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INNOVATIVE RESOURCE PLANNING IN

URBAN PUBLIC SAFETY SYSTEMS —

PROGRESS REPORT,

NOVEMBER 1973 - NOVEMBER 1974

TECHNICAL REPORT

"INNOVATIVE RESOURCE PLANNING IN URBAN PUBLIC SAFETY SYSTEMS"

OPERATIONS RESEARCH CENTER
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

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FOREWORD

The research project, "Innovative Resource Planning in Urban Public Safety Systems" (IRP), is a multi-disciplinary activity supported by the National Science Foundation, and involving faculty and students from the M.I.T. Schools of Engineering, Architecture and Urban Planning, and Management. The administrative home for the project is the M.I.T. Operations Research Center. The research focuses on three areas: 1) <u>evaluation criteria</u>, 2) <u>analytical tools</u>, and 3) <u>impacts upon traditional methods, standards, roles and operating procedures</u>. The description of project activities presented in this paper was compiled by members of the IRP staff and is intended to provide an overview of our research progress during the period of November 1973 to November 1974. Additional project materials, including monthly newsletters and project reports, are available from the IRP Project Secretary, Room 4-209, M.I.T., Cambridge, Massachusetts 02139.

The work reported herein was supported by the National Science Foundation under Grant GI38004.

Richard C. Larson
Principal Investigator

CONTENTS

The "Innovative Resource Planning in Urban Public Safety Systems" project began in April 1973. In November 1973 a site visit was conducted to provide feedback and guidance to the project staff at the eight-month mark. This document will provide a brief summary of the progress since that site visit and thereby serve as an overview of IRP activities during the period of November 1973 to November 1974.

Briefly reviewing the overall structure of the research effort, the project is broken down into three components:

1. A comprehensive analysis of <u>evaluation criteria</u> of urban public safety services, directed toward the understanding of productivity and effectiveness of urban public safety services.

2. A set of <u>analytical and simulation models</u> that will be useful as planning, research, and management tools for urban public safety systems in many cities.

3. An evaluation of the <u>impact of new criteria, methodologies, technologies, and organizational forms</u> upon traditional crime hazard rating schemes, insurance rating methods, related regulations and standards, personnel performance criteria, system operating policies, neighborhood service indicators, and employees and their organizations.

As will be discussed on the following pages, Tasks P1 and P3 comprise component 1, Tasks A1, A2 and A3 comprise component 2, and Tasks I1, I4, and I5 comprise component 3. If the research components are envisioned as horizontal "cuts," <u>police</u> and <u>emergency medical services</u> are the two primary vertical cuts, representing the two specific kinds of urban public safety systems upon which the research is focused.

Before outlining the work on each of the tasks, we will present a brief overview of various project highlights which have occurred since November, 1973.

Working with the Agencies

Increasingly, staff members have been interacting with professionals in other institutions and agencies. In the police area:

In February, Dick Larson met with Mr. Mike Sheean of the newly-created Massachusetts Police Institute. The Institute provides technical consultive services (free of charge) to police departments in small municipalities throughout Massachusetts. Discussion focused on how the resource allocation methodologies of Tasks Al and A2 could be of use in providing guidance to police administrators in such towns as Gardner and North Attleboro, MA.

Dr. R. Paul McCauly, director of graduate studies, School of Police Administration, University of Louisville, KY, visited project headquarters in June. He was interested in newly developed models, such as the hypercube model for police sector design, as police management training aids for a new course in his graduate program.

Gary Marx and Dick Larson have assisted the Massachusetts Governor's Committee on Law Enforcement and Administration of Justice. Their efforts have focused on planning and evaluation activities of the Worcester Impact Program. Additionally, Larson has evaluated a proposed set of software specifications for the Worcester Police Department to set up a data collection and analysis system that will facilitate evaluation of the Impact Program.

Mark McKnew and Rick Jarvis have been working with the Arlington and Wellesley (MA) police departments. The Arlington data has been aggregated into a form which can be input to the hypercube

queuing model. And some experimental patrol changes have been instituted as a result of preliminary crime data analysis. The same efforts will be completed in Wellesley by April, 1975, and will provide an additional comparison between data analysis results and model predictions.

During the summer, Ken Chelst served as a consultant to the New York City-Rand Institute. The majority of his time was spent with the New Haven, CT, Department of Police Services on a technology transfer project supported by the U.S. Department of Housing and Urban Development. He worked closely with the police department in setting up the data bases necessary for the running of the hypercube approximation procedure and for the sector redesign programs.

The simulation model (originally described in Chapter 6 of Dick Larson's book, <u>Urban Police Patrol Analysis</u>) is currently being implemented in the Washington, D.C., Metropolitan Police Department by Mathematica, Inc., with LEAA support. That effort should be completed within six to eight months, resulting in a freely available PL/I simulation (used in the batch processing mode) for use by any police department. Inspector Herbert Miller of the D.C. police, and a member of the IRP Police Advisory Board, has been closely involved with this implementation; as has Saul Gass of Mathematica, the Principal Investigator of the LEAA contract.

Messers. F.R. Lipsett and J.G. Arnold of the National Research Council of Canada have programmed a FORTRAN version of the model for use by Canadian police departments. Initial implementation experience has been with the Ottawa Police Department and the Gloucester Township Police Department. Their work was based on Dick Larson's

report, "Models for the Allocation of Urban Police Patrol Forces."
Simulation implementation, carried out for the Gloucester police
force, was published as "Computer Simulation of Patrol Operations
of a Semi-Rural Police Force," by Lipsett and Arnold ("Journal of
Police Science and Administration," Vol. 2, No. 2, pp. 190-207).
One of their conclusions was that:

> The possibility of "queueing saturation" is a real one
> for all police forces, and may be the most important
> analytical result of the present work. It might be
> worthwhile for many police forces to analyze and/or
> simulate their operations solely in order to ensure
> that they are not operating at the onset of saturation.

The district-by-district and tour-by-tour patrol allocation
algorithm (first described in Chapter 5 in Urban Police Patrol
Analysis) has been implemented in the New York City Police Depart-
ment by the New York City-Rand Institute. After many years of de-
bate and discussion over resource allocation methods and prerogatives
(as described by Margaret Levi in "And the Beat Goes On: Patrolmen's
Unionism in New York City"), this algorithm now resides on an NYPD
computer and is used as the basis for manpower allocation decisions
among NYC's 72 police precincts. The planning and research staff
of the Seattle Police Department has obtained a copy of the FORTRAN
program used by the NYPD, and they are now implementing the method
in Seattle. In Los Angeles, based on a course project by students
of Jan Chaiken (RAND and UCLA), the Los Angeles Police Department is
now considering the method for its own use. In Rotterdam, The
Netherlands, this algorithm is being used currently as the basis for
patrol unit allocation. In June, Dick Larson visited with Mr. J.
v.d.Meer, Director of Planning and Research, and his assistant, Mr.

Caroll, in the Rotterdam Police Department. For two years, Mr. v.d. Meer and Mr. Caroll have been studying and implementing new police patrol deployment techniques. Using the new deployment philosophies that have been developed in recent years, they have reallocated patrol units throughout Rotterdam so as to accurately reflect spatial and temporal patterns of demands for service. Their new deployments employ several procedural innovations including preemption (i.e., interrupting units providing on-scene service to a low priority call in order to dispatch the unit to a near-by high priority call, such as a felony in progress or a seriously injured person) and adaptive total manning (i.e., interrupting meal breaks and other rest breaks when necessary in order to avoid system saturation). A report recently submitted to the federal government in The Hague recommends implementation of this patrol allocation method in the other two large cities in The Netherlands: Amsterdam and The Hague. Consideration is also being given to limited implementation in the next five largest cities. The constraints in each case would be availability of technically trained personnel and a computer-based information system.

Dave Fahrland of the Quincy Police Department has completed analysis of several alternative police sector designs for Quincy (based on time of day), using the hypercube model. He has been working with a police task force within the department--and the new sector plans should be implemented by the end of the year. A final report on this work should be available by December 1.

In related research, Dick Larson and Mark McKnew are working with Captain Glenn Pauly of the St. Louis Police Department, in

evaluating the automatic vehicle monitoring (AVM) system called FLAIR, "Fleet Location and Information Reporting."

In <u>emergency medical services</u>, agency interaction has included:

In August, Rick Jarvis, Keith Stevenson and Tom Willemain visited the Wheeling, WV, area as the guests of the Bel-O-Mar Inter-state Planning Commission and Regional Council. Bel-O-Mar was awarded a planning grant under section 1202 of the Emergency Medical Services Systems Act (PL93-154). Also, through interaction with the Panhandle Health Planning, Inc. of West Virginia, the project staff has been given the opportunity to implement the spatial allocation models on a four-county EMS region around Wheeling. Bel-O-Mar has collected data on ambulance operations in the area. These will be used to run the models which will then provide the information both to evaluate current operations and to discover the consequences of various con-figurations of regional cooperation.

The project's interaction with Rhode Island Health Services Research, Inc. (SEARCH) has borne some fruit recently. The city of Pawtucket, in improving its emergency ambulance service used the results of an analysis prepared by Keith Stevenson in arriving at a cost effective configuration for its fire department-operated rescue service. In addition, the Naval Underwater Systems Center at Newport has designed an EMS communications system for RI, relying heavily on Stevenson's thesis, "Operational Aspects of Emergency Ambulance Services," for determining the number of channels needed.

Richard Weissberg currently is working with the North Shore Health Planning Council in an effort to combine the ambulance services of several communities north of Boston (Lynn, Lynnfield, Nahant,

Peabody, Saugus, and Swampscott). Basically, the Council hopes to develop a statistical profile of the demand for ambulance services in these communities, a profile of the existing services capabilities in terms of response time and availability, and an examination of the effect of varying the number and location of ambulances on the response time of the system. In the next few months, they hope to use the hypercube model in generating a centralized system requiring fewer ambulance units, but rendering service at least equivalent to the present configuration.

Keith Stevenson serves as a member of a statewide Emergency Medical Care Advisory Board, appointed by the Massachusetts Commissioner of Public Health to provide advice and comment on EMS planning in the state by the Public Health Department's Office of Emergency Medical Services(OEMS). He is a member of task forces on communications, transportation and ambulance operations evaluation. OEMS is particularly active, having recently received a $1.9 million EMS implementation grant from HEW, and the EMS staff of IRP was recently approached by the Office's Director, Ms. Linda Leddy, and asked to provide the criteria and methodology for the statewide distribution of new ambulances. An initial short-term analysis is being prepared and will be followed up by a more detailed evaluation of alternative allocations, including regionalized services, using both the hypercube model and the regional ambulance model of Bernstein and Thomas.

Dissemination

At this time last year, our project newsletter circulation was about 400. Presently, circulation is approximately 1600. Published

monthly by Cheryl Birdsall, the newsletter carries information about the project's activities into police departments, hospitals, universities, federal, state and local agencies, research institutes and private homes across the United States and overseas. Description of research work and announcements and summaries of seminars help to keep other researchers and local agencies abreast of our current activities. Listings and summaries of project-related publications ensure that our results reach people concerned with public safety very soon after public release. And even the listing of our library acquisitions has been the agent whereby researchers unrelated to the IRP project have been brought into contact with one another. Every month, Cheryl answers over 150 requests for information or for copies of one or more publications.

Since last November, the following publications have been produced.

"Search Theory" by Philip M. Morse

"Urban Violence and Risk to the Individual" by Arnold Barnett and Daniel Kleitman

"Simple Paths in a Directed Network" by Pitu Mirchandani

"An Interactive Approach to Police Sector Design" by Kenneth Chelst

"Location of Facilities on a Network" by Amedeo R. Odoni

"On Urban Homicide: A Statistical Analysis" by Arnold Barnett, Daniel Kleitman, and Richard Larson

"On Urban Homicide" (a nontechnical version) by Arnold Barnett Daniel Kleitman, and Richard Larson

"Optimal Server Assignment Policies in M/M/N/O Queuing Systems with Distinguishable Servers and Customer Classes" by James P. Jarvis and Richard C. Larson

"Using Interactive Graphics in Simulating the Hospital Emergency Room" by Richard R. Weissberg

"Patient and Bystander Response to Medical Emergencies" by R. Peter Mogielnicki, Keith Stevenson, and Thomas R. Willemain

"The Status of Performance Measures for Emergency Medical Services" by Thomas R. Willemain

"Resource Allocation in Public Safety Services" by Richard C. Larson

"The Hypercube Queuing Model for Facility Location and Redistricting in Urban Emergency Services" by Richard C. Larson

"Approximate Analysis of a Hierarchical Queuing Network" by Thomas R. Willemain·

"Information Theory and Probability Distributions" by Philip M. Morse

"And the Beat Goes On: Patrolmen's Unionism in New York City" by Margaret A. Levi with the assistance of Suzanne Young

"Performance Measures for the Allocation of Police Patrol Forces: Annotated Bibliography" compiled by Suzanne Young

"Conflict and Collusion: Police Collective Bargaining" by Margaret Levi

"Analyzing the Process of Screening Calls for Emergency Service" by Keith Stevenson and Thomas R. Willemain

"Location of Facilities on a Stochastic Network" by Pitu Mirchandani

"On Searching for Events of Limited Duration" by Arnold Barnett

"Computers and the Police Revisited: A Second Look at the Experience of Police Departments in Implementing New Information Technology" by Kent W. Colton

"Alternative Measures of Police Performance" by Gary T. Marx

"An Application of Some Alternative Measures: Validation of the 1972 Police Selection Exam" by Gary T. Marx

Dick Larson traveled to Rochester, NY, on February 22, to present an invited seminar on current research in urban public safety systems. The seminar was jointly sponsored by the Quantitative Methods Group of the Graduate School of Management (University of Rochester) and the Rochester-Monroe County Criminal Justice Pilot City Program (supported by LEAA). As a result of the visit, it is likely that the Pilot City Program staff and the IRP staff will open new lines of communication, including the possibility of trial implementation in Rochester of several of the IRP research products.

On April 22, Dick Larson chaired a session on "Operations Research and Urban Services," at the 45th meeting of the Operations Research Society of America, held in Boston.

In May, Dick Larson presented two lecture sessions on patrol resource allocation to 110 participants in the IACP Patrol Management Seminar, in St. Louis.

Tom Willemain served as moderator of a panel discussion on "Evaluation of Operational and Economic Aspects" at a conference on "The Front-end Health Professional in Telemedicine Systems." The conference, held at Brandeis University and funded by NSF-RANN, explored the value and viability of paramedical personnel in spatially distributed health care systems. Willemain illustrated the use of mathematical models in predicting the productivity of allied health manpower.

In July, Dick Larson and Amedeo Odoni presented, for the second consecutive summer, a special one-week course, "Analysis of Urban Service Systems." Twenty-six students attended including police

representatives from Seattle, WA; Louisville, KY; and New York City.

Additionally, EMS planners, criminal justice planners, and city

administrators were present. Several academicians plan to develop

a similar course (or to embark on similar research) at their own

universities. Seventeen respondents to a detailed evaluation ques-

tionnaire on the course said that they planned to use material learned

in the course in their own professional settings. Some brief descrip-

tions of these plans are:

> I will probably use (with appropriate credits) some of
> the "rules of thumb" and some of the notes on queuing,
> probabilistic vs. deterministic thinking, etc., in an
> introductory seminar for this Department's patrol command
> personnel. Later on, I can see application of both the
> Resource Allocation Program and the Hypercube Model or
> Simulation Model for our Department. This will depend
> on getting our data resources in better order.

> Network design and allocation techniques, the hypercube
> model, and the resource allocation model will be util-
> ized extensively for resource deployment and allocation.

> I have already made use of some of the cost-effective-
> ness materials. I will be instructing some emergency
> service personnel on work scheduling. I hope to have
> the opportunity to employ Jan Chaiken's fire station
> allocation package.

> I hope to use network analysis, simulation modeling,
> and queuing theory in developing cost effective systems
> at the national level for use by local organizations.

Also, in July, Dick Larson, Amedeo Odoni and Sue Young attended a

conference on police productivity. The one-day meeting was presented

by the Department of Industrial Engineering, Lehigh University, at

Bethlehem, PA; in cooperation with the National Commission on

Productivity and supported by the Proctor and Gamble Foundation.

There were approximately 100 attendees, mostly from police departments

in the eastern U.S. The IRP staff presented some preliminary results

from their research on "Operational Police Performance Measures and Their Use in Resource Allocation."

Tom Willemain presented an invited paper at the national meeting of the Society for Industrial and Applied Mathematics in Pasadena, June 24-25. His paper, "Contexts for Mathematics in Health Planning," reviewed both the state of the quantitative health planning literature and the status of comprehensive health planning.

Eight members of the IRP project presented papers at the ORSA/TIMS joint meeting in San Juan, Puerto Rico, in October. In addition, Dick Larson chaired a session on "Urban Public Safety Analysis" and participated in a panel on "Future Prospects for Urban Analysis."

Interaction and dissemination of project research is also accomplished through a series of seminars held at MIT. Since last November, project seminars have included:

Dr. George L. Kelling of the Police Foundation on the Kansas City, MO, preventive patrol experiment.

Dr. Geoffrey Gibson and Lawrence A. Rose, M.D., of the Bureau of Health Services Research, Department of Health, Education and Welfare, on "Evaluative Criteria for Emergency Medical Services."

Patricia Murchie and Charles Neave, M.D., of the Massachusetts Department of Public Health, on "Planning Emergency Medical Services on a Statewide Basis."

Joseph Ferreira and Miguel Torrado-Martinez of the IRP staff, on "Defining and Utilizing Measures of Urban Risk."

Margaret Levi of Harvard University, on "Conflict and Collusion: Police Collective Bargaining."

Keith Stevenson, of IRP staff, on "The Impact of Police Activity on Subway Crime."

Arnold Barnett, of IRP staff, "Notes on Homicide."

Dr. Jan Chaiken of Rand Corporation, on "Analysis of the Criminal Investigation Process."

Gary Marx, of IRP staff, on "Measuring Individual Police Performance: An Application to the Recent Massachusetts Selection Procedure."

Kent W. Colton and Scott Hebert of IRP staff, on "Computer Technology and the Police."

Police Advisory Panel

In May, the police advisory panel held its second meeting.

Members of the panel are:

Captain Daniel Cawley, Management Information Systems Division, New York City Police Department

Sydney Cooper, Chief Administrator, Office of School Safety, Brooklyn, NY

Michael J. Codd, Police Commissioner, New York City Police Department (represented by Matthew F. McPartland, Commanding Officer, Office of Programs and Policies)

Robert J. diGrazia, Police Commissioner, Boston Police Department

Mark Furstenberg, Director of Planning and Research, Boston Police Department

Joseph D. McNamara, Chief of Police, Kansas City Police Department

Inspector Herbert F. Miller, Jr., Director, Operations Planning and Data Processing Division, Washington, DC, Metropolitan Police Department

Patrick V. Murphy, President, Police Foundation, Washington, DC

James R. Newman, Regional Administrator, Office of Operations and Compliance, Federal Energy Regional Office, Kansas City, MO

Captain Glenn Pauly, Commander, Planning and Development Division, St. Louis Police Department

Palmer Stinson, Chief, Planning and Programs Branch, Office of Criminal Justice Planning, Sacramento, CA

Dr. Thomas Repetto, Associate Professor, John Jay College
of Criminal Justice, City University of New York

The feedback from panel members was quite helpful, resulting in
several additional effectiveness measures for the resource allocation
models; a broadening of the urban risk work that to date has focused
on urban homicide; suggestions for administering questionnaires in
Kent Colton's work on police and computers; and recommendations for
extending the work of Bob Fogelson, Margaret Levi and others on
police unions.

Task Pl: Performance Measures, Literature Analysis: Police

Personnel: Richard C. Larson, Amedeo R. Odoni, Sue Young

The results of the literature search have been published as

"Performance Measures for the Allocation of Police Patrol Forces:

Annotated Bibliography." Prior to final publication, this work

was distributed to various IRP staff members, police advisory panel

members, and others for any recommendations, particularly as to major

relevant reports which might have been omitted inadvertently.

Pertinent documents will be added to the bibliography as they are

brought to our attention.

Work is continuing on the report, "Operational Police Per-

formance Measures and Their Use in Resource Allocation." This

document will include a history of patrol methods. The background

study will show what criteria have been used in the past, how

standards have changed throughout the years, and what changes have

occurred due to innovative planning. Based on these trends and

innovations, Dick Larson will offer his own theory for future use

and implications of new methods of patrol distribution on performance.

Contributions to the report will be made also by Joe Ferreira on

hazard formulas for police patrol distribution and by Gary Marx on

individual patrolmen's performance in relation to the civil service

selection process.

Amedeo Odoni has been studying trends in near-term (1958-1974)

expenditures and performance characteristics of major U.S. police

departments. Specific items reviewed are: police department budgets

in relation to GNP growth (with and without inflation), population changes, allocation of resources within a city, expenditures for other services, and breakdown between personnel and non-personnel expenses; trends in salaries and benefits--maximum and minimum salaries, paid holidays and vacations reviewed in relation to rank of the officer, size of the department, and comparable trends in other professions; and manpower and mechanization trends including manpower changes in absolute numbers and relative to population, uniformed vs. civilian personnel, foot vs. car patrols, and manpower for administrative and supporting duties. The data are being examined in order to check the validity of several common assumptions in these areas; offer predictions about future developments, after considering a number of additional factors such as the emergence of strong unionism in police contract negotiations; and devise simple cost-effectiveness measures of police department activities. The latter effort will use, in part, a survey of existing "econometric"-type models of police (e.g., models which try to correlate aspects of police activity to various socio-economic and demographic factors). After reviewing the statistics and studying the trends, Odoni will make recommendations for possible standardization and centralization of information gathering on such items.

Task Pl: Performance Measures, Literature Analysis: EMS

Personnel: Thomas R. Willemain

The purposes of this task are to identify quantitative indicators of the operations of emergency medical systems (EMS), to review the relevant literature, and to cull from these measures and relationships useful to our analytical modelling efforts and to the evaluation of emergency medical systems. Although there is a strong tradition of using quantitative measures in the medical field (surveys, infant mortality, longevity), as in most medical systems it is extremely difficult to find good objective measures of EMS output or to relate the few existing output measures to the system inputs (e.g., to link the degree of residual disability to staff training). In particular, the stress on mortality as a measure is being recognized as inappropriate since the vast majority of EMS patients survive their treatment.

The major effort in this task was concluded with the publication of technical report TR-06-74, "The Status of Performance Measures for Emergency Medical Services," by Thomas Willemain. This review divided performance measures into three types: input, process and outcome. It noted the limited usefulness of the first two for evaluation since they reveal little or nothing about system performance, although they do constitute the majority of the measures used in discussing emergency medical services in both the medical and operations research literature. Valid outcome measures were hard to find and were usually difficult to implement. The review, which

includes a substantial bibliography, concluded that the sophistication of currently available performance measures does not match the complexity of the systems to be evaluated; and that consequently much EMS evaluation has been by proclamation, usually by those responsible for implementation. Supporting examples are included in the report.

Task P3:   Incident and Service Scenarios: Police

Personnel: Gary Marx

This project has completed a paper on "Alternative Measures of Police Performance" and a draft of a long questionnaire designed to assess differences in the attitudes of those who use, work for, and manage urban police systems. Currently, Marx is involved in trying to apply some of the above in conjunction with efforts to validate the 1972 selection exam for police officers in Massachusetts. In addition, a new study on one type of civilian technical specialist --the police planner--was started in May.

The paper on alternative measures of police performance reviews and critiques current efforts to assess individual performance. It argues for the need to find indicators for areas other than law enforcement, indicators which tell us about the quality of performance beyond sheer quantity, and techniques of evaluation which go beyond the subjective rating of a supervisor. It suggests some alternative measures involving the quality of service rendered and citizen satisfaction.

The questionnaire includes incident scenarios, forced ranking of items, knowledge of police powers and activities, and beliefs and priorities regarding police goals and means. It asks questions about what citizens think police should spend most of their time on and be most concerned with; what citizens think of various means used by the police, or that the police might use; citizens' knowledge of the legality of certain police practices and beliefs about the extent

of police use of various means available to them; and various actions
that citizens have taken, or would take, regarding the criminal
justice system.

Because of a pattern of racial exclusion in the hiring of
police officers; under a ruling by Federal Judge Wyzanski, Massachu-
setts was required to develop and validate a non-discriminatory
selection examination. The validation efforts offered the chance to
develop and apply some of the measures argued for in the above work.
Forms for academy, supervisory, peer and self evaluation have been
developed, along with various objective performance statistics.
Some citizen evaluation efforts may also be undertaken.

Data are being gathered on the 500 new police officers hired
since 1972. These will be broken into various dimensions of per-
formance and related to scores on the parts of the 1972 selection
exam. A preliminary analysis of the first round of data will be
ready in June.

The study on police planners is being done in conjunction with
Massachusetts LEAA. It involves case studies of 11 planning pro-
jects. It seeks to determine the natural history and forming
of such projects, problems faced by civilian planners, skills needed
by the planners, the options involved in setting up such projects,
criteria by which they might be evaluated, and their consequences.
The methodology involves interviews, observation, and the analysis
of documents. The basic data have been collected and the analysis
is beginning now.

Task P3:   Incident and Service Scenarios: EMS

Personnel: Thomas R. Willemain, Keith A. Stevenson, Dr. R. Peter
             Mogielnicki (consultant)

In previous published work pertaining to analytical models
and the associated performance measures in EMS, little attention
has been given explicitly to the attitudes, goal structures and
behavior of the different groups involved in EMS, i.e., administra-
tors, professional staff and consumers. Yet if these models are to
be at all relevant for policy-making (and there are signs that in
the next few years EMS will enjoy much more legislative interest
than previously), the associated objectives, measures and alterna-
tives proposed must be credible to the various actors, and must
also take account of their behavior in actual emergency situations.

The work of this task is to explore these goals and percep-
tions, and to take account of group behavior. The results of the
work primarily inform some of the analytical work of the project,
but secondarily provide previously unavailable information to health
planners. The task has been broken into two components.

A study was completed at the Cambridge Hospital of the behavior and
beliefs of patients and bystanders involved in medical emergencies prior
to their contacting the emergency ambulance service. This is an area
previously ignored by people concerned with the organization of emergency
medical services. The results revealed serious shortcomings in the pub-
lic's ability to respond appropriately to such situations. Decision de-
lays at least as long as ambulance response delays were found to be the

result of confusion regarding the seriousness of the emergency, con-
fusion regarding the appropriate reaction to the emergency, and a
reluctance to burden the rescue service unnecessarily. A significant
group of high-risk patients was identified who not only reacted
slowly but bypassed the emergency ambulance service entirely. A
substantial fraction of these patients had had prior contact with
the local medical care system for problems related or identical to
the one causing the emergency.

The study concluded that on an individual basis, physicians
might benefit their patients by making a more conscientious effort
to educate those at risk about the indications for and use of local
emergency transportation. Viewing the medical care delivery system
as a whole, an argument can be made for developing a telephone
system providing emergency medical information easily accessible
to any patients who think they may be experiencing an emergency.

The primary focus of the task has been on the development and
distribution of a survey instrument to explore attitudes and goals
relating to EMS policy issues among the three groups of actors (ad-
ministrators, staff and patients). The issues chosen include the
methods of provision of emergency ambulance service, the financing
of the service, the use of policemen and firemen in emergency medical
work, the use of paramedics, the regional organization of EMS, the
importance of delays in reaching medical care, and the response to
innovations in service delivery.

A questionnaire was developed, and through the cooperation
of the Massachusetts Department of Public Health, the Massachusetts
Hospital Association, the Massachusetts Chapters of the American

College of Emergency Physicians and the Emergency Department Nurses
Association, the National Registry of Emergency Medical Technicians,
and local comprehensive health planning agencies, it was distributed
to 2500 people throughout Massachusetts. The overall response rate
is about 50%, which is encouraging for surveys of this type. A
great deal of interest has been expressed locally in the outcome
of the survey, and copies of the final report have been promised
to all those who make a request. The completed responses have been
coded, keypunched and are currently undergoing analysis. It is
expected that a preliminary report of findings will be available
at the site visit, and that a final report will be out by December 1.

In a very much more modest effort, Panhandle Health Planning,
Inc., a comprehensive health planning agency in Wheeling, WV,
distributed about 250 questionnaires in its region of responsibility
(three counties in northern West Virginia and one in Ohio). Al-
though the number of returns is too small to analyze differences
among the southern respondents, it will be possible to make overall
comparisons between the Massachusetts and West Virginia replies.

Tasks A1, A2:   Quantitative Models for Improved Resource Allocation

Personnel: Richard C. Larson, Amedeo R. Odoni, James P. Jarvis,
             Mark McKnew, Kenneth Chelst, Richard Weissberg, Arnold
             Barnett, Pitu Mirchandani

Dick Larson is coordinating the A1-A2 effort. In addition,
he has been working on a final version of the hypercube computer
model operating under batch processing. A user's manual is currently
being drafted. The final version, reflecting the comments of users
during the past year and of members of the Police Advisory Panel,
includes the following changes, additions, and new options:

> Option to compute frequency of crime preventive patrol
> in each reporting area of the city.
>
> Option to name each response unit, district, and reporting
> area (with names reflecting policies in the city under
> study). Facilitates modeling of all types of municipal
> emergency services.
>
> Option to selectively override the travel time default
> that assumes right-angle travel distance. (With this
> option, one can more accurately model the effects of
> barriers, superhighways, and other unusual travel
> configurations.)
>
> Option to selectively override the dispatch preference
> procedure. Example: dispatch the car estimated to be
> closest except if it's a sergeant's car or a preventive
> patrol specialist; in either of latter cases, dispatch
> as last resort
>
> More efficient allocation of core storage.
>
> Various print options.
>
> Glossary option. Examples: "response unit" = "ambulance";
> "district" = "ambulance zone"; etc.

The documentation on this model should be available in October.

Rick Jarvis' research effort has been aimed primarily at
extending the hypercube models and developing optimization techniques

for the models. Earlier work on optimal dispatch rules has been generalized to include the case where service times are server dependent. In addition, the hypercube model has been extended to allow for unit and server dependent exponential service times and service times which are distributed as the convolution of exponential random variables. For the latter case, a simple postulate concerning the relationship of the hypercube and convolution models proved to be incorrect but did motivate an approximation procedure for general service times. This procedure is similar to one initially developed by Dick Larson.

In conjunction with the hypercube models, Jarvis is developing a linear programming formulation of optimal facility location. This will allow for "optimal" location of new facilities or police preventive patrol frequencies under constraints such as proximity of facilities or sector overlap. In addition, Jarvis is examining questions concerning special cost structures and relationships between multiple performance measures. This particular research effort is scheduled for completion in February, 1975.

Rick Jarvis and Mark McKnew have been working with the police departments of Arlington and Wellesley (MA) concerning sector redesign. One consequence of this work was a seminar designed to introduce police and administrative officials of smaller cities and towns to some of the quantitative techniques being developed by the project. The seminar was held November 6 and included both lecture and demonstration in an interactive environment. Ken Chelst assisted with the seminar.

The Arlington work will result in an IRP technical report detailing the type of effort required to use the hypercube model in departments with no previous use of data processing facilities. The paper will deal at length with the overhead involved in the use of the models and the benefits to be derived from data reorganization within the police department. The results of the sector redesign and service data analyses will also be discussed.

Before April 1, 1975, much of the same effort will be completed in Wellesley. One reason this similar sort of project is being undertaken is the involvement of Special Officer McKnew with the Wellesley Police Department. It is hoped that this closer relationship will allow a greater degree of control in the comparison of the data analysis results with model predictions.

Also, Mark McKnew has been continuing his work evaluating the FLAIR vehicle monitoring project in St. Louis, MO. During July and the early part of August, Mark, with the assistance of Kent Colton, developed a survey to administer to all patrol personnel in Districts 3 and 5 in the St. Louis Metropolitan Police Department. (District 3 was selected by the department to be the test district, while District 5 was chosen to be the control area for the FLAIR experiment.) The surveys were designed to gauge officer perceptions in the areas of police tasks, discipline, and individual behavior. In addition, several of the officers in District 3 were individually interviewed to gain further insight into their views.

McKnew will take a leave of absence from his graduate studies at MIT to work full-time in St. Louis during this spring semester.

The study will continue with a similar type of survey to be administered to the same personnel after the FLAIR system has been in operation for approximately six months. With this information, Mark will be able to pinpoint changes in officer attitudes and behavior in the field. If St. Louis decides to implement the system city-wide, a survey will be made of all officers within the department. It is hoped that the results of this analysis will include a recommendation on the desirability of a vehicle monitoring system and, should it be found desirable, on methods for introducing such a system into a police department.

Richard Weissberg has completed work on version one of the natural language interface for the Larson/Jarvis hypercube models. The natural language interface (or "Monitor" as it has come to be called) evolved in response to a need which became apparent in using the original batch version of the Larson hypercube model. Using the batch version can seem a formidable task to one with little or no technical background. Therefore, a conversational time-sharing version was written which would make the model more readily acceptable to those in the public sector who might use the model to implement constructive changes. Eventually, the IRP staff hopes to add computer graphics to the interactive models. Towards this end, we have acquired the use of an IMLAC mini-computer which comes equipped with a CRT and a powerful graphics processor. Over the coming months, Weissberg will be involved in making this machine compatible with the IBM TSO system now being used by IRP. He is also making tentative plans for developing graphical versions of IRP's computer models currently in use or under development. Planning the usage

of the IMLAC is currently in preliminary stages.

Charles Jackson has joined the IRP staff as a research assistant working on the application of hypercube-type modeling methods to regionalization of emergency services communications systems. He will be using the hypercube model to explore the consequences of alternative regionalization schemes in terms of the effects on performance measures of the communications network. This may lead additionally to broader policy issues in land-mobile communications, including alternative strategies for radio frequency allocation.

Amedeo Odoni and Pitu Mirchandani are working on network-based models of urban emergency services. Techniques based on the theory of network analysis have been used in the past to model and investigate aspects of urban emergency service systems. The research summarized here has focused on three well-known problems in this area: the reliability of emergency service systems networks; the optimal location of facilities on them; and, finally, strategies for extracting such networks from "crisis" situations. IRP research conducted in these three problems during the last year has helped advance the state-of-the-art in all three. The work has focused on methodological aspects and on the algorithmic solution of the three problems. Mirchandani's doctoral dissertation entitled "Analysis of Stochastic Networks in Urban Emergency Services" is expected to be the primary documentation on this research. This report is concerned with stochastic networks and most particularly with those cases in which deviations from the "normal" may reach such extremes that the

system breaks down and a "crisis" may exist. With regard to emergency services, loss of connectivity between the center and the demand points, or excessive travel time between them, constitute a system breakdown. The work deals with analytical, design and operational considerations that would minimize the travel time to a random incident and decrease the probability of a system breakdown.

Ken Chelst is developing a basic methodology in search theory. In a recently completed paper, he outlined the basic characteristics of a police crime-related patrol and some basic misconceptions in earlier applications of search theory to police patrol. The paper presents a new model for police patrol based on differential equations which indicated that the probability of intercepting a crime in progress decreased when preventive patrol was scheduled in large blocks of time. Another result was that probability of intercepting a crime was higher under an overlapping patrol policy rather than with a disjoint patrol policy.

Chelst has been working also on the development of an interactive system for police sector redesign (IRP working paper, "An Interactive Approach to Police Sector Design"). Three individual programs have been written for the interactive sector design system. These programs focus on significantly reducing workload or travel-time imbalances in existing sector design. The programs have been tested on data from Boston, New York and New Haven and have been proven rapid enough to be feasible on interactive systems. One additional program will be developed for the problem

of allocating N cars to M (greater than N) sectors to produce balanced workloads. Richard Weissberg will assist Chelst in developing the interactive superstructure which will tie together the four programs.

During the summer, Chelst served as a consultant to the New York City-Rand Institute. The majority of his time was spent with the New Haven, CT, Department of Police Services on a technology transfer project supported by the U.S. Department of Housing and Urban Development. He worked closely with the police department in setting up the data bases necessary for the running of the hypercube approximation procedure and for the sector redesign programs. The various programs were run for sample beat configurations. However, the emphasis in these runs was not on developing recommendations for redeployment, but rather on teaching people in the department how to use the models so that a detailed evaluation of present and alternative deployment strategies could be carried out by the department. As part of the training process, a meeting was held with the heads of patrol, planning, and information services during which the capabilities and limitations of the models were discussed. Interestingly, the discussion went beyond questions of balancing workloads and travel times and began to focus on the potential of these models in addressing policy issues such as directed patrol.

Another area Ken began working on this summer was the validation of the approximation procedure using New Haven and New York data. A comparison of the observed distribution of workloads in New Haven with those predicted by the models proved to be very close. With the New York data the approximation procedure was

compared to a validated simulation program, and here too initial results seemed good.

Arnold Barnett has worked on a problem in mathematical search theory motivated by the preventive patrol activities of police departments. Whereas most search theory literature concerns objects assumed to exist forever, Barnett's model deals with events which arise randomly in time and space, can occur simultaneously, and are of limited duration (e.g., crimes). His resulting publication is entitled "On Searching for Events of Limited Duration." Briefly, this report discusses the following problem: An observer wishes to detect as many as possible of a set of events. The events arise at several discrete points according to independent Poisson processes and identically distributed random variables. The specific problem is: given that the observer can only "visit" one point per unit time, in what sequence should he make his "visits" so as to maximize the steady-state fraction of events he detects? Some results about the optimal search policy are obtained, and the best policy is found precisely in some circumstances.

Task A3:   Modelling Emergency Medical Service Systems

Personnel: Thomas Willemain, Keith Stevenson, Shan Cretin,
            Richard Weissberg; Shelley Bernstein, Michael Thomas
            (research assistants)

The models which constitute this task are closely related to those in Tasks A1 and A2, and are separated more for convenience than because of substantial differences in intellectual approach. There have been two primary efforts:

1. a model of the risk of death from myocardial infarction ("heart attack") which has been developed mainly by Shan Cretin; and

2. a computerized queuing model of the impact of regionalization on the provision of emergency medical services, undertaken by Shelley Bernstein and Michael Thomas.

Other modelling efforts have been undertaken in screening calls for emergency service, computer graphical determination of emergency room staff and resource needs, and the regional categorization of emergency rooms.

The Risk of Death from Cardiac Arrest

The difficulty of generating useful measures of performance for emergency medical services has long been acknowledged. Typically, analytical modellers have made use of process measures like response time and queuing delays as surrogates for the outcome measures they needed. Shan Cretin has taken the precarious, but long overdue step of linking process and outcome in an analysis of the risk of death from cardiac arrest, one of the leading causes of death in the United States.

Using data from the cardiology literature, this study develops

a state transition model of the incidence of myocardial infarction, from which long- and short-term survival statistics can be obtained for a variety of strategies used in treating and preventing infarctions. The long range impact of changes in in-hospital case-fatality rates, reductions in pre-hospital mortality, and even reductions in the incidence of the disease may be compared.

In addition, a detailed companion model of pre-hospital death, focusing on death from ventricular fibrillation, was also developed. The impact of ambulance response time and resuscitative capability on pre-hospital mortality is explored and found to be highly dependent on the patient delay in calling the ambulance. Reducing ambulance response time from 20 minutes to 5 minutes halves the pre-hospital mortality of patients who summon the ambulance 10 minutes after the onset of symptoms, while having little effect on the already higher mortality of those who wait 2 to 3 hours-- the median delay observed in many communities.

Cost comparisons are made in a hypothetical urban setting between strategies to reduce pre-hospital mortality from infarction by:

1. providing a large fleet of conventional ambulances which achieve relatively short response times but can do no more than transport the infarcted patient; and

2. providing a smaller fleet of mobile coronary care units (MCCU) which experience longer response times but are capable of resuscitating fibrillating patients.

These comparisons suggest that a few MCCU's are a more cost-effective method than many conventional ambulances for reducing

pre-hospital mortality in cardiac arrest.

Finally, results from the state-transition model of infarc-
tion indicate that achievable reductions in pre-hospital mortality
(from .2 to .12) may extend the expected remaining life of a 55
year old infarction victim by over a year (from 11½ to 13 years)
if good in-hospital care is available. However, the impact of
MCCU's on this and other survival statistics is on the order of
the improvement observed when in-hospital coronary care units
are introduced. The hoped-for dramatic effects are unlikely,
and under the best in-hospital and pre-hospital mortality condi-
tions now achievable, the occurence of an infarction at age 55
still reduces the expected remaining life from over 20 years to
13 years.

This work is an excellent illustration of the benefits of
the cross-fertilization that is possible in a comprehensive inte-
grated research project. The literature review undertaken in Task
P1 provided both the incentive to carry out the work by pointing
up the gap in previous research, and also the data that made it
feasible. The concern with patient delay as an obstacle to the
reduction in the probability of pre-hospital death arose first
as part of Task P3. The analysis of ambulance response times relies
on the kinds of models developed in Tasks A1 and A2. Finally, by
relating patient outcomes to measures like delay and response time,
this part of Task A3 increases the power of the models in Tasks A1
and A2.

A Queuing Model for Regionalization

Shelley Bernstein and Mike Thomas are studying the regionali-

zation of emergency medical services. To this end, they have developed a computer model to analyze the expected performance of an EMS system composed of several ambulance services in hypothetical regional configurations. The model combines simulation and queuing approaches to the description of system operations. It consists of seven main components--generation of incidents in a region by Monte Carlo simulation; collection of travel time data between hospitals, ambulances, and the incidents; calculation of an initial estimate for average service time; solving queuing equations; estimation by an iterative procedure of utilization rates for individual ambulances; estimation by an iterative procedure of an accurate service time; and the computation of output statistics describing the system's operation. Four kinds of statistics are generated--the inner workings of the iterative procedure, the operation of the region's service, the service provided each town under the regional configuration, and each ambulance's activity under the test conditions.

The model allows them to test certain performance measures for configurations of towns in a regionalized scheme. It also permits flexibility in hypothetically relocating ambulances or instituting different dispatch policies. Future work with the model will involve experimental configuration designs using real and hypothetical regions to aid in the development of criteria for evaluating regionalized EMS systems.

Relative to this work, Shelley Bernstein spent the summer working at The Rand Corporation on a project funded by the Robert Wood Johnson Foundation. The project is a study involving a $15 million grant program that recently distributed grants to 44 regions nationwide in an attempt to encourage regionalization of emergency medical services along with improved communications and increased levels of training, public education, and use of new technologies (e.g., telemetry). The objective of the study is to examine the impacts of regionalization on the system operation, patient outcomes, and the cost of providing service. Eight regions have been selected to be the subject of the study, in addition to several regions which will be doing their own evaluations. Half of these regions can be characterized as rural and the rest as expanding urban regions. Shelley spent most of her time in San Bernadino County, CA, working with the County's Emergency Medical Care Committee and its representatives. A baseline data collection system was developed in the form of hospital logs, as well as a standard ambulance reporting form that was drafted for approval by the ambulance providers in the county. Much time was spent visiting ambulance operations, private companies and public agencies, and hospital administrators in an attempt to understand how the present EMS system works and how the operation will change as a result of the grant implementation. Shelley also worked with the county ambulance association, the Emergency Department Nurse Association, the Emergency Medical Care Committee, the Regional Medical Program, and the Inland Counties Comprehensive Health Planning Council.

Analyzing the Process of Screening Calls for Emergency Service

The increasing demand (and in some cases the need to increase the demand--see EMS Task P3) for urban emergency services raises the possibility that the quality of service provided might be improved by a better matching of resources to needs through a process of screening. Because of the risk of errors on the part of the screener, there is a natural reluctance on the part of those responsible for providing these services to undertake such a program. In this study, carried out by Keith Stevenson and Tom Willemain, a methodology has been provided to characterize the quality of a screening program and to establish the conditions under which the introduction of screening can improve service. Screening is also compared to adding response units as an alternative method for improving service.

While it is probably impossible to determine the actual performance of screeners theoretically, it is possible to analyze mathematically a rather simple process called "categorical screening." We have determined the optimal categorical screening policy under two conditions: "loss screening," in which screened calls receive secondary rather than primary service; and "priority screening," in which screened calls are assigned low priority in any queues that form. The fact that a screening method as crude as categorical screening can improve service suggests that trained personnel should be able to do much better.

Computer Graphics and Emergency Rooms

Richard Weissberg has completed his report on "Using Inter-
active Graphics in Simulating the Hospital Emergency Room." The
hospital emergency room is a complex system having many interrelated
factors contributing to its operation. The emergency room adminis-
trator has limited control over certain of these factors: numbers
of beds, nurses, doctors, x-ray units, for example. Other factors
such as patient arrival rates and demands made upon available
resources are largely uncontrollable. One of the main problems
facing the emergency room manager is to find a reasonable balance
among the many factors over which one has control in the face of
a range of values of the factors over which little control is
possible.

A computer program has been designed which uses computer
graphics and interaction with the user to create a flexible modeling
environment for analysis of hospital emergency rooms. The program,
the Tool for Interactive Graphical Emergency Room Simulation (TIGERS),
is a simulation-based modeling environment which has been implemented
on the PDP-10 computer of the Programming Technology Division of
Project MAC at M.I.T. This first effort, although general in scope,
is based upon the emergency room at Cambridge Hospital. A pre-
liminary model based upon this emergency room has been implemented.
Valuable feedback has been obtained from Dr. Peter Mogielnicki there,
and other doctors in the Boston area may soon try out the system
as well. The main thrust of the research is being concentrated
not on designing a highly accurate model of a particular emergency

room, but rather on developing a tool which can be used for such a purpose.

Regional Categorization of Emergency Rooms

One major focus of current EMS planning is the regional categorization of emergency rooms by care capability. This process is underway in Massachusetts and other states and is mandated by the EMSS Act of 1973. Two problems arise in this process: how to classify emergency room care capability and how to evaluate a given spatial distribution of care capabilities. The first problem has been addressed in the literature in a somewhat unsatisfactory way, as noted by Willemain in TR-06-74 (Task P1). The second problem has not been addressed in the literature and is the subject of a master's thesis in city planning which is nearing completion under Willemain's supervision. The goal of this work is to make available a simple scheme to aid EMS planners in evaluating proposed regional categorization methods.

Task I1:   Impact of Aggregate Ratings of Risk

Personnel: Joseph Ferreira, Arnold Barnett, Miguel Torrado-Martinez

Besides the search theory efforts for Tasks A1 and A2, Arnold Barnett has been working on an analysis of murder statistics for Task I1. The homicide study proposed new indices to measure the incidence of murder in American cities, specifically (1) the probability that a randomly chosen baby born in City X this year, who lives there all his life, will eventually die of murder and (2) the decline in life expectancy of this baby because of risk of homicide. These indices were calculated for the 50 largest American cities under four different models for future homicide rates. The models themselves were formulated after a detailed statistical analysis of homicide in American urban centers since 1930.

Among the more interesting results of the review of past patterns were the revelations that (1) murder growth in the 50 largest cities has been surprisingly uniform since the current period of increase began about 1964; so much so that, once city populations are "normalized" to their 1964 ethnic distributions, differences in murder growth between cities can be explained as normal random fluctuations about a common trend; (2) contrary to the popular view among criminologists, the post-war baby boom and changes in racial distributions account for less than 10% of the recent murder "boom." (1) and (2) together have interesting implications for the various theories that have appeared to explain the recent doubling of homicide rates. But probably the most striking result of the study is the estimate that if murder rates stabilize at current levels, 2% of

all babies and 3% of the male babies born in large American cities this year will be murdered (unless they leave town). If homicide rates continue to grow, the murder probabilities will rise correspondingly; even a relatively modest growth model projects the killing of one in 20 of this year's urban babies. The study does not suggest what precisely should be done, but it does make explicit the implications of doing nothing.

Two papers were written on the subject: "On Urban Homicide: A Statistical Analysis" and "On Urban Homicide." The second article was a qualitative version of the first. Professors Daniel J. Kleitman and Richard C. Larson helped in the research and are co-authors of the papers. Both articles have been submitted for publication. On April 8, 1974, Barnett gave a joint IRP-Operations Research Seminar on the subject, which was reported extensively by such media outlets as the CBS television and radio network, the Canadian Broadcasting System, the British Broadcast Corporation and the Associated Press. Recently, Mr. Allan Otten, senior Washington correspondent of The Wall Street Journal, wrote an essay about the homicide study with the apt title "Grisly Prospects," (editorial page, 9/12/74). A huge amount of correspondence on the subject has been received from criminologists, psychologists, law enforcement personnel and government officials. The Library of Congress, acting on behalf of the House committee, requested copies of the two papers. And the reports have been distributed also to several senators.

Many people, including Syd Cooper of the IRP Police Advisory Panel, have suggested that the approach used to analyze homicide

statistics be used to describe victimization for such crimes as robbery, rape, and assault. Extending the investigation to non-lethal crimes is the next project Barnett will undertake. In some sense, homicide is an "easy" crime for this approach because (1) a baby born this year can, after all, be murdered at most once; hence the only real question concerns the probability of this happening, and (2) murder statistics are generally believed to be highly accurate. Neither of these conditions applies to nonlethal crimes. The prognosis for a baby born this year should include not only the chance of being victimized, but information about the probability distribution of the number of relevant crimes sustained over his lifetime. And as LEAA surveys showed recently, it is likely that only a minority of the crimes committed are actually recorded on police blotters. But these complications can be over-come. A careful analysis of the LEAA reports can provide the basis of a mathematical model of crime underreporting. This model should enable us to provide a more accurate picture of recent crime trends than that suggested by police figures, and allow us to search for correlations perhaps previously obscured by imprecise data. Several probabilistic models for future crime levels will be proposed based on the analysis. In the new studies, more attention will be paid to the variation of risk levels for different citizens than was paid in the murder report. The overall goals of the research are twofold: 1) to learn as much as possible from the crime victimization patterns of recent years and 2) to propose and calculate indices for each crime which indicate graphically and clearly the magnitude of the problem. A report on the felonies robbery and assault should be

completed by next spring.

Joseph Ferreira and Miguel Torrado-Martinez have been comparing hazard formulas with other simple allocation techniques requiring minimal data. The intent is to estimate and explain how much difference the choice of allocation technique makes in patrol assignments and in selected performance measures, such as each district's travel time, dispatch delay, patrol hours per outside crime, patrol frequency, and patrol car workload.

Three types of hazard formulas were considered. One was a "call-for-service" hazard formula that defined a district's hazard in terms of its share of crimes and calls for service. The second technique was a "geographic" hazard formula that included in its hazard measure population, street miles, and area as well as crime. Third was a "workload balancing" method that divided the patrol force among districts in a way that matched the average patrol car workloads of the district.

As an alternative to hazard formulas, a so-called "allocation by objective" method was considered. This method assigned each district the number of cars needed to meet specified performance standards and then allocated the rest in a way that minimized average dispatch delay. The rationale underlying the use of this method is very different from that for hazard formulas. The "allocation by objective" method assumes that one's utility for various levels of patrol unit performance among a city's districts is very low unless each district meets some minimum performance standards. Hazard formulas assume that patrol allocation should be in proportion to need and that each district's need can be expressed as a linear,

additive, function of certain district characteristics.

The four methods were tested on 1968 and 1970 New York City data for its 71 precincts (districts) and on a simulated city with four districts. Each method was used to divide a fixed number of patrol units among the city's districts. Using the small test city helped identify the tradeoffs in performance measures that the different methods produced for districts with particular geographic, demographic and crime characteristics. To compare the flexibility of the four techniques, allocations were made for peakload and average shift conditions.

For peakload conditions, when the patrol cars were most heavily utilized, the "allocation by objective" method generated patrol car assignments that produced the best city-wide average for all performance measures. In addition, the variation in performance measures among districts was minimal. The "calls for service" hazard formula performed the worst and the other two fell in between. The "allocation by objective" and the "calls for service" methods specified district-by-district allocations that differed by about 33%. The "geographic" and "workload balancing" methods pro- duced assignments that differed by about 18% from the "allocation by objective" method. A draft of a paper entitled "Comparing Methods of Dividing Patrol Units Among Police Districts" has been written and copies of the final report will be available for distribution this fall.

Miguel is writing a flexible computer program for use on TSO that can estimate the performance measures that result for a given

allocation of patrol units among districts and can compute assignments using the "allocation by objective" method. A previously available program, developed mainly for demonstration purposes, could handle only a few districts and a fixed set of performance standards and could not be used on the TSO system.

Joe Ferreira (initially with Don Grossman) has been studying ways in which better measures of fire department services may be incorporated into rating schemes for fire insurance. The same questions might be asked about the effect of police and emergency medical services on crime and health insurance. However, the way in which these other types of insurance are provided and/or the state of the art in measuring the effect of the emergency services on the level of risk complicated the analysis and limited the potential that better service measures might have.

A survey of current fire insurance rating practices and the procedures used to rank fire department capabilities indicated that (1) strategies for deploying fire department resources in response to alarms have no explicit effect on fire insurance rates, (2) a city's fire insurance rates are surcharged or discounted depending on their fire department's size, equipment and available water supply, (3) current variations in insurance rates due to the quality of protection are relatively small with large differences (more than 40%) arising only between cities with and without full-time professional fire department services, and (4) various data needed to estimate empirically the effect of fire fighting services on fire losses have been collected only during the last few years.

Incorporating some operational notion of the availability

of fire fighting services (e.g., average response) into fire in-
surance rating schemes would tend to favor areas with small depart-
ments or low fire incident rates when compared with charges under
the present system. Nevertheless, adjustments of current rating
schemes that only reflect improved treatment of fire protection are
not likely to increase inner city rates sufficiently so that they are
not still subsidized by newer suburbs. Evidently other significant
geographic distinctions (besides available fire fighting services)
affect the loss distribution of similarly constructed structures
and are not explicitly considered in current risk classification
systems. This situation complicates efforts to alter current rating
practices to the extent that proposed revisions affect subsidies
which government regulatory agencies may regard as proper and
equitable.

Currently Prof. Ferreira is writing several short papers that
(1) describe current fire insurance rating and data collection
practices with particular attention to factors relating to fire
fighting services, (2) illustrate the way in which more operational
measures of fire fighting services might be employed and estimate
the differences that would result for selected Massachusetts cities,
and (3) identify the equity and statistical reliability questions
that face government regulatory agencies when rich data sources
currently being developed are used to classify risks and to make
insurance rates dependent upon the quality of emergency services.

To date, reduced manpower has resulted in slower progress
on this part of Task I.1 than was originally anticipated. The level
of activity devoted to developing and calibrating specific alternative

rating schemes during the remainder of the project will depend upon feedback from the three papers mentioned above.

Task I4:   Current and Projected Impact of Technology

Personnel: Kent Colton, Scott Hebert

The work on this task is a follow-up study to a 1971 survey carried out under the aegis of the International City Management Association (ICMA) and will build on the information and insight gained from that study.

One major finding of the 1971 survey was that the most important variables in determining the effective utilization of information systems were not technical or economic, but behavioral factors.   Therefore, the effect of such behavioral or organizational factors on the successful implementation of these systems was given special attention in the 1974 study.   Also, resource allocation was perceived by police officials to be the most important computer application.   This 1971 result was pursued also to see if perceptions remained the same and to examine how resource allocation applications have been used and with what impact.

The survey work has been completed.   In January, 1974, the ICMA mailed the survey, designed by Kent Colton, to police departments in all cities with a population of 50,000 or more.   Over a total of three mailings, Colton and Scott Hebert received an 80% response rate to the survey.   In addition, in late spring of 1974, telephone interviews were conducted with the Chiefs of Police in 28 cities (about a one-third sampling of 82 police departments who had responded to the survey, were using a computer and had a population over 100,000).

Three general conclusions have emerged from the survey and

the interviews: 1) the results in 1971 and 1974 are not very different, the latest survey confirming patterns identified in 1971; 2) the process of implementation is slower than departments had anticipated in 1971; and 3) there have been some slight changes in attitudes and perceptions. Major problems noted by departments are primarily people-oriented, not technical, hardware problems. A number of departments also mentioned the lack of any formal means for transfer of information between departments.

Significant work is underway also on the case studies, the other major aspect of Task I4. Based on recommendations from the IRP Police Advisory Panel members, the case studies were reorganized completely. Rather than spread themselves too thin, Colton and Hebert decided to concentrate on two areas of technological innovation: resource allocation and police command and control. In turn, in each of these areas, they expended efforts so as to be able to complete a number of case studies in each.

A beginning effort will be made to tie together the various cases in each of the two areas. Therefore, not only will the individual case studies be available in published form, but also the two areas (resource allocation and command and control) will be combined in a comprehensive report which will link together the various cases.

In September, Kent Colton began his leave of absence from MIT to become a White House Fellow. Scott Hebert has assumed major responsibility for completion of the case studies.

Task I5: The Personnel and Their Organizations: Their Responses
to Proposed Change

Personnel: Robert Fogelson, Margaret Levi, Rory Albert, Christine
Herzog

Task I5 deals with the response of the rank-and-file
organizations to proposed innovations in big-city police depart-
ments. Margaret Levi, who has left to take a position as Assistant
Professor of Political Science, University of Washington, Seattle,
has completed her case studies of the transformation of the New
York PBA into a de facto labor union, the controversy over the
proposed fourth platoon in New York, the outbreak of the so-called
"blue flu" in Detroit, and the emergence of a militant rank and
file in Atlanta. These studies, which are, we believe, a major
contribution to the literature, are available from IRP as "And the
Beat Goes On: Patrolmen's Unionism in New York City" and "Conflict
and Collusion: Police Collective Bargaining."

Christine Herzog, an MCP candidate at MIT, is finishing her
study of the Chicago Patrolmen's Association's reaction to Commis-
sioner O.W. Wilson's proposed reorganization of the Chicago police
force in the early 1960's. Her analysis, which documents the weak-
ness of the CPA, should be ready in a month or two. Rory Albert,
who has left to attend Columbia Law School, has completed his study
of the Boston Police Patrolmen's Association's response to Commis-
sioner Robert J. diGrazia's proposed reform of the Boston police
force in the early 1970's. His report, which spells out the growing
influence of the BPPA, will be available soon from IRP as "A Time
for Reform: A Case Study of the Interaction Between the Commissioner

of the Boston Police Department and the Boston Police Patrolmen's
Association."

Professor Fogelson, who has supervised the above studies, is
finishing a paper which focuses on the transformation of the
fraternal and benevolent associations into de facto unions and
discusses the implications for the course of police reform. His
paper, which provides a context for the others, should be ready in
a month or two.

For the remainder of the project, we are currently exploring
three avenues of research. We have asked Judy Levenson, a Ph.D.
candidate at MIT, to look into the response of the rank-and-file
groups to the proposed shift from two-man to one-man squad cars,
a shift that was implemented in Los Angeles, Kansas City, and other
cities in the 1950's but abandoned in the face of strenuous opposi-
tion from the PBA and the PPA in New York and Boston. We are also
seeking another graduate student at MIT to do an analysis of the
attitude of these rank-and-file groups to proposals to substitute
civilians for sworn officers in clerical, secretarial, and other
so-called non-police posts (which would presumably release additional
manpower for patrol duty) as well as in high-level planning and
research positions (which would supposedly enhance the analytic
capabilities of the departments). And as an outgrowth of the
work of Professors Levi and Colton, we are looking for another
graduate student at MIT to examine, in a general way, the attempts
of the rank-and-file organizations to gain a voice in patrol
allocation (or, in other words, in the allocation in time and space

of the patrol force) and to introduce into the decision-making
process such considerations as seniority that management views as
an unwarranted infringement on its authority.

These studies, which will be started in the near future,
should be ready in early 1975.

END