TASK FORCE REPORT

SCIENCE AND TECHNOLOGY

A Report to
THE PRESIDENT'S COMMISSION ON LAW ENFORCEMENT AND ADMINISTRATION OF JUSTICE

Prepared by
THE INSTITUTE FOR DEFENSE ANALYSES
FOREWORD

In February of this year the President's Commission on Law Enforcement and Administration of Justice issued its General Report, *The Challenge of Crime in a Free Society*. As noted in the Foreword to that Report, the Commission's work was a joint undertaking, involving the collaboration of Federal, State, local, and private agencies and groups, hundreds of expert consultants and advisers, and the Commission's own staff. Chapter 11 of that Report made findings and recommendations relating to the possible contributions of science and technology to the problems of criminal justice.

This volume, the Task Force Report on Science and Technology, embodies the research and analysis which underlie those findings and recommendations, and in many instances it elaborates on them. As noted in the Preface, the Institute for Defense Analyses (IDA) with funding from the Office of Law Enforcement Assistance of the Department of Justice, undertook the responsibility for organization of the Science and Technology Task Force for the Commission. Thus, this volume represents the report of IDA to the Commission and reflects the work of IDA with advice and assistance from some members of the Commission and its staff.

The Commission is grateful to IDA for undertaking this important task and to those who worked on this volume including consultants, advisers and collaborating agencies whose efforts are reflected in this volume.

NICHOLAS DEHAVEN BICKFORD, Chairman.
Preface

This report of the Science and Technology Task Force of the President's Commission on Law Enforcement and Administration of Justice was prepared by the Institute for Defense Analyses (IDA). The material in it is intended to supplement and amplify the discussion of science and technology in the general report of the Commission to the President, "The Challenge of Crime in a Free Society," which contains the Commission's recommendations. The work was conducted under a grant for Defense Analyses (IDA). The material in it is intended to supplement and amplify the Commission's work. But the substance of the report was the study were brought together from industry, universities, government, and IDA. The major portion of the work was conducted during the summer and fall of 1966.

Its preparation by an outside organization and the technical nature of its subject matter distinguish this report from the other works of the Commission. Some of the major thrusts and the general coverage of the Task Force's work were discussed by the Commission members, and the Commission's staff advised and consulted with the Science and Technology Task Force staff during all work on the important problems, to assist in many of the functions. The work of the Task Force was under the overall direction of Dr. Alfred Blumstein and was prepared as an integrated effort by the staff and a number of consultants. The regular members of the staff and the subjects they covered were:

- Mr. Ronald Finkler, Institute for Defense Analyses, systems analysis and corrections operations.
- Prof. Ronald Finkler, Institute for Defense Analyses, systems analysis and corrections operations.
- Dr. Saul I. Gass, International Business Machines, police operations.
- Mrs. Sue Johnson, consultant, systems analysis.
- Dr. Peter Kelly, Kelly Scientific Corp., communications and electronics.
- Mr. Raymond Knickel, consultant, police electronics equipment.
- Mr. Richard Larson, Massachusetts Institute of Technology, systems analysis.
- Dr. Joseph Navarro, Institute for Defense Analyses, court operations.
- Miss Jean Taylor, Institute for Defense Analyses, court operations.

In addition to this basic staff a number of consultants undertook separate studies in close coordination with the staff:

- Prof. Thomas Bartee, Harvard University, fingerprint recognition.
- Prof. Mandell Bellmore, Johns Hopkins University, operations research.
- Mr. Albert Bush-Brown, Rhode Island School of Design, city planning.
- Mr. Joseph Coats, Institute for Defense Analyses, nonlethal weapons.
- Mr. P. A. DovVito, consultant, cost analysis.
- Mr. Leonard Goodman, Bureau of Social Science Research, attitude survey.
- Dr. William Herrmann, consultant, police operations.
- Mr. Howard Issac, consultant, survey of police field operations.
- Mr. Robert Jones, C-E-I-R, information systems.
- Dr. Vincent Kremin, consultant, laboratory instrumentation.
- Prof. Peter Lejins, University of Maryland, criminology.
- Dr. William Ottill, International Business Machines, court operations.
- Mr. Lloyd Perper, consultant, alarms.
- Prof. Thomas Schelling, Harvard University, economic analysis.
- Mr. Peter Scanlon, Bureau of the Budget, program budgeting.
- Dr. Claude Walton, International Business Machines, information systems.
- Prof. Leslie Wilkins, University of California, criminology.

The work of the staff and of these consultants is reflected in the main body of this report. Ten of the specific papers generated are presented as appendices through J. Additional papers on apprehension by police, nonlethal weapons, the overall criminal justice system, delay in courts and information flow are more extensive and technical to be presented here. These reports are now in preparation and will be available from the Clearinghouse for Federal Scientific and Technical Information of the National Bureau of Standards. Papers on computer operations in the courts, on economic analysis of organized crime, on the design of rational criminal justice statistical systems, and on the projection of populations under correctional supervision appear as appendices in the Task Force reports on Courts, Organized Crime, Assessment of Crime, and Corrections, respectively.

Since the Task Force staff of scientists and engineers had little prior knowledge of criminal justice operations and problems, it relied heavily on the Commission staff and numerous criminal justice officials for identification of the operational problems of the system.

The Federal Bureau of Investigation was extremely helpful in this regard, especially in providing data on crime in the United States. Among State agencies, the California Bureau of Criminal Statistics and the New York State Identification and Intelligence System also made valuable contributions.

The police departments of Baltimore, Boston, Chicago, New York, Los Angeles, San Francisco, St. Louis, and Washington, D.C., among others, were generous in their counsel and provided staff members with some operational experience in patrol, communications, and other police functions. The International Association of Chiefs of Police was a valuable source of data and advice.

Experience and data on court operations were provided by the Court of Common Pleas of Allegheny County, Pa., the courts in the District of Columbia, and the Administrative Office of the U.S. Courts. Similar contributions in corrections came from the Federal Bureau of Prisons, the California Youth and Adult Authorities, the Draper Correctional Center, Lorton Reformatory, and the National Training School for Boys.

Scientists and engineers from industry, government, and universities contributed many suggestions and provided the needed technical details. In the Federal Government, the Federal Bureau of Investigation, the Federal Communications Commission, the Institute of Telecommunication Sciences and Aeronomy, and the Agency for International Development were among the agencies providing valuable advice and information. A number of companies in the electronics, data processing, telephone, and automobile industries were especially helpful.
A number of individual consultants provided data or guidance, reviewed preliminary papers, and generally assisted in the work of the Task Force. Among others too numerous to mention, this group included:

Miss Sylvia Bacon, Assistant Director, President’s Commission on Crime in the District of Columbia.

Mr. James E. Barr, Chief, Safety and Special Radio Services Bureau, Federal Communications Commission.

Mr. Ronald Beckman, Research and Design Institute.

Mr. Richard Braun, Criminal Division, Department of Justice.

Mr. Robert Brooking, Communications Engineer, City of Burbank, Calif.

Mr. Jerome Daunt, Chief, Uniform Crime Reporting Section, FBI, Department of Justice.

Dr. Robert Emrich, Office of Law Enforcement Assistance, Department of Justice.

Hon. Richard F. C. Hayden, Judge of the Superior Court of Los Angeles.

Dr. Jerry Kidd, National Science Foundation.

Mr. Richard McGee, Administrator, Youth and Adult Corrections Agency, Sacramento, Calif.

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Computer programming assistance was provided by Thomas Celi, Robert Cohen, Janice Heineken, Thomas Humphrey, Charles McBride, Frans Nauta, and Vera Wilson. Additional research assistance was provided by Mary Ellen Angell, Mara Auerbach, Lois Martin, Marsha Smith, and Ray Vickery.

Secretarial and general administrative operations were coordinated by Carolyn Tillman. She was assisted by many members of the IDA secretarial staff.

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*Staff members, advisers, and consultants of the Science and Technology Task Force are listed in the Preface.
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TABLE OF RECOMMENDATIONS

This Table of Recommendations is reprinted from the general report of the Commission, "The Challenge of Crime in a Free Society." It lists the Commission's recommendations on science and technology and shows where this volume each is treated in more detail.

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- ROLE OF SCIENCE AND TECHNOLOGY IN CRIMINAL JUSTICE
- The natural sciences and technology have long helped the police solve specific crimes. Scientists and engineers have had a direct impact, however, on the overall operations of the criminal justice system and its principal components: police, courts, and prisons. More than 200,000 scientists and engineers have devoted themselves to solving military problems and hundreds of them are more innovation in other areas of modern life, but only a handful are working to control the crimes that injure or frighten millions of Americans each year. Yet, the two communities have much to offer each other: science and technology is a valuable resource of knowledge and techniques for combating crime; the criminal justice system represents a vast area of challenging problems.

**Equipment**

In the traditional view, science and technology primarily means new equipment. And modern technology indeed, provide a vast array of devices beyond those now in general use to improve the operations of criminal justice agencies, particularly in helping the police deter crime and apprehend criminals. Some of the more important possibilities are:

- Electronic computers for processing the enormous quantities of needed data.
- Police radio networks connecting officers and neighboring departments.
- inexpensive, light two-way portable radios for every patrolman.
- Computers for processing fingerprints.
- Instruments for identifying criminals by their voice, photographs, hair, blood, body chemistry, etc.
- Devices for dramatic and continual reporting of all police car locations.
- Helicopters for airborne police patrol.
- Inexpensive, reliable burglary and robbery alarms.
- Nonlethal weapons to subdue dangerous criminals without inflicting permanent harm.

- Perimeter surveillance devices for prisons.
- Automatic transcription devices for courtroom testimony.

Many of these devices are now in existence, some as prototypes and some available commercially. Others still require basic development but are at least technically feasible and worthy of further exploration. But for many reasons, even available devices have only slowly been incorporated into criminal justice operations. Federal funds have been scarce, industry has only limited interest in product development for an uncertain and fragmented market, and criminal justice agencies have few technically trained people on their staffs. Much closer communication is needed between the criminal justice officials and engineers to identify the problems for the engineers and to enumerate the possibilities for the officials' consideration.

Also, conventional methods of governmental budgeting often tend to restrict the application of new technology. Budgets are traditionally prepared with item categories such as "personnel" and "equipment," rather than with functional or program categories, such as "maintaining general police patrol." Under such circumstances, a reasonable equipment expenditure may be seen as a large increase in the equipment budget. For instance, if each car in a 50-vehicle fleet is provided with a $200 piece of equipment, the additional $10,000 might dominate the increase in the equipment budget. When it is considered, however, that it costs about $100,000 per year to operate a two-man patrol car continuously, an investment of even a few thousand dollars per car, amortized over at least 3 years, is a small cost if it significantly improves patrol operations. Compared to a $3 million budget for "patrol," a $10,000 increment is very small.

The Federal Government, as well as some State and local governments, is moving from item budgeting to program budgeting to obtain a clearer picture of how its resources are being allocated. Such an approach seems particularly appropriate for criminal justice agencies, especially as their operations become more interrelated in a criminal justice system.

In the realm of technology it is far easier to imagine interesting possibilities than to choose the ones in which to invest necessarily limited acquisition funds. Technology can fill most reasonable requests and can thereby contribute to the operations of criminal justice agencies daily.
provide considerable help to law enforcement. But so far, no one has decided what it means relative to the price it will be paying in dollars, in invasion of privacy, and other costs. Consequently, for example, the auto theft deterrence project being conducted by a radio transmitter in every car in America and tracking them all electronically. But this might cost a billion dollars and could create an intolerable climate of surveillance. Science can provide the capability, but the public as a whole may still be apprehensive of whether or not the capability is worth the costs.

This is often a difficult decision to make, since for most inventors the cost of making one more invention is too small to consider. For example, long before auto theft became a problem, no one knew how serious the problem was. Inventions can cut costs or they can increase costs. The key is to compare the cost of preventing something or doing something at an earlier stage with the cost of doing it later. Thus, it is necessary to narrow the focus of the criminal justice system in order to make the most effective use of the system and to prevent crime.

Information about the consequences of actions by the criminal justice system is essential for informing those actions. The criminal justice system is an example of how complex and ambiguous the system is. It may be compared to a blind man flying down the side of a mountain. If he wants to reach the top, he must first move. And it matters little whether his first move is up or down, because any movement with subsequent evaluation will tell him which way is up. A step by step process of experiment, evaluating, and modifying must be undertaken. Both innovation and the subsequent evaluation of its consequences are essential to climbing up.

The project is inherently slow and expensive, and it must be conducted with care to avoid misleading results. Scientists cannot help by participating in the efficient design of experiments and the evaluation of their results. The fact-finding, analytical, and experimental methods of science can help develop the required information. Once the information is developed, then the modern technology of data collection, retrieval, analysis, and transmission can help process and deliver it where and when it is needed.

Such carefully controlled testing offers some valuable opportunities for making the criminal justice system more efficient and productive. Correctional agencies have experimented with assigning at random a group of offenders to different treatment programs and evaluating their relative effectiveness in terms of recidivism and social adjustment. Analysis and statistics are used in the evaluation of drugs and other treatment by the medical sciences. Similarly, police departments experiment with marked and unmarked cars patrolling various precincts to evaluate the effects upon crime rates in these and adjoining precincts. The design of such experiments must be carefully undertaken to avoid spurious experimental effects and to avoid taking otherwise undesirable or unethical actions.

Crime control, being largely a social problem, may appear to be outside the realm of the scientists' skills. Indeed, many aspects of the problem do fall outside their scope. The experience of science in the military, however, suggests that a fruitful collaboration can be established between criminal justice officials on one hand and engineers, physicists, economists, and social and behavioral scientists on the other. The military research scientists in these different professions, working with military officers in interdisciplinary teams, have attacked defense problems in a similar vein as those with long military experience. Similar developments appear possible in criminal justice.

The Task Force sought:

1. A broad look at the system's objectives and the possible conclusions can be drawn. Furthermore, this work was based on both specific and hypothetical situations and the conclusions examined may not necessarily apply in any given local situation. They are intended more as an illustration of an approach than for the generality of their conclusions.

The SCIENCE AND TECHNOLOGY TASK FORCE

The Science and Technology Task Force was established to investigate in greater detail some of the applications of science and technology to crime, and especially to improving the criminal justice system. The Task Force sought:

1. To identify the problems, immediate and long-range, that science and technology is most likely to help solve, and to suggest the kinds of research and development needed.
To identify and describe crime control problems in a form more susceptible to quantitative analysis.

To point out the kinds of important data on crime control and the criminal justice system that are lacking, unreliable, or otherwise unusable, and to propose means of correcting such deficiencies.

To analyze problems in crime assessment, police, courts, and corrections as an aid to the Commission and other task forces.

To suggest organizational formats within which technical devices and systems can be developed, field tested, and rendered useful.

With a scope so broad and time and manpower severely limited, it was necessary to make an early selection of areas to be emphasized. The social and behavioral sciences were deemphasized, largely because these were subjects already receiving treatment elsewhere in the Commission’s work. The system sciences—information systems and computer applications, communications systems, and systems analysis—were given primary emphasis. In examining the applicability of technology, the emphasis was placed on identifying requirements rather than on detailed design or selection among equipment alternatives.

Among crimes, the primary focus was on the “index” crimes—wilful homicide, forcible rape, aggravated assault, robbery, burglary, larceny of $50 and over, and auto theft—the predatory crimes which are a principal source of public concern today. Only limited attention was paid to public disorder and vice crimes, and to “white collar crimes,” such as illegal price fixing, tax evasion, and antitrust violations.

The organization and emphasis in the Task Force’s work are illustrated in figure 2. The heavier outlines indicate the subjects of major attention. Of the methods for controlling or reducing crime, the primary focus was on the criminal justice system—the police, courts, and corrections agencies. Within the criminal justice system the greatest potential for immediate improvement by analysis and technological innovation appears to be in police operations. Hence, police problems were emphasized heavily; less attention was given the problems of courts; and still less to the inherently behavioral problems of corrections.

FIGURE 1. A SIMPLIFIED ILLUSTRATION OF A SYSTEMS APPROACH RELATING TECHNOLOGY TO CRIME CONTROL

FIGURE 2. STRUCTURE OF THE WORK OF THE SCIENCE AND TECHNOLOGY TASK FORCE

ORGANIZATION OF REPORT

Both chapters 2 and 3 cover aspects of police operations, especially in the apprehension of criminals. The apprehension process is examined in detail with data from one city, relating apprehension to factors in the crime and in the police response to it. Since response time was found to be an important factor, various elements of the apprehension process were analyzed to find the optimum way to cut response time. In addition, specific aspects of the apprehension process are examined in some detail.

Operation of the police communications center offers an opportunity for major technological improvement so this subject is discussed in detail in chapter 3, including means of modernizing the command and control process and of reducing the radio frequency congestion characteristic of most large city police departments.

Chapter 4 deals with some aspects of court management, corrections and crime prevention. The court management discussion focuses on the problem of reducing delay in processing cases. Simulation of court operations is discussed as a means for conducting experiments and evaluating possible improvements in court procedures in order to reduce congestion.

Two aspects of corrections are reviewed in chapter 4—the use of programed instruction as an aid to rehabilitation and the use of statistical techniques to aid in making correctional decisions.

Two specific examples of how technological means may reduce opportunities for crime—auto ignition devices and street lighting—are also discussed in chapter 4.

Chapter 5 examines the use of systems analysis for study of the entire criminal justice system as an integrated whole. A generic model of a total system is used to calculate reduction rates and operating costs associated with different crime control programs. This preliminary effort is limited largely by the available data, and so, more than producing solid results, identifies critical data requirements.

The potential role of modern information technology is the subject of chapter 6, to which a possible integrated information system for criminal justice is described.

Clearly, these subjects are only a sampling of the many opportunities for science and technology to contribute to the control of crime. Within the limited time, there was no attempt to address questions of the basic causes of crime, or even to stray very far outside the criminal justice system for means of crime control. Even within the criminal justice system, many more areas need intensive study and evaluation. The subject of criminalistics, the traditional tie between technology and criminal justice, has been treated only marginally and needs specific investigation. Many fields of science and technology offer promising opportunities for exploration in addition to those covered in this brief survey, and some of these may turn out to be more significant than those covered here. Some of the other possibilities for the use of science and technology within the criminal justice system are mentioned in chapters 2 through 4.

Chapter 7 outlines a program of research and development by which the Federal Government can stimulate a major infusion of science and technology into the criminal justice process and to attack the broader problems of the control of crime.

RESULTS OF TASK FORCE WORK

From its investigations, the Task Force produced a number of preliminary results and recommendations, including:
Chapter 2

**Police Operations—the Apprehension Process**

Of all criminal justice agencies, the police traditionally have had the closest ties to science and technology. There is considerably more scope for the equipment technology in policing than in other parts of the criminal justice process. Police communications, transportation, weapons, crime detection, and crime investigation all depend on science and technology, to an extent that may not be appreciated in courts and corrections. Yet even today, many potential contributions remain untouched. In addition, contributions from research, information processing, and systems analysis are only now beginning to be exploited. For these reasons, the Task Force focused a major part of its efforts on police operations.

The prevention or deterrence of crime is indirectly promoted by the police through such diverse means as community relations and public information programs, the selection and training of effective personnel, contingency planning for disasters or disorders, and the maintenance of an effective intelligence system.

Science and technology can improve the capabilities of the police in these areas in many different ways. The techniques of industrial psychology can aid in selecting effective police officers. Educational technology can aid in training. Programmed learning texts can be used for individual study while an officer is waiting for appearance in court; closed-circuit television can be used to present skilled lectures to a number of police precincts or departments at the same time; and simulated exercises can be used to train groups of police officers to work as an integrated team in handling unusual large-scale disturbances. The techniques of operations research can be used to allocate resources and to develop equipment maintenance and replacement schedules.

The Task Force's prime concern, however, was with what contributions science and technology could make to those police operations directly concerned with controlling crime by apprehending criminals or by deterring potential criminals with a convincing threat of apprehension. The Task Force focused on the operations of the police force in apprehension of individuals after they commit criminal acts. The oldest ties police field operations have to technology center around apprehension. Automobiles, radios, crime laboratories, scientific investigation, and police weaponry are all essential technical aids to the operations of a modern police force.

The apprehension process ([chapter 3](#)) begins with the detection of a crime by the cruising police force or by a report to the police by an alarm, witness, or victim. Once the information is communicated to the police, an appropriate response must be selected, and patrol officers dispatched to the scene. Then mobile and investigative personnel, data gathering, suspect checks, and then, perhaps, arrest.

The choice of which technological possibilities in this area to pursue is made more difficult by the lack of data on just what situations confront the police, and by the lack of systematic studies of police patrol and apprehension operations. To try to fill this gap, the Task Force studied the factors in the apprehension process with original field data and techniques of cost-effectiveness analysis

Within the apprehension process, the functions of command-and-control and communications were found to be sufficiently important to warrant separate treatment, and are covered in chapter 3.

The remainder of this chapter examines the other stages in the apprehension process: detection, police mobility, nonlethal weapons, evidence gathering by fingerprints, and analysis by crime laboratories. Some of the potential scientific and technological contributions to each are identified. In addition, the problem of effective assignment of patrolmen, which overlays the entire process, is examined.

**ANALYSIS OF FIELD DATA ON APPREHENSION**

With the cooperation and extensive assistance of the Los Angeles Police Department (LAPD), a study was conducted to identify and assess the influence of various factors in the apprehension process on the solution of crimes. The study was an analysis of police records: Reports of calls for service, patrol field activity, crimes, detective investigations, and arrests and other case clearances were systematically analyzed. Data were collected on time delays within the communications center and response times in the field.

The sample of cases represented the total activity in 2 of 15 field divisions for the month of January 1966. The sample included 4,705 incidents, of which 1,905 actually involved reported crimes. Such police activities as arresting drunks and vagrants and handling traffic inci-
The study suggests considering two possible approaches to improving police effectiveness against the unnamed suspect. First, more intensive preliminary investigation at the crime scene might produce more leads for fruitful followup by detectives. Perhaps specially trained civilian investigative specialists who need not meet the physical requirements of a patrol officer could handle this job. Evaluation would be necessary to establish whether these would produce enough additional information to warrant the effort. Second, considerable detective resources are presently allocated to followup investigations in burglary cases. It is clear from the data, however, that the most effective weapon against the burglar is the on-scene arrest. The detective followup resources might be more effectively used in the field, such as in tactical detective squads or in stake-outs in heavy burglary areas. The relative effectiveness of these uses is also problematic, so such a reallocation should be carefully assessed in a controlled experiment.

RESPONSE TIME

The overall response time from call for service to arrival at the scene consists of two major components: Communications center response time (the time required in the communications center from receipt of a telephone call to transmission of a dispatching message) and field response time (the time between receipt of the dispatch message by the patrol unit and arrival at the scene). Within the LAPD communications center, dispatch messages are divided into two general categories: emergency and nonemergency. There is an intermediate category of "nonemergency but urgent" messages which sends a patrol officer to the scene as rapidly as possible, but not in a high-speed mode.

Methods by which detectives identified suspects heavily emphasized use of speed property and vehicle information, interrogation of arrestees, and identification by victims. Modus operandi techniques and weapon information were used in only a very few cases.

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FIGURE 5. PERCENT OF ARRESTS IN RELATION TO OVERALL RESPONSE TIME

OVERALL RESPONSE TIME IN MINUTES (1)

- 70
- 60
- 50
- 40
- 30
- 20
- 10
- 0

PERCENT OR ARRESTS

Number of arrests

100
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
500
525
550
575
600
625
650
675
700
725
750
775
800
825
850
875
900
925
950
975
1000

Number of arrests with response time less than 1 minute

Time of criticism for processing of traffic delays

- 10
- 9
- 8
- 7
- 6
- 5
- 4
- 3
- 2
- 1
- 0

Time in seconds

100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
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7500
7600
7700
7800
7900
8000
8100
8200
8300
8400
8500
8600
8700
8800
8900
9000
9100
9200
9300
9400
9500
9600
9700
9800
9900
10000

- 100
- 50
- 0

Number of emergency calls

- 100
- 50
- 0

Number of nonemergency calls

- 100
- 50
- 0

Number of total calls

- 100
- 50
- 0

Table 2—Results of Radio Calls

<table>
<thead>
<tr>
<th>Emergency calls</th>
<th>Nonemergency calls</th>
<th>Total calls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio calls</td>
<td>124</td>
<td>127</td>
</tr>
<tr>
<td>Percent of total calls</td>
<td>17%</td>
<td>6%</td>
</tr>
<tr>
<td>Radio calls only</td>
<td>127</td>
<td>61</td>
</tr>
<tr>
<td>Percent of radio calls</td>
<td>24%</td>
<td>48%</td>
</tr>
<tr>
<td>Unlisted crime</td>
<td>120</td>
<td>38</td>
</tr>
<tr>
<td>Percent of calls</td>
<td>100</td>
<td>36</td>
</tr>
<tr>
<td>Percent of crimes</td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>Percent of clerk</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Percent of patrol cars</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

30.3% of the emergency calls were handled as nonemergencies. This is because the 834 emergency calls handled with no indication of urgency. Of these 834, 1,368 (or 10%) of these were shown in table 2. Among these 1,368 (or 10%) involved crimes, of which 2,179 (or 25 percent) were cleared; most of these calls were handled with no indication of urgency. Of these, 3,976 (or 40 percent) were handled with no indication of urgency. Of these, 3,976 (or 40 percent) actually involved crimes. The processing of the apprehension process was calculated on an hourly basis to simplify data collection by the investigating officer. A specific research program should be undertaken to evaluate and design new procedures. This program would evaluate the present priority assignment criteria through a detailed examination of incoming calls for service and associated field response. An audit of the results of responses to calls could guide improvement of the process. The results of responses to calls could guide improvement of the criteria, and these could then be reevaluated through the same methods employed in the initial evaluation.

4. SYSTEMS ANALYSIS OF RESPONSE TIME IN A HYPOTHETICAL CITY

On the basis of the correlation between response time and arrests, and because officials desire rapid response to create an impression of effective police presence as well as to aid in apprehension, the Task Force examined means of reducing response time. In particular, an analysis was conducted to determine how to get the greatest reduction in response time per dollar of cost. This analysis was accomplished by making a mathematical model of the apprehension process in a hypothetical city. Although the numerical values used in this example are based on averages from several large cities, they typify a generalized method by which they could be adapted. Any specific police department would have to develop and use data developed for its own city.

The hypothetical city covers 100 square miles and has a police force, telephone system, and other variables shown in table 3. A city this size would have a population of about 300,000 and be comparable in population density to Atlanta or Indianapolis.

In the analysis, time delays in the apprehension process were related to system resources (table 4), and costs were associated with each resource. The analysis computes the time reduction and costs associated with various means of reducing response time. The improvements were measured in average number of seconds of delay saved per dollar of additional annual cost.

Table 3—Description of Hypothetical City

<table>
<thead>
<tr>
<th>City</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>City size</td>
<td>100 square miles</td>
</tr>
<tr>
<td>Crime frequency</td>
<td>100,000 crimes</td>
</tr>
<tr>
<td>Police mobile units dispatched</td>
<td>30 non-maximum units are dispatched per hour.</td>
</tr>
<tr>
<td>Total mobile time</td>
<td>40 seconds per call</td>
</tr>
<tr>
<td>Signal of maximum force</td>
<td>60 seconds per call</td>
</tr>
<tr>
<td>Public telephone directory</td>
<td>1,000 directories throughout city</td>
</tr>
<tr>
<td>Call service time</td>
<td>30 minutes average</td>
</tr>
<tr>
<td>Number of non-emergency calls</td>
<td>3000</td>
</tr>
</tbody>
</table>

Table 4—Cost-Effectiveness Analysis of Delay Reduction in Hypothetical City

<table>
<thead>
<tr>
<th>Elements of delay</th>
<th>Unit cost of additional unit</th>
<th>Number of units of delay reduced</th>
<th>Cost savings per dollar of cost (after additional unit installed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public response delay</td>
<td>Public call box............</td>
<td>1,000</td>
<td>96</td>
</tr>
<tr>
<td>Police mobile units dispatched per hour</td>
<td>Public call box............</td>
<td>10,000</td>
<td>96</td>
</tr>
<tr>
<td>Telecommunications delay due to lack of communication</td>
<td>Telephone call box............</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Telecommunications delay due to lack of communication</td>
<td>Telephone call box............</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>216</td>
<td>$21,060</td>
</tr>
</tbody>
</table>

5. The results of the analysis are summarized in table 5. In the first column the delays caused by each activity are identified. For example, the patrol mobility delay is the time from the time of the dispatcher's arrival to the scene of the crime. The basic operating unit associated with this activity is a one-man patrol car (col. 2). There are 40 such units already in use (col. 3). The amount of this delay is 216 seconds (col. 4). If one additional unit was added, the average response time would decrease by 4 seconds (col. 5). The patrol units are expected to be used 264,000 times a year (col. 6). The cost of an additional unit is $50,000 per year (col. 7). Multiplying the delay saved per call per additional unit (col. 5) by the frequency of use (col. 6) and dividing by the cost of the additional unit (col. 7), one obtains 2.11 seconds saved per dollar (col. 8).

Employing this technique, one can evaluate the changes in other components such as the complaint clerk, public call box, automatic car locator, and computer and collar equipment for the communications center. For this case, automating the command center is the most attractive alternative. If there are only two complaint clerks, adding a third is the next most desirable step. Even though the telephone queue waiting time with two clerks is only 7.2 seconds the value in assigning a third complaint clerk is comparatively large. The low cost of the clerk and the high frequency with which he becomes involved in calls justifies such a move. As is shown in table 5, adding a fourth would not be desirable.
The third most significant contribution lies in the installation of an automatic car-locator system. For the city of X, California, the installation of an automatic car-locator system would be directly attributable to choosing an available car other than the one closest to the disturbance. Even though a small portion of the overall delay time is reduced, the marginal cost of such a system would be quite low. Cities with locked call boxes should be encouraged to use them. Another possibility is the installation of a distributed receivers system. If the city had some form of distributed receivers, such as in the call box car-locator system discussed in the next section, the time delay in receiving an alarm would probably be several minutes shorter, since the delay would consist of the time for the car to reach the scene. The advantage of this system is that a-bomb can be strategically placed, or false alarms might frustrate their use.

Doubling the distance (measured as the time of the signal transmission) could reduce the use of individuals, since these points were located for an alarm to be transmitted every 62 cars scanned was wanted on an alarm for stolen cars or for a warrant as a scavenger. The police would then be able to determine the exact location of the car and to follow it, using the same police car, to its destination. The disadvantage is that the police car would have to be careful to avoid being seen, since it might be used by other thieves. The announcement of the theft, or the presence of the police car, could unobtrusively trigger to send a magnetic, radio, or ultrasonic signal to a remote receiver nearby. The device could be powered by a battery, or by a small generator, or by some other simple energy storage medium. Such a device could be installed in remote areas, or could be used in high-crime areas. Alarms could also be used to detect crime, or to signal for help.

There are many ways by which burglary sensors can be used to detect crime. Liquor stores and service stations are independent. One can calculate the probability of detecting a crime as a function of the relevant variables: duration and visibility of the event, and the presence or absence of witnesses. The probability of detection increases as the time of the event increases, and decreases as the visibility of the event decreases. However, there is little evidence on how much crime is thereby prevented or on how much would be prevented with alternative tactics.

The police continue and central areas are being the best place to invest dollars to decrease response time. Automatic car-locator systems costing under $100,000 per year to operate would decrease the system delay at least twice as much as a comparable investment in additional police}

IMPROVING APPREHENSION CAPABILITIES

In this section, several specific components of the apprehension process—alarms, detection and surveillance devices, and penalties—are discussed.

DETECTION OF CRIMES

The apprehension process is initiated by the detection of a crime by police on patrol, by a witness, or else automatically by an alarm or surveillance device.

Police Detection

Police on "preventive patrol" cruise the streets to look for crimes in progress. Presumably, this activity prevents crime because it poses a threat of detection and immediate apprehension. However, there is little evidence on how much crime is thereby prevented or on how much would be prevented with alternative tactics.

Probability of detection tends to deter crime, or at least to disguise it. On the other hand, such inconspicuous methods to be used alone, they might, after all, be less effective. The loss of the public confidence that are achieved by conspicuous patrol. Again, this illustrates the need to examine the relationship between apprehension, deterrence, and ever more carefully controlled experimentation.

Detection by Alarms and Surveillance Devices

There is a rich store of devices which can aid detection.

Burglar alarms are designed to detect intrusion automatically. Robbery alarms enable a victim of a robbery or an attack to signal for help. Such devices can be installed in elevators, hallways, homes and apartments, businesses and factories, and subways, as well as on the street in high-crime areas. Alarms could deter some potential criminals from attacking targets so protected. If alarms were prevalent and not visible, then they might merit to suppress crime generally, although there is no empirical evidence on this point. In addition, the alarms can summon the police when they are needed.

All alarms must perform three functions: sensing or initiation of the signal, transmission of the signal, and announcement of the alarm. A burglar alarm needs a sensor to detect human presence or activity in an unoccupied area like a building or a room. A robbery alarm could use a wall switch, or by triggering a portable transmitter which would send the alarm signal to a remote receiver. The signal could sound locally as a loud noise to frighten away a criminal, or it can be sent silently by wire to a central point such as a police station or a private alarm company. Centralized annunciators require either private lines from each alarm point, or the transmission of some information on the location of the signal. There are many simple ways to increase the probability of detection of a crime. Liquor stores and service stations could provide an unobtrusive view of the interior from the street. The visibility from the patrol car could be improved by full-view mirrors. Brighter and more prevalent street lights could extend the patrol car's visibility, especially in large, normally dark areas such as schools and other targets of vandalism.

Reducing the conspicuousness of police officers could possibly increase the probability of detecting criminal action because the offender is not aware of the police presence. Special forces travel in work clothes in unmarked cars. The Long Beach, Calif., Police Department has vehicles designed to be used in high crime areas. According to the "New York Times": "No screaming sirens or flashing lights anymore. The police are no longer conspicuous, independently and with mobility up sidewalks, between buildings, or through parks." In 1 year, the two police men made arrests in eight strong-arm robberies, five armed robberies, eight burglaries. Street crimes were reported to have been reduced markedly supporting the general assumption that increasing the apprehension probability tends to deter crime, or at least to disguise it. On the other hand, such inconspicuous methods to be used alone, they might, after all, be less effective. The loss of the public confidence that are achieved by conspicuous patrol. Again, this illustrates the need to examine the relationship between apprehension, deterrence, and ever more carefully controlled experimentation.

Detection by Alarms and Surveillance Devices
False alarms are problems for any alarm system. In Washington, D.C., in 1963, 4,450 alarms were directed to the police. The average time for answering each was 45 seconds. Since answering each false alarm takes an average of about 30 minutes, these alarms consume about 5,000 car-hours each year, or 25% of the equivalent of one quarter of a full-time patrol car. However, in those cases where the alarm is for an actual crime, the apprehension probability could be very high, so that the assignment of high priority service to all alarm soundings is probably an efficient allocation of resources.

Now low-cost private alarm systems that can automatically send prerecorded messages directly to the police are becoming widely used. As a consequence, the police should expect a significant increase in the number of false alarms. To prevent this increase from seriously disrupting police operations, police departments should establish minimum standards for direct-calling alarm installations. On-site inspection should be required to assure that the alarm itself is mechanically and electrically reliable (unusually a serious problem), that its installation is not subject to simple accidental failure (as from a blowing wind), and that it is not subject to accidental triggering by the occupants. The false-alarm rate can be reduced by means such as requiring that detection sensors be used, that a test installation should be established, that signal amplifiers be provided, and that an annual test be made.

POLICE VEHICLES

Once a crime is detected, the information concerning it is communicated to the police, the appropriate police response is selected, and orders are communicated to the patrol force. Travel time in reaching the crime scene is the largest single component of police response time. While the patrol car will undoubtedly continue as the primary police vehicle, the motorized special vehicle of other kinds of vehicles need further exploration. Many cities are now using motor scooters or bicycles to give their foot patrol forces an added mobility. At the other extreme, helicopters offer a potential for demonstrating a police presence, for searching a large patrol area and for responding rapidly (over 100 miles per hour) to an emergency call when the action is taking place in the streets, on rooftops, or on highways. Their potential has not yet been adequately explored.

Despite the other possibilities, the conventional patrol car will continue to be the police scene. For the patrol officer, it serves as his office, means of locomotion and pursuit, observation post, and van for transporting prisoners. The patrol car is merely a specialized vehicle, with a flashing light and radio installed, and perhaps with a modified engine. Since it costs about $100,000 per year to operate, it is worth exploring alternatives. It would be surprising if the operation could not be appreciably improved by a capital investment of more than the current costs.

The Federal Government should sponsor a design competition and support the development of an experimental police car. It should include in its design nonlethal innovations, such as convenient radio controls, tele­phone, intercom, and other viewing devices to improve visibility and dictating equipment for filing of reports and record­keeping. Continued use of the radio and frequent necessity for written record-keeping suggest a rearrange­ment of the interior to facilitate these functions. Develop­ment of the new design should include human fac­tor considerations derived from a study of the patrol opera­tion. Such a car would provide a useful prototype for testing new equipment, and would stimulate police de­partments to reconsider how they might use their vehicles.

NONLETHAL WEAPONS

A patrol officer, in meeting the diverse criminal situa­tions he must face, has a limited range of weaponry—either the short-range nightstick or the potentially lethal handgun. He should have other possibilities to help him do his job while minimizing the danger of excessive injury or public antagonism. If an officer feels that his life is threatened, he may have to shoot, with the attendant risk that suspects or bystanders may be killed. In many situations, however, he may not be in immediate mortal danger, but his sight may be inadequate, either because the target is out of range, there are too many people to handle, or it may inflict more severe injury than the situation warrants. Relevant situations involving one or a few officers include:

- Approaching a fleeing suspect.
- Approaching an individual in a closed building.
- Subduing a belligerent person under the influ­ence of alcohol.
- Restraining a psychotic intent upon attacking bystanders or upon departing.

A larger group of officers may be confronted with a number of people who must be controlled, channelized, or dispersed, as in the case of public riots, prison riots and gang rumbles. If a suitable range of graduated alter­natives were available, and if there is time for weapon selection, then officers could use the weapons most ap­propriate to the situation.

For a nonlethal weapon to be an acceptable replace­ment for a handgun, it must incapacitate its victim at least as fast as a gun. Even then, there might be some objection to it. A criminal knowledge that he cannot be killed might act more aggressively than he would facing a gun. Even when a criminal is thus prevented from acting on criminal impulses, it would be surprising if the operation could not be appreciably improved by a capital investment of more than the current costs.

Operational Standards. Survey of a wide range of possi­bilities leads to the conclusion that these requirements cannot be met by current technology. For example, dart guns have been used to inject tranquillizing drugs into animals. However, the drugs presently available offer too great a risk of death, because of the close correspondence between the dose required to incapacitate quickly and a lethal dose. Nonlethal weapons are presently available that could serve as a replacement for the handgun, but a continuing effort to achieve such a weapon should be pursued. In this connection the products of military research should be continually examined for potential applicability.

When a nonlethal weapon is considered as a supple­ment to, rather than replacement for, the policeman's gun, the requirements for immediate incapacitation can be relaxed. Supplemental nonlethal weapons, such as dispensers of tear gas or CS gas or liquid solutions, might be used temporarily to disrupt or immobilize targets in circumstances in which an officer's life was not threatened. A number of nonlethal weapons are presently available and those potentially available in the future may be considered as supplements to, rather than replacements for, firearms.

Table 5.—Some Possible Nonlethal Weapons

<table>
<thead>
<tr>
<th>Weapons</th>
<th>Immediate partial incapacitation</th>
<th>Immediate total incapacitation</th>
<th>Long-term incapacitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas atomized</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Liquid atomized</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Sprayed</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Exposed</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Inhaled</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Injected</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
<tr>
<td>Ejected</td>
<td>Ineffective or partial incapacitation</td>
<td>Partial incapacitation</td>
<td>Effective incapacitation</td>
</tr>
</tbody>
</table>

Table 6.—Some Possible Agents for Nonlethal Weapons

<table>
<thead>
<tr>
<th>Agent</th>
<th>Mode of delivery</th>
<th>Physical effects intended</th>
<th>Potential hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
<tr>
<td>Liquid (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
<tr>
<td>Sprayed (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
<tr>
<td>Exposed (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
<tr>
<td>Injected (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
<tr>
<td>Ejected (e.g., tear, CS)</td>
<td>Inhaling (ingesting), breathing, etc.</td>
<td>Injury resulting from inhaling</td>
<td>Eyes, nose, throat irritation</td>
</tr>
</tbody>
</table>

Table 7.—Some Possible Agents for Nonlethal Weapons

<table>
<thead>
<tr>
<th>Agent</th>
<th>Mode of delivery</th>
<th>Physical effects intended</th>
<th>Potential hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbamate</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Dust</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Gas</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Liquid</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Sprayed</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Exposed</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Injected</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
<tr>
<td>Ejected</td>
<td>Inhalation</td>
<td>Marked for later identification</td>
<td>Nontoxic dyes, marking, etc.</td>
</tr>
</tbody>
</table>

1. See the Los Angeles apprehension study, there were 38 actual apprehensions reported by about 60,000 people, and so the apprehension rate is about 1 in 1,500,000.
2. See the Los Angeles apprehension study, there were 38 actual apprehensions reported by about 60,000 people, and so the apprehension rate is about 1 in 1,500,000.
3. See the Los Angeles apprehension study, there were 38 actual apprehensions reported by about 60,000 people, and so the apprehension rate is about 1 in 1,500,000.
4. See the Los Angeles apprehension study, there were 38 actual apprehensions reported by about 60,000 people, and so the apprehension rate is about 1 in 1,500,000.
the bloodstream, which is much slower than transmission through the nervous system. Injected agents would be expected to incapacitate the victim within 15 minutes or in the muscle. (The possibility of direct depositing in a vein or artery is remote.) Thus, the time for absorption would be longer than that for direct depositing in a muscle. A minimum strength required to incapacitate a large, healthy man may exceed the danger threshold for others such as women, children, older people, and people in motion. In order to minimize this problem, it is necessary to search for agents for which the ratio of hazardous to effective dose is sufficiently high to assure sufficient danger in the latter cases. A possibility is to decrease the chemical agent modified so as to speed up the onset of its effects. Thus, while adequate agents are available today, the results of military research should be carefully followed, both to identify potentially useful agents and to assess their effects.

Selecting weapons for further development or procurement requires adequate information on their operational effectiveness and hazards. The data must include the effects on the intended targets, the effect in influencing behavior under different circumstances, and the general reaction of the public to the use of the technique. The evaluation must include both situations in which the weapons were used effectively and ones in which they failed in their intended purpose. The reporting of the direct, desirable and undesirable side effects and the behavioral response of the specific targets and the general public is particularly important in situations when weapons are used to control crowds. An independent organization should be assigned the responsibility of collecting, collating and disseminating all types of such data and reports.

When additional weapons are distributed to a police force, the control that should be exercise should be carefully established. These reviews are particularly necessary, since the introduction of less harmful weapons makes their use in marginal situations more likely. The guidance of all responsible segments of the community should be sought in establishing the controls. With the rapid expansion of the range of potential weapon possibilities, these issues must be constantly reviewed with respect to both old and new weapons.

**Identification**

Evidence found at and near the scene of the crime must be collected and analyzed to solve crimes for which no suspect is identified. Witnesses can describe the criminal's appearance, the mode of transportation, and other information that can be inferred and physical evidence such as latent fingerprints, blood, articles of clothing, bullets, and tool marks, can be collected and matched to suspects and their possessions. This information searches the evidence to eliminate the maximum number of people from the list of possible suspects.

**Fingerprint Identification**

Effective police work uses fingerprint identification both to apprehend those who leave "latent" prints at the scene of a crime and to identify positively persons held in custody.

Positive identification of persons already held makes use of two methods: manual and automatic. Manual techniques of fingerprint identification may be used with any number of sets of prints which must be processed—each day the FBI receives about 30,000 sets for processing, of which approximately 10,000 are based on arrests. Advances are not expected to increase the workload capacity and to reduce the costs and time delays of the fingerprint classification and search processes.

In search to regulate the fingerprint field, the classification formula now in use, a full set of 10 fingerprints is needed. When a criminal inadvertently leaves fingerprints at a crime, only one or a few fingerprints are usually available to law enforcement officers. If once a suspect has been taken into custody, his fingerprints can be compared with even a single print recovered from the crime of the crime. By the same token, a single print can be matched against complete prints of a short list of likely suspects. But the process is now entirely manual and so time-consuming that it cannot be used to check less than a full set of prints against a national file or even a substantial local file of previous offenders. As a result, single prints are used to a much smaller extent, generally containing only a few thousand prints (compared to millions in the larger 10-finger file) and are very infrequently used.

Most large police departments maintain a specially organized file of single fingerprints of several thousand persistent criminals. Probably more than 100 different fingerprint systems are in use today. In searching files of single fingerprints of persons who have been judged likely to violate the law persistently. Comparison of their relative performance should provide a valuable guide in developing future systems.

Computer technology can significantly enhance fingerprint processing. For the problem of reading from fingerprint cards or films using a computer, at least 2,500 cases per day and then categorizing the fingerprints completely automatically exceeds present technology. Pattern recognition technology that has been developed for the problem of 10-print classification of fingerprints has been applied to the processing of fingerprint data. It is necessary to develop classification schemes that use it efficiently.

Some preliminary indications of the utility were provided by the Los Angeles apprehension data (appendix B). A "technical specialist," usually a fingerprint technician, was requested to visit the scene of the crime in most cases in which fingerprints were to be processed in the study sample. Each request was made because a patrol officer suspected the presence of fingerprints. No information was available on the technique for the data actually arrived at the scene. In fact, there is some reason to believe that due to lack of staff, the requested specialist did not actually arrive at the scene. This technique used by the FBI has been a difficult technique for law enforcement agencies because of the large volume of prints which must be processed. The FBI has collected proposals from industry, and several companies have invented modest amounts of money in research efforts. The present level of support is almost certainly below a critical threshold, so additional government support should be committed.

**Personal Identification by Physical Features**

Techniques for arriving at standardized classifications of physical characteristics other than fingerprints have long been used in police work. Perpetrators of a crime are often described by witnesses or victims in terms of facial features. The Bureau of Identification System which preceded the widespread use of fingerprints was based on body measurements. Recently there have been attempts to use voice prints (which are reliable according to the FBI's research) and other methods of identification and comparison procedures for facial characteristics. Devices are now available which can enable a trained operator, with the aid of a witness, to form a composite picture of a suspect's face and to translate that composite into a numerical code. Testing is needed to ascertain the reliability of each of these techniques. For those which are reliable, further developments are possible, using computers to develop efficient sequences of questions to witnesses to converge quickly to the proper description.

Recent studies of voice analysis and synthesis, originally motivated by problems of efficient telephone transmission, have led to the development of the audio-frequency profile or "voice print." Each voice print may be sufficiently unique to permit developing a unique classification scheme and perhaps even to make positive identification. This "voice print" system is currently under development and may be tested. A classification system that relies on experts to perform the identification, controlled laboratory tests are needed to establish with certainty whether any of these tests are free from errors of omission and commission by the experts.

**Analysis of Evidence* Evidence in Crime Laboratories**

The crime laboratory has been the oldest and strongest link between science and technology and criminal justice.
and Technology Task Force did not devote major attention to criminalistics. There are some excellent laboratories in key locations around the country. However, the great majority of police departments have only minimal equipment and lack highly skilled personnel.

Traditional efforts of crime laboratory specialists have been directed toward the identification of materials found at the crime scene. Many instruments have been constructed which enable specialists to determine the chemical composition of various substances. Particularly important are analyses of drugs, paints, fibers, oils, and human hair and blood. In the classification and comparison process, it is not necessary to know the exact chemical composition of the material, but only how it compares to a known standard, such as a known drug, or another part of the same object, such as a paint chip. When it is necessary to know of the presence of a particular chemical element, it is often the minor or trace elements which are of interest, not the major elements.

The instrumentation industry is constantly devising new ways to measure smaller samples with greater precision. Unfortunately, the high cost of many of these instruments and their demand for skilled operators impedes wider use in law enforcement. To bring these advantages more directly into police operations, improvement in crime laboratories must proceed in two directions:

- Establishment of regional laboratories to serve the combined needs of police departments in metropolitan areas
- Expansion of research activities in major existing and new laboratories

The need for the regional laboratories follows naturally from the increasingly expensive facilities and the increasing demand for individuals of superior technical competence. The research is needed to speed the application of new instrumentation possibilities. A national laboratory specifically devoted to research on criminalistics might handle the following complex of functions:

- Maintain close contact with the general science and engineering community so as to become aware of new devices and techniques to expedite their introduction into the operations of crime laboratories
- Understand the instrumentation needs of crime laboratories and stimulate the industry to develop new instruments to meet their needs
- Conduct its own research, experimentation, and development of techniques and apparatus
- Develop a data base for the identification of common crime-related materials by various techniques
- Disseminate the results of its work

Because of the wide range of technology involved in criminalistics and the many opportunities for advanced applications, a broad study directed at identifying the most fruitful of these opportunities should be undertaken.

ALLOCATING PATROL FORCES BY EFFECTIVENESS IN DETERRING CRIME

Basic to the police apprehension system is the overriding problem of the allocation of manpower and equipment in such a manner as to achieve most effectively the department's main objectives of prevention, detection, and apprehension. The importance and magnitude of the problem is evident not only in crime statistics, but in the fact that, nationwide, the patrol function costs approximately $600 million. Manpower allocation procedures which might increase patrol effectiveness by 5 percent, could reflect a possible savings of about $30 million.

All police departments have the problem of allocating patrol forces—how many men to assign to each shift and to each precinct. Related problems amenable to analysis include selecting the size of patrol beats as a function of amount of crime and other demands on the police; optimizing search patrol patterns; and shifting units hour-by-hour in the sectors where and when the crime is most likely to occur. These and other patrol-related problems can be analyzed in depth using statistical analysis, mathematical programming, and other operations research techniques. There must be a close tie between analysis and controlled field experimentation to test the results of the analyses.

In allocating patrol forces most departments assign men equally to all shifts, which simplifies scheduling but reflects less than the most efficient use of manpower. The Los Angeles Police Department has a more sophisticated procedure for assigning men to patrol divisions. They use a formula which weights the previous year's crimes, radio calls, population, etc., for each division, and then they assign the patrol force proportionately to the division's weighted score.

For example, if there were 1,000 crimes in Precinct A and 600 crimes in Precinct B, this procedure might suggest transferring officers from Precinct B to Precinct A. But the conditions in Precinct B might be more conducive to deterrence. If an additional officer in Precinct B could suppress 50 crimes whereas in Precinct A could suppress only 10 crimes, then it would be desirable to transfer an officer from A to B.

Estimating this relative effectiveness of a police officer is, of course, extremely difficult, since the number of assigned officers is only one of many factors influencing the crime rate. It is, however, important to develop such an estimate to make efficient use of the police force. Statistical techniques, such as regression analysis, can be used to develop such estimates. Even though the final determination of the effect of an officer on crime must come from controlled experiments in the field, the experiments should be preceded by preliminary analysis so that the experiments can be more productive of both information and crime reduction.

An inherent difficulty in most statistical analysis is its inability to distinguish between cause and effect. For example, in many police precincts, additional officers are assigned as crime increases. Because the additional crime causes additional manpower allocations, the two may appear positively correlated. But this certainly does not permit the blind conclusion that the additional police cause the additional crime. Thus, any results must be used with caution, checking the predictions against actual observations before acting on the results.

The Task Force undertook a preliminary analysis based on limited data contained in the "Statistical Digests of the Los Angeles Police Department from 1955 to 1965. The statistical technique of regression analysis was used to relate the number of reported serious crimes in each of the department's divisions to the number of patrol officers assigned to the division. In this analysis, an attempt was made to factor out effects due to changes in the population and simple time trends resulting from changing characteristics of the population, thus separating them from the effect of the number of patrol officers assigned. This model could be improved by adding such variables as median education level of the inhabitants and median income, and by replacing total population with population by age groups, when data become available.

The model used was:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon \]

where \( Y \) is the number of crimes in a division during the year, \( X_1 \) is population of the division during the year, \( X_2 \) is the number of police assigned to the division during the year, \( \beta_0 \) is an intercept term, and \( \epsilon \) is a disturbance term.

The regression analysis was used to estimate numerical values for the constants.

\[ \text{For the division A,} \quad Y = 1.7 + 0.04 X_1 + 0.0001 X_2 + \epsilon \]

Even with this limited effort and the limited data available, in 4 of 11 divisions most of the changes in the numbers of crimes could be accounted for by the model. In the four divisions, the manpower allocation for 1963 was examined and a study made to determine if a different allocation of police assigned to these four divisions might have resulted in an overall decrease in reported Part I crimes. In 1963, there were 824 police officers assigned to the 4 patrol divisions. The approach was to determine a reallocation among the divisions which might reduce the predicted number of Part I crimes. To avoid major perturbations, no reductions of more than 10 percent in the number of officers per division were considered. The analysis suggested that a shift of officers might have led to a net decrease in reported Part I crimes for the four divisions, primarily due to what appeared to be a particularly high officer effectiveness in one of the four divisions.

The validity of such predictions can be determined only by controlled experimentation in which suggested changes and means of measuring their effects are established. Other models should be tried, and better and more complete data on items such as social-economic factors are required in order to extend and refine the approach. Data collection and experimentation programs should be set up to develop improved procedures for estimating the effects of allocation decisions on crimes and for improving police allocation. This was merely a first limited step in a continuing cycle of analysis, data collection, field test, and analysis. Further theoretical development and trials in actual operations are needed. Several such approaches should be tried to develop methodologies that can be applied by other police departments.

Another possible model might be:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \]

where \( X_1 \) and \( X_2 \) are the numbers of crimes in the divisions A and B, \( X_3 \) represents another variable, such as the number of residents in the divisions, and \( \epsilon \) represents the "unexplained variability" of police assigned to the division. The regression analysis may be used to estimate numerical values for the constants.

The Task Force's work is only the first attempt to make efficient use of the police force. Statistical techniques, such as regression analysis, can be used to develop such estimates. Even though the final determination of the effect of an officer on crime must come from controlled experiments in the field, the experiments should be preceded by preliminary analysis so that the experiments can be more productive of both information and crime reduction. An inherent difficulty in most statistical analysis is its inability to distinguish between cause and effect. For example, in many police precincts, additional officers are assigned as crime increases. Because the additional crime causes additional manpower allocations, the two may appear positively correlated. But this certainly does not permit the blind conclusion that the additional police cause the additional crime. Thus, any results must be used with caution, checking the predictions against actual observations before acting on the results.

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Many aspects of a police department's patrol operation may be likened to a living organism, with sensory organs, nerve networks, a central brain, and motor extremities. Its sensory organs include the means of detecting crime: patrolling officers, alarms, surveillance devices, witnesses, and victims. The primary input network is the public telephone system, and the output network is the mobile police radio network. The counterpart of the brain is the police communications center, which receives the public's calls and dispatches the patrol force in response. The major extremities are the patrol officers who take field action.

With the accelerating trends in telephone ownership, motorization of the police force, and use of two-way radios for police communications, this network has assumed increasing importance. The needs for improvement have expanded faster than its technological development. Fortunately, the potential for improvement is probably greater here than in any other aspect of police operations. The developments to meet the military needs for portable communications equipment and for command and control of military forces provide an extensive reservoir of untapped capability.

COMMAND AND CONTROL

"Command and control" is military terminology for the planning, direction, and control of operations. It involves the organization of personnel and facilities to perform the functions of planning, situation intelligence, force status monitoring, decision making, and execution. These concepts can also be applied to analogous police operations, leading to the possibility that command and control technology might also be applied. Before discussing these possibilities, present police command and control operations will be described.

PRESENT POLICE COMMAND AND CONTROL OPERATIONS

In most police departments, command and control is performed in the communications center, the focal point of almost all the public's calls to the police. Figure 6 depicts a typical communications center in a large city. Situated in an area of approximately 1,000 square feet are several telephone answering stations; a number of radio dispatchers; a board designed to show the patrol beat assignments and the availability of each patrol car; and associated devices such as clocks and time stamps. Files of street locations, stolen automobiles, and wanted persons are usually present or readily available via telephone, teletype, or pneumatic tube stations.

A call for help first appears as a blinking light on a complaint clerk's telephone switchboard. If all the clerks are busy, the caller must wait until a clerk completes an earlier call. The waiting time depends on the rate of calls, which varies markedly with time of day, and on the number of complaint clerks. There is usually a sufficient number of trunk lines so that busy signals are rare.
Obviously, the urgency of a call cannot be evaluated until it is answered. It may concern a crime in progress, a report on an old crime, or a family dispute. Only after he answers a call, in order of arrival, can the complaint clerk determine the type of call, its urgency, and the location of the incident. If he then decides that a car should be dispatched, he writes the information on a time-stamped "complaint card" and sends it to a dispatcher by a conveyor belt, pneumatic tube, or by hand. For extreme emergency calls, he might alert the dispatcher to switch into the telephone conversation; he at least indicates the emergency nature of the call on the complaint card. The dispatcher, when choosing the next card, takes the one with the highest priority. Usually, his only information about the call is the information on the card; he rarely participates in the telephone conversation.

The dispatcher must translate the address of the incident into a patrol district in order to find the car. To switch into the communications center, little of it can be readily recalled by whomever may need it. The center gets very little feedback on the results of its actions.

At best, the location of patrol cars is only crudely given by their beat assignment.

The communications center delay is a significant part of the total response time. Studies in Los Angeles indicate that on the average it takes 1.5 minutes for a priority call and 5.9 minutes for a nonpriority call to be processed through the communications center. The patrol cars take an average of 3.8 and 6.8 minutes to reach the scene of the crime in case of priority and nonpriority calls, respectively.

Most large-city police departments are faced with a severe radio spectrum congestion problem resulting in radio communication queues of patrol officers trying to reach their dispatchers. This situation will grow worse in the future as more cars and radios are added.

Staffing is a perennial problem for the police and, as the size and complexity of an operation grows, merely adding more people is not the answer. The problems of information transfer and coordination increase severely as more people are added.

A city seeking to improve its operations has no guidelines on how best to design and organize a communications center. The great variability in approach from city to city, coupled with the lack of experimental evaluation of different methods, prevent any consensus on technical or operational approaches.

Contingency planning for command and control during emergency situations such as riots or disasters has been neglected by many police departments.

There are three ways in which science and technology can help address these problems. The first is conceptual—analyzing the process and drawing on insights gained in previous related analyses such as those conducted for military command and control systems. The second is in evaluation and modification of existing designs and procedures. The third draws on modern computer technology.

**Command and Control Concepts**

Effective use of the radio-dispatched mobile patrol force requires knowing at all times where the units are and what they are doing, and matching them appropriately to the public's needs. Information is the essential element in making such assignment decisions: information about criminal activity, the status of police resources, and the environment and general circumstances in which operations must be conducted. The information must be gathered, organized, and displayed in a timely fashion so that it can be utilized for decisionmaking.

As noted earlier, these functions fit the generally accepted concept of command and control. Since the early 1950's the Department of Defense and the individual military services have been intensively developing command-and-control systems to support military commanders. Figure 7 illustrates the functions which are basic to the discharge of command responsibilities. The commander must know the environment and circumstances in which he must operate; this capability is provided by the situation monitoring and analysis function.

![Figure 7: Basic Command and Control Functions](image-url)
He must have a steady flow of data on the factors concerning his capabilities; this is provided by the resource monitoring function. These data enable him to evaluate his plans and orders, and if necessary, to change them in response to the changing requirements. This is the command execution function. As events occur and plans prove inadequate, the center monitors the operations of his field forces and uses this information to revise and update his estimate of the current situation and its available resources. This is the operations monitoring function.

The command-and-control concepts have not been studied or adapted formally in the police context. It is not suggested that police departments adopt the concepts of military command-and-control systems in their entirety. Rather, they can use the general approach, drawing on the many years of research and development supported by the Department of Defense. They can adapt the concepts to their needs, and select those elements that are pertinent. For example, one essential element that should be incorporated into police command-and-control systems is the operations monitoring function. This facility provides “feedback” to the commander to assist him in evaluating the effects of his decisions and to provide him with further information upon which to base his next decisions.

In both military and police work, rapid and complete information gathering, decision-making, and dissemination, are essential. As shown in the previous chapter, police response time can often be reduced most efficiently by speeding up the command-and-control function. Selecting the best vehicle to assign in response to a call requires knowledge at the dispatching point of the location and the status of all the available units. This implies continual monitoring of the mobile force, and organization and display of the position and status information in a convenient form.

In both police and military operations, decision aids and reliable communications can contribute substantially to improving the situation. But the police operation in dispatching and controlling field forces, diagrammed in figure 8, does exhibit important differences from military command centers. In both military operations, particularly during peacetime, considerably more emphasis is placed on planning and allocating resources for potential threats to be encountered. In police work, planning and allocation of resources are also important, and will become more so in the event of an emergency situation. The heavier emphasis, however, is on the execution phase of command and control.

Improvement of Existing Systems

Before considering introduction of major new technology, some immediate steps can be taken to improve existing command-and-control operations. Improving such simple aspects of command and control as field layout, design of electronic equipment, installation of field units, and allocation of resources are important steps that can be taken today. The heavier emphasis, however, is on the execution phase of command and control.

The command-and-control center operates almost entirely with telephones and radio communications. It has very little direct physical contact with the outside world. Therefore, for intervention in emergency situations, it is easy to substitute simulated events for real ones, and to conduct tests on reasonable analogues of real situations. In this manner, link with digital plans and procedures can be tested, decision rules can be evaluated, and training and experience can be provided police officers under simulated extreme conditions.

Computer-Assisted Command and Control

The most dramatic way technology can assist command-and-control operations is through the introduction of modern information processing and communication technology. To benefit fully from the technology, however, its introduction should not be limited to simple mechanization of existing procedures which were developed in the face of technological constraints that may no longer be relevant. Rather, the entire police command-and-control function, including many aspects of patrol operations, should be subjected to a basic re-examination, taking full account of the new capabilities offered by computers and communications links. This review should consider questions of when, where, and how to use the police patrol force. It should evaluate how police should respond to various types of routine and emergency situations. It should examine by study and by experiment the extent to which preventive patrol deters crime, how forces should be allocated by time and by geography, and how to plan procedures, appropriate conditions for conspicuousness and for covertness, how to respond to riots, and many other germane questions.

Patrol operations, then, may be able to benefit markedly from computer assistance—much more than by merely automating the police courthouse.

It is possible to describe the general outlines of a computer-assisted command-and-control system for certain large-scale situations. For example, if equipped with a telephone call to the police are still answered by a patrol vehicle teleprinter discussed later in this chapter. Both the police force and the patrol vehicle teleprinter system are automated. The current processing time can be reduced by the use of patrol vehicle teleprinter discussed later in this chapter. Since field response time depends strongly on the assigned car’s distance from the call, automatic car-location devices could be tied directly to the central command-and-control computer, so that it would find and dispatch the closest car. Car locator devices would permit assignment of the two or three nearest patrol cars to the scene of the emergency, other cars could be strategically deployed along escape routes.

Similarly, as is shown in appendix E, most of the advantages of having a car locator can be achieved with comparatively inaccurate devices, errors of about one-quarter mile being acceptable.

There are four techniques that show promise of providing the necessary accuracy of an acceptable level of cost:

A system of police car emitters and call box sensors. A modified radio transponder system. A medium frequency radio-direction-finder system. A combination of position computation and reporting system.

These are discussed in appendix E.

In the police car emitter—call box system each car carries an emitter, visual, audio, or electromagnetic identifying emitter that can be detected by receivers located in police and fire cemeteries. Information gathered by the sensors could then be sent back to the communications center by land lines. The inverse of this technique could also be employed, with coded emitters installed along the street and sensors installed in patrol cars. A radio link would then be needed in the car to relay the car's identification and location to the communications center.

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18 The New York City Police Department, with its 50,000 officers, is already using some significant steps in this direction.
In Washington, D.C., for example, there are approximately 920 police callboxes, located as shown in figure 10. There are about 14 callboxes per square mile or approximately one every quarter mile. This would provide sufficient precision for patrol car location. If finer precision was desired, consideration could be given to locating sensors in the 2,000 fire callboxes.

Use of a radar system requires special transponder techniques to overcome reflections from the numerous buildings, towers, and other structures in a metropolitan area. One possible approach would be to use a central interrogator, transmitting pulses through a directional antenna. Each police car's transponder would reply to an assigned interrogation pulse a specified interval after a synchronization pulse.

A medium-frequency radio direction-finding system can determine the direction of a radiating transmitter even when the transmitter is located in the midst of tall structures. Conventional direction finders employing triangulation techniques could therefore be used to locate police cars equipped with a simple low-power medium-frequency transmitter. The police radio frequencies in the 2-3 MHz range should be suitable for this application.

In a airborne position computation and reporting system, the patrol car would continually compute and record its own location with an integrating compass, odometer, and resolver computers. It could transmit that information upon receipt of a proper interrogation signal.

All four of these basic car locator techniques appear to be technologically feasible. On the basis of this limited in-
The location of the incoming telephone call might also be determined automatically in order to reduce the time spent on locating the patrol car. The modified radar system for a remote display at the precinct station.

A computer-assisted command-and-control system offers many new possibilities for the deployment and control of a patrol force. As the crime pattern in a city changes, the size and location of a patrol force can be changed to meet this need. Once the caller reaches the police, he must be made to understand that a two-man patrol beat costs about $200,000 a year in operating communications centers. It is estimated that the total operating cost of such a system would range from $500 to $2,000 per call.

The primary input to the command and control system, and the most frequent initiator of the apprehension process, is a call from a victim of a crime or a witness to one. In the case of street crimes, however, it is often possible to determine if the victim is a witness to call the police promptly. A number of things can be done to improve existing street communications equipment to meet such a need.

Communications to the Police

The victim of a robber careful enough to steal his last dime cannot now use the public telephone. Public telephones were designed for cars that can be reached by the telephone controller; as the number of available locations from which citizens could reach the police promptly. A number of things are needed to make it easier to reach the police. In the case of street crimes, however, it is often possible to determine if the victim is a witness to call the police promptly. A number of things can be done to improve existing street communications equipment to meet such a need.

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With a few notable exceptions, radio communication is based on the same operational concepts as in the 1930's.

Congestion will intensify as more mobile radios are used and as additional communication devices such as portable radios and radioteletype are introduced.

Little effort has gone into planning or accumulating the data necessary to estimate either present or future radio spectrum requirements as a function of time, location, and frequency; nor have these requirements been presented in clear-cut form for consideration by the FCC.

Although data detailing the national radio spectrum shortage are particularly difficult to obtain, the individual examples from many areas are sufficiently dramatic to make a compelling case for the reality of the shortage in many metropolitan areas. In the Chicago metropolitan area, for example, 38 separate suburban cities with 350 patrol cars must share 1 frequency. This congestion results in excessive delays and unnecessary police force while patrol officers wait to gain the air. No police officer who needs help should have to wait for a clear frequency.

An emergency message from a police dispatcher always has top priority and, even in extremely congested police radio networks, that message gets through. However, the radio spectrum congestion evidences itself in less obvious ways. For example, some police departments have limited the number of police cars on the streets because of lack of radio spectrum availability and have delayed purchasing such new equipment as portable radios for patrolmen on foot for similar reasons. Thus, the shortage cannot be concealed or rectified by using the latest technology, rather than limiting the use of modern technology, rather than limiting the use of modern technology, rather than

In radio communications, a receiver can be designed so that it is turned on upon receipt of a subaudible frequency code. Thus, by the use of the subaudible frequency code, it is possible to communicate with a chosen car or a group of cars equipped to respond to the code. Other cars tuned to the same frequency but responding to a different code can be addressed separately at different times. This coding permits greater flexibility in the use of each frequency. The same channel may be used at different times for detective work, for addressing supervisory vehicles alone, or for citywide purposes by variation of the code. Although some switching capability can be achieved without the use of selective coding, obviously much greater flexibility is available through its use. Hence, police departments should make greater use of selective coding for addressing in their radio networks to enable them to switch their radio channels to meet their changing demands.

Police radio networks should also make greater use of multiple frequency trunking. The trunking concept is illustrated in figure 11. The top of figure 11 depicts the method currently used to provide radio coverage for a police mobile fleet. The city is divided into a number of major geographical sectors, each one patrolled by usually no more than 50 vehicles. The number of sectors is the same as the number of radio channels used, four, in this example. The vehicles assigned to a sector are all linked to a dispatcher in police headquarters by the same single radio channel. The channel may be simple (the cars and the dispatcher all use the same frequency) or duplex (one frequency is used by the dispatcher and another is shared by the cars). The middle of figure 11 shows the simplest version of multiple frequency trunking in which sectors are paired and two channels are assigned to each pair to use in common. Patrol vehicles still communicate only with their own dispatcher; a request to switch is accomplished by means of selective frequency coding rather than by simple frequency addressing. The individual user in the top situation will sometimes find himself connected with another user in the same sector. In this case, several channels are assigned to each pair of sectors. The channel may be simple (the cars and the dispatcher all use the same frequency) or duplex (one frequency is used by the dispatcher and another is shared by the cars).

Even though the demand on the two channels is twice that on one, delay is less likely to occur when the channels are shared, since each car can use either of its assigned channels. For instance, if each of two sectors uses its private channel 50 percent of the time, then each one finds it busy half the time. When sectors are paired, a user would find both channels busy only 25 percent of the time. Thus, both have better service with the shared arrangement. In the bottom figure, all four channels are shared by all the sectors in a trunking arrangement, and delay is still less likely, occurring 20 percent of the time in the above example. In this case all four channels must be busy simultaneously for a call to be delayed. These principles have been utilized in conventional telegraphic networks, in the AT&T mobile radio service, and in electric-power networks.

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Communications are congested and additional frequencies late their needs into a system design and then decide. The FCC has recognized the need for multiple use of radio frequencies by establishing within the Public Safety Radio Service a band of local government frequencies which can be used by all political subdivisions. The availability of the frequencies in the public safety bands are, however, limited by type of user and forbidden to users not within the specified category. As a result, a city may have insufficient total radio spectrum resources to create a highly efficient network. If using all departments, the police may be desperately short of spectrum. This situation is not likely to change in the absence of outside assistance.

The primary responsibility for allocating frequency resources among police and fire protection and other municipal functions properly rests with the local government rather than with the FCC. The present policy of assigning frequencies below the municipal government level is, to some extent, inadvertently injecting the FCC into local government affairs, increasing the difficulty of its own task, and placing artificial restraints upon the municipal government. This, of course, was not a problem before radio spectrum became congested. Under the broader characterization of the frequencies involved, the FCC retains its responsibility to see that there are adequate spectrum resources for municipal functions. Where appropriate, individual requests could still be considered.

This policy would make the municipal government responsible for the efficient use of its total radio spectrum resources. Then, with designs based on larger networks, greater efficiency becomes possible. The municipality retains the freedom over the entire spectrum to develop a network in cooperation with neighboring cities, or its own coordinated public safety network, or any combination of the two. From the FCC viewpoint, the primary consideration should be efficient use of the limited radio frequency resources.

Finally, in order to develop coordinated plans for the future, the FCC should inform the States and local governments of large metropolitan areas that they will, in the future, be expected to provide justification for their radio frequency needs in the form of overall projected public safety requirements for the following decade.
to record confessions and witness testimony, and to provide evidence that apprehended suspects had been properly informed of their constitutional rights.

INEXPENSIVE PORTABLE TWO-WAY RADIOS

Police officers have been unanimous in their desire for small, lightweight, inexpensive, portable two-way radios for both foot and mobile patrols to carry at all times. With a radio, a patrolman can always call for help and have immediate assistance by his command. The radio must work inside most buildings, on the street between tall buildings, and must not be so cumbersome as to impede his regular police actions. Furthermore, it must be inexpensive enough for a police department to assign one to every man on duty.

Experience has shown that in typical situations, hand-held two-way radios must have a power output of about 1 to 5 watts for reliable operation even limited but useful ranges (1/4 mile to 2 miles). The range of the units is limited primarily by such things as obstructing walls or buildings, electrical noise from industrial equipment, low antenna heights, and the inefficient antennas of hand-held units. In order to extend the range by increasing the power of the units it would be necessary to increase greatly the size, weight, and cost of the units before even a marginal improvement in range could be detected. On the other hand, reducing the power much below the 1 to 5 watt ranges results in unreliable performance under many conditions. Because of the limited range of the hand-held two-way radios, radios are needed to pick up, amplify, and relay the signal from the portable radio.

The two-way car radio of the patrol car could be used as a repeater for the cruiser patrolman since he would ordinarily be found close to his car. Alternatively, repeaters could be placed at fixed locations around the city, such as on top of precinct houses.

Portable two-way radios available today are far from satisfactory: they need to be lighter, less bulky, easier to operate, and less expensive. Even though existing transistorized units weigh only 1 to 3 pounds, this is too much for liberal distribution to field officers, who must pull out the antenna and hold the radio so that the antenna is away from his body. Sweater, Trouser leg, and monitor its development.

Table 8—Performance Factors vs. Frequency of Portable Police Radio Equipment

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Body wave antenna</th>
<th>Body wave shadow loss</th>
<th>Industrial/road interference</th>
<th>Fog loss</th>
<th>Building penetration ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 MHz</td>
<td>-6 to -15 dB</td>
<td>-40 to -47 dB</td>
<td>Higher</td>
<td>Less than 150 MHz</td>
<td>Greater</td>
</tr>
<tr>
<td>450 MHz</td>
<td>-2 to -9 dB</td>
<td>-40 to 47 dB</td>
<td>Less than 150 MHz</td>
<td>Less than 450 MHz</td>
<td>Greater</td>
</tr>
<tr>
<td>900 MHz</td>
<td>+3 to +6 dB</td>
<td>+40 to +75 dB</td>
<td>Less than 150 MHz</td>
<td>More than 450 MHz</td>
<td>Greater</td>
</tr>
</tbody>
</table>

Although microprocessorization of present equipment designs can significantly improve equipment and reduce costs, optimized design of the total communication chain between the officer on foot and the dispatcher may well bring about even greater improvements with possibly further reductions in equipment cost and weight.

One of the first steps in optimizing the design of portable radio equipment is to compare equipment performance at the different police frequencies, including possible new allocations. It is possible that penetration of buildings and effectiveness of antennas worn on the body may be superior to present use of frequencies. In addition, natural and man-made noise is lower at the higher frequencies. However, fading loss tends to increase with frequency. There may well be other factors that would dominate the choice of frequency. Table 8 summarizes the relationship between some of the performance factors and frequency.

There are many disadvantages to each available and each frequency propagation characteristics in a city environment which can be used for system design. In some tests, Motorola found that the antennas at 150 MHz penetrated into buildings lower than frequencies now in use. These disadvantages are being supported by work carried out at Bell Telephone Laboratories. To clarify these issues, a test program should be conducted to perform a comparative evaluation of frequencies in the range from 150 to 3000 MHz for police communications.

If the radiowaves at higher frequencies were utilized, it would be possible to design equipment that would be much less awkward to operate in emergency situations and that might provide much more reliable communications, particularly from the inside of buildings. This may lead to important reductions in the size and the cost of the battery, which would be important because battery weight and size are a large portion (perhaps as much as 50 percent) of the weight and cost of the entire microprocessorized unit.

The motorized police officer can take advantage of his powerful and reliable car radio when he is on foot away from his car by such means as:

Making the car radio detachable so that he can carry it with him.

Making the car receiver detachable and giving the officer a separate short-range transmitter whose signal would be rebroadcast by the car transmitter.

Developing a simplified transceiver to communicate with a matched unit in the car connected to the two-way car radio for rebroadcasting.

Having a car radio capable of being switched to a simple repeater mode and providing the officer with a transceiver operating on base-station frequencies.

Developing a simple short-range signaling device that could signal the car and trigger an alarm.

Each of the above techniques, discussed in appendix E, would provide the motorized patrolman with a relatively reliable means of communication when he is away from his vehicle. Each of these techniques is simple, reliable, and has advantages and limitations discussed in appendix E.

While the departments describe both for the foot patrolman and the patrolman away from his car appear to be producible, a mass market is needed. No single police agency, not even the largest one, represents sufficient market potential to support a microprocessorized component production line at the price level indicated.

The Federal Government should assume the leadership in initiating the development of these portable police radios. The possible approaches include disseminating the results of the technical work to potential suppliers, paying for a major part of the development costs, or guaranteeing the sale of an initial production run of perhaps 20,000 units.

The Government should assign to an existing operating agency the responsibility to manage this program. That agency should call on the advice of both large and small police departments, and small computer manufacturers, to establish the specifications for a family of radios. They should work with industry to solicit bids on the radios and monitor its development.

DIGITAL COMMUNICATIONS

Although voice is an indispensable mode of communications for patrol vehicles, it has a number of limitations: It is very wasteful of the already overcrowded radio frequency spectrum. It provides no protection against unauthorized interception of official police communications unless expensive scramblers are employed. It does not create a written record. It is subject to phonetic errors. It cannot be received by an unattended patrol car without special recording equipment.

These problems could all be alleviated by augmenting the voice radio by some form of digital communications link. This would improve the bandwidth efficiency in using the network and would also permit direct communications between a police officer and a computer—for direct inquiry regarding a stolen auto, for example. A number of manufacturers have recently developed teleprinters suitable for installation in patrol cars. These provide security of transmission and a written copy of the message even if the car is unattended. On the other hand, any such system is beyond the officer's most busy sense—vision—especially when he operates as a one-man patrol.

The teleprinter signal can be narrow-band, thereby offering a potential for much more efficient use of the available spectrum. Operational tests will show how much of that advantage is reduced by the need for redundancy of transmission to compensate for errors which result from the many nodes in received signal power that exist in urban communities. Although some transmission errors will occur while the vehicle is in motion, there are various ways to reduce the error rate. Study is needed on the best means for integrating teleprinters into the police communications system both operationally and technically. Also, studies are needed to identify the most appropriate technique to be used. A receive-only teleprinter could receive the radio broadcast messages, such as stolen-car reports. In order to provide a digital link, an encoder unit would have to be added to the teleprinter. With this capability, a patrol officer could communicate directly with an on-line computer. Receive-only teleprinters cost about $1,000 to
$2,000 each and two-way teleprinters units would cost about $3,000 to $6,000 per car.

Simple coded signal transmitting devices for field units are technically feasible. These units could be used to forward such information as availability (e.g., available, out-of-service, occupied but available) for priority assignment, using the "10-series" of codes. If the number of possible coded messages is small, a simple set of switches on the control head of the car radio could code the messages. The officer could flip the appropriate switch and an automatic signal on the vehicle's identification and availability would be sent to the communications center. An indicator light could stay on to remind the officer of his last report.

**Potential for Standardization**

Standardization of police mobile equipment should contribute substantially to field efficiency. A police officer is not always in the same car with the same equipment, and he must use the radio equipment while his attention is elsewhere. Standardization of the controls will avoid fumbling, distraction, and errors. Standardization of such basic details as cable connections and mounting brackets will make a police department less dependent on its previous supplier in purchasing spare parts or replacement equipment. The ability to accept competitive bids should increase the chances of a lower price.

Equipment standardization should be nationwide in scope since there are only a few major mobile radio suppliers and there is little practical justification for limiting standardization to a local area.

Standardization could overcome disadvantages in present police radio equipment such as the following: Patrol cars fitted with cabling and racks for one make of equipment cannot accept equipment of another make without substantial modification. Few parts are common among different makes of equipment, defeating the inventory problem. Test equipment that is designed for use with one manufacturer's equipment frequently cannot be used with similar equipment made by another.

**Disimilarity of Circuitry Places Additional Training Requirements Upon Maintenance Personnel**

Disimilarity in the way operating controls are positioned and variations in their function complicate the operational problem. Equipment of one manufacturer is not always electronically compatible with the equipment of another. For example, the selective signaling system of one manufacturer's equipment generally will not operate another selective signaling device.

Standardization limited to items such as cable connectors, mounting hardware, and control heads could be implemented within a relatively short time and should provide very positive benefits in terms of operations and maintenance.

Thus, a program of nationwide standardization of police mobile radio equipment should be established. The standardization program should be limited to considerations of basic equipment compatibility such as the following:

- Sockets and plugs.
- Terminal strips and the utilization of the individual terminals.
- Housing dimensions.
- Mounting racks and baseplates.
- Control heads.
- Selective signaling techniques.
- Crystals and crystal holders.

The Associated Public Safety Communications Office (APCO) has taken the position that the standardization of control heads is of fundamental importance. With APCO's encouragement, Mr. David Niblack of the Colorado Highway Patrol has designed a standard radio control head. This program is described in more detail in appendix E.

**Because of the complexities in extending the scope of standardization, the further possibilities should be explored and developed on the basis of experience in the limited standardization program to assure that its benefits can be obtained without having a negative effect upon manufactures' efforts to improve their products.**

Although the major emphasis of the Task Force's work focused on police apprehension operations, a significant effort was directed at the problem of reducing delay in processing defendants through the courts. In addition, some work was done on two aspects of corrections—the use of programmed learning techniques to aid rehabilitation and the use of statistical techniques to aid both sentencing and correctional decisions—and technological aspects of crime prevention through reducing opportunities for crime—redesign of automobile components to make auto theft more difficult and street lighting. These studies are discussed in this chapter. In addition, a number of other possible applications of science and technology, which have not been studied in detail, are mentioned.

**COURT OPERATIONS—REDUCING DELAY**

It is a basic precept of our society that justice should not be administered with one eye on the clock and the other on the checkbook. It is often the fact, however, that justice in the United States is rationed because of the limited resources at its disposal and the inefficient way in which they are used. At the same time justice may be effectively denied because of inordinate delays between arrest and final disposition. The techniques of modern management technology can help to achieve the most efficient use of the available resources, within the limits of procedures designed to ensure the due administration of justice.

The Task Force has focused its attention on the processing of defendants through a court, with special emphasis on the reduction of delay. Various solutions to the delay problem have been suggested by judges, lawyers, and court administrators. Whether or not any of these solutions would indeed reduce delay can only be determined after they have been put into effect. In order to make preliminary tests of some alternatives without disrupting the operating courts, the Task Force examined the feasibility of using computer simulation techniques for experimenting with various modifications in the criminal court processing system. The judicial decision making process was not a subject of this study.

Because court systems in the Nation differ in organization and procedure, no single model will serve to represent them all. The approach taken was to test the feasibility of simulating one of these systems, namely the system for processing felony defendants in the District of Columbia. The steps followed were:

1. Describing in detail the organization and structure of the court system for processing felony defendants;  
2. Analyzing the available data on felony defendants in the U.S. District Court for the District of Columbia to determine the distribution of total time to disposition, time intervals between major events in the system, potential areas of delay and possible causes;  
3. Developing a computer simulation of the processing of felony defendants in the District of Columbia trial court system which:
   a. Operated like that observed in the data (i.e., to produce the average time intervals between steps in the process similar to those observed in the data);  
   b. Could be manipulated to investigate possible organizational or procedural changes in the system and to measure their impact on delay and on resource requirements.

**The District of Columbia Court System for Processing Felonies**

The various steps and the associated resources for processing felony defendants in the District of Columbia court system are shown in simplified form in figure 12. The first step is presentment, which occurs before a judge of the Court of General Sessions (the general jurisdiction court of first instance of the District of Columbia) or the U.S. Commissioner. Both are available for presentment and preliminary hearing in felony cases. Presentment is often preceded by a review or screening of the case by an Assistant U.S. Attorney, Court of General Sessions Division. He determines whether to reduce the felony charge to a misdemeanor, to terminate the case ("no papering"), or to proceed with prosecution.
The case is next processed in the office of the U.S. Attorney, Grand Jury Unit. It is screened again and calendared for presentation to the grand jury. The grand jury votes an indictment if there is concurrence of 12 or more of the jurors. Therefore, the indictment is signed by the foreman and by the U.S. Attorney and returned (generally on Monday) in open court.

Arraignment is the next step. It is generally a perfunctory proceeding in which the accused appears, is advised of the formal charge and enters a plea--usually not guilty. At about this time the case is assigned to an Assistant U.S. Attorney who will probably handle it until final disposition, and a defense counsel is appointed by the court for a defendant who cannot afford counsel. Following arraignment, trial preparation proceeds; motions are filed and heard, the case is placed on a calendar and, finally, progresses to trial. Only about 30 percent of the 1965 dispositions resulted in a trial; approximately 55 percent pleaded guilty to the offense charged or to a lesser offense prior to or during trial. The remaining 15 percent of the defendants were dismissed.

TIME DELAY IN PROCESSING FELONIES

The time delay problem was approached by analyzing in detail the data on 1,550 felony defendants whose cases commenced by filing of indictment or information in the U.S. District Court for the District of Columbia in 1965.1 The time periods that these defendants were in the court system were compared with the timetable developed by the Commission's Administration of Justice Task Force. That timetable proposes that the period from arrest to trial of felony cases be not more than 4 months, with a maximum observed time of 463 days. The timetable recommends a maximum of 63 days between arraignment and trial in summary. One-half of the defendants who pleaded guilty or were dismissed were in the court system longer than 4 months. From initial appearance to conviction or acquittal, 20 percent longer than 9 months. Contrary to generally held beliefs, motions were not the main cause of delays. Only one-half of the defendants filed one or more motions; however, one-half of these were filed more than 40 days after arraignment.

Experienced lawyers have pointed out that most of the steps in the actual processing of felony defendants require very little actual court time. The initial hearing for a defendant takes only a few minutes; a preliminary hearing takes a few minutes; motions can be heard in 10 minutes. A guilty plea requires as much court time as it takes a defendant to answer a dozen questions. The court time spent on a defendant who pleads guilty (approximately one-half of the felony defendants) probably totals less than 1 hour, yet in the District of Columbia the median time from initial appearance to disposition is 4 months. The data indicated that one-third of the time was spent waiting for return of the grand jury indictment. After arraignment on the indictment, additional time is required for the preparation of the necessary papers. But for the typical case, the actual time devoted to this process is a few days at the most, not weeks or months.

To study the impact of alternative methods of alleviating the delay in the processing of felony cases, the Task Force developed a computer simulation of the court processing activity. The simulation permitted experimentation with the court operating procedures with no disruption to the actual court operation. To make best use of the limited time available, an established simulation language was selected, IBM's General Purpose Systems Simulator (GPSS). The language, designed primarily for simulating industrial production processes, proved quite adequate to handle the court process.

The resulting model, called COURTSIM, is described more fully in appendix I. Figure 14 is a flow diagram of the process as it existed in the District of Columbia Court system. The circles represent processing units or "milestones" in the processing of a felon. For example,
the circle labeled PRS represents the Court of General Sessions, U.S. Branch, where the defendant makes his first appearance before the courts. The circle labeled USC represents the U.S. Commissioner, where defendants can also be presented. The arrows from one circle to another indicate the possible paths that the processing of a defendant may take; for example, from ARR (arrested) he may be presented to the U.S. Commissioner or his case may be discussed with the DAA (an Assistant U.S. Attorney, General Sessions) for possible presentation at PRS.

Finally, the squares represent possible locations in the process where a defendant may exit from the system due to a dismissal, reduction of the charge to a misdemeanor, or his case being handled in another part of the system due to a "no paper," etc.

The numbers on the arrows represent the percentage of defendants from each processing unit which take the indicated path. These percentages were estimated from the data and by staff members of the President’s Commission on Crime in the District of Columbia.

COURTSIM was used to simulate the flow of the 1965 felony defendants through the District of Columbia court system. As the model is presently designed it does not handle the small percentage of cases that require exceptionally long times between events in the system; these could be incorporated into a later version.

The results of several of the simulation runs are presented in table 9 with a summary of a few of the more important time intervals starting from presentment of the defendant. The first row presents the median times from the 1965 District of Columbia data. The last row presents the recommended timetable of the Administration of Justice Task Force. The other rows contain the times generated by computer simulation runs.

The second row is a time summary of the simulation using the conditions in 1965. In 1965, one grand jury was sitting and an average of five district court judges were assigned to the criminal part of the court. Under these conditions, the simulation reflected the actual court operation. In both there was an average time of approximately 6 weeks between initial presentment and the return of an indictment, and an average of at least 15 weeks from

<table>
<thead>
<tr>
<th>Table 9.—Representative Felony Processing Times in Days</th>
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<tbody>
<tr>
<td><strong>COURTSIM run</strong></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>1965 data (median days)</td>
</tr>
<tr>
<td>1965 data (grand jury)</td>
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<td>1965 data (grand jury + grand jury)</td>
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<tr>
<td>1965 data (grand jury + grand jury + grand jury)</td>
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<td>1965 data (grand jury + grand jury + grand jury + grand jury)</td>
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1. Cases with initial pretrial motions. 2. First motions decided. 3. To trial date. 4. The many number of days is used in rows 2-7.
The close correspondence between the actual and the simulated times suggests that the model is a valid representation of actual operations.

The simulation indicated that most of the time prior to arraignment was spent in the Grand Jury Unit awaiting return of indictment (5 out of 7 weeks). By simulating the system with a second grand jury sitting part of the time, the time spent in the Grand Jury Unit was reduced from 5 weeks to less than 1 week, resulting in a time of approximately 2 weeks from initial presentment to return of the indictment. This is shown in line 3 of table 9.

Thus, it appears that for a cost of probably less than $50,000 per year for the additional grand jury and associated support resources, the delay from presentment to return of indictment could be reduced by 70 percent. The total time until the defendant is ready for trial would be reduced from 160 days to 127 days.

The fourth row gives a lower bound on the average times if, in addition, all transit times were eliminated, i.e., as soon as one processing stage finishes with a defendant, he proceeds immediately to the next and waits only if the next processor is unavailable because of weekends or is busy. If such a condition had existed in the District of Columbia courts in 1965, a defendant would have an average of approximately 2 months after presentment to be ready for trial. Comparing these times with that of the last row (the Administration of Justice Task Force recommended maximum), one can see that the timetable appears to be reasonable.

An organizational change was next examined, namely the preliminary processing of all defendants done by the U.S. Commissioner (instead of by both the Commissioner and the U.S. Branch, Court of General Sessions). The results of this run (row 5) indicate that the workload on the Commissioner was not excessive and that the...
time from presentment to return of indictment was not significantly increased. An additional example of the use of the simulation model is in evaluation of the possible consequences of changes in defendants' behavior resulting from changes in court procedure. Accordingly, the inputs to COURT SIM and potential effects of such changes were evaluated to determine the estimated workload and fiscal impact of the new procedure. The model was run with the following assumptions: (1) a decrease in the number of defendants pleading guilty, a possible result of the Bail Reform and the Criminal Justice Act; (2) a delay in the entry of a guilty plea; and (3) the amendment of rule 87. In addition, the current calendaring procedures were retained, and scheduled times for arraignments and trials were used in the analysis.

The results are summarized below. The average time from presentment to return of indictment was not significantly increased. The time from presentment to return of indictment was not significantly increased.

**OTHER POSSIBLE APPLICATIONS**

There are a number of other areas in which science and technology appear to be applicable to court operations. Although the Task Force did not explore these in detail, they appear to warrant further examination. Some of these are summarized below.

As new instrumentation techniques, such as voice prints and neutron activation analysis, are developed, objective laboratory test can be undertaken to test their validity and to provide guidance in evaluating testimony based on them. This can take place in laboratories apart from specific court cases rather than only waiting for the accumulation of case by case data.

Modern techniques of recording, such as magnetic tape, TV recording, and computerized versions of stenographic records might provide rapid and easily accessible courtroom documentation. A number of decisions made by appellate judges could be facilitated by referrals and analyses of operational data relevant to these decisions. Criminal case files and analysis of data relevant to these decisions can help the judges weigh the impact of the various decisions on criminal justice policies.

In court management, improved scheduling procedures might be useful in assigning court resources to cases. More realistic scheduling might help in handling the logistics of individual cases by bringing together the necessary resources at the appropriate time and place. Electronic data processing systems, for example, could be provided to witness to expediently resolve cases so that they could be called on short notice even if inaccessible by telephone. The Task Force recommended a pilot study of court administration, such as improved dockets, records, redesign of forms, use of electronic data processing and other matters of basic business practice could improve court efficiency.

**CORRECTIONS—PROGRAMMED LEARNING AND STATISTICAL AIDS TO DECISIONS**

One of the important objectives of the criminal justice system is the rehabilitation of identified offenders. By the pursuit of this objective has met with only limited success. Most arrests are of people who have previously been arrested. The FBl reports that 75 percent of the fingerprints sent to police departments are already in their criminal files. Of these people who have been arrested, over 75 percent return for another term. A major source of the problem is the large number of offenders corrections agencies must treat with limited resources in funds and trained manpower. In 1966 there were about 1.5 million people under correctional supervision on any given day. Projectors developed by the Task Force and shown in figure 10 estimate that there will be over 1.8 million people under correctional supervision by 1975.

Corrections involves both rehabilitating and maintaining custody of offenders. There are two elements of custody—maintaining the well-being of prisoners and preventing escape. Security technology can find many uses in prisons. Electrically controlled locks, doors, ramps, and gates can be installed to make it possible for any of the staff to remotely control access to any area of the institution. Smoke detectors, pressure sensitive mats, and other alarm devices can be installed in hallways and rooms to alert staff if a prisoner tries to break out of his cell. Security systems can also be used to provide safekeeping for valuable institutional items, such as guest checks, cash, and valuables stored in mail bags.

There has been much discussion concerning use of technology in maintaining security in community treatment programs, which are receiving increasing emphasis in corrections. Innovations of this sort might make it possible for law enforcement agencies to be sent to the scene of a crime in a matter of minutes and also alert local law enforcement agencies to the presence of a criminal. The primary reason for the rapid growth in the use of technology is the technology is rapidly becoming more effective and is being used in more and more places. It is not always clear, however, that the net effect of such technology will be to help rehabilitation and reduce recidivism. Furthermore, the availability of crime data is not always clear, and there is doubt whether any of them would be acceptable in a free society. As with many technological devices that raise such complex issues, it is left to the users of such technologies to determine whether or not they should be used.

Because of the inherently behavioral aspects of most rehabilitation problems, research designs and the output could be used. Closed-circuit television techniques of experiment design, and data analysis can be used in making decisions. These techniques can be used to make decisions about the rehabilitation of correctional staff. For example, close-circuit television can be used to monitor the behavior of correctional staff and to determine the effectiveness of the staff's interaction with the inmates. The output could be used to train correctional staff and to determine the effectiveness of the training programs. The output could also be used to determine the effectiveness of the rehabilitation programs and to determine the effectiveness of the staff's interaction with the inmates. The output could also be used to determine the effectiveness of the rehabilitation programs and to determine the effectiveness of the staff's interaction with the inmates. The output could also be used to determine the effectiveness of the rehabilitation programs and to determine the effectiveness of the staff's interaction with the inmates. The output could also be used to determine the effectiveness of the rehabilitation programs and to determine the effectiveness of the staff's interaction with the inmates.
The great bulk of crime and delinquency in the United States is committed by males in an age group extending from the mid-teens to the mid-twenties. In 1965, the grand total of 19,527,213 arrests for all offenses is the sum of 13,926,560 male arrests. Furthermore, the percentage of females arrested for the same offenses is much smaller than that of males. Most of these individuals begin their criminal or delinquent careers while still juveniles.

Most dropouts, moreover, drop out of school, to idleness and unemployment, with a consequent increase in the number of persons classified as criminals. Hence, efforts to reduce the number of dropouts fail because they cannot adapt to a classroom setting dominated by the needs of students in their late teens or early twenties. Although they are generally not particularly bright, they are well trained in the pragmatic way of calculating costs and benefits, they might find a more remunerative place in the community and refrain from crime.

The populations of the jails in correctional programs are usually composed of individuals in their late teens or early twenties. Thus, if they are to be significantly helped, they must be given a chance to upgrade their skills, to develop, writing, and publishing the programs. Therefore, the students in the Rehabilitation Research Foundation at the Draper Correctional Institution, in Elmore, Ala., has been conducting an educational program project using programmed instruction, not exclusive with conventional instruction by a guest speaker. The academic instruction at Draper covers more than 350 courses, ranging from literacy training to college preparatory work. Students spend 35 hours a week on their academic courses and have found that only 1 percent of the students fall below the 85-percent requirement on final mastery tests. In addition, for the past 2 years vocational training programs have been offered, using, in part, programmed learning aids. The programs have been integrated into vocational courses covering barbering, bricklaying, carpentry, secretarial training, automobile servicing, and technical writing. These courses were set up to correspond to a job placement pattern which had been developed in the community. The learning programs used in these vocational courses were developed and written by the Rehabilitation Research Foundation at Draper. As of early 1965, over 25 vocational booklets were either published or in preparation. The entire vocational training program at Draper is designed to be completed in not more than 8 hours per student per hour. This includes the cost of vocational instruction, counseling services, and the cost to provide supplementary reading and written materials.

3 The introduction of computer assistance in programmed instruction is a point particularly useful for handling many men students with more complex programs. Their present costs are somewhat greater than the manual techniques. This is true both in the cost of development and booklets.

In one study at Draper Correctional Center, it was found that the students completed 1 academic year of school work in about 47 instructional hours of work with programmed learning materials. The average rate of advancement was therefore well under $400. Based on this rate of advancement, it is estimated that if the student is to be ready for vocational training by his 28th birthday, he will have to spend at least 25 years in school. Thus, if he is to enter vocational training by his 28th birthday, an improved chance of a fuller life for the individuals involved.

About 70 percent of the first class of graduates from this program have been employed, 28 percent had previously been retained, and 37 percent continued in school. If the program succeeds, it shows considerable success. Over 50 percent of the boys involved achieved in academic upgrading of 4 school years during the first 2 months of 1966.

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the nature of the specific problem under consideration. Various forms of multivariate statistical analysis can be used. Multiple discriminant analysis, employing regression estimation techniques, can be used when the variables to be predicted are in discrete categories (e.g., types of crimes), rather than along some naturally ordered continuum. This analysis is usually aimed at determining the effect of differing treatment regimens, sex roles in correctional programs, and planning.

Role in correctional programs. Rehabilitation offers perhaps the best opportunity to be REDUCING causes of crime. The most basic means of mentally, economically causes of crime through programs which have basic problems were outside the scope of the work of the Federal Bureau of Investigation. A threat especially potential repeaters, generally through punishment; by temporarily donning; by making them less vulnerable to theft and by protected by better safes and locks; magnetic owners will be able to establish immediate identity and

In addition to hardening the target, the environment can be made less conducive to crime. Criminals can be inhibited by increasing the probability that their illegal activity will be detected. Many kinds of signals and alarms can be discussed in chapter 11, and continuous surveillance by a camera that photographs all check cashers. People subject to a high risk of robbery, such as liquor store owners near gas stations, are particularly vulnerable, in their cars. They can be engaged in diversions while in their vehicle, or can be engaged in diversions while in their vehicle, or can be engaged in diversions while in their vehicle, or can be engaged in diversions while in their vehicle.

Increasing the difficulty of auto theft

Auto theft is prevalent and costly. In 1965, 496,000 autos valued at over $10 million were stolen. About 28 percent of the inhabitants of Federal prisons are there as a result of conviction of interstate auto theft under the Dyer Act. In California, where thefts cost the victims over $60 million yearly. The great majority of auto theft is for temporary use rather than resale, as evidenced by the fact that 68 percent of stolen auto parts were recovered within 2 days and about 80 percent within 3 weeks. Chicago reports that 71 percent of the recovered autos were found within 4 miles of the point of theft. Data from Berkeley showed that 82 percent of the recovered autos were found in Berkeley or in police jurisdictions contiguous to it. The FBI estimates that 8 percent of stolen cars are taken for the purpose of stripping them for parts, 12 percent for resale, and 5 percent for use in another crime. Auto theft has been generally thought of as a victimless crime, but its importance has increased as these numbers have increased. A more fundamental view is that the ignition system connector cable much more difficult to remove the key from the ignition. Hopefully, other manufacturers will also address this problem.

Although the above steps will contribute to the reduction of auto thefts, the following additional improvements should be carefully considered:

A steering column and/or transmission lock which immobilizes the car when the gear-shift lever is put into the proper position and the key removed. With this device, the driver cannot start a car; and the engine by shorting the ignition does not permit the car to be driven away.

An ignition system which causes the driver to remove the key from the ignition. This can be done by a spring-loaded lock or lock which pushes the key out; or by requiring the key to be not only turned, but also pulled out of the ignition in order to stop the engine; or by attaching a buzzer which goes off if the key is left in the ignition when the engine is turned off. Although the automobile manufacturers are best able to integrate these devices into the design of their vehicles, it is necessary that some Federal agency work with them to establish minimum requirements on the actual implementation. This responsibility could well be assigned to the National Highway Safety Bureau as part of its program to establish safety standards for automobiles.

Street lighting

Improved street lighting is frequently advocated by police, municipal, and other public officials for combating crime. Its proponents believe that adequate
street lighting will (1) deter certain types of street crimes by increasing the risk of detection of the offender; and (2) enhance the probability of apprehending the offender. These assumptions are fortified by the general sense of security which is induced in the individual by the presence of adequate street lighting. Police and citizens alike frequently remark that they have no proof that improved street lighting reduces crime, but they do know that they feel safer. And if lighting encourages greater use of public streets and parks, this in itself may discourage criminals. Since much of crime occurs at night, there is considerable intuitive support for the feeling that street lighting will suppress crime incidence.

According to data compiled by the Los Angeles Police Department during the year of 1965, there were 164,000 reported offenses and attempts. Of these, 49,000 were committed during the day, 75,000 at night, and 40,000 at unknown times. Likewise, certain crimes such as highway robbery, aggravated assault, purse snatching, and rape have a higher probability of being perpetrated at night.

Unfortunately, existing studies do not present definitive conclusions as to the effects of lighting on crime. In 1956, the central business district of Flint, Mich., was relighted. Six-thousand-lumen incandescent lights were replaced with 20,000-lumen multiple fluorescent bracket-type lights. A study over a 6-month period indicated that there was a 60 percent reduction in the number of felonies and misdemeanors, and 80 percent reduction of larcenies. However, there was, at the same time, an increase in police surveillance in the area. Since the experiment was not controlled, the effects of patrol and relighting are combined, so that any conclusions on the effects of street lighting must be considered only tentative.

In New York City, four police precincts designated as high crime areas were converted from incandescent lighting to mercury vapor lighting. The rate of nighttime crimes dropped by 49 percent after the installation of the lights. In 1964, after 80 percent of the city street lighting had been converted over a 4-year period at a cost of $38 million, the total felonies in the city increased by approximately 43 percent. It is impossible to determine what the felony rate would have been if the lights had not been installed.

In St. Louis, there seems to exist evidence of a favorable impact by street lighting on certain types of crime. A program of improved street lighting was first begun in 1964 in a principal business district in the downtown area. In a comparison of recorded criminal acts in 1963 with those of 1965, it was found that crimes against the person decreased by 40.8 percent, auto theft by 28.6 percent, and business burglary by 12.8 percent. In another study involving a high crime district known as Central West End, an increase in crimes was recorded, but the rate of increase was not as high as in the surrounding areas. In addition, the overall increase of crime was lower than anticipated in these two areas.

The studies do not present definite conclusions as to the effects of lighting on crime. Methodologically, there are many problems which need to be overcome before definitive statements can be made. For example, very few experiments can be labeled as controlled. As noted in the Flint study, improved street lighting may be accompanied by other changes such as increased police surveillance.

Likewise, subtle changes in the size and character of the population may accompany the lighting change and markedly affect the crime rate. In addition to these problems, the task of conducting unbiased and controlled experiments is difficult and may involve considerable expense. One would want to discover which crimes were affected and under what conditions, i.e., what kinds of lighting are effective in what kinds of situations. This would require a statistical breakdown of crimes by block before and after relighting, not only in the relighted area, but in adjoining areas. It would require information as to the past, present, and projected crime rates and it would involve correlating these rates to the kind and intensity of the light. At present, these data are not available. The only results it is possible to reach now are:

There is no conclusive evidence that improved lighting will have lasting or significant impact on crime rates, although there are strong intuitive reasons to believe it will be helpful.

Improved street lighting may reduce some types of crimes in some areas, i.e., given a light and dark street to commit a crime, a criminal will probably choose the dark street.

Improved street lighting accompanied by increased police patrol can reduce crime rates in an area.

When new lighting programs are instituted, police departments should be encouraged to maintain records of crimes in the relighted and adjoining areas. With information on past, present, and projected crime rates, it may be possible to assess the better impact of lighting on crime.
Analysis of Crime and the Overall Criminal Justice System

NEED FOR ANALYSIS OF THE OVERALL CRIMINAL JUSTICE SYSTEM

Previous chapters have examined some of the ways in which systems analysis can be used to help improve the operations of the police and court components of the criminal justice system. There are distinct limitations, however, in looking only at the parts. What is also needed is a means of relating the parts to each other. The criminal justice system must be viewed as an integrated whole, especially in formulating budgets and in developing programs at State and local levels.

Police, court, and corrections officials all share the objective of reducing crime. But each uses different, sometimes conflicting, methods and so focuses frequently on inconsistent subobjectives. The police role, for example, is focused on deterrence. Most modern correctional philosophy, on the other hand, focuses on rehabilitation and argues that placing the offender back into society under a supervised community treatment program provides the best chance for his rehabilitation as a law-abiding citizen. But community treatment may involve some loss of deterrent effect, and the ready arrest of marginal offenders, intended to heighten deterrence, may by affixing a criminal label complicate rehabilitation. The latent conflict between the parts may not be apparent from the viewpoint of either subsystem, but there is an obvious need to balance and rationalize them so as to achieve optimum overall effectiveness.

This process of balancing and rationalizing potentially inconsistent subobjectives is done at present, when it is done at all, on a largely subjective basis rather than through measured assessment of the consequences of various alternatives. The allocation of necessarily limited budgets and the choice of methods with which to handle various offenses and offenders could be done more accurately if such overall system assessment could be made.

Systems analysis provides one framework for attempting an objective assessment of the criminal justice system as a whole. The discussion in this chapter takes some preliminary steps in these directions, using a simulation model of the criminal justice system. The model was developed and computations performed with the limited available data, supplemented by hypothetical data, more so to illustrate what might be done than to arrive at definitive conclusions. As such, the work raises some basic questions and provides a foundation upon which further research can be built. It also identifies data which must be collected to be able to evaluate alternative actions in the total system context.

One of several possible examples can illustrate how little of the basic data is now available. Although it is fairly well documented that there are over 6 million arrests made each year in the United States for nontraffic offenses, it has not been known what percentage of the population ever gets arrested. The incompleteness of most arrest records makes it difficult to estimate the proportion of arrests in any year that are of persons never before arrested, a figure necessary for determining what percentage of the population ever gets arrested. A mathematical analysis presented in appendix J uses the lowest estimate—one new offender in eight arrests—on the basis of which it was calculated that if present trends continue at least 40 percent of the male children living in the United States today will be arrested for a nontraffic offense sometime in their lives. For boys living in cities, the figure is in the order of 60 percent; for Negro boys living in cities, it is about 50 percent. These projections are based on current arrest rates, which have been increasing in recent years, so in some respects they might even be conservative. On the other hand, the inherent incompleteness in arrest records leaves open the possibility that even the one-eighth estimate at the first-arrest rate may be high. Of course, changes in arrest practices, such as widespread adoption of the Commissioner’s recommendaion not to treat drunkenness as a criminal offense, could reverse the trend.

The fact that these projections are so surprising to most observers illustrates how little is known in fact about basic questions in the criminal area and how important it is to try to find more answers. For if sustained by additional data, these estimates must raise many basic questions about the operation of the criminal justice system and about the nature of police intervention. They would refute the common notion that most people never encounter the criminal justice system and only a small class of "criminals" do. Although these statistics, and many like them, are vital to understanding how the criminal justice system operates and to raising critical questions, there are no new estimates, however tentative, of many such numbers.

Even more important for policy guidance is the need for information on the likely consequences of actions that change the system. One way to collect data about such
relationships would be to make changes in the operations and observe the effects directly. Wherever practical, this kind of controlled experimentation is clearly to be preferred. But it is often impracticable and even undesirable. Not only are the costs often prohibitive, but normal operations are frequently too sensitive to be disrupted. Instead, it is necessary to formulate a mathematical model of the system and thereby permit a sharper focus on the critical value questions of policy by the legislator and the administrator.

MEASURING THE EFFECTIVENESS OF THE CRIMINAL JUSTICE SYSTEM

Systems analysis begins with an examination of the objectives of the system of interest. These objectives are then translated as far as possible into quantitative measures of effectiveness of the system. Various alternative means of improving the system can be compared numerically with a mathematical model which calculates the measures of effectiveness associated with each alternative. At the current state of development, with only very poor data and gross uncertainty about the consequences of any actions taken, any attempt to accomplish this for the criminal justice system must be regarded as preliminary.

The criminal justice system is generally regarded as being somewhat amenable to quantitative description. But it is often impracticable and even undesirable. Not only are the costs often prohibitive, but normal operations are frequently too sensitive to be disrupted. Instead, it is necessary to formulate a mathematical model of the system and thereby permit a sharper focus on the critical value questions of policy by the legislator and the administrator.

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to identify the exposure rate associated with the intended interpretation.

Failing to measure the crime is the inability to distinguish between changes in the amount of crime committed and the amount of crime reported. This difficulty is shown when one compares how the two sets of cases are distributed on the UCR ranking of seriousness, which is shown also in table 10.

<table>
<thead>
<tr>
<th>Table 10.—Disutilities of Part I Crimes</th>
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<tbody>
<tr>
<td>Type of crime reported by UCR</td>
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<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Robbery</td>
</tr>
<tr>
<td>Murder</td>
</tr>
<tr>
<td>Rape</td>
</tr>
<tr>
<td>Forcible rape</td>
</tr>
<tr>
<td>Forcible sodomy</td>
</tr>
<tr>
<td>Petty larceny</td>
</tr>
<tr>
<td>Total disutility</td>
</tr>
</tbody>
</table>

The disutility for personal crimes and felons are very crude estimates based on the government's disutility for the crime. The disutility for property crimes is the sum of the disutility for the crime and the disutility for a public injury caused by the crime.

(1) Aggregate a number of related processing stages consistent with the form of the available data. For example, the booking and initial appearance stages might be combined into a single one.

(2) Describe the probability that an arrest person is routed along the alternative paths of either processing or release, and the amount of disutility. This work includes the proportion of individuals following off-stage routes as a function of the type of crime, characteristic of the individual such as age and prior criminal record, and characteristics of the processing stage.

(3) Attribute to each individual the costs of processing and offense, including both the atypical home and the total disutility associated with the offense. This stage involves assigning disutilities to the various types of offenses.

(4) Determine the resources required to process and offenses, and to estimate the costs associated with the processing stage. These costs are then used to estimate the cost of processing and offenses, and the costs of the processing stage.

(5) For each possible route out of the system, calculate the probability that an individual will again commit the same crime. This stage involves assigning disutilities to the various types of offenses.

(6) Translate these disutilities into computer code, so that numerical results can be calculated.

(7) Collect data to estimate each of the model parameters in the above description.

(8) Change the variables characterizing the system, and calculate the consequences of these changes on costs and on crimes.

A simplified version of the model which was developed by the Task Force following this process is shown in figure 17. It can be used to calculate what happens to an offender after he is arrested and processed in the system. The results for all the Index crimes were then totaled to get the costs incurred at each stage, and the number of people processed through the system. The numbers resulted in a very crude estimate of the costs associated with processing and offenses.

FBI estimates of the index of crimes are derived from an unweighted sum of the reported Index crimes. This Index is dominated by the far more prevalent crime against property and is relatively insensitive to changes in the classification of the crimes. Thus, the number of crimes could increase by 1,000 percent, but if auto theft fell by 10 percent, the Index would decline.

All too frequently, crime is too expensive. Most people would be willing to tolerate a considerable amount of private, even if perhaps shoplifting, if they could know that doing so would reduce the amount of street robbery. The trade-offs among different types of crime is an important consideration in allocating enforcement resources. Decisions, for example, on transferring detectives from the vice squad to the robbery squad must account for the relative amounts of crime disutility they could reduce on each squad.

Crime derives its seriousness from many different effects, and it is very difficult to assess the importance of each in order to determine their relative importance. One way of resolving these difficult issues is to measure public attitudes toward being a victim of different crimes, using a representative sample of individuals and applying scaling techniques. Some preliminary results have been obtained by Sellin and Wolfgang. They asked a sample of people to weigh the seriousness of various crimes. The concepts of utility theory can then be applied to these results, resulting in estimated disutilities of each part I crime and in the crime seriousness estimates of seriousness differ somewhat from the UCR ranking of seriousness, which is shown also in table 10.
A general view of The Criminal Justice System

This chart seeks to present a simple yet comprehensive view of the movement of cases through the criminal justice system. Procedures in individual jurisdictions may vary from the pattern shown here. The differing weights of lines indicate the relative volumes of cases disposed of at various points in the system, but this is only suggestive since no nationwide data of this sort exists.

1. May continue until trial.
2. Administrative record of arrest. First also of which temporary release on bail may be available.
4. Preliminary hearing. No separate preliminary hearing for misdemeanors in some systems.
5. Charges filed by prosecutor on basis of information submitted by police or citizens. Alternative to grand jury indictment; used for felonies, arrestees in misdemeanor.
6. Review whether Government evidence sufficient to justify trial. Some states have no grand jury system.
7. Appearance for plea; defendant elects trial by judge or jury (if available) except for indigent usually appointed here in felonies. Usually not at all in other cases.
8. Charge may be reduced at any time prior to trial in return for plea of guilty or for other reasons.
9. Challenge on constitutional grounds to legality of detention. May be sought at any point in process.
10. Probation officer decides desirability of further court action.
11. Welfare agency, social services, counseling, medical care, etc., for cases where adjudicatory handling not needed.
individuals arrested for Index crimes are sentenced and only about 30 percent of these are sentenced to prison. In the model, recidivism was measured at the point of rearrest. This brings into the sample a number of people arrested for crimes they did not commit, but reduces the selection effect in ignoring people freed for legal or technical reasons even though they did commit the crime.

In the model, the probability that a person is rearrested was made to depend on his age, his previous crime, and on his exit point from the criminal justice system. These data indicated the Index crime as decreasing constantly with age.

The distributions of time lags between arrests were based on data from the FBI criminal careers study and on data from several jurisdictions. These data indicated that rearrest, if it happens, occurs within 5 years after release in about 99 percent of the cases and within 2 years in over 60 percent of the cases. Another factor that must be included in a model to describe recidivism is the type of crime which a recidivist tends to commit. An individual's subsequent crimes are related to his previous crimes. The estimated array of these conditional probabilities for each of the seven Index crimes is shown in table 11. The table displays the chance of switching from each crime type to each other when rearrest occurs.

USES OF THE MODEL
Criminal Justice System Direct Operating Costs for Index Crimes

The direct costs of processing offenders at each stage were calculated for each Index crime on the basis of processing time and unit time costs. In figure 10, the system costs for each kind of Index crime are distributed among the major cost components. Corrections costs account for a large portion of the total costs in murder and nonnegligent manslaughter (81 percent), forcible rape (42 percent), and robbery (42 percent). In all three crimes, police clearance rates tend to be high. For the prison crimes, which have lower clearance rates, police costs are a much larger proportion, about 70 percent of the total costs. For all the Index crimes, the court costs are a very small portion of the total: 8 percent for murder, 9 to 5 percent for the other personal crimes, and 1 percent for the property crimes. Figure 20 shows how these costs are attributable to each of the 1965 Index crimes in the United States in 1965. It can be seen that the property crimes of burglary, larceny of $50 and over, and auto theft, which account for 87 percent of the Index crimes, also account for the bulk (81 percent) of the system costs for Index crimes. The figure also shows how these system costs for Index crimes are distributed among the major system components. Police costs are the largest (67 percent), followed by correctional programs (including probation) which account for 20 percent.

In table 12 the system costs are presented as the cost per individual crime. Each reported Index crime costs the criminal justice system directly about $750. The cost per offender arrested, however, is about $3,500 since there are only about one-fourth as many arrests as Index crimes reported.

Another costing approach would omit the large amounts of police costs charged to the offenders, and charge them instead as fixed costs of the system. If offenders are not charged with any of the costs of police patrol, then the cost per offender arrested is reduced to about $1,000.

Criminal Careers

The criminal justice system pays a price for permitting a person to enter a life of crime. The cost is measured by the "criminal-career cost," or the total cost to the system during the life of the criminal. The criminal-career cost includes all the costs charged to the offender during his criminal tenure, plus the costs of processing all the crimes until they were processed as adult at age 30.

\[ \text{Criminal-career cost} = \sum_{i=1}^{n} \text{Cost of crime } i \]

The criminal-career cost is a function of the costs charged to the offender during his criminal tenure, plus the costs of processing all the crimes until they were entered into the system as adult at age 30.

\[ \text{Criminal-career cost} = \sum_{i=1}^{n} \text{Cost of crime } i + \sum_{t=1}^{T} \text{Cost of processing } t \]

The criminal-career cost is a function of the costs charged to the offender during his criminal tenure, plus the costs of processing all the crimes until they were entered into the system as adult at age 30.

\[ \text{Criminal-career cost} = \sum_{i=1}^{n} \text{Cost of crime } i + \sum_{t=1}^{T} \text{Cost of processing } t \]

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\[ \text{Criminal-career cost} = \sum_{i=1}^{n} \text{Cost of crime } i + \sum_{t=1}^{T} \text{Cost of processing } t \]
Figure 19. Estimated Criminal Justice System Direct Operating Costs for U.S. Index Crimes, 1965

<table>
<thead>
<tr>
<th>Crime Type</th>
<th>Cost (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burglary</td>
<td>762,400</td>
</tr>
<tr>
<td>Larceny</td>
<td>486,600</td>
</tr>
<tr>
<td>Auto Theft</td>
<td>206,700</td>
</tr>
<tr>
<td>Aggravated Assault</td>
<td>118,920</td>
</tr>
<tr>
<td>Robbery</td>
<td>9,850</td>
</tr>
<tr>
<td>Murder and Nonnegligent Manslaughter</td>
<td>2,780,000</td>
</tr>
<tr>
<td>Forcible Rape</td>
<td>820</td>
</tr>
<tr>
<td>Burglary</td>
<td>660</td>
</tr>
<tr>
<td>Larceny</td>
<td>370</td>
</tr>
<tr>
<td>Auto Theft</td>
<td>140</td>
</tr>
<tr>
<td>Aggravated Assault</td>
<td>48</td>
</tr>
</tbody>
</table>

Table 11.—Rearest Crime-Switch Matrix

<table>
<thead>
<tr>
<th>Last Index arrest for</th>
<th>If arrested again for an index crime, the probability it will be for—</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murder and nonnegligent manslaughter</td>
<td>Murder and nonnegligent manslaughter</td>
</tr>
<tr>
<td>Forcible rape</td>
<td>0.025</td>
</tr>
<tr>
<td>Burglary</td>
<td>0.020</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>0.015</td>
</tr>
<tr>
<td>Larceny</td>
<td>0.010</td>
</tr>
<tr>
<td>Auto theft</td>
<td>0.125</td>
</tr>
</tbody>
</table>

Table 12.—Total 1965 U.S. Criminal Justice System Costs for Index Crimes

<table>
<thead>
<tr>
<th>Crime Type</th>
<th>Total System Costs (dollars)</th>
<th>Police Costs (dollars)</th>
<th>Prosecutors and Defenders (dollars)</th>
<th>Public Defender Costs (dollars)</th>
<th>Defense Costs (dollars)</th>
<th>Court Costs (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murder</td>
<td>5,900</td>
<td>3,100</td>
<td>1,800</td>
<td>100</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Forcible rape</td>
<td>7,100</td>
<td>3,900</td>
<td>2,600</td>
<td>150</td>
<td>150</td>
<td>420</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>7,700</td>
<td>3,900</td>
<td>2,600</td>
<td>150</td>
<td>150</td>
<td>420</td>
</tr>
<tr>
<td>Larceny</td>
<td>9,300</td>
<td>4,400</td>
<td>3,100</td>
<td>180</td>
<td>180</td>
<td>420</td>
</tr>
<tr>
<td>Auto theft</td>
<td>11,900</td>
<td>5,600</td>
<td>4,300</td>
<td>230</td>
<td>230</td>
<td>420</td>
</tr>
</tbody>
</table>

2. Best estimates based on inadequate data.
criminal justice system over the life of the offender for prevention purposes. A simulated sample of 1,000 offenders, arrested for the first time at age 16, was taken for each Index crime category, and the nearest patterns over the Index crimes were computed using the nearest matrix of probabilities which were given in table 11. The resulting criminal career patterns given in table 13 were derived. For example, 1,000 offenders arrested initially for robbery would accumulate during their lives: 50 arrests for murder, 70 for forcible rape, 500 more for robbery, 250 for aggravated assault, 1,400 for burglary, 730 for grand larceny, and 370 for auto theft—a total of 3,670 rearrests for Index crimes alone.

Based on these basic criminal career patterns, the criminal-career costs were calculated to be about $12,000 per individual, representing about 3 to 4 arrests for Index crimes per offender. This demonstrates the value of an investment in preventive programs that would avert criminal careers.

The model can also be used to examine the differences between the types of crimes for which first offenders are arrested and those for which repeaters are arrested. An example of such an examination is shown in table 14. The results are tabulated according to the order of seriousness used by the FBI in the Uniform Crime Reports. A typical distribution of 1,000 first arrests for Index offenses was taken. The criminal careers of these 1,000 individuals were then simulated by cycling through the model, using the probabilities of rearrest over time, and the distribution among the Index crimes of each group of rearrested persons broken down according to the crime for which they were rearrested. The simulation showed an eventual accumulation of 3,010 subsequent arrests. These include a greater proportion of the more serious offenses than the 1,000 original offenses. For example, homicides, rapes, and robberies were several times more prevalent among the rearrests than among the first arrests. The less serious Index crimes of larceny and forgery, on the other hand, became less prevalent.

These results, though only tentative, raise the question about why subsequent arrests appear to be for more serious crimes. This phenomenon may be due to the aging of the individuals, to the development of antisocial attitudes, or possibly even to reactions to treatment by the criminal justice system. If the first arrest does not time in reducing criminal conduct, of the problem of recidivism. A question to be explored is whether the recent probabilities of the crime-type distributions become worse for those who are processed further through the system. If that is the case, it may result either from differences among individuals who reach the various stages or from the treatment itself. Unobtained data to examine basic questions do not now exist, but the questions are sufficiently important to warrant an intensive effort to collect the pertinent data and, ultimately, after hypotheses are developed, to conduct appropriate controlled experiments.

Effects of a Hypothetical Treatment Program

The first illustration above focused on costs and the second on crime control effectiveness as reflected in crime career arrest patterns. The model can also be used to compare alternative criminal justice system designs in terms of both cost and effectiveness. This third illustration examines a hypothetical treatment program in this context. It assume no adequate data were available, complexity of the problem, and simplified assumptions represent a hypothetical program which were chosen for the illustrative purposes described above to become available, descriptive realistic results can be obtained.

Table 13—Criminal Career Patterns for Index Crimes

<table>
<thead>
<tr>
<th>Number of lifetime rearrests</th>
<th>Murder and non-negligent manslaughter</th>
<th>Robbery</th>
<th>Aggravated assault</th>
<th>Burglary</th>
<th>Larceny</th>
<th>Auto theft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murder and non-negligent manslaughter</td>
<td>300</td>
<td>250</td>
<td>400</td>
<td>450</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>Robbery</td>
<td>500</td>
<td>150</td>
<td>100</td>
<td>300</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>500</td>
<td>300</td>
<td>150</td>
<td>100</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Burglary</td>
<td>300</td>
<td>150</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Larceny</td>
<td>300</td>
<td>150</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Auto theft</td>
<td>300</td>
<td>150</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

The average number of career arrests and costs of these crimes were calculated under the defined set of circumstances, as shown in table 15:

First, conditions typifying present programs.

Second, all sentenced adults are assumed put into a hypothetical intensive treatment program which produces a one-third reduction in rearrest probabilities. Compared to current probation, offenders remain in the new program 40 percent longer and receive four times as intensive supervision (i.e., it was assumed to cost four times as much to provide a day's supervision to an offender).

Third, instead of a new program for sentenced adults, all arrested juveniles are assumed to be put into a hypothetical intensive treatment program which produces a one-third reduction in their rearrest probabilities. To illustrate another approach to handling of costs, the additional costs of the new programs are ignored in this computation. This could be done where there is great uncertainty about the additional costs; one can still estimate the cost savings resulting from the increase in effectiveness to indicate a minimum warranted investment, but a complete cost-effectiveness analysis cannot be conducted.

In this example, the sentenced-adult program was found to reduce rearrests and career costs by about 7 percent per offender. The value is too low because fewer than 20 percent of the adults are ever sentenced and thus exposed to the new program. Juvenile offenders have no access to a program restricted to sentenced adults.

If all arrested juveniles could be treated so that there would be a reduction in their rearrest probabilities, there would be a 40 percent reduction in average career arrests and an associated reduction in criminal justice system costs of about $5,000 per individual. Thus, at first glance, one could justify spending per individual to achieve this reduction and undoubtedly more considering the other advantages of the reduction in crime. These hypothetical results merely indicate that if an effective corrections program were available, it would have a greater impact if it were applied earlier in the life of the individual, and at an earlier stage in the system where more people can benefit. There is no suggestion that such a program is now available.

Further Model Developments and Data Needs

The coming years will almost surely see a wide variety of innovative programs by correction agencies. If these programs are accompanied by careful experimental design, and evaluation, they will begin to provide some of the basic data needed to extend the use of systems analysis and of models such as that developed by the Task Force. In the development of such systems analysis will increasingly suggest new alternatives that identify additional data needs and required research and experimentation. In time it will be possible to address much greater accuracy and uncertainty than those which were possible with the model—questions such as:

- the effects upon court and correctional caseloads and operating costs of a given percentage increase in police clearance rates.
- the effects upon court and correctional costs and workloads of providing free counsel to all arrestees.
- the effects upon costs and arrest rates in a particular state of instituting a given community treatment program for certain sentenced offenders.
- the projected workloads and operating costs of police, courts and corrections for a given number of years.
- the effects upon recidivism and associated costs of statistical techniques which permit sentencing judges to prescribe optimum treatment programs.
- the effects upon criminal costs and career costs of with or of without a hypothetical program, whether or not individuals are arrested and sentenced. To undertake such analyses will require a completeness and detail of description and a level of data which will
take many years of research to develop and which will always have elements of uncertainty. It is therefore important that further work on total system models be undertaken in conjunction with specific State and local agencies. The work should include further methodological development such as sensitivity analysis to determine the sensitivity of the results to values of the various input parameters, examination of different cost allocation procedures, examination of the interactions among system components (e.g., effect of improved police effectiveness on sentencing decisions), and validation of the model by comparison with actual program experience. The work on the model should be supported by a comprehensive program to collect data on other relevant costs in addition to direct operating costs, and on arrest rates as a function of factors like age, economic level, and previous treatment by the criminal justice system. Some specific present data needs have been highlighted by the work with this system model. Much of the published data are incomplete, inaccurate, and inadequate. For example, different criminal justice agencies report their operations in inconsistent unitsof the police report "arrests," the courts report "cases," and corrections agencies report "offenders." These are adequate for managing the individual agencies, but preclude relating information across the system. The numbers of people processed at each stage by each agency are needed. A major limitation of available data is that they are collected with reference to a legal taxonomy of problems in using the available statistics for the study of police and corrections operations. The mugging assault is indistinguishable from the argument that got out of hand, the professional auto theft indistinguishable from the joyride. This data problem is severe and until uniform standards in greater detail prescribe the type of information reported and the basic definitions used, all analysis of the criminal justice system will be hobbled. There are many important variables describing the crime, the situation, the victim, and the perpetrator, etc., that are not available but are required to characterize a crime more usefully for research, operational planning, and assessment of the crime problem. Included among these are the following:

- Location of crime (e.g., home of victim, private building, public place).
- Time of crime.
- Nature of the offender (e.g., conspiracy, individual; in addition, age, sex, residence, economic status, and other personal qualities).
- Apparent purpose of the crime (e.g., harm, gratification, economic gain, temporary use of property).
- Nature of force involved (e.g., weapon, physical force against person, forced entry into premises, threat).

There are many instances in which no data at all is available. Merely improving the quality of information reported today is not going to be sufficient for analyzing the problem of crime. We know much too little about how various actions of the criminal justice system affect the number and types of crimes committed by different classes of offenders. The quantitative effects upon crime rates of administrative changes in the criminal law, in police operations, in prosecutorial policies, in court practices, and in correctional methods is largely unknown. To remedy this situation, data are needed on recidivism (e.g., recidivism, reconviction rate) by type of crime and treatment accorded individuals by the criminal justice system. It is important to know how recidivism varies with how far a person travels through the criminal process (released after arrest, prosecution dropped, dismissed or acquitted at various stages in court proceedings, put on probation, paroled, discharged from a correctional institution). Rearrest rates are needed at each stage, as a function of age and other relevant demographic variables, and also related data on how various actions of the criminal justice system affect the problem of crime. This information is needed to estimate rearrest probabilities as a function of treatment by the criminal justice system.

In summary, the following are the basic requirements for improved data collection:

- Accurate and complete data on all system-related events from arrest through release are needed to describe the operations of the various agencies of police, courts, and corrections.

About the only data now available from controlled experiments relates to the effects of some experimental rehabilitation programs upon recidivism. Even these are limited by " Hawthorne effects"—the changes in behavior created merely by the awareness of participating in a special experimental program. Furthermore, treatment parameters in experimental programs tend to be far more consistent and more motivated than the average. It is important to be able to estimate what will happen when the program is placed in the hands of the ordinary staffs. One way to develop the needed data would be to keep detailed records on a large sample—perhaps 20,000—of those arrested in a particular jurisdiction, following them as they are processed through the police, courts, and corrections agencies. Data would be recorded on the costs incurred, the delays experienced, and the proportion following each route through the process as a function of the type of crime committed and characteristics of the individual, including age, previous record, economic status, type of counsel, etc. These data should then be related to the future criminal activity of this cohort of arrested individuals to estimate recidivism probability as a function of treatment by the criminal justice system.

Each event in police, court, and corrections operations should be related to the number and characteristics of the offenders involved in it. Data should be collected on the number of arrests and charges processed by the police and the number of offenders arrested and charged. Simpler data should be collected on the number of cases at each stage in court proceedings and the numbers of defendants in these cases.

The rearrest rates at each system exit point should be estimated as a function of age, sex, and other personal attributes. The probabilities that released offenders will switch among the various types of crime on rearrest should be obtained for each exit point.

Retrospective studies of criminal careers of samples of matched offenders should be undertaken as soon as possible to tap available sources of data.

Prospective studies of cohorts of juveniles and offenders released at various stages should be started now so that the limitations of retrospective studies can be overcome in the future.

While collecting and processing such a large amount of data is clearly a difficult task, it is well within the capabilities of today's technology and will be considerably aided by the development of a national criminal justice information system.
Criminal Justice Information Systems

Chapter 6

The need for better information capabilities

The importance of having complete and timely information about crimes and offenders available at the right place and the right time has been demonstrated throughout this report and, indeed, throughout the Commission's work. With timely information, a police officer could work. With more detailed background on how certain kinds of offenders respond to correctional treatment, a judge could sentence to changing patterns of crime on an integrated information system. At each governmental level, and in all system components, good statistical and management information is needed. Some of the statistical needs have been discussed in the previous chapter. Inquiry information is needed primarily by the police, especially at State and local levels. Personal information is needed for arrest, sentencing, and correctional decisions at all levels. A major difficulty in obtaining needed inquiry or personal information today arises from the fact that it is frequently recorded in a jurisdiction other than the one in which it is needed. The mobility of offenders and narrow police jurisdictions require sharing common information banks. A stolen car or a wanted person can traverse many jurisdictions in a few hours. Criminals often leave an area where they are well known. The mobility of offenders and stolen property is evidenced by the following:

- In 1965, 18.7 percent of stolen autos were recovered outside the police jurisdiction of theft.
- Over twenty thousand stolen autos were recovered under the Interstate Transportation of Stolen Automobiles Act (the Dyer Act) in 1965.
- In 1965, 8,804 fugitives sought by State and local law enforcement agencies were identified by fingerprint submits to the FBI by agencies other than the agency wanting the person.
- Almost 50 percent of recent offenders in FBI files had been arrested in two or more States.

These data provide important indications of the utility of information transfer, but they are only preliminary. Much more study is needed on the extent of mobility within a metropolitan area, within a State, within a region, and nationally. Furthermore, the value of various kinds of files in apprehending offenders and in deterring crime must still be determined. There must be a strong and continuing reassessment of the effectiveness of information systems in criminal justice. There are now no good measures of the value of information systems, and the operating statistics on which to base such estimates are not now being systematically gathered. These data are needed to design future systems and to decide what functions they should perform. Only then can the cost of implementing various functions be weighed against their utility.

Even more fundamental is the question of the value of various information items themselves. What information system should simply put into a computer that which is now being collected. Rather, it should re-examine the information currently recorded, consider other items, and then by careful judgment, analysis, and experiment, try to ascertain what information is most important. Once a prototype installation is operating, evaluation of its performance will help highlight the critical information that should be kept and make available and the operational value in doing so.

Despite the difficulty of estimating their value or specifying their optimum information needs, information systems should be developed. Experience in other applications has shown that in a new field it is more important to implement systems in a modest way to gain practical experience and understanding in operating them, using these initial installations to aid in the design of following systems. Similarly with statistics, their precise value cannot be estimated. But understanding and analysis of other large social systems, such as the economy, developed only after good operating statistics became available for analysis.

The assessment of the value of information systems should begin immediately with one now operating. A number of systems are now operating or being planned at each governmental level. For example:

- The National Crime Information Center (NCIC) has been implemented by the FBI to provide immediate access to stolen-auto, stolen-property, and wanted-persons information nationally. It services 15 terminals initially, and will eventually be extended to all States and many large cities.
- The New York State Intelligence and Identification System (NYSIS) and the California Intelligence and Identification System plan to provide statewide services such as crime patterns, fingerprint, and name identification files, wanted-persons files, gun registration, modus operandi, sex and narcotic registration, and other statistical information.
- The California Auto-Stats and the New York State Police inquiry systems provide immediate access to stolen-auto and wanted-persons files.
- The Police Information System (PINS) of Alameda County, Calif., provides access to wanted-persons files for county and local law enforcement agencies as well as an automatic tie-in to the California Auto-Stats System for wanted vehicles.
- St. Louis, Chicago, New York, and other cities have computer systems that provide information on stolen autos, stolen property, wanted persons, crimes, arrests, other management statistics, and help in police resource allocation.

Some of these systems duplicate files kept at higher government levels-auto files, for instance. Each agency addresses its own specific and immediate needs. To mini-

Sentencing and correctional decisions.-Providing more complete history of an offender and his actions to prior correctional actions; statistical studies of the effects of different kinds of treatment on different kinds of offenders.

Development of correctional programs.-Analyzing complete criminal case histories to evaluate effectiveness of different programs.

Protection of individual rights.-Assuming the arrest records include court disposition, thereby presenting a fairer picture to the police and judges; restricting access to certain criminal records after a specified period of good conduct.

Budgeting.-Collecting uniform statistics on agency operations and workloads, providing a basis for estimating personnel needs and for optimal allocation of men and dollars.

Research.-Providing a collection of anonymous criminal histories to find out how best to intercept a developing criminal career and to achieve a better understanding of how to control crime.

Public education.-Portraying the true magnitude of the problem of crime in the United States.

The information problem has three principal divine slots:

1. Type of information:
   - Inquiry information.-Facts about wanted persons or property needed on immediate recall ("on-line" in "real-time") by the police.
   - Personal information.-Containing relevant background facts about people with whom the system must deal.
   - Management information.-Needed by a criminal justice official on the operation of his agency to help him manage it better.

2. Component of the criminal justice system:
   - Police.
   - Courts.
   - Corrections.

3. Government level:
   - Federal.
   - State.
   - Local, including county, city, and metropolitan area.

All combinations of these items must be considered in an integrated information system. At each governmental level, and in all system components, good statistical and management information is needed. Some of the statistical needs have been discussed in the previous chapter. Inquiry information is needed primarily by the police, especially at State and local levels. Personal information is needed for arrest, sentencing, and correctional decisions at all levels. A major difficulty in obtaining needed inquiry or personal information today arises from the fact that it is frequently recorded in a jurisdiction other than the one in which it is needed. The mobility of offenders and narrow police jurisdictions require sharing common information banks. A stolen car or a wanted person can traverse many jurisdictions in a few hours. Criminals often leave an area where they are well known. The mobility of offenders and stolen property is evidenced by the following:

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- Almost 50 percent of recent offenders in FBI files had been arrested in two or more States.

These data provide important indications of the utility of information transfer, but they are only preliminary. Much more study is needed on the extent of mobility within a metropolitan area, within a State, within a region, and nationally. Furthermore, the value of various kinds of files in apprehending offenders and in deterring crime must still be determined. There must be a strong and continuing reassessment of the effectiveness of information systems in criminal justice. There are now no good measures of the value of information systems, and the operating statistics on which to base such estimates are not now being systematically gathered. These data are needed to design future systems and to decide what functions they should perform. Only then can the cost of implementing various functions be weighed against their utility.

1. "Uniform Crime Reports," 1965. The police job description of necessity would change if the information currently recorded were compared against other "criminal" factors. For example, the simple fact that fingerprinting is not now done on all arrestees, as it is deemed in favor of Federal objectives.  
2. "Uniform Crime Reports," 1965, based on a survey of about 335,000 agencies in the FBI "Uniform Crime Reporting System," a representative sample of all effective. This is based on favor of Federal objectives.
mize this duplication and potential conflict, it would be desirable to establish some overall system structure and program of implementation. Active development to meet immediate local needs could then proceed in a more integrated way. This chapter attempts to outline such an overall program.

In developing such a program, the problems and needs are best approached not in terms of a detailed system of operational personnel for information were discussed with knowledgeable opera­
tional agencies, and many of the organizations which have impor­
tance. For example, the need for a centralized Federal system with information about criminal justice system employees and detailed information about their background.

The possible system configurations range from a highly saturated with useless information. The possible system configurations range from a highly centralized Federal system, containing an index of index of record information as the base collection of related background information. The possible system configurations range from a highly centralized Federal system, containing an index of record information as the base collection of related background information. Such files could also be used to provide basic data for assessing the effectiveness of the State's different correctional programs. Because of the sensitivity of much of the information in the registry, its use should be restricted only to court or correctional agencies.

A large number of criminal justice agencies designating their own systems, the most serious crimes. Access to the national directory will normally be only for investiga­tion.

The required time to respond to a request varied from 3 to 6 weeks. A more secure file, accessible only for investiga­tion of the most serious crimes.

Table 16—Users of Files in an Integrated National Criminal Justice Information System

<table>
<thead>
<tr>
<th>Type of File</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>Police</td>
</tr>
<tr>
<td>State</td>
<td>County</td>
</tr>
<tr>
<td>Local</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

The Science and Technology Task Force collaborated with the Task Force on Assessment of Crime in developing a program for a National Criminal Justice Statistics Center. The proposal is detailed in full as chapter 10 of the Task Force volume.

The State level, an inquiry file similar to the national file would be maintained in many States. The State file would be more extensive, however. It would include other kinds of files—motor vehicle registration and gun registrations, for example—and would have a lower threshold of se­crecy—persons wanted for nondelinquent offenses, less serious violations, perhaps.

A State would also have a directory recording a person's contacts of record with the State's criminal justice agencies. Here, too, the threshold would be lowered to include offenses not serious enough for the national directory.

In addition, to support court and correctional decision-making, some States could establish more detailed records on persons in their directories. Active development could con­tain such background information as education, employ­ment, military service, and probation records. Such files could also be used to provide basic data for assessing the effectiveness of the State's different correctional programs. Because of the sensitivity of much of the information in the registry, its use should be restricted only to court or correctional agencies.

In large cities and metropolitan areas, police information systems would be established to provide access to State and national inquiry systems, to record crime and arrest reports, and for analysis of crime patterns, resource allocation, and other local management functions. In a metropolitan area, the system could be operated by a joint authority serving all the associated communities or by the city police department offering services to the neighboring police departments on a fee basis.

IMMEDIATE RESPONSE INQUIRY SYSTEMS

A police officer frequently needs to know, within a matter of minutes, who owns a vehicle or other property, are wanted within his jurisdiction or elsewhere. This information must be available rapidly—within 1 to 2 minutes—and should also include the inconvenience to the detainted person. Other information, which may not be needed so quickly, could be included in a more comprehensive file. This includes vehicle and firearm registrations, crime reports, and missing person reports.

An inquiry system could also support crime investigations. One of a small group of frequent serious offenders could be identified in response to an inquiry of name, aliases, personal appearance, mode of transportation, or other characteristics revealed in a crime investigation. The design and use of such a file must be carefully considered to assure that the inquiries and the individuals' descriptions are complete enough to produce only a small number of extraneous records. The required time to respond to an inquiry would also be different for each kind of file.

Separate statewide inquiry systems could provide immediate information on stolen property and persons wanted within the State. An automobile recovered with proper license plates could be checked against the files of the State in which it is registered. For other property and for
persons, such an inquiry would theoretically have to be addressed to every State, requiring each State to implement its own system and calling for complex communications to every other State. A second alternative would be to centralize the inquiry system at a single location and use computer systems to communicate with one another. In such a system, a State would send a report to a central computer, which would then send a message to all other States that an inquiry was made. The cost of such a system would be approximately $25 per month, which is less than the cost of maintaining a separate computer system. Therefore, a centralized system would be more economical than a separate computer system.

3. A completely decentralized inquiry system is one in which each State maintains the complete national file. For each of these configurations, two cases were considered:

1. Each State transfers its stolen auto information to the national system after 24 hours and uses the national system to service all its interregional inquiries.

2. Each State maintains its own stolen auto file and interrogates the national system on an off-hour basis.

The results of the analysis are shown in Table 18. The most economical system for the conditions considered is the single central system in which States maintain their own records of stolen automobiles even after they are reported to the national file. The Federal cost for such a system would be about $10 per month. The two systems follow from the fact that computer operating costs are far more dominant than communication costs. They also depend on an assumption that information is transferred to the national system by each entry to permit any inquiry to be interpolated into the entire national file. The stable cost of maintaining multiple computer installations would be additional.

Because communication costs are so low, the total cost of the centralized system is relatively insensitive to the location of the computer. The optimum location would be to raise the national costs by about $1 per month—less than 2 percent.

Table 18.—Estimated Monthly Operating Costs of National Inquiry Systems

<table>
<thead>
<tr>
<th>Cost element</th>
<th>Centralized system (Springfield, Ill.)</th>
<th>Nationalized system (Springfield, Ill.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National inquiries, per transaction</td>
<td>$10.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>State inquiries, per transaction</td>
<td>$5.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>Total</td>
<td>$15.00</td>
<td>$15.00</td>
</tr>
</tbody>
</table>

Note: Costs were estimated for 1970, with a 5% increase in each of the 3 years 1971-1973. The cost of the centralized system includes the cost of maintaining a separate computer system at the state level. The cost of the nationalized system includes the cost of maintaining a separate computer system at the state level and an additional $10 per month to cover the cost of maintaining a separate computer system at the state level.
The cost of converting manual records into a computer form would be small for an inquiry file. These are active files with relatively short lives, so that over a period of 6 months to a year the files could be created even without the conversion program. There are several modifications to the postulated configurations that could give rise to noncentralized systems with relatively low costs comparable to that of the single centralized system:

- Each user could update his closest file (in his State or region) with the other files updated in the slack time or at night. This would reduce the peak demand on each of the computers, and so reduce their required operating capacity and computer costs. In this case, the cost of storing about $3,200 per month would be duplicated at each installation.
- Each regional system would handle entries and inquiries only from its own region. This introduces the unprecedented penalty of losing track of people and property that cross regional boundaries.

In either case, the economic penalties resulting from more, smaller installations and the additional fixed costs of operating the multiple installations would tend to favor the single central system.

State inquiry systems

Since each State has its own internal structure, legal codes, registration and reporting requirements, and crime problems, each will fashion its inquiry system to its particular needs. Many States do not have the volume of criminal information to justify a single computer system, and the costs might be more than the net savings before taxes. Such inactivity might motivate a State to establish a more central system, perhaps to save the cost of maintaining the files. The advantage of the centralized system is the ability to handle many units of data efficiently and swiftly.

In some States, the primary requirement comes from one or two metropolitan areas with very large problems. In some areas, several States will join together into an inter-State region and create a single common inquiry system. The accuracy of the information in the national file is the responsibility of the States since the national system is a service to the States and no means are provided for verifying the information on a national level. In general, the State systems should not duplicate information available from the national file, except perhaps for autos and property information. Only items above some threshold of importance should be kept nationally. States could keep files on residents below that threshold, e.g., stolen property worth less than $1,000, wanted persons they would not extradite, and intrastate repeat minor offenders.

In addition, States could provide access to the motor vehicle registration files. Also, some States require gun registration, sex and narcotics offender registries, fraudulent documents registers, and missing persons files. While these should be made available on-line requires further examination of their utility and cost. The State would have the further responsibility of distributing within the State access to and responses from the national inquiry system.

Local inquiry systems

Whether cities, counties, or metropolitan areas establish their own inquiry systems depends on what the State implements. In a complete, implemented system to the State and national system would normally be sufficient. Where there is no State system, major metropolitan areas probably want to establish their own. Even where there is a State system, certain routine functions might be implemented locally. These might include a local stolen property file, pawn-ticket records, a warrant file including "attempts to serve," and preparation of stolen-auto and wanted-person "bit sheets" for distribution to patrol officers and detectives.

Handling personal information

The problems of privacy

The most delicate part of any criminal justice information system is the record of previously arrested people and accompanying information about them. Such information is valuable in making prosecution, sentencing, and correctional decisions. But wherever government records contain derogatory personal information, the creation serious public policy problems:

- The record may contain incomplete or incorrect information.
- The information may fall into the wrong hands and be used to intimidate or embarrass.
- The information may be retained too long after it has lost its usefulness and serves only to harass ex-offenders, or its mere existence may diminish an officer's belief in the possibility of redemption.

Herefore, the inherent inefficiencies of manual files containing millions of names have provided a big protection. Accessibility will be greatly reduced if not impossible by putting the files in a computer, so that the protection afforded is made by efficiency. In the absence of special attention not be directed at protecting privacy. However the new technology can create both more useful information and greater individual protection.

Some of these problems were reviewed in recent congressional hearings on the Federal data bank. The hearings were directed at protecting privacy. However the new technology can create both more useful information and greater individual protection.

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The New York Civil Liberties Union, the Vera Foundation, and Committees of the Association of the Bar of the City of New York also supported the use with recommendations.

The New York State Identification and Intelligence Information has addressed the problems of handling personal information in a State information system:

- The system will not attempt to duplicate all of the detailed information currently stored in the individual files. Such information can be obtained, with luck and without difficulty, from the appropriate agency's records to those sources, such as indications that are currently on probation or parole is confined in a particular facility.
- The risk involved now in entrusting the liberties of the American people to the men of power is the possibility of misuse of personal information. The names of whom we do not even know and whose benevolence we cannot presume to guarantee, is too great for us to take.

However, when dealing with law enforcement purposes, the rights of society must also be protected. Although it was argued against dangers to individual rights, the American Civil Liberties Union has also recognized the value of a national data bank system. John Daf Pemberton, Jr., Executive Secretary, made the following observation regarding the FBI's National Crime Information Center:

- Certain valid law enforcement purposes will be served by the creation of such a data center. Police pursuit if information concerning major crimes is feasible. In addition, such a center can serve as a police practices in the United States.
- However, Mr. Pemberton pointed out the dangers inherent in incomplete arrest information and information regard to political expressions or groups. Among other considerations, he proposes several important safeguards.

- Restricting the information content to matters of record.
- Restricting the dissemination to criminal justice agencies.
- Penalizing improper disclosure.
- Providing individuals access to their records and means for correcting them.

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"We must call upon the scientific community, which is responsible for the development of this [computer] technology, to bear the equal responsibility for its use, in order to guarantee adequate protection of the freedoms we now enjoy."

ORGANIZATION OF PERSONAL INFORMATION FILES

On the basis of the limited examination it was possible to make, it now appears that personal criminal record information should be organized as follows:

- There should be a national law enforcement directory that records an individual’s arrest for felonies and serious misdemeanors, the disposition of each case and every subsequent formal contact with criminal justice agencies related to those arrests. Access should be limited to criminal justice agencies.
- There should be State law enforcement directories similar to the national directory, but including less serious offenses.
- States could consider criminal justice registries that could record any ancillary factual information (e.g., education and employment records, probation, parole, etc.) concerning an individual and be available only to courts or correctional officers.

The national directory would be similar to an index or telephone directory. It would contain personal information, such as finantal information, number, and description. In addition, it would specify, for example, dates and ages, and the assignments to correctional, the court, the court officer supervision. No further background information other than the others of what record should be maintained in the national directory to ensure that the most up-to-date information is maintained for each arrest, the date of the arrest, the information is often needed within a week or less.

In addition to aiding criminal justice agencies directly, the directory, with names removed, represents a valuable resource for researchers and teachers as they may choose to establish a more complete directory containing information such as personal appearance, or mode of operation.

A majority of States today maintain some identification bureau similar to the FBI service. These States would presumably continue to maintain their bureaus until there was a more rapidly responding national directory. A national directory, or fingerprint records and biographical data would appear in the FBI service directory, particularly in order to maintain criminal records below the threshold of awareness of the national directory.

To support decisions by courts and correctional agencies, as well as to evaluate the effectiveness of correctional programs, States may choose to establish a more complete registry containing supplementary information such as probation reports, probation-institution parole history, as well as referential to medical or psychiatric opinions, schooling, or employment records. This information would aid in preparing reports and in selecting candidates for positions in order to reduce the dangers of such a file developing into a central directory of individuals, there should be no national registry.

This is to be maintained on a State level and accessible only to courts or correctional officers.

As with directories, the entry of new records, the purging of the file, and the record of the files from the file, are critically important questions to be addressed. The present manual system takes about 2 weeks to respond to the transmission time is now a matter of concern.

The fingerprint file contains a record of every criminal career of an individual, whether or not he has been arrested or convicted, which is purged, that is purged, or at the state and local level, as has been done in Chicago.

We are therefore, be some such link between the national and State systems that would be applicable to more than a few localities. However, it is in just this area that major direction, advice, and support should be provided to agencies desiring to implement information systems.

A survey was made of about 40 agencies which now have operating information systems in order to identify the uses, costs, and other system characteristics.

The basic criminal justice operations occur at the local level, and computers can help managers in their daily-to-day decisions. Since these functions vary so widely, it is difficult to describe in complete detail specific systems that would be applicable to more than a few localities.

A separate survey was undertaken on the potential for modernizing court information systems to the court scheduling, case monitoring, and management statistics, the estimated total monthly costs, including personnel, for each of the 100 counties with populations in excess of 1,500,000, the minimum cost is $16,750 per month. For smaller counties (100,000 to 200,000 population), punched card systems are appropriate with costs between $1,670 and $4,170 per month. For counties with less than 100,000 population, improved manual procedures should suffice. The report, which contains the guidelines and models, is available from the U.S. Bureau of Justice Administration and the U.S. Department of Justice.

The turnaround time of urgently needed requests can be reduced to several hours or less by facsimile transmission of the fingerprint card to the central fingerprint file.

The FBI has established a national fingerprint file, including time and cost, to determine whether the card is in its file, and whether a card is a better and less expensive way to transmit information.

The turnaround time of urgently needed requests can be reduced to several hours or less by facsimile transmission of the fingerprint file to the central fingerprint file and at least one terminal in each State and major metropolitan area.

Similarly, State files should be connected to each major police jurisdiction within the State. New York State is installing such a statewide network. Even a large city could connect its precincts to the State fingerprint files that have been done in Chicago.

After identification has been made with the fingerprint, the directory record can be sent to the requesting decision maker, via the inquiry system communication network.

MANAGEMENT INFORMATION

The basic criminal justice information system is not only a part of the department’s management system, but a tool in the department’s daily operations. For example, if a police report is written by an officer, the information contained in that report must be stored in the management information system for future reference. When a new problem arises in the department, the management information system can provide the necessary data to address the problem.

The cost of developing a computer-based information system can range from $10,000 to $500,000, depending on the size and complexity of the system. It is important to carefully plan and manage the development process to ensure that the system meets the needs of the department.

The following is a list of some of the key considerations when developing a computer-based information system:

1. Define the problem and scope of the project.
2. Identify the users and their needs.
3. Determine the data requirements.
4. Choose the appropriate technology.
5. Develop the system specifications.
6. Implement the system.
7. Test and evaluate the system.
8. Training and support.

Police Management Information Systems

Management statistics

Police management data are used to measure the performance of the police department and to make decisions about the allocation of resources. The following are some examples of police management statistics:

- Crime rate per 1,000 population
- Arrest rate per 1,000 population
- Property crime rate per 1,000 population
- Quality of policing
- Patrol workload
- Crime pattern analysis
- Correlation of crimes by type, time, location
- Crime occurrence by beat, precinct, etc.
- Patrol workload by beat, precinct, etc.
One major information problem in the criminal justice system is the dispersion of information with no ready means of communicating even its existence to agencies required to acquire the information. Thus, the first step in establishing a remote-access information system to service criminal justice agencies is the development of the basic communication network which ties together the various users and repositories of information. The communications may take the form of voice, radio, digital data links, written reports, and the mail.

Contrary to current assumptions, the need for common definitions and coding of data standards is not a problem.
Chapter 7

Scientific Research and Development Program

The material in the preceding chapters is only a sampling of what may be the potential contributions of science and technology to control of crime and to the operation of the criminal justice system. While many subjects have been mentioned, only a few could be treated in depth, and even those are still only preliminary. Certain studies with raw data, such as those of court delay in Washington and criminal apprehensions in Los Angeles, must be repeated elsewhere to assess the degree to which their conclusions are generally applicable. Other studies, such as the cost-effectiveness optimization of response time reduction and the total system evaluation of alternative treatment programs, had to be conducted with hypothetical data, and real data must obviously be used. Many technological possibilities have been mentioned, but their potential contributions need further consideration, and their selection for specific applications requires prototype development, testing, and evaluation.

Many areas other than those discussed in this report are proper subjects for scientific research and technological development, and some may well have potential for equal or greater contributions to better understanding of the nature of crime and its control and to improving the effectiveness of the criminal justice system. In particular, the social and behavioral sciences, which were outside the scope of this Task Force, have major contributions to make in clarifying the relationships between crime and education, employment, residence, and other environmental variables, and in developing programs for diverting individuals from criminal activity and for rehabilitating them if prevention fails. The biological sciences may also offer important treatment opportunities. All of these subjects should be considered as part of a major research and development program into the problems of crime and its control.

Federal initiative and support will be needed in establishing and pursuing such a research and development program. Whether it be basic research, equipment development, field experimentation, data collection, or analytical studies, the limited budgets of individual State and local criminal justice agencies cannot alone provide the necessary investment. The personnel and agencies capable of undertaking the necessary work are in short supply, and so unnecessary duplication should be avoided. Furthermore, any useful results will be of nationwide benefit. These conditions all make Federal involvement both appropriate and necessary.

A program to introduce science and technology to criminal justice must adopt a number of complementary approaches. The Federal Government should sponsor research, development, test, and evaluation (R.D.T & E.) projects at the local and State levels, especially supporting those widely useful projects that no single agency could support alone. The Government should help criminal justice agencies get the technical support they need to incorporate the results of these projects into their operations. To infuse science and technology directly into day-to-day activities, operational research groups should be established in the larger criminal justice agencies. The program should include graduate fellowships to attract and train competent new professionals. It should provide means for more effective dissemination of results to operating agencies. Finally, to provide a base for broad research advances, a major science and technology program should be established in a research institute of the highest quality. The President's Science Advisory Committee has reviewed and supports these recommendations.

Within a period of 3-5 years, the total federal research and development program in criminal justice might profitably reach a level of about $60 million. Such a level is in fact perhaps an underestimate of the need and potential, and would be limited primarily by the availability of competent personnel. In funding this program, the Government should support development by industry, research by scientists, tests and evaluation by criminal justice agencies in conjunction with scientific consultants, and innovation in the operations of criminal justice agencies through demonstration projects. The operational portion of the costs of demonstration projects should be borne by the agency directly. The Federal funding should include the incremental cost associated with the innovative features—costs for development, high risk, and extra planning. In addition, all demonstration projects should be accompanied by careful and independent evaluation which assess the utility of the project to provide guidance for further development of that project and for other agencies considering similar ones.
The R.D.T. & E. program would have to be developed in detail by the office administering it. The program would have to be housed in an agency that was sympathetic to research and development, and could attract the high-caliber scientific staff needed to manage the program.

The program would inevitably require technical guidance of a breadth and quality exceeding that which could be expected of any internal technical staff. Advisory committees comprising scientists and criminal justice officials would be needed to review proposals in specific subject areas. In many cases, another government office would be the best choice to manage a specific project; the Army Materiel Command might direct the development of a portable radio, for example. Nonprofit or profitmaking contractors, as used by the Department of Defense, might furnish broad technical guidance.

The research grant part of the program should rely heavily on proposals submitted by scientific investigators, primarily at universities, but also at nonprofit corporations, in industry, government, and criminal justice agencies. The in-house staff should stimulate important proposals by competent researchers. Proposals should be selected for support by a series process of screening by the in-house staff, review by advisory groups combining criminal justice officials with competent researchers, and final determination by the in-house staff.

The development part of the program would have to focus its efforts more carefully. Equipment development can be very expensive, and for the next few years only a few major projects will be possible. The projects selected should not depend on the chance that appropriate proposals will be submitted. Rather, requirement studies and cost-effectiveness analyses should be undertaken, and those developments that appear to contribute most to controlling crime and to improving the operations of criminal justice agencies should be funded.

The results of the R.D.T. & E. program should be disseminated both throughout the interested research community and to all persons in the various criminal justice agencies who might benefit from the work. Journals directed at each of these audiences should be supported or new ones established if existing ones are found inadequate.

TECHNICAL SUPPORT AND ESTABLISHMENT OF EQUIPMENT STANDARDS

As the Federal Government plays a more important role in aiding criminal justice agencies to share in the products of modern technology, it will become necessary to help them use it effectively. To this end, there will be a need for centralization of technical standards (for radios, computer codes, etc.) and for provision of technical assistance and guidance.

A Federal agency should be assigned to coordinate the establishment of standards for equipment to be used by criminal justice agencies, and to provide these agencies with technical assistance. This organization should be an adjunct to an existing Federal agency already technically
strong and familiar with standardization problems. The National Bureau of Standards is one such agency. It could organize committees of users and manufacturers to develop consensus standards. It would be a center with growing competence in criminal justice data problems, and would be staffed by scientists and engineers in the most relevant technologies—electronics, computer sciences, operations research, chemistry, etc. The organization would help criminal justice agencies draw on local technical resources such as consultants, professional societies, and manufacturers, and would help the agencies access the results products.

The assistance it would offer be a cross between that of the architect to the inexperienced home buyer and the agricultural county agent to the private farmer.

OPERATIONS RESEARCH GROUPS WITHIN CRIMINAL JUSTICE AGENCIES

As an important mechanism for innovation, the large criminal justice agencies, and especially large police departments, should establish small operations research groups with professionally trained scientists, mathematicians, and engineers, including at least one person competent in statistics. The group would analyze the operations, design and evaluate experiments, and provide general technological assistance. Such groups have proved extremely valuable to industry, government, and the military in large defense projects.

The research institute would have to develop its own program in detail, probably with the guidance of a standing committee comprising senior criminal justice officials and outstanding research scientists. Its program might include such subjects as: basic studies on crime (e.g., its measurement, factors related to, and basic causes); operations of the total criminal justice system (including development of system models and collection of the needed data on costs, flow rates, recidivism, and operating policies); management of the criminal justice system (including allocation of resources, scheduling of activities, and selection, training, and evaluation of personnel); information systems (including evaluation of the value of different types of information and development of information needed to aid investigative, sentencing and correctional decisions); method of investigation and solving crimes (ranging from vocational training to intensive police patrol); police apprehension (including cost-effectiveness analyses, studies, simulation projects, and preliminary design of new equipment); criminalistics (including development and evaluation of new techniques); and offender rehabilitation (including development and evaluation of techniques).

Research into any of these subject areas would normally require participation by several academic disciplines and most of the subjects would affect industries throughout the criminal justice system rather than being limited to the traditional divisions into police, courts, and corrections. Only a few of the problems are basic and can be attacked by using a single method; most involve different methods to attack problems on the scale they demand. If the proper research environment were created, the problems could draw on the nation's best scientific resources.

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TABLE A-1.—A Program Budget for a City Police Force

I. CONTROLS AND REDUCTION OF CRIME PROGRAM

A. Prevention/Suppression
   1. General Purpose Patrol
   2. Special Purpose Patrol (by type of offense)
   3. Intelligence
   4. Community Relations

B. Investigation/Apprehension
   1. Crimes Involving Major Risk of Personal Injury
      a. Murder
      b. Assault
      c. Rape
      d. Armed Robbery
   2. Burglary—Homes
   3. Burglary—Business
   4. Accident Investigation

C. Crimes Not Involving Major Risk of Personal Injury
   1. Theft
   2. Unarmed Robbery
   3. Auto Theft
   4. Etc.

D. Narcotics
   1. Narcotics
   2. Prostitution
   3. Gambling
   4. Etc.

E. General Services
   1. Communications
   2. Records and Data Processing
   3. Technical Services
   4. Forensic Services
      a. Fingerprint
      b. Ballistics
   5. Laboratory Analysis

II. MOVEMENT AND CONTROL OF TRAFFIC PROGRAM

A. Traffic Movement
   1. Direction of Traffic
   2. Enforcement of Traffic-oriented Parking Rules
   3. Emergency Road Services
   4. Weather Emergency Procedures
   5. Identification and Reporting of Congestion Points

B. Traffic Safety
   1. Enforcement of Regulations
      a. Patrolling/Apprehension of Moving Violations
      b. Enforcement of Safety-oriented Parking Rules
   2. Driver Training
   3. Educational Programs
   4. Vehicle Inspections
   5. Accident Investigation

III. MAINTENANCE OF PUBLIC ORDER PROGRAM

A. Public Events
   1. Sporting Events
   2. Public Ceremonies
      a. Parade and Receptions
      b. Public Meetings
   3. Conventions, etc.

B. Minor Disturbances
   1. Private Quarrels
   2. Parties
   3. Drinkings
   4. Disputes
   5. Miscellaneous Malicious

C. Major Disturbances
   1. Public Order
      a. Disorder
      b. Disruptions
      c. Riot
      d. Etc.

IV. PROVISION OF PUBLIC SERVICES PROGRAM

A. Emergency Services
   1. Police
      a. Custody
      b. Intermediate
      c. Ultimate
   2. Fire
      a. Equipment
      b. Training
   3. Medical
      a. Emergency Medical
      b. Advanced Care
   4. Power Failure
   5. Civil Defense
   6. Miscellaneous
   7. Missing Person
   8. Lost Property
   9. Miscellaneous

TABLE A-2.—Programs in the Reduction and Control of Crime

I. SUPPRESSION/APPREHENSION PROGRAM

A. Suppression
   1. General Purpose Patrol
   2. Special Purpose Patrol (by type of crime)

B. Investigation/Apprehension
   1. Crime Involving Major Risk of Personal Injury
      a. Murder
      b. Assault
      c. Rape
      d. Armed Robbery
   2. Burglary—Homes
   3. Burglary—Business
   4. Accident Investigation

C. Crimes Not Involving Major Risk of Personal Injury
   1. Theft
   2. Unarmed Robbery
   3. Auto Theft
   4. Etc.

D. Narcotics
   1. Narcotics
   2. Prostitution
   3. Gambling
   4. Etc.

E. General Services
   1. Communications
   2. Records and Data Processing
   3. Technical Services
   4. Forensic Services
      a. Fingerprint
      b. Ballistics
   5. Laboratory Analysis

D. Administrative Services
   1. Personnel
      a. Recruitment
      b. Training
   2. Administration
      a. Basic
      b. Advanced

TABLE A-1.—A Program Budget for a City Police Force—Continued

V. ADMINISTRATION AND SUPPORT PROGRAM

A. Direction and Control
   1. General
   2. Planning and Development
   3. Internal Inspection and Review

B. Training and Personnel
   1. Recruitment
   2. Training
      a. Basic
      b. Advanced

C. Budget
   1. Records
   2. Communications
   3. Administration

TABLE A-2.—Programs in the Reduction and Control of Crime—Continued

II. ADJUDICATION PROGRAM

A. Pretrial
   1. Intake
   2. Sentencing
      a. fingerprint
      b. Advanced
   3. Review

B. Trial
   1. Prosecution
   2. Defense
   3. Verdict or Disposition

C. Appeal
   1. Intermediate
   2. Supreme

III. CORRECTION PROGRAM

A. Institutional Correction
   1. Custody
   2. Correction
      a. Education
      b. Training
      c. Medical
      d. Etc.

B. Parole
   1. Probation
   2. Parole
   3. Welfare
   4. Etc.

D. Direction and General
   1. Planning and Review
      a. Data Systems
      b. Analysis

IV. GENERAL ADMINISTRATION PROGRAM

A. Executive Direction
   1. Statistics
   2. Crime Statistics
   3. Criminal Justice System Costs
   4. Crime Rates
   5. Comparative Statistics, Other Jurisdictions

C. Analysis
   1. Crime Prevention
   2. Allocation of Resources
   3. Criminal Justice System (traded among components)
   4. Programs in Mitigation of Victim Losses
   5. Administrative Services
TABLE A-3.—Federal Programs in the Reduction and Control of Crime

I. SUPPRESSION/APPREHENSION PROGRAM—Cont.

C. Special Purpose Grants—Cont.
   a. Information Systems
      i. Research and Development
      ii. Implementation
   b. Description of Methodologies and Techniques
   c. Project Planning and Management
   d. Evaluation and Assessment
   e. Program Administration

C. Federal Grants to States and Localities—Cont.
   1. Special Purpose Grants
   a. Information Systems
   b. Research and Development
   c. Implementation
   d. Evaluation and Assessment
   e. Program Administration

C. Federal Grants to States and Localities—Cont.
   2. Special Purpose Grants
   a. Information Systems
   b. Research and Development
   c. Implementation
   d. Evaluation and Assessment
   e. Program Administration

C. Federal Grants to States and Localities—Cont.
   3. Special Purpose Grants
   a. Information Systems
   b. Research and Development
   c. Implementation
   d. Evaluation and Assessment
   e. Program Administration
Appendix B

A STUDY OF COMMUNICATIONS, CRIMES, AND ARRESTS IN A METROPOLITAN POLICE DEPARTMENT
by Herbert H. Isaacs

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INTRODUCTION
This appendix summarizes a study conducted in the Los Angeles Police Department in August and September 1966. The study was concerned with factors affecting clearance of crimes. It traced the sequence of police activities beginning with a call for service by a citizen, the field activity of the patrol officer, the reporting of a crime, the follow-up investigation by detectives, and the clearance of the case by arrest or some other disposition. These data were analyzed to evaluate the effects of 1) time elements such as response time and overall response time, 2) methods of clearance of crimes. A third stimulus for the study was less obvious. The study was influenced by certain other considerations, such as an attempt to reduce response time to calls for service, and also by the desire to extend general scientific curiosity about the nature of crime.

In conducting the study, the first task was to select an appropriate sample of police activity to study. Through negotiations with the Los Angeles Police Department, a sample of police activity was gained from the communications center records. This sample included all calls from August 1966. The data were coded on a standardized form designed and pretested by the researchers, and then punched and analyzed with the aid of computer programs written for the purpose.

The substance of the report is presented in four sections below. The first is a general discussion describing the approach to the study, its objectives, and the constraints affecting the results.

The second section is an analysis of the communications center activity. By type of call, detailed breakdowns are provided of the communications center delays, field response time, and overall response time. The third section is a discussion of arrest and other methods of clearance of crimes. A breakdown of clearance methods is given, and investigative practices and problems are analyzed.

The final section summarizes the major conclusions and offers some recommendations for further research.

GENERAL APPROACH
This research study was initially stimulated in three ways. First, there was the general intuitive feeling among many police officers and analysts that fast response to calls for service is a critical operational factor. Because many aspects of technology provide an opportunity to reduce response time, it was important in the work of the Task Force to determine whether response time was a significant factor in apprehending a suspect at the scene of the crime.

Second, there was the desire to identify how the ability to solve a crime was influenced by certain characteristics of the event and the subsequent police activities.

A third stimulus for the study was less explicit: a general scientific curiosity about the nature of crime and arrest data. Significant conclusions about the operation of a system are often derived merely by collecting and analyzing specific data about the system operations, and then suspecting and analyzing that data for observable pattern.

In conducting the study, the first task was to select an appropriate sample of police activity to study. Through negotiations with the Los Angeles Police Department, a sample of police activity was gained from the communications center records. This sample included all calls from August 1966. The data were coded on a standardized form designed and pretested by the researchers, and then punched and analyzed with the aid of computer programs written for the purpose.

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The second section is an analysis of the communications center activity. By type of call, detailed breakdowns are provided of the communications center delays, field response time, and overall response time. The third section is a discussion of arrest and other methods of clearance of crimes. A breakdown of clearance methods is given, and investigative practices and problems are analyzed.

The final section summarizes the major conclusions and offers some recommendations for further research.

In the course of studying the communications center delay, there were several constraints which limit the ability of the analysis program to sort on any item of information, there were several constraints which limit the conclusions of the findings. Because of the short time period available for both data collection and analy-
The data collected were limited to historical information already available in the police department, subject to all the errors and ambiguity inherent in data not collected specifically for a statistical study.

The second constraint was the requirement to utilize existing collectors. Even though these were police officers, there were significant variations in their backgrounds and training so that the coding of information was not always consistent. Furthermore, the particular orientation of these officers was toward operational situations with which they were familiar, whereas the terms used by the researchers to specify data collection were sometimes at variance with conventional operational definitions. The process of shucking down this semantic difficulty was slow and never completely successful.

A third constraint stemmed from the inherent problem of categorizing data into predefined groups. Ninety percent of the information confronted in a study was sometimes at variance with conventional situations with which they were familiar, whereas the terms used by the researchers to specify data collection were sometimes at variance with conventional operational definitions. The process of shucking down this semantic difficulty was slow and never completely successful.

In order to cope with the problems of semantic orientation and categorization error, some specific conventions were adopted, recorded, and disseminated to the officers collecting data in order to minimize the consistency of results. Complete list of these conventions is provided in annex 2. Some of the more significant ones are given below:

1. If no actual arrest were made, the case was not coded as cleared by arrest, even if the investigator's follow-up listed the case as cleared by arrest. In those cases, the "other clearance" box was checked by our data collectors. This was especially important in the case where a warrant was issued but the arrest had not been actually consummated at the time of our study.

2. Some detective follow-up reports were found in the file which did not indicate any actual investigative action by the detective, but merely recorded supplemental information given by the victim, e.g., adding a serial number for a stolen television, or providing a list of additional property stolen and its value. In those cases, the officers were instructed to ignore that information, as if it were reported to the police, but not actually recorded in the file. Thus, the case was not coded as cleared by arrest.

3. There was a lack of followup reports in misdemeanor arrests. It was established that the department's policy was to file automatically for a complaint whenever a misdemeanor arrest was made. Hence, a misdemeanor case always resulted in a "yes-filing" category in the cleared-by-arrest item.

4. Where no arrest was made, no case was actually recorded in the file. This is a "yes-filing" item, even though there may have been some other method of clearance. Discrepancies in counting can be accurately corrected by the "other clearances" separate from the arrests.

COMMUNICATIONS CENTER ANALYSIS

Dispatch messages within the communications center tend to be divided into two general categories: emergency calls and nonemergency calls. These are coded in the Los Angeles Police Department on blue as white tickets, respectively. There is an intermediate category of nonemergency but urgent (white/Code 3). The Code 2 message instructs the patrol officer to get to the scene as rapidly as possible using red light and sirens.

From the standpoint of first procedure, a distinction can be observed in the method of handling the two types of calls. The blue emergency tickets are usually answered by the closest available car, although it is a different unit than the one assigned responsibility in the dispatching message. For the white ticket, however, whether "Code 2" or not, the unit assigned responds directly. Other units, even if in the vicinity, rarely appear at the scene of a nonemergency call. The major exception is when a unit in the vicinity is questions to handle the call, in which case it becomes assigned.

Frequently, the designated unit is either not available or responds a delay in arriving. This causes a delay in the communications center, while an alternate unit is sent out to dispatched. This problem with white tickets, but may also affect the dispatching time emergency calls.

The overall response time analysis in this study was to split these two major components: Communications center delay time and field response time. Figure 8-1 also shows that in the process of receiving a call, alert time continuum beginning with the time that an event occurs. It is seen that the communications center delay time is essentially constant, as evidenced by the 328 cases in which unadjusted response times were recorded, and Figure 8-3 reflects cases in which arrests were made.

From examining the table that almost every case included multiple dispatching. This extra delay results in more than twice as much time being taken in the center between receipt of a call and dispatching. For the emergency calls, less than 10 percent have extra delays associated with them, whereas the relative communications center delay time is much greater—as high as 3.08 times the normal emergency call delay time.

A distinct difference in communications center delay time can be seen in the handling of emergency compared to nonemergency calls. Special procedures were established for handling emergency calls. Figure 8-3 shows the actual field response time result in reduction of the average time from 5 minutes to less than 2 minutes.

Table B-1—Communications Center Delay Time for All Radio Calls

<table>
<thead>
<tr>
<th>Type of Call</th>
<th>All Calls</th>
<th>Blue code 1</th>
<th>Blue code 2</th>
<th>Blue code 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>White ticket (Excludes)</td>
<td>164</td>
<td>166</td>
<td>166</td>
<td>166</td>
</tr>
<tr>
<td>Single All</td>
<td>164</td>
<td>164</td>
<td>164</td>
<td>164</td>
</tr>
<tr>
<td>Average time</td>
<td>2.989</td>
<td>2.989</td>
<td>2.989</td>
<td>2.989</td>
</tr>
<tr>
<td>Number of cases</td>
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<td>164</td>
</tr>
</tbody>
</table>

Table B-1 summarizes the communications center delay time results. The table gives the average time delay for all radio calls, by type of call, and number percent of cases.

Table B-2 gives the same information for three classes of calls: those in which a single time stamp for dispatching was evidenced; those in which the time delays were evidenced by multiple stamping; all calls, combining the previous two categories. Of the 6,704 total cases, 328 did not have time data, primarily because these were not initiated by radio calls. These cases were excluded from the time calculations. Table B-2 gives the same information for three classes of calls in which unadjusted response times were recorded, and Table B-3 reflects cases in which arrests were made.

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The field response time result in reduction of the average time from 5 minutes to less than 2 minutes.

FIELD RESPONSE TIME

Accurate determination of field response time is possible only in those cases where there was a "Code 6" message. This message is given by radio by a field officer when he arrives at the scene of a call. Other field responses included, but not limited to, "Code 4," which is a message indicating that no further assistance is required at the scene, and a series of other messages, including a request for further information, the broadcast of information on the event, and other requests. However, these other responses bear little relation to actual field response time, as defined earlier.

We have therefore limited our field response time estimates to "Code 6" messages only. Unfortunately, because of the operational procedures established, only a
Table B-2.—Communications Center Delay Time for Uncleared Crimes

<table>
<thead>
<tr>
<th>Type of ticket</th>
<th>All radio calls</th>
<th>Calls with arrests</th>
<th>Uninclear time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All calls</td>
<td>Calls with arrests</td>
<td>Uninclear time</td>
</tr>
<tr>
<td></td>
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<td>Calls with arrests</td>
<td>Uninclear time</td>
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</tbody>
</table>

Table B-3.—Communications Center Delay Time for Cases With Arrests

<table>
<thead>
<tr>
<th>Type of ticket</th>
<th>All radio calls</th>
<th>Calls with arrests</th>
<th>Uninclear time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All calls</td>
<td>Calls with arrests</td>
<td>Uninclear time</td>
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</tbody>
</table>

Table B-4.—Field Response Time

<table>
<thead>
<tr>
<th>Type of ticket</th>
<th>All radio calls</th>
<th>Calls with arrests</th>
<th>Uninclear time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All calls</td>
<td>Calls with arrests</td>
<td>Uninclear time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table B-5.—Response Time and Arrests

<table>
<thead>
<tr>
<th>Type of call</th>
<th>Average response time (minutes)</th>
<th>Average response time with arrests (minutes)</th>
<th>Average response time with arrests (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table B-6.—Radio Calls and Crimes Reported

<table>
<thead>
<tr>
<th>Type of call</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Table B-7.—Clearance of Radio Calls With Crimes Reported

<table>
<thead>
<tr>
<th>Type of call</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

EMERGENCY DISPATCHING CRITERIA

There is another significant result concerning response time which needs to be examined. Table B-6 provides a breakdown of the emergency and nonemergency radio calls in terms of which crimes were reported. Table B-7 indicates for all radio call crimes the number and percent in each dispatching category that were cleared by arrest or other methods.

Examination of these tables suggests an interesting hypothesis concerning emergency dispatching criteria. First, note that the overall number of crimes reported, given a radio call, is 1,014 of 4,376 (or 23 percent). The emergency calls, however, only show 24.7 percent crimes reported. This is low primarily because of the false alarm rate for alert burglary alarms. The nonemergency cases on the other hand, result in 49.5 percent crimes reported.

If we examine the uncleared crimes in this category, we note that 1,138 (or 25 percent) of nonemergency radio calls are not cleared. About 90 percent of those 1,138 are to take a crime report after the crime has already been committed (burglary, for example). As we will show below, this is the most difficult type of case to clear. However, of the 1,138 uncleared nonemergency calls, we have found that in 112 cases (or 10 percent), the information available at the communication center at the time about rapid response time being significant in police effectiveness. The results of this analysis seem to imply that both communications center delay and field response delay should be minimized.
nately, a number of these tend to escalate into more
serious situations such as aggravated assaults.

These considerations strongly suggest the need for modi-
fied criteria for emergency dispatching. Increasing the
number of calls which receive priority assignment may
tend to degrade slightly the response time on existing
priority assignments. Nevertheless, an examination of the
table alarm rate rapidly leads one to the conclusion
that the number of emergency calls negatively affected by the
change would be very small, compared to the number of
calls in which improved effectiveness of the police
would result. With our present knowledge of calls for
service, however, it is not possible to state the specific
modifications and criteria that seem to be implied by the
results of this study. The criteria for assigning such
priority must be developed from a research and develop-
ment program with that specific objective. Such a pro-
gram is outlined in the last section.

**ARREST AND OTHER TYPES OF CLEARANCE**

Table B-9 lists the types of crimes reflected in this study.
Of the total 1,905 crimes, 482 were cleared by arrest or
some other means of clearance. Before discussing its
specific results, a general discussion of case clearance
methods may be helpful. If an arrest is made, a com-
plainant may or may not eventually be filed against the
arrestee. If a complaint is not filed, the “other clearance”
category in our coding scheme indicates one of several
possible reasons. For example, the subject may be a
juvenile, in which case special procedures are required.
The prosecutor may choose not to file due to the lack of
sufficient evidence or the victim may refuse to prosecute.
Followup investigations in a case may indicate that no
crime was actually committed. Finally, there may be a
variety of other reasons for not filing a complaint, includ-
ing (a) on-scene; (b) other location; (c) and (d) unclear.

Even if the suspect is not arrested, the case may be
cleared in one of the several “other” ways including (a)
just described or by issuing a warrant for his arrest.
Arrest may result in several ways. For example, in
slapping off cases, the arrest is frequently made by a re-
certainty officer in a retail establishment who summons
patrol officers to take the offender into custody. Arrests
may also be made at the scene by the patrol officer, fol-
lowing his observations of criminal activity or perhaps
a wanted person or wanted vehicle. Arrests may be
made in response to a radio call of either the emergency
or nonemergency variety. Occasionally, a patrol officer
will make an arrest at the residence of an individual who
was reported as a prior crime.

**CLEARANCE DATA**

Table B-10 gives a summary breakdown of arrests and
other clearance. Of the 482 cleared cases, 304 actual
arrests were made, 50 by patrol. It is seen that patrol
officers make, greater than 99 percent of all arrests. The
remaining 10 percent are made by the detective force,
in most cases through followup investigations of a
particular crime. Although the detectives actually make
very few arrests themselves, their followup investigations
frequently identify wanted persons who are later the sub-
ject of patrol officer arrests. The exact number of those
was not specifically collected in the study, but an ap-
plication figure inferred from other collected data indi-
cates that about 25 percent of patrol arrests are of indi-
viduals previously named in detective followups.

The breakdown of other clearance methods is given
in Table B-11. About one-third of these cases involved
juveniles where some procedure other than arrest was
utilized. Another third involved cases in which either
the prosecutor chose not to file, the victim refused to
prosecute, or later investigation indicated no crime was
actually involved. The last third contains the other meth-
ods including city attorney’s hearings and issuance of war-
rents. Initial design of data collection methods for this
study did not envision such a large volume of “other”
clearance. As it became evident during the data collec-
tion that the “other” category was too broad, an attempt
was made to sample crimes in that category to determine
what the general breakdown reflected. A sample of 20
such cases of other clearance impacted in the determina-
tion that approximately two-thirds involved city atto-
ney’s hearings, and the remainder involved warrants for
arrest of a suspect. In the sample of 20, only one case
involved some dispositional action other than the hear-
ring or warrant.

In examining the breakdown of types of crimes in
cleared cases, some differences are apparent between ar-
rests and other methods of clearance. Table B-12 illus-
trates these differences for some crimes. It is seen

---

### Table B-8—Nonemergency Dispatching Problem Calls: Breakdown of Types of Cases

<table>
<thead>
<tr>
<th>Type of Crime</th>
<th>Total Cases</th>
<th>Arrested by Patrol</th>
<th>Arrested by Other</th>
<th>Total cleared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known murder</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Burglary</td>
<td>23</td>
<td>7</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>Grand theft—auto</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Nonnegligent vehicular</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Malicious mischief</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>304</td>
<td>304</td>
<td>304</td>
</tr>
</tbody>
</table>

---

### Table B-9—Breakdown of Types of Crimes

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murder</td>
<td></td>
</tr>
<tr>
<td>Aggravated assault</td>
<td></td>
</tr>
<tr>
<td>Burglary</td>
<td></td>
</tr>
<tr>
<td>Grand theft—auto</td>
<td></td>
</tr>
<tr>
<td>Nonnegligent vehicular</td>
<td></td>
</tr>
<tr>
<td>Malicious mischief</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1052</td>
</tr>
</tbody>
</table>

---

### Table B-10—Cleared Cases

<table>
<thead>
<tr>
<th>Type of Crime</th>
<th>Total Cases</th>
<th>Arrested by Patrol</th>
<th>Arrested by Other</th>
<th>Total cleared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known murder</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Burglary</td>
<td>23</td>
<td>7</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>Grand theft—auto</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Nonnegligent vehicular</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Malicious mischief</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>106</td>
<td>106</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>304</td>
<td>304</td>
<td>304</td>
</tr>
</tbody>
</table>

---

Data Sources:

- Table B-8 gives a breakdown of the types of cases we
  are discussing. In this sample of 112 calls, 57 cases
  actually appeared in the communications center to be sus-
  pect on-scene calls. When the officer arrived, he may
  have been too late to do anything more than take a crime
  report, or the subject might have just left, or might
  still have been on the scene. This total of 57 cases in-
  cludes a significant proportion of serious crimes such as
  burglary, robbery, and aggravated assault. If we now
  examine the calls that appeared to the communications
  center to be possible crimes, we again note a number of
  cases of significance, including one homicide; and a series
  of lesser crimes, particularly a large number of malicious
  mischief cases.

- It is clear that response time is not critical in some
  of these cases, especially the possible crimes which resulted
  in "take report" calls. But a significant proportion of these
  112 nonemergency calls would have greatly benefited
  from decreased response time, especially the felonious
  crimes where the suspect appeared to be on the scene
  at the time of the call. In addition, there are the cases
  concerning husband-wife or neighbor disputes, fights or
  juvenile delinquency which may be initially communica-
  ted to the police by a witness who does not know the
  seriousness of the event (and, indeed, many of the events
  are not at all serious at the time of the call).

- Table B-7 gives a breakdown of the types of crimes we
  are discussing. In this sample of 112 calls, 57 cases
  actually appeared in the communications center to be sus-
  pect on-scene calls. When the officer arrived, he may
  have been too late to do anything more than take a crime
  report, or the subject might have just left, or might
  still have been on the scene. This total of 57 cases in-
  cludes a significant proportion of serious crimes such as
  burglary, robbery, and aggravated assault. If we now
  examine the calls that appeared to the communications
  center to be possible crimes, we again note a number of
  cases of significance, including one homicide; and a series
  of lesser crimes, particularly a large number of malicious
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- It is clear that response time is not critical in some
  of these cases, especially the possible crimes which resulted
  in "take report" calls. But a significant proportion of these
  112 nonemergency calls would have greatly benefited
  from decreased response time, especially the felonious
  crimes where the suspect appeared to be on the scene
  at the time of the call. In addition, there are the cases
  concerning husband-wife or neighbor disputes, fights or
  juvenile delinquency which may be initially communica-
  ted to the police by a witness who does not know the
  seriousness of the event (and, indeed, many of the events
  are not at all serious at the time of the call).
Another of the most significant characteristics of a case, affecting its chances of being cleared, is whether the suspect was named in the crime report by the victim. However, before we examine the data on this characteristic, some explanation of the ambiguities involved is required.

There are really three general categories of cases concerning named or unnamed suspects. The first category is where the suspect is actually known to the victim. The second category is where the suspect was not known to the victim, but was arrested in the process of committing the crime and, therefore, directly identified at the time the crime report was made. The third category is where the suspect was not known to the victim but was arrested on-scene arrest does not imply the patrol officer of some multiple suspects and/or multiple cases involved. Table 8-1 summarizes the total number of crimes both cleared and uncleared, with named and unnamed suspects.

Examination of this table shows that over 60 percent of the cleared cases are those in which the suspect was named in the crime report. As we have indicated from our special sample, about half of those were arrests on-scene of unknown suspects. In the uncleared cases we note the high correlation with the named suspect characteristic. Out of a total 1,423 uncleared cases, 1,375 concerned unnamed suspects. In considering the 46 uncleared cases with named suspects, these divide into 23 cases with unconfirmed names, and 23 cases with confirmed names. Of the 23 confirmed name cases, followup investigations were made in 13 of these. In only six cases was the unconfirmed name confirmed by the followup investigation. In the 23 uncleared cases coded as confirmed name, only 6 followup reports were made, and only 4 of these confirmed the originally named suspect. This means that a total of 48 uncleared cases coded as possibly having named suspects, only 29 actually were confirmed.

The impact of the named suspect characteristic can be seen more specifically by examining some particular types of crimes. For example, with a retail store, a very high proportion of assaults involve the named suspects. Out of a total of 154 aggravated and simple assaults, 116 (or 75 percent) were named suspects in the 154 arrests, 123 (or 80 percent) were cleared.

A similar result is seen in rape cases. Out of 14 total cases in this category, 10 were cleared. Nine of the 14 cases involved named suspects. Burglaries, on the other hand, generally involve unnamed suspects. Of the 626 burglaries, only 31 (or 5 percent) had named suspects. This significantly affects the clearance rate. While burglaries represent 56 percent of the total number of cases, they comprise only 15 percent of the total number of cleared cases.

The impact of the named suspect characteristic on clearance of crimes raises a question concerning the response time and arrest data presented previously. In attempting to insure that the named suspect problem did not bias the conclusion about the relationship between response time and arrest, the results were checked. We eliminated the named suspect cases and made calculations similar to those displayed in figure 8-2. Although the sample of cases was reduced considerably, the results reinforced the previous conclusions on response time. Of the 34 total cases, 8 arrests were made, 7 of these in cases with 2-minute response time or less.

**Investigative Practice and Problems**

Table 8-15 summarizes the information collected on investigative followup practice. Two intuitive observations about detective activity are supported by the information in this table.

The first observation is that detectives tend to put their energies in cases where there is something positive to investigate. Almost two-thirds of their followups in cleared cases were associated with suspects named in the crime report. Furthermore, the followups in the unnamed suspect cases, although an appreciable one-third of the total, included only a relatively small number of cases that were solved primarily by detective followup investigation. On-scene patrol arrests accounted for the clearance of more than 300 cases of cleared cases. The followup reports made in those 70 represent only the investigation needed to request filling of a complaint against the suspect or a suspect in custody. It leaves less than 66 out of 365 followups, or less than 20 percent, in which the detective effort was not initiated by knowledge of a specific suspect, and was cleared.

Of the 1,423 uncleared cases, only 84 followups were actually made by detectives, and the suspect was named in 96
only 18 of these. This does not imply necessarily that the detectives work only on cases which can be cleared. But it does imply that detectives do not make followup reports when there is nothing to report. To put it another way, the bulk of the 1,423 uncleared cases had little or no evidence on which detectives could base a followup investigation.

Detectives also allocate their efforts according to the value of the case. Table B-17 shows the differences in average property value for cleared and uncleared cases in which property was taken. It can be seen that the average value in cleared cases is significantly higher than in the uncleared ones. Furthermore, the cleared cases having detectives followups tend to be even higher.

Tables B-18 and B-19 examine some of the methods by which suspects are linked with cases in the detective followup reports. As we noted, using such linking devices as vehicle information is not as a rule used by patrol officers rather than as a result of followup investigation. Table B-19 summarizes the total number of unnamed suspects in cases under each category. These methods include identification of suspects from photos, modus operandi techniques, stolen property, weapons, vehicles, interrogation of arrestees, and identification by victims (incorporated in the "other" category).

Modus operandi techniques and weapon information are used in only a few cases. Table B-19 provides some information on the use of these methods to identify suspects in different types of crimes. Table B-20 summarizes the data on clearance of the 1,031,626 crimes in this study. Of the 1,031,626 crimes, 231 had vehicle descriptions, 94 of which had license data. About 60 percent of these unnamed suspects were made in 94 total cases, 63 were cleared, 54 by arrests.

This section on investigative practices and problems has described some of the existing methods of clearing crimes. It has also exposed how little we know, in explicit terms, of the effectiveness of present methods. For example, for the purposes of optimum allocation of detective resources, it would be extremely valuable to have some quantitative estimates of the chances of clearing a particular type of case, given a followup investigation of a certain level of effort. This study did not attempt to explore that question, however, future research in the area should consider the possibility of a systematic experimental approach to development of information to assist police departments in allocating their investigative efforts.

ON-SCENE PATROL ARRESTS

An analysis of patrol arrests arrests to the importance of the patrol function in dealing with crimes with unknown suspects. Of the 482 cleared cases, 127 were cleared due to an arrest made by a police officer, not a radio call. As shown in Table B-21, these 127 clearances included 116 arrests, 86 of which involved actual observations by an officer in the field. Only 5 of these were arrests at the suspect's residence.

Table B-22 lists the type of cases in the 116 radio call arrests. One of the most significant aspects of this table is the "other crime" category. This category includes a large number of narcotics offenses for which a specific category was not originally designated in data collection. Referring to Table B-9, of the 112 cases in the "other" category, 76 were cleared. Thirty-nine of these resulted from nonradio call arrests. These represented almost 94 percent of all such arrests. Yet, the "other crime" category represents only 6 percent of all crimes. This result is clearly attributable to the high incidence of narcotics violations detected by field officers stopping vehicles for traffic violations or other suspicious activity.

The officer dealing with these field observation situations tends to rely considerably on the vehicle and warrant check. Table B-23 indicates the use of vehicle information in those cases in which the officer is making a field observation. Information about what suspects and vehicles are wanted. The basis for this is the large percentage of the police done by patrol officers. "Twenty-eight" crime cases in this sample had vehicle alarms, 19 of which were activated by the suspect, and 5 activated by the victim and 4 unidentified. Of the 24 identified alarms, 7 arrests were made, all by patrol. However, where the suspect activated the alarm, only 4 of 10 arrests were made, whereas where the victim activated the alarm, 3 out of 5 arrests were made.
Table B-22—Types of Crimes in Nonradio Call Arrests

<table>
<thead>
<tr>
<th>Crime Type</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burglary</td>
<td>1,556</td>
<td>52.0</td>
</tr>
<tr>
<td>Arson</td>
<td>27</td>
<td>0.9</td>
</tr>
<tr>
<td>Aggravated assault</td>
<td>67</td>
<td>2.2</td>
</tr>
<tr>
<td>Robbery</td>
<td>40</td>
<td>1.3</td>
</tr>
<tr>
<td>Simple assault</td>
<td>40</td>
<td>1.3</td>
</tr>
<tr>
<td>Rape</td>
<td>81</td>
<td>2.7</td>
</tr>
<tr>
<td>Vehicle theft</td>
<td>23</td>
<td>0.7</td>
</tr>
<tr>
<td>Larceny</td>
<td>441</td>
<td>14.5</td>
</tr>
<tr>
<td>Fraud</td>
<td>27</td>
<td>0.9</td>
</tr>
<tr>
<td>Vandalism</td>
<td>11</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>3,063</td>
<td>100.0</td>
</tr>
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</table>

Table B-23—Supplementary Information Used in Field Arrests

<table>
<thead>
<tr>
<th>Query results</th>
<th>Used</th>
<th>Positive</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle license</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Driver's license</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Passenger's name</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Witness name</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Address</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
</tr>
<tr>
<td>Description of vehicle</td>
<td>2</td>
<td>2</td>
<td>100.0</td>
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</tbody>
</table>

Table B-24—Field Call Disposition

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrest</td>
<td>1,126</td>
</tr>
<tr>
<td>Release</td>
<td>1,937</td>
</tr>
<tr>
<td>Other</td>
<td>980</td>
</tr>
</tbody>
</table>

Discussion of Results

The results of the foregoing analysis imply two very significant preliminary recommendations. The first regards preliminary investigation at the crime scene. We have noted that very little follow-up is undertaken by the police for many crimes when there is little or no indication of someone being present at the crime scene. Thus, the police are being directed to begin preliminary investigation at the scene. Theoretically, he should make a check of the victim to see if he is present or absent. Unfortunately, due to lack of manpower and other pressures, preliminary investigation at the scene is not always carried out. This is understandable, of course, since the information available in the police department is collected for current operational reasons, rather than to satisfy research objectives. Yet, such research on police operations is sorely needed. Police operations are often based on several operational hypotheses about what makes for effective police work. The researchers in this study have also developed some hypotheses based on different orientations to the police work. But few of these hypotheses can be really validated with the existing level of information available. Furthermore, many of the crucial operational issues are decided on intuitive grounds which may or may not reflect the actual situation.

What is needed, therefore, is a fundamental research and analysis program over a several year time period in one or more large metropolitan police departments. This program would attempt to explore more detail the characteristics of crime, arrests, and field investigation practices that just explored in a preliminary manner in this study. Special data collection methods would have to be developed in order to obtain information on field practices without unduly influencing the practices by the fact that observations were being conducted. New methods of recording information specifically for the research studies would have to be employed and there would be some additional collection required on the part of a sample of patrol and detective officers.

This study would have to be of an iterative nature. It would begin with a series of hypotheses based on the results of this study, and follow up that data with more specific analysis that will indicate more specific analysis. It seems, however, that in the type of crime in most cases the officers have no preliminary information on the scene. In the second operational recommendation concerns the current allocation of detective resources. In most departments the detective is used primarily as a followup to the crime scene, and the success or failure of the followup investigation is highly dependent on the productivity of the field officer. Therefore, attention must be given to the effectiveness of the field officer. This is a very productive field of research.

Improving Clearance of Crimes with Unnamed Suspects

The study indicates that the clearance rate of cases with unnamed suspects is very low. Of 1,556 crimes that occurred in a particular time period, only 181 were cleared. It was noted that few followups were made by detectives in these cases, primarily because of lack of information to initiate any investigation. Furthermore, most of the 181 clearance results resulted from on-scene arrests stimulated by radio call or field officer observations. Two conclusions about improving clearance of unnamed suspect cases follow. First, more preliminary investigation at the scene is required. Because the resources are scarce, a civilian preliminary investigative squad is recommended to serve this function. Second, the utilization of followup investigators to a tactical force operating specifically against burglaries and thefts would be desirable.

CONCLUSIONS

This section reiterates some of the conclusions from the previous chapter on Police Department as an educational effort.

RECOMMENDATIONS

One possible solution to this shortage is to employ civilian personnel who are especially trained in investigative techniques but who do not require the operational training and physical capability of the field officer. A further recommendation that might be made is that the Civilian Investigative Force could be called to the scene of a crime by the field officer after he has determined that no operational concern is involved.

It seems, however, that the success or failure of the followup investigation is highly dependent on the productivity of the field officer. Therefore, attention must be given to the effectiveness of the field officer. This is a very productive field of research.

Criteria for Emergency Dispatching

One specific area of research uncovered by this present study is the need to examine criteria for priority dispatching. A specific program is recommended with the two basic objectives described and would also have to be tested and special data collected for those purposes. It is clear that studies of this kind in various departments are of great interest and would be supported by the research community.

Conclusions

The data collected on the response time in dispatchable field units appears to support the hypothesis that the response time leads to more arrests. The present method of dispatching for emergency calls still results in an additional 3 to 5 minutes field response. The response time is minimized if the closest available

More automated command and control systems can reduce the overall response time.

Criteria for Priority Call Assignments

The study of cleared and uncleared crimes related to radio calls constitutes a possible area of research in crime prevention and case clearance. This would involve higher priority assignment for a selected number of suspects cases follow. First, more preliminary investigation at the scene is required. Because the resources are scarce, a civilian preliminary investigative squad is recommended to serve this function. Second, the utilization of followup investigators to a tactical force operating specifically against burglaries and thefts would be desirable.

Latent Fingerpint Search Capability

In an estimated 2,500 burglaries per year in the city of Los Angeles, fingerprints are left at the scene. The prints can indicate a possible fingerprint, and if the suspect is not yet known, a fingerprint search may be made. The latent fingerprint file on a single-finger but hypotenuse of the finger as an investigative device. The latent fingerprint file on a single-finger but hypotenuse of the finger as an investigative device. The latent fingerprint file on a single-finger but hypotenuse of the finger as an investigative device.
crimes not events in progress. The "emergency calls" also include some crimes which have actually been completed at the point where a crime has occurred. In other cases, the information received by telephone is just not sufficient to make an accurate judgment. Obviously, if the communications center knew which calls fit into which categories in advance, it could make perfect priority assignments. The problem, of course, is that from the standpoint of the communications center, the situation in the field is not always clear.

At the present time there is a series of criteria which are used to assign priority to a call. The present study is used to assign priority to a call. The present study is designed to develop and test new sets of criteria and see if they improve performance. A necessary requirement to accomplish this type of evaluation and testing is an audit of the present results of dispatching. This audit requires an evaluation of response time from receipt of a call to arrival at the scene, and a careful evaluation of the results of the field activity: Whether it involved proactive action, arrest or other clearance methods. Once the data collection techniques for such an audit are designed they should be used to compare the present criteria against any new criteria that may be developed.

Specific tasks required for this research program include the following. It will first be necessary to monitor calls for service, preferably through recordings, to develop, from vehicle, to develop, a taxonomy of characteristics which can be used forケース analysis. Patrol responses to calls would also be studied in a balanced sample in the field. For this, it would be necessary for the patrol officer to make careful recording of his receipt of call and arrival times. This could be simplified by the use of dictation equipment.

After this information is collected we would then be in a position to evaluate the communications characteristics with the field activities. The present priority call assignment criteria could then be analyzed and evaluated against the results of field activity evaluated as well. We would then be in a position to design a new set of dispatching criteria and test these criteria under operational conditions with the same methods used to test the present set. This would lead to an evaluation of the new criteria. At this point we would probably want to retest on our design concepts and test once more before making the final recommendations.

(2) Determine how many cases are actually events in progress;
(3) Evaluate what proportion of these escalate into crimes which would be preventable by rapid response;
(4) Evaluate what proportion are presently considered priority calls; and
(5) Determine the distinguishing characteristics of these escalate events as seen from the communications center.

In some cases in progress are not actually considered crimes in progress. The "emergency calls" also include some crimes which have actually been completed at the point where a crime has occurred. In other cases, the information received by telephone is just not sufficient to make an accurate judgment. Obviously, if the communications center knew which calls fit into which categories in advance, it could make perfect priority assignments. The problem, of course, is that from the standpoint of the communications center, the situation in the field is not always clear.

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ANNEX 2: DEFINITIONS, MEANINGS, AND CATEGORIZATION

1. If no actual arrest was made, the case was not coded as cleared by arrest, even though the followup listing the case as cleared by arrest. This was equally important in cases where a warrant was issued but the arrest had not been actually consummated at the time of our study.

2. Some followups were found in the file which did not indicate any actual investigative action by the detective, but merely reported supplemental information provided by the victim, e.g., adding a serial number for a stolen television, or providing a list of additional property stolen and its value. In those cases the officers were instructed to followup listed the case as cleared by arrest. In those cases, the followup was coded as "other clearance." All other "other clearance" was not coded as any arrest was made, no case was actually coded as cleared and no case was actually cleared.

3. It was established that the department's policy was to automatically file for a complaint whenever a misdemeanor arrest was made. Hence, a misdemeanor arrest always resulted in a "yes-filing" category in the cleared-arrest item.

4. Where no arrest was made, no case was actually ruled as cleared in the "No. of cleared" item even though that followup report listed the case as cleared and no arrest was made.

5. In theft from the automobile the dollar value of the property was often missing in the crime report. We established the policy that the coding officer would estimate that value.

6. Grand theft—Auto was not coded as a crime in vehicle with the value less than $200. Some cases, however, may involve loss of that amount, particularly if guns, citrus fruit, or certain animals were stolen.

7. Even in cases where no crime was reported, the officers attempted to fill in the "category" column whenever a filed." However, in general the dollar value was coded as cleared and no arrest was made.

8. Warrant document or fraud was not coded as attempting to take property. However, in some cases, indicating whether, when the field officer arrived, the suspect was on the scene, etc.
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10. In considering the source of prior information, the category "informant" was used to designate a witness as well as a specific informant to the police department.

11. If a suspect was named in the crime report but was not named in the followup investigation, the implication is that there was no evidence to connect that suspect to the crime.

12. In examining the method of naming the suspect in the followup investigation, provision was made for photo identification as a specific category. However, identification through observation by victim or witness was coded as "other" because of the lack of an appropriate category.

ACKNOWLEDGMENT

The author wishes to acknowledge the support of the Los Angeles Police Department in making this study possible. The assistance of Chief Thomas Raddyn and Deputy Chief Edward Bass, of the Los Angeles Police Department, and Sergeant Edward Bass, of the Los Angeles Police Department, was used to designate a witness as well as a specific informant to the police department.

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The uniqueness of fingerprints as a method of identification has led to their widespread use and to large collections of fingerprints being stored at city, state, and national levels. This considerable use of fingerprints for identification has led to several problems in maintaining and searching the large files. Also, the present systems have a basic limitation of not being able to locate a suspect on the basis of fingerprints left at a crime from any but a small subset of the total prints now on record.

As an example of the magnitude of the present problem, let us consider the largest single collection of fingerprints now in existence, which is maintained by the FBI in Washington, D.C. The FBI files now contain about 16 million sets of different criminal prints plus about 62 million different civil Service and Armed Forces prints. Many persons have several sets of fingerprints in these files so that the total number of fingerprint cards now in the files exceeds 179 million. Each day the FBI receives about 30,000 sets of fingerprints to be processed, of which approximately 10,000 sets are based on arrest. Most of the remaining prints relate to national security, being used for identification of Government employees and for checking to see if persons who will be employed in security positions have arrest records. The FBI employs about 1,100 personnel to process these daily demands for identification, add new prints to the file and delete old prints.

Given a set of fingerprints which are to be searched against the criminal file to see if the person owning the print has a prior criminal record, some system is needed whereby the total number of cards to be examined by visual inspection can be limited to relatively few. This is the problem of fingerprint classification. The system which has been and is most used was basically set down by Sir Edward Richard Henry in about 1903. This system has been subsequently modified to meet particular demands but remains the fundamental technique for fingerprint classification.

The Henry system is that primarily used by the FBI, New York State, for instance, uses what is called the American system 1 which differs only in detail from the Henry system. In any fingerprint system, whether manual, semiautomatic, or automatic, the classification system is of primary importance, for it is the classification system which determines the extent and the efficiency of the search process.

The most significant aspect of the present search procedures lies in the fact that one must have 10 ordered fingerprints in order to use the present classification system. This is to say that in order to enter the prints, using the classification formula now in use, one must have a full set of 10 fingers. An immediate drawback to this system can be readily seen. When fingerprints are inadvertently left by a criminal at a crime, only one or perhaps several prints may be available to law enforcement officers. Using the present system, there is, therefore, no means of directly entering the files to search for prints of this type. In order to get around this problem, some city, State, and Federal agencies have, in addition to their large files, small files called "latent files" classified so that it is possible to search them on a finger-by-finger basis.

The mechanics of this search are of course different from that of the 10-finger search and the actual categorization of latent prints depends greatly upon the ability of certain fingerprint experts both to work with and to extrapolate data from the latent prints (which are liable to be quite poor) and to manipulate the latent print files. As a result, latent print files tend to be very small, generally containing only a few thousand prints. For both Federal and State agencies, the latent print files will contain only the fingerprints of criminals who are particularly likely to be involved in certain kinds of crimes, and

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1 "Methods of Fingerprint Classification," New York State Department of Corrections, Bureau of Identifications, Albany, N.Y., 1944.

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FINGERPRINT CLASSIFICATION
by Thomas C. Barlow

Appendix C

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print patterns such as loop, whorl, and arch, and finally, ridge count or whorl tracing. The classification formula which is used to locate fingerprints falling in a particular category is simplified into an alphanumeric form. In order to facilitate the filing and search process, the formula is segmented into primary, secondary, and extension parts, but these are subsequent to the principal formula. Addition
classes of information such as sometimes used to
<|im_sep|>3. Remember that more people are involved.

4. Once a suspect is identified, fingerprint experts are employed to make a final determination.

5. The fingerprint expert will then compare the suspect's fingerprint with those on file and determine if a match has been found.

6. If a match is found, the suspect will be arrested and charged with the crime.

7. The fingerprint expert will then provide a detailed report on the suspect's fingerprint, including the type of print, its orientation, and any other relevant information.

8. This information will then be entered into a database where it can be accessed by law enforcement agencies around the world.

9. The fingerprint expert will also provide a fingerprint card or image of the suspect's fingerprint to the police for use in future investigations.

10. Finally, the fingerprint expert will provide training to law enforcement officers on how to properly handle and process fingerprints.

These are the steps involved in the fingerprint identification process, from the moment a fingerprint is made until the moment it is used to identify a suspect. It is a complex and time-consuming process, but it is one that is essential for the proper functioning of the justice system.
There are several in the file varics according to the operator so the there be some interaction between the computer which is called for in order to locate the SCRAM, significantly reduced. For example the FBI file, which are offered to the system. It is examined is quite large,.not of this sort the total volume of the stored data of external storage is low and least as well as present systems. .need for an operator to extract meaningful data from be kept to a minimum, and an efficient way to store high adequte storage at a quite modest price. .entmanual systems would be Again, the price is the problem the total volume of the stored data in actual prints and records of the system, and this is the problem of the file such that the number of prints, the computing load appears to make. With such bulk storage devices as, the problem is the problem of the file into a very small set or prints being "examined" on the data bank into a very small set. It is clear that such a system an individual cards might be delivered for existing systems to exist, but the in most cases to possible other problems, such as ridge ending or bifurcation with another. In addition, there is angular information associated with each of these singular points which might be also used as adscripitive data but this appears to lack the variance necessary to further the refinement of the file. Unfortunately, it is difficult to say at this time exactly which of the proposed schemes will be used to set the stage for fingerprint data. In order to make an effective system, it is therefore which will be studied using a simulated semiautomatic system and to actual prints using such a system would be studied using a simulated classification system which would resemble the present system, after using the fundamental studies would be restricted to work with statistical contributions and these are not presently available. The cost of such a study would be perhaps $1 million. Several consoles which are commercially available can be

### The Fingerprint Classification Techniques Study

Let us return once more to the problem of classification of fingerprints in a large file of fingerprints. A number of different techniques for matching fingerprints in a file. For instance, recent industry proposals suggest that by means of a Fourier, series, or by considering fingerprint data as vector space associated with Laplace equations, parameters can be mathematically generated and used to classify the fingerprint data in a system. In contrast with the problem of fingerprint classification the fingerprint characteristics, relief patterns, after using the fundamental statements and bifurcations. The location of these is used by fingerprint data for locating prints in the file. It is our impression that it will enable the classification procedure to go beyond the initial stages. It appears in most reports, however, that it is not the general contour in a print which makes the print identifiable, but the existence of irregularities in the flow lines or ridges. For this reason, it is recommended that the proposed systems using minutiae to characterize and categorize fingerprint data be studied in some detail using actual prints for data. In addition to examining the minutiae in the print, which is straightforward for an operator and not too difficult for a computer, it is necessary either to establish a coordinate system in order to recognize the location of the file which localizes or prints, the computing load appears to make. This will specify which of the files such that the number of prints which are offered to the system. It is examined is quite large. the problem in actual operating practice the proposed systems, utilizing several consoles with operators to extract fingerprint cards from one of the present files. By repeatedly attempting to apply fingerprint data and by a systematic study of the characteristics of the file on file, it will be possible to determine which of the proposed classification systems will work best. The question is the step in the automatic retrieval process which contains major problems at the present. There is certainly no problem in the information retrieval part of the system given an adequate classification system, nor is there a problem with the volume of data nor in providing the computer speeds necessary to retrieve cards efficiently given adequate input data. It seems clear that a study of the classification problem part of the system such as fingerprint data and cards and fingerprints are involved in our existing files. Theoretically, the studies would be restricted to work with statistical distributions and these are not presently available. The cost of such a study would be perhaps $1 million. Several consoles which are commercially available can be

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**Note:** The text contains some formatting issues and may require further refinement for clarity and readability. The original text is a scientific document discussing fingerprint classification techniques and related studies, focusing on the difficulties and potential approaches for improving classification accuracy and efficiency.
purchased in the immediate future. Study contracts can be let and, given cooperation of a major law enforcement agency, it would be possible to initiate such a study in the very near future. This seems the necessary first step to any implementation of a computerized fingerprint retrieval system. If it would, in addition, give us considerable information on the subject of locating latent prints in files which are now in existence, and should be helpful to all law enforcement agencies in coping with their problems associated with latent prints. It would also supply statistical information concerning the anticipated consequences of enlarging the present files.

Further steps would, of course, be based on the results of the first study. There appears, however, to be no basic reason why a classification system cannot be implemented. The problem is simply that sufficient knowledge is not now available. The study would, of course, provide more knowledge than this, for simulating certain parts of the proposed system will give accurate information on operational speeds and efficiency which will be useful in any future system.

INTRODUCTION

POLICE RADIO OPERATIONS

Large police mobile radio networks are characteristically organized in a centralized geometry with the two-way communications channels radiating outward from the dispatching center to the mobile units in the field as the spokes of a wheel radiate out from the hub. This network geometry is consistent for the normal mode of police operations, but less well adapted to the emergency mode.

The normal mode of operation of a police mobile radio network is built around the individual mobile police vehicle and its occupants as the fundamental guardians of law and order. The mobile units patrol well defined "beats," receiving assignments from the dispatching center, and monitor the activities of mobile units on adjacent beats, moving to be in a position to render aid in pursuit if needed.

The emergency mode of operation of the police mobile radio network must provide for the organization of police mobile units into tactical operation units for dealing with large scale riots, disasters, or demonstrations. The network topography is no longer a simple spoke, since control of the tactical force may be given to a command vehicle on location in the emergency area. This latter mode of operation is one for which police departments generally have not been prepared in the past. In recent years, however, the forward looking departments have been making substantial changes both in organizational procedures and in design of their communications networks to be able to shift into this mode of operation as required.

In a number of the larger, single-agency, police networks, the geometry just described can be recognized particularly if future plans as well as present status are taken into account. Over major population areas, however, because of the multiplicity of municipal, county, and State agencies involved, a large number of individual networks are found to exist, all overlapping each other in the radio coverage. In taking areawide overviews, it is difficult to identify any discernible pattern. In addition, the existing police radio networks are plagued with a number of severe shortcomings. The most serious of these shortcomings is the severe crowding of the police radio bands. The overall shortcomings of present police radio communications have a number of clearly defined characteristics:

The congestion of the police radio channels is most severe in the areas around the major population centers. In these areas, there are too many police radio users and too few radio channels allocated for police use. In these major population areas, as in all areas of the country, police radio is characteristically organized into a large number of small, independent networks which are ineffective in terms of interagency communications and coordination and inefficient in use of the limited available radio spectrum. Each little municipality will often have its own small, independent police network.

Even in those areas where large police networks exist as in major cities or countywide systems, there is virtually no use made of the methods of modern communications technology to even the channel loading or relieve the congestion at times of heavy traffic.

New devices required for improved police operation such as automatic car locations, small personal radios for use away from the car, and teletype in the car can be expected to create requirements for additional radio spectrum space for police use.
The spectrum congestion evidence itself is not in an accurate picture of police communications. The dispatchers' messages to the cars are sufficiently impertinent that police mobile equipment is not the fundamental cause of adverse circumstances. The spectrum congestion evidence itself more nearly in a gradual degree functions to police capability to be used in land mobile applications. The individual examples are numerous enough and are drawn from enough separate parts of the lack of an overall, thorough, and detailed field measurement investigation.

The limitations from limited field tests undertaken by the FCC in Los Angeles and New York, from the preoccupation with the spectral efficiency of the Land Mobile Service by the Land Mobile Section of the Electronic Industries Association, and from evidence gathered and presented to the study made by the Land Mobile Services Commission has led to the conclusion that the FCC has opened in recent years point to serious congestion and a growing demand on the Land Mobile Services and to radio traffic volume for 1965 was reported as

There is a large number of examples of the effects of the spectrum shape. Until recently, in New York City, for 2,000 police mobile units was provided by 81-kilohertz frequency for the subject to a 24-hour day, a police patrol vehicle receives about one call per hour. Further, on the average calls for service from the public, it appears that it takes a population of about 25,000 to generate the average 1 call per hour for a mobile patrol vehicle. Thus, the cost of the 35 mobile vehicles in New York City has put the idea of voice communication and equipment and personnel for conducting police mobile patrol. For a two-man police radio car on 24-hour duty, three shifts of two men are required, plus two additional shifts for relief—6 days off, other duty, vacation, etc. Hence, 10 men are needed per vehicle at approximately $10,000 per year. (These figures are halved for the one-man car.)

The equipment costs are $2,000 for the car, $700 for radio equipment, and $100 for the shotgun and other equipment totaling $2,800. These equipment costs are amortized over a 3- to 5-year period. Thus, using 3 years as a conservative estimate, the annual equipment costs not including maintenance and personnel costs is assumed. Thus, for New York City, the traffic loading in police radio channels is busy, would be indicative of the extent of the congestion. Naturally, the traffic loading in police radio channels varies, the channels being most busy in the evening hours and on weekends. An average loading of about 60 percent, however, indicates an extremely busy channel.

Sample studies taken in the course of the work indicate that on the average, over a 24-hour day, a police patrol vehicle receives about one call per hour. Further, on the average calls for service from the public, it appears that it takes a population of about 25,000 to generate the average 1 call per hour for a mobile patrol vehicle. Thus, the cost of the 35 mobile vehicles in New York City has put the idea of voice communication and equipment and personnel for conducting police mobile patrol. For a two-man police radio car on 24-hour duty, three shifts of two men are required, plus two additional shifts for relief—6 days off, other duty, vacation, etc. Hence, 10 men are needed per vehicle at approximately $10,000 per year. (These figures are halved for the one-man car.)

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pered by inadequate radio communications while large portions of the TV spectrum are underutilized. Recommendations are made for remediating this situation, recommendations which should have only minor effect upon the radio spectrum capacity available for TV but which should provide immediate and major measures of relief for the police community.

PRESENT DIVISIONS OF THE RADIO SPECTRUM

The broad features of spectrum allocation are:
about 27 percent of the spectrum is reserved for government use, 58 percent is reserved for nongovernment use and 15 percent is shared between the two. Of the nongovernment share, 88 percent is reserved for broadcasting. The mobile radio bands are about 5 percent of the total available for nongovernmental use. The usage of the mobile bands has been characterized by a phenomenal growth in the past 15 years. The causes of this growth are complex, including the general business growth, the characteristics of a nation "on the move," and the policy of the FCC in recent years of encouraging maximum use of the radio spectrum potential. The Business Radio Service, first established in 1958, had over 220,000 transmitters authorized in its first 3 years of service. The police had approximately 5,000 licensed users in 1949, today they number over 200,000. It is this rapid growth that has led to the severe crowding in the mobile bands. The FCC has allocated three basic bands to the mobile users. While generally insufficient analysis and experimentation has been carried out in the mobile bands, as compared with the government military bands or the broadcast bands, the Bell System did publish, a fundamental comparison of the relative desirability for mobile use of the three bands.

OPTIMUM CHOICE OF FREQUENCIES FOR POLICE MOBILE RADIO NETWORKS

As indicated in table D-1 the police community prefers the "high band" or VHF frequency range. As more efficient police mobile networks are developed, there will be a strong tendency for the police to ask for additional frequencies in the range they are using in order to minimize the changes required in their existing equipment. This trend can already be seen in cities which have designed for multifequency transceivers—Los Angeles, Chicago, and Washington, D.C. Hence, there will be a tendency for the police to desire additional allocations in the VHF band.

The Bell Laboratories ran a series of experiments in New York to find the optimum range of frequencies for the Land Mobile Service. Their results were reported by Young. These results are summarized here in a series of graphs derived from the Bell System article. Figures D-1, D-2 and D-3 show that transmission efficiency decreases with frequency but also decreases as a result of increased interference in the broadcast band around 450 KHz. Thus, the police might obtain somewhat superior service using the high band.

Table D-1—Characteristics of Police Frequency Bands

<table>
<thead>
<tr>
<th>Band in which police frequencies are located</th>
<th>Bandwidth</th>
<th>Noise or Interference characteristics</th>
<th>Distance characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>37-45 MHz (low band)</td>
<td>25 KHz</td>
<td>Very good coupling over long distances</td>
<td>Good distance characteristics</td>
<td>Broadly used by police.</td>
</tr>
<tr>
<td>151-159 MHz (high band)</td>
<td>25 KHz</td>
<td>High noise bands, particularly in urban areas.</td>
<td>Poor distance characteristics</td>
<td>Radiated rather than high band in urban areas.</td>
</tr>
<tr>
<td>452-459 MHz</td>
<td>50 KHz</td>
<td>Lower noise bands than high band in urban areas.</td>
<td>Poor distance characteristics</td>
<td>Police more reluctant to use this band because of high cost and incompatibility with high band equipment.</td>
</tr>
</tbody>
</table>


Note: Data furnished in semifinal experimental by W. R. Young, Jr., Office of Technical Operations.
It is generally agreed that lowband, with its skip interference, is undesirable for police use although major police departments—Baltimore County, Md.; Fairfax County, Va.—are among those still operating in this band because of the spectrum shortage. Section 05.01 (g) of FCC rules advises users in the Public Safety Services to use frequencies in the highest portions of the spectrum because they are not subject to skip interference from distant stations due to reflection off the ionosphere.

REALLOCATION POTENTIAL WITHIN THE PUBLIC SAFETY BANDS

Table D-2 provides a picture of the spectrum crowding in these bands in a very general way since it considers all the transmitters licensed all over the country. It is valid as a general picture, however, since most mobile bands users, with a few notable exceptions, experience the most severe crowding in the same places—the population centers.

Since the police suffer more severely from congestion than the other Public Safety Services it appears to be available to them relief by reallocation from the other user allocated bands. These other bands are also well used, however, and a more practical approach would seem to be that the user identification within the Public Safety Bands be eliminated and local governments be made responsible for the efficient usage of all their assigned frequencies. This would eliminate the need for further consideration of reallocation within the Public Safety Bands.

Table D-2—Relative Congestion Among Users of the Mobile Bands

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Public Safety</th>
<th>Police emergency</th>
<th>Telecommunications</th>
<th>Broadcast</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-50 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>50-70 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>70-100 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>100-125 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>125-150 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>150-175 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
<tr>
<td>175-200 MHz</td>
<td>200,000</td>
<td>30,000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
</tr>
</tbody>
</table>

It would seem that the use of mobile base station transmitters operating at adjacent frequencies in the same area would be more practicable. Figures D-4 and D-5, taken from the EIA analysis, are the composite graphs of VHF TV receiver characteristic curves for a low-band channel, channel 5, and for a high-band channel, channel 11. These curves, which show the level of interference noticeable to the viewer, show that, as expected, the receiver is most sensitive to interference within the channel rather than to interference in neighboring channels. Further, the receiver is more susceptible to interference in the channel below the channel to which it is tuned than it is to interference from above. The figures specifically consider the interfering effect of a CW or narrow-band, land-mobile transmitter signal. In most cases, for adjacent channel signals, the interfering signal must be above the TV signal level, which is taken here as 225 microvolts, to cause noticeable effects. This is expected TV-signal level at the edge of the grade B service contour. Figure D-6 shows that if the land-mobile transmitter signal is kept 55 db below the 225-microvolt reference, there would be no interference to the TV even at band edge.

Figure D-7 shows the various frequencies that must be avoided in the land mobile services to minimize the possibility of local adjacent-channel television interference. The video and audio carrier should be avoided to minimize interference to the mobile receivers. A land-mobile transmitter on the upper channel sound frequency—78 in the diagram—will mix with the upper channel video carrier which is 4.5 MHz away to produce 4.5 MHz sound I.F., which will cause audio interference to the channel. Similar interference effects are caused by transmissions on the other frequencies indicated in figure D-7. At a result of their analysis, developed more completely in the referenced EIA analysis, the EIA recommended land mobile frequency assignments shown in figure D-8 for adjacent channel operation. Further, they recommend at this time that operations in adjacent channels be limited to fixed stations.

Table D-3—Bands Adjacent to VHF TV

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency (MHz)</th>
<th>Adjacent usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54-68</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>2</td>
<td>60-74</td>
<td>FM broadcast</td>
</tr>
<tr>
<td>3</td>
<td>70-84</td>
<td>FM broadcast</td>
</tr>
<tr>
<td>4</td>
<td>85-99</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>5</td>
<td>98-112</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>6</td>
<td>112-126</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>7</td>
<td>126-140</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>8</td>
<td>140-154</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>9</td>
<td>154-168</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>10</td>
<td>168-182</td>
<td>AM broadcast</td>
</tr>
</tbody>
</table>

Table D-4—Land Mobile Channels Available in Los Angeles in VHF TV Bands

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency (MHz)</th>
<th>Adjacent usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60-64</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>2</td>
<td>64-68</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>3</td>
<td>68-72</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>4</td>
<td>72-76</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>5</td>
<td>76-80</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>6</td>
<td>80-84</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>7</td>
<td>84-88</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>8</td>
<td>88-92</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>9</td>
<td>92-96</td>
<td>AM broadcast</td>
</tr>
<tr>
<td>10</td>
<td>96-100</td>
<td>AM broadcast</td>
</tr>
</tbody>
</table>

FCC orders the National Association of Broadcasters, FCC docket No. 123, to keep track of the number of channels taken from the Los Angeles area.
The analysis in favor of the practicability of sharing is considered to be sufficiently sound and valid in its development, and the need is sufficiently intense that the matter can be expected to be amenable to decision at an early date. On the basis of the foregoing, it is recommended to the FCC that the field investigation of the practicability of sharing VHF TV spectrum with mobile users be given top priority and that when the technical conditions for sharing have been established, an appropriate portion of these spectrum resources be made available to the police community.

Reallocation of UHF TV Spectrum Space

Table D-5 shows the very large amount of radio spectrum space that is devoted to UHF TV. While there is currently intense interest in the potential utility of this portion of the spectrum for educational TV, the fact nevertheless remains that it represents an enormous amount of spectrum--enough for 14,000 30-kHz mobile radio channels. Just one TV channel provides sufficient bandwidth for 200 such channels. Finally, simple arithmetic shows that a reallocation, for example, of two UHF TV channels would reduce that total capacity by less than 5 percent. It is extremely doubtful whether it is possible to project the future growth of UHF TV to within this order of accuracy. Accordingly, it is recommended to the FCC that consideration be given to reallocating radio spectrum space from UHF TV to land mobile use.

Table D-5.—Spectrum Allocations in Brief

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Amount of frequency space</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>470-512 MHz</td>
<td>215 MHz</td>
<td>Most heavily used mobile frequencies for mobile services, TV broadcasting, radio services, and radio spectrum allocated to Government services and aircraft warning frequencies. Also available for emergency communications, civil defense, and defense communication use.</td>
</tr>
<tr>
<td>512-706 MHz</td>
<td>254 MHz</td>
<td>Commercial services: SSTV, TV, and other frequency bands.</td>
</tr>
<tr>
<td>706-880 MHz</td>
<td>126 MHz</td>
<td>Commercial services: SSTV, TV, and other frequency bands.</td>
</tr>
</tbody>
</table>

The efficient design of municipal mobile radio networks

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</tr>
</tbody>
</table>

Although it can become complex in mathematical formulation, the concept is that the allocation of communication channels on an exclusive basis is extremely wasteful in terms of use of resources as compared to the sharing of channel resources among a number of users. Many studies have shown that the distribution of the number of telephone messages per hour may be approximated by a Poisson distribution with parameter \( L \), where \( L \) is the average number of messages per hour. This distribution will be assumed for police messages. That is, \( K_c(t) \), the probability that there are \( n \) police messages during a time interval of \( t \) seconds is given by:

\[
K_c(t) = \frac{(Lt)^n}{n!} \exp(-Lt)
\]

Additionally, it is convenient to assume that the message length is a negative exponential distribution with mean \( 1/L \). That is, the probability that a message lasts longer than \( t \) time units is \( t \exp(-t/L) \).

The analysis presented here was provided by Dr. H. Hillstrom at Bell Telephone Laboratories, New York, in 1969, and was translated into English by Copeland Telephone Co., Copenhagen, 1969.
service time.

Because police communication systems have a varying number of users, the delay in delivery of a particular message, then the problem described is a real one. Because police communication systems have a varying number of users, the delay in delivery of a particular message, then the problem described is a real one. Because police communication systems have a varying number of users, the delay in delivery of a particular message, then the problem described is a real one.

These equations have been evaluated and the results graphed in figures D-9 and D-10. One might extend this analysis by including different classes of messages, each class with distinct u and L. In particular, one might separate the outgoing from the incoming messages, or possibly those messages from the traffic division from those messages from the patrol division. These details would be appropriate when analyzing a specific problem area.

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FIGURE D-6. LAND-MOBILE FREQUENCY ASSIGNMENT
(For 60-mile Minimum Adjacent Channel)

| LAND-MOBILE | CO-AREA TV | NO. OF |
| TRANSMITTERS | IN VHF | TRANSMITTERS | IN VHF | LAND-MOBILE |
| CHANNELS | CHANNELS | CHANNELS |
| 2, 5, or 7 | 3, 6, or 8 | 82 |
| 3, 8, 9, 10, 11, or 12 | 2, 4, 7, 9, | 42 |
| | 5, 10, 12, or 11 and 13 | |
| 4, 6, or 13 | 3, 5, or 12 | 139 |

AS A REFERENCE

<table>
<thead>
<tr>
<th>CHANNEL FREQUENCY (MHz)</th>
<th>VHF CHANNEL FREQUENCY (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 54-60 7 7 174-180 7</td>
<td></td>
</tr>
<tr>
<td>3 60-66 8 180-186 8</td>
<td></td>
</tr>
<tr>
<td>4 66-72 9 184-192 9</td>
<td></td>
</tr>
<tr>
<td>5 76-82 10 192-198 10</td>
<td></td>
</tr>
<tr>
<td>6 82-88 11 196-204 11</td>
<td></td>
</tr>
<tr>
<td>7 204-210 12</td>
<td></td>
</tr>
<tr>
<td>8 210-216 13</td>
<td></td>
</tr>
</tbody>
</table>

D E S I G N T E C H N I Q U E S A P P L I E D T O WASHINGTON METROPOLITAN AREA

Present Situation in Washington Metropolitan Area

The Washington metropolitan area (fig. D-11), is defined here to include the District of Columbia, Montgomery and Prince Georges Counties in Maryland, and Arlington and Fairfax Counties, Va., and the independent city of Alexandria, Va. It is an area of approximately 1,400 square miles with approximately 2 million inhabitants. This complex comprises two States and a Federal jurisdiction.

The D.C. metropolitan police force, serving 614 square miles and 764,000 people, currently uses three duplex channels to control a mobile fleet of approximately 106 cars on patrol at any one time.22 See table D-6. In addition, two duplex channels are used in a well-designed system for communicating with foot patrolmen from the precinct houses. These latter channels will not be referred to again as the need for them is peculiar to the District and the small size constraints on handhelds inhibits the use of multiple channels in any sharing arrangement.

Montgomery County, bordering the District to the north and west, controls approximately 40 mobile units on patrol by means of two simplex channels, reserving a third simplex channel for emergency use. The county police department is responsible for the policing of all of Montgomery County, approximately 500 square miles and 341,000 people, with the exception of the city of Takoma Park which is partly within Montgomery County and partly within Prince Georges County. Table D-7 summarizes the police radio frequency usage in the Washington.
It is a municipality of 16,799 population (1960 census) and 2.2 square miles with a 28-man police force.

While Prince Georges County has a police force, a number of incorporated municipalities in the county have their own independent forces whose cars are dispatched by county police headquarters. In addition, the cities of Mt. Rainier, Hyattsville, and Greenbelt possess their own communications system for about 20 police mobile units.

The loading for Prince Georges County has been adjusted to include usage of a special channel on a day-to-day basis. This may be somewhat unrealistic since the channel is sufficiently large that the special channel may be required frequently as to be unavailable for control of mobile forces when needed. Nevertheless, the unmodified load is 67 percent and this figure results in such lengthy delays in placing messages—on the order of 5 minutes—that the additional channel should be used when available. These two channels are also available to Herndon.

**Optimization of Washington Metropolitan Area Police Communications—On a County Basis**

As a first step in considering the possibilities for a more effective police mobile communications system for the Washington metropolitan area, consider the coordination of all such communications within the jurisdictions of the individual counties in this area. For realism, it can be assumed that there is no transfer of radio spectrum resources across county lines, but that complete cooperation within an individual county is expected.

Under the above ground rules, integration of the duplex channels of Washington, D.C., would result in the improvement indicated in table D-9. The communications facilities of Montgomery County are already integrated on a countywide basis with the exception of Takoma Park. For simplification, in this model, Takoma Park will be included with Prince Georges County.

In Prince Georges County, the mobile police communications facilities of Takoma Park, Mt. Rainier, Hyattsville, and Greenbelt are to be combined with those of the county. To the integrated facility, the following frequencies are available:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prince Georges County</td>
<td>156.00</td>
</tr>
<tr>
<td>Greenbelt</td>
<td>153.38</td>
</tr>
<tr>
<td>Hyattsville</td>
<td>155.13</td>
</tr>
<tr>
<td>Mt. Rainier</td>
<td>154.65</td>
</tr>
<tr>
<td>Takoma Park</td>
<td>155.82</td>
</tr>
</tbody>
</table>

Accordingly, the integrated system, as shown in table D-9, may be designed to have 3 duplex channels to handle the approximately 65 cars on patrol in the county. This would be an entirely adequate system for all normal purposes and would provide improved performance for all police in the county as is shown in table D-10.

The loading on the new system was estimated by noting that the average loading on five channels previously was 14.4 percent. Converting this to a three-channel system yields 24 percent average channel loading in the new system. Note, from the table, that this channel system results in very efficient service.

It may appear that a new channel would be particularly benefit from the change to a countywide system. Note, however, that their communications facilities, originally one channel for an average of two cars, were entirely adequate and continue to be so after the consolidation. In addition, Mt. Rainier force is now tied in with a larger capability and may tap those larger resources when the situation requires.

The example just presented of an integrated police mobile communications system for Prince Georges County is valid from the viewpoint of systems engineering but has some shortcomings in terms of component or subsystem design. Suppliers of mobile radio equipment prefer...
### TABLE D-9 - SUMMARY OF CURRENT POLICE SPECTRUM LOADING IN WASHINGTON METROPOLITAN AREA

<table>
<thead>
<tr>
<th>User Original Position</th>
<th>Diagram</th>
<th>Table Load</th>
<th>Aes Modified Load</th>
<th>Probability of Delay</th>
<th>Expected Delay (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, D.C.</td>
<td>155.080</td>
<td>106</td>
<td>0.37</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.030</td>
<td>106</td>
<td>0.37</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.010</td>
<td>106</td>
<td>0.37</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Montgomery County</td>
<td>158.73</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Takoma Park</td>
<td>158.73</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Prince Georges County</td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.70</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Fairfax (City)</td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.70</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Falls Church</td>
<td>156.15</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156.14</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156.13</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Vienna</td>
<td>155.70</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.69</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.68</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Herndon</td>
<td>155.64</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.63</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.62</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Fairfax County</td>
<td>155.64</td>
<td>100%</td>
<td>0.14</td>
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</tr>
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<td>155.63</td>
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<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.62</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>

1Shares channel with Fairfax County

| Code: D | Dispatcher
| Code: S | Simplex Radio Channel
| Code: T | Talk-out Half of Duplex
| Code: W | Talk-in Half of Duplex

### TABLE D-9 - POLICE SPECTRUM LOADING IN COORDINATED COUNTY SYSTEMS

<table>
<thead>
<tr>
<th>User Original Position</th>
<th>Diagram</th>
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</tr>
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<td>158.73</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Prince Georges County</td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.70</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Fairfax (City)</td>
<td>158.72</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.71</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.70</td>
<td>50%</td>
<td>0.50</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Falls Church</td>
<td>156.15</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156.14</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156.13</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Vienna</td>
<td>155.70</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.69</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.68</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Herndon</td>
<td>155.64</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.63</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.62</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Fairfax County</td>
<td>155.64</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.63</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>155.62</td>
<td>100%</td>
<td>0.14</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>

1Shares channel with Fairfax County

| Code: D | Dispatcher
| Code: S | Simplex Radio Channel
| Code: T | Talk-out Half of Duplex
| Code: W | Talk-in Half of Duplex

### Table D-10 — Communications Delays Within Prince Georges County

<table>
<thead>
<tr>
<th>Police Department</th>
<th>Present communications system</th>
<th>Integrated County System</th>
<th>Delay (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montrose</td>
<td>0.54</td>
<td>0.54</td>
<td>1.2</td>
</tr>
<tr>
<td>College Park</td>
<td>0.75</td>
<td>0.75</td>
<td>1.2</td>
</tr>
<tr>
<td>Park Potomac</td>
<td>0.54</td>
<td>0.54</td>
<td>1.2</td>
</tr>
<tr>
<td>Prince Georges County</td>
<td>0.54</td>
<td>0.54</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Closed spaced channels in order to simplify the design of their equipment and so keep costs within limits. The frequencies available to Prince Georges County are awkwardly spaced for inclusion in a single multichannel set due to the 158.73 MHz frequency and indicate the shortcomings and the additional costs involved in pooling on a relatively small base. Thus, the economies of scale that result from coordinated communications networks are twofold. First, the efficiencies derived from channel sharing and the resulting decrease in probability of delay in placing calls are more impressive as more channels are used. Second, the larger the base for the coordination,
In Fairfax County, the following frequencies are available:

<table>
<thead>
<tr>
<th>County</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairfax</td>
<td>154.79</td>
</tr>
<tr>
<td>Prince</td>
<td>154.80</td>
</tr>
<tr>
<td>Falls Church</td>
<td>154.81</td>
</tr>
<tr>
<td>Falls Church</td>
<td>154.82</td>
</tr>
</tbody>
</table>

A three-channel duplex system is suggested with VHF channels used for talking out to the cars and the HF frequencies used for talking back to the dispatcher from the car. The average loading of the new system, calculated before it is implemented, is approximately 32 percent. The receiving antennas at the fixed sites should be designed for low angle coverage to take advantage of the transmitted signal. All such systems would have duplex channels, with the exception of Montgomery County's system which uses simplex channels.

By the present simplified analysis, if the above recommendations were adopted all police mobile communications would be adequate but with neither growth capability nor the ability to accommodate additional required services such as hand-to-hand and communication links away from the car. The latter requirement calls for additional frequencies.

With the immediate problems at least partially solved, in this hypothetical case, examples of the features of the situation that would exist in Virginia. The police officer in his mobile vehicle, when he wished to place a call, would press the microphone on the radio to form a circuit to the central station. Alternately the coded address could be a part of the pre-taped talk function, automatically transmitted while listening to the radio. The officer's reply might be expressed by some of the police officers in his department. The coded address could be a part of the pre-taped talk function, automatically transmitted while listening to the radio. The officer's reply might be expressed by some of the police officers in his department.

The frequency at this point in simplified analysis, if the above recommendations were adopted, all police mobile communications would be adequate but with neither growth capability nor the ability to accommodate additional required services such as hand-to-hand and communication links away from the car.

Table D-9 summarizes the material.

### Table D-11—Communications Delays Within Fairfax County

<table>
<thead>
<tr>
<th>Police Department</th>
<th>Integrated County System</th>
<th>Percent of Calls</th>
<th>Probability of Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairfax County</td>
<td>85.00</td>
<td>96.00</td>
<td>0.24</td>
</tr>
<tr>
<td>Prince George's</td>
<td>85.00</td>
<td>96.00</td>
<td>0.24</td>
</tr>
<tr>
<td>Falls Church</td>
<td>85.00</td>
<td>96.00</td>
<td>0.24</td>
</tr>
</tbody>
</table>

### Consideration of Area-Wide Coordination

From Table D-9 it is seen that through coordination on a countywide basis the loading of the system is nearly satisfactory for all police mobile forces, with the notable exception of the county of Arlington. The situation is somewhat artificial, however, for the following reasons:

- The frequencies included in Prince George's County are spaced two channels apart for efficient equipment design;
- Specifically, the 158.73 MHz channel should be exchanged for one in the 154 MHz region.
- The Fairfax County system uses HF frequencies that are generally undesirable because of the HF interference.
- One solution, the Fairfax County problem would be an integrated Virginia suburban system combining the city of Fairfax, Prince George's, and Fairfax County.
- Such a system would have enough VHF frequencies for four duplex VHF channels and would have an average loading of 39 percent, which would result in probabilities of delay less than 8 percent and expected waiting times of only 4 seconds.
- The frequencies available are 154.74, 154.80, 154.90, 155.00, 156.79, 158.79, 158.91, and 158.97 MHz.
- The frequencies result in the system being spaced away from the channel and we would suggest that the integrated system be exchanged 154.79 MHz for a frequency in the 154 MHz range.
- In the event that such a change were made, all cars in the area would have at least three send-and-receive channels. All such systems would have duplex channels, with the exception of the Prince George's County system which uses simplex channels.
- This point in simplified analysis, if the above recommendations were adopted all police mobile communications would be adequate but with neither growth capability nor the ability to accommodate additional required services such as hand-to-hand and communication links away from the car.
- The latter requirement calls for additional frequencies.
- With the immediate problems at least partially solved, in this hypothetical case, examples of the features of the situation that would exist in Virginia. The police officer in his mobile vehicle, when he wished to place a call, would press the microphone on the radio to form a circuit to the central station. Alternately the coded address could be a part of the pre-taped talk function, automatically transmitted while listening to the radio. The officer's reply might be expressed by some of the police officers in his department. The coded address could be a part of the pre-taped talk function, automatically transmitted while listening to the radio. The officer's reply might be expressed by some of the police officers in his department.

Local political situations in any local area will also play a part in determining the configuration of network and equipment.

The police department is sufficiently well equipped and are directed to accommodate channel sharing that any realignment of additional frequencies will be considered.

As they do for more efficient spectrum utilization and for much greater flexibility in establishing compatible systems. In a somewhat different arrangement, for example, the Arlington police could call Alexandria police cars either directly or by being patched through to the system. This frequency may be removed from general service and assigned to a tactical force working on a car-to-car or car-to-base basis if so required. It is to be emphasized that frequencies allocated for the same use in different locations, although the same frequency band, will involve different costs. It should not be difficult, however, with selective calling to design and implement systems which are so built that they can later be modified to accommodate additional desirable features.

The concept of multiple selection of channels must be taken as only a recommended approach for investigation until such time as the detailed design and development has been accomplished on a specific system. One feature of the system that must be extremely attractive to the police community is the ability to create special channels without putting a frequency "on-the-shelf." Thus a single spare channel for the Washington metropolitan area could be provided by proper coding and the proper placement of transmitters and receivers and the frequency planned for use by that channel may be used on all occasions, even by a neighboring county when the coordinated networking is required, by a police department in its normal day-to-day operations. This practice contrasts very favorably with the alternative one of holding frequencies in reserve for detective work or citywide use but not allowing these frequencies available for general use at other times.

### Critique of the Example

The example just given shows that a great deal can be done by the police themselves to alleviate their spectrum crowding problems. The solution arrived at the specific police need is by no means a perfect one. Further, it is evident that major gains in more effective use of the radio spectrum shortage is sufficiently severe that any realignment of frequencies which might be made available to the police as backup frequencies for emergency purposes or for weekend radio traffic are not directly concerned with public safety.

There are problems involved in designing such networks. The highway maintenance frequencies which might be made available to the police as backup frequencies for emergency purposes or for weekend radio traffic are not directly concerned with public safety.

Police should be encouraged to make a case for using police frequencies in reserve for detective work or citywide use but not allowing these frequencies available for general use at other times.

### The Design of Public Safety Networks

Since the times of heaviest usage of the different public safety communications channels do not coincide, it is evident that major gains in more effective use of the radio frequency spectrum can be made by the creation of such networks combining various public safety users. While the police and fire channels are used all 7 days of the week, in the evening and night hours as well, the same is not nearly as true for highway maintenance or for local government frequencies used for miscellaneous local activities not directly concerned with public safety.

There are problems involved in designing such networks. The highway maintenance frequencies which might be made available to the police as backup frequencies for emergency purposes or for weekend radio traffic are not directly concerned with public safety.

Further consideration which has been raised by police communicators is that if they can acquire additional channels, as needed, from other municipal services, then they are not directly concerned with public safety. Further, it is evident that major gains in more effective use of the radio spectrum shortage is sufficiently severe that any realignment of frequencies which might be made available to the police as backup frequencies for emergency purposes or for weekend radio traffic are not directly concerned with public safety.
police is created for a large number of individual mobile radio networks. Nevertheless, these centers represent a distinct advantage in the patchwork of small separate dispatch centers that exist in most counties.

Some cities, notably Los Angeles, Chicago, and New York, however, have such large police departments that they already have the advantages of scale needed to develop networks along the lines proposed in the future. In some of these cities, a distinct and entirely separate police dispatching center would continue to be needed.

The possibility of viewing public safety needs from a total municipal viewpoint has important implications in terms of FCC allocations and assignments. These topics are considered separately.

THE RELATIONSHIP BETWEEN THE POLICE AND THE FCC

The allocation of different portions of the spectrum to different usage is carried out by international agreement. Within the United States and in the nongovernment sector of the radio spectrum, the allocation of bands of frequencies to different governments and organizations is determined by the FCC. Within the framework of these allocations, assignments are made to users of individual frequencies, including agencies of the Federal Government, and are then made by the FCC. The coordination of activities in the Government bands—which refers to Federal Government only since State and local government use of the radio spectrum is under FCC jurisdiction—is carried out by the Intragovernmental Radio Advisory Committee (IRAC). IRAC has a permanent staff located within the Telecommunications Management of the Executive Office of the President.

In earlier years it was not uncommon for considerable sharing of frequency resources to exist on a somewhat informal basis. Before World War II the communications center of the large municipal Police Departments—dispatch station and, unless otherwise required, the actual workings of the system have been kept completely separate from the use of frequencies on a highly individual basis. The result has been that, although users need relief from frequency congestion, there is no significant sharing of the frequency resources. The one exception to this is the police radio network, which is a public service. This allows the police to address the frequency questions on a national level with which it must be concerned.

The increased metropolitan congestion and the shift to the less interference-prone VHF and UHF bands, however, have caused the large metropolitan police forces to have been too large to provide service to their smaller neighbors. Their coverage has been too limited to reach distant neighborhoods reliably. As indicated in the preceding sections, it is proposed once again to return to a system of closer intermunicipal cooperation in the interest of more efficient use of the radio frequency spectrum. The significant change proposed here, and which was made previously in the case of the average not-yet-large local area, is to locate the police radio network in major metropolitan areas with which it will deal directly. The FCC allocates frequency assignments in the Public Safety Radio Service.

This system on a national level with which it must be concerned. The President's Office has reviewed this recommendation and has recommended that the FCC assign frequencies only to the local government and not the municipality, which is recommended that the FCC assign frequencies only to the local government and not the local government itself is not involved. The only exception is the Public Safety Radio Service. The frequency advisor does not have any authority or desire to consider the necessity for the request and he must avoid jurisdictional disputes. In effect, they, all users deal directly with the FCC. The FCC has no hierarchy of organization among users and no overall communications planning that extends beyond the limits of individual police departments. In many cases, however, the frequency advisor can contact the local radio spectrum resource Under section 89.101 of the FCC, the selective code is analogous to the telephone number.

To a large extent, radio policy is in spirit already in cooperation with the Intragovernmental Radio Advisory Committee. However, the police may be desperately short of radio resources. It is probable that this is the case in a number of metropolitan areas with serious police communications problems.

The response from the one knowledgeable and experienced individual to the suggestion that the assignments of the radio spectrum resources be made directly to the local government was the President's Office has reviewed this recommendation and has recommended that the FCC assign frequencies only to the local government, or any combination of the two. From the FCC.
The contributions from all of these groups has, in spite of the informal nature of an advisory function, often been substantial as evidenced by analyses presented in FCC dockets.

DETENTION BY THE FCC OF RESPONSIBILITY FOR SPECTRUM ASSIGNMENT

Finally, in connection with the frequency assignment procedures, the suggestion has been made on several occasions that the public safety bands be placed in a special category distinct and separate from that of the commercial, industrial, and broadcast users and possibly outside the FCC jurisdiction. The approach has obvious merit in that the criteria for evaluation of the needs in public safety are, and should be, totally different from those used for the needs of the commercial interests. This difference is emphasized by analyses currently being made of the "dollars value per unit wave length" of the spectrum. It is difficult to apply this dollar approach to the public safety users.

In spite of the fact that the public safety users are in a different category than are the commercial and industrial users of the spectrum, the creation of a special category for public safety does not appear to be practicable. The three possibilities are:

Transfer public safety from the nongovernment bands, under the FCC jurisdiction, to the government bands, under IRAC jurisdiction.

Create a new category and a new agency to handle the public safety portion of the spectrum.

Retain the present status but create conditions to improve the "bargaining power" of public safety users vis-a-vis broadcasters and commercial users.

The first possibility does not appear to offer any advantage to the public safety user, and in particular, appears to have several disadvantages. IRAC, (Intergovernmental Radio Advisory Committee) is a committee of Government agencies which operates under the support of the Executive Office, Office of Telecommunications Management. In working with IRAC public safety officials would find themselves immersed in Federal Government activities with which they were not familiar and often discover that essential information on frequencies was classified by the military. There are obviously monstrous advantages to working in a completely open atmosphere with the FCC and for this reason the shift to IRAC is not recommended.

The second possibility of a new category and a new agency is also considered to be inadvisable. The creation of a new category and a new agency would further complicate the problem of government administration of spectrum allocations. Considerations of reallocation of spectrum space in the nongovernment portion of the radio spectrum would involve interactions between two Federal agencies which would inevitably slow the process and make it more difficult the decisions.

Accordingly, it is recommended that the public safety bands be retained in the nongovernment portion of the radio spectrum under the jurisdiction of the FCC. This recommendation rejects the suggestion that this band of frequencies be transferred out from under FCC control to the government portion of the spectrum.

Consider now the third possibility, that of retaining the present administrative machinery, making only those changes necessary to improve the relative position of the public safety users.

PROCEDURES FOR DEVELOPMENT OF QUANTITATIVE PROJECTIONS OF NEEDS

The International Association of Fire Chiefs (IAFC)

The International Association of Chiefs of Police (IACP)

The American Association of State Highway Officials (AASHTO)

The Land Mobile Section of the Electronics Industries Association (EIA)

The Public Safety Communications Council

The Advisory Committee of the FCC for Land Mobile Radio Services

Eastern States Police Radio League (ESPLR)

FIRE

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PROCEDURES FOR DEVELOPMENT OF QUANTITATIVE PROJECTIONS OF NEEDS

With the exception of the Associated Public Safety Communication Officers (APCO), the organizations which provide guidance to the FCC in public communications matters do so from the overall viewpoint of the land-mobile users. Further, industry is well represented in these other organizations which include the Land Mobile Advisory Committee of the FCC and the Land Mobile Section of the Electronics Industries Association. While there is no fundamental objection to industry working in support of public safety—and indeed the technical personnel supplied by industry have made some outstanding contributions—the industry sales base in public communications is small compared to its sales base in commercial and industrial mobile communications.

The only organization, then, that represents the public communications community directly is APCO. APCO, however, is a professional organization composed mainly of public safety communications personnel who pay their own dues to provide operating funds. There are some State, county, and municipal memberships (governmental) in Illinois, Arizona, and California, but for the most part, the local governments provide no formal support. While a greatly strengthened FCC field organization would relieve APCO of many of its radio spectrum user coordination responsibilities such a development would represent outside monitoring rather than voluntary user cooperation and would represent a more expensive and probably less effective means of effecting an FCC user interface. APCO, presuming it can obtain the financial support necessary to carry out the duties involved, is probably the most logical organization to provide the FCC with continued projections of public needs and to guide the public community toward a unified approach to their radio-spectrum problems. In spite of these handicaps, APCO has provided important input to publicizing to the FCC the communications problems of public safety and the police.

The organization supports a Washington-based
Electronics Equipment Associated with the Police Car

By Raymond Knickel

Introduction

Senior police officials, in addition to being concerned about alleviating the spectrum congestion problem, expressed a need for a number of new electronic techniques and devices. Three new techniques and devices would all in one way or another increase operational effectiveness or decrease costs. In the limited time available, the following were considered and are reported on herein:

1. The potential for equipment standardization to reduce cost and ease maintenance and operation problems.
2. The use of mobile teleprinters in patrol cars to provide officers with written instructions, and to reduce the likelihood of unauthorized interception.
3. The advantages of utilizing microminiaturization techniques to design small personalized two-way radios for police use.
4. The advantages of car-locator devices and the techniques available for implementing car-locator systems.

As the result of the success of AID and the Association of American Railroads in standardizing mobile two-way radio equipment, it appears that a limited standardization program would provide substantial benefits to the police community, and that a limited standardization program could be undertaken immediately. The benefits of a broad standardization program are less certain.

A number of manufacturers have recently developed teleprinters suitable for installation in patrol cars. It appears that their use can do much to relieve the problems of frequency congestion, security, unattended operation, written records and instructions, and the problem of phonetic errors with voice communications. Although some errors in transmission occur when teleprinter equipped patrol cars operate in urban areas while the vehicle is in motion, there are various error-correcting techniques that could be employed. The best means for operationally and technically integrating mobile teleprinters into the police communications system, including the most appropriate error-reducing techniques, still need further study.

Some phrases that are frequently used in police communications have been coded and are widely used to speed communications and improve accuracy. Simple, coded, switch-operated signal devices could be designed to transmit these standard phrases in digital form. The devices could ultimately improve network efficiency and provide direct communication between a police officer and a computer. The potential uses for these coded signal transmitting devices and their probable cost must still be defined.

Presently available hand-held two-way radios for police use are unnecessarily expensive and cumbersome. Microminiaturization techniques could be employed to greatly reduce their size, weight, and cost. Patrol car radios could be converted to radio repeaters for amplifying and relaying messages from small low-powered units carried by the officer when he is away from his car. Contrary to popular belief, there are indications that hand-held units might provide more reliable communications on higher frequencies such as 960 MHz, particularly when trying to communicate from the inside of a building. Because definitive data on this issue is lacking, however, a test program is needed to determine whether further reductions in size and more reliable communication could...
result from using higher frequencies. The Federal Government should assume the leadership in carrying out this test program, in bringing about the standardization of mobile police equipment and in developing methods for the officer away from his car to use his car radio as a repeater.

There is a recognized need by the police community for a means of tracking and plotting the locations of police vehicles. It is known that several companies have assumed that for a carlocator system to be effective they would have to be accurate to within about one block. An analysis showed that the potential benefit of a carlocator system could be achieved with a system having an accuracy better than a quarter of a mile, which opens the possibility of using techniques that had been previously considered to be too inaccurate.

A patrol car emits a callbox sensor technique and a modified radar transponder technique, as well as other possible techniques, appian for further study.

**POTENTIAL FOR STANDARDIZATION OF POLICE PORTABLE RADIO EQUIPMENT**

Equipment is already standardized to a large extent in police radio but only because a few large suppliers dominate the field, as shown in Table E-1. Their products become standard for the police department that uses them; replacement units purchased from any other supplier in a later year would be incompatible.

| Suppliers | Major manufacturer | Model |-
|---|---|---|---|
| Major manufacturer | Model |-
| Police radio units | $125 |-
| Total police radio units | $125 |-

**Table E-1** The Police Mobile Radio Market

Suppliers

- Major supplier: $500,000
- 2 smaller suppliers: $250,000 each
- Other suppliers: $100,000

**Costs:**
- Total cost of units: $100,000
- Total cost of replacement units: $5,000
- Total cost of assembly: $250,000

The radio industry tends to argue against standardization beyond the electrical and performance standards that are now by the EIA. These standards cover such topics as:

- Minimum power supply life
- Average relay life
- Amount of spurious radiation
- Average radiation sensitivity

The industry has long been successful in terms of use of operating controls, ease of maintenance, and ease of replacing one manufacturer's equipment with that of another.

**POTENTIAL ADVANTAGES OF STANDARDIZATION**

There are a number of possible ways in which standardizing police equipment can lead to cost savings:

- Equipment standardization would allow community, counties, and even States to combine their equipment procurements so that essentially identical equipment purchased can be bought in large quantities to reduce the competitive bid.
- Less test equipment, and in some instances simplified test equipment, should be required to maintain equipment in repair.
- A smaller variety and smaller overall number of spare parts and interchangeable plug-in modules would have to be kept on hand if equipment were standardized. If all the communities within a metropolitan area used identical equipment, economies could be effected by combining their repair facilities.
- When improvements or modifications to standardized equipment are required, identical modification kits could be procured in large quantities at a lower unit cost by combining the requirements of several police organizations.
- With only one type of equipment to repair, police radio technicians would require less training.

**POTENTIAL HAZARDS OF STANDARDIZATION**

Despite the many genuine advantages of equipment standardization, there are also potential disadvantages.

- The manufacturers of police radio equipment point to the objectivity of the standardization. They argue that standardization would stifle their incentive and desire to keep improving their product. The manufacturers point out that they spend a great deal of their own funds on research and development and that their efforts to develop improvements would gain them no rewarding competitive advantage.
- Every attempt should be made in adopting standardized equipment to utilize designs that will be as simple and as easy to maintain as possible, thereby lessening dependence on the service organizations of the manufacturers.

The hazards of standardization should not be looked at where there is not a clear-cut advantage to standardization. Carrying standardization to the limit where every electrical component and its location is precisely specified will cut costs at the consumer but could result in the dire consequences of standardization predicted by the manufacturers. On the other hand, standardization to the point where police departments avoid becoming captive markets would certainly appear to be the minimum that should be considered.

**SUMMARY OF STANDARIZATION**

The Telecommunications Branch of the Office of Public Safety of the Agency for International Development (AID), under the direction of Mr. Paul Katz, has designed a line of mobile radio receivers primarily for use in Vietnam. These units have been made standard units by the Office of Public Safety and they are now scheduled for AID public safety programs in Costa Rica, Colombia, Thailand, Laos, and Guatemala. AID estimates that more than $4.5 million has been saved as of 30 March 1966 as a result of adopting these transceivers as standard units for AID public safety programs throughout the world.

The AID equipment was developed originally because of the need for simplified communications, a problem which provided police radio technicians with less training. The AID design fulfilled these requirements in a very limited sense, such as requiring interchangeability of receivers, transmitters and power supplies, the manufacturers claiming that their efforts to develop improvements would gain them no rewarding competitive advantage.

The AID design can be a model of what would be achieved at a very early date, and with a minimum of effort, through a program of limited standardization. The full benefit of standardization, based on equipment designs incorporating the latest and most modern techniques for enhancing the effectiveness of police communications, might require a broader and more prolonged program of standardization.

**Limited Standardization Program**

The objectives of the limited standardization program should be to standardize equipment to the point that equipment units built by different manufacturers would be operationally compatible, electrically and physically interchangeable, and equipped with identical standard controls. This would include standardization of the following aspects of equipment design:

- Sockets and plugs
- Terminals and the utilization of the individual terminals: housing dimensions
- Mounting racks and base plates
- Control heads
- Technique for selective signaling
- Crystals and crystal holders

The Association of American Railroads has successfully standardized its equipment so that all of its mobile radios are electrically and physically interchangeable. They
I have accomplished this by standardizing sockets, plugs, terminal strips, housing dimensions, mounting racks, and base plates. The Colorado Highway Patrol has designed and implemented a series of standard test equipment for each category of equipment manufactured by the city. This eliminates the need for special test equipment and reduces cost. Thus, the proposed limited standardization program has been demonstrated and is feasible.

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**Terminal Police Services**

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**Terminal Police Services**

should be to develop a checklist or series of instructions for installing and setting up the two teleprinter channels within the 5,000 Hz voice channel of existing police networks. If it were completely de
ced to achieve optimal performance, it is likely that the system would have been designed using proprietary or special purpose hardware.

**Broad Standardization Program**

The objectives of the broad standardization program would be to develop and implement the following three objectives:

1. The equipment should be designed to incorporate advanced features as they become available and are needed by individual departments. In order to keep the equipment cost at a minimum, any unnecessary features should be eliminated from the basic design. In addition, there would be the benefit of acceptance of the equipment so that it could be built in large quantities.

2. Any such standardization program must be continuously reviewed in order that police radios keep pace with technological advances. The initial program defined the operational problems in

3. Digital communications links that would augment the voice communication links could do much to alleviate these problems. Such digital links could be provided for teleprinter links or coded signal device links, either of which could be one-way or two-way.

**TELEPRINTER LINKS**

In addition to meeting some of the problems of voice communications, two-way teleprinter links could connect a patrolman in a car directly to a computer so that he could check for wanted persons or stolen autos. A receiver-only teleprinter in the patrol car would be much less expensive than a transceiver unit, and such a device would be useful for more general communications, such as those concerning crimes in progress, pursuits, and so on.

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**Digital Communications in the Police Mobile Radio Network**

Although voice is an indispensable mode of communications for patrol vehicles, it has a number of problems:

1. It is wasteful of the already overcrowded radio-frequency spectrum.

2. It provides no protection against unauthorized interception of official police communications unless expensive scramblers are employed.

3. It does not provide a set of written instructions or documents that can be used for reference.

4. It is subject to phonetic errors.

5. It cannot be received by an unattended patrol car without special recording equipment.

Digital communications links that would augment the voice communication links could do much to alleviate these problems. Such digital links could be provided for teleprinter links or coded signal device links, either of which could be one-way or two-way.

**Teleprinter or digital data communications are inherently more secure than is the use of filters, scramblers, or special equipment to prevent eavesdropping or scrambling. Monitoring of police communications frequencies would become less productive to the criminal. Should it be the intent of teleprinter recorders to transmits signals in the vicinity of 150 and 450 MHz. Propagation in built-up areas at these frequencies is known to take place by reflection and scattering of the radio waves as they bounce off buildings and other reflecting objects. As a result, the signal received at any point is usually the sum of several signals arriving via different paths. If the signals from the different paths all arrive in phase, the combined signal will be very strong. If all of the signals from the different paths are completely out of phase, the resulting combined signal will be lost in the noise. Moving the antenna a fraction of a wave length, in this case only a few inches or feet, can completely change the phase relationship of the arriving signals making the resulting signal either much stronger or weaker.**

Thus, the signal strength at the antenna of a car in motion will be continually varying. With frequency modulation, which is universally employed by police units, there are constant excursions in received signal strength that are generally noticed only when the signal drops so low that it cannot be detected. Even then, since this situation is usually only momentary, in voice communications only a part of the signal is lost. Digital communications, however, are much more susceptible to momentary fades. During the momentary signal fade, the patrol car receiver emits a burst of noise. Any data link, teleprinter, or coded signal device would respond to this noise and print some character that will almost always be out-of-character.

Since teleprinters for mobile use have only recently become available, there is insufficient data available to determine the extent of the problem of bit errors. Correcting codes could also be used to reduce the error rate.

There are techniques, both operational and technical, for reducing the error rate. One operational technique is to use error-correcting codes. A second technique is to use more powerful error-correcting codes that could also be used to reduce the error rate.

Although it would add to the cost, the technique of space diversity reception could reduce the error rate significantly. This technique depends on the fact that if one antenna receives a signal that is above the noise level, then a second antenna placed a few feet away will also be in a signal null at the same time. Therefore, using two antennas would result in an increase of the signal-to-noise ratio. This would improve the performance of the system by reducing the number of errors.

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spaced antennas and by duplicating portions of the patrol receiving a usable signal, the teleprinter records the correspondence in car receiver, it is possible to combine the signals of the two antennas in such a way that if either antenna is receiving a signal, the teleprinter records the correspondence. Since the cost of implementing this technique is estimated to be for each link, could also be employed. Significant degree of security to communications. Since transmission still further and at the same time add a noticeable degradation of the voice quality. The coded signal link to an existing voice channel link without E-1 for teleprinter links. In this case, however, instead of integrate a specialized receiving unit. A specialized receiving system is probably limited primarily to police users, who represent but a small percentage of the total vehicular communications market to which teleprinters could be sold. A mobile teleprinter has very broad use across many markets and is more likely to be mass produced.

**Conclusions**

Both teleprinter and coded signal device links with patrol cars are technically feasible. Although two-way teleprinter links are probably too expensive for general use at this time, there may be specific applications that would warrant their cost.

Receive-only coded signal devices for vehicle would be cost as much as a counterpart teleprinter link, and receive-only teleprinter links would cost between $1,000 and $2,000 per car, depending on the elaborateness of the equipment (for instance, strip printers or page printers) and the extent to which it is found necessary to implement error correcting techniques. The advantages gained by the use of patrol car receive-only teleprinters warrants their consideration for general use. An operational evaluation should be undertaken to assess the advantage of mobile teleprinters for police operations. If these are found to be significant, then a system design program would be needed to:

- Examine how mobile teleprinters can be integrated into the existing police voice communication systems.
- Determine through analysis and test the magnitude of the error rate problem in high multipath areas.
- Make a comparative evaluation of alternative error reducing techniques.
- Evaluate alternative methods for multiplexing teleprinter links within voice channels.
- Prepare equipment and system specifications.

Powerful portable equipment available today does not satisfactorily fulfill this urgent need. It is too heavy, too bulky, too expensive, too awkward to operate, and does not provide reliable communications from the inside of buildings. Even though existing transmitted units weigh only 2 to 3 pounds, this is a burden when added to the other equipment that an officer must carry. Furthermore, existing units are awkward to operate in emergency situations, primarily because the officer must pull out the antenna and hold the unit so that the antenna is away from his body. Shirt sleeve, trouser leg, and earphone cord antennas have been developed, but they are very inefficient because of body shadow loss. Also, existing units for the officer on foot are too costly. The average unit with attachments generally costs from $500 to $750. Most police departments are not willing to pay this high a price even if they are willing to put up with the size and weight of the units. This is a burden when added to the other equipment that an officer must carry. It would appear that existing technology can provide a partial, if not a complete, solution to this problem of portable voice communication for foot patrolmen. The technology of microelectronics employing integrated circuits can greatly reduce the size and cost of units.

**Potential for the Application of Microelectronics**

Microelectronics is already revolutionizing many sectors of the electronics industry. Microelectronics, a small piece of the overall electronics industry, can dramatically reduce the size and weight of electronic equipment. At the same time, this miniaturization results in increased reliability. Perhaps the most significant advantage of these new circuits, however, is that they can be produced cheaply. Leading microelectronics manufacturers agreed that microminiaturized versions of currently used police units would weigh about 12 oz. and could be manufactured at a cost of about $150 in lots of 20,000 or more. This would represent a reduction in cost by about four-fifths.
One of the first steps in the design of portable radio systems would be to compare radio link performance at the different frequencies that either are now available or could be made available to the police in the future. For example, operation at higher frequencies might mean less efficient transmitters, more efficient transmitting and receiving antennas, better building penetration, greater foliage loss, decreased receiver sensitivity, and less competition with industrial electrical noise. The combined net effect could be favorable or unfavorable. There are some indications that if small personal two-way radios were operated at higher frequencies, such as 960 MHz, there might be a net improvement over the presently used frequencies, especially when trying to communicate from inside buildings. Motorola Corp. reported in an in-house paper* as follows:

Another Motorola in-house report** on this same series of trials reported excellent communications at 960 MHz from a test vehicle parked 40 feet underground in a parking garage. Bell Telephone Laboratories found in a test that if 900 MHz is to be favored somewhat for mobile communications over 150 MHz from a transmission standpoint if full use is made of the potentially available antenna gain. In comparing the building penetration capability of 35 MHz and 150 MHz, Bell Telephone Laboratories found that the expected range of coverage into buildings is somewhat greater at 150 MHz than at 35 MHz.* Police and others consistently report better operation results from within buildings at 450 MHz than at 150 MHz.** These results could be explained by theorizing that the window and other surfaces of buildings, being large in comparison to the shorter wave length, become more transparent and that the hallways of buildings act as ducts for the radio frequency. An increase in different radio wave guide operators also exist above cutoff.

Unfortunately, there is no thoroughly collected data on the extent to which the higher frequencies outperform the lower frequencies with regard to building penetration. If experimental results verify that building penetration at the higher frequencies is substantially better than at the lower frequencies, it should be possible to design equipment that could be much less expensive and operate in emergency situations and would provide much more reliable communications from inside buildings. More efficient transmitting and receiving antennas, battery weight and power would represent a large portion (perhaps in the order of 40 percent) of the weight and cost of the entire unit.

There are reasons other than improved building penetration why the higher frequencies might be superior. For ease of operation, the equipment should be capable of being "worn" on the officer instead of being handheld. At 150 or 450 MHz, some sort of telescopin receiver or microphonecoop antenna is required in addition to 8 or 9 dB body shadow loss. In addition, at 150 MHz, because there is no effective ground plane and the antennas do not even approach a quarter wavelength, the antennas are 8 to 15 db less efficient than a dipole antenna. At 450 MHz such antennas come within 2 or 3 dB of regular dipole performance.

At a frequency of 1000 MHz, a quarter-wave dipole antenna would be only 7.3 cm, about 3 inches long. The antenna could easily be worn on the shoulder or the top of a policeman’s helmet with a small metal plate as a ground plane. Such an antenna would have a performance once at least equal to a simple dipole and it probably would be possible to provide some gain in the horizontal plane, yielding another 1 or 2 db of improvement. Therefore, by having a more efficient antenna and avoiding both body shadow loss, it appears that antennas at 1000 MHz could be made 17 to 26 db better than current 150 MHz body-worn antennas, and 11 to 14 db better than current 450 MHz antennas. Table E.2 summarizes how some of these performance factors vary with frequency. It is apparent that a factor militating against higher frequencies is that foliage loss tends to increase with frequency. There could well be a technique that would militate either for or against going to higher frequencies.

To resolve this frequency question, test data must be collected. The test program required to gather the necessary data would be similar to those conducted by L. F. Rice in 1959 and by W. Y. Young in 1962, but expanded to cover the frequency range to 3000 MHz and to include use within buildings.

Table E.2—Performance Factors vs. Frequency of Portable Police Radio Equipment

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Gall with respect to a</th>
<th>Industrial and medical noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 MHz</td>
<td>-3 dB (receiver or amplifier noise)</td>
<td>-8 to -9 dB (trouser leg or earphone cord)</td>
</tr>
<tr>
<td>450 MHz</td>
<td>-8 to -9 dB (trouser leg or earphone cord)</td>
<td>-15 to -17 dB (receiver or amplifier noise)</td>
</tr>
<tr>
<td>900 MHz</td>
<td>-13 to -14 dB (receiver or amplifier noise)</td>
<td>-10 to -12 dB (receiver or amplifier noise)</td>
</tr>
<tr>
<td>1000 MHz</td>
<td>-9 to -10 dB (receiver or amplifier noise)</td>
<td>-10 to -12 dB (receiver or amplifier noise)</td>
</tr>
<tr>
<td>1500 MHz</td>
<td>-10 to -11 dB (receiver or amplifier noise)</td>
<td>-10 to -12 dB (receiver or amplifier noise)</td>
</tr>
<tr>
<td>3000 MHz</td>
<td>-11 to -12 dB (receiver or amplifier noise)</td>
<td>-10 to -12 dB (receiver or amplifier noise)</td>
</tr>
</tbody>
</table>

The Single Frequency Repeater Problem

The above techniques, except for the first and the last, would use the patrol car radio as some form of a radio repeater, with the car receiver audio output switched onto the car transmitter microphone input. This requires that the repeater’s transmitter operate on a different frequency from the repeater’s receiver so that the signal output of the receiver will block the transmitter. However, many police radio networks operate in a simplex mode in which each car’s transmitter and receiver do operate at the same frequency. Furthermore, the car radio units are usually designed so that switching of receiver and transmitter frequency is performed simultaneously with the turning of one switch so that the transmitter and the receiver automatically stay tuned to the same frequency. There are three possible techniques for coping with this problem:

- Use fairly complicated time sharing and signal sampling techniques to switch the receiver and transmitter portions of the repeater alternately on and off at an ultrasonic rate, thereby permitting single frequency repeater operation.
- Have police network operate in a simplex mode.
- Modify two-way car radios so that the frequency of receiver and transmitter portions can be switched separately.

The first technique would be too expensive. The second technique would be wasteful of radio spectrum and may introduce the operational deh抓住of blocking car-to-car communications. The third appears relatively easy to accomplish, does not cost extra frequencies linking the car and the patrolman, but acquiring frequencies for such short-range use with low power should not be a serious problem.

** Dettacable Car Radio

The concept of a detachable car radio has the obvious appeal that it represents additional frequencies and it avoids the single frequency repeater’s probable lack of additional equipment which would be a portabie antenna and a snap-on battery power supply.

There are, however, serious disadvantages in this technique:

- Even with fully transmitted mobile transceivers, the set would be cumbersome in size and weight.
- The detached unit probably could not include the final amplifier on the transmitter and it would, therefore, be a comparatively small unit.
- If the car transceiver is operating at a frequency that is less than optimum for transmission from within buildings, communications reliability would be unduly impaired.

**Detachable Car Receiver**

This approach is diagrammed in figure E-2. The regular car radio receiving at frequency $f_1$, would be detached and serve as the receiver unit to be carried by the officer. It would be powered by a recharge battery pack. The officer would also be supplied with a small, inexpensive, short-range transmitter ($T_3$) to transmit to a small receiver ($R_3$) installed in the car. The output of receiver $R_3$ would feed into the regular car transmitter for retransmission to the base station. It is presumed that units could be developed for this purpose that would be relatively simple and inexpensive. This is because the $T_3$ to $R_3$ link (fig. E-2) would always be very short and could be at whatever band of frequencies is found to be optimum for communicating from within buildings. This would mean that the transmitter $T_3$ could have very low power output and the receiver $R_3$ could be relatively insensitive. The advantages and disadvantages are compared in table E-5.

As an alternative, the officer could be provided with only the transmit capability, $T_3$ in figure E-3, and a call to him on the radio could be signaled by remotely sounding the horn or siren of his car. The possible problem of "active multipath intermodulation" warrants some consideration. It is conceivable that two or more patrol cars in a range of a patrolman's hand-held units might have their radio equipment switched into a repeater mode. Even though the transmitters could be controlled and presumably operating on the same frequency, they would almost certainly be separated in frequency by several cycles. Reception of two signals of about equal intensity separated in frequency by only several cycles would result in severe intermodulation and probable loss of intelligibility. It may be possible to handle this problem by means of operating circuit discipline, or if further analysis shows that this is not sufficient, selective coding techniques can be employed so that the hand-held unit would turn on only the one repeater as intended.

**Table E-3.-Evaluation of Detachable Receiver Approach**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requires equipment of an extra frequency for the officer to patrol link.</td>
<td>Requires an extra transmitter and radio control link.</td>
</tr>
<tr>
<td>Requires a very simple small radio control link.</td>
<td>Requires a very simple small radio control link.</td>
</tr>
</tbody>
</table>

**Simultaneous Transceiver**

Another technique is pictured in figure E-3. This method would theoretically provide the most reliable communications since equipment in the car would be used as a repeater for both outgoing and incoming transmissions. This method would involve providing the patrolman with a small inexpensive transceiver and installing a similar unit in the car, which would be connected to the car's regular car two-way radio as shown in figure E-3.

**FIGURE E-3. CONFIGURATION FOR DETACHABLE CAR RECEIVER METHOD**

Compared to the previous concept, this mode avoids engaging and disengaging the regular car receiver and the portable package. It would normally require two additional frequencies for the officer-to-car link units special circuitry were used that would enable operation with one additional frequency. The regular two-way car radio would have to have an additional transceiver capable of linking up with the hand-held transceiver. This method may also recognize the use of selective coding techniques to avoid the "active multipath intermodulation" problem.

**Car Radio Converted to a Simple Repeater**

For radio networks operating in a duplex mode, the output of the car receiver could be connected to the transmitter microphone jack, thereby converting the two-way car radio into a simple repeater. (See fig. E-4.) The officer would be provided with a small, short-range, inexpensive transceiver which would use the same receiving and transmitting frequencies as the base station. This method would not work with simple communication networks where both receiver and transmitter frequencies are the same.

With this method, every transmission by the base station, as well as every transmission by the patrolman, would be retransmitted by the car radio on its regular transmission frequency. No additional frequencies would have to be assigned. The only additional equipment required would be a relatively low power hand-held transceiver to be carried by the officer.

**Use of Simple Short-Range Signalling Devices**

For distress calls, the officer away from his car could be provided with a very simple low powered transmitter ($T_2$). When the officer presses a button, the transmitter would send a coded signal to the companion receiver ($R_2$) in the patrol car transmitter to broadcast an automatic call for assistance. Use of the proper code from $T_2$, the patrol car receiver ($R_2$) would activate a switch that would cause the patrol car transmitter to broadcast an automatic call for assistance. This has the clear advantage that the very narrow bandwidth of the radio control link signal permits a design that could greatly increase the sensitivity of the control link receiver, and thus the link could operate with a very low power hand-held transmitter. It has the obvious disadvantage that the officer cannot describe his predicament without the call being received. Acknowledgement that this call has been received. The dispatcher must rely on a previously reported location. Although expected to be inexpensive, the radio control link would require an additional hand-held transmitter and an additional receiver in the car.

**FIGURE E-4. CONFIGURATION FOR THE CAR RADIO CONVERTED TO A SIMPLE REPEATER**

**Use of Fixed Repeaters**

Although all of the methods for utilizing the patrol car radio as a repeater would greatly improve the communications available to the patrolman away from the car, the methods all share some important disadvantages:

All methods require at least some modification to the patrol car radio. In high multipath areas such as in downtown areas, there are numerous "dead spots"; furthermore the locations of these dead spots can change when nearby vehicles are moved. Therefore, there is a possibility that a patrol car may be ineffective as a repeater because it was inadvertently parked in a dead spot.

Because of the low height of the patrol car antennas, it is not an ideal repeater.

The above disadvantages raise the possibility that other methods may be superior to using the car radio as a repeater. These would include the possibility of a hand-held transmitter linking the patrolman directly to headquarters or to strategically located fixed repeaters. It would not be practical to communicate directly to headquarters in large cities where the patrolman might be inside a building that is several miles from headquarters. On the other hand, smaller cities may find this method both practical and economical, as exemplified by the experience of Berkeley, Calif.

The use of fixed repeaters would be particularly practical in cities such as Washington, D.C., which have already installed a system of repeaters for their foot patrolmen, who are equipped with hand-held transceivers.
there are a number of methods by which the officer away from his patrol car could be provided with relatively reliable communications by using the patrol car radio as a repeater station. Virtually all such methods require the assignment of additional frequencies and some modification of the patrol car equipment. Each of the methods discussed previously away from his patrol car could be provided with relatively $150.

Once the frequency tests previously are conducted, it will be possible to prepare equipment performance specifications for various situations. These could then lead to a development and production program providing micro-miniaturized hand-held units for less than $150.

COMMUNICATIONS FOR THE FOOT PATROLMAN

The approach to a design of a portable radio transceiver for foot patrolmen could be very similar to that discussed above. There are, however, important differences. The foot patrolman’s equipment has to communicate over a greater range since he does not have a nearby vehicle whose radio could serve as a repeater. Although foot patrolmen have a genuine need to be able to communicate from the inside of buildings, they do not have the need on as many occasions as does the motorized patrolman.

Although the foot patrolman most likely cannot take advantage of a nearby car radio repeater, fixed station repeaters can be located at frequent intervals throughout a city so as to reduce the power and range requirements of the portable radio. This, in turn, reduces the size, weight, and cost of the units.

The theoretical line-of-sight range can be shown not to be a limiting factor in the communications range of a typical portable radio; however, the frequency tests discussed above. The frequency range of communications is over 1,100 miles. Under these circumstances, the frequency range of communications is over 1,100 miles. Considering the high frequencies and some modifications when considering more than a few blocks, it is obvious that factors other than transmitter power and the closest available patrol car would have to be introduced to a base station with an antenna height of 50 feet, the horizon-limited line-of-sight range is 13.5 miles. In actual practice, even a range of 13.5 miles would seldom be achieved with a portable police unit. The reason is that foot patrolmen are normally trying to communicate in an environment where the line-of-sight horizon is broken by obstacles from their transistor to the receiver unit is blocked by towers, high buildings, or other similar obstacles. The point at which the two units is possible then only by virtue of scattering and reflections from these obstacles.

This serves to emphasize the need for performing a statistical analysis of actual field measurements to provide the data necessary for realistic predictions of useful range for hand held transceivers.

In order to develop performance specifications for foot patrolman radios and for the design of city networks, field data will be needed on reliable communication range as a function of frequency and power output and on the use of transceivers and repeaters.

Design of radio systems for the foot patrolmen should be related to the number of foot patrolmen, to the type of work they do, and the time they are away from their cars. If the method selected turns out to be that of providing the foot patrolman with a hand-held transistor, then it would be advisable to combine the two specifications. It might be advisable, however, to have two versions of the same equipment. The unit for motorized patrolmen might have a low power output, and the one for the foot patrolman higher power. If the performance specifications for the two types of units are similar, their developments should be combined. If the two units are considerably different, two separate systems might be more practical.

To bring this about, the Federal Government could institute a study to determine size of the immediate market and also the technical specifications which the product should satisfy in order to qualify for the market. The results of this study would be made available to industry in the expectation that the competitive process would bring about the remainder of the developments.

The Federal Government might also initiate a program to develop working prototype equipment. The highly successful programs that have been carried out in any car directed portable radio unit followed this basic approach.

Finally, it might be hoped that the exposure of the equipment here would be sufficient to spur industry to develop the required equipment.

AUTOMATIC CAR LOCATORS

INTRODUCTION

Reducing the response time in getting field units to the scene upon receipt of a call from a citizen has been shown in chapter 2 to be related to improving the probability of on-the-scene resolution of emergency situations. There is an unnecessarily long response time from assigning a patrol car that may falsely appear or maybe available patrol car. Automatic patrol car locators could reduce this problem.

At present, the locations of various patrol cars within a city are known only to the extent that they are patrolling in an assigned sector. As a result, the location of a patrol car is actually known only within 1 to 4 miles traveling distance of its presumed location. Therefore, when handling an emergency call a dispatcher often requests any car in the vicinity of the incident to respond. This usually results in an unnecessarily large number of cars responding to the closest car generally being one of the units.

There are many instances, however, when the closest patrolman or his radio locator system to the location of the caller might not be aware that he is the closest available car to the scene. It was shown in chapter 2 that many calls that are classified as routine actually escalate into emergency situations before the police arrive. In the case of routine calls only one particular car is assigned and it often occurs that the car that is assigned is actually not the closest car. Car locator devices would make it possible to select and assign the available units when this happens.

Of equal significance, however, is the fact that car locator devices make possible more detailed control of the police dispatch. Advantages of traffic control and other radio locator systems are the basis for a more effective use of police officers and the police radio in the traffic control system. The dispatcher can provide more accurate information to the police officer and get a more accurate picture of the traffic situation at the scene. It was shown that the response time for a police request is faster in a city having a radio locator system than in a city without such a system.

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The Federal Government might also initiate a program to develop working prototype equipment. The highly successful programs that have been carried out in any car directed portable radio unit followed this basic approach.

Finally, it might be hoped that the exposure of the equipment here would be sufficient to spur industry to develop the required equipment.
drawn for each car and if the number was less than the out-of-service rate, then the car was assumed to be previously committed and not available for answering a call. A call for service was then generated randomly within the area being simulated. The closest car which was available for service was determined and the actual distance between the call for service and the closest car was calculated. The car which the dispatcher believed to be closest under each assumed set of conditions was then determined. The distance between this car, believed to be the closest, and the call for service was then calculated. The difference, if any, between these two distances was calculated and recorded. The entire process was repeated 100 times. From the mean values (i.e., resolution distance and out-of-service rate) were read and the fraction of the time there was at least 1-mile beat were 2 miles by 2 miles then the additional distance would be 0.6 additional miles. Note that approximately all the value of a car locator is obtained with a resolution of about 0.2. That is, if the beats are 1 mile by 1 mile, the subbeats should be 3/4 mile by 3/4 mile. Furthermore, resolution of 0.4 appears acceptable if there would be a dollar savings obtained by going to 0.4 resolution. This is particularly true for the higher out-of-service rates.

**SOME POSSIBLE LOCATOR TECHNIQUES**

With these relatively loose accuracy requirements, several car locator system designs can be considered. Four techniques show promise of providing the necessary accuracy at an acceptable level of cost:

- A system of patrol car emitters and callbox sensors.
- A modified radar transponder system.
- A medium-frequency radio-direction-finder system.
- A carborne position computation and reporting system.

Patrol Car Emitter-Callbox Sensor System

In this system each car would carry some kind of magnetic, acoustic, or radio emitter that could be detected by a sensing device located in police callboxes. For example, the emitter could be a very low power electromagnetic radiator whose output could be detected by very simple receivers located in police department callboxes, fire department callboxes, or both. Information gathered by the sensors could then be sent back to the communications center over land lines.

Operationally, the system could work in the following manner: The emitter in each car could be a very low frequency induction field device or a very low powered MF or VHF radio transmitter. The emitter could employ solid-state circuit elements and operate from the car battery. It could be mounted near seat and operate in conjunction with the regular two-way radio and could share its antenna. It would be designed to radiate so little power that it could be detected only within a few feet of its antenna. At these power levels no FCC license would be required. Each car's transmissions would be continuously modulated by an identity code, either a selected combination of tones or a coded sequence of pulses. While a solid-state or transistor type modulator is preferred for reasons of reliability, long life, and compactness, it is also possible to provide a motor-driven layer of the cam type such as that used in the caged fire alarm.

A car emitting signal could be sent from the dispatching center to the bus com-
pany to alert them to the situation. The location of the box could also be presented on the computer-driven display.

In Washington, D.C., for example, there are approximately 120 police callboxes (fig. E-10), about 14 per square mile or one every quarter of a mile. This would provide sufficient accuracy for patrol car location. If finer accuracy were desired, consideration could be given to locating sensors in the 2,000 D.C. fire callboxes.

If there were not a sufficient number of callboxes in a city, or if the callboxes use party line circuits, it may be necessary to use carrier derived circuits which can be superimposed upon existing physical circuits, such as fire and police cables, without impairing the present service. The carrier or radio frequency technique is widely used to locating sensors in the field of telephony, radio, and powerline telemetry and control. In telephony, a significant portion of all trunk and subscriber circuits are carrier derived without impairment of the physical services at a cost well below that of additional circuits.

The inverse of this technique could also be employed with coded emitters installed at fixed locations along the street and sensors installed in patrol cars. A radio link would then be needed in the car to relay the car's identification and location to the communications center. The emitter and detector devices should be comparable in cost to the transmitter and receiver devices used with automatic garage door openers. In large volumes, it is estimated that the emitter units would cost about $20 each and the callbox detector units about $30. Thus, the equipment for 1,000 callboxes and 200 patrol cars would cost approximately $30,000.

To this must be added the installation costs and the cost of the central display system, which is difficult to estimate at this time. If a city has a suitable computer available for time sharing and it chooses to use the simplest type of display system, the cost may be as low as $100,000 to $200,000.

**Modular Radar Transponder System**

Because of multipath problems, conventional radar transponder techniques cannot be used as a means for locating police cars. In a conventional radar transponder system a radar interrogator would transmit a coded pulse train in the form of a short burst lasting no more than a few microseconds. The transponder in a patrol car would recognize its code and reply with a short signal pulse. The transit time between transmission of the interrogation pulse and receipt of the transponder reply would be a measure of the distance to the car being interrogated. Azimuth would be determined by the pointing direction of the interrogator antenna.

Unfortunately, the coded pulse train would generally be unrecognizable to the intended transponder because of the overlapping of signals at all they would be received over the various paths. This multipath phenomenon was investigated by W. R. Young and L. Y. Lacy.11 Their investigations indicate that, although VHF pulse signals are modulated severely by reflections in an urban area, they do get through, with the leading edges of the pulses substantially intiiuided in almost every instance. This suggests that some modified radar transponder system not using coded pulse trains might be used.

Two techniques have been suggested. One would be to use the selective signaling system of the car radio system to sequentially turn on transponders for a fraction of a second. During this time, the transponder would be interrogated and range and bearing determined based on the leading edges of the received pulses. No coded pulse train would be required to identify the car being interrogated because this would have been accomplished by the selective signaling technique. This technique has the disadvantage that the times transmitted in the selective signaling process would lend up a voice channel to such an extent that it would not be usable for voice communication.

A second technique uses a periodically synchronized timing system in each car to turn on the car's transponder at predetermined short periods of time. In this technique, a central beacon interrogator with a directional antenna, rotating mechanically or electronically, transmits pulse interrogations. The interrogations and replies are essentially single pulses with a pulse width in the order of 2 μsec. Two different frequencies (in the same band) are used for interrogation and the other for reply. The frequencies used may be in the 120 or 450 MHz bands, or perhaps in the vicinity of 1,000 MHz.

The basic idea in the approach is the use of a relatively high interrogation rate by the interrogator (in the order of 5 kHz), coupled with a time apportionment system where any given interrogator replies to 1 and only 1 interrogator out of roughly 100 interrogations; the interrogation answered by each transponder is different and represents the transponder's identity.

At the start of every 100-interrogation cycle, a special synchronizing signal is transmitted. Each transponder then starts to "count off" successive interrogations until its assigned one is reached. The transponder replies to that interrogation (and no other interrogation) with a single pulse. Thus, each transponder replies to every 100th interrogation at a rate of about 50 Hz, and each interrogation is replied to by only one car. This makes it possible to see closely spaced cars despite reflections, and provides for a very simple identification that does not require either interrogator or transponder pulse modulation.

An important question to be resolved before a final judgment can be made on the feasibility and practicability of this system is what are the effects of reflections on effective interrogator antenna directivity. It is possible that the multiple transmission paths (via different reflections) may cause effective beamwidth broadening and bore sight shift, and presence of false targets at certain values of azimuth. The beamwidth broadening, if not too severe, could be tolerable. The false targets, resulting from the presence of large reflecting surfaces in certain directions, may be reduced to an acceptable level by displacing continuous car trains (for true targets, which would make sporadically received reflections easily distinguishable from true targets). Some limited field tests are needed to observe the actual effects of reflections and to verify the feasibility of the basic approach.

**Medium Frequency Radio Direction Finder System**

Because of their relatively long wave length, MF radio signals are not characterized by extreme multipath propa-
A simple continuous wave (c.w.) radio transmitter in each car.

At least three automatic radio direction finding stations.

Computer to compute the coordinates of each car from the bearing information received from the direction finding stations.

Display device to display the location of each car as determined by the computer.

The selective signaling device envisioned here is included in most existing police mobile radio systems. Selective signaling is accomplished by sending a series or combination of different tones. The receiver can then operate a switch to perform some intended function as turning on a light or a siren. In this case, it would turn on the car's MF radio transmitter for 2 to 3 seconds. The transmitter could be a very simple device consisting of little more than a crystal oscillator. The car transmitter would not have to transmit any coded identification signal since identity of the car would have been established through the selective signaling process.

The major problems foreseen with the direction finder system are that the selective signaling device would seriously load one communication channel, and the time required to take a bearing would limit the number of cars that could be accommodated by a one-frequency system. It might be possible through coding techniques to increase by a factor of two or three the number of cars accommodated and still stay within the 100-Hz bandwidth limitation of these police frequencies.

The approximate costs for a one-frequency system (capable of handling up to about 25 cars) based on available information may be broken down as follows:

<table>
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<th>Component</th>
<th>Cost</th>
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<tr>
<td>Selective signaling feature</td>
<td>$75 per car, including installation.</td>
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<tr>
<td>Carborne transmitter</td>
<td>$15 per car, including installation.</td>
</tr>
<tr>
<td>Direction finder unit</td>
<td>$6,000 for required set of three including installation.</td>
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</table>

Triangulation computer and display system.

Carborne Position Computation and Reporting System

Carborne position computation and reporting systems are here taken to include all systems in which the patrol car sequentially activates the car's position location storage register. The approximate costs for a one-frequency system including installation are shown in the following table.

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The magnetic compass and odometer system is virtually identical to the previous system except that a magnetic compass replaces the inertial compass. Unfortunately, carborne magnetic compasses would normally be subject to variations in magnetic field which could introduce errors that probably would be unacceptable. A higher resolution could be obtained through utilizing dual magnetic compasses and averaging readings.

With the system of manual updating of position location storage registers, a city is divided into relatively small sectors. When a patrol car moves from one sector to another, the new sector number is manually fed into the position location storage register. This system is presently underway by the carabineri in Rome, Italy.

This technique is the most simple to instrument and the most foolproof. Its main drawback is the requirement for continual manual updating of the position location.
The use of data processing by agencies in the criminal justice system has undergone a pronounced increase in the past 5 years and current indications are that it will experience an even greater growth in the future. One of the big advantages of data processing equipment is its inherent flexibility; this flexibility can be a mixed blessing, however, to the agency which is just planning to install a data processing system. The question of which applications should be implemented first and what equipment to use can be difficult to answer because of the numerous alternatives that are possible. The experience of the agencies which have already installed data processing equipment should prove valuable to those agencies which are just beginning to consider its use. Accordingly, as one part of the information handling study of the Science and Technology Task Force, a questionnaire was mailed to 45 agencies which were known to be using data processing in their operations. Thirty-two replies were received in response to the questionnaire. The data from these responses have been used to develop the discussion in the following section and provide the basis for the summary tables presented there. The last section presents the detailed information supplied by each agency which responded to the questionnaire and should serve as a valuable finder list for any organization which is planning to install a data processing system. It will serve to identify agencies which have developed and implemented similar data processing applications and can thus be contacted for further guidance and advice.

INTRODUCTION

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ANALYSIS SUMMARY

PATTERN OF DEVELOPMENT

The application of data processing by criminal justice agencies in general has followed a fairly standard pattern of development. The majority of those agencies that are now using data processing started by utilizing a basic punched-card processing system. This basic system was expanded by adding new punched-card machines as the size and complexity of the applications to be processed increased. When the scope of their operations began to exceed the capability of their punched-card system, and as their financial resources permitted, the solution was to install an electronic data processing system to replace the punched-card system. In a number of instances, the transition from punched-card machines to the electronic data processing system was made easier by retaining the punched-card data base, and, in effect, operating the system as a card computer. This system was then capable of being upgraded by the addition of magnetic tape storage or disk storage when it became necessary to accommodate larger loads, add more flexibility and increase throughput of data. The final step was to install an on-line electronic data processing system to provide even more effective support to a wider number of users within the agency.

This pattern of system development has obviously been one of system evolution. A number of the agencies now using electronic data processing systems have followed this pattern. However, some agencies have bypassed certain steps in this development cycle and those agencies just beginning to use data processing will also be able to bypass some of these steps by building on the experience of those who have preceded them. The evolutionary pattern of development has one significant advantage, however, in its orderly growth; the operating experience gained in one phase of the system cycle can be of great value in analyzing and designing the next phase of the system. Perhaps even more significantly, the early phases permit the orderly development of a data base in a machine readable form, thereby minimizing to a certain extent the problems and cost associated with converting from a manual operation to a data processing operation.
Punched-card processing

Punched-card processing has enjoyed wide application by police departments. This is not surprising when we remember the long history of usage of punched-card equipment, the variety of such equipment available, and the flexible nature of the punched-card systems whose size and cost can be constrained to fall within the fiscal capabilities and administrative policies of the departments. As a matter of fact, several of the organizations responding to the questionnaire reported that they had started using punched-card equipment more than 20 years ago, and one major police department had first used punched-card equipment in 1923.

One aspect of the survey was an attempt to establish certain cost and planning factors which might be of value to other agencies which are just now planning to implement their own systems. The information was derived from an analysis of the questionnaires returned by those organizations which are using punched-card processing systems. Several interesting facts were revealed. Among the very useful inferences to be drawn is the fact that the population of the city being served by the police departments responding to the survey varied in size from small communities to metropolitan areas.

Several of the police departments have been able to implement their own systems. The information was not confined to the speed and complexity of the unit. Any further variations are caused by the size and age of the city, ranging from 6 to 11 people. This narrow spread is not too surprising, however, if we note that there is a basic set of equipment inherent in the punched-card processing system which is used to generate statistical and special reports to permit better direction, planning, and coordination of police activities. Other applications in this area are: a traffic court docket file (type of accident, location, modus operandi); and a motor vehicle registration data file to permit rapid determination of the owner's name and address through the auto license number.

In police administration, punched-card systems are being used for such purposes as maintaining personnel data on all uniformed and civilian personnel in the department, keeping track of employees' time for paycheck and vacation purposes, and for budget and expense control for police department vehicles.

Among the police departments now using electronic data processing systems, a large variation was noted in the amount of effort spent in systems analysis prior to implementing and installing their systems; the effort ranged from 6 to 75 man-months and, as would be expected, was a function of the size of the department. The equipment costs varied over a wide spectrum but did not seem related to population. Three of the police departments reporting were in the enviable position of having all their computing equipment (including equipment and personnel) paid for by their own resources. The police departments shared computers with other local governmental agencies and were, therefore, able to utilize the equipment and personnel at much less cost than those which had to operate their own computing systems. For those police departments operating in an off-line mode (as contrasted to an on-line system) the cost of the equipment and personnel with the county clerk so its operating costs are kept low.

Electronic data processing

The electronic data processing system presents the potential user with a much more bewildering number of alternative punch-card equipment configurations than the punched-card processing system when it was introduced. This stems not only from the great flexibility of the electronic computer but also from the wide variety of central computing equipment and peripheral equipment that are on the market today.

When they were initially introduced, electronic computers were so expensive that only the largest businesses and government agencies could contemplate their use. The advent of the so-called third generation computers with their increased performance and reduced prices has made the electronic data processing system available to a much larger number of user organizations. As a result, the equipment costs have declined and the relatively recent development of time-sharing systems, the prospective user has available several additional alternatives which can also offer the computing capacity that he needs at reduced costs.

The police departments have data processing requirements of sufficient magnitude to justify their own electronic data processing installations. However, another trend has been the development of centralized municipal data processing centers which are designed to provide data processing support to all the municipal agencies who need it, including the police department and the municipal courts. This trend to centralization is very useful in those areas if data processing is accessible to those smaller agencies who would otherwise be unable to purchase the equipment. The system is further limited to the smaller city, since the city of Los Angeles had to take this approach to satisfy its citywide processing needs.
complexity of an on-line system, however, is such that larger staffs are required to implement and operate them. The Chicago Police Department, for example, has 15 programmer/analysts on its staff, while the St. Louis Police Department has 12. The total size of the St. Louis Police Department's on-line processing staff is 72 people; this figure includes 50 terminal teletypewriter operators. The average salary for electronic data processing personnel is higher than that for punched-card personnel, averaging $7,200 a year for those agencies responding to the questionnaire. Experienced computer programmers are in relatively short supply today; and their salaries are the main factor contributing to the higher average salary of electronic data processing personnel. While programmers' salaries were not reported separately, they would approximate $10,000 per year. A review made of the various applications which are currently in operation on police department computers or are planned for the future. Table F-2 is a summation of those applications. As in the case of the punched-card systems, those applications are organized into the four categories of crime-related applications, until-relations applications, personnel, and police administration. A comparison of Table F-2 and Table F-3 shows a similar variation of applications but this is not too surprising since most departments now use computers previously had punched-card systems. What they have done is to take their existing applications and data bases and upgrade these to the electronic computer adding more capability and flexibility in the process.

In punched-card systems there is a tendency to develop many separate files to facilitate the type of processing that has to be done. These files, although treated separately, have many data elements in common. Many police departments have followed this trend and when they converted to electronic computers they maintained their numerous separate files. Now that the various agencies have gained experience in the use of computers, they are starting a new and more desirable trend. This is the consolidation of their many files into fewer but more extensive files. These consolidated files, while structurally more complex, can be designed to permit faster access, and as a result they facilitate demand searches in addition to the batch processing approach which was necessary in punched-card systems. Examples of these consolidated files are persons files where information about victims, suspects, arrestees, persons, warrants, and fugitives can be consolidated to permit quick on-line access for the police officer. The investigative officer who needs this information to carry out his duties. Another example is the establishment of a serial number file which can be organized for rapid searching on such items as license numbers, article serial numbers, stolen auto numbers, etc. A number of the agencies responding to the questionnaire reported that they are in various stages of planning or procuring new equipment to convert their systems to on-line systems. There is also a continuing need for batch processing operations; the statistical analyses, special reports, and management studies will still have to be done. The need thus exists not for on-line systems alone, but for on-line systems which are also capable of doing background processing.

Two capabilities that are important to the operation of criminal justice agencies are somewhat conspicuous by their absence from the applications list. These are fingerprint and veto (request) searching. Our present ability to do either in a completely effective manner is limited by the current state of the art. Continued emphasis needs to be applied to the development of such capabilities and to incorporate them into the existing operating systems as they become available.

In addition to these capabilities, there are several other developments underway which should be mentioned, since they will also have long-range impact on the development of future systems. The New York City Police Department is in the process of advertising for bids from several contractors for implementation of the SPRINT (Special Police Radio Inquiry Network) system which is designed to increase the speed of their radio dispatching operations. At the State level, the New York State Identification and Intelligence System is developing an on-line system with a comprehensive data base to facilitate information sharing among the criminal justice agencies in New York State. In the corrections area, the State of California is planning for the installation of a correctional data base and implementation of the OPLEA (On-Line Police and Law Enforcement Assistance) for funding several studies aimed at improving the information processing and management capabilities of law enforcement agencies.

### APPLICATIONS DATA

This section contains the data received from those agencies which responded to our questionnaire. It has been organized into city and State police, courts, and corrections agencies. Computer systems have been separated from electronic accounting machines. Table F-3 presents details on the individual installations, type of equipment, equipment costs, operating personnel, installation dates, and future equipment plans. Table F-4 lists the uses to which equipment is now being put and planned applications for the future.

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### Table F-2.—Police Computer Applications

<table>
<thead>
<tr>
<th>Agency and key individual</th>
<th>Equipment currently used</th>
<th>Personnel</th>
<th>Data stored on</th>
<th>Site name</th>
<th>Equipment new to department</th>
<th>Type</th>
<th>Data</th>
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<th>Initial Man.</th>
<th>Planned Man.</th>
<th>Data storage equipment</th>
<th>Planned electronic data processing equipment</th>
</tr>
</thead>
</table>

CLEVELAND POLICE DEPARTMENT

Current applications:
2. Police traffic court docket report, continued docket, and monthly disposition report.
3. Physical characteristics and modus operandi of arrested persons.
4. Payroll authorization list.
5. Control of the sicktime, overtime, holidays, and through time for each employee of the department.
6. Parking citations received and amount paid.

LOS ANGELES COUNTY SHERIFF'S DEPARTMENT

Current applications:
1. Arrests and bookings.
2. Cases handled.
3. Time and location of moving traffic violations.

Table F-4.—Continued

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<tr>
<th>Agency and sub-division</th>
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DETROIT POLICE DEPARTMENT

Current applications:
1. General crime—by precinct, time, day, object of attack, struck car area.
2. Traffic tickets—by ticket number, violation, precinct issued.
3. Arrest analysis—by prosecution, age, sex, color, precinct, etc.
4. Accident analysis—by cause, violation, day, night, etc.
5. Stolen car inquiry—stolen cars by license number, vehicle identification number, serial number.

Table F-4.—Continued

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FORT WORTH POLICE DEPARTMENT

Current applications:
1. Radio calls.
2. Traffic accidents.
3. Offense reports, clearance and recovery reports.
4. Fugitive searches.
5. Traffic citations.
6. Police personnel record.
7. Police uniform lists are kept on IBM cards.

Table F-4.—Continued

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INDIANAPOLIS POLICE DEPARTMENT

Current applications:
1. Records of calls for service and response time, location, and area.
2. Delinquent notices for unpaid traffic violations.

Table F-4.—Continued

<table>
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<tr>
<th>Agency and sub-division</th>
<th>Equipment currently used</th>
<th>Rental cost or rent</th>
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NEW YORK CITY POLICE DEPARTMENT
Current applications: No information. Planned applications:
2. Vehicle identification and license plate identification.
3. Impounded vehicle identification "phonetic code" name file.
4. Personnel files.
5. Computer assisted fingerprint file searching.
7. Crime type, location, date, time, and other data.
8. Computer aided personal and equipment allocation.

PHOENIX POLICE DEPARTMENT
Current applications:
1. Monthly reports on crime distributions and times
gross on cases in different locations.
2. Best summary and patrol distribution based upon
the time and location of offenses.
3. Traffic accidents reports by type, frequency, and
location.
4. Juvenile criminal activity reports by sex, age, and
case disposition.

MICHIGAN DEPARTMENT OF STATE POLICE
Current applications:
1. Daily activity reports.
2. Criminal arrest statistics.
3. Traffic accident and enforcement summary.
4. Accounting of payments to court appointed doctors
and case abstract reports for department of motor
vehicles.

NEW JERSEY STATE POLICE
Current applications:
1. Fingerprint search.
2. Criminal arrest.
6. Summons control.

Pennsylvania State Police
Current applications:
1. Daily activity reports.
2. Criminal arrest statistics.
3. Traffic accidents and enforcement summary.
4. Traffic arrest statistics by location.

City of San Antonio Police Department
Current applications:
1. Statistical data of police activity.
2. Records of accountability status, follow-up activity,
and final disposition for traffic (moving violation) arrest.

New York State Police
Current applications:
1. Message switching for teletype traffic.
2. Serial car file listing and searching.
3. Distribution of personnel.
4. Personnel time and activity records.

Planned applications:
1. Inmate histories including background histories,
based on mail list.
2. Arrests and court disposition of persons arrested
for major offenses.
3. Inmate population statistics.
4. Directory of police agencies in New York State.

Table F-4—Continued

THE LOS ANGELES SUPERIOR COURT—Continued
2. Prior record information.
3. Automatic arrest warrants, removing, notices, payroll,
and travel reports.
4. Fingerprint search.
5. Criminal arrest search.
7. Motor vehicle crimes.
9. Summons control.

New York State Department of Correction
Current applications:
1. Offenders known to police and arrest by police
agencies in New York State.
2. Court disposition of arrests.
3. Arrests and court disposition of persons arrested
for major offenses.
4. Inmate population statistics.
5. Directory of police agencies in New York State.

Table F-4—Continued
INTRODUCTION

In designing or revising an information handling system, the system planner must be able to identify those functions and processes which represent either the greatest difficulties, bottlenecks, or inefficiencies, or provide the greatest potential for improvement from either a cost or efficiency point of view. This requires an understanding and description of the way in which information is generated, transmitted, and processed in the system. An accurate description of the system is necessary:

To obtain data on the information flow rates, volumes, processing times, elapsed time intervals, sequences of operations and operating costs.

To provide the foundation and benchmark against which to measure the performance of any proposed new system.

To serve as an experimental model for testing and evaluating changes to the system.

If the operation being analyzed is a complex one, the system planner is faced with the problem of collecting the information in a systematic way so that he is not inundated by a huge assortment of facts and figures. He needs to organize his description of the current operation so that it can be effectively used for system design purposes. One tool that has been useful in the analysis of an information handling system is the system flow diagram. The flow diagram by itself is not sufficient, however. Generally more operational data is needed than can be conveniently shown on a chart or a diagram. Accordingly, a unique approach was developed and programmed to assist in analysis effort of the police, the courts, and the correctional systems. This method is described in detail in a separate report. The encoded information was used by a computer to draw the information flow charts in the following sections.

These flow charts can serve as a model of the first step necessary in analyzing the information flow in any department, organization, or jurisdiction. To utilize this information, the flow charts must be tailored to represent the specific system being analyzed. With this framework, important questions, such as whether each functioning entity is receiving the information it requires and whether it is receiving unnecessary or redundant information, can be addressed and proper adjustments made to streamline and optimize the information flow. Then specific operational data and statistics can be gathered. The sum total of these are the system requirements and design which may then be presented to appropriate levels of supervision and management for review and approval. They then serve as a basis for detailed system planning, approval, and implementation.

It must be realized that these flow charts are only a tool for the systematic description of complex operating systems and are only as valuable as the competence and insight of the planner using them.
understanding of the system designer makes them. Insofar as the included flow charts represent reality, they can serve to elucidate the complex information flow in the criminal justice system and serve as an example of one approach to the design of such information systems.

SYSTEM CONVENTION

The following system conventions are used in depicting the information flow in the criminal justice system. The information system was divided into four subsystems: police, courts, corrections, "other" (persons or systems outside the criminal justice system). The functions and information paths are encoded as follows:

- **POLICE FLOW**

The last three digits of the codes are arbitrarily assigned. Conventions for function blocks and information flows are shown in figures G-1 and G-2.

POLICE FLOW DIAGRAM

The constraints of time and manpower precluded the possibility of undertaking and completing detailed analysis of the information flow within several major U.S. police departments in order to arrive at a model for the information flow within a typical or generic police department. Instead, the police information flow diagrams were developed on the basis of a prior detailed analysis of a major city police department. The information flow data collected during that extensive analysis were generalized to form the basis for the information flow diagram presented in this section. While it is recognized that there are differences in procedure from one police department to another, it is felt that this generalized information flow diagram represents the major functions in the police system with sufficient accuracy to provide at least a starting point for other police information handling systems.

The police flow diagram is presented in figure G-3. The main activities of the police department have been categorized and included in the 22 functions shown in the flow diagram. Each of these functions consists of many nodes which are not shown on this diagram. The police activities have been aggregated into these functions concerned with patrol and traffic, investigation, command and communication, supporting and management activities, and those activities through which the police system interfaces with other systems.

Many important police activities are embodied in the function that has been labeled field officer (patrol and traffic) (5005). This function in the form of field observations, field interviews, preliminary investigations, arrests, and "other" reporting is an extremely important source of information for the entire police system. In turn, it is one of the main instruments of the department in detecting crime and apprehending criminals. If it is to carry out this latter mission effectively, then the field officer in turn needs information from a number of other functions as is evidenced by the information paths on the flow diagram.

Command and control is an extremely important aspect of the field activity, and within the constraints of the current system, is maintained through the reporting hierarchy of the patrol supervisor (5006), patrol commander (5007), bureau chiefs, and the chief of police (5009). The communications center function (5012) is, of course, vital to the entire field operation. This is particularly true for monitoring patrol activities, allocating resources for routine or emergency needs, and deploying officers for special situations.

Another important function of the police department is the investigative function (5001). Here the flow of...
information becomes even more important. This function must rely heavily on information provided to it from the division and central records unit (5015, 5016), but it in turn is also an important contributor of information as a natural product of its investigative activities. The investigative function also has a hierarchical command structure through the investigative supervisor (5020) and commander functions (5005), which are concerned with effectiveness monitoring and control, allocation of resources, and deployment of personnel for special problems. As indicated, the field officer and investigative functions interact with the citizen (5008), who provides information concerning incidents or requests assistance from the police. Until an arrest is made, the information generated and transmitted in the police system concerns itself with various aspects of the incident. Once an arrest is made, the information generated and transmitted begins to center around the arrestee (5009) himself as he proceeds through the booking function (5015) and is picked up, or booked in on bail or own recognition. At this point, the system begins to interface with the courts and corrections systems.

The flow of processing of information associated primarily with adults for those incidents associated with juveniles, a special element of the investigative function is involved and at this point the police system interfaces with the juvenile court and the correction agencies (7201).

The supporting functions of the police system are those concerned with analysis, planning and management. The planning function (5003) is concerned with such broad management functions as the formulation of policy, budgeting, and resource inventory activities. The planning function (5007) is concerned with the analysis of statistical incidents to detect patterns of activity which are used for alerting the other elements of the department.

The corrections function (5002) is concerned with the receipt, retention, and disposition of all arrested persons. The police department must interact with a number of other systems which have not been portrayed in detail, but have been considered in the overall system diagram. These agencies are other local police agencies, State agencies, and Federal agencies. The State agencies include such important functions as State highway patrol, motor vehicle bureau, criminal identification bureau, etc. Federal agencies include organizations such as the FBI which both collects data from and supplies data to the police department.

**COURT FLOW DIAGRAM**

The flow of information in the court closely parallels the course of the case as it proceeds through the court system. The information flow diagram presented here in figure G-4 is based on an analysis made of the operation of the criminal courts in a typical county in an Eastern United States State. The function levels and the areas are important differences in the procedures and operations of the courts from State to State, this analysis reflects only the generally broad aspects of the operations of the court system.

The flow of information starts with the decision by the prosecutor (6010) to prepare a complaint which identifies the accused and the charge against him. The complaint goes to the municipal court clerk (6001) who prepares the municipal court docket and prepares the court calendar. If the accused has been arrested for a misdemeanor, the clerk schedules the municipal trial (6008) and notifies the various parties involved—the accused (6004), his counsel (6005), the prosecutor, and the witnesses (State's 6002, defense's 6003) of the date for the trial. If the accused has been arrested for a felony, the court schedules a preliminary hearing (6009). At this preliminary hearing, the information relating to the accused is reviewed and if probable cause is established, the accused is arraigned. At the arraignment hearing, the information forms the basis of the indictment (6101) of the offense. If so, the prosecutor's investigative report plus the earlier information on the case are presented to the grand jury hearing (6018) which is scheduled by the grand jury clerk (6016). If the grand jury reviews results in a decision to indict, then the indictment, after judicial review (6020), is transmitted to the clerk of the criminal court (6021) who prepares a docket for the case. An arraignment and plea schedule (6022) is prepared, the accused pleads guilty or not guilty, or is arraigned (6024). If the accused pleads not guilty, a trial (6026) is necessary and the case must be added to the court calendar (6046), the principals notified, and any required summons issued. If the defendant pleads guilty or is found guilty, he must be sentenced (6030, 6034). At this point the court system is divided into two operations systems in the form of the pre-sentence report which is prepared by the court's probation department (7112).

The next functional area involves a pre-sentence investigation, usually requested by the municipal (6008) or the felony court judge (6030, 6034). This is initiated by the assignment of a county probation department field officer (7111, 7112) who primarily utilizes the investigative techniques (6114) to establish pertinent information concerning the background of the accused from persons acquainted with him and information related to the crime from any available source. Specific requests—a person who casts an eye on the suspect, and an FBI identification record (6111), if available. If the accused is found guilty, the prosecution and defense summations are added to the investigation details. The field officer then makes a summary report and sentences, when requested, adds this recommendation for sentencing.

Another function involves the temporary evaluation and/or treatment of the accused by the department of mental hygiene. A transfer of the accused is taken on recommendation by the court. A mental health report is generated and forwarded to the court upon release of the accused from the institution.

**PROBATION (7114)** is a corrections area procedure initiated by appropriate court order. The order, the terms of the case, and the provisions of law are forwarded to the assigned probation field office supervisor (7115). The supervisor conducts periodic interviews with the probationer (9125), reviews the file of the probationer, and his field work and issuing periodic probation reports which go to the probation board of inquiry (9126) or any other board retained by the state (7126). The case may be retained by the probationer, the police, or the prosecutor indicating possible violation of probation is reviewed by the field office personnel. If the report is found sufficient, submitted to the probation department (7116) for a decision on dismissal or court referral. On referral, the court will hear a probation plan hearing (6115, 6114) and either discharges charges or issues a detention order. Appropriate notices go to the supervisor and to the probation department.

If the sentence involves short term detention, a detention order accompanies the sentence to the local detention facility (7130). There the duration of detention varies from days and weeks in municipal jail or short-term city institutions to weeks and months in county jail, camp, or farm.

**STATE ADULT CORRECTIONS**

As shown in figure G-6, a sentence for State detention is given by the court (6036) in more serious cases where confinement duration of at least 1 year is called for. Upon issuance of such a sentence, the court's detention notice and presentence report accompany the offender to the State institution reception center (7138) for reception processing. This processing includes the solicitation of specific information about the individual's background and about his current attitudes via questionnaire forms to the defendant and his attorney (9140), his employers, teachers, parents, relatives, friends, and religious and civic leaders (9142) that may have information about him. Based on all the available information on the offender, a decision is reached on the appropriate State institution to be used for his confinement.

Upon receipt of reception center advice, including detention terms and the inmate's record, an institution classification committee selects (7141) the appropriate program from among those available within the assigned institution based on security requirements and rehabilitative goals. An assigned institution program supervises (7142) monitors the inmate's progress, performs counseling (7145), and prepares periodic assessment reports, which are regularly reviewed by a reclassification committee. Based on supervisor recommendations, security or program recommendations, a sentence of confinement under specific periods of detention time, a decision is reached on reclassification (7144) of the inmate. Infant terms are included in this classification, and transfer to another program in the institution (7146), transfer to another State institution (7147), submission of a parole plan (7140), parole board (7147), or release upon completion of sentence.

The State parole board, which receives the parole plan and available assessment reports, reviews the plan and either rejects it or agrees to parole (7148) for investigation (7141) to augment existing information for subsequent acceptability review. The investigation is conducted by a State parole officer (7149), who gathers and organizes his field work and issuing periodic parole reports which go to the parole board (9147) which is regularly reviewed by the parole board (7149). The procedure and the investigation (7149) are presented as the basis of a preliminary parole report; details are retained in the State parole office in the form of a parole investigation file (9140). Submission of a parole plan (7140) to the parole board for its acceptability review (7151).

Prior to a parole decision, the board may require psychiatric treatment (7148) for the inmate in the institional psychiatric clinic. A treatment order for temporary
CONTINUED

2 OF 3
detention is issued to the clinic and a treatment report is returned upon termination of this temporary detention. This acceptance or rejection of parole is based upon the parole officer's report, and the appropriate notice goes to the institutional classification committee and, if accepted, parole advice from the parole board is transferred to the parole office, where a parole supervisor is assigned (7152). The parole supervisor (7155) initiates periodic interviews with the parolee (7154) from his file and submits periodic parole reports to the State parole office.

During the period of time that the parole supervisor has responsibility for the parolee, it may happen that the supervisor would feel the need for the parolee to get special treatment. If so, he may arrange for temporary detention of the parolee with either the outpatient psychiatric clinic (7154) or the State narcotic center (7155). A treatment request would be submitted upon admission and an appropriate treatment report would go to the supervisor upon return of the individual to parole status. If any alleged parole violation information is received by the parole supervisor (7156) from any source, such as the parolee, the police (7156), or the prosecutor (7156), it forwards the violation report to the parole supervisor who, if he considers it serious enough. A review by the parole supervisor (7157) may result in either no further action or the transfer of violation charges to the State parole office. A hearing (7158) by the board will result in dismissal of violation charges or the transfer of detention notice to the appropriate institution. In either case, the decision is forwarded to the supervisor.

COUNTY JUVENILE CORRECTIONS

As shown in figure G-7, the county probation office (7201) can receive referrals on juvenile suspects from municipal courts (8201), from juvenile complaints (5011), or from community agencies (5016). Complaint petitions may also come from police as a result of booking (5016) or preliminary investigation functions (5001). An initial, but incomplete, file on the juvenile is likely to be received from municipal court or police sources. The probation office usually initiates a prepetition investigation. The assignment notice and incomplete juvenile file go to the investigating officer (7202), who conducts interviews (7203) for obtaining information on the juvenile's background and on the circumstances of the charges. Summaries are made by the officers based on interviews with the juvenile (9203), his parents (9204), his doctors (9207), religious and civic leaders (9209), welfare agencies (9205), and his employer (9206). Complaints and interviews could result in a petition hearing or rejected (7215, 7216). Data pertinent to acceptable parole situations is desirable. Among other points of review in the juvenile's periodic assessment is that of parole consideration. Parole recommendations from the juvenile file are submitted to the State youth authority board upon decision by institutional supervisors to recommend parole. A preliminary review is made by the State youth authority board (7258). The board may reject parole at this time, or it may request a pre-parole investigation by the State parole division.

Assignment (7229) is made to the State investigating officer for determination of the details (7230) of an appropriate parole situation. The officer interviews (7231) the parolee or others to be interviewed, and the juvenile's activities are to be centered. Details and summaries of these interviews are submitted to the State parole division, where a specific parole plan is prepared (7231).
ANALYSIS OF THE COSTS OF A CENTRALIZED VERSUS DECENTRALIZED NATIONAL INQUIRY SYSTEM

by Ronald Finkler

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INTRODUCTION

Modern computer technology makes possible a national inquiry system by which local law enforcement agencies can obtain information from a national file on stolen automobiles, stolen identifiable property, guns, and wanted persons. An analysis has been conducted to investigate several alternative system configurations to determine which one involves the least incremental system cost. The three major cost factors considered are: the cost of operation, the cost of computer storage, and the cost of communication. The cost and workload estimates are based on analyses being carried out for the Fire by the Institute of Telecommunications Sciences and Aeronautics of the Environmental Sciences Service Administration of the Department of Commerce. The information is preliminary since its final report has not yet been written.

Three national system models were chosen for this analysis. The first is a centralized system where all functions are performed at a single centralized location. For this model, two location alternatives were considered: the minimum cost location and Washington, D.C. The second model was a national system maintained in two locations to minimize communication costs. Here again, two alternatives were considered: a minimum cost pair of locations, and a pair of locations where one was constrained to be Washington, D.C. and the second positioned so as to minimize costs. It is assumed that each location has a complete copy of the national file. The third model was a completely distributed system where each state had to interrogate all states in order to search the national file completely.

The analysis of the three system models was essentially divided into two parts, one related to the problem of stolen autos and the second related to the problem of stolen identifiable property, guns, and wanted persons. This differentiation was made because inquiries of the stolen auto file, based on license plate information, have a specific State location to which they can be addressed. This is not the case for inquiries of the other files. A second consideration is that about 45 percent of stolen autos are recovered within 24 hours and about 70 percent are recovered within the jurisdiction of theft, with a high probability that a large fraction of the remainder are recovered in surrounding jurisdictions. In the case of wanted property, guns, and persons, the probability of inquiry also decreases rapidly with distance from the point of theft or crime. More data are needed to assess the value of national integration of the inquiry system. Eventually, a judgment must be made whether the loss in nonoverlapping is not as serious as the cost of maintaining such a file. This cost analysis will attempt at least to place cost on some aspects of these various alternatives.

The costs of any system studied here, including the decentralized one, were nationally integrated in the sense that a complete national file is made available to each inquiry station. It is still possible to have separate, nonintegrated State or regional systems, accepting the penalty of losing track of people or property crossing the regional boundary.

THE COST MODEL

It is assumed in the cost model that each state has implemented in its State capital a State-wide inquiry system to serve its needs. From the resulting workload, only the following portions are treated in this analysis:

- Stolen autos;
- Stolen identifiable property over $1,000 in value;
- Wanted persons whom the State is willing to extra­date from anywhere in the United States.

This workload consists of:

- Entries either the generation or deletion of a record in a file of reports of thefts or wants;
- Inquiries, the processing and searching of these files.

After processing each entry, other than those relating to stolen autos, the State will pass on the entry to the national system for the generation or deletion of a file available to other State systems. Similarly, after processing each inquiry, other than those related to stolen autos, the State will pass on the inquiry for search of the national file. This is necessary since a given item or person may appear in either or both the State and national files even with the nonoverlapping definitions of the files.

For the stolen auto file, two cases are considered:

Case 1.—Entries related to the theft of an auto are sent to the national system after 24 hours and the entry is deleted from the State file. Inquiries related to this file must be processed both in the State system and sent on to the national system since the time of theft would not be known.

Case 2.—Entries are still sent on to the national system after 24 hours but they are not deleted from the State file. Inquiries related to this file must be processed both in the State system and sent on to the national system for the two cases considered are given by:

\[ C_{i} = \text{Computer cost per unit computer time.} \]

For this analysis, we assume that:

\[ r_{n} = 0, \quad r_{m} = 1 \text{ second} \]

Therefore,

\[ C_{1} = (E_{2} + I)C_{s} \]

where:

\[ C_{s} = \text{Cost per second of computer time.} \]

The incremental cost equation for storage in the jth State is given by:

\[ \text{Case 1: } \quad C_{s,j} = C_{s} \]

\[ \text{Case 2: } \quad C_{s,j} = C_{s} \]

\[ C_{s} = \text{Storage cost per million characters.} \]

It is assumed in the cost model that communications between the State and national systems will be provided on a dedicated line basis by GSA utilizing Telpak lines at standard GSA rates. This cost per line is of the form:

\[ C_{l} = \text{Cost per line/month.} \]

The number of lines required between the jth State and the national system for the two cases considered are given by:

\[ L_{j} = \text{Total number of entries/month generated in the jth State.} \]

\[ L_{j} = \text{Total number of inquiries/month generated in the jth State.} \]

\[ r_{m} = \text{Computer time necessary to process one entry.} \]

\[ r_{n} = \text{Computer time necessary to process one inquiry.} \]

\[ C_{s} = \text{Cost per unit computer time.} \]

\[ C_{s} = \text{Storage cost per million characters.} \]

\[ C_{l} = \text{Cost per line/month.} \]

\[ L_{j} = \text{Total number of lines required between the jth State and the national system.} \]

\[ L_{j} = \text{Total number of lines required between the jth State and the national system.} \]
Based on the following considerations:

- The unit cost of data transfer is used to compensate for peak loads caused by the variability of the communication load over the day. It is used to insure a high probability of a line being free when required with minimum delay.
- The factor 0.5 applied to \( E_{11} \) is based on data indicating that approximately 50 percent of stolen autos are recovered within 24 hours, therefore only one-half of the entries generated within the State would be passed on to the national system.
- The factor 0.5 applied to \( E_{11} \) in Case 2 is based on the assumption that when a State is maintaining its own stolen auto file, approximately 3 percent of the inquiries would be on out-of-State autos or autos without license plates.

Three national system models were chosen for this analysis. The first is a centralized system where all functions are performed at a single centralized location. For this model, two alternatives were considered: The minimum cost location and Washington, D.C. The second model was a national system in two locations to minimize communication costs. Here again, two alternatives were considered: A minimum cost pair of locations and a pair of locations where one was constrained to be Washington, D.C., and the second positioned so as to minimize costs. It is assumed that each location has a complete copy of the national file. The third model was a completely distributed system where each State had to interrogate all States in order to completely search the national file.

**Centralized National System**

For the centralized system (fig. H-1), the computer time cost equations for the two cases are given by:

**Case 1:**

\[
C_0 = \sum (E_{11} + E_{21}) (r_{ca} + r_{a} + I_{aj}) C_0
\]

**Case 2:**

\[
C_0 = \sum (E_{11} + E_{21}) (r_{ca} + r_{a} + I_{aj} + 0.15 I_{aj}) C_0
\]

Where the variables are defined as before and if the assumption that \( r_{ca} = r_{a} = 1 \) second is made as before:

**Case 1:**

\[
C_0 = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj}) C_0
\]

**Case 2:**

\[
C_0 = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj} + 0.15 I_{aj}) C_0
\]

The cost equation for storage for both cases is given by:

\[
C_2 = S_{n} C_0
\]

Where:

- \( S_{n} = \) National file storage size in millions of characters.
- \( C_2 = \) Before.

**Two-Location National System**

For the two-location national system (fig. H-2), the computer time cost equations for the two cases (again assuming that \( r_{ca} = r_{a} = 1 \) second) are given by:

**Case 1** (first location):

\[
C' = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj}) C_0
\]

**Case 2**:

\[
C' = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj} + 0.15 I_{aj}) C_0
\]

The cost for storage at each location for both cases is given by:

\[
C_0 = C' + C_2
\]

Similarly for Case 2, the computer time cost is the same.

In addition to this cost, there is the further cost of each location updating the other in order that each maintains a complete national file. This cost for both cases is given by:

\[
C_0 = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj}) C_0
\]

\[
C_0 = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.15 I_{aj}) C_0
\]

**Distributed System**

For a fully distributed system (fig. H-3), the system configuration assumes complete State file storage maintained in each State and a centralized communications switching point for distributing the inquiries from each State to all the other States. The total computer time cost equation (neglecting the cost of the central switching point) is given by:

\[
C_0 = \sum (E_{11} + E_{21}) (0.5 I_{aj} + 0.5 I_{aj} + 0.15 I_{aj}) C_0
\]

The total storage cost equation is given by:

\[
C_0 = \sum C_2
\]
The number of communication lines required between the jth and kth State and the central switching point is given by:

\[ L_{jk} = \left\lfloor 4K \left( L_{j} + 0.05L_{k} \right) r_{jk} \right\rfloor + 1 \]

\[ + \left\lfloor 4K \left( \sum \left( L_{j} + 0.05L_{k} \right) r_{jk} - L_{j} - 0.05L_{k} \right) \right\rfloor + 1 \]

ESTIMATION OF NUMBER OF ENTRIES AND INQUIRIES

The following is an abstract of the Fifth Progress Report in the series on the National Crime Information Center, Telecommunications Study, FYSA Project Number V2369420. Their analysis estimates the workload requirements on the NCIC system for 1970. The number of offenses for that period was estimated in two different ways. The first based on a straight-line extrapolation of crimes as a function of population at the current crime rate, and the second based on extrapolation of the crime rate. In table H-1, of the two numbers given for each State, the upper number is the straight-line extrapolation and the lower number is based on the crime rate extrapolation.

The first consideration which must be given to any telecommunications network design problem is the data rate. For the NCIC study, crime data published in "Uniform Crime Reports," an annual publication published by the FBI, have been used as the numerical data foundation. In addition, two real time systems, smaller in scope but similar to the NCIC in operation, are now functioning in the United States. These are in California and St. Louis, Mo. The experience gained from these two automated systems has been used in predicting system usage.

The State of California has had more experience with the use of real time computerized law enforcement data than any similar organization in the Nation, and on a wider scale, since all levels of State and local government are involved in the California program. The California statistics, on the usage of the "Uniform Crime Reports," have been used as the basis for usage predictions for the NCIC network.

In Table H-1 the first and second columns are the 1970 predictions for number of stolen autos and the number of all other offenses, respectively. Of the stolen autos, 50 percent are recovered within 24 hours and will not be reported to NCIC. Eighty-nine percent of the remaining 50 percent, or 44.5 percent of the total, are eventually recovered and their entries will need to be deleted. Together the entries and deletions (called "entries" in the table) amount to the equivalent of 94.5 percent of the total number of stolen autos. This gives a monthly rate of approximately 8 percent of the total number of stolen cars per year.

California in 1965 had 27,000 entries per month, exclusive of autos, or 314,000 entries per year. For the same period, there were 410,000 offenses in California for the same group of crimes. These figures give 0.08 as average offenses as entries for the year, or approximately 0.07 times as many entries per month as offenses per year. Thus:

Offenses (per year) \times 0.07 = interrogations per month for crimes other than auto theft.

In 1965, California had an average of 46 interrogations per hour of their Auto-Statis center. This amount to 345,600 interrogations per year. During the same period 81,772 autos were reported stolen. Therefore, during the year, there were 4.51 interrogations per stolen auto. Reduced to a monthly basis, this is 0.35 interrogation per month, per stolen car, per year.

Stolen cars (per year) \times 0.35 = interrogations per month

Interrogations of NCIC, for offenses other than auto theft, probably should be based on the number of arrests, since arrested persons are likely to be the ones checked against the information at NCIC. From "Uniform Crime Reports, 1965," a population of 134 million had 4,935,000 arrests. Deleting the
Table H-1—Continued

<table>
<thead>
<tr>
<th>State</th>
<th>Auto</th>
<th>Others</th>
<th>Auto</th>
<th>Others</th>
<th>Auto</th>
<th>Others</th>
<th>Auto</th>
<th>Others</th>
<th>Auto</th>
<th>Others</th>
<th>Total</th>
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</thead>
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<td>3,420</td>
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<td>4,548</td>
<td>6,020</td>
<td>4,440</td>
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<td>1,850</td>
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<td>6,920</td>
<td>10,800</td>
<td>6,920</td>
<td>21,600</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>5,080</td>
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<td>321</td>
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<td>12,350</td>
<td>7,320</td>
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<td>2,720</td>
<td>1,560</td>
<td>5,520</td>
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<td>Vermont</td>
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<td>1,380</td>
<td>4,820</td>
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<tr>
<td>Virginia</td>
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<td>5,270</td>
<td>17,560</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
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<td>4,080</td>
<td>6,920</td>
<td>4,050</td>
<td>6,920</td>
<td>4,050</td>
<td>13,930</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Virginia</td>
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<td>2,360</td>
<td>4,100</td>
<td>2,340</td>
<td>4,100</td>
<td>2,340</td>
<td>8,430</td>
<td></td>
<td></td>
<td></td>
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<td>Wisconsin</td>
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<td>12,610</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming</td>
<td>2,020</td>
<td>1,140</td>
<td>2,000</td>
<td>1,120</td>
<td>2,000</td>
<td>1,120</td>
<td>4,040</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The upper number given in each column is the state total; the lower number is based on the crime rate extrapolated.

<table>
<thead>
<tr>
<th>District</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>District of Columbia</td>
<td>457,000</td>
</tr>
<tr>
<td>New Mexico</td>
<td>53,000</td>
</tr>
<tr>
<td>New York</td>
<td>85,000</td>
</tr>
<tr>
<td>North Carolina</td>
<td>8,000</td>
</tr>
<tr>
<td>North Dakota</td>
<td>23,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>120,000</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>97,000</td>
</tr>
<tr>
<td>Oregon</td>
<td>18,000</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>315,000</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>62,000</td>
</tr>
<tr>
<td>South Carolina</td>
<td>92,000</td>
</tr>
<tr>
<td>South Dakota</td>
<td>12,000</td>
</tr>
<tr>
<td>Tennessee</td>
<td>92,000</td>
</tr>
<tr>
<td>Texas</td>
<td>1,000</td>
</tr>
<tr>
<td>Utah</td>
<td>16,000</td>
</tr>
<tr>
<td>Vermont</td>
<td>5,000</td>
</tr>
<tr>
<td>Virginia</td>
<td>168,000</td>
</tr>
<tr>
<td>Washington</td>
<td>85,000</td>
</tr>
<tr>
<td>West Virginia</td>
<td>58,000</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>118,000</td>
</tr>
<tr>
<td>Wyoming</td>
<td>21,000</td>
</tr>
<tr>
<td>Total</td>
<td>2,333,000</td>
</tr>
</tbody>
</table>

Arrests for crimes of a purely local nature (arson 6,000; offenses against family, 61,000; driving while intoxicated, 292,000; drunkenness, 555,000; disorderly conduct, 510,000; and vagrancy, 120,000) leaves 2,300,000 arrests, which should be a basis for extrapolation. Extrapolating this to a population of 194 million gives 3,307,000 arrests per year. This is 1.2 times as many arrests as offenses.

The 1965 interdiction rate in California for these offenses was 70 per hour, or 626,000 per year. The number of offenses in California during this time was 410,000 which represents 1.47 interrogations per offense. This is a monthly rate of 0.125 times as many interrogrations as offenses per year.

Offenses (per year) \( \times 0.125 = \) interrogations (per month)

Since entries do not require a reply, it is estimated that each entry will use 20 seconds on the line, and each interrogation, with reply, will average 30 seconds on the line. Using the above methods and data from "Uniform Crime Reports," the estimates for 1970 were calculated and given in table H-1. The figures for the United States are calculated directly from the 1965 figures, for the United States, and are not a sum total of the figures for the States.

For this analysis only the 48 continental States plus the District of Columbia were considered. The relationship between the data of table H-1 and the parameters given previously in the cost equations is as follows:

\[ E_i = E_{ai} + E_{oi} \]

District of Columbia was considered. The relationship between the data of table H-1 and the parameters given previously in the cost equations is as follows:

\[ E_i = E_{ai} + E_{oi} \]

Column 3: Entries/month, auto=\( E_{si} \)

Column 4: Entries/month, others=\( E_{oi} \)

Column 5: Interrogations/month, auto=\( I_{ai} \)

Column 6: Interrogations/month, others=\( I_{oi} \)

and

\[ E_i = E_{si} + E_{oi} \]

\[ I_i = I_{ai} + I_{oi} \]

 Inquiry line time \( t_i = 30 \text{ seconds average} \)

 Entry line time \( t_e = 20 \text{ seconds average} \)

ESTIMATION OF REQUIRED STORAGE SIZE

The storage size requirements are based on data contained in the Sixth Progress Report on the NIGIC project by ITSA for the FBI and in part on other data made available by the FBI.

STOLEN AUTO FILE

In estimating the storage requirements for the stolen auto file, the major parameters required are the theft or entry rate, the recovery rate or decay time of the file, and the length of time unrecovered autos will be kept in the file.

From the number of auto thefts given in the UCR of 486,568 and an estimated annual growth of 2.29 percent in the rate of auto thefts and 5.96 percent in population, the number of auto thefts will increase at a rate of 8.4 percent per year. It is assumed that the recovery rate of stolen autos will remain at 90 percent.

Present plans for NIGIC call for maintaining records of stolen autos in the file for the calendar year of theft plus 4 years.

Table H-2 then gives the estimated number of stolen autos in the file at the end of each year through 1970 assuming that NIGIC was fully implemented in 1966.

Table H-3 (based on data from the Los Angeles Police Department Statistical Digest) gives an assumed recovery rate as a function of time elapsed since theft as a fraction of the autos recovered (i.e., the 90 percent). It is as:

\[ SF_{30-70} = SF_{30} \cdot U_{30} \]

where:

\[ SF \] = the storage factor for the given period.

\[ T \] = number of days in the period.

\[ U \] = fraction of unrecovered autos on the given day.

Then:

\[ SF_{30-70} = 24.04 \cdot \frac{S_{30}}{10} \]

where:

\[ SF_{30} = \frac{10}{10} \cdot \frac{S_{30}}{10} - 0 \]

The total number of stolen autos in the national file will then be:

\[ = \left[ \frac{311,707 + 300,707}{311,707 + 300,707} \right] \text{ of 324,369} \]
The present NCIC file format for stolen autos contains 125 characters or
$S_{stolen} = 40.461$ million characters
required for the national stolen auto file.

For the State files, considering the sum over all the States, for Case 1 only, 1 day's records (2,000 stolen autos) are maintained as:

**Case 1:**

$$S_{a} = \sum_{i} S_{a,i} = 277,547 \times 125 = 35.65 \text{ million characters}$$

For Case 2, assuming the 4-plus years of record retention, the required storage will be the same as for the national file or:

**Case 8:**

$$S_{a} = \sum_{i} S_{a,i} = 40.461 \text{ million characters}$$

Also maintained in the stolen auto file are records of stolen license plates which, however, do not show up in the same license plates for several years, a value of 194 million characters; therefore, in the national file:

$$S_{sp} = 15.8,000,000 \times 340 = 80.8 \text{ million characters}$$

It is estimated that the States would keep similar files on twice this number of persons or:

$$S_{sp} = \sum_{i} S_{sp,i} = 81.6 \text{ million characters}$$

**STOLEN PROPERTY FILE**

The storage requirements for the stolen identifiable property is based on the ITSA report. Records will be kept in the file for the year of theft plus 2 years. It is estimated that 20 percent of the property is recovered in the year of theft and 10 percent in each of the succeeding years. The results are summarized in Table H-4 where the number of records at end of year is given by:

$$147,500 \times 0.8 + 133,750 \times 0.7 + 121,250 \times 0.6$$

The file format for these records contains 100 characters; therefore, the size of the national file is:

$$S_{sp} = 56.8 \text{ million characters}$$

It is estimated that the State files will contain twice as many records or:

$$S_{sp} = \sum_{i} S_{sp,i} = 56.8 \text{ million characters}$$

**STOLEN GUN FILE**

The final file considered in this analysis is the stolen gun file. In the ITSA report, a rough estimate is made that this file, by the end of 1970, would contain approximately 100,000 records. The file format for this record contains 76 characters or:

$$S_{sp} = 7.8 \text{ million characters}$$

**Table H-4.—Unrecovered Property in Inquiry File**

<table>
<thead>
<tr>
<th>Year</th>
<th>Outstanding entries</th>
<th>Number at end of year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>125,400</td>
<td>125,400</td>
</tr>
<tr>
<td>1971</td>
<td>125,400</td>
<td>125,400</td>
</tr>
</tbody>
</table>

Since several of the more populous States do keep the same license plates for several years, a value of 160,000 records in the file was assumed. The file format for these records is 63 characters long; therefore, in the national file:

$$S_{l} = 160,000 \times 0.03 = 10.8 \text{ million characters}$$

For the State files:

**Case 1:**

$$S_{l} = \sum_{i} S_{l,i} = 277,547 \times 0.03 = 83.2 \text{ million characters}$$

**Case 2:**

$$S_{l} = \sum_{i} S_{l,i} = 40.461 \text{ million characters}$$

**WANTED PERSONS FILE**

The storage requirements for the wanted persons file is based on the number of outstanding persons notices presently maintained in the FBI's fingerprint file extrapolated to 1970. At present, the number of notices is 80,000, and at the growth rate of 6.6 percent per year, it would be approximately 120,000 in 1970. The NCIC format contains 340 characters per record; therefore, in the national file:

$$S_{wp} = 15.8,000,000 \times 340 = 80.8 \text{ million characters}$$

Additionally, in the analysis it is assumed that the States do not maintain a duplicate file, so

$$S_{1,wp} = 0$$

**Table H-5.—Storage Requirements for the Inquiry Files**

<table>
<thead>
<tr>
<th>File</th>
<th>Record size (characters)</th>
<th>Number of records</th>
<th>Number of inquiries (per year)</th>
<th>Number of records</th>
<th>Number of inquiries (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>125</td>
<td>276,908</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>Total of all States (case 1)</td>
<td>125</td>
<td>276,908</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>State</td>
<td>125</td>
<td>173,200</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>Total of all States (case 2)</td>
<td>125</td>
<td>173,200</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>State</td>
<td>125</td>
<td>160,000</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>Total of all States (case 3)</td>
<td>125</td>
<td>160,000</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
<tr>
<td>Total</td>
<td>125</td>
<td>83,200</td>
<td>45,444</td>
<td>2,126</td>
<td>840</td>
</tr>
</tbody>
</table>

COST FACTORS

As mentioned previously, the analysis is based on three major cost factors, the cost of computation, the cost of computer storage, and the cost of communication. The most difficult to estimate is the cost of computation, especially when it is considered that there may be as many as 50 different systems implemented (the 48 continental States, the District of Columbia, and the national system). Because of these difficulties, an incremental cost model with identical linear costs was assumed. An incremental cost model, however, is not the best model for a fragmented system since it does not consider:

- Variations in the ratio of fixed to variable costs due to different size facilities required in the different States,
- Variations in the cost per computation as function of speed of computation (the square foot of computer space required is a function of speed of the computer and location at each State).

**COST SUMMARIES**

The following summarizes the various cost elements developed previously:

$$C = \sum_{i} (C_{i1} + I)$$

The cost of computation, based on budgetary estimates for NCIC, considering a facilities 360/40 system, is composed of personnel costs, which are assumed at $56,000 per month or $675,000 (750 hr month). As mentioned before, it is assumed that the time required to process one entry or one inquiry is one second. A factor of 4 is used to take into account queuing delays, other computer processing variation of demand over the 24 hr day, giving an average processing rate of 900/hr. This gives a cost per entry or inquiry of:

$$C = \frac{8.05}{900} = 0.0086 \text{ entry or inquiry}$$

The computer storage cost is based on the cost of a Disk Pack memory (IBM 2314) quoted in a General Services Administration price list.

The communications cost estimate is based on the General Services Administration communication cost used in purchasing A.T. & T. Telpak services for Government agencies. These are based primarily on Telpak C and Telpak D Hiilk structures. The GSA charges are on a mileage basis plus a monthly terminal charge. The charges used in this analysis are $620.50 per month for terminal and line conditioning plus 45c per mile per month. This is based on a single 4 kHz voice grade line which can be subdivided into the 100 words per minute duplex teletype circuits. On a per duplex circuit basis:

$$C = \frac{437.5}{800} \text{/month}$$

This includes a 10 percent wasted capacity cost because of inefficiencies in grouping the narrow band lines from the single terminal location at each State capital.
The cost of communication is the only cost which is a function of the choice of location(s) of the national file. Because of the particular form of the equations and the need to minimize the sum, these costs had to be computed by means of a computer program. The results are summarized below:

\[ C_l = \min \left( \sum \left( C_i + C_d \right) L_i \right) \]

\[ = \min \left( \sum \left( (127.58) + 0.02 \right) L_i \right) \]

\[ = 6,251,101.13 \] (Location: Springfield, Ill.)

These costs are summarized for various locations in tables H-6, H-7, and H-8. The total systems costs for the various alternatives are summarized in table H-9. The lowest national and total system cost occurred for a centralized system located at Springfield, Ill. (Case 1). However, there would be an increase of only $945 per month if the location were moved to Washington, D.C. Since other costs such as facilities, staffing, and administrative control would far outweigh this, these computations would indicate that any other city, including Washington, D.C., would be as good a choice for the location of the national system. These computations do show that, within the assumptions, it would be best if the States maintained their own stolen auto files. This does not mean necessarily that the national system could not provide this service for some interim period or, in the case of smaller States, for an indefinite period.

For the two-location system, the major difference in cost was the cost attributed to each of the two information centers updating each other. If this cost were removed by assuming that such updating was accomplished during times of low demand (in effect reducing the size of the computer required for meeting the peak demand), the centralized system is slightly less expensive, since the savings in communications by having two or more centers would be more than offset by the increase in storage costs. The additional administrative costs of the two locations, which have not been taken into account, would far outweigh any differences calculated here. From the point of view of system reliability, although two locations might have some small advantages, a single location can be made more than sufficiently reliable for this application.

The decentralized system suffers from the major problem that all States must process the inquiries of all other States and the resulting communications and administrative costs are high. Admittedly, this is an extreme case, but it illustrates the problem of trying to provide a national capability without a centralized national system. On the other hand, if the States were interested in maintaining only information of concern to themselves without any national exchange, the costs would be essentially that given as the State costs for a Case 2 situation, i.e., about $65,000 per month.

This cost model is admittedly crude and does not take into account such items as the ratio of fixed to variable costs, the relatively high cost per operation for small computers, and data conversion costs. It is indicative, however, of the magnitude of the costs and the relative costs of the several systems alternatives investigated.

Table H-8.—Communications Costs for Decentralized Inquiry Systems

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------------------------------</td>
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<td>------------------</td>
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</tr>
<tr>
<td>---------------------------------------</td>
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<td>------------------</td>
<td>------------------</td>
<td>----------------------------------------</td>
<td>---------------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
</tbody>
</table>

Notes: Estimates for Springfield, Ill. include only the communication costs between Springfield, Ill., and the States of the Midwest. Springfield, Ill., is the location of the inquiry system. The rate of communication costs is $0.25 per mile. Springfield, Ill., is also the location of the switching center and is the location of the computer required for maintaining the peak demand. The case is for a single location at Springfield, Ill., and it is not implied that the inquiry system is located at Springfield, Ill., and the switching center is located in Washington, D.C. The case is for a single location at Springfield, Ill., and it is not implied that the inquiry system is located at Springfield, Ill., and the switching center is located in Washington, D.C. The case is for a single location at Springfield, Ill., and it is not implied that the inquiry system is located at Springfield, Ill., and the switching center is located in Washington, D.C. The case is for a single location at Springfield, Ill., and it is not implied that the inquiry system is located at Springfield, Ill., and the switching center is located in Washington, D.C. The case is for a single location at Springfield, Ill., and it is not implied that the inquiry system is located at Springfield, Ill., and the switching center is located in Washington, D.C.
DATA ANALYSES AND SIMULATION OF COURT SYSTEM IN THE DISTRICT OF COLUMBIA FOR THE PROCESSING OF FELONY DEFENDANTS

by Joseph A. Navarro and Jean G. Taylor

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The D.C. Court System for Processing Felonies .................. 199
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In chapter 4, the Task Force study of the processing of felony defendants in the District Court for the District of Columbia is summarized. This appendix provides more detailed description of the court statistics and the simulation model. To provide continuity in the appendix, certain parts of the summary in chapter 4 have been repeated here.

INTRODUCTION

For years judges, lawyers, and court administrators have been grappling with the problem of delay. Many solutions have been tried but found wanting. Some have been rejected out of hand; others, obvious to a management expert, either have not been thought of or have been deemed too disruptive for the anticipated improvement. A test of any proposed solution might require considerable disruption of court operations and a vast expenditure of time and energy which might prove worthwhile. Courts could be helped appreciably if means were developed for accurately analyzing the causes of delay and then pretesting alternative approaches to reducing delay.

The Task Force has explored the feasibility of computer simulation of court operations to meet this need. Briefly, a simulation model is a representation of the system and its operations which can be used to examine the effect of changes in the system.1 In the courts, simulation could provide a means for examining methods for expediting the processing of defendants through the system. Further, simulated pretesting would provide a first estimate of the effects of proposed changes on resources, workloads, and delays. This process allows the administrator to test alternative allocations of resources and find the combination which balances delay reduction against expended resources.

The simulation developed here required, as all simulations do, first, a description of the system being simulated; and, second, collection and analysis of data describing court operations. Only then could the model be constructed and manipulated. Thus the work was conducted in three parts:

1. The organization and structure of the trial court system for the District of Columbia and its procedures for processing felony defendants were described.
2. The available data on felony defendants in the District Court were analyzed to determine the distribution of time to disposition, time intervals between major events in the system, potential areas of delays, and possible causes.
3. A simulation model of the processing of felony defendants in the District of Columbia trial court system was developed which:
   a. Operated like that observed in the data (i.e., to produce the average time intervals between steps in the process similar to those observed in the data).
   b. Could be manipulated to investigate possible organizational or procedural changes in the system and to measure their impact on reducing delay and on the available resources in the system.

In this analysis neither the substantive law nor the use of improved business practices were addressed.

THE D.C. COURT SYSTEM FOR PROCESSING FELONIES

The U.S. District Court for the District of Columbia (referred to hereafter as the District Court) is unique in the Federal system because it has jurisdiction over all felonies committed in the District of Columbia. It

1 Publication has been made successfully by the military and industry for planning and for evaluating various classes of actions. Although simulation has been used for many years in other types of court systems in the United States, the task force examined only what we refer to below as the U.S. District Court of the District of Columbia. The methodology, however, is applicable to any jurisdiction which can collect adequate data about its present operations.
### FIGURE I. STEPS IN PROCEEDINGS OF FELONY DEFENDANTS

<table>
<thead>
<tr>
<th>COURT OF GENERAL SESSIONS</th>
<th>U.S. COMMISSIONER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arrest</strong></td>
<td><strong>Pretrial</strong></td>
</tr>
<tr>
<td>No pretrial by Assistant U.S. Attorney.</td>
<td>Federal charge reduced to misdemeanors.</td>
</tr>
<tr>
<td>Felony charge reduced to misdemeanors.</td>
<td>Indicted to Court of General Sessions.</td>
</tr>
<tr>
<td>Received in presentment to Court of General Sessions.</td>
<td>Brought before Assistant U.S. Attorney.</td>
</tr>
<tr>
<td>PRELIMINARY HEARING</td>
<td><strong>Indictment</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Trial</strong></th>
<th><strong>Sentencing</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
<tr>
<td>Acquitted.</td>
<td>Dismissed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Grand Jury</strong></th>
<th><strong>U.S. DISTRICT COURT</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grand Jury</strong></td>
<td><strong>Charges</strong></td>
</tr>
<tr>
<td>DAY 1 GRAND JURY</td>
<td>CHARGES</td>
</tr>
<tr>
<td><strong>U.S. ATTORNEYS</strong></td>
<td><strong>U.S. ATTORNEYS</strong></td>
</tr>
<tr>
<td>1</td>
<td>1 GRAND JURY</td>
</tr>
<tr>
<td>2</td>
<td>2 GRAND JURY</td>
</tr>
<tr>
<td>3</td>
<td>3 GRAND JURY</td>
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<td>4</td>
<td>4 GRAND JURY</td>
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<td>5</td>
<td>5 GRAND JURY</td>
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<td>6</td>
<td>6 GRAND JURY</td>
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<tr>
<td>7</td>
<td>7 GRAND JURY</td>
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<tr>
<td>8</td>
<td>8 GRAND JURY</td>
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<td>9</td>
<td>9 GRAND JURY</td>
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<td>10</td>
<td>10 GRAND JURY</td>
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<td>11</td>
<td>11 GRAND JURY</td>
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<tr>
<td>12</td>
<td>12 GRAND JURY</td>
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<tr>
<td>13</td>
<td>13 GRAND JURY</td>
</tr>
<tr>
<td>14</td>
<td>14 GRAND JURY</td>
</tr>
<tr>
<td>15</td>
<td>15 GRAND JURY</td>
</tr>
</tbody>
</table>

---

is not confined, like other Federal courts, to Federal crimes such as tax evasion and fraud. It also precedes felonies which would ordinarily be handled in a State court. Further, because the court is operating in a Federal jurisdiction, the procedure followed in all criminal cases is that of the Federal Rules of Criminal Procedure and the interpretation of these rules by the court. The Federal laws, such as the Bail Reform Act, and the Criminal Justice Act apply to all cases.

The first step in the development of a simulation is a description of the court system. This must be described in terms of the flow of defendants and the flow of information through the system, and the assignment of the court resources (judges, courtrooms, attorneys, etc.) to the various events associated with the processing of the defendants.

The various steps and the associated resources for processing felony defendants in the District of Columbia court system are shown in simplified form in Figure I. The first step is presentment which occurs before a judge of the Court of General Sessions (the municipal court of the District of Columbia), or the U.S. Commissioner.

Both are available for presentment and preliminary hearing in felony cases. Presentment is often followed by a review or screening of the case by an Assistant U.S. Attorney (Court of General Sessions Division). He determines whether to reduce the felony charge to a misdemeanor, to terminate the case ("no probable cause").

In 1965, the U.S. Branch I of the Court of General Sessions handled approximately 12,000 defendants. About 2,500 of these were arrested on a felony charge. From among these 6,000 present arrest for a felony charge, about 2,000 were held for action by the grand jury (i.e., the defendant either waived preliminary hearing or the preliminary hearing had led to a finding of probable cause to hold the accused for grand jury action) 2.

A case is next processed in the office of the U.S. Attorney (Grand Jury Unit). It is screened again and calendared for presentation to the grand jury. The grand jury votes an indictment if there is concurrence of 12 or more of the jurors.3 Thereafter, the indictment is served on the defendant by the U.S. Attorney and returned (generally on Monday) in open court.

Arraignment is the next step. It is in general a perfunctory proceeding in which the accused appears,4 is advised of the formal charge and enter a plea—usually not guilty. At about this time the case is assigned to an Assistant U.S. Attorney who will probably handle it until final disposition, and a defense counsel is appointed by the court for a defendant who cannot afford counsel.

Following arraignment, trial preparation proceeds, motions are filed and heard, the case is placed on a calendar and finally progresses to trial. Of the defendants disposed of in 1965, only about 50 percent completed the final step of trial; approximately 55 percent pleaded guilty to the offense charged or to a lesser offense prior to or during the trial. The remaining 15 percent of the defendants were dismissed.

If the indictment is prepared by a clerk in the U.S. Attorney's office, prepared by both the clerk and the U.S. Attorney, and reviewed by both the Chief Assistant U.S. Attorney and the Chief of General Sessions Division, the indictment is forwarded to the District of Columbia by certified mail. If the indictment is in the District of Columbia, it is forwarded to the Clerk of General Sessions and the Chief of General Sessions Division, and is forwarded to the Clerk of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Chief of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Clerk of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Chief of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Clerk of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Chief of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Clerk of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Chief of General Sessions Division. If the indictment is in the District of Columbia, it is forwarded to the Clerk of General Sessions Division.

The number of judges assigned to Criminal Court increased to 7 in 1965.
Finally, it should be noted that the District Court handles a very small proportion of criminal cases. In the District of Columbia there were approximately 150,000 nontraffic adult arrests in fiscal year 1985, but only about 6,000 adult persons were arraigned on felony charges. Only 1,603 of those came before the District Court; the other 4,700 either had their cases reduced to a misdemeanor charge, were papered, or otherwise dropped.58 The median time for trial disposition of cases commenced in 1985 was 5.3 months. For nontraffic disposition, the median was 4.2 months.59 The observed times between the various stages of the process are shown on figure 1-2. The median intervals are summarized in table 1-2.

The observed time between processing stages can be compared to the model timetable proposed by the Administration of Justice Task Force. That Task Force concluded that the processing of criminal cases takes too long and recommended a model timetable (table 1-2) with a maximum of 4 months from arrest to trial disposition (fig. 1-2). This difference indicates that the distribution of times is skewed positively, that is, there are some very high values, i.e., while most cases are dealt with in a relatively narrow range of time, a few cases take much longer time. Furthermore, when the median values are compared with the model timetable, it is found that about 50 percent of the defendants are being processed in accordance with the model timetable. In other words, the defendants are being processed at or below the median. This means that the defendants are being processed at a level that does not exceed the maximum time allowed by the model timetable. The observed time between stages can be compared to the model timetable proposed by the Administration of Justice Task Force. That Task Force concluded that the processing of criminal cases takes too long and recommended a model timetable (table 1-2) with a maximum of 4 months from arrest to trial disposition. This difference between the observed and model times can be attributed to the model timetable's assumption of a normal distribution. The model timetable does not account for the skewness in the observed times, which is likely due to the presence of a few extremely long cases.

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Table I—Median Elapsed Times Between Stages in the District of Columbia Courts for Defendants Whose Cases Were Filed in the District Court in 1965

<table>
<thead>
<tr>
<th>Stage in process</th>
<th>Number of defendants (N)</th>
<th>Time (in days)</th>
<th>Mean</th>
<th>Median</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentment to preliminary hearing</td>
<td>272</td>
<td>335-606</td>
<td>282</td>
<td>134</td>
<td>47</td>
</tr>
<tr>
<td>Preliminary hearing to return of indictment</td>
<td>350</td>
<td>182-350</td>
<td>182</td>
<td>182</td>
<td>50</td>
</tr>
<tr>
<td>Indictment to arraignment</td>
<td>266</td>
<td>67-256</td>
<td>106</td>
<td>88</td>
<td>50</td>
</tr>
<tr>
<td>Arraignment to filing of first motion</td>
<td>188</td>
<td>22-279</td>
<td>63</td>
<td>63</td>
<td>50</td>
</tr>
<tr>
<td>Arraignment to filing of second motion</td>
<td>89</td>
<td>18-102</td>
<td>44</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td>Arraignment to trial disposition (by guilty plea or dismissal)</td>
<td>67</td>
<td>9-67</td>
<td>32</td>
<td>32</td>
<td>50</td>
</tr>
<tr>
<td>Arraignment to nontrial disposition (by guilty plea or dismissal)</td>
<td>29</td>
<td>8-29</td>
<td>14</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>Arraignment to trial disposition (by trial)</td>
<td>205</td>
<td>22-1,060</td>
<td>105</td>
<td>105</td>
<td>50</td>
</tr>
</tbody>
</table>

Note: The data suggested that motion practice contributes to delay. In 1965 approximately half of the defendants filed one or more motions prior to disposition. Table I-4 shows that in those cases where no motions were filed, the median time from arraignment to nontrial disposition (guilty plea or dismissal) was 7 weeks; to trial disposition, it was 11 weeks. Where two or more motions were filed, these median times were doubled. A median of 40 days elapsed between arraignment and the filing of the first motion, and 30 days between the filing of the first and second motions. This clearly establishes the need for enforcement of the new 10-day motion rule.

Possible causes of the differences emerge from an examination of the operation of the Court of General Sessions and the U.S. Commissioner. The data in table I-3 indicate that the Court of General Sessions processed more defendants than the Commissioner, but there was a substantial difference in the types of crimes. Eighty percent of the defendants charged at the Court of General Sessions were charged with either robbery, assault, burglary, larceny, auto theft, or rape. On the other hand, 70 percent of the defendants who were processed by the U.S. Commissioner were charged with murder, narcotics, gambling, robbery, or larceny. In addition, the U.S. Commissioner holds hearings on Tuesday and Thursday mornings and generally schedules preliminary hearings for 2 weeks after initial presentment. In contrast the Court of General Sessions does not continue preliminary hearings for 2 weeks and, in fact, schedules half of the preliminary hearings on the day of initial presentment.

Detailed data analysis can be used to rule out possible causes of delay. For example, a preliminary hearing does not materially increase the amount of time between arrest and indictment. On the other hand, this can be sensitive to the type of crime. An example of such a comparison is plotted on figure 1.3. Aside from gambling, which took by far the longest, most types of crimes had comparable time distributions. This phenomenon may be explained by a local practice in which the demand for a preliminary hearing is really a device for obtaining a continuance in the early stages of the process. Thus every defendant demands a preliminary hearing, but many ultimately waive it when the scheduled day arrives.

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position is 5.5 months. For the convicted, an additional median time of 38 days elapses between conviction and sentence. The time between arraignment and disposition varies with the type of felony. Gambling, murder, and assault take the longest; burglary, auto theft, and robbery take the shortest time. The time also varies with the types and number of motions filed and the tactics of counsel; but the effects of the latter are not easily measured except when they request continuances or file motions.

The median processing times from presentment to disposition as shown in figure 1.4 exceed the maximum of Table I-4. Time (in weeks) between Arraignment and Disposition for Felony Defendants Whose Cases Were Filed in the District Court in 1965

<table>
<thead>
<tr>
<th>Time interval (in days)</th>
<th>U.S. Breach of General Sessions</th>
<th>U.S. Commissioner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentment to preliminary hearing</td>
<td>335-606</td>
<td>282</td>
</tr>
<tr>
<td>Preliminary hearing to return of indictment</td>
<td>182-350</td>
<td>182</td>
</tr>
<tr>
<td>Indictment to arraignment</td>
<td>182-256</td>
<td>63</td>
</tr>
<tr>
<td>Arraignment to filing of first motion</td>
<td>182-279</td>
<td>44</td>
</tr>
<tr>
<td>Arraignment to filing of second motion</td>
<td>182-102</td>
<td>32</td>
</tr>
<tr>
<td>Arraignment to trial disposition (by guilty plea or dismissal)</td>
<td>182-67</td>
<td>32</td>
</tr>
<tr>
<td>Arraignment to nontrial disposition (by guilty plea or dismissal)</td>
<td>182-29</td>
<td>14</td>
</tr>
<tr>
<td>Arraignment to trial disposition (by trial)</td>
<td>182-1,060</td>
<td>105</td>
</tr>
</tbody>
</table>

Note: The data suggested that motion practice contributes to delay. In 1965 approximately half of the defendants filed one or more motions prior to disposition. Table I-4 shows that in those cases where no motions were filed, the median time from arraignment to nontrial disposition (guilty plea or dismissal) was 7 weeks; to trial disposition, it was 11 weeks. Where two or more motions were filed, these median times were doubled. A median of 40 days elapsed between arraignment and the filing of the first motion, and 30 days between the filing of the first and second motions. This clearly establishes the need for enforcement of the new 10-day motion rule.

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4 months recommended in the proposed model timetable. These times are long despite the fact that most of the steps in the process require very little actual court time. A defendant may be represented by a magistrate in a few minutes. A preliminary hearing takes between 15 and 30 minutes unless there is extensive cross-examination or the Government is forced to produce many witnesses. A grand jury may hear, consider, and vote on the average case in 30 minutes. Arraignment takes a few minutes. Most motions can be heard in 10 minutes, and when these, in evidence, is taken, may require as much as half a day. A guilty plea usually takes no more than 5 minutes. An arraignment and some hearings involving motions take an average of 30 minutes. Inwren; and 4 months recommended in the proposed model.

The average elapse time (including weekends and holidays) between the beginning of the trial and the verdict (for the 1965 felony cases examined) was 2 days for nonjury trials and 3 days for jury trials. The courtroom days for trials in the District Court are Monday through Thursday with a reported average of 4-6 judges sitting on the criminal side in 1965. There was then, as there is now, a backlog of cases awaiting trial. In November 1966, it was observed that there were 302 cases on the reserve calendar, all motions having been completed but with some imposition preventing their going to trial, and 147 cases on the ready calendar with all impediments removed. It was also reported that in October 1966 the court had disposed of 40 cases with seven judges sitting in the criminal division. Further the backlog appears to be increasing; from July 1965 to July 1966 an increase of 20 percent was reported (from 449 to 601).

SIMULATION OF THE PROCESSING OF FELONY CASES IN THE D.C. COURT SYSTEM

There are a number of alternative methods which suggest themselves to protest some of these and evaluate the feasibility of meeting a timetable such as that proposed in the Commission in chapter 5 of the general report, The Secretary of the District of Columbia Task Force developed a simulation of the processing of felony cases in the District Court system. The two main reasons for using a simulation program are:

- A computer would simulate what has happened and show the various alternatives which would have been possible.
- Results of the simulation can be used to test and evaluate the relative impact of various proposed policies and changes, such as firm timetables, increasing resources, etc.

Due to the limited time available for the development of the simulation, an analog simulation language (IBM's General Purpose System Simulator (GPSS)), which is used to simulate the criminal processing language, will be used to simulate the criminal processing system. The language, although not primarily designed for simulations, is flexible and can be adapted for use in simulations. The resulting model, called COURTSM, is described in more detail in a separate report. Figure 5-1 is a flow diagram of the simulation model.

COURTSM is a continuous simulation model which may be introduced, in any one of the following fashions: in its present form, or in its modified form. The model may also be read into an existing simulation model which has been developed to simulate other aspects of the criminal justice system. For example, the model may be used to simulate the processing of a defendant who has been arrested and is being processed by the system at the time of his arrest. The model may also be used to simulate the processing of a defendant who has been arraigned and is being processed by the system at the time of his arraignment. The model may also be used to simulate the processing of a defendant who has been convicted and is being processed by the system at the time of his conviction. The model may also be used to simulate the processing of a defendant who has been sentenced and is being processed by the system at the time of his sentencing. The model may also be used to simulate the processing of a defendant who has been released on probation and is being processed by the system at the time of his release on probation. The model may also be used to simulate the processing of a defendant who has been paroled and is being processed by the system at the time of his parole. The model may also be used to simulate the processing of a defendant who has been paroled and is being processed by the system at the time of his parole revocation. The model may also be used to simulate the processing of a defendant who has been paroled and is being processed by the system at the time of his parole revocation revocation.
The amount of time a defendant spends at a given processing unit is determined by the characteristics of the actual process being simulated. At some places processing is estimated to require a fixed amount of time; at other processing units the time is randomly distributed within certain limits.

Table 1-3 summarizes the conditions used in the simulation of the courts in 1965. It shows the estimated average capacity of each unit and the processing times required per defendant in that unit.

When a defendant arrives at a processing unit an attempt is made to process his case immediately. Any one of the following conditions can prevent immediate action and consequently result in his entering a queue:

1. The processing unit is currently being used to capacity.
2. The shared resources required at this processing unit are not available.
3. The unit is not open on this day of the week or hour of the day.

When the above conditions are no longer in effect, the processing unit is ready to accept another case from its queue. If the queue is empty, a portion of the processing unit's capacity remains idle until a defendant arrives for processing.

The results of the COURTSIM simulation are provided in statistical output form. These outputs consist of three types of statistics that are tabulated and computed during the computer run. They are associated with queues, processing units, and lengths of time required for defendants to move between selected points (stages) in the system. The reported queue data include: average queue length, maximum queue length, mean length of time spent in queue. Information on processing units includes: average utilization, maximum utilization and average processing time. Statistical output on times between various units includes: percentiles, mean, and standard deviation of the elapsed times.

Table 1-6 summarizes some of the COURTSIM features presently incorporated. The first column represents...
The partial list of the computer statements or instructions used to simulate the conditions in 1965 of the District of Columbia was obtained from the computer runs, the median times from the 1965 District of Columbia data. The other rows contain similar data obtained from the computer runs. In particular, the second row is a time summary of COURTSIM, when used to simulate the conditions in 1965. Of interest is the fact that from presentment to arraignment takes approximately 7 to 8 weeks (observed both in the District of Columbia data and Run 7 of COURTSIM); some 5 weeks of this time was spent waiting for the return of an indictment in the simulation. When this delay was reduced to an average of 8 days, as a result of adding additional resources at the grand jury, COURTSIM yielded the times shown in the third row. Hence, the time awaiting return of the indictment was reduced by some 4 weeks.

The fourth row gives a lower bound on the average times if all transit times were eliminated, i.e., as soon as one processing stage finishes, a defendant, is processed immediately to the next and waits only if the next processor is busy or is unavailable because of weekends. If such a condition had existed in the District of Columbia courts in 1965, a defendant would have taken an average of approximately 2 months after presentment to be ready for trial. Comparing these times with that of

<table>
<thead>
<tr>
<th>Table 1-7—COURTSIM Computer Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>5</td>
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<td>6</td>
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<td>7</td>
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<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

The table below summarizes the processing times observed during the simulation runs.

<table>
<thead>
<tr>
<th>Table 1-6.—COURTSIM Processing Unit Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Advance</td>
</tr>
<tr>
<td>Frisky</td>
</tr>
<tr>
<td>Queue</td>
</tr>
<tr>
<td>Report</td>
</tr>
<tr>
<td>Enter</td>
</tr>
<tr>
<td>Leave</td>
</tr>
<tr>
<td>Arrest</td>
</tr>
<tr>
<td>Test</td>
</tr>
<tr>
<td>Transfer</td>
</tr>
<tr>
<td>Receive</td>
</tr>
</tbody>
</table>

The table below summarizes the processing times observed during the simulation runs.
the eighth year (the Administration of Justice Task Force recommended maximums), one can see that the time tableed to trial approximates the allowable.

The inputs to COURTSIM were modified to reflect some changes in rules and procedures of the District Court and their possible implications. These modifications include such factors as (1) decreased number of defendants pleading guilty as a possible result of the Bail Reform and the Elimination of Jails Act; (2) a delay in the entry of a guilty plea; and (3) the amendment of rule 70. In addition, the input computer run was incorporated. Cases were scheduled for trial with priorities given to guilty defendants and old cases provided there was no conflict with the case-assigned District Attorney. The 1965 input data was used, plus the above modifications. The results are tabulated in rows 6 and 7 of table 1-8. Row 6 reflects the effects of enforcing rule 87 on elapsing times after arraignment. Row 7 shows the simulated effect of requiring one grand jury sitting regularly and with an additional grand jury sitting when necessary to keep the average waiting time in the Grand Jury Unit under 1 day. This Run also reflects the effects of maintaining the 1965 guilty plea rate of 50 percent. This last result again suggests that the timetable recommended by the Administration of Justice Task Force apparently can be met up to trial.

Other changes can be examined with minor modification of COURTSIM. For example, one could examine:

- What would happen to bottlenecks and time delays if a different calendaring system was used in the District Court?
- What would happen if more cases had to be brought by indictment?
- What would be the effect of further changes in the scheduling of motions, sentencing, and trial dates?

The above analyses indicate what can be done with a tool like COURTSIM in studying the impact on time intervals of changes in the court procedures. Associated with these analyses one must also look at the potential changes in the workload. Table 1-9 shows the court workloads obtained from the various computer runs of COURTSIM. In Runs 4, 6, 7, and 8, about 30 percent of the estimated number of hours the U.S. Commissioner has available for pretrial and preliminary proceedings was used for this purpose. On the other hand, the U.S. Branch, Court of General Sessions, was used at approximately 90 percent of its available capacity in these simulations. (This Branch also tries misdemeanors.)

To see the effect of reliefs of this workload on the U.S. Branch, a run of COURTSIM (Run 2) was made with all felony defendants (about 6,300) having preliminary proceedings before the U.S. Commissioner. This tentative conclusion bears further investigation; however, these preliminary results suggest that such actions could be considered. If all defendants were processed only at the U.S. Branch, Court of General Sessions (Run 5), the workload would be excessive, with a slight increase in the time to disposition, not including the time between conviction and sentencing. This is an overall successful, for example, in the 1965 simulation, the cases that went to trial (i.e., 30 percent of the total cases) took approximately 5 weeks less when the bottleneck at the grand jury was eliminated. There was only a slight increase in the time it took to go from arraignment to trial disposition. The explanation for this probably lies in the nature of the data that were available for the simulation.

(1) Number of Judges: In 1965 an average of five judges was reported to have been sitting on the criminal side of the U.S. District Court for the District of Columbia.

(2) Available Judge Hours: The courtroom hours for 1965 were 10:00-12:30 and 1:45-5:00 (with two 10-minute breaks) 4 days a week; the fifth day was reserved for motions and sentencing.

From the above, it was assumed that 5,000 hours per year were available for trial of criminal cases in the District Court in 1965 (3 judges x 20 hours/week x 52 weeks/year).

(3) Required Trial Time: The available data on felony trial times were as follows:

(a) From the D.C. Crime Commission 1965 felony cases, an average of 2 days and 3 days for nonjury and jury trials, respectively (these represent breakdowns in that weekends are included and fractional days are considered full days).

(b) From the Administrative Office of the U.S. Courts, Annual Report 1965, table 36, the average nonjury trial time was computed to be 1.3 days, the average jury trial time was computed to be 2.8 days. (This is an overall average of all U.S. District Courts.)

In the simulation an average of 1.3 days was used for single defendant nonjury cases, 1.8 days for single defendant jury cases. These values were used for multiple defendant cases (35 percent of the cases) for an overall average of 1.5 days and 2.2 days for nonjury and jury trials, respectively. These times do not include Friday, Saturday, and Sunday for cases that run over the weekend. When that time is included, an average of 2 days and 3.6 days for nonjury and jury trials, respectively, resulted in the simulation.

(4) Number of Trials: In the simulation a total of 540 cases went to trial; this compares with 407 reported for the U.S. District Court for District of Columbia in fiscal year 1965 in the Administrative Office report (table C7).

Based on (1) to (4) above, the simulation indicated that the total number of trial hours required in 1965 was 50 percent of the trial hours actually used. Reducing the queue at the grand jury a temporary surge was eliminated and increased the load on the judges by an additional 15 percent. The slight queue resulting from this did not significantly increase the total average time for trial disposition.

In summary an average of 25 percent time reduction was observed for the combined trial and sentenc ing dispositions. This reduction is due to the fact that there were only a small increase in time for those who had trial disposition (due to the temporary surge by releasing the queue at the grand jury) under the assumptions in the simulation.

Further, if one required that all motions be filed and heard within 17 days, (Run 8) in association with the increase in the Grand Jury Unit resources, the simulation results indicated that the mean time from initial prement time to trial disposition was reduced from 5.5 months to 3 months.

There appears to be some evidence that since 1965 there have been increasing demands on the courts. This time is not satisfactory.
might be attributed to several recent changes, e.g., the Bail Reform Act and the Criminal Justice Act. The study in question did not assess these changes in detail. Furthermore, the procedure for scheduling cases for trial has been modified, and the percentage of cases disposed of by guilty pleas has reportedly declined.

During the period from 1960-63, the yearly averages were 1,099 filings and 1,077 terminations, a close balance that maintained a steady rate over the period 1964-65 averaged about 1,200 cases per year. From 1963-66, filings increased at a rate of over 100 cases per year to a level of 1,653 in 1966. The backlog of pending cases, which was stable at no average value at 480 in the period 1960-64, climbed to 610 in 1960 and 913 in 1966. This would seem to offer strong evidence that significant changes occurred in the District of Columbia courts during the 1965-67 time period. Because of the above, a detailed analysis of the courts in the present time period would be required to evaluate the court's resources necessary to handle the current workload. Unfortunately, the data required for this analysis and simulation are not readily available and for certain types of data (e.g., processing time) are not being collected. The computer simulation tool developed here can be used in this evaluation provided that these data are made available.

The data deficiencies which have limited all the Task Force's efforts have also hampened the court analyses, even though the District of Columbia criminal felony data is far more extensive than any examined. Some of the required data are not available in court records nor in the present criminal jackets or records. To alleviate this deficiency:

(1) Data should be collected not only on those cases for which return of indictments are made but also on those cases (or defendants) which drop out from the felony processing route. This can be accomplished by establishing a felony disposition file made up of jackets which store the information on each case until disposition. Each jacket should contain all the required information on the case, including all the data presently being collected in the felony jackets as well as the following types of information: Amount of court time spent at each processing stage, e.g., length of time for preliminary leaning.

Number of witnesses used at each processing stage. The date the case was ready to be processed and the date it actually was processed, e.g., when the case was handed to the Grand Jury Unit for processing, when it was presented, and when the indictment was voted. (The jackets should be designed and coded so as to minimize the problems associated with conversion to computer tapes or cards. To achieve a maximum of uniformity and consistency, the jacket design should use a multiple-choice selection layout. Such a design has been established by the Administrative Board of the Judicial Conference of the State of New York. A felony disposition jacket should be formatted so as to be applicable on a unit-wide basis using the New York approach as a guide. A misdemeanor disposition record will be designed concurrently with the same features.

No data have been collected to investigate the possible cost for data collection or those costs associated with the changes investigated in the court system. Obviously, such analyses are required in order to determine which of several proposed changes achieves a desired level of improvement, such as meeting a model timetable, most economically.

The general approach, called cost-effectiveness analysis, has become standard within the Department of Defense and has applicability to criminal justice as well, as discussed in chapters 2 and 5. One estimate made indicated that an additional increase of 25 percent of manpower resources in the Grand Jury Unit (one U.S. Attorney, one clerk, both full time, and one grand jury, one quarter of the year) would cost approximately $30,000. Some conclusions and recommendations can be drawn based on the results of the analyses of the District of Columbia felony data and the running of COURTSIM. Some require more detailed analyses based on accurate measures of processing times. Others call for close, coordinated work between the court staff and a research team to refine, examine, and test some of the tentative conclusions.

Based on the examination of the processing of felony cases in the District of Columbia:

- Serious consideration should be given to using the U.S. Commissioner's office for the preliminary processing of felony defendants, thereby relieving the workload on the U.S. Branch of the Court of General Sessions. Readjustment of resources in the U.S. Attorney's Office and additional hearing days at the U.S. Commissioner's would probably be required.
- Based on the above analyses, the elapsed time between presentment and return of indictment can be reduced from an average of 8 weeks to 2 weeks by eliminating the queue at the grand jury. This would require some additional hours by the grand jury, a more expeditious manner of preparing and processing the indictments and a review of the additional U.S. Attorney and clerical manpower requirements. Relief of this delay at the grand jury will have an impact on the queue that exists for trial. A close examination of the extent to which court rules for filing motions and granting motions are enforced, the practicality of extensive use of pretrial hearings, together with an analysis of the number of hours and trial days available would reveal the impact of relieving the grand jury queue on the total time before disposition for defendants going to trial.
- The timetable recommended by the Administration of Justice Task Force appears to be reasonable for the District of Columbia court system and could be used as a standard against which to measure delay.
- An intensive data collection effort should be initiated in the District of Columbia court system in order that the present processing can be refined and other analyses performed. This data collection should record the time, in minutes and hours, not just days, that is actually spent in processing the defendant, by what court official or staff member this is done, and what action is taken. This should cover all cases from time of arrest to final disposition, not just those cases that are commenced in District Courts. Such an effort would not be unduly burdensome; statistical sampling techniques can be used, forms prepared and those persons already involved in the system could record the necessary information.
- The COURTSIM model can be refined with better data and in close coordination with court officials; it should be pursued and imbedded in the court system to provide court management with a useful tool. Furthermore, it has the potential for including processing of misdemeanor cases in the Court of General Sessions.

The analysis of court operations, although focused on delay in the processing of felony defendants in the District of Columbia, leads to recommendations for court operations in general:

- A uniform data base should be established in order that meaningful and useful analyses can be accomplished to isolate problem areas and recommend solutions on a county, State, or National level.
- The COURTSIM model should be extended to several large urban areas as a pilot study to determine its applicability to other court systems and its overall usefulness. Concurrently with these pilot studies, a more sophisticated computer language should be developed to increase the efficiency and flexibility of the simulation program.

The Task Force has focused on delay and workload. Clearly there are other sets of equal importance that deserve close examination; updated management procedures administered by a court administrator; evaluation of the cost and manpower requirements associated with potential changes in the system; organizational changes in some courts; and the layout of physical facilities.

ACKNOWLEDGEMENTS The authors gratefully acknowledge the valuable assistance of Robert H. Cohen and Janice R. Holoven, both of IDA, in the preparation of the simulation.
The object of this note is to provide an estimate of the proportion of the future U.S. population which will have an arrest record. It is necessary to make careful assumptions about how the population will change in the future. In general, we make the assumption that "steady state" or the current situation will continue into the future. This is not intended to suggest that the present situation will necessarily continue, but that the projections will be as indicated if it does continue. If, for instance, the projection of arrest probability is viewed as undesirably high, then that would suggest a reconsideration of the factors making it so high.

During the last 5 years, the probability of being arrested as a function of age has been increasing for each age group of the population, the increase being most pronounced for the younger age groups. However, for purposes of this calculation, we will make the conservative assumption that the age-specific arrest probabilities for future years will remain the same as they were in 1965. This tends to underestimate the probability of eventual arrest. Yet, this probability will be found to be strikingly high even with this and other conservative assumptions.

**METHOD USED**

Suppose \( p_i \) is the probability of a person in the class of interest being arrested as a 5-year-old. Then the probability of an individual in this class being arrested during his life is

\[
P = T \left( 1 - p_i \right) \frac{1}{1 - \left( 1 - p_i \right)} \]

where \( T \) is a large number, say 90 years, after which age few people are arrested for the first time.

However, suppose \( p_i \) is the probability of an individual in the class of interest being arrested for the first time as a 5-year-old. Then

\[
P = \frac{T}{1 - \left( 1 - p_i \right)}
\]

The two equations are, of course, equivalent since

\[
p_i = \left( 1 - p_{i+1} \right) \cdots \left( 1 - p_{i+T} \right) p_i
\]

Our model is steady state in the sense that we assume that the age-dependent arrest probabilities for 1965 carry forward unchanging into the future.

In Figure J-1, three persons 5 years old in 1965 fall in the lower right-hand shaded box in the figure. (We use 5-year-olds since this is approximately the age at which most arrests begin to occur.) At time 3, this group advances up the series of diagonal boxes. Because of the steady state assumption, all boxes along a horizontal line express identical arrest probabilities. Thus, we refer back across to the associated box in the 1965 data base to establish the appropriate \( p_i \).

Let \( L \) be the number of first arrests in the 5-year-old box and \( M_i \) be the total number of people in the \( i \)th box. Then

\[
p_i = \frac{L_i}{M_i}
\]

is the probability of first arrest for someone in the \( i \)th box.

The proportion of the 5-year-olds who, from survival statistics, will live to be 1 year old is \( L_0 \) (see Table J-1). Thus, the probability of a person who is 5 years old today being first arrested as a 6-year-old is \( L_0 p_i \).

Summing, we get

\[
\sum p_i
\]

as the probability of someone 5 years old today being arrested by the time he is a 6-year-old. The summation is proper since being arrested for the first time at one age and being arrested for the first time at a different age are disjoint events.

**DATA ON ARRESTS AND VIRGIN ARREST RATIO**

Figure J-2 shows the distribution of the total number of arrests in 1950 by age as recorded in the 1965 UCR. The total area below the top curve integrates to a total of 5,031,395 arrests by reporting agencies servicing a population of 134,095,000 (about 60 percent of the total U.S. census estimate of 194,400,000 for 1950). We will assume that the crime characteristics of this population resemble those of the entire population as well as on those arrested in 1965.

1 The denominator used is the total number of people in the 5th age group, and not just those who would be at risk of arrest. We are assuming that the arrest probability for some ages, say 10 years old, is very small and that the small number of such ages is not important. When age is not considered, the arrest probability for any age is assumed to be the same as at 10 years old; this assumption is not very far from reality. The arrest probability of a 5-year-old being arrested and never being arrested is assumed to be identical for each age group.

2 By "interest" we mean the smallest percentage in the entire age range of those reported to the UCR. It is the percentage of individuals in any given age range whose offense is never reported to the police (i.e., the "virgin arrest ratio.")
1.7. The statistics of those arrested at least once in lifetime, therefore, are insufficiently complete, resulting in an unrealistically high figure. For example, according to the Bureau of the Census, about 32 percent of the arrests in San Mateo County between July 1, 1961, and June 30, 1962, were of individuals with no prior record. A breakthrough of this percentage by crime type is given as follows:

<table>
<thead>
<tr>
<th>Crime Type</th>
<th>Virgin Arrests</th>
<th>Misdeemeanor Arrests</th>
<th>Virgin Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>larceny</td>
<td>52.7</td>
<td>47.3</td>
<td>52.7</td>
</tr>
<tr>
<td>burglary</td>
<td>57.3</td>
<td>42.7</td>
<td>57.3</td>
</tr>
<tr>
<td>other theft</td>
<td>48.7</td>
<td>51.3</td>
<td>48.7</td>
</tr>
<tr>
<td>assault</td>
<td>51.9</td>
<td>48.1</td>
<td>51.9</td>
</tr>
<tr>
<td>other</td>
<td>58.9</td>
<td>41.1</td>
<td>58.9</td>
</tr>
<tr>
<td>total</td>
<td>54.4</td>
<td>45.6</td>
<td>54.4</td>
</tr>
</tbody>
</table>

1.8. A study was made of the UCR data and the number of arrests was calculated by the formula: 

\[ \frac{\text{Virgin Arrests} \times 100}{\text{Total Arrests}} \]

This gives us estimates of the virgin arrest ratio for two different age groups, those below 18 and those 18 and above. (Although the juvenile-adult dividing line varies from jurisdiction to jurisdiction and can even depend upon the case within a jurisdiction, we will use the average of about 18 years of age for purposes of these computations.) However, if we want to know the probability of an individual acquiring a record by the time he reaches a given age, then we must know explicitly how the ratio

"..."
A curve which meets these requirements is also shown in figure 1-4. Having found \( r_t \), we can plot \( r_t N_t \) as a function of \( t \). This is the lower curve on figure 1-2, representing the number of virgin arrests in 1965 as a function of age of individuals sentenced. The number of virgin arrests is about 630,000 out of a total of 5,031,393, giving an overall virgin arrest ratio of about one-eighth, or 12.5 percent.

In general the age-specific ratio, \( r_t \), for any given age \( t \), is highest for white females, next highest for Negro females, next for white males, and lowest for Negro males. However the available data is insufficient to enable us to estimate very reliably the difference in the functional form of \( r_t \) for each of these four categories. Instead when we come to the end of the calculation we will simply correct the weighted average to 0.15 for whites and 0.08 for Negroes, in accordance with the District of Columbia Crime Commission data. Since males constituted the bulk, 94.1 percent, of the arrests in these samples, these figures are really estimates for males and not for females. Data for 1965 from the County Court of Philadelphia indicates that the virgin arrest ratio is about two times as great for females as for males. We will also make this correction at the end of the calculation.

\[
\sum_{t=0}^{T} r_t N_t = 0.31
\]

\[
N_t = \text{Number of UCR arrests in 1965 of } t\text{-year-olds}
\]

where:

- \( N_t \) = Number of UCR arrests in 1965 of \( t\)-year-olds

A curve which meets these requirements is also shown in figure 1-4. Having found \( r_t \), we can plot \( r_t N_t \) as a function of \( t \). This is the lower curve on figure 1-2, representing the number of virgin arrests in 1965 as a function of age of individuals sentenced. The number of virgin arrests is about 630,000 out of a total of 5,031,393, giving an overall virgin arrest ratio of about one-eighth, or 12.5 percent.

In general the age-specific ratio, \( r_t \), for any given age \( t \), is highest for white females, next highest for Negro females, next for white males, and lowest for Negro males. However the available data is insufficient to enable us to estimate very reliably the difference in the functional form of \( r_t \) for each of these four categories. Instead when we come to the end of the calculation we will simply correct the weighted average to 0.15 for whites and 0.08 for Negroes, in accordance with the District of Columbia Crime Commission data. Since males constituted the bulk, 94.1 percent, of the arrests in these samples, these figures are really estimates for males and not for females. Data for 1965 from the County Court of Philadelphia indicates that the virgin arrest ratio is about two times as great for females as for males. We will also make this correction at the end of the calculation.
cent population median age of 29.5) since the probability of being arrested was lower in years prior to 1965. A statewide representative sample of 1,132 Minnesota boys and girls (84 percent of all 9th-grade public school children for the 1953-54 school year) showed that by the time they reached 17½ years of age 24.2 percent of the boys and 6.3 percent of the girls had either police or court records for offenses more serious than a minor difficulty with the police, such as a traffic contact. 14 Using 1965 arrest probabilities, figure J-7 shows that, to an age of 17½ years, our analysis gives an estimate of about 25.1 percent for males and 6.5 percent for females.

Statistical research of the County Court of Philadelphia, together with school census figures and U.S. census data, shows that as of 1961 about 21.4 percent of Philadelphia boys and 7.1 percent of the girls were referred to courts before reaching age 18. 15 In Fayette County, Ky., as of 1960 it has been estimated that 20.7 percent of the boys and 5.2 percent of the girls were referred to juvenile court before age 18. 14 Based on data from a representative nationwide sample of juvenile courts, it has been estimated that about 1 in 6 boys and about 1 in 23 girls in the country will be brought into juvenile court for delinquency before 18 years of age. 16

To distinguish city, suburban, and rural populations on the curves in figure J-8, the appropriate correction factors are:

For example, the city male correction factor was calculated as follows:

\[
\text{Number UCR city male arrests in 1965} \times \frac{1965 \text{ UCR population}}{\text{U.S. male fraction}} \times \frac{1965 \text{ UCR city population}}{\text{Urban male fraction}}
\]

The "United States in general" figures were obtained from the specific figures for "city," "suburban," and "rural" by allocating 67 percent of the U.S. population to city, 12.6 percent to suburban, and 20.4 percent to rural. 19

---


This then corrects the overall results to roughly account for the disproportionate urban reporting to the UCR. If we wanted to break these figures down finer the next logical factor to consider would be economic level. But data correlating arrests to income are not available. However, some racial breakdowns are available, and this provides limited information on the effects of economic level. Once factors such as sex, income, and residence are taken into account, any additional differences due to race are small. As a result, we break down the data for arrests by race as recorded in the Census Bureau, and the basic virgin arrest fraction by race taken as 15 percent for whites and 8 percent for nonwhites. The results are tabulated below:

<table>
<thead>
<tr>
<th>Race</th>
<th>Percent</th>
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<tbody>
<tr>
<td>White</td>
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<td>8%</td>
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To get a racial breakdown, we correct for the number of arrests by race as recorded in the Census Bureau, and the basic virgin arrest fraction by race taken as 15 percent for whites and 8 percent for nonwhites. The data problems which limited the previous analysis can be applied to the arrest calculations. This would have resulted in estimates of 64 and 17.5 percent for lifetime arrest probabilities of males and females, respectively. Instead of 52 and 13 percent which resulted from the actual distribution. Since most virgin convictions occur within a few years after first virgin arrests, it is reasonable to estimate the actual lifetime conviction results by introducing correction factors of 0.08 for males and 0.07 for females.

The probability of an adult being charged with a part I offense and being convicted (of the charged offense or a lesser offense) in an adult court in 1965 was:23

\[
\text{Probability} = 0.0256
\]

Next we need the fraction of those convicted who do not have a prior conviction record. For a sample of 88 U.S. District Courts in 1964 this was 0.359, implying that the fraction of convictions per part I arrest, we can make estimates of the life time conviction probabilities for all UCR-type charges:

\[
\text{Probability} = 0.49
\]

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occurrence is given by the Poisson distribution. Then if \( p \) is the probability of being arrested at least once, the probability of being arrested \( n \) times is given by \( p_n \), where:

\[
q^n = \frac{p_n}{p_{n-1}} \epsilon^{-p}
\]

is the probability of \( n \) subsequent arrests given a first arrest, and:

\[
S = \frac{1}{p}
\]

is the average number of subsequent arrests of those arrested at least once.

For \( p = 0.5 \) and \( r = 0.125 \), the resulting curve is plotted on figure J-9 (dotted line), where the vertical axis is number of arrests \( x \) and the horizontal axis is arrest-proneness \( x \) measured in percentage of the population arrested in order of decreasing number of arrests. For example, an individual having arrest-proneness \( a = 0.30 \) percent means that 30 percent of the male population is arrested at least as many times as he is.

Another estimate of the profile can be obtained from District of Columbia Crime Commission data. The percent of the sample of convicted adult felons with a history of a specific number of arrests versus the number of arrests is plotted on figure J-8. Subdividing the \( p = 0.5 \) percent accordingly, we obtain the dashed curve on figure J-9. Although convicted adult felons may not represent the arrested population generally in terms of number of arrests, this appears to be the best data available. The points on the dashed curve, drawn in step fashion, can be approximated rather closely by a simple exponential function of the form

\[
x = 50e^{-0.1x}
\]

where \( x \) is the mean number of arrests of those who have been arrested at least once. The fact that \( x \) is the mean can be verified in the equation:

\[
50e = \int_0^\infty x \, dx
\]

Using 1965 UCR data, the area under the curve should be:

\[
A = \frac{50}{\text{average male lifetime}} \times \text{age distribution correction factor/geographic correction factor} \times 100 \%
\]

\[
= \frac{\int_0^\infty x \, dx}{0.492 \times 134,058,000,000} \times 0.95 \times 100
\]

\[
= 382
\]

\[\text{Figure J-9. Projected arrest history profile for U.S. male population} \]

\[\text{Figure J-10. Projected arrest history profile for U.S. female population} \]

Suppose, for example, we define strong repeaters as those who experience more than the average number of arrests (7.6) for nontraffic offenses in their lifetimes. The percentage of the male population who are strong repeaters is then:

\[
x = 50e^{-0.1x} \approx 18\% \text{ percent}
\]

From figure J-9, we can also calculate the probabilities \( p_i \) given the individual is arrested at least \( i \) times, that he is arrested at least \( i + 1 \) times.

We have already established that \( p_0 = 0.5 \). To find \( p_i \) for \( i = 1 \), we set \( i = n + 1 \) and evaluate:

\[
p_i = p_n e^a
\]

(\text{by the definition of } a)

Using \( a = 7.6 \),

\[
p_i = p_n e^{7.6} \text{ for all } i \geq 1
\]

These results show that there is a striking difference between those people who get arrested at least once and those who do not. The strong correlation between the first arrest and subsequent arrests, which shows up in the fact that \( p_0 p_i \), for \( i = 1 \), indicates that there is a phenomenon of arrest-proneness. Were there no correlation between arrests, then they would be Poisson distributed over the whole population and not just the arrested population. If \( p \), then we would expect the average number of arrests of those arrested at least once to be only:

\[
\frac{-ln(1-p)}{p} = 1.30
\]

In reality it is about eight, a much larger number. So arrests are not Poisson distributed over the whole population. In fact, there is even a correlation between subsequent arrests, since the distribution over the arrested population is closer to an exponential distribution than to a Poisson distribution, as we have seen.

Repeating this same calculation for females, we have:

\[
A' = \frac{(509,768,727)(0.508)}{(134,058,000,000)(0.95)} 
\]

\[
= 49.8 \times 0.13 = 6.6 \times 100
\]

\[
= 6.6\% \text{ percent}
\]

If arrest were uncorrelated, one would expect \( p_i \) to be

\[
\frac{-ln(1-p)}{p} = 1.96
\]

The resulting curve:

\[
x = 13e^{x^{2/3}}
\]

is plotted on figure J-10. Using the same definition, the percentage of strong repeaters among the female population is:

\[
x = 5\% \text{ percent}
\]

\[\text{Lifetime conviction history profiles} \]

In the previous section, we estimated lifetime arrest history profiles. We now turn to convictions. For males, the relevant data is:

\[\text{Convictions per male arrest} \quad A' = (0.36)382 \]

\[= 137 \]

\[a' = 19 \]

\[= 7.2 \]

\[\text{226} \quad \text{To the President on Crime in the District of Columbia, 1966, app., p. 691.} \]

\[\text{227} \quad \text{We note that the average number of convictions during the life of those convincted of arrest one year are (statistically significant for the things we are interested in). \( = 2.5 \).} \]

\[\text{Some evidence tends to bear into the future, is expected to be this for males.} \]
The resulting curve

\[ y = 10e^{-0.7x^2} \]

is the upper curve on Figure J-11. The corresponding curve

\[ y' = 5e^{-0.8x} \]

corresponds to females on Figure J-11. Using a definition of "strong repeaters" for convictions similar to that for arrests, we obtain

\[ y = 7 \text{ percent} \]
\[ y' = 2 \text{ percent} \]

as the percentage of the male and female populations, respectively, who are strong repeaters in convictions (over 7.2 lifetime convictions for males and 4.1 for females).