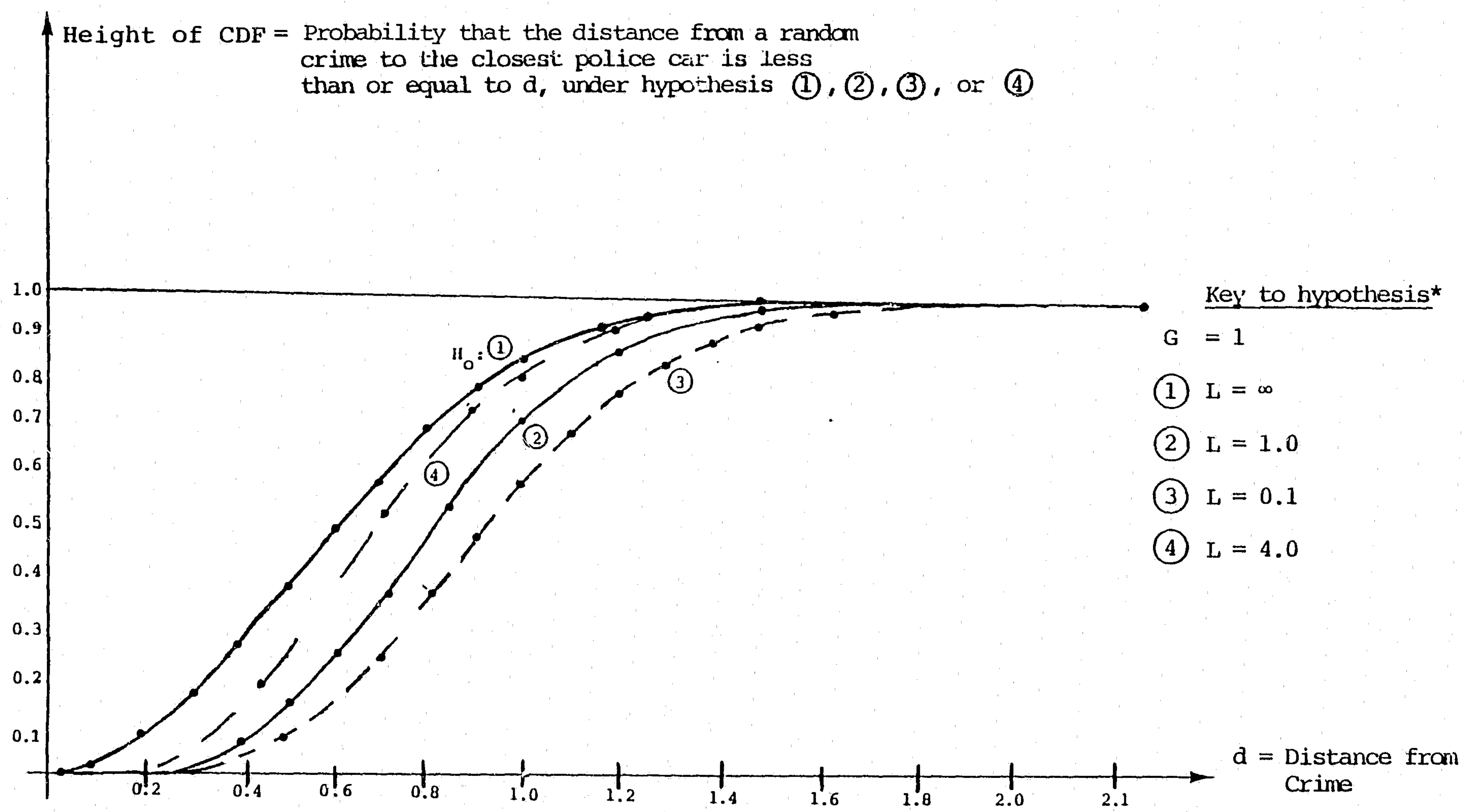
[10] i.e., $\overline{D}(G,\infty) < \overline{D}(G,L)$ for $L<\infty$.

[11] As discussed in Appendix IV, the CDF curves shown in Exhibit 5.7 also apply (with modified values for parameters) in the presence of <u>un</u>monitored but marked patrol vehicles which, in effect, would contaminate somewhat the experimental conditions. The net effect of such contamination is to shift any CDF curve which demonstrates avoidance toward the CDF curve (the "Rayleigh" curve) that shows no avoidance. While undoubtedly there was some positive level of contamination in District 3 during our data collection period, we ignore it through the remainder of this chapter. First, as shown in Appendix IV, small levels of contamination do not significantly alter the results. Second, our strategy tends to make any measured level of avoidance a conservative estimate of true avoidance.

Exhibit 5.7

Alternative CDFs for Distances from a Crime

to the Closest Police Car



* See text for definitions of terms

5.2 THE SAMPLE OF 117

In this section we report on data collection activities in St. Louis that measured distances from actual crimes in progress to the closest police cars. The purpose of this analysis is to utilize the theory regarding the null and alternative hypotheses described in Section 5.1 and the related theory in Appendix IV, to test whether crimes occur independently of patrol car locations.

5.2.1 The First Sample

In our data collection activities we actually collected two different samples. The first sample, collected during the late spring and early summer of 1981, comprised the distances to the five closest police cars from the locations of 200 crimes reported in progress. After the data were collected, extensive statistical testing was conducted. The results revealed a serious bias in the data whereby police cars were generally located closer to a crime than would be predicted by random independent behavior.

This decidedly counter-intuitive measured phenomenon prompted us to review our data gathering procedures. We found that several of our data recording mechanisms were sufficiently coarse to account for the bias we had measured. The key element was improper data recording procedures by on-site data gatherers. Upon notification via dispatch transmission that a crime was in progress, the data gatherers had been instructed to take a "snapshot" of the entire area on the FLAIR console both at the 4X magnification level and at the 16X magnification level, and to record these snapshots on the PSE videotape equipment. Then, after the event was over, the distances to the five closest police cars could be analyzed at leisure from the videotape recordings.

Apparently, for a significant fraction of events, the distances to the five closest police cars were recorded from the FLAIR console in real time.

This required a time-consuming process using FLAIR's "locate" feature, to zero in on each of the five closest police cars as determined by visual inspection, and to measure distances between the crime and the police car. The time required to repeat this process for five police cars could be two to three minutes or more, depending on the response time of the FLAIR system. This delay represented precious time in which the police cars could move significantly, most likely toward the crime if it were serious in nature. This process, then, provided a plausible hypothesis for explaining the measured bias in the data, and represented a serious threat to validity.

It turned out that a second problematic feature of this data set was a lenient screening policy for determining which crimes initially reported in progress were in fact actual crimes, and not false alarms or other uninteresting events (uninteresting from the point of view of this study). We thus decided to revise totally our experimental procedure and take a second sample of incidents.

5.2.2 The Second Sample

The second closest car test data collection period, conducted under revised procedures, extended from November 13, 1981 to January 10, 1982. Starting between 4:00 and 5:00 PM each evening, and continuing until 2:00 AM the next morning,[12] police activity in District 3 was monitored by police radio and the FLAIR system. With videotape continuously recording all radio transmissions and the FLAIR 4X display of the district, a PSE staff member listened for dispatchers' broadcasts alerting patrol officers to the occurrence of a criminal incident. In response to such broadcasts, the researcher would

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[12] This time period was chosen (1) in order to maximize the number of sample values obtained during 8 or 9 hours of daily monitoring and (2) to coincide with a period in which non-District 3 "special police vehicles" were not very active.

CONTINUED

manipulate the FLAIR console controls in order to ascertain the exact location (i.e., with the detailed 16X display) of the five patrol cars nearest the incident location. Locating the closest cars was accomplished quickly due to familiarity with District 3 street locations and block numbers, and also due to the videotape arrangement which automatically recorded car locations. This arrangement permitted the researcher to disregard the recording task during the crucial "real-time" period while officers are responding to an incident. The locating task is estimated to have consumed an average of 40 seconds following the broadcast of an incident.

5.2.3 The Screening Process

The car-locating task was performed in response to 2,518 radio dispatches during the data collection period. These alleged incidents were each subjected to a rigid screening process to determine whether 1) the incident was bona fide (i.e., there was physical evidence or a witness's account of the crime), 2) the incident occurred at a location visible to patrolmen and thereby potentially influenced by police visibility at that location, and 3) the incident was reported immediately and broadcasted promptly by the dispatcher. To facilitate objectivity, a "blind" procedure was utilized whereby all screening was done prior to and independent of the examination of patrol car locations in any of the recorded incidents. As the first step in the screening process, SLMPD Chronological Car Activity Reports were compared with the project log to determine which among the 2,518 videotaped incidents were bona fide (i.e., assigned complaint numbers by the department); 425 incidents met this criterion. The associated complaint report for each bona fide incident was then examined to determine whether the second and third screening criteria were also met.

Visibility to patrol was judged on the basis of the crime descriptions in the complaint reports. Events disqualified on this basis usually involved

larceny from department stores or assaults occurring within the confines of a home or apartment. (Although application of this screening criterion sometimes required a subjective judgment, it should be noted that any incident improperly included in the sample would tend to have a conservative effect on any statistical result that suggested criminal avoidance of police.)

In the closest car test, the usefulness of knowing a car's location X minutes after a crime's occurrence is inversely related to the value of X. Routine patrol movements continuing after a crime's occurrence permit change in the spatial distribution of cars around the incident location, eventually obscuring whatever pattern may have existed when the incident transpired. In the earlier data collection period a five minute standard had been established as the maximum allowable elapsed time between a crime's reported time of occurrence and the time at which the dispatcher's broadcast alerted the district (and the researcher) to respond accordingly. This standard was adopted in the second data collection period as well. Also during the second data collection period, incidents broadcast between five and ten minutes after their occurrence were retained as of possible secondary value to the analysis.

Application of the visibility criterion and the five minute elapsed time standard reduced the number of useable incidents to 103. An additional 32 incidents met the relaxed ten minute standard.

5.2.4 Use of Videotaped Records

The videotaped records for these 135 incidents included the precise locations of closest cars at the time of the dispatcher's broadcast, and the FLAIR 4X map for the several minutes preceding the broadcast, back to the moment at which the crime reportedly occurred. Availability of this videotape of the pre-broadcast period permits the adjustment of patrol car locations retrospective to this crucial moment.

This retrospective adjustment was accomplished using as a basis the post-broadcast detailed 16X maps for precise car locations in each incident, and then reviewing the pre-broadcast 4X display to determine whether the relevant patrol cars had shifted locations in the interim. Such movement was found to have occurred with at least one monitored car in almost all of the sampled incidents. In these cases, the videotape was studied to determine the cars' locations at the crime's reported moment of occurrence. Absolute precision in this task was not possible because the 4X FLAIR display reveals only those streets which mark half-mile intervals throughout the district. In most cases it was therefore necessary to estimate the car's location. Several clues enabled attainment of a high degree of accuracy in this estimation. Primarily, these included the car's relationship to the streets displayed on the 4X map and to other patrol cars remaining stationary throughout the videotaped interval. Visually observable information on the car's direction and distance traveled prior to being precisely located on the detailed 16X map also aided in the readjustment. This process proved accurate within about one city block, or 500 feet.

The use of retrospective adjustment suggested the potential for augmenting the 103 incident sample with the 32 incidents of the secondary sample. However this was found to be possible in only 14 cases. For the other 18 incidents there were insufficient clues available to accurately retrace the movements of relevant patrol cars over this extended length of time.

Patrol car mobility in the moments preceding a crime's broadcast produced significant change in at least one of the 5 closest cars' locations in approximately 80 to 90 percent of the 117 incidents comprising the final sample. Although the lack of precision in the retrospective adjustment of these car locations represents a source of error in the data, this error is far

exceeded by that which would be permitted through the inclusion of several minutes of patrol movement subsequent to a crime's occurrence. To promote the randomness of the adjustment error, the retrospective adjustment process was completed in ignorance of the crime's exact location; on the hard-copy incident maps ultimately used for distance measurement, all car mapping and adjustment was completed prior to the marking of the incident location.

5.2.5 Sample Characteristics

In this section our purpose is to describe briefly the characteristics of the 117 crime incidents in our sample. Exhibit 5.8 shows the distribution of incidents as initially reported and finally recorded. When first reported to the SLMPD the 117 incidents fell into of 25 different crime code categories. The most frequent categories were hold-up (n = 12), larceny just occurred (n = 12), and disturbance (n = 11). In writing up the associated incident report, the investigating police officers often re-categorized the incident into a final crime code classification. Items like "burglars in the building" and "alarm sounding" were re-categorized as burglary or attempted burglary; items such as "larceny just occurred" or "holding for larceny" were re-categorized as "stealing under" or "stealing over" (the threshold value being $150). The most numerous final crime categories were "stealing under" (n = 20), "destruction of property" (n = 18), "robbery" (n = 17), and "burglary" (n = 15).

In considering the plausibility of the avoidance hypothesis, one could reasonably argue that certain crimes are more conducive to rational analysis before the fact than others. Our conjecture was that non-rational, or "assaultive" crimes may be supportive of the null hypothesis of independence, whereas the rational, of "property" crimes may occur in an environment of deliberate avoidance. In this light, we categorized the 117 incidents into assaultive crimes and property crimes, as shown in Exhibit 5.9.

Exhibit 5.8

Incident (Crime) Categories, Sample of 117

Code	Incident Type	Number in Sample: Initially Reported	Number in Sample: Finally Reported
10	Rape	1	1
15	Kidnapping	0	1
20	Robbery	1	17
21	Hold-up	12	1
22	Strong Arm	1	0
23	Purse Snatch	3	0
24	Stealing Under	0	20
25	Stealing Over	0	2
26	Attempted Robbery	2	3
31	Assault (I, II, III)	6	13
32	Shooting	1	0
34	Fight	5	0
40	Burglary	3	15
41	Attempted Burglary	1	5
42	Burglars in Building	6	0
43	Alarm Sounding	4	0
50	Larceny Just Occurred	12	0
52	Holding for Larceny	8	0
60	Stolen Auto	1	1
61	Tampering	5	6
70	Destruction of Property	7	18
71	Window Smash	2	0
72	Prowlers/Suspicious Person	6	0
73	Prowlers Attempting Entry	6	0
80	Flourishing (a Weapon)	4	3
81	Shots Fired/Discharging	6	5
90	Disturbance	11	4
91	General Call for Police	3	0
95	VMCSL (Drug Possession)	0	2

Exhibit 5.9

Two-Way Classifications of Crimes

Crimes in Sample of 117	Mednick-Stack Categorizations (R=Rational N=Not Rational)	PSE Categorization (P=Property A=Assaultive Crimes)	Agreement Mednick-Stack and PSE Categorizations
Assault	N	A	Yes
Burglary	R	P	Yes
Burglary (Attempted)	R	P	Yes
Destruction of Property	N	A	Yes
Disturbance	N	A	Yes
Flourishing (a weapon)	N	A	Yes
Hold-up	R	P/A	Yes*
Kidnapping	-**	A	Yes
Larceny	R	P	Yes
Rape	N	A	Yes
Robbery	R	P/A	Yes*
Robbery (attempt)	-**	P	-
Shots Fired/Discharging	-**	A	-
Stolen Auto	R/N	P	Yes***
Tampering (with property, especially auto)	R	P	Yes

*For robberies and hold-ups, we performed our analyses two ways: first, by including these crimes among the property crimes; second, among the risk crimes.

**Mednick and Stack either were not asked about these types of crimes or offered no categorizations.

***We assigned stolen auto to the property class of crime.

As an independent cross-check, we sent our sample to Dr. S.A., Mednick, who has studied the relationship of biological factors with crime and criminality.[12] His categorization of "rational" and "nonrational" crimes is also shown in Exhibit 5.9.[13] While Mednick and his assistant Stack categorized hold-up and robbery as "rational" crimes, we were less certain of their status as these acts involve the use of a potentially lethal weapon. Thus, we decided to designate hold-up and robbery as crimes which could be grouped either with the property crimes or with the assaultive crimes, and conducted our analyses accordingly.

The distribution of assaultive, or nonrational crimes is displayed in Exhibit 5.10. The essential core of assaultive crimes, called A_1 crimes, is limited to assault, destruction of property, disturbance, flourishing (a weapon), rape, and shots fired/discharging. There were 44 such incidents in the sample of 117. A_2 crimes include all the A_1 crimes plus robberies and hold-ups; the total number of A_2 crimes is 62. Exhibit 5.11 presents a similar distribution for the property, or rational, crimes. The core of the property crimes, called P_1 crimes, is stealing under, stealing over, attempted robbery, burglary, attempted burglary, stolen automobile and tampering. There were 62 such incidents in the sample of 117. When the crimes of robbery and hold-up are added to the P_1 crimes, we then have the P_2 crime category, which totals 70 in number. We were able to categorize 114 of the 117 sampled crimes in this manner. We did not include the single kidnapping crime or the two arrests for possession of drugs.

[12] S.A. Mednick and J. Bolavka, "Biology and Crime," In N. Morris and M. Tonry, eds., Crime and Justice, an Annual Review of Research Volume 2 (Chicago: The University of Chicago Press, 1980), pp. 85-158. Our thanks also to Mr. George Shollenberger, NIJ grant monitor, for referring us to Dr. Mednick.

[13] These categorizations were provided by Dr. Mednick's research assistant, Susan Stack.

Exhibit 5.10

The Assaultive or Non-rational Crimes

	Crime Type		Number in Sample
A_1	Assault		13
	Destruction of Property		18
	Disturbance		4
	Flourishing (a weapon)		3
	Rape		1
	Shots Fired/Discharging		5
		TOTAL	44
A_2	All A_1 Crimes		44
	Robbery		17
	Hold-up		1
		TOTAL	62

Exhibit 5.11

The Property or Rational Crimes

	Crime Type		Number in Sample
P_1	Stealing Under		20
	Stealing Over		2
	Attempted Robbery		3
	Burglary		15
	Attempted Burglary		5
	Stolen Auto		1
	Tampering		6
		TOTAL	52
P_2	All P_1 Crimes		52
	Robbery		17
	Hold-up		1
		TOTAL	70

5.3 STATISTICAL ANALYSES

With the sample of 117 verified crime incidents from District 3, our statistical problem is basically one of inference. That is, which of two competing hypotheses is true: H_o, that crimes occur independently of police car locations; or H_1, that criminals to some extent deliberately avoid police cars when committing their criminal acts. As indicated earlier in this chapter, our H_1 hypothesis is, in fact, a family of hypotheses as suggested by the value of the nonavoidance parameter L. We are faced with the fact that the range of plausible values for the average distance from an actual crime to the closest police car is from 0 percent to only 50 percent above the value that would be found under H_o. This range of models as expressed by cumulative distribution functions has been shown previously in Exhibit 5.7.

In order to develop an intuition for model parameter values, suppose we find that P{C}, the probability that a potential crime becomes an actual crime, is estimated to be 0.8. If this estimate were in fact correct, then 80 percent of potential crimes would result immediately in actual crimes occurring. An 80 percent value for this parameter would require that L be precisely four times the measured patrol density G. For instance, if the patrol density were one patrol car per unit area, then L would equal 4 in order to obtain the 80 percent figure. With L=4, we would have

$$a(d) = 1 - e^{-8xd^2}$$

Recall that a(d) is the probability that a potential crime will result in an actual crime, given that the closest police car is d units of distance away.

If the unit of distance is miles, and the closest police car is 0.05 miles away (i.e., approximately 260 feet away), then $a(d) = 1 - e^{-8(0.05)^2} = 0.0198$; that is, less than 2 percent of potential crimes occurring 260 feet away from the closest police car result in actual crimes. If the distance to the closest

car is doubled to 0.1 mile, then a(d) = 0.0769. If it is doubled again to 0.2 miles, the a(d) = 0.2739. However, if the closest car is as far away as 0.5 miles, then a(d) = 0.8647. In summary, an L value that causes 20 percent of potential crimes not to occur requires tremendous reluctance on the part of the potential criminal to commit a crime when the closest police car is within, say, one or two city blocks of the potential crime. Yet, the L=4 CDF is the one closest to the null hypothesis CDF in Exhibit 5.7. The maximum separation between these two curves is only 0.13 along the vertical probability axis. Thus, with a small or moderate sample size, random fluctuations around the correct theoretical CDF could create difficulties for the statistician in determining whether H_o or H_1 (L=4) is the correct model.

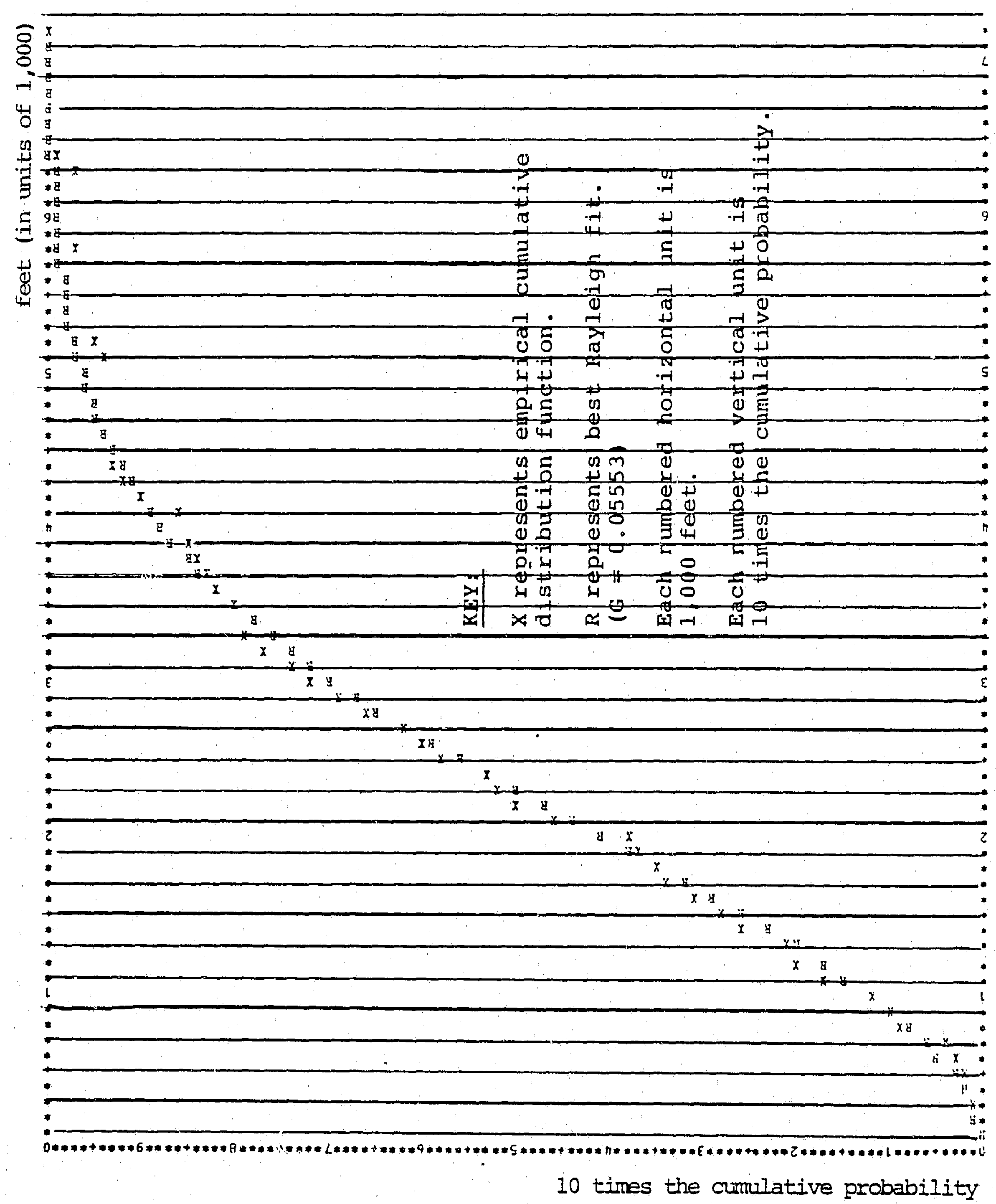
With the above discussion as general background, we now provide some of the empirical results. In Exhibit 5.12 we display the empirical CDF for the distance between an actual crime (in our sample of 117) to the closest monitored police car. Distances are measured in units of 1,000 feet. Also shown in the figure is the closest cumulative distribution Rayleigh curve, where closeness is measured in minimum sum of squared errors.[14] The best estimate for patrol car density for this curve is 0.06627 cars per 1,000 square feet or, equivalently, 1.848 cars per square mile. If one holds this estimate of G fixed and then searches for the best estimate of the nonavoidance parameter L, again using least squares as one's fit criterion, one finds an L value of 37.112. This relatively huge L value suggests almost complete nonavoidance (i.e., independence between criminals and police cars) as indicated by P{C} = 0.9982. Thus, for the entire sample of 117 incidents, when the Rayleigh curve is fitted to the entire range of distances, one finds

[14] Alternative hypotheses testing procedures are discussed in Appendix IV. We use least squares here since it allows hypothesis testing via chi-squared analysis, perhaps the most well-known method of testing hypotheses with distribution data.

Exhibit 5.12

CDF for the Distance from a Crime to the

Nearest FLAIR-Observable Patrol Car, Entire Sample of 117



one support whatsoever for policy relevant or statistically significant avoidance on the part of potential criminals. A chi-square goodness-of-fit test indicated that the Rayleigh Curve could not be discarded at the 0.05 level of significance.[15]

Because of the exceedingly good fit of the Rayleigh distribution to the two other distributions derived to model the null hypothesis (the other two were found by simulation and by the pseudo-incidents method), an effort was also made to fit the underlying parametric curves only through the first 60th percentile of measured response distances. When the best Rayleigh curve is fitted just through the 60th percentile of the CDF for the entire sample of 117 incidents, the best estimate for G changes slightly from 0.06627 to 0.06596, or a drop of approximately only of one-half of one percent. With this fit too, the measured L (19.36) suggests virtual independence of criminals from the location of police cars. Because of the theoretical rationale for fitting curves only through their 60th percentile, it will be those fits which are emphasized subsequently in this section.

Shown in Exhibit 5.13 are results for the 52 incidents known as the "P_1" property crimes. The figure shows CDFs for the empirical findings for the best Rayleigh fit, and for the best fit allowing avoidance. In all cases, we

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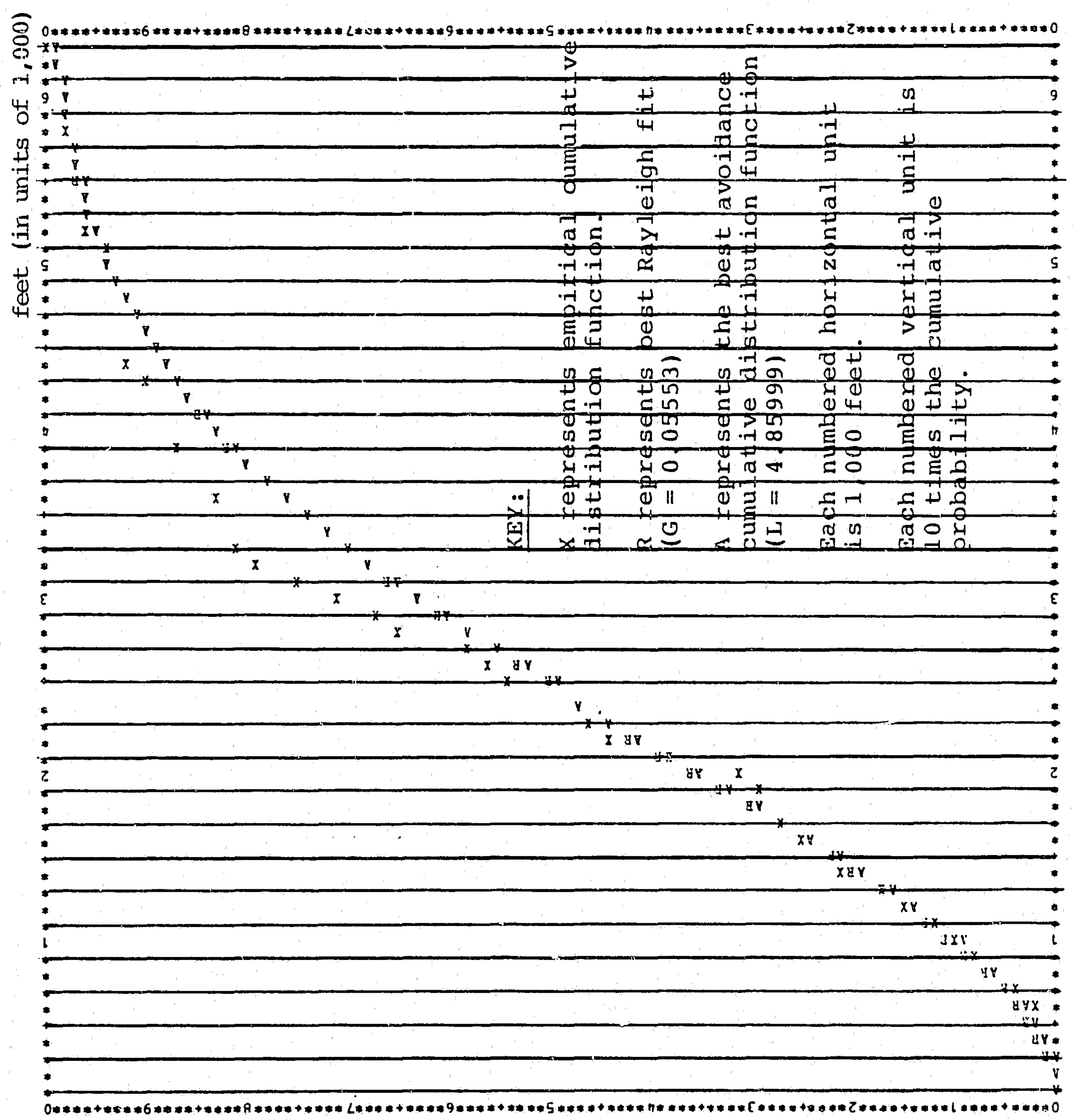
[15]Each step size in the chi-square test is the smallest multiple of 200 feet required to have an expected number of observations greater than 5. Chi-square values were tabulated for each number of step size, from 1, 2, 3, ..., starting at the origin (namely 0 feet). The chi-square values were exceedingly good up through 7 degrees freedom with 44 observations, yielding a chi-square value of 7.006, which is approximately the value that one would expect by random chance if the model being tested were precisely the correct model. Larger values for chi-square, which became statistically significant at the 0.1 level, but not at the 0.05 level, occurred with larger degrees of freedom. Even if the null hypothesis is precisely correct, this behavior can be expected since the Rayleigh curve fails to accurately track the empirically found H_o curve beyond about the 60th percentile.

Exhibit 5.13

CDF for the Distance from a Crime to the

Nearest FLAIR-Observable Patrol Car, for the 52 P_1 Crimes



first estimate the parameter G representing the density of patrol cars, then hold this estimate fixed while we search for the best estimate for the nonavoidance parameter L. In this instance the best estimate of G is 0.05553. The corresponding best estimate of L is 4.85999. This corresponds to a P{C} = 0.9887. Thus the best fit in this case for the P_1 property crimes suggests that slightly more than one percent of potential property crimes are deterred, deferred, or displaced due to the presence of police. This small amount of avoidance becomes even smaller when one adds robbery and hold-up to the P_1 crimes, thereby making the P_2 crime category.

When one studies the A_2 crimes, and attempts to fit the best L value, one always finds (whether fitting the 100 percent sample or only through the first 60th percentile) that the corresponding L value is <u>infinity</u>. That is, the computer program used to get best fits shows that total non-avoidance of police by assaultive type criminals is the most appropriate model. The chi-square goodness-of-fit values of the Rayleigh curve with the A_2 data are remarkably good, with typical chi-square values equalling the number of degrees of freedom—values which would typically occur only if the postulated underlying model were exactly correct.

We now return our attention to the P_1 and P_2 property crime categories. In particular, we are interested in whether or not there is any statistical evidence beyond that reported so far which suggests deliberate police avoidance by property criminals. In reporting results above for the property crimes, we found that the probability that a potential crime would not occur because of police presence was on the order of one percent. In that analysis we fit simultaneously the parameters G and L to the empirical data. The problem with that procedure is that G represents a known physical quantity, namely the density of patrol cars (in either number of patrol cars per square mile or number of patrol cars per 1,000 square feet, or some other equivalent measure). Thus, estimating G from the empirical curves tends to give an extra degree of freedom to the curve fitting that is not warranted from physical considerations.

Analyses reported already in this chapter have given us independent means for estimating G. For instance, with the SIMBASE simulation model (with the station house) the implied G value from the best Rayleigh curve fit was 0.08796 cars per 1,000 square feet. When analyzing the independently derived pseudo-incidents, we adjusted the median of the Rayleigh to equal the median of the CDF of the pseudo-incident curve, and thereby derived an estimate for G to be 0.0841 cars per 1,000 square feet. Finally, as noted in the footnote on page 131, the measured physical density of patrol cars is 2.449 cars per square mile or about 0.0878 cars per 1,000 square feet. Thus, the G estimates derived from independent work are somewhat greater than the 0.06627 value obtained from the best G fit over the entire sample of 117 incidents reported earlier. And we are aware of no substantial change in the number of FLAIR-equipped vehicles within District 3 during the collection period for the sample of 117 incidents versus during the period of the 1,000 pseudo-incidents. Thus it seems appropriate to assume a G value, independently derived, somewhere between 0.084 and 0.088. Given a particular G value, one then uses least squares methods to determine the best value for L, for both the P_1 and the P_2 property crime types. An excellent summary measure to indicate the aggregate degree of avoidance by potential property criminals is the quantity

$P\{C\} = L \div (L+G)$ = the probability than an actual crime will immediately result, given that a potential crime occurs.

The extent to which this quantity is strictly less than one indicates, as discussed earlier, the extent of deliberate avoidance of police cars by potential criminals.

We have summarized our L estimation analysis for the property crimes in Exhibit 5.14. In the left most column is the estimated value of G that is used for the entries in the corresponding row. As can be seen, the first two G entries were obtained from the simulation model (with station house) and the Rayleigh model (with median calibrated to that of the pseudo-incident curve). The other six G values were estimated from the sample. The third entry was derived from the entire sample (n = 117) and the fourth from the first 60th percentile. Entries 5 through 8 were derived from fitting a Rayleigh curve to the various crime categories. The thought was that since the assaultivecrime categories so closely follow the Rayleigh curve, estimating G from these empirical results should not lead to seriously erroneous G estimates. Entries 5 and 6 correspond to the G estimates for the A_1 crimes: entry 5 where the Rayleigh curve is fit to all A_2 crimes (n = 44) and entry 6 where the Rayleigh curve is fit only to the first 60th percentile of A_2 crimes (N = 26). Entries 7 and 8 correspond to the A_2 crimes: entry 7 for all A_2 crimes (n = 62), and entry 8 for the first 60th percentile of A_2 crimes (n = 37).

As one notes by studying the G values in column 1 of Exhibit 5.14, the G values range from approximately 0.066 cars per 1,000 square feet to 0.0914 cars per 1,000 square feet. The independently estimated G values of 0.0841 and 0.08796 fall in the middle of this range. Column 2 is a shorthand depiction of the source of the corresponding G value. Column 3 is the best L value that can be found using a least squares criterion for the given G value. The curve fit is for the entire sample; the top entry corresponds to the P_1 crimes only, whereas the bottom entry corresponds to the P_2 crimes (which equal the P_1 crimes plus robbery and hold-ups). Column 4 yields the fundamental quantity of interest, namely the probability that a crime will occur, given that a crime opportunity has occurred. Note that for the G values that seem to be most representative, namely those between 0.084 and 0.088, the measure). Thus, estimating G from the empirical curves tends to give an extra degree of freedom to the curve fitting that is not warranted from physical considerations.

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Exhibit 5.14

Probability that a Potential Crime Results in an Actual Crime
Under Alternative Plausible Assumptions Regarding System Parameters

	(1)	(2)	(3)	(4)	(5)	(6)
	G Value	Obtained from	Best L Value (100% sample)	$P\{C\} = \frac{L}{L+G}$ (100% sample)	Best L value (1st 60th percentile)	$P\{C\} = \frac{L}{L+G}$ (1st 60th percentile)
(1)	0.08796	Simulation model with station house	0.2143 0.2240	0.7090 0.7180	0.2251 0.2535	0.7190 0.7424
(2)	0.0841	Calibration median of Rayleigh with median of Pseudo-Incident curve	0.2564 0.2728	0.7530 0.7643	0.2643 0.3027	0.7586 0.7826
(3)	0.06627	Entire sample (n=117)	0.9735 1.34441	0.9363 0.9530	0.80532 1.21283	0.9240 0.9482
(4)	0.06596	1st 60th percentile (n=70)	1.01243 1.41208	0.9338 0.9554	0.82986 1.2590	0.9264 0.9502
(5)	0.08118	All A_1 Crimes (n=44)	0.29721 0.32189	0.7855 0.7986	0.30135 0.35157	0.7878 0.8124
(6)	0.09137	1st 60th percentile of A_1 Crimes (n=26)	0.18455 0.19106	0.6689 0.6765	0.1971 0.21922	0.68324 0.7058
(7)	0.07431	All A_2 Crimes (n=62)	0.45178 0.52549	0.8588 0.8761	0.43324 0.54814	0.8536 0.8806
(8)	0.08200	1st 60th percentile of A_2 Crimes (n=37)	0.28485 0.3064	0.7765 0.7889	0.29023 0.33686	0.7754 0.8042

KEY: Top Entry: P_1 Crimes Bottom Entry: P_2 Crimes: ($=P_1$ Crimes + robbery and hold-up) probability that a potential crime will result in an actual occurrence tends to fall between 0.70 and 0.75. If this is in fact true, it suggests that police presence either deters, defers, or displaces 25-30 percent of prospective street-visible property crimes that could occur. The last two columns correspond to the previous two columns except that the best L value is determined by fitting the parametric curve only to the first 60th percentile of the empircal curve. As can be seen from Exhibit 5.14, there is little policy significance in the difference between columns 6 and 4.

Illustrative graphical interpretations of these results are shown in Exhibits 5.15 and 5.16. Each of these figures contains plots of three quantities:

1. The empirical CDF for distance to the nearest police car for P_1 crimes.

2. The Rayleigh CDF corresponding to a given (prespecified) G value (G=0.08796 for Exhibit 5.15 and G=0.08118 for Exhibit 5.16).

3. The best avoidance CDF holding fixed the given G value (and letting only the L value vary).

Even a casual inspection of the curves reveals a marked separation between the Rayleigh ("independence") curve and the other two—the empirical curve and the best fit to the empirical curve. The separation is given by a shift to the right of the Rayleigh curve, a shift that suggests a measurable deliberate avoidance of police by property criminals.

The above analyses have provided limited statistical support for the following hypotheses:

1. Individuals who commit assaultive crimes do so with nearly total disregard for the whereabouts of police patrol cars.

2. Individuals who commit property crimes that are potentially visible from the street, do so with at least a limited awareness of nearby patrol cars, and tend to commit their crimes at a distance further from the cars than could be explained by chance alone.

Exhibit 5.15

P_1 Crimes: CDF for the Distance from a Crime to the Nearest FLAIR-Observable Patrol Car, and Theoretical CDFs Holding G Fixed at 0.8796

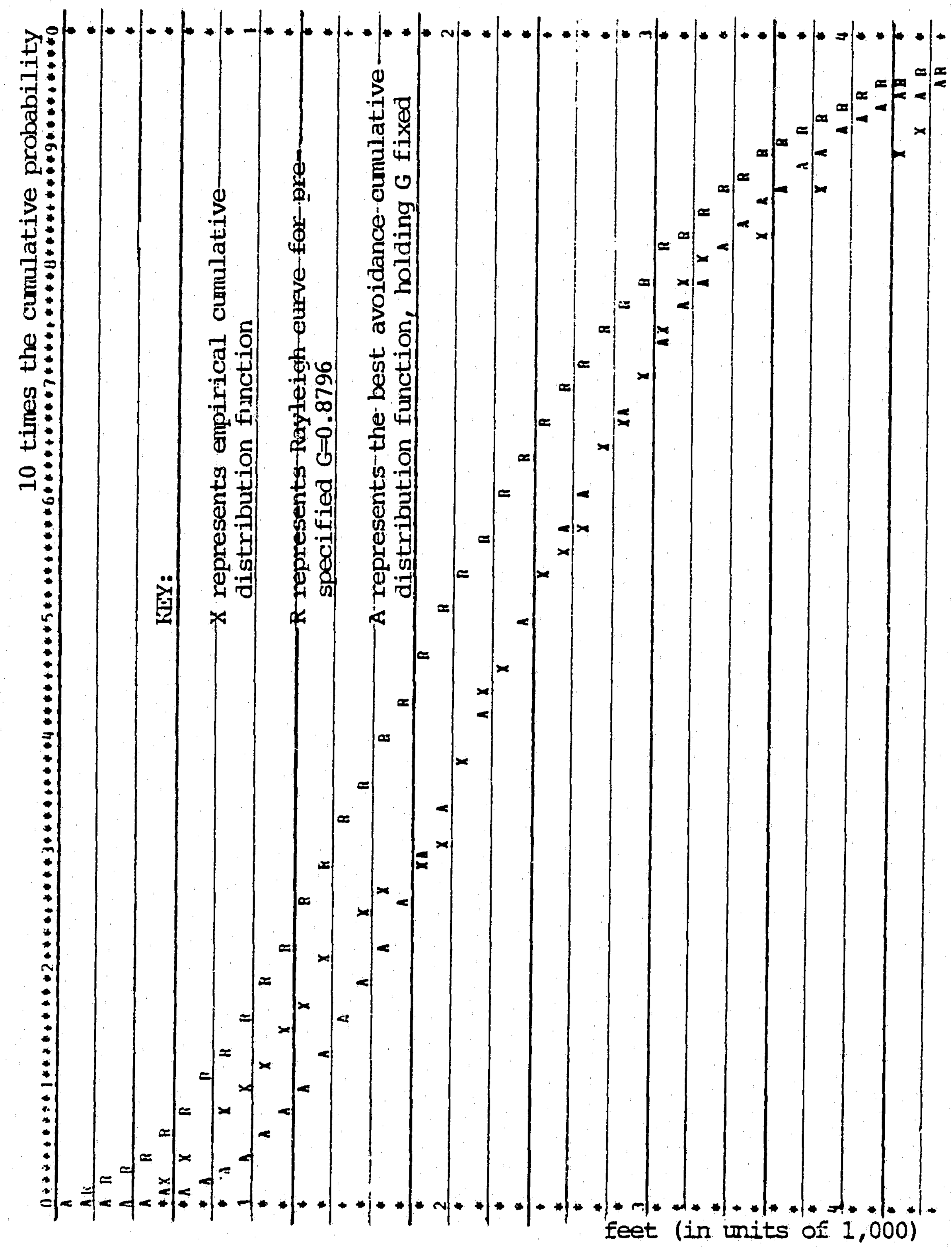
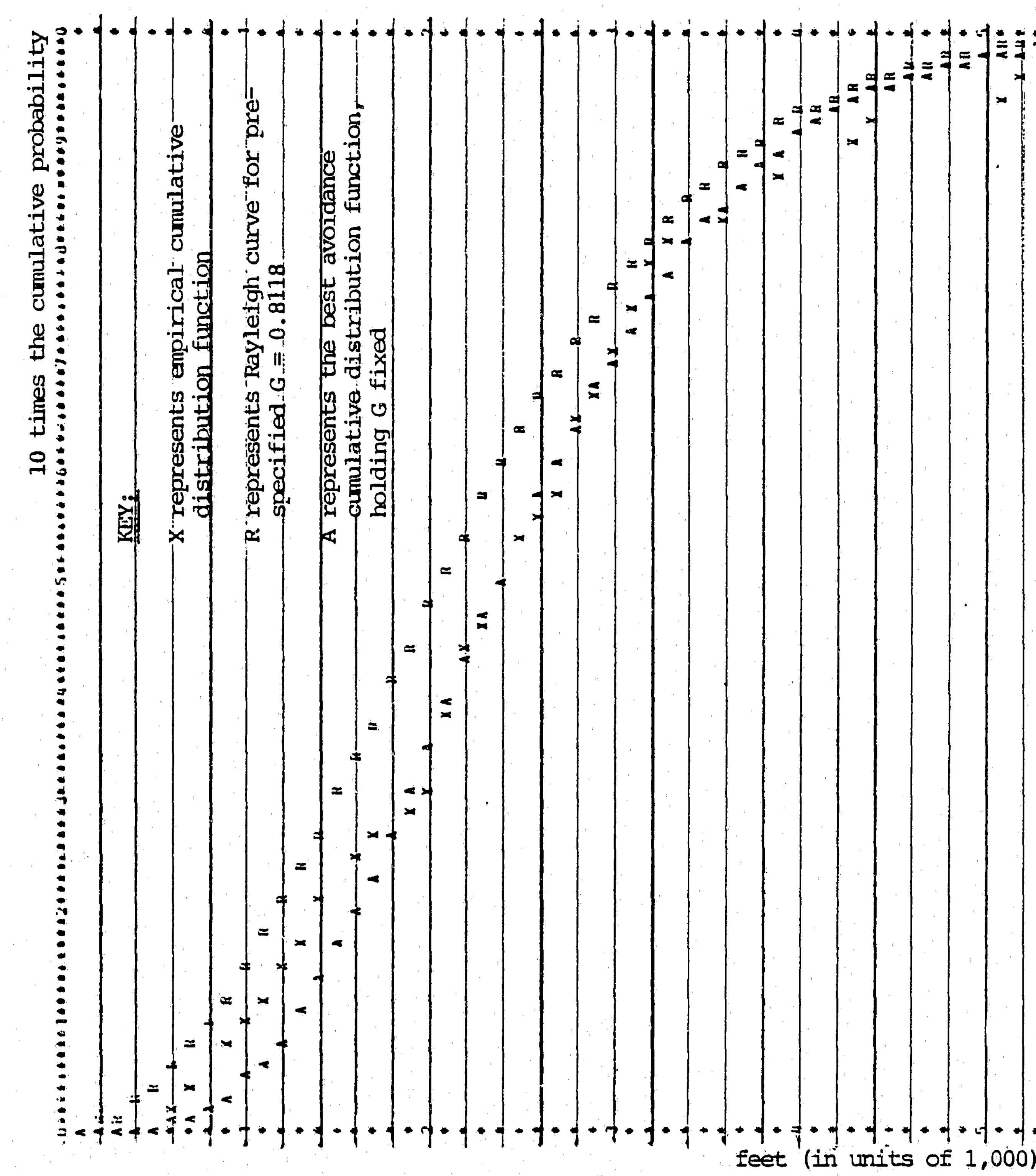


Exhibit 5.16

P_1 Crimes: CDF for the Distance from a Crime to the Nearest FLAIR-Observable Patrol Car, and Theoretical CDFs Holding G Fixed at 0.8118



In other words, criminals committing assaultive, or nonrational, crimes (according to our sample of results) demonstrate no visible mechanism of deliberate police avoidance, whereas those committing property, or rational, crimes do demonstrate a limited amount of police avoidance.

5.4 SOME POLICY IMPLICATIONS

The purpose of this section is to speculate on the possible policy significance of these results, should they be replicated with a larger sample size.

5.4.1 The "Rational" vs. the "Nonational" Criminal

Our research supports both those who model the criminal offender as a "rational decisionmaker" and those who seek other explanations of behavior (such as biological[16]). The rational decisionmaker[17] appears as one who consciously minimizes the risk of police apprehension; the nonrational criminal is driven by other factors without regard to the risk of police apprehension. Those who committed the property crimes in our sample appear to behave somewhat more rationally than those who committed the assaultive crimes. However, no one individual over his or her criminal career is likely to be associated solely with a single crime type—those who commit assaultive crimes oftenwill subsequently commit property crimes, and vice versa. Thus, our results, even if shown to be true in a larger study, do not allow us to distinguish between the individual and the type of crime an individual is contemplating, vis-a-vis the question of avoidance of police.

Phillip Cook, in his survey of research on criminal deterrence,[18] argues

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[16]See for instance, Mednick and Bolakva, pp. 85-158.

[17]See for instance, the seminal paper by G. Becker, "Crime and Punishment; An Economic Approach," Journal of Political Economy 78(1968):526-36.

[18]Phillip J. Cook, "Research and Criminal Deterrence: Laying the Groundwork for the Second Decade," in Morris and Tonry, pp. 211-268.

for more research regarding the potential criminal's decisionmaking about risks of apprehension;

> ...careful descriptive studies and laboratory experiments to investigate the way in which individuals acquire information and evaluate opportunities may well yield some insights to criminal decision-making, insights that will help refine the predictions of rational choice models and even suggest means of increasing the effectiveness of the (criminal justice) system in deterring crime (remark in parentheses added) [p. 227].

Cook argues that potential criminals should be affected by the "visible presence of enforcers." He says,

> The proximity of police emits a potent signal that the probability of arrest for a crime committed in the immediate vicinity is high. A police cruiser eliminates driving infractions in its immediate area—an effect which is extended by CB radio communication. Private guards in stores, airports, and other public locations produce an analogous signal for would-be robbers, hijackers, and shoplifters [p. 223].

Cook goes on to raise a number of important issues that are relevant to the findings of our own study. He concludes with suggesting a research agenda which includes, among other things,

> Interviews with active and potential criminals to determine what sorts of information they regularly acquire on the effectiveness of law enforcement activities. And studies of the criminal's response to specific environmental cues related to the likelihood of arrest and punishment, including visible police patrol, signs posted to warn would be violators ("shoplifters will be prosecuted") and so forth [p. 260].

Undertaking such an agenda, especially if conducted compatibly with the type of research study reported here, should yield important new results which would allow refinement of the avoidance hypothesis proposed here.

5.4.2 Deterrence, Deferrence, and Displacement

Even if the measured avoidance indicated by our property crime results is shown to be valid in a larger study, one is faced with an additional complexity regarding potential crimes which do not occur. Does the nonoccurrence of a potential crime imply a net reduction in the overall crime rate, or does it simply mean that the potential criminal has rescheduled his criminal act for a later time, or that he has decided to commit his criminal act at a different place? A net reduction in crime would correspond to deterrence whereas a rescheduling is referred to as deferrence and relocation as displacement.

As a visual image, imagine a juvenile walking down the street who passes by an automobile whose owner left the keys in the ignition and the engine running. This situation surely presents a crime opportunity. Suppose that the juvenile, upon looking up and down the street, sees a police cruiser two blocks away, and because of this decides not to steal the automobile. The juvenile may decide to wait nearby until the police cruiser is far from the scene; then, if the automobile is still available for easy theft, he may decide to steal it at that time. This delay action is deferrence. If, on the other hand, the juvenile decides to go to another street where there is no visible police presence, and if he finds another target of opportunity, the car stolen on the new street would be referred to as a displaced crime. Deterrence only occurs if the juvenile does not commit a crime that he otherwise would have committed except for the presence of police. Thus, in this example, an auto theft would have been deterred by police presence if the juvenile decided not to steal the car in question because of the threat of police apprehension and did not shortly thereafter steal another car.

In our property crime statistical analyses, we typically found that 25 to 30 percent of criminal opportunities did not become actual crimes. (This statement tacitly assumes the underlying causal mechanisms generating the model are correct.) Even if this figure is true, one does not know at this time what fraction corresponds to deterrence, and what fractions correspond to deferrence and displacement. That remains a subject for future research.

5.4.3 Reppetto's Study of Residential Burglars

Thomas Reppetto, in a 1974 study,[19] analyzed residential robbery and burglary. Particularly important with respect to our preliminary crime findings regarding property crimes, are his interviews with residential burglars. According to his study,

> Approximately three quarters of the interviewees indicated that they engaged in some kind of planning, with the older burglars tending to do somewhat more planning and drug addicts and young burglars somewhat less. All of the groups were primarily concerned (although drug addicts somewhat less concerned) with establishing whether or not the dwelling was occupied, since they much preferred to hit unoccupied residences [page 17].

The planning aspect of residential burglary tends to confirm the "rational decisionmaker" version of criminal behavior. Even the rational decisionmakers however, seem to place a low priority on police patrolling as a risk mechanism:

> Few of the interviewees spent time assessing the frequency of police patrol, location of entrances or availability of escape routes although, again, the oldest group was most likely to be concerned with these matters. Probably as a result of their greater attention to planning, the oldest group was most confident about their ability to operate in well protected neighborhoods and least likely to be deterred by police patrols or burglar alarms [page 18].

In Repetto's sample of 1,910 burglaries, only 19 percent of the interviewees mentioned "few police security patrols" as a main reason for their choice of neighborhood and house for burglary break-in. Thus, it would appear that these rational decisionmakers assess the risk of random police apprehension to be so low as to be largely ignored in comparison to other risks, such as the occupants of the residence being home or coming home. Related interview studies in Washington, D.C. and Boston, (where the interviews were conducted mostly of burglars and robbers) suggested similar conclusions.[20]

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[19] T.A. Reppetto, Residential Crime (Cambridge, MA: Ballinger Publishing Company, 1974).

[20] L.H. Goodman, T. Miller, and P. DeForrest, A Study of the Deterrence Value of Crime Prevention Measures as Perceived By Criminal Offenders, (Washington, DC: Bureau of Social Research, 1966); and J. Conklin Robbery and the Criminal Justice System, (Philadelphia: J.B. Lippincott, Co., 1972).

In Reppetto's interviews with 86 convicted burglars, only 14 percent indicated that "police security patrol" would prevent an anticipated offense. This 14 percent is analogous to our estimated quantity, G/(G+L) = probability that a potential crime will not become an actual crime. On the other hand, these interview results become somewhat ambiguous since 37 percent of the interviewees suggest that police security patrols "might prevent an anticipated offense," whereas 49 percent reported that police security patrols would have "no effect" on an anticipated crime occurring or not occurring. Thus, of the 37 percent who said that police security patrols might prevent the offense, there is some fraction of anticipated offenses that would probably not occur as a result of police presence. These figures are compatible with our estimates of 25 to 30 percent of anticipated street-visible property crimes not occurring. One must recognize, however, that Reppetto's results are for a different city and specifically for residential burglary, a property crime whose visibility from the street is considerably reduced compared to many other types of urban property crimes.

5.4.4 Random Patrol Models of Crime Interception

Several police researchers, including Elliot[21] and Larson,[22] have utilized operations research models derived primarily from search theory to predict the probability that a crime will be intercepted while in progress by a patrolling police vehicle. These interception patrol models assume strict statistical independence between the location of police patrols and crimes while in progress. In the context of our hypothesized model, they assume that the null hypothesis H_0 is operating. Then, if police patrols occur at a rate n

[21] J.F. Elliot, Interception Patrol (Springfield, IL: Charles C. Thomas, 1973).

[22] Larson, Urban Police Patrol Analysis, Chapter 4.

(patrol passings per hour), and if a crime occurs that is visible to the street for a duration T, then the probability that the police car will pass the crime during a period of potential visibility is nT.[23] This is the maximum probability of detection and apprehension of a criminal, maximum because space-time coincidence does not guarantee detection.

Our preliminary results suggest that this random search model is adequate for assaultive crimes, but inadequate for property crimes visible from the street. If in fact property criminals are rational decisionmakers and tend to avoid criminality when patrol cars are nearby, then the random search theory model results represent an upper bound to the true results. This is somewhat shocking since the numerical findings one usually obtains from applying a random search theory model suggest that very few property crimes will be intercepted by random police patrols (typically 1 or 2 per 100). If now, these are shown to be upper bounds to the true state of affairs, the true probability of apprehension of a property criminal by a patrolling police car is likely to be even lower than the "1-in-100" type calculation that one typically finds with random patrol models.

Elliot, Larson and others have also suggested applying Koopman's optimum allocation of search efforts for determining where to place police patrol efforts. However, the optimum allocation of effort, a la Koopman, requires the independence assumption to hold. If now, one finds that the independence assumption no longer holds for property crimes, then one requires the construction of an entire new set of optimum patrol allocation procedures based on a more complex model. Clearly, these questions require further research.

5.4.5 Relationship to the Kansas City Preventive Patrol Experiment

The most famous police patrol experiment that has occurred to date is the

[23] Assuming nT is considerably less than 1. A more complex exponential formula applies in general.

Kansas City Preventive Patrol Experiment (KCPPE),[24] which took place over a 12-month period in 1972 and 1973. The key questions addressed in the KCPPE included the effect of various levels of police patrols on crime rates and on citizen attitudes. Thus, in an aggregate way the KCPPE researchers focused on some of the same issues (and a broader set of issues) as pilot study.

The designers and evaluators of the KCPPE concentrated on an area in the city with 15 police beats. Of these beats, five were designated control beats in which one patrol vehicle was assigned (as is the usual practice in most U.S. police departments) and five pro-active beats in which a second vehicle was added to provide extra police coverage. In the most controversial of the three experimental treatments, the last five beats were designated reactive beats in which the regularly assigned patrol vehicle was removed from patrolling the beat; instead, that vehicle was to remain on or near a common boundary with an adjacent pro-active beat, in effect adding at least a fractional vehicle to the two already assigned there. Reactive beats were to be entered only when necessary for purposes other than patrol, such as responding to citizen calls for police service, delivering warrants, and completing a small fraction of police-initiated activities (such chasing a speeding motorist).

The KCPPE researchers found primarily negative results (that is, nearly all monitored outcome measures [including crime rates] displayed no significant results). If one were to interpret literally the results of the KCPPE to say, "criminal activity occurs independently of police patrolling activity," then our results for assaultive crimes would support that conclusion. However, because of a number of difficulties with the KCPPE, one is not encouraged to interpret the results so strongly. But the measured lack of dependence of

[24] G.L. Kelling, et. al., The Kansas City Preventive Patrol Experiment (Washington, DC: Police Foundation, 1974).

criminal activity on police patrolling activity by the KCPPE researchers does tend to be supported by our assaultive crime analysis.

The dependence we have observed for the property crimes, on the other hand, would at first glance tend to be in contradiction to the independence findings of the KCPPE researchers. However, this interpretation is not necessarily valid because our results are consistent with any mix of deterrence, deferrence, and displacement levels that yield the avoidance level measured. If, say, 20 percent of potential crimes are deterred, deferred or displaced, we do not know which fraction is in each category. If, say, only 5 percent are deterred then the other 15 percent fall into the deferrence or displacement category. These small percentages within a limited sample size as in the KCPPE would be extremely difficult to detect. Thus, even a microscopicly strong dependence such as we have preliminarily discovered for the property crimes does not necessarily reflect itself in a strong macroscopic dependence of the type the KCPPE researchers attempted to measure or refute. Clearly, additional work is required on linking the microscopic behaviors reflected by our research with the macroscopic studies illustrated by the KCPPE. In physics, there is an analogy here to statistical mechanics (the study of individual particles and their interactions) and classical thermodynamics (the macroscopic behavior of gasses as reflected by their pressure, temperature, etc.).

5.5 DESIGNING A MORE DETAILED TEST

The results reported here, while detailed and somewhat extensive, have been limited by small sample size and rudimentary experimental technology available to the researchers. A much more comprehensive study using AVM technology could be undertaken if a 24-hour playback capability were available. By this we mean a technological capability which would allow the researchers to play back, on a city-wide basis, the locations and movements of all police cars during the previous 24-hour period. The manufacturers of the AVM system in St. Louis had proposed such a playback capability in their initial system design over ten years ago. However, due to escalating costs and diminished funding resources, this capability was discarded from the final design specifications. In St. Louis, the 24-hour playback capability was to be derived by using a redundant duplex computer which sits idle the majority of the time. One would read in (via computer tape) the previous day's raw data from the radio transmission lines into the second computer, thereby simulating a real-time input to the second computer. In fact, in the original system design, it would have been possible to play back patrol movements up to ten times normal speed, thereby facilitating the researcher's tasks. However, since no such comprehensive playback capability existed for PSE researchers in St. Louis, we were forced to resort to manual monitoring with standard home videotape recording equipment. This limitation forced us to settle for the small sample size of 117 verified incidents.

If a more comprehensive playback capability were available, one could obtain a significantly larger sample size and ask a wide range of statistical questions within reasonable cost bounds. Instead of examining the question of dependence or independence on one variable, namely distance from the crime to the closest police car, one would design the experiment with a vector of variables. The elements of the vector might include:

1. Distance to the closest car.[25]
2. Distances to the second, third and additional closest cars.[25]
3. A flag variable indicating whether or not the closest car is visible from the crime scene.

[25]We have these available for our sample of 117.

4. The elapsed time between the time of last passing of a patrol car at the scene of the crime and the time of a crime.
5. A flag variable indicating whether or not the car assigned to the patrol area of the crime is busy or available at the time of the crime.
6. The average empirically measured patrol frequency past the crime scene during the previous 24 hours.

Each of the elements of a such a vector of variables could be relatively easily obtained by an analyst reviewing the previous 24-hour's operations for verified crime incidents only. Thus, for instance, if it was found that an armed robbery occurred at a particular corner at 9:12 pm of the previous evening, then the researcher could run the tape for the 24-hour period that ends at 9:12 pm of the previous evening, focusing exclusively on the corner at which the crime occurred. Numerical values for each of these indicated variables above could be read off in, say, two to three hours of monitoring with the playback capability. If the previous 24-hour's patrol frequency were not required, the analyst could probably get the first five variables cited above in approximately one half hour. In fact, it is not difficult to imagine that many, if not most of the variables cited above could be automatically obtained by specially-written computer programs.

APPENDICES

APPENDIX I

ST. LOUIS DISTRICT PATROL PLAN

METROPOLITAN POLICE DEPARTMENT – CITY OF ST. LOUIS
OFFICE OF THE CHIEF OF POLICE
SPECIAL ORDER

Date Issued January 29, 1982 Order No. 82-S-5

Effective Date January 4, 1982 Expiration Indefinite

Reference

Cancelled Publications 73-S-35; 74-B-1

Subject DISTRICT PATROL PLAN

TO: ALL BUREAUS, DISTRICTS AND DIVISIONS

PURPOSE:

To provide procedures governing the operation of the patrol plan in the police districts.

TABLE OF CONTENTS

MPD Form 251-3

I. BASIC ORGANIZATIONAL STRUCTURE OF THE DISTRICT PATROL PLAN

A. Platoon Organization. Each district will be organized according to the following platoon structure:

1. Separate "A" and "B" Platoons which will rotate every three weeks between the Day and Afternoon Watches.

2. A "C" Platoon which will consist of officers working a permanent Night Watch.

3. Separate "N" and "P" Platoons which will rotate every three weeks between watches extending from 10 A.M. to 6 P.M. and 6 P.M. to 2 A.M.

NOTE: The "N" and "P" Platoons will have their own precinct sergeants, who will work the same duty hours as their men.

4. A "Q" Platoon which will consist of officers working a permanent 6 P.M. to 2 A.M. Watch (except in the Fourth District).

NOTE: For administrative purposes, the "Q" Platoon officers will be assigned to the Overlay Watch Relief sergeant. For supervision purposes, they will be responsible to the on-duty Overlay Watch sergeant.

5. A "D" Platoon which will contain administrative and support positions authorized by the Chief of Police.

NOTE: A limited number of officers designated as 'discretionary manpower' will be authorized under the "D" Platoon in each district. The District Commander may, at his discretion, utilize such officers for (1) motorized directed patrol; or (2) footbeat duty.

B. District Manning Tables. District Manning Tables will be periodically published by the Chief of Police reflecting the number of men authorized in each district by platoon and assignment.

II. ASSIGNMENT OF MEN TO WATCHES.

A. Assignment of Officers to Administrative and Support Positions. The District Commander will assign officers to the following administrative and support positions within his district:

Captain's Aide
Property/Warrant Officer
Tri-Car Duty
Discretionary manpower

B. Assignment of Officers to Rotating/Fixed Watches

1. Selection of Watches

a. Officers will choose among the following work schedules on a seniority basis:

(1) Rotation between Day and Afternoon Watches every three weeks.
(2) Rotation between 10 AM-6 PM and 6 PM-2 AM Watches every three weeks.
(3) Fixed 6 PM-2AM Watch.
(4) Fixed 11 PM-7 AM Watch.

b. Commissioned officers assigned to the police districts will re-select their work schedules on or about October 1 of each year, prior to the selection of their vacation periods for the following year.

C. Selection by Seniority

1. General Information. In determining seniority for work schedule selection purposes, preference will be given within each rank by seniority of service in that rank. EXCEPTION: Officers in the rank of 'police officer', 'probationary police officer' and 'turnkey' will be considered of the same rank for seniority purposes. Seniority will be based on the date of commissioned appointment, corrected, if applicable, for periods of breaks in commissioned service.

2. Military Reinstatement. In determining seniority for work schedule selection purposes, the officer's original commissioned appointment date will be used. The time absent for military duty will not be deducted. NOTE: To qualify as a military reinstatee, the employee must have been employed by the Department immediately prior to his entry on active military duty, and must have returned to the Department within 90 days of honorable discharge or separation from active military service.

3. Determining Seniority When Officers Have Equal Time in Rank. In the event two officers of the same rank have equal time in that rank, the officer with the longer length of total service as a St. Louis commissioned officer will receive preference. In the event two officers of the same rank have equal time as St. Louis commissioned officers, the officer with the longer length of previous civilian service within the Department (if applicable) will receive preference. In the event two officers of the same rank have exactly equal time as Department employees, the unit will devise a method of selection agreeable to the officers involved.

D. Assignment to a Platoon

1. After an officer has made his work schedule selection, assignment to a specific platoon ("A" or "B", "N" or "P", as appropriate), will be at the discretion of the District Commander.

2. Insofar as practicable, an equal number of officers will be assigned to the "A" and "B" Platoons. In addition, an equal number of officers will be assigned to the "N" and "P" Platoons. In the assignment of men to recreation brackets, an equal number of men will be assigned to each bracket, insofar as possible.

E. Platoon Assignment When Transferred Into a District. If an officer is transferred from one district to another, or from another unit to a district, assignment to a watch or platoon will be at the discretion of the district commander. The transferred officer will have to await the annual re-selection of work schedules before using seniority to obtain his work schedule preference.

F. Deployment of Overlay Watch Manpower ("N" and "P" Platoons)

1. Rotation Schedule. The "N" and "P" Platoons will rotate every three weeks in conjunction with the "A" and "B" Platoons according to the following schedule:

Platoon on 7 AM-3 PM Watch	Platoon on 10 AM-6 PM Watch	Platoon on 3 PM-11 PM Watch	Platoon on 6 PM-2 AM Watch
A	N	B	P
B	P	A	N

2. Assignment of Overlay Watch Sergeants, Officers

a. All Districts Except Third

(1) One Overlay Watch sergeant will be assigned to both the "N" and "P" Platoons, and one sergeant assigned as the Relief Overlay Watch sergeant. When either the "N" or "P" Platoon sergeant is off-duty, the Relief Overlay Watch sergeant will assume the responsibilities of the off-duty sergeant.

(2) The "N" Platoon sergeant will be assigned to Bracket 1 of his Platoon's schedule, while the "P" Platoon sergeant will be assigned to Bracket 2 of his Platoon's schedule. The Relief Overlay Watch sergeant will be assigned to Bracket 3 of either schedule, and he will alternate between the two Overlay Watches during the course of the Watch.

b. Third District

(1) Three Overlay Watch sergeants will be assigned to both the "N" and "P" Platoons, with one sergeant on each Platoon serving as a Relief Sergeant.

(2) All Overlay Watch officers will work the same duty schedule as their sergeant (i.e., Bracket 1 sergeant to supervise officers assigned to Brackets 1-4, etc.). The Relief Overlay Watch sergeants will have men assigned directly under their supervision.

G. Temporary Reassignment to Another Platoon

As circumstances necessitate, e.g., extended sick leave, detachments, or suspensions, the district commander may temporarily reassign officer(s) from their current platoon to another.

III. VACATION AND RECREATION PROCEDURES

A. Recreation schedules for district officers assigned to the A, B, C, N and P Platoons will be prepared annually by the Planning Section.

B. Recreation schedules for officers assigned to the "Q" Platoon and to discretionary duties will be determined by the district commander, based on the needs of his district, with consideration given to the preferences of the involved officers. The following options are open to the Commander:

(1) Use one of the sample schedules prepared by the Planning Section, which provide for an increased number of officers to be off on Sundays; or

(2) Use one of the schedules for the A-N, B-P or C Platoons.

NOTE: When the needs of the individual districts arise, the district commander may re-schedule the recreation days of the discretionary manpower.

C. The district commander may temporarily change an officer's recreation bracket. An officer's assigned recreation bracket can be changed permanently only with the approval of the area commander.

D. Other procedures relating to the scheduling of vacations and recreation days are contained in the Special Order entitled "Watch Rotation, Recreation, Vacation and Related Procedures."

IV. CAR BEAT OPERATION

A. General Information

1. There will be two separate car beat maps for each district: (1) a high-car map which will be in effect from 10 AM to 2 AM and (2) a low-car map which will be in operation from 2 AM to 10 AM.

2. The number of car beats authorized in the various districts will be determined by the Chief of Police.

3. Car beats will be periodically reviewed by the Planning and Development Division to determine if there is approximately equal workload between the various car beats.

B. Operational Procedures

1. Change in Car Beat Maps.

a. At 10 AM daily, each district will change from the low- to the high-car map. The number of precincts will be increased (usually from two to three), with a change in the boundaries of the car beat areas. Overlay Watch officers beginning duty at 10 AM will be assigned to independent patrol units, and will work under their own sergeants.

b. At 2 AM each day, each district will revert from the high-car to the low-car map.

2. Notifying Communications Division of Cars to be In-Service

Prior to the start of each watch at 7 AM, 10 AM, 3 PM, 6 PM, and 11 PM, each district watch commander will arrange for the preparation by district personnel of a District Patrol Unit Availability Work Sheet, MPD Form OPP-29, to reflect the patrol units and beats that will be in service during the coming watch, and whether the units will be one or two-man operations. The work sheet information will be sent via computer message to the Communications Division. If there is a change in the patrol unit/beat information originally submitted, the watch commander will insure that the Communications Division is notified by phone and/or radio.

NOTE: The Communications Division will incorporate the information concerning patrol unit availability received via computer message from the districts on MPD Form GEN-146, "Service Unit Manpower Allocation." A copy of Form GEN-146 will then be forwarded daily to the Bureau of Field Operations and the Planning Section.

3. Roll Call Procedures for Officers Starting Duty at 10 AM and 6 PM

a. The Day Watch Commander will insure that officers beginning duty at 10 AM receive the same information as the officers attending the 7 AM roll call, in addition to any new information received since that time. Likewise, the Afternoon Watch Commander will insure that officers beginning duty at 6 PM receive the same information as the officers attending the 3 PM roll call, plus any new information received since that time. NOTE: Televised roll calls will be held at 10 AM and 6 PM.

b. Officers beginning duty at 10 AM and 6 PM will notify the dispatcher via FLAIR code as soon as they are in service and whether their unit is a one or two-man car. In addition, officers deadheading their vehicles upon going off duty at 2 AM will notify the dispatcher via FLAIR code. NOTE: If the FLAIR system is not operating, the notifications will be made via radio.

V. DIRECTED PATROL OPERATION

A. To aid the District Commander in deploying manpower to specific problem areas, he may, at his discretion, remove up to two area patrol cars from radio control and assign them to a specific area.

B. The responsibility for the vacated area(s) will be assumed by an adjacent radio car(s), as designated by the Watch Commander, until such time as the original car(s) return to normal patrol. In addition, the cars utilized in the 'directed patrol' program will be available for radio assignments when (1) all other district cars are out-of-service; and (2) as designated by the Watch Commander (e.g., the Watch Commander can designate that the 'directed patrol' cars are available to handle any directed incident call, just Priority I calls, etc.).

NOTE: When utilizing the 'directed patrol' operation, the Watch Commander will arrange for the sending of a computer message to the Communications Division advising of any changes in car beat responsibility, and which radio assignments can be handled by the 'directed patrol' units.

VI. PATROL—WITH—A—PURPOSE OPERATION

A. General Information. All patrol car officers assigned to the Night Watch will participate in the "Patrol-with-a-purpose" Program during the hours from 11 PM to 7 AM.

B. Operating Procedures

2. The work schedule for tri-car officers will be prepared at the discretion of the district commander. The commander may schedule all of his tri-car officers to be off-duty on a particular day (such as Sunday) if he feels that there is a limited need for such officers on that day.

3. The tri-car officers will be assigned to the "D" Platoon; however, the commander will assign the tri-car officers under the supervision of a regular sergeant.

C. Tactical Deployment of Tri-Car Officers

1. District tri-car officers will be assigned to patrol those areas selected by the district commander, who will examine the latest statistical information concerning the crime situation before making that decision. The watch commander will insure that such patrol area information is (1) included on the District Patrol Unit Availability Work Sheet, MPD Form OPP-29; and (2) reported to the Communications Division prior to the start of each watch.

2. A discretionary officer utilized as a footbeat officer may be assigned to patrol his area on the extra tri-car available in each district, so long as he is tri-car qualified.

IX. ASSIGNMENT OF MUNICIPAL COURT TRIAL DATES

A. The Court Liaison Office will assign Municipal Court trial dates according to the following schedule, whenever possible:

Platoon(s)	Times for Trial Sessions
A,B	1 PM and 2 PM (when on 7 AM - 3 PM Watch)
N,P	1 PM and 2 PM (when on 10 AM - 6 PM Watch)
C	8 AM
Q	4 PM

B. The duty hours of an officer scheduled to appear at a court session which begins two hours or less prior to the start of his regular tour of duty will be changed by the commander to permit on -duty court appearance, whenever possible (see Section VI of Special Order entitled "Commissioned and Civilian Overtime, Court Time and Shift Differential Policy and Procedures" for additional details.

By Order of:

EUGENE J. CAMP
Colonel
Chief of Police

EJC/fd, jm, cc:as
250:81:084

METROPOLITAN POLICE DEPARTMENT - CITY OF ST. LOUIS

250;81;084

1982 District Recreation Schedule

"A" & "N" PLATOON

DAY
Period 1

JANUARY

DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R									R	R
5			R	R								H	R	R	R	R					
6						R	R	R	R								R	R			

AFTERNOON
Period 2

JANUARY FEBRUARY

DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1						R	R	R	R								R	R			
2	R	R								R	R									R	R
3			R	R									R	R	R	R					
4					H	R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			R	R								H	R	R	R	R					

DAY
Period 3

FEBRUARY MARCH

DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2					H	R	R	H	R								R	H			
3	R	R								R	R								H	R	R
4			R	R									R	R	R	R					
5						R	R	R	R								R	R			
6	R	R								R	R									R	R

AFTERNOON
Period 4

MARCH

DAY OF MONTH	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	R
2			R	R									R	R	R	R					
3						R	R	R	R								R	R			
4	R	R								R	R								H	R	R
5			R	R								H	R	R	R	R					
6					H	R	R	R	R								R	R			

DAY
Period 5

MARCH APRIL

DAY OF MONTH	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	R	R	R	R								R	R			
2	R	R								R	R								H	R	R
3			R	R								H	R	R	R	R					
4						R	R	R	R								R	R			
5	R	R								R	R									R	R
6			R	R								H	R	R	R	R					

AFTERNOON
Period 6

APRIL MAY

DAY OF MONTH	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2						R	R	R	R								R	R			
3	R	R								R	R								H	R	R
4			R	R								H	R	R	R	R					
5					H	R	R	R	R								R	R			
6	R	R								R	R								H	R	P

DAY
Period 7

MAY

DAY OF MONTH	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	H
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R								H	R	R
5			R	R									R	R	R	R					
6						R	R	R	R								R	R			

AFTERNOON
Period 8

MAY JUNE

DAY OF MONTH	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	R	R	R	R								R	R			
2	R	H								R	R								H	R	R
3			R	R									R	R	R	R					
4					H	R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			R	R								H	R	R	R	R					

DAY
Period 9

JUNE JULY

DAY OF MONTH	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R	R	R							A	A	A	R	R				
2							R	R	R	R			A	A	A			R	R		
3	R	R									R	R	A	A	A					R	R
4			R	R	R	R							A	A	A	R	R				
5							R	R	R	R			A	A	A			R	R		
6	R	R									R	R	A	A	A					R	H

A VEILED PROPHET FAIR (NO OFFICERS PERMITTED OFF EXCEPT FOR VACATIONS)

HOLIDAYS APPEARING IN SCHEDULE

Brackets	1	2	3	4	5	6	7	8	9	10
1	Jan 22	Feb 26*	Apr 2*	Apr 30*	Jun 4*	July 30	Sept 3*	Oct 8*	Dec 3	Dec 24
2	Jan 15*	Feb 19*	Apr 16	May 21*	Jun 18	July 23*	Sept 24*	Oct 22	Nov 26*	Dec 17
3	Jan 8*	Mar 5	Apr 9*	May 7	May 14*	July 16*	Sept 10	Oct 15*	Nov 19*	Dec 31
4	Jan 29*	Mar 26	Apr 30*	May 28	Jun 4*	Aug 6	Sept 3*	Oct 1	Nov 5*	Dec 24
5	Jan 15*	Feb 12	Mar 19*	Apr 23*	Jun 18	July 23*	Aug 27*	Sept 24*	Oct 22	Dec 17
6	Feb 5*	Mar 12*	Apr 9*	May 7	Jun 11*	Aug 13*	Sept 17*	Nov 12	Dec 10	Dec 31

* Denotes 6 Days Off in a Row.

"A" & "N" PLATOON (Cont'd)

AFTERNOON

Period 10

	JULY																				AUGUST
DAY OF MONTH	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R									R	R
5			R	R								H	R	R	R	R					
6						R	R	R	R								R	R			

DAY

Period 11

	AUGUST																				
DAY OF MONTH	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1		B				R	R									R	R	R	R		
2	R	B						R	R	R										R	R
3		B	R									R	R	R	R						
4		B			H	R	R									R	R	R	R		
5	R	B						R	R	R										R	R
6		B	R	H							H	R	R	R	H						

[B] PRIMARY ELECTION (NO OFFICERS PERMITTED OFF, EXCEPT FOR VACATION).

AFTERNOON

Period 12

	AUGUST									SEPTEMBER											
DAY OF MONTH	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2						R	H	R	R								R	R			
3	R	R								R	R								H	R	R
4			R	R								H	R	R	R	R					
5					H	R	R	R	R								R	R			
6	R	R								R	R									R	R

DAY

Period 13

	SEPTEMBER																		OCTOBER		
DAY OF MONTH	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	R
2			R	R								H	R	R	R	R					
3						R	R	R	R								R	H			
4	R	R								R	R								H	R	R
5			R	R								H	R	R	R	R					
6					H	R	R	R	R								R	R			

AFTERNOON

Period 14

	OCTOBER																				
DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	R	R	R	R								R	R			
2	R	R								R	R								H	R	R
3			R	R								H	R	R	R	R					
4						R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			R	R									R	R	H	R					

DAY

Period 15

	OCTOBER							NOVEMBER													
DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R					C				R	R	R	R					
2					R	R	R	R	C								R	H			
3	R	R							C	R	R									R	R
4			R	R					C			H	R	K	R	R					
5					R	R	R	R	C								R	H			
6	R	R							C	R	R								H	R	R

[C] GENERAL ELECTION (NO OFFICERS PERMITTED OFF, EXCEPT FOR VACATION).

AFTERNOON

Period 16

	NOVEMBER																DECEMBER				
DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R									R	R
5			R	R									R	R	R	R					
6						R	R	R	R								R	R			

DAY

Period 17

	DECEMBER																				
DAY OF MONTH	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1						R	R	R	R								R	R	H		
2	R	R								R	R	H								R	R
3			R	R									R	R	R	R					
4						R	R	R	R								R	R	H		
5	R	R								R	R	H								H	R
6			R	R	H								R	R	R	H					

DAY

Period 17 (cont')

	DECEMBER					JANUARY 1983	
DAY OF MONTH	27	28	29	30	31	1	2
DAY OF WEEK	M	T	W	T	F	S	S
BRK 1			R	K			
2	R	R					
3					H	R	R
4			K	R			
5	R	R					
6					H	R	R

METROPOLITAN POLICE DEPARTMENT - CITY OF ST. LOUIS

250:81:084

1982 District Recreation Schedule
"B" & "P" PLATOON

AFTERNOON
Period 1

JANUARY																					
DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	H								R	R									R	R
5			R	R								H	R	R	R	R					
6						R	R	R	R								R	R			

DAY
Period 2

	JANUARY							FEBRUARY													
DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1						R	R	H	R								R	R			
2	R	R								R	R									R	R
3			R	R									R	R	R	R					
4					H	R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			H	R								H	R	R	R	R					

AFTERNOON
Period 3

	FEBRUARY														MARCH						
DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2					H	R	R	R	R								R	H			
3	R	R								R	R								H	R	R
4			R	R									R	R	R	R					
5						R	R	R	R								R	H			
6	R	R								R	R									R	R

DAY
Period 4

	MARCH																				
DAY OF MONTH	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	R
2			R	R									R	R	R	R					
3						R	R	R	R								R	R			
4	R	R								R	R								H	R	R
5			R	R								H	R	R	R	R					
6					H	R	R	R	R								R	R			

AFTERNOON
Period 5

	MARCH			APRIL																	
DAY OF MONTH	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	H	R	R	R								R	R			
2	R	R								R	R								H	R	R
3			R	R								H	R	R	R	R					
4						R	R	R	R								R	R			
5	R	R								R	R									R	R
6			R	R								H	R	R	R	R					

DAY
Period 6

	APRIL												MAY								
DAY OF MONTH	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2						R	R	R	R								R	R			
3	R	R								R	R								H	R	R
4			R	R								H	R	R	R	R					
5					H	R	R	R	H								R	R			
6	H	R								R	R								H	R	R

AFTERNOON
Period 7

	MAY																				
DAY OF MONTH	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R								H	R	R
5			R	R									H	R	R	R					
6						R	R	R	R								R	R			

DAY
Period 8

	MAY	JUNE																			
DAY OF MONTH	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	R	R	R	R								R	R			
2	R	R								R	R								H	R	R
3			R	R									R	R	R	R					
4					H	R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			R	R								H	R	R	R	R					

AFTERNOON
Period 9

	JUNE										JULY										
DAY OF MONTH	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R	H	R							A	A	A	R	R				
2							R	R	R	R			A	A	A			R	R		
3	R	R									R	R	A	A	A					R	R
4			R	R	R	R							A	A	A	R	R				
5							R	R	R	R			A	A	A			R	R		
6	R	R									R	R	A	A	A					R	R

A VEILED PROPHET FAIR (NO OFFICERS PERMITTED OFF EXCEPT FOR VACATIONS)

HOLIDAYS APPEARING IN SCHEDULE

Breakout	1	2	3	4	5	6	7	8	9	10
1	Jan 22	Feb 26	Apr 2*	Apr 30*	Jun 4*	July 30	Sept 3*	Oct 8*	Dec 3	Dec 24
2	Jan 15*	Feb 18*	Apr 16	May 21*	Jun 18	July 23*	Sept 24*	Oct 22	Nov 26*	Dec 17
3	Jan 8*	Mar 6	Apr 8*	May 7	May 14*	July 16*	Sept 10	Oct 15*	Nov 19*	Dec 31
4	Jan 29*	Mar 26	Apr 30*	May 28	Jun 4*	Aug 6	Sept 3*	Oct 1	Nov 5*	Dec 24
5	Jan 15*	Feb 12	Mar 19*	Apr 23*	Jun 18	July 23*	Aug 27*	Sept 24*	Oct 22	Dec 17
6	Feb 5*	Mar 12*	Apr 8*	May 7	Jun 11*	Aug 12*	Sept 17*	Nov 12	Dec 10	Dec 31

* Denotes 5 Days Off in a Row.

"B" & "P" PLATOON (Cont'd)

DAY

Period 10

JULY — AUGUST

DAY OF MONTH	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R									R	R
5			R	R								H	R	R	R	R					
6						R	R	R	R								R	R			

AFTERNOON

Period 11

AUGUST

DAY OF MONTH	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1		B				R	R									R	R	R	R		
2	R	B						R	R	R										R	R
3		B	R	R								R	R	R	R						
4		B			H	R	R									R	R	R	R		
5	R	B						R	R	R										R	R
6		B	R	R							H	R	R	R	R						

DAY

Period 12

AUGUST — SEPTEMBER

DAY OF MONTH	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R								H	R	R	R	R					
2						R	R	R	R								R	R			
3	R	R								R	R								H	R	R
4			R	R								H	R	R	R	R					
5					H	R	R	R	R								R	R			
6	R	R								R	R									R	R

B PRIMARY ELECTION (NO OFFICERS PERMITTED OFF, EXCEPT FOR VACATION).

AFTERNOON

Period 13

SEPTEMBER — OCTOBER

DAY OF MONTH	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R									R	R
2			R	R								H	R	R	R	R					
3						R	R	R	R								R	R			
4	R	R								R	R								H	R	R
5			R	R								H	R	R	R	R					
6					H	R	R	R	R								R	R			

DAY

Period 14

OCTOBER

DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1					H	R	R	R	R								R	R			
2	R	R								R	R								H	R	R
3			R	R								H	R	R	R	R					
4						R	R	R	R								R	R			
5	R	R								R	R								H	R	R
6			R	R									R	R	R	R					

AFTERNOON

Period 15

OCTOBER — NOVEMBER

DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1			R	R					C				R	R	R	R					
2					R	R	R	R	C								R	R			
3	R	R							C	R	R									R	R
4			R	R					C			H	R	R	R	R					
5					R	R	R	R	C								R	R			
6	H	R							C	R	R								H	R	R

C GENERAL ELECTION (NO OFFICERS PERMITTED OFF, EXCEPT FOR VACATIONS)

DAY

Period 16

NOVEMBER — DECEMBER

DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R	R								R	R								H	R	R
2			R	R								H	R	R	R	R					
3					H	R	R	R	R								R	R			
4	R	R								R	R									R	R
5			R	R									R	R	R	R					
6						R	R	R	R								R	R			

AFTERNOON

Period 17

DECEMBER

DAY OF MONTH	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1						R	R	R	R								R	R	H		
2	R	R								R	R	H								R	R
3			R	R									R	R	R	R					
4						R	R	R	R								R	R	H		
5	R	R								R	R	H								R	R
6			R	R	H								R	R	R	R					

AFTERNOON

Period 17 (Cont'd)

DECEMBER — JANUARY 1983

DAY OF MONTH	27	28	29	30	31	1	2
DAY OF WEEK	M	T	W	T	F	S	S
BRK 1			R	R			
2	R	R					
3					H	R	R
4			R	R			
5	R	R					
6					H	R	R

METROPOLITAN POLICE DEPARTMENT - CITY OF ST. LOUIS

250:81:084

1982 District Recreation Schedule
C PLATOON

NIGHT

Period 1

JANUARY

DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT

Period 2

JANUARY FEBRUARY

DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT

Period 3

FEBRUARY MARCH

DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R									H	R
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		H	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT

PERIOD 4

MARCH

DAY OF MONTH	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R									R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT

PERIOD 5

MARCH APRIL

DAY OF MONTH	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R									R	R
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT

PERIOD 6

APRIL MAY

DAY OF MONTH	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R									R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT

Period 7

MAY

DAY OF MONTH	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	H								R	R	R									R	H
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	H	R						
6					H	R	R	R								R	R	R			

NIGHT

Period 8

MAY JUNE

DAY OF MONTH	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	H	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	H								R	R	R									R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT

Period 9

JUNE JULY

DAY OF MONTH	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1							R	R	R				A	A	A				R	R	R
2	R	R	R							R	R	R	A	A	A						
3				R	R	R							A	A	A	R	R	R			
4							R	R	R				A	A	A				R	R	R
5	R	R	R							R	R	R	A	A	A						
6				R	R	R							A	A	A	R	R	R			

A VEILED PROPHET FAIR (NO OFFICERS PERMITTED OFF EXCEPT FOR VACATIONS)

HOLIDAYS APPEARING IN SCHEDULE

Brackets	1	2	3	4	5	6	7	8	9	10
1	Jan 22	Feb 12	Mar 26	May 7	Jun 18	Aug 20	Oct 1	Oct 22	Nov 12	Dec 3
2	Jan 15	Feb 5	Mar 19	Apr 30	Jun 11	Aug 13	Sept 24	Nov 5	Dec 17	Dec 29
3	Jan 8	Jan 29	Mar 12	Apr 23	Jun 4	Aug 6	Sept 17	Oct 29	Dec 10	Dec 24
4	Jan 22	Feb 12	Mar 5	Apr 16	May 28	July 30	Sept 10	Oct 22	Nov 12	Dec 3
5	Jan 15	Feb 5	Feb 26	Apr 9	May 21	July 23	Sept 3	Oct 15	Nov 26	Dec 29
6	Jan 8	Jan 29	Feb 19	Apr 2	May 14	July 16	Aug 27	Oct 8	Nov 19	Dec 24

"C" PLATOON (Cont'd)

NIGHT
PERIOD 10

JULY — AUGUST

DAY OF MONTH	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R									R	R
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT
PERIOD 11

AUGUST

DAY OF MONTH	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	H								H	R	H
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R									R	H
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT
PERIOD 12

AUGUST — SEPTEMBER

DAY OF MONTH	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R									R	H
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	H
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT
PERIOD 13

SEPTEMBER — OCTOBER

DAY OF MONTH	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	H
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R									R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT
PERIOD 14

OCTOBER

DAY OF MONTH	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	H			

NIGHT
PERIOD 15

OCTOBER — NOVEMBER

DAY OF MONTH	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	H
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R			

NIGHT
PERIOD 16

NOVEMBER — DECEMBER

DAY OF MONTH	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R								H	R	R
2		R	R	R									R	R	R						
3						R	R	R								R	R	R			
4	R								R	R	R								H	R	R
5		R	R	R								H	R	R	R						
6					H	R	R	R								R	R	R			

NIGHT
PERIOD 17

DECEMBER

DAY OF MONTH	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
DAY OF WEEK	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
BRK 1	R								R	R	R									R	R
2		R	R	R								H	R	R	R						
3					H	R	R	R								R	R	R	H		
4	R								R	R	R									R	R
5		R	R	R									R	R	R						
6						R	R	R								R	R	R	H		

NIGHT
PERIOD 17 (Cont'd)

DECEMBER — JANUARY 1983

DAY OF MONTH	27	28	29	30	31	1	2														
DAY OF WEEK	M	T	W	T	F	S	S														
BRK 1	R	R																			
2			H	R	R																
3						R	R														
4	R	R																			
5			H	R	R																
6						R	R														

APPENDIX II

SAMPLE FLAIR OUTPUT

SUMMARY REPORT START

DAILY SUMMARY REPORT
PART I

DATES: 03/14B81 TO 03/14B81

REPORT INTERVAL: 15: 0 HRS. TO 23: 0 HRS.

CONSOLE ASSIGNMENT BY DISTRICT

TIME	DISTRICT / CONSOLE	1	2	3	4	5	6	7	8	9
16: 0		71	1	82	3	3	4	6	4	5

EMERGENCY TRANSMISSIONS

TIME	CALL NO.	X-LOCATION (FEET)	Y-LOCATION (FEET)
22:46	225	30434.	11123.

AUTOMATIC INITIALIZATIONS

INDEX	COUNT	INDEX	COUNT	INDEX	COUNT	INDEX	COUNT	INDEX	COUNT
1	11	26	19	51	31	76	21	101	23
2	29	27	75	52	14	77	5	102	0
3	43	28	5	53	8	78	24	103	8
4	9	29	29	54	15	79	11	104	10
5	3	30	11	55	11	80	10	105	59
6	16	31	54	56	8	81	0	106	0
7	0	32	40	57	14	82	3	107	0
8	17	33	81	58	14	83	26	108	0
9	2	34	22	59	8	84	15	109	0
10	26	35	0	60	42	85	1	110	0
13	51	36	20	63	.6	88	5	113	0
14	20	9	1	64	11	89	31	114	0
15	5	40	6	65	8	90	21	115	0
16	21	41	0	66	69	91	28	116	0
17	9	42	40	67	36	92	3	117	0
18	27	43	9	68	33	93	12	118	0
19	26	44	56	69	0	94	29	119	0
20	1	45	6	70	34	95	5	120	0
21	19	46	5	71	7	96	0	121	0
22	55	47	5	72	5	97	0	122	0
23	17	48	0	73	1	98	8	123	0
24	26	49	5	74	1	99	30	124	0
25	15	50	108	75	7	100	26	125	0

DAILY SUMMARY REPORT (CONT'D)
PART III
DAILY ACTIVITY REPORT

DATES: 03/14B81 TO 03/14B81
REPORT INTERVAL: 15: 0 HRS. TO 23: 0 HRS.

DISTRICT	1	2	3	4	5	6	7	8	9	TOTAL
1. TOTAL DIGITAL CODES:	315	331	756	337	473	426	232	389	401	3660
2. SPECIAL DIGITAL CODE NO. 1 (70)	13	18	21	16	15	17	10	26	12	148
3. SPECIAL DIGITAL CODE NO. 2 (67)	4	0	6	0	1	4	1	1	3	20
4. DISPLAY EVENT										
A. INITIA. (DISPATCHER ASSIST)	6	7	10	23	15	29	9	6	21	126
B. CLEAR STATUS	45	41	44	27	50	109	19	97	43	475
C. ASSIGN	2	0	5	4	1	4	13	0	0	29
D. CURSOR MAP CHANGE (BY CONSOLE)	58	47	31	32	35	27	2	0		232
E. LOCATE CAR	30	46	142	51	37	52	72	20	32	482
F. CHANGE MAP SCALE (BY CONSOLE)	15	6	11	0	7	0	2	0		41
G. VERIFY REQUESTS	6	4	7	14	7	19	8	5	13	83
5. NO. OF CARS IN SYSTEM	11	12	25	13	10	14	16	11	14	127
6 TOTAL MILEAGE FOR ALL CARS	498.	457.	1093.	433.	396.	643.	607.	388.	494.	5009
7. AVG. MILEAGE/CAR	45.	38.	44.	33.	40.	46.	38.	35.	35.	39
8. SELF-INITIAL.	1	0	0	0	0	0	2	0	0	3
9 SIGNPOST - INITIAL.	142	151	383	296	162	217	204	192	142	1889

DAILY SUMMARY REPORT (CONT'D)
PART IV
DAILY REPORT CAR PERFORMANCE

DATES: 03/14B81 TO 03/14B81
REPORT INTERVAL: 15: 0 HRS. TO 23: 0 HRS.

1. ****************
   A ****************************** .64% 15.378
   B "PROGRAM" (AVG./CAR): 22.969
2. AVG "MILES / VERIFY FLAG": 61.084
3. AVG. MILE/INITIAL. : 40.394
4. LIST OF 20 MOST ACTIVE CARS

NO.	REJECTED DATA AUTOIP FLAIR NO.	COUNT	PROGRAM FLAIR NO.	COUNT	VERIFY FLAGS FLAIR NO.	COUNT	DISPATCHER INITIAL FLAIR NO.	COUNT
1	1173	57	1134	208	1165	5	1165	7
2	1063	47	1066	182	1092	4	1092	6
4	1075	42	1175	73	1178	4	1178	5
5	1074	3	1063	67	1113	4	1107	[illegible]
6	1041	37	1086	66	1180	3	1113	5
7	1070	33	1165	56	1097	2	1069	5
8	1097	32	1127	54	1128	2	1108	4
9	1044	30	1140	50	1057	2	1085	3
10	1123	30	1100	50	1188	2	1103	3
11	1086	27	1069	49	1110	2	1157	3
12	1094	27	1064	49	1121	2	1110	3
13	1026	26	1113	41	1069	2	1146	3
14	1138	26	1121	41	1157	2	1128	3
15	1057	26	1107	37	1145	2	1159	3
16	1043	25	1017	37	1172	2	1105	2
17	1102	24	1065	36	1127	2	1161	2
18	1181	24	1074	36	1094	2	1155	2
19	1091	24	1075	35	1159	2	1160	2
20	1126	24	1010	33	1105	1	1097	2

5. PER CAR DATA HISTORY

FLAIR NO.	CALL NO	MILEAGE	REJECTED DATA AUTOIP	PROGRAM	VERIFY FLAGS	INITIALIZATION DISP.	SELF
1001	106	39.2	18	25	0	0	0
1002	111	47.9	10	21	0	0	0
1003	112	54.5	18	16	0	0	0
1004	122	14.3	0	3	0	1	0
1006	123	44.7	10	8	1	2	0
1007	124	49.9	10	15	1	1	0
1008	125	62.9	20	21	0	0	0
1009	126	59.1	20	7	0	0	0
1010	127	50.1	16	33	1	1	0
1012	129	26.1	10	10	1	0	1
1017	206	72.1	20	37	0	0	0
1018	211	14.7	0	2	0	0	0
1019	212	18.6	6	5	0	0	0
1020	221	51.1	7	11	1	1	0
1023	224	42.7	18	7	0	0	0
1024	225	25.0	8	13	1	1	0
1025	226	43.4	20	18	0	1	0
1026	227	55.6	26	20	1	2	0
1027	228	35.6	15	16	0	0	0
1028	229	39.5	16	16	0	1	0
1029	230	50.7	15	20	1	1	0
1030	0*	7.5	2	0	0	0	0
1034	311	52.6	22	21	0	0	0
1036	313	11.7	6	33	1	0	0
1037	0*	6.2	4	2	0	0	0
1038	315	57.0	7	11	0	0	0
1039	321	55.2	17	24	0	0	0
1041	323	63.7	37	26	0	0	0
1043	325	37.1	25	15	0	1	0
1044	326	31.5	30	10	0	0	0
1045	327	32.1	16	17	0	1	0
1046	328	60.8	6	13	1	1	0
1047	329	56.5	23	15	0	0	0
1048	330	55.3	18	20	0	0	0
1049	331	56.1 -	9	26	1	1	0
1050	332	73.3	13	26	0	0	0
1051	333	70.8	22	33	0	0	0
1052	334	41.0	18	8	1	1	0
1053	0*	41.5	11	16	0	1	0
1055	337	68.2	19	19	0	0	0
1056	335	34.8	21	5	1	1	0
1057	342	52.9	26	23	2	2	0
1058	322	48.9	19	29	0	0	0
1059	324	43.9	12	23	0	1	0
1060	341	36.0	16	15	0	0	0
1091	529	55.1	24	9	0	1	0
1092	527	53.9	16	22	4	6	0
1093	526	23.7	7	9	0	1	0
1094	528	57.6	27	19	2	2	0
1097	606	55.7	32	27	2	2	0
1098	611	33.0	17	15	1	1	0

1100	613	2.2	0	50	0	1	0
1102	624	44.0	24	22	0	0	0
1103	625	72.0	21	18	0	3	0
1104	626	45.8	17	12	1	1	0
1105	627	50.6	22	7	1	2	0
1106	628	36.1	9	19	0	0	0
1107	629	68.9	17	37	4	5	0
1108	630	39.9	9	8	1	4	0
1110	632	65.7	19	26	2	3	0
1111	0*	4.7	2	0	0	0	0
1113	631	43.2	14	41	4	5	0
1116	727	16.0	7	7	0	0	0
1120	722	49.5	14	29	0	0	0
1121	723	52.7	21	41	2	2	0
1123	726	46.7	30	26	0	0	0
1125	728	54.3	16	15	0	0	0
1126	729	53.2	24	29	0	0	0
1127	731	51.3	0	54	2	2	0
1128	732	65.9	23	12	2	3	0
1129	733	44.9	2	18	1	0	1
1130	734	45.7	14	15	0	0	0
1131	736	30.4	15	20	0	0	0
1132	737	11.4	8	3	0	0	0
1133	714	53.5	23	27	1	1	1
1134	738	7.1	5	208	0	0	0
1138	806	38.8	26	22	0	0	0
1139	807	32.2	17	26	1	0	0
1141	812	72.5	42	12	0	0	0
1145	825	51.4	15	10	2	2	0
1146	826	42.6	12	29	1	3	0
1148	828	33.6	17	12	0	0	0
1149	0*	5.6	0	5	0	0	0
1153	906	51.7	17	103	1	1	0
1154	911	13.5	8	6	0	0	0
1155	912	24.6	5	16	1	2	0
1156	913	26.0	14	24	0	0	0
1157	921	41.0	11	15	2	3	0
1158	922	31.4	4	9	0	0	0
1159	923	60.8	16	17	2	3	0
1160	924	28.5	8	8	1	2	0
1161	925	66.0	19	29	1	2	0
1163	927	42.8	18	25	0	0	0
1164	928	32.7	9	12	0	0	0
1173	427	.2	57	25	0	0	0
1175	0*	5.5	5	73	0	0	0
1178	421	27.7	11	7	4	5	0
1180	426	22.4	1	22	3	5	0
1181	823	31.7	24	5	1	1	0
1182	822	41.4	23	13	0	0	0
1183	0*	24.7	5	0	0	0	0
1186	827	37.9	16	11	0	0	0
1188	612	81.0	16	4	2	1	0
1195	1195	17.0	8	4	0	0	0

SUMMARY REPORT COMPLETE

APPENDIX III

SAMPLE QUESTIONNAIRE

Public Systems Evaluation, Inc.

To the Police Officers of St. Louis:

Public Systems Evaluation, Inc. (PSE) is a not-for-profit organization that conducts research in various areas of law enforcement. We are currently working with your department under the terms of a federal grant to examine various aspects of police preventive patrol. In this regard, we would be most appreciative if you would take the time to answer the questions in the enclosed questionnaire. As you will notice, there is no place for you to write your name. We are interested in your opinions about a number of items and issues; we are not interested in knowing which officer said what. No one will see these questionnaires except employees of PSE, and any results of the questionnaires will be in statistical form. We estimate that the questionnaire will take about 30 minutes to complete.

As you will see, the questions ask that you express your opinions in a number of different ways. Some ask that you rate items on a scale of 0 to 10, others ask how strongly you agree or disagree with statements and others ask for how often you feel something might occur. If you have any problems, feel free to contact us.

Thank you in advance for sharing your opinions with us.

Sincerely yours,

PUBLIC SYSTEMS EVALUATION, INC.

Richard C. Larson
President

John F. Runcie
Project Manager

929 Massachusetts Avenue, Cambridge, Massachusetts 02139 617/547-7620

Public Systems Evaluation, Inc.

ST. LOUIS METROPOLITAN POLICE DEPARTMENT QUESTIONNAIRE

1. How do you think the FLAIR system has affected the department's overall performance?
   Improved _______ No effect _______ Worsened _______

2. Overall, how has FLAIR's performance compared with your early expectations:
   Better than I expected _______ About what I expected _______
   Not as good as I expected _______

3. How do you think FLAIR has affected your ability to do your job? Has it:
   Helped you _______ Made no difference _______ Made it harder _______

4. How does the FLAIR system affect the way you feel about your job?
   More satisfying _______ No difference _______ Less satisfying _______

5. What effect has FLAIR had on the following aspects of police operations? Please be certain to answer all parts, A - D.

	Improved	No Effect	Worsened
A. Keeping track of the patrol force	_______	_______	_______
B. Handling extraordinary events, like pursuits	_______	_______	_______
C. Effective resource allocation	_______	_______	_______
D. Efficient use of available patrol time (for example, bunching up)	_______	_______	_______

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6. As a result of FLAIR, how do you think your task as a patrolman has been altered in each of the following areas? Please be certain to answer all parts, A - D.

	Increased	Stayed the same	Decreased
A. Preventive patrol miles traveled	_____	_____	_____
B. Flexibility to follow individual hunches	_____	_____	_____
C. Coordinated operations with fellow officers	_____	_____	_____
D. Other (please be specific) _____________	_____	_____	_____

7. To what extent do you think that new technologies are a good idea for a police department? Indicate your answer on the scale below from 1 - 7 by putting a checkmark above the number that best describes your opinion.

____	____	____	____	____	____	____
1 Very Good Idea	2	3	4	5	6	7 Very Bad Idea

8. To what extent do you think that new procedures are a good idea for a police department? Indicate your answer on the scale below from 1 - 7 by putting a checkmark above the number that best describes your opinion.

____	____	____	____	____	____	____
1 Very Good Idea	2	3	4	5	6	7 Very Bad Idea

9. In designing and operating the FLAIR system, do you think the suggestions of patrol officers were seriously considered?

Yes _______ No _______

10. In general, do you think it is a good idea or not a good idea to have the FLAIR system in St. Louis?

Good idea _______ Bad idea _______

PSE/SL-2

11. Please evaluate how FLAIR has affected the department's performance in each of the following areas. Please be certain to answer all parts, A - G.

	Improved	No effect	Worsened
A. Reducing response time	_____	_____	_____
B. Officer safety	_____	_____	_____
C. Departmental disciplinary procedures	_____	_____	_____
D. Dispatch operations	_____	_____	_____
E. Increasing radio access	_____	_____	_____
F. Reducing frequency congestion	_____	_____	_____
G. Command and control	_____	_____	_____
H. Other (please be specific) _____________	_____	_____	_____

12. If you had the chance would you change the kind of police work you do?

Yes _______ No _______

A. If you said Yes, what kind of police work would you like to do?

____

____

13. If you could change one thing in your present job to make your work life better, what would it be? ____

____

14. Please evaluate the effectiveness of preventive patrol in terms of each of the following issues. For our purposes, when we say preventive patrol we mean the physical presence of officers in an area where the officers are unpredictably visible due to their movements and their actions.

	Very effective	Effective	Not very effective	No opinion
A. Preventing crimes	_____	_____	_____	_____
B. Deterring crimes	_____	_____	_____	_____
C. Increasing police visibility in the street	_____	_____	_____	_____

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15. Please evaluate the effectiveness of directed patrol in terms of each of the following issues. For our purposes, when we say directed patrol, we mean the use of crime analysis data to locate specific kinds of crimes and the deliberate allocation of patrol efforts based on this data.

	Very effective	Effective	Not very effective	No opinion
A. Preventing crimes	____	____	____	____
B. Deterring crimes	____	____	____	____
C. Increasing police visibility in the street	____	____	____	____

16. Should the police department alter the present mix of civilian and sworn personnel?

Yes ______ No ______

A. If you said Yes, should they:

1. Add more civilian employees ______
2. Add more sworn employees ______
3. Add more of both ______
4. Decrease the number of civilian employees ______
5. Decrease the number of sworn employees ______
6. Decrease both groups ______
7. Change nothing ______

17. Do civilian employees affect the quality of the delivery of police services in the community?

Yes ______ No ______

A. If you said Yes, do they:

1. Improve the quality of the delivery ______
2. Decrease the quality of the delivery ______

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18. Please consider the following list of tactics in terms of how effective each would be in preventive patrol (as we defined it in item 14 above). For each tactic, put a check mark in the box that represents how you feel. For each tactic, tell us if you think it is Very Effective, Somewhat Effective, Somewhat Ineffective, Very Ineffective, or you are Uncertain how you feel.

Very Effective	Somewhat Effective	Somewhat Ineffective	Very Ineffective	Uncertain	
					• Aggressive checking of doors and windows
					• Questioning of suspicious persons
					• Splitting the force into a force only answering calls for service and a force only doing patrol
					• Delaying response to low priority calls for service
					• Surveillance
					• Stake-out
					• Marked cars
					• Slow speed patrol
					• One officer cars
					• Off-duty use of patrol cars
					• Civilians to handle noncritical calls for service
					• Foot patrol
					• Quicker response time
					• Knowing the whereabouts of formerly convicted offenders in the community
					• Knowing the leaders of youth gangs in the community
					• Having one or more patrol cars deliberately follow a lead car (with one or two blocks separating them) so that criminals could not predict times of relative safety to commit crimes
					• Knowing the modus operandi of recently committed crimes
					• Saturation patrol
					• Unmarked cars
					• High speed patrol
					• Two officer cars
					• District meetings to discuss critical police issues among officers

PSE/SL-2

19. Please consider the following list of tactics in terms of how effective each would be in directed patrol (as we defined it in item 15 above). For each tactic, put a check mark in the box that represents how you feel. For each tactic, tell us if you think it is Very Effective, Somewhat Effective, Somewhat Ineffective, Very Ineffective, or you are Uncertain how you feel.

Very Effective	Somewhat Effective	Somewhat Ineffective	Very Ineffective	Uncertain	
					• Aggressive checking of doors and windows
					• Questioning of suspicious persons
					• Splitting the force into a force only answering calls for service and a force only doing patrol
					• Delaying response to low priority calls for service
					• Surveillance
					• Stake-out
					• Marked cars
					• Slow speed patrol
					• One officer cars
					• Off-duty use of patrol cars
					• Civilians to handle noncritical calls for service
					• Foot patrol
					• Quicker response time
					• Knowing the whereabouts of formerly convicted offenders in the community
					• Knowing the leaders of youth gangs in the community
					• Having one or more patrol cars deliberately follow a lead car (with one or two blocks separating them) so that criminals could not predict times of relative safety to commit crimes
					• Knowing the modus operandi of recently committed crimes
					• Saturation patrol
					• Unmarked cars
					• High speed patrol
					• Two officer cars
					• District meetings to discuss critical police issues among officers

20. Who decides where you patrol within the district?

Yourself ______ Sergeant ______ Lieutenant ______
Captain ______ ICAP ______ A combination of the above ______
Other (please specify) ______________________ ______

21. Who decides what pattern your patrol takes within the district?

Yourself ______ Sergeant ______ Lieutenant ______
Captain ______ ICAP ______ A combination of the above ______
Other (please specify) ______________________ ______

22. Are crime statistics used to help you improve the effectiveness of your patrol?

Yes ______ No ______

A. If you said Yes, how are they used? Please be certain to check all that apply.

______ At roll call

______ By individual notification

______ By your sergeant

______ On the street

______ Some other (please be specific) ______________________

23. Overall, how do you think the use of crime statistics to position or direct patrol would affect your job? Would it:

______ Improve your job

______ Make no difference in your job

______ Worsen your job

24. In your opinion, what is the best way to improve the effectiveness of patrol?

____

____

____

____

____

25. During an average tour of duty, about what percentage of your time is spent on each of the following duties:

A. Answering calls for service ________%

B. Preventive patrol ________%

C. Directed patrol ________%

D. Foot patrol ________%

E. Administrative matters ________%

F. Rest or other breaks ________%

G. Other (please be specific)

________________ ________%

TOTAL = 100%

26. What amount of off-duty social contact do you have with residents of your beat?

_______ I have frequent social contacts

_______ I have occasional social contacts

_______ I rarely have social contacts

_______ I have no social contacts

27. How many members of the community in your patrol area do you know on a first-name basis?

_______ None

_______ One to four

_______ Five to nine

_______ 10 - 19

_______ 20 - 29

_______ 30 - 49

_______ 50 - 99

_______ 100 - 199

_______ 200 or more

28. During an average tour of duty, about how many times do you stop and talk to the members of your community?

_______ None

_______ One to four

_______ Five to nine

_______ 10 - 19

_______ 20 or more

29. During an average tour of duty, about how many times do you get a chance to talk to other police officers, sergeants or command officers?

	None	1 - 4	5 - 9	10 - 19	20 or more
A. Other police officers	___	___	___	___	___
B. Sergeants	___	___	___	___	___
C. Command officers	___	___	___	___	___

30. If you had the chance, would you change the kind of work that you do? (That is, would you go into another line of work?)

Yes _______ No _______

A. If you said Yes, what kind of work would you like to do? ____________

____

31. How often do you do things in your job that you wouldn't do if it were up to you?

Never ___ Once in a while ___ Often ___ Fairly often ___ Very often ___

32. Around here, it's not important how much you know, but who you know that really counts. How do you feel about this statement? Do you:

Strongly agree _______ Disagree _______

Agree _______ Strongly disagree _______

Uncertain _______

33. How much say or influence does a person like you have on the way the police department is run?

A lot _______ Some _______ Very little _______ None _______

34. How often do you tell your supervisor your own ideas about things you might do in your work?

Never ___ Once in a while ___ Often ___ Fairly often ___ Very often ___

35. "In order to avoid apprehension, many criminals time their crimes to be immediately after a patrol car passes." Indicate your opinion on the scale below from 0 - 10 by putting a checkmark above the number that best describes your feelings.

___ 0 ___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___ 8 ___ 9 ___ 10

0 = Definitely not correct; 4–5 = Somewhat correct; 10 = Definitely correct

36. "Many house breakers listen to the police radio and time their break-ins to occur when the local beat car is busy on a call for service." Indicate your opinion on the scale below from 0 - 10 by putting a checkmark above the number that best describes your feelings.

0	1	2	3	4	5	6	7	8	9	10
Definitely not correct					Somewhat correct					Definitely correct

37. "Many armed robbers choose the location of their robbery without regard to the whereabouts and activities of the nearby patrol cars." Indicate your opinion on the scale below from 0 - 10 by putting a checkmark above the number that best describes your feelings.

0	1	2	3	4	5	6	7	8	9	10
Definitely not correct					Somewhat correct					Definitely correct

38. For each of the following types of crimes, please give a score of 0 to 10 depending on how effective you think police patrol can be in preventing or deterring the crime. At one end of the scale, a score of 0 will mean that you think effective police patrol can do little or nothing to prevent or deter such crimes, at the other end of the scale a score of 10 will mean that you think effective police patrol can virtually eliminate such crimes, and a score of 5 means that you think effective police patrol has a moderate effect on preventing or deterring such crimes. For this question, please write the score in the space provided.

0	1	2	3	4	5	6	7	8	9	10
Not effective					Somewhat effective					Very effective

	SCORE
A. First-degree murder of an acquaintance	____
B. Armed robbery of a liquor store	____
C. Armed robbery of a person in the street	____
D. House break of a single-family home	____
E. Rape in a public place	____
F. Auto theft on a street	____
G. Street assault of a stranger	____

39. For each of the following types of crime, please give a score of 0 to 10 depending on whether <u>in your opinion</u> perpetrators <u>when performing a crime</u> totally ignore the locations and activities of nearby patrol cars. A score of 0 means that you think the perpetrator totally ignores the presence and activities of nearby patrol cars, a score of 10 means that you think the perpetrator will not commit a crime if there are patrol cars nearby that pose a threat of apprehension, and a score of 5 means that you think the perpetrator somewhat takes the location and activities of the nearby patrol cars into account in deciding to commit a crime. For this question, please write the score in the space provided.

0	1	2	3	4	5	6	7	8	9	10
Ignores nearby patrol cars					Somewhat concerned about patrol cars					Observes nearby patrol cars

	SCORE
A. First-degree murder of an acquaintance	____
B. Armed robbery of a liquor store	____
C. Armed robbery of a person in the street	____
D. House break of a single-family home	____
E. Rape in a public place	____
F. Auto theft on a street	____
G. Street assault of a stranger	____

40. Overall, how satisfying do you find your profession as a police officer? Indicate your answer on the scale below from 0 - 10 by putting a checkmark above the number that best describes your opinion.

0	1	2	3	4	5	6	7	8	9	10
Not at all satisfying					Somewhat satisfying					Extremely satisfying

Background Information

1. Are you a Male _______ or a Female _______?

2. You do not have to answer this question if you would rather not, but can you please tell me what race you are:

   A. American Indian _______
   B. Black _______
   C. Hispanic _______
   D. White _______
   E. Other (please be specific): _______________

3. How many years of school did you complete?

   A. 0 - 8 _______
   B. 9 - 12 _______
   C. High school graduate _______
   D. College 1 - 4 _______
   E. College graduate _______
   F. Graduate school _______
   G. Other (please be specific): _______________

4. Have you had any special police-related training (such as Criminal Justice college courses, FBI Academy, etc.)?

   Yes _______ No _______

   A. If you said Yes, please describe this training: _______________

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5. How many years have you been on the police force?

   A. 0 - 2 _______
   B. 3 - 5 _______
   C. 6 - 10 _______
   D. 11 - 15 _______
   E. 16 or more _______

6. How many years have you been assigned to this district?

   A. 0 - 2 _______
   B. 3 - 5 _______
   C. 6 - 10 _______
   D. 11 - 15 _______
   E. 16 or more _______

7. What is your rank?

   A. Patrol Officer _______
   B. Sergeant _______
   C. Lieutenant _______
   D. Captain _______
   E. Other (please be specific): _______________

IF THERE IS ANY INFORMATION YOU WOULD LIKE TO ADD, ELABORATE ON, OR ADD TO WHAT YOU HAVE ALREADY SAID, PLEASE FEEL FREE TO : ITE ON THE BACK OF THE QUESTIONNAIRE.

Thank you again for your help.

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Analyzing the Distance Between A Crime and A Monitored Police Car

by

Richard C. Larson

Public Systems Evaluation, Inc.
929 Massachusetts Avenue
Cambridge, Machusetts 02139

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LIST OF FIGURES

1 INTRODUCTION

Automatic Vehicle Location (AVL) systems provide continuous position monitoring of all vehicles in an AVL-equipped fleet. In police applications such systems allow researchers to perform police patrol experiments with full knowledge of the patrolling and response patterns of all AVL-equipped police vehicles in an experimental area.

The St. Louis Metropolitan Police Department (SLMPD) is the first major U.S. city to have an operational city-wide accurate AVL system. Public Systems Evaluation, Inc., (PSE) as part of a project called the Directed Patrol Experiment [Grant No. 78-NI-AX-0112 from the National Institute of Justice of the U.S. Department of Justice], is conducting the first set of experimental trials in this unique environment. All previous experiments with alternative police patrol strategies have been done without the researchers knowing the whereabouts of patrol vehicles in the experimental area. Thus, they could not be assured that experimental conditions were upheld or even estimate the extent of non-compliance with experimental conditions. The AVL technology introduces a capability for urban researchers—on a markedly different scale, of course—analogous to the microscope for biological researchers. And, not surprisingly, some geometrically oriented statistical techniques heretofore useful for studying, say, mutant versus ordinary cells under a microscope are now becoming useful in this new urban laboratory. But now the entities of interest are crimes and police patrol vehicles.

A major component of this study is the analysis of the dependence (if any) of crime locations and times upon the locations and patrolling patterns of nearby police vehicles. A critical part of the analysis is the study of the distance between a crime (reported while in progress) and the closest patrol car that is experimentally monitored (i.e., whose location is known to the experimenters). Two special features must be incorporated into the analysis:

AVOIDANCE: If a criminal does choose the time and location of his/her crime with some dependence on nearby police patrol cars, then rules of rational behavior would indicate that he/she attempts to avoid the police. Thus, the analysis must consider different degrees of possible avoidance.

CONTAMINATION: The experimental area is likely to have a certain number of marked police vehicles unequipped for experimental monitoring. While such vehicles provide police visibility to potential criminals, they are invisible to the experimenters. Thus, unmonitored vehicles contaminate the experiment in ways which must be quantified in the analysis.

It is the purpose of this paper to develop models and procedures for analyzing distance to the closest monitored police car in the presence of avoidance and contamination.

Our approach is primarily model-based. We assume that police patrol vehicles—both those that can be observed (monitored) by experimenters and those that cannot (unmonitored)—are distributed randomly and independently over an area that is large compared to typical travel distances. The most appropriate (and analytically tractable) model for such a spatial dispersion of vehicles is the spatial Poisson process. Thus, much of our development focuses on essentially geometrical relationships among entities (i.e., crimes and police vehicles) in the presence of the Poisson assumption. In Section 2 we define the basic Poisson model for monitored and unmonitored vehicles. In Section 3 we address the issue of deliberate criminal avoidance of police; a postulated avoidance-type behavior is attributed to the potential criminal, and a resultant probability law is derived for the distance to the closest police vehicle (monitored or unmonitored) for a given level of such avoidance. In Section 4 we study contamination by unmonitored vehicles and discover a relationship [Equation (7)] between two probability laws: one for the distance from a crime to the closest monitored vehicle and the other for the distance to the closest vehicle (monitored or unmonitored). In Section 5 we combine ideas of avoidance and contamination to derive our major result [Equation (8)]: the probability law for the distance between a crime and the closest monitored vehicle in the presence of a given amount of both contamination and avoidance. Somewhat surprisingly, we find that increasing contamination (by having more unmonitored vehicles) yields a revised probability law for the distance to the closest monitored vehicle that is identical to that which one would obtain with no contamination but with less avoidance. In Section 6 we address some relevant statistical questions, involving structuring an hypothesis test, estimating the amount of avoidance, and testing the reasonableness of the spatial Poisson assumption.

2 BASIC MODEL

Suppose that experimentally monitored vehicles are spatially Poisson distributed with rate γ_1 vehicles/km². Suppose further that unmonitored vehicles are spatially Poisson distributed with rate γ_2 vehicles/km². Define $\gamma \equiv \gamma_1+\gamma_2$. Under the null hypothesis (H_o) of independence of crime and patrol locations, the probability density function (PDF) for the right-angle (rectilinear) distance R_1 (R_2) between the crime and the closest monitored (unmonitored) vehicle is Rayleigh with parameter $\sqrt{4\gamma_1}$ ($\sqrt{4\gamma_2}$).[1] Still under the null hypothesis, the right-angle distance $R_{MIN} \equiv \text{MIN}\ [R_1, R_2]$ is Rayleigh distributed with parameter $\sqrt{4(\gamma_1+\gamma_2)}$. [2] The respective means and variances are:

$$E[R_1] = \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1}} \qquad \sigma^2_{R_1} = (2-\frac{\pi}{2})\frac{1}{4\gamma_1} \qquad \text{(a)}$$

[1] Larson, R.C. and A.R. Odoni, Urban Operations Research, (Englewood Cliffs, NJ: Prentice Hall, 1981)., p. 151.

$$E[R_2] = \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_2}} \qquad \sigma^2_{R_1} = (2 - \frac{\pi}{2})\ \frac{1}{4\gamma_2} \qquad \text{(b)} \qquad (1)$$

$$E[R_{MIN}] = \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1+\gamma_2}} \qquad \sigma^2_{R_{MIN}} = (2 - \frac{\pi}{2})\ \frac{1}{4(\gamma_1+\gamma_2)} \qquad \text{(c)}$$

Under an alternative hypothesis H_1, crimes would tend to occur away from patrol units, both monitored and unmonitored. If R_1', R_2' and R_{MIN}' are the respective variables under the alternative hypothesis, then we are hypothesizing an avoidance between crime and police locations that would shift the Rayleigh PDF for R_{MIN} to the right, as indicated in Figure 1.

3 AVOIDANCE

To model criminal avoidance of police, suppose that potential crimes occur as a homogeneous Poisson process (both in space and time). Given the occurrence of a potential crime at point (x,y) and given that the closest police vehicle (at $[x_1, y_1]$) is right-angle distance r away (i.e., $r = |x-x_1|+|y-y_1|$), then we assume that an actual crime will now occur at (x,y) with probability a(r). Intuitively, one would expect a(r) to have the following properties:

1. a(0) = 0, that is, no crime occurrence "in front of" a policeman.
2. $a(\infty) = 1$
3. a(r) should be monotonically increasing.

For our analysis we will choose:

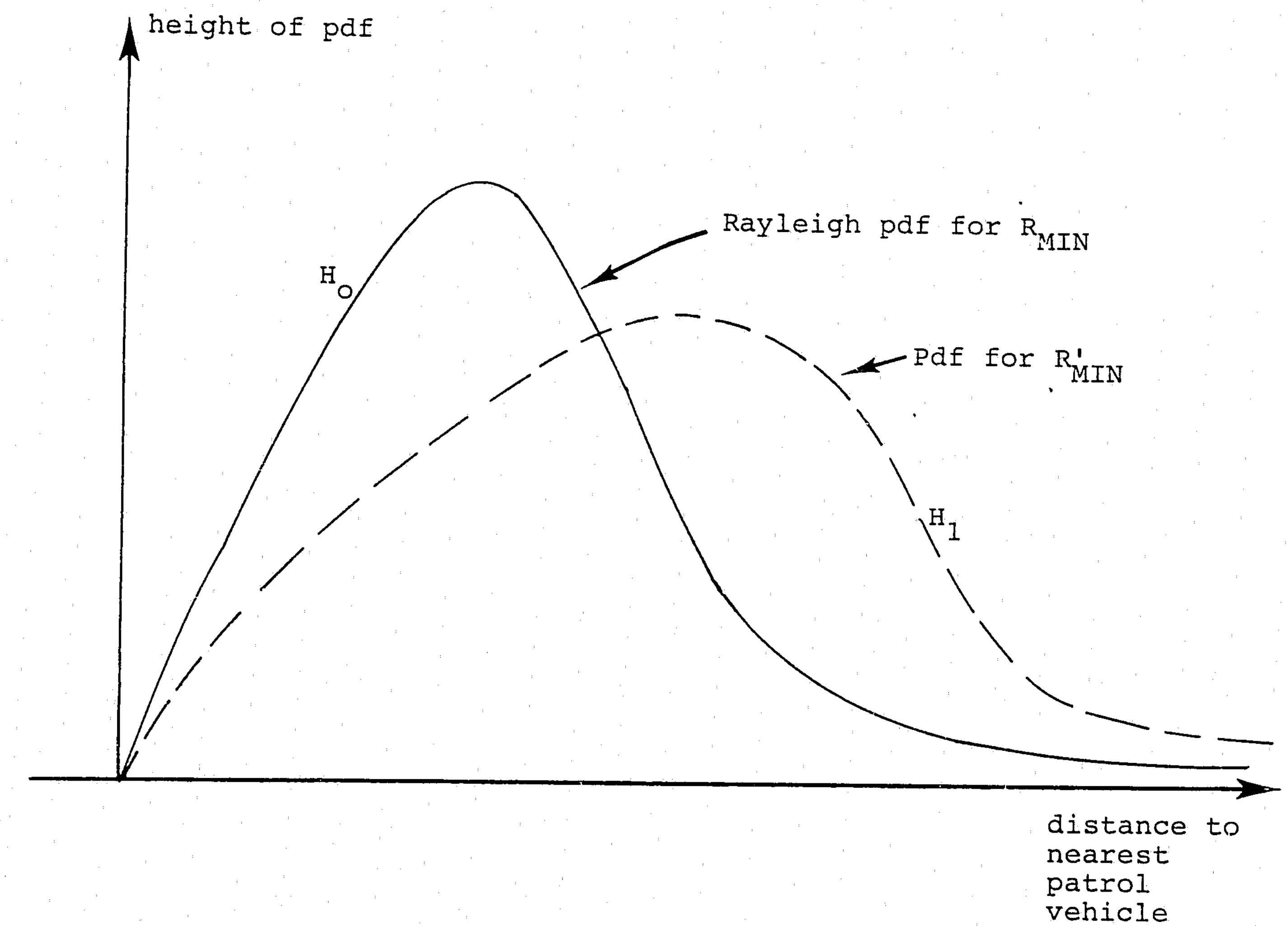
$$a(r) = 1 - e^{-2\lambda r^2} \qquad \lambda > 0 \qquad (2)$$

Here λ is an index of nonavoidance, with nonavoidance increasing as λ increases. Very large λ implies almost no deliberate avoidance of police by the criminal, thus supporting the null hypothesis of independence. Very small

[2] Urban Operations Research, p. 174.

Figure 1

Hypothetical Distance to the Nearest Patrol Vehicle



λ implies considerable avoidance (or, equivalently, virtually no nonavoidance).[3] We should recall that the locus of points equidistant (at right angle distance d) from a given point is a square centered at the given point and rotated 45° with respect to the coordinate axes; the area of this square is $2d^2$. The functional form of Equation (2) is then also suggestive: it implies that avoidance decreases exponentially as the area of the rotated square centered at the criminal's position and having size determined by the closest police vehicle. In a sense, the size of the square may reflect to the potential criminal the chances of successful escape, the larger the square, the larger the "police-free zone" centered at the location of his potential illegal act.

Let us now consider the effects of avoidance, as given in Equation (2). Since potential crimes occur spatially as a Poisson process independently of police locations, the PDF for the distance from a potential crime to a patrol vehicle is Rayleigh with parameter $\sqrt{4\gamma}$. Hence, given a potential crime, the probability that an actual crime will immediately result is:

$$P\,\{\text{crime occurs}\} = P\{C\} = \int_0^{\infty} 4\,\gamma r e^{-2\gamma r^2} a(r)\,dr.$$

Substituting Equation (2) and integrating, we find:

$$P\{C\} = \frac{\lambda}{\gamma+\lambda} \qquad (3)$$

As expected very large λ implies $P\{C\} \approx 1$, while very small λ implies $P\{C\} \approx 0$. We do not equate crime avoidance with deterrence, because avoidance may simply imply delay or displacement of a crime which the potential criminal is determined to commit.

Of fundamental importance is the distribution of distance between a potential crime and the closest police vehicle, <u>given</u> that an actual crime

[3] We will use both terms, avoidance and nonavoidance, in this paper; the latter is usually chosen whenever we are discussing increasing or decreasing values of λ.

immediately results. Call the desired PDF $f_{R_{MIN}}(r|\text{crime})$, where the random variable R_{MIN} is the distance to the closest car. Invoking the appropriate form of Baye's rule:

$$f_{R_{MIN}}(r|\text{crime})\,dr = \frac{P\{r < R_{MIN} \le r+dr,\ \text{crime occurs}\}}{P\{\text{crime occurs}\}}$$

$$= \frac{P\{\text{crime occurs}|r \le R_{MIN} \le r+dr\}P\{r \le R_{MIN} \le r+dr\}}{P\{\text{crime occurs}\}}$$

$$= \frac{(1-e^{-2\lambda r^2})4\gamma r e^{-2\gamma r^2}dr}{[\lambda/(\gamma+\lambda)]}$$

or,

$$f_{R_{MIN}}(r|\text{crime}) = 4\gamma(1+\gamma/\lambda) r e^{-2\gamma r^2}\,[1-e^{-2\lambda r^2}] \quad r \ge 0 \qquad (4)$$

Straightforward integration shows that the mean and second moment are, respectively,

$$E\,[R_{MIN}|\text{crime}] = \frac{1}{4}\left\{(1+\frac{\gamma}{\lambda})\sqrt{\frac{2\pi}{\gamma}} - \frac{\gamma}{\lambda}\sqrt{\frac{2\pi}{\gamma+\lambda}}\right\} \qquad (a)$$

$$E\,[R^2_{MIN}|\text{crime}] = \frac{\lambda+\gamma}{2\lambda\gamma} - \frac{\gamma}{2\lambda(\gamma+\lambda)} \qquad (b)$$

(5)

As we expect, avoidance implies

$$E\,[R_{MIN}|\text{crime}] \ge E\,[R_{MIN}].$$

With minimal voidance,

$$\lim_{\lambda\to 0} E\,[R_{MIN}|\text{crime}] = \frac{1}{4}\sqrt{\frac{2\pi}{\gamma}} = E[R_{MIN}].$$

Somewhat surprisingly, with maximal avoidance,

$$\lim_{\lambda\to 0} E\,(R_{MIN}|\text{crime}) = \frac{3}{8}\sqrt{\frac{2\pi}{\gamma}} \qquad (6)$$

Thus, there is only a 50 percent range of possible variability above the base case of no avoidance. This could make difficult the statistical detection of

CONTINUED

3 OF 4

avoidance. A plot of $E[R_{MIN}|\text{crime}]$ versus level of avoidance is given in Figure 2.

We have displayed in Figure 3 the PDF of Equation (4) for $\gamma=1$ and for different values of λ: $\lambda = \infty$ (no avoidance); $\lambda= 4$ (20 percent of crimes not occurring immediately due to avoidance); $\lambda=1$; $\lambda=0.1$ (High avoidance: 91 percent of crimes not occurring immediately). One's intuition is verified: as avoidance increases, the conditional PDF of distance between the crime and the closest police vehicle shifts to the right. Particularly important is the marked shift to the right near the origin (i.e., for small distances), even for relatively low levels of avoidance.

4 CONTAMINATION BY UNMONITORED VEHICLES

We now introduce into the analysis the effect of unmonitored vehicles. Intuitively one would think that such contamination of the experimental condition would make more difficult the detection and estimation of criminal avoidance—because criminals would be avoiding some vehicles that are invisible to the experimenters, thereby introducing noise into the experimental results.

As usual, let γ_1 (γ_2) be the spatial density of monitored (unmonitored) vehicles. Define

$f_{R_1}'(r)\,dr \equiv$ Prob {closest monitored vehicle is a right-angle distance r to (r + dr) from the crime}

$f_{R_1}'(r)\,dr \equiv$ Prob {closest monitored vehicle is a right-angle distance r to (r + dr) from the crime}.

We assume we are dealing with actual crimes and that any dependence of crime location on vehicle location is due to the proximity of the closest vehicle only (i.e., the criminal wants to increase the distance between himself or herself and the closest vehicle, but does not care about the second closest, third closest, etc.).

Figure 2

Expected Distance From Actual Crime to Closest Police Vehicle as a Function of Avoidance Level (and No Contamination)

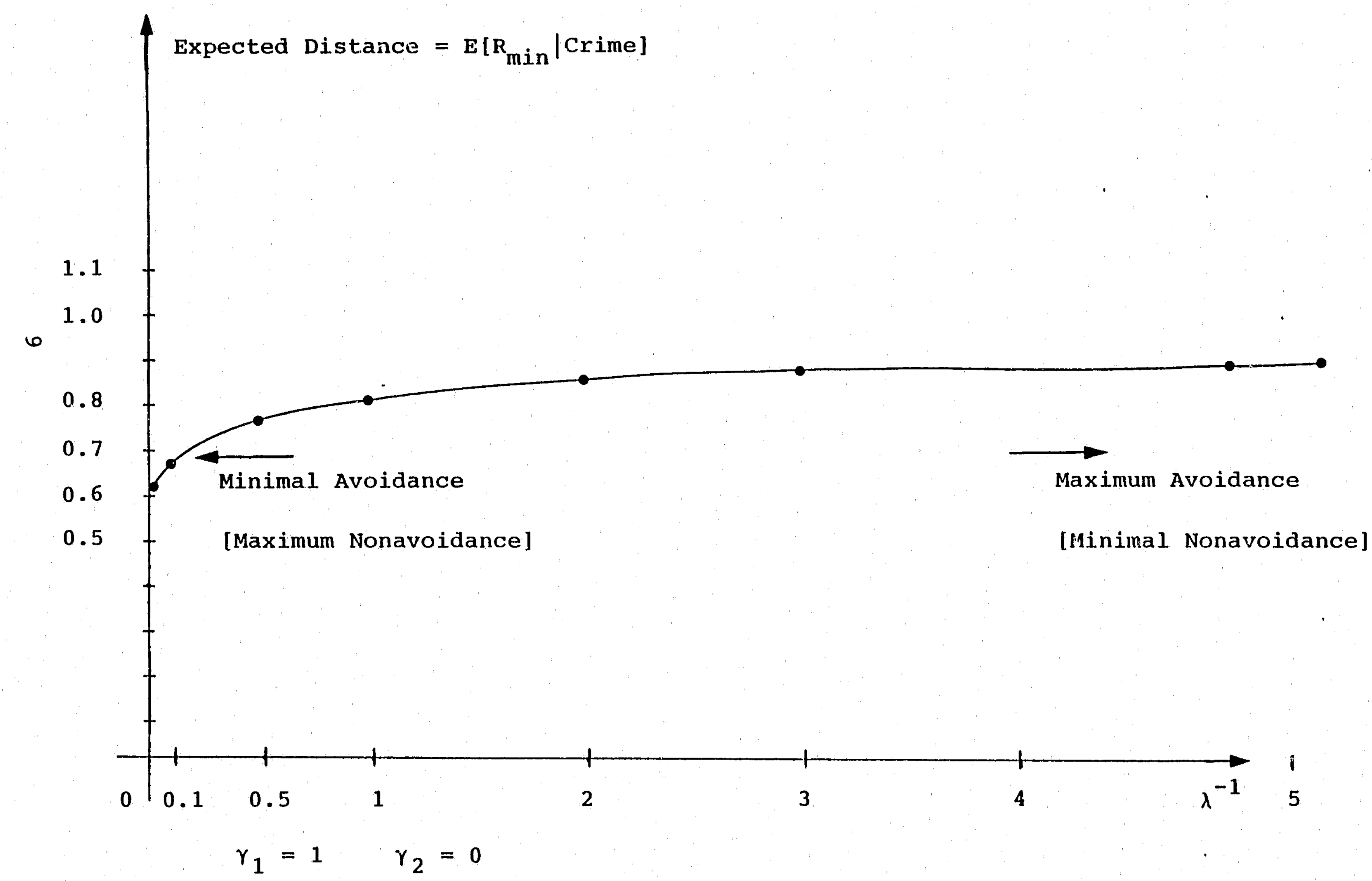
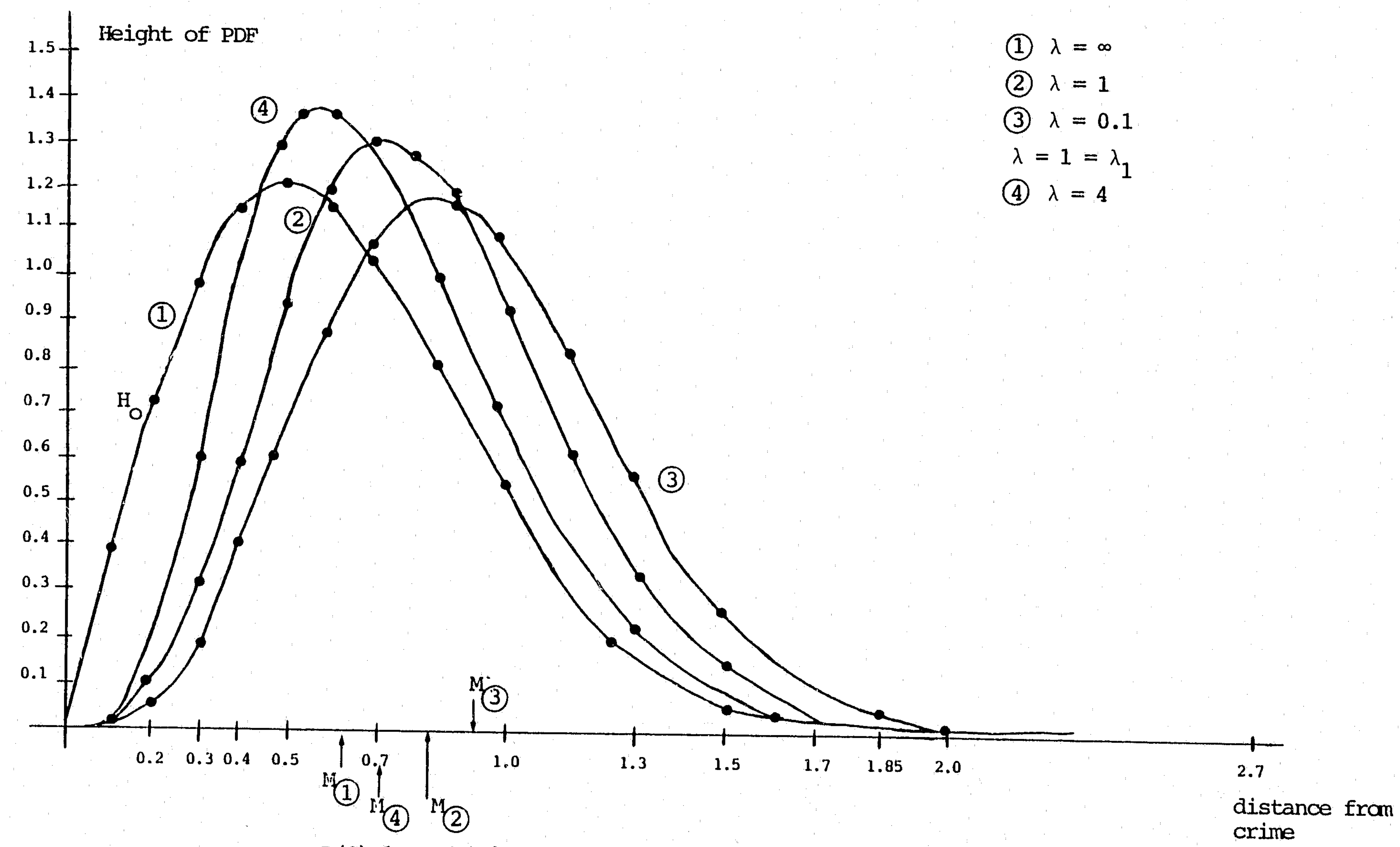


Figure 3

PDF for Distance from Actual Crime to Closest Police Vehicle

Under Different Levels of Avoidance (and No Contamination)



We wish to determine an equation relating $f_{R_1'}(\ )$ and $f_{R'_{MIN}}(\ )$. We note that with probability $\gamma_1/(\gamma_1+\gamma_2)$ the closest vehicle will be a monitored vehicle. We collect together our probabilities first verbally:

Probability that the closest vehicle is between r and r+dr =

① Probability that the closest vehicle is between r and r+dr <u>and</u> that it is a monitored vehicle <u>PLUS</u>

② Probability that the closest vehicle is closer than r <u>and</u> that it is not a monitored vehicle <u>and</u> that the closest monitored vehicle is between r and r+dr.

The first component of the RHS is straightforward:

$$① = f_{R'_{MIN}}(r)dr \; \frac{\gamma_1}{\gamma_1+\gamma_2}$$

To find an expression for ② suppose that the closest vehicle (which is unmonitored) is between ρ and $\rho+d\rho$. Consulting Figure 4, we see that the intersection of four events yields the event we are considering and, by independence, the individual probabilities multiply to give the probability of the joint event, P {joint event} = ⓐ · ⓑ · ⓒ · ⓓ , where:

ⓐ = Prob {closest vehicle is a distance ρ to $\rho+d\rho$ from the crime}

ⓑ = Prob {closest vehicle is unmonitored}

ⓒ = Prob {no monitored vehicles in the cross-hatched region on Figure 4}

ⓓ = Prob {one monitored vehicle in the infinitesimal strip of width dr}.

The respective probabilities are given as,

$$ⓐ = f_{R'_{MIN}}(\rho)d\rho$$

$$ⓑ = \gamma_2/(\gamma_1+\gamma_2)$$

$$ⓒ = e^{-\gamma_1[\text{area of cross-hatched region}]} = e^{-\gamma_1 2[r^2-\rho^2]}$$

$$ⓓ = \gamma_1[\text{area of infinitesimal strip}] = \gamma_1 4rdr$$

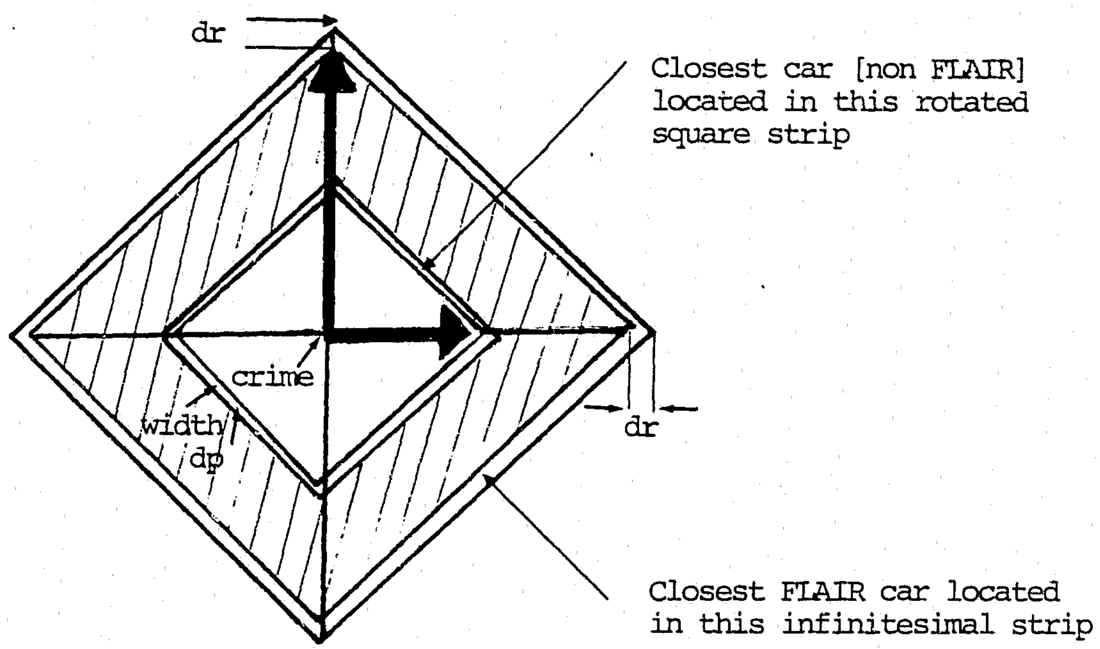
We obtain the desired probability ② by writing

$$② = \int_{\rho=0}^{\rho=r} ⓐ\,ⓑ\,ⓒ\,ⓓ$$

Figure 4

Spatial Relationships Between Location of

Closest Vehicle and Closest Monitored Car



Pooling all of our results, we obtain the desired relationship,

$$f_{R_1'}(r)dr = \frac{\gamma_1}{\gamma_1+\gamma_2} f_{R'_{MIN}}(r)dr + \frac{\gamma_2}{\gamma_1+\gamma_2} \int_0^r f_{R'_{MIN}}(\rho)e^{-\gamma_1 2[r^2-\rho^2]}d\rho \; 4r\gamma_1 dr \quad (7)$$

Equation (7) is an integral equation relating the often known function $f_{R_1'}(r)$ [known via measurement] to the often unknown function $f_{R'_{MIN}}(r)$.

As a check of Equation (7), if we discover that $f_{R_1'}(r)$ is Rayleigh with parameter $\sqrt{4\gamma_1}$ (i.e., that the null hypothesis holds for monitored vehicles), then simple substitution shows that a solution to the equation is given by $f_{R'_{MIN}}(r) = 4(\gamma_1+\gamma_2)re^{-2(\gamma_1+\gamma_2)r^2}$ [i.e., a Rayleigh PDF with parameter $\sqrt{4(\gamma_1+\gamma_2)}$]. This would be substantiation for the null hypothesis.

5 MEASURED AVOIDANCE IN THE PRESENCE OF CONTAMINATION

We can now combine our ideas of contamination and avoidance. Suppose there is a given level of nonavoidance as reflected by a particular value of λ and suppose that the PDF for the distance from a crime to the closest vehicle (monitored or unmonitored) is give by Equation (4). Then $f_{R'_{MIN}}(r|\text{crime})$ of Equation (4) can be substituted on the RHS of Equation (7) as $f_{R'_{MIN}}(r)$. After some manipulation, we obtain an expression for $f_{R'}(r)$, which now represents the PDF for the distance between an actual crime and the closest monitored vehicle, in the presence of contamination level γ_2 and a nonavoidance level λ; the result is

$$\begin{aligned} f_{R_1'}(r|\gamma_1,\gamma_2,\lambda) &= f_{R_1'}(r|\gamma_1,\lambda+\gamma_2) \\ &= 4\gamma_1(1+\frac{\gamma_1}{\lambda+\gamma_2})re^{-2\gamma_1 r^2}\,[1-e^{-2(\lambda+\gamma_2)r^2}], \quad r \geq 0 \end{aligned} \quad (8)$$

Equation (8) has the same functional form as Equation (4), with γ of Equation (4) replaced here by γ_1, and λ of Equation (4) replaced by $\lambda+\gamma_2$. Hence, a contamination level γ_2 effectively increases measurable nonavoidance from λ to

$(\lambda+\gamma_2)$ (recall that higher λ values imply lower avoidance levels). The mean and second moment are, respectively,

$$E[R'_1|\gamma_1,\lambda+\gamma_2] = \frac{1}{4}\left\{(1+\frac{\gamma_1}{\lambda+\gamma_2})\sqrt{\frac{2\pi}{\gamma_1}} - \frac{\gamma_1}{\lambda+\gamma_2}\sqrt{\frac{2\pi}{\gamma_1+\gamma_2+\lambda}}\right\} \quad (a)$$

$$E[R^2_{MIN}|\gamma_1,\lambda+\gamma_2] = \frac{\lambda+\gamma_1+\gamma_2}{2(\lambda+\gamma_2)\gamma_1} - \frac{\gamma_1}{2(\lambda+\gamma_2)\ (\gamma_1+\gamma_2+\lambda)} \quad (b)$$

(9)

We have displayed in Figure 5 a set of curves directly analogous to those of Figure 3, for the case of extreme contamination: $\gamma_1 = \gamma_2 = 1.0$ (i.e., fully 50 percent of the vehicles are unmonitored). Note that for relatively high levels of nonavoidance (as illustrated by the case $\lambda = 4$) the contamination does not significantly change the PDF for distance from that found in the uncontaminated case. However, for cases of extreme avoidance (e.g., $\lambda = 0.1$) the contamination significantly shifts the PDF to the left, making it closer to the H_o curve. Since contamination effectively increases λ [increases measurable nonavoidance] by an amount γ_2, a contamination of $\gamma_2 = 1$ with $\lambda = 0.1$ is equivalent to a nonavoidance of $\lambda = 1 + 0.1 = 1.1$ in a situation with no contamination; in fact, curve ③ of Figure 5 looks very much like curve ② [$\lambda = 1.0$] of Figure 3.

In experimental situations, it is of interest to know the effect of contamination in reducing the mean distance from the crime to the nearest monitored patrol vehicle. In terms of the notation of Equation (9) (a), the base case of no avoidance occurs with $\lambda = \infty$, yielding a mean distance

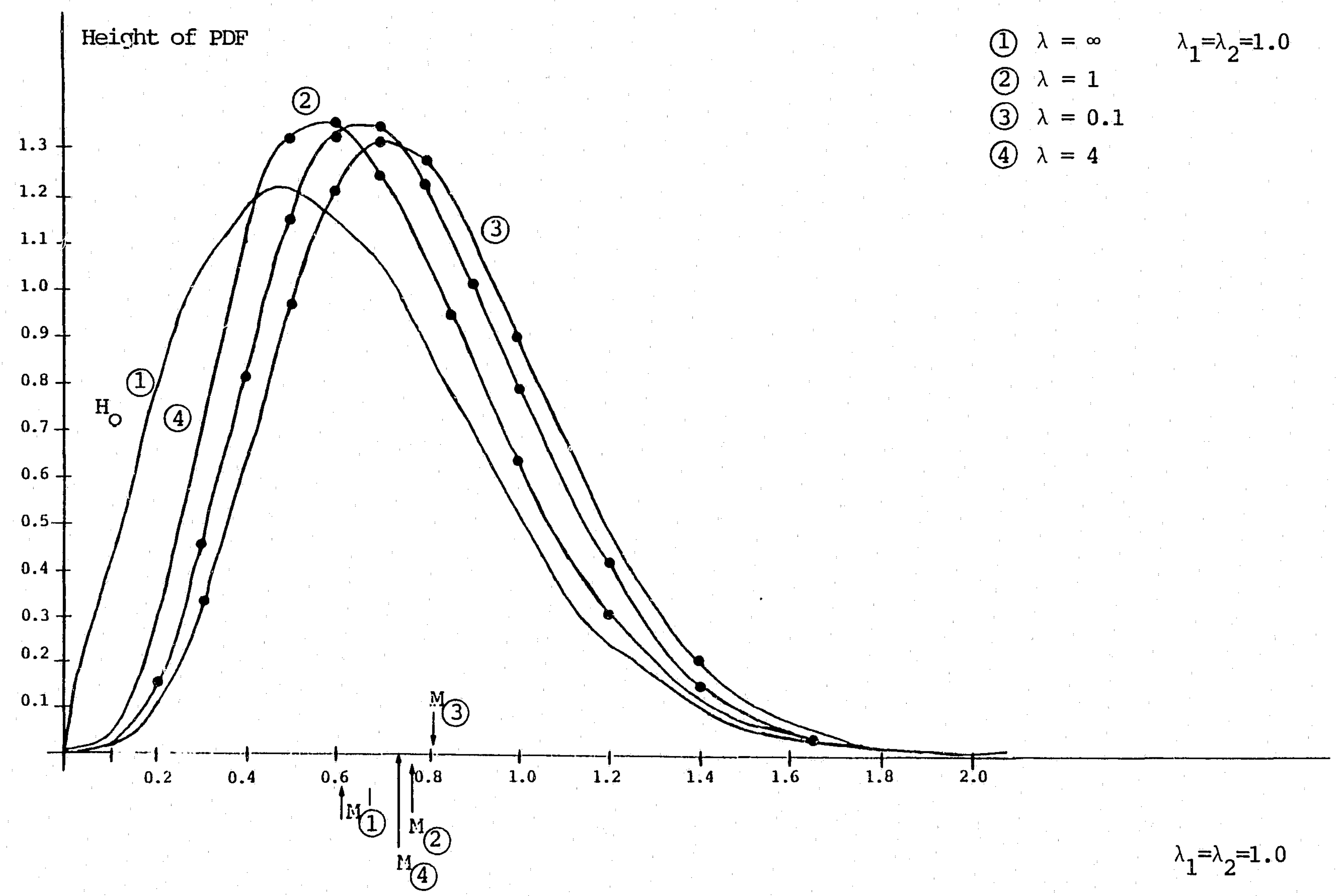
$$E[R'_1|\gamma_1,\infty] = \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1}}$$

If we set $\gamma_1 = 1$ (as we have done throughout), then a reasonable measure of efficiency for computing the mean in the presence of contamination would be

Figure 5

PDF for Distance from Actual Crime to Closest Monitored Police Vehicle

Under Different Levels of Avoidance with 50 Percent Contimination



$$\% \text{ Efficiency} = \frac{E[R'_1 | \gamma_1{=}1, \lambda{+}\gamma_2] - \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1}}}{E[R'_1 | \gamma_1{=}1, \lambda] - \frac{1}{4}\sqrt{\frac{2\pi}{\gamma 1}}} \times 100\% \qquad (10)$$

This measure is plotted in Figure 6 as a function of contamination level γ_2 for various values of λ. An interesting feature of these curves is the relatively high efficiencies associated with small and moderate levels of contamination. For instance, a contamination of 20 percent still provides 89 percent efficiency for the case of extreme avoidance: λ=0.1. Thus, the mere presence of unmonitored vehicles in the experimental area does not preclude the possibility of detecting and estimating the extent of avoidance.

6 STATISTICAL ISSUES

In an experimental situation, one usually knows γ_1 and γ_2 and one wants to test an hypothesis that λ is different from $+\infty$ (i.e., no avoidance) and/or to obtain a numerical estimate for λ.

6.1 A Hypothesis Test

In the simple two-hypothesis test mode of analysis, H_o is represented by the familiar Rayleigh PDF with parameter $\sqrt{4\gamma_1}$ and H_1 is really a family of alternative hypotheses, $H_1(\gamma_1, \lambda+\gamma_2)$. Owing to the marked differences between the H_o and H_1 PDFs near the origin, an hypothesis test focusing on values of the cumulative distribution function (CDF) in this region would seem appropriate. Integrating Equation (8), the CDF for the random variable R'_1 is

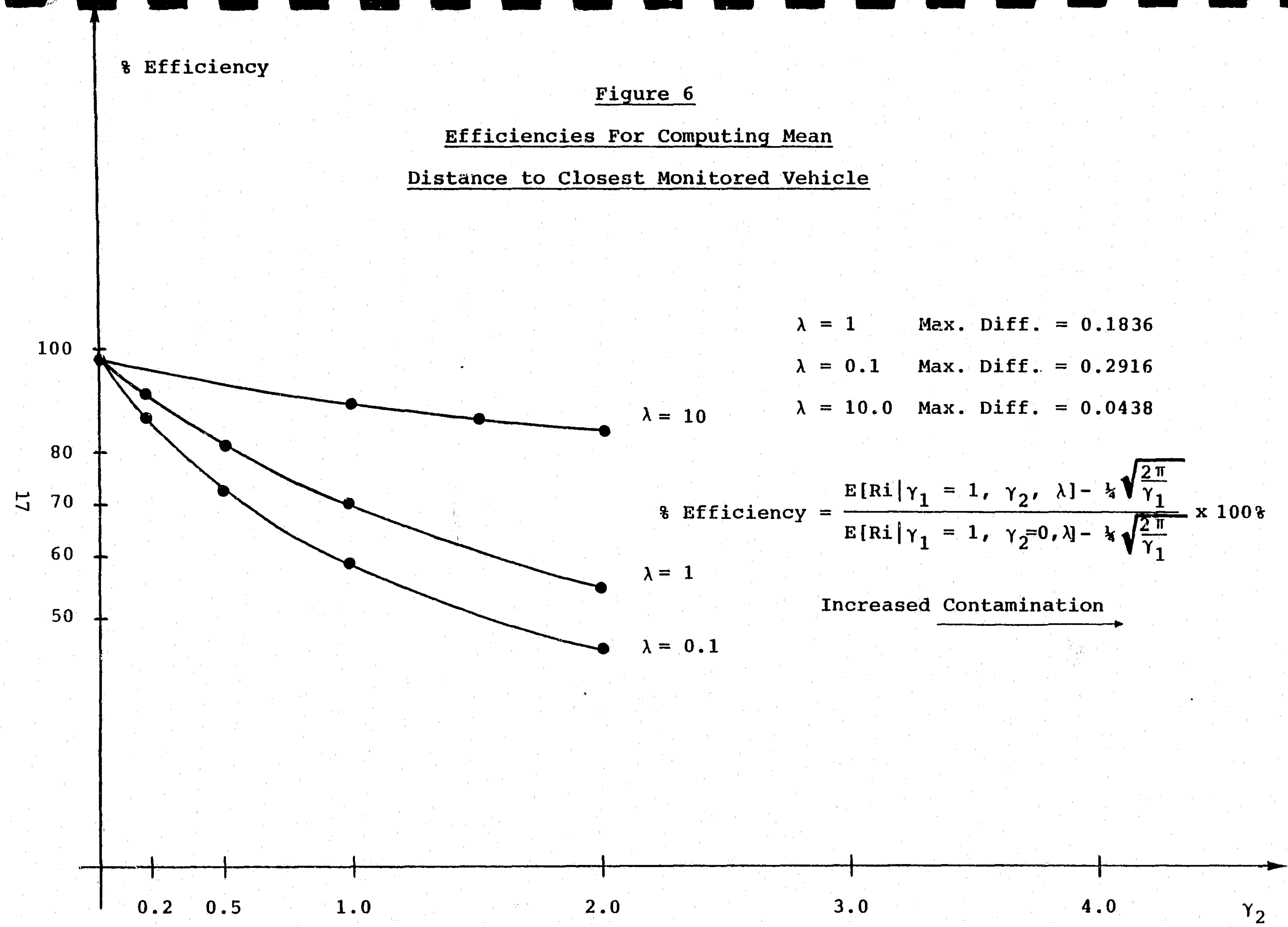
$$F_{R'_1}(r | \gamma_1, \lambda+\gamma_2) \equiv \text{Prob}\,\{R'_1 \leq r\}$$

$$= 1 - \frac{\lambda+\gamma}{\gamma+\gamma_2}\, e^{-2\gamma_1 r^2} + \frac{\gamma_1}{\lambda+\gamma_2}\, e^{-2(\lambda+\gamma) r^2} \qquad r \geq 0 \qquad (11)$$

Figure 6

Efficiencies For Computing Mean

Distance to Closest Monitored Vehicle



$\lambda = 1$ Max. Diff. = 0.1836

$\lambda = 0.1$ Max. Diff. = 0.2916

$\lambda = 10.0$ Max. Diff. = 0.0438

$$\%\ \text{Efficiency} = \frac{E[Ri \mid \gamma_1 = 1,\ \gamma_2,\ \lambda] - \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1}}}{E[Ri \mid \gamma_1 = 1,\ \gamma_2 = 0, \lambda] - \frac{1}{4}\sqrt{\frac{2\pi}{\gamma_1}}} \times 100\%$$

For any given r, the difference between the CDF for H_o and the CDF for $H_1(\gamma_1, \lambda+\gamma_2)$ is

$$F_{R_1'}(r|\lambda_1, \infty) - F_{R_1}(r|\gamma_1, \lambda+\gamma_2) \equiv \Delta(r|\gamma_1, \lambda+\gamma_2).$$

By straightforward application of differential calculus, one finds that the maximum difference [i.e., $\underset{r}{\text{MAX}}$ {$\Delta(r|\gamma_1, \lambda+\gamma_2)$}] occurs at

$$r^*(\gamma_1, \lambda+\gamma_2) = \sqrt{\frac{1}{2(\lambda+\gamma_2)} \, ln \, \frac{\lambda+\gamma_1+\gamma_2}{\gamma_1}} \qquad (12)$$

Plots of the four CDFs corresponding to the four PDFs of Figure 3 are shown in Figure 7, together with the respective r*'s and the corresponding values of $\Delta(r^*|\gamma_1, \lambda+\gamma_2)$. (Figure 7 combines both avoidance and contamination through values of the sum $\lambda+\gamma_2$.) For instance, from Figure 7, if the alternative hypothesis H_1 stipulates $\lambda+\gamma_2$ = 1.0 (with γ_1 always set at 1.0), then the maximum separation between the CDFs for H_o and H_1 occurs at

$r^*(1,1) = \sqrt{\tfrac{1}{2}\, ln\, 2} = 0.5887$; at that value, we find

$F_{R_1'}(\sqrt{\tfrac{1}{2} ln 2}|1, \ ) = \tfrac{1}{2}$ and

$F_{R_1'}(\sqrt{\tfrac{1}{2} ln 2}|1,1) = \tfrac{1}{4}$, thus the difference

is $\Delta(\sqrt{\tfrac{1}{2} ln 2}|1,1) = \tfrac{1}{4} = 0.25$.

We can now construct an hypothesis test about the value r*. Suppose we select a sample of n independently drawn measured distances. Under the null hypothesis each sample value has a chance $P_o \equiv F_{R_1'}(r^*|\gamma_1, \ )$ of assuming a value less than or equal to r* and a chance $(1-P_o) = (1-F_{R_1'}(r^*|\gamma_1, \infty))$ of assuming a value greater than r*. Define the indicator random variable

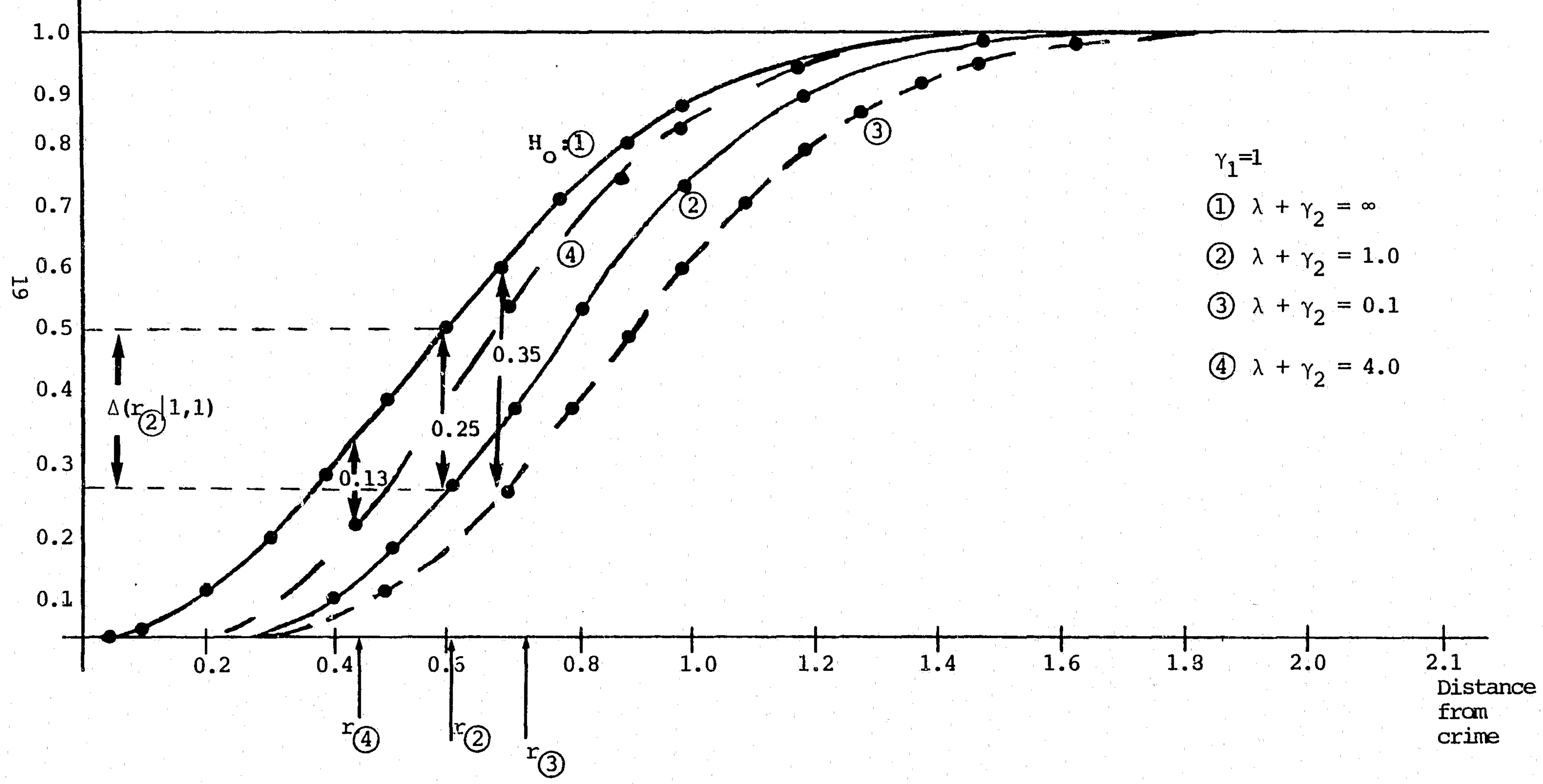
$$X_i \equiv \begin{cases} 1 \text{ if the measured distance } \leq r^* \\ 0 \text{ otherwise} \end{cases}$$

Then the total number of "successes" in n trials, where a success is defined to be an experimental value less than or equal to r*, is

Figure 7

Determining the Distances from a Crime at

Which to Conduct Hypothesis Tests



$$Y_o(n)=\sum_{i=1}^{n} X_i$$

The X_i's represent a sequence of independent identically distributed Bernoulli random variables, each with mean $E[X_i] = P_o$ and variance $\sigma^2_{X_i} = P_o(1-P_o)$. The random variable $Y_o(n)$ has mean nP_o and variance $nP_o(1-P_o)$. Invoking the Central Limit Theorem, as n gets large, $Y_o(n)$ tends to a Gaussian random variable with the aforementioned mean and variance.

Under an alternative hypothesis H_1, each sample value has a chance $P_1 \equiv F_{R'}(r^*|\gamma_1,\lambda+\gamma_2)$ of assuming a value less than or equal to r^* and a chance $(1-P_1) \equiv (1-F_{R'_1}(r^*|\gamma_1,\lambda+\gamma))$ of assuming a value greater than r^*. Here the total number of successes $Y_1(n)$ in n trials tends (as n gets large) to a Gaussian PDF with mean nP_1 and variance $nP_1(1-P_1)$.

A reasonable hypothesis test would be one in which the probability of false rejection of the null hypothesis (α) would be equal to the probability of false rejection of the alternative hypothesis (β), with $\alpha=\beta=0.05$. Since $P_1<P_o$ the decision region for acceptance of H_o would be to the right of some threshold value T. For $\sum_{i=1}^{n} X_i > T$, we accept H_o, otherwise we accept H_1. At the desired T, the area under the H_o Gaussian PDF to the left of T and the area under the H_1 Gaussian PDF to the right of T would both be equal to 0.05. Consulting tables of the Gaussian CDF, we find that 95 percent of the area under the Gaussian curve occurs at values of the Gaussian random variable less than or equal to the mean plus 1.645 standard deviations. Hence 95 percent of the H_1 PDF lies to the left of $nP_1 + 1.645 \quad nP_1(1-P_1)$ and 95 percent of the H_o PDF lies to the right of $nP_o - 1.645 \quad nP_o(1-P_o)$. Our desired threshold T is found by equating these two quantities and solving for the appropriate sample size n^*. The result is

$$n^* = 1.645 \left[\frac{P_1(1-P_1) + P_o(1-P_o)}{P_o - P_1}\right]^2 \tag{13}$$

A plot of n^* versus $\lambda+\gamma_2$ is given in Figure 8. In reading this figure, a sample size of say, 200, would be appropriate to detect at 0.05 level of significance (and 0.05 level of false rejection) any H_1 having $\lambda+\gamma_2$ less than or equal to about 6.8. Of course, if $\lambda+\gamma_2$ were less than 6.8 the significance level with 200 sample values would be improved over 0.05.

6.2 Estimating the Amount of Nonavoidance

Suppose above we have n independently drawn distances to the nearest monitored patrol vehicle, $r_1, r_2, \ldots, r_n \equiv \underline{r}$. Now we wish to estimate using maximum likelihood techniques the amount of nonavoidance λ. We assume that the spatial densities γ_1 and γ_2 of monitored and unmonitored vehicles, respectively, are known. Due to independence of the r_i's, the appropriate likelihood function is the product of n values of the PDF for r_i, each PDF value determined by the corresponding sample value r_i. Defining the likelihood function as $L(\underline{r}, \lambda)$, we can write:

$$L(\underline{r},\lambda) = [4\gamma_1(1 + \frac{\gamma_1}{\lambda+\gamma_2})]^n \sum_{i=1}^{n} r_i e^{-2\gamma_1 r^2}[1-e^{-2(\lambda+\gamma_2)r_i^2}] \tag{14}$$

The natural algorithm of $L(\underline{r},\lambda)$ is

$$L(\underline{r},\lambda) = n \quad 4\gamma_1(1 + \frac{\gamma_1}{\lambda+\gamma_2}) + \sum_{i=1}^{n} r_i - 2\gamma_1 \sum_{i=1}^{n} r_i^2 + \sum_{i=1}^{n} [1-e^{-2(\lambda+\gamma_2)r_i^2}] \tag{15}$$

We want to find that value for $\lambda>0$ which maximizes $L(\underline{r} \quad \lambda)$ or, equivalently, $L(\underline{r},\lambda)$. Computing $\frac{\partial}{\partial \lambda} L(\underline{r},\lambda)$ and setting the resultant expression equal to zero, we find that the maximum likelihood estimate for λ is that value which solves that following equation:

$$\frac{n\gamma_1}{(\lambda+\gamma)(\lambda+\gamma_2)} = \sum_{i=1}^{n} \frac{2r_i^2}{1-e^{-2(\lambda+\gamma_2)r_i^2}} \tag{16}$$

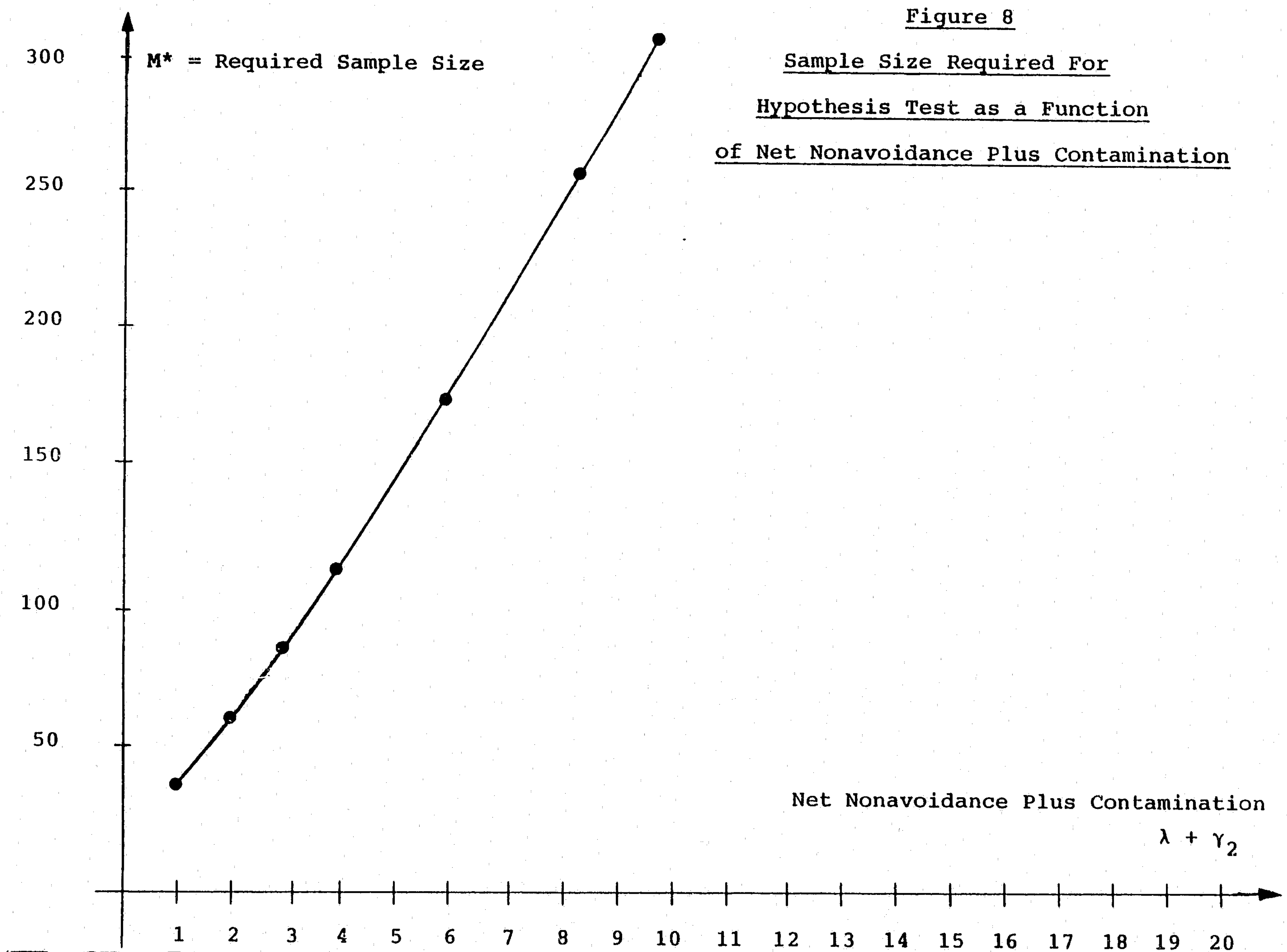


Figure 8

Sample Size Required For Hypothesis Test as a Function of Net Nonavoidance Plus Contamination

It should not be difficult to program a computer to solve iteratively for the appropriate value.[4]

6.3 Adequacy of the Spatial Poisson Assumption

The entire analysis in this paper rests on the assumption that both monitored and unmonitored vehicles are spatially distributed as homogeneous Poisson processes, with rate parameter γ_1 and γ_2 respectively. One may justifiably question the reasonableness of this assumption in a complex urban environment.

In a homogenous city having square police beats and full availability of patrol units, with one unit randomly located in each beat, previous studies have shown that the average distance to the closest police car from a random point is approximately

$$0.59\sqrt{\frac{1}{8}}$$

where γ is the number of beats/km² (or equivalently, the number of vehicles/km²).[5] Rather than requiring each unit to be within a prespecified beat, the spatial Poisson model allows units to be independently located over the entire region. That model predicts that the average distance to the closest police car from a random point is

$$\frac{1}{4}\sqrt{\frac{2\pi}{\gamma}} \approx 0.627\sqrt{\frac{1}{\gamma}} ,$$

or about 6 percent greater than the beat model. As the utilization factor ρ of a unit increases, where ρ is the fraction of time that a unit is busy, Kolesar and Blum[6] have shown that mean distance to the closest available

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[4] Of course any solution $\hat{\lambda}$ to (16) must satisfy $\hat{\lambda} > 0$ and be such that the second derivative of $ln\ L(\underline{r}\lambda)$ with respect to λ is positive, reflecting the occurrence of a minimum.

[5] Larson, R.C., Urban Police Patrol Analysis, (Cambridge, MA: M.I.T. Press, 1972), Chapter 7.

[6] Kolesar, P. and E. Blum, Square Root Laws for Fire Engine Response Distances Management Science, 19(1973), 1368-1378.

vehicle increases in proportion to $[\gamma(1-\rho)]^{-1/2}$. Similarly, it is known that unavailable vehicles are distributed as a spatial Poisson process with mean $\gamma\rho$ vehicles/km². [7] As ρ increases, one would expect that the spatial density of available vehicles in their beats would—over the entire region—appear more and more random, because a fraction ρ of nearby randomly selected vehicles are no longer available, leaving a patchwork spatial distribution of vehicles that may quite closely resemble a random sample from a spatial Poisson process. Thus, as ρ increases, we have two (not quite independent) spatial processes—one exactly Poisson (for unavailable units), the other approximately Poisson (for available units). We might expect that the closest distance to the closest vehicle (busy or free) would increase with increasing ρ, eventually to the value predicted by the spatial Poisson model. In fact, the spatial Poisson model is precisely correct when ρ approaches unity.

A second feature contributing to the reasonableness of the spatial Poisson assumption is the presence of unmonitored vehicles, with density γ_2 vehicles/km². In most police applications these vehicles do not have fixed boundaries in which to operate and it would be reasonable to assume that they are distributed randomly (following the assumptions of the spatial Poisson process). And it would seem appropriate to assume that this process operates independently of the beat patrol vehicles, whether busy or free.

Thus, the 6 percent error in the mean computed at zero workload with no contamination could reasonably be expected to be an upper bound on the error attributable to the spatial Poisson model.

Still, such features as spatial inhomogenities and boundary effects could reduce the accuracy of the spatial Poisson model. One way to check and calibrate the spatial Poisson assumption for monitored vehicles would be to

[7] Urban Operations Research, p. 339.

select random points in the experimental area at random times and to determine the distance to the closest monitored police vehicle. n such samples, for suitably large n, could provide an empirical cumulative distribution function which could be compared to that of the spatial Poisson model. Any deviations from the theoretical model could be used to adjust the procedures of this paper to the idiosyncrasies of the given experimental area.

END