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Computer mapping – a new technique in crime analysis*

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INTRODUCTION

The efficient use of police manpower has always been a problem, but it has become increasingly serious in the last few years. Crime in the United States is on the rise, both totally and by category; and the demand for police services has kept pace with this increase in crime. In the past, such increases have been met by hiring more men and purchasing more equipment. This saturation approach becomes wasteful and useless after a certain point, however, even supposing that municipalities possessed the unlimited financial resources necessary to fund the indicated hiring and purchasing. Attention has become focused, therefore, on finding more efficient and more effective ways of using the presently available resources of police manpower and material.

In recognition of the problem, the St. Louis Police Department acquired a computer system several years ago, and immediately set about the task of utilizing this new technical capability in the area of resource allocation. The obvious area in which to concentrate these efforts was that of police patrol. This portion of the force comprised the greatest number of officers, performed the greatest variety of functions, and was the most geographically scattered. These factors made the patrol force the most difficult unit to manage and co-ordinate efficiently, as well as the unit whose effective management was most important. Any improvement in this area would thus be of widespread importance, and would most directly achieve the goal of getting the best results at the least cost, using the fewest men.

As a result, the patrol force was divided into two distinct units. Traditionally, there had been no differentiation of kinds of patrol functions; rather, the field command used the same group of men to answer calls for service, patrol for crime prevention, and meet any other needs which might arise. It seemed, however, that there were two basic functions which the patrol performed, and that a division of the patrol into two entirely distinct units, based on these respective functions, would make for higher efficiency and easier management. Thus the patrol force was divided into a calls for service unit, which exclusively answered these calls, and the remainder of the patrol force became a unit whose primary responsibility was to cut down preventable crime.

Initially, the Department's intention was to center the Resource Allocation Project on the calls for service function, collecting and updating data on past calls for service and, on this basis, predicting future needs in this area. It soon developed, however, that there were many applications of computer technology in the management of preventive patrol. Especially important was the possibility of using the computer to produce maps which would graphically illustrate the location and density of both total crime and the various major types of crime. Such maps would provide the field command with an extremely useful and easily-used tool in the allocation of preventive patrol resources.

Since the use of the computer and the functional division of the police patrol into called for services and reserve units were such new concepts, and since it became necessary to develop procedures for the implementation of these new methods, it was thought best to begin slowly and in a very controlled way. Thus, one of the city's total of nine police districts was chosen as the test district, in which these new procedures were to be fully implemented, and another was chosen as a control district, which would be used as a standard against which to measure the results in the test district. After this over-all procedure had been decided upon, the St. Louis Police Department applied to the Office of Law Enforcement Assistance, under the Law Enforcement Assistance Act of 1965, for a grant to help fund this project as a test and demonstration of what might be achieved in the area of resource allocation using these new, computer-based methods. A grant of $170,000 was subsequently

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awarded the St. Louis Police Department, by the Office of Law Enforcement Assistance, for the period of July 1, 1966 to December 30, 1967.

The purpose of this paper is to describe the methods so far developed by the Resource Allocation Research Unit of the St. Louis Police Department in the implementation of the reserve force's crime prevention function, specifically through the use of computer mapping techniques.

The prime objective of the Resource Allocation Research Unit in the area of crime prevention is to provide the district commander with information indicating those areas in which he should concentrate his preventive patrol. One obvious use of computer capabilities in this regard is in the collection of reported crime data and its organization by location and time into statistical tables. Due to the electronic speed with which the computer operates, it is possible to keep these tables current on a day to day basis. Such statistical tables, however, are of limited usefulness, since it is difficult to read, remember, and compare such numerical information. For maximum utility, this statistical information should be translated into a graphical illustration, or map, which would embody the collected data in such a way that the reported incidence both of total crime, and of each of the eight major categories of crime, would be shown by location on a daily basis. Thus, a district commander could look at a map of his district, see where total crime was highest, and, on this basis, assign his preventive patrol.

The Resource Allocation Research Unit knew that it was possible to write a program which would cause the computer to produce such maps, provided the proper information was provided.* But there were certain prerequisites which had to be fulfilled before any computer mapping could take place.

First, the accuracy of the data collected had to be assured. For this purpose, Mr. Grant H. Buby, of the Governmental Research Institute of St. Louis, a consultant to the Project, conducted several audits of the data collected and the processing of this data. This was to insure in the first place that criminal incidents were being properly reported; for example, that a burglary was not reported and recorded as a larceny or a destruction of property. Secondly, Mr. Buby checked to assure that crimes, and a large volume of other activities, such as Field Interrogation Reports, Traffic Summonses, and Curfew and Truancy Notices, were being properly processed, and that no errors were being made in the data processing. On the basis of his recommendations, the error factor in data collection was reduced and held to a negligible percentage. These audits took place during the pre-test phase of the Project, July 1 to December 31, 1966—and they are continuing, in order to measure the maintenance of accurate reporting and processing.

In order for this data to be meaningful and useful, however, the basic geographical unit for which it was gathered had to be fixed. Statistics gathered for an entire district would be of no use to the command in deciding where to concentrate preventive patrol in the district; some differentiation into basic units was obviously necessary. On the other hand, a city block is too small a unit, since at any given time there would be no measurable incidence of crime in any given block. Since the geographical unit should be permanent in order to permit efficient collection and meaningful comparison over long periods of time, the beat structure should not be used; for ideally, it should be flexible in order to adapt to changing needs. Sgt. Glenn A. Pauly, Project Implementation Officer, therefore set to work developing a new uniform geographic subdivision for the purpose of data collection. The unit finally decided upon came to be known as the "Pauly Area."

As seen in Figure 1, the City of St. Louis has been divided into nine sections, each of approximately equal area. The boundaries of these sections are formed by four of the major city streets. Each of these nine sections is then further divided into a number of Pauly Areas, which comprise the basic geographical units spoken of above (see Figure 2). There are between 37 and 79 Pauly Areas in each Section. The criteria used in constructing the Pauly Areas are that each be a fairly homogeneous geographic unit, and approximately 1/16th of a square mile in size, which will remain a permanent subdivision. These Pauly Areas are numbered consecutively within each Section, and each therefore has a unique number, formed by simply prefixing the Section number to the area number within that Section. Thus Area 23 in Section 4 is designated 4-23, while Area 23 in Section 8 is 8-23.

As finally determined, each Pauly Area comprises from 9 to 12 city blocks, and is thus smaller than a beat. Since these permanently fixed areas are distinct from the flexible patrol beats, the stability necessary for valid data collection has been achieved with no loss of the adaptibility necessary to meet the changing needs of crime prevention. Since each area is smaller than a beat, it is possible to differentiate where crime is occurring and on this basis to change the beat structure if this seems advisable.

The next problem was how to correlate the reports of criminal incidents, which are the source of the data, with the Pauly Areas, in terms of which these data are to be represented. Since a prohibitive amount of time and effort would have had to be expended by the

*For a computer program which produces maps, we are greatly indebted to Mr. Howard T. Fischer of Harvard University.

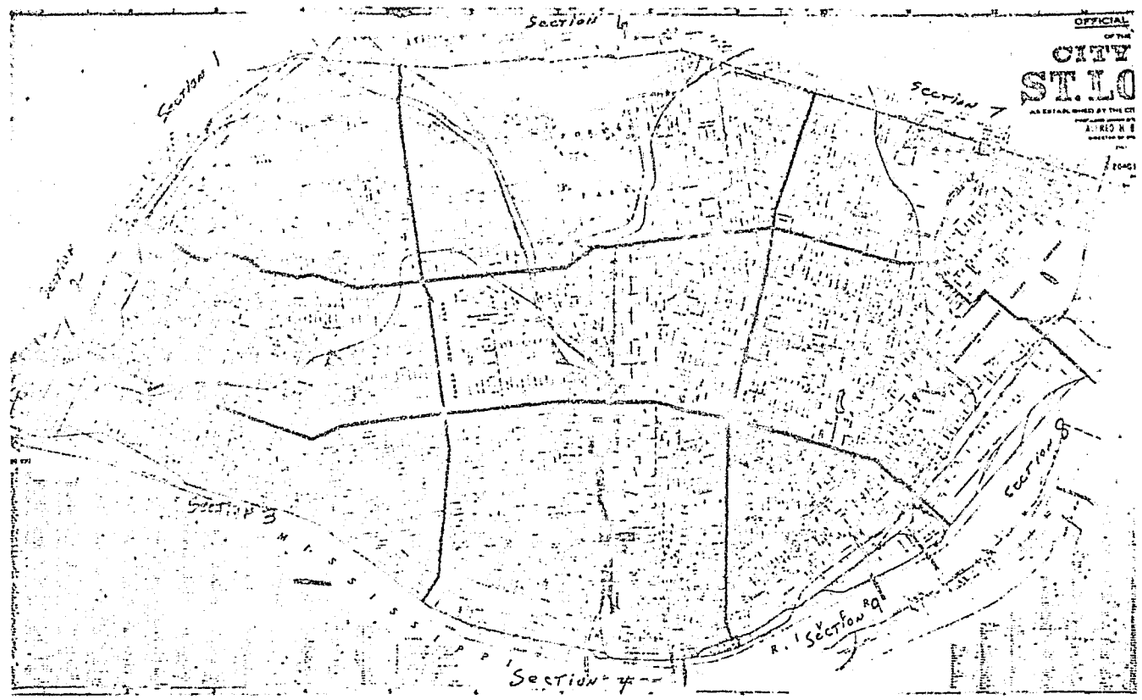

Figure 1 – City of St. Louis divided into nine sections

reporting officer in manually determining the Pauly Area, a computer-based street file system was developed by Mr. Thomas McEwen to automatically correlate street location with Pauly Area. The first step in the construction of the Street File System was the development of the "New Location Code." By this code, a specific number was assigned to all locations within and outside of the city, ranging from streets to foreign countries. The basic unit of the New Location Code is the "Q" number, which has a numerical range from 1 to 3000, with specific categories grouped together, and with room left for expansion either within a category or of the number of categories. The categories and their numbers are as follows:

CATEGORY	Q# RANGE
St. Louis Streets	1 - 1599
St. Louis Parks and Other Areas	1600 - 1999
States	2000 - 2051
Foreign Countries	2252 - 2299
Missouri Towns	2300 - 2599
Illinois Towns	2600 - 2799

Under this System, a unique code number was assigned to each street within the city, in ascending order, based on the incidence of activity on that street as reported by the police patrol. Thus, Delmar Boulevard, which has the highest frequency of reported activity, was designated "Q" number 1.

Three distinct types of coding were decided upon: house address, street intersection, and area. House address is coded by house number, a slash (/), and the Q number of the street. Thus, 2173 Manchester Avenue is coded 2173/62, 62 being the Q for Manchester Avenue. A street intersection is represented by the Q of one street, an X, and the Q of the other street. Thus, the code number of the intersection of Delmar Boulevard and Manchester Avenue is designated 1 X 62. Areas are coded by prefixing the letter P or G to the assigned Q number. P is used if the area is a park, cemetery, or bridge within the city, G if the area is located outside of St. Louis. Thus, Forest Park is P1617, and Clayton, Mo., is G2320.

Once the New Location Code had been constructed, a program was devised which, by means of a random access disk file, translates the coded source data into data in terms of Pauly Areas, and then writes this information out on tape or cards. Another program can then use this information to print out crime maps which show the density of preventable crime and other reported activity in terms of the Pauly Areas. In addition to Pauly Areas, statistics can be produced

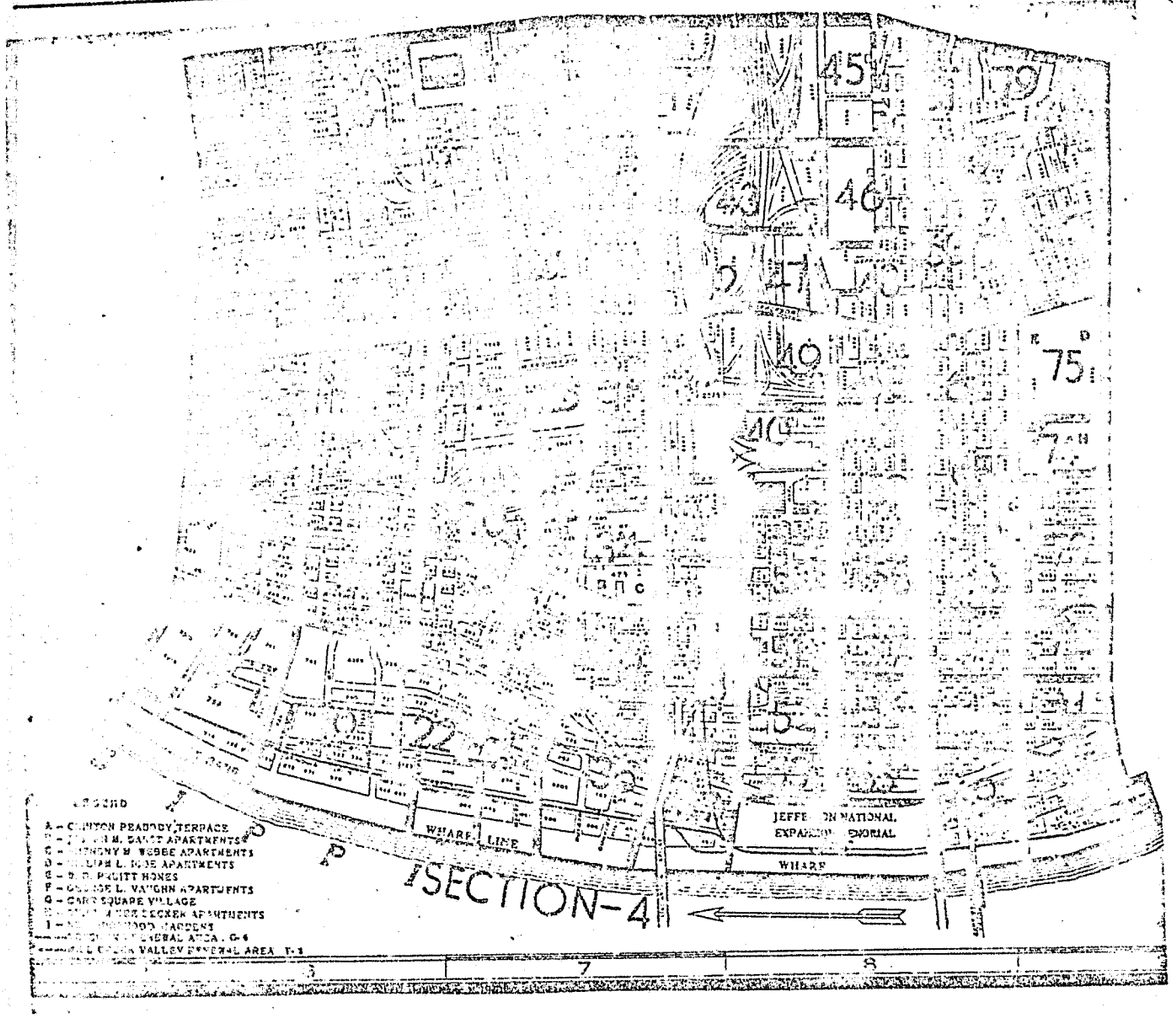

Figure 2—Section four

in terms of the District, Beat, and Census tract in which the reported incidents occurred. These statistics can be produced for any period of time: an hour, day, week, and so on.

When the Pauly Areas, and the New Location Code, and the connecting programs which make up the Street File System, had been developed, it was possible to turn to the actual production of maps. Mr. Howard T. Fischer of Harvard University had developed a computer program which he termed SYMAP, an acronym for Synagraphic Computer Mapping Program. Mr. Stephen J. Finch, of the Resource Allocation Research Unit, visited Harvard in the summer of 1966 to learn from Mr. Fischer if and how SYMAP could be adapted to the needs of the St. Louis Police Department. It became clear that SYMAP had two important applications for police work. This program converts statistical data, as to the number of incidents of a given kind occurring at fixed points within a given location, into a map which indicates the density of occurrence by shading. Thus, the heavier the shading, the greater the frequency of occurrence. The advantages of such maps for purposes of resource allocation have already been enumerated; basically, computer mapping is a management tool which provides the command with a quick perception of the frequency of reported incidents by the location at which they occurred, and enables the command to modify beat structures to adapt to the needs so indicated.

There are two distinct kinds of maps which the Resource Allocation Unit has been producing. The first is the flat-tone map (see Figure 3). This type of map is called "flat-tone," because the shading with-

in each Pauly Area is uniform and there is no attempt made to show the interrelationship or gradation of activity for the entire district. Such a map is produced in the following manner. First, the total number of incidents is determined for each Pauly Area. Then a scale is made with values ranging from zero incidents to the greatest number of incidents reported for any one Pauly Area. Thus, in Figure 3, which indicates the total Index Crime for District Nine for January of 1967, the scale ranges from 0 to 96. There are ten possible shadings available to the computer, using SYMAP, and so the scale is subdivided into ten equal levels, 0-9.60, 9.60-19.20, and so on, up to 86.40–96.00. Each of these progressively heavier shadings thus represents one of the ten numerical levels of incidents reported. These levels and the shadings which symbolize them are printed out at the bottom of the map, along with the number of Pauly Areas whose number of reported incidents falls within each level. For example, there were 38 Pauly Areas with 0–9.60 incidents, and only 3 with over 48.00. It can be seen on the map itself that the level number is printed in each Pauly Area, so that the person using the map does not have to remember which shading represents which level.

On this map, therefore, are summarized the total number of crimes in the district, the highest number of incidents reported in any one Pauly Area, and the distributions of reported incidents for each Pauly Area. Especially important is the fact that all this information can be "seen," thus greatly assisting the district commander in remembering where incidents have been reported most and least often, and in deciding on this basis where to concentrate his preventive patrol.

As stated above, maps are produced not only for Total Index Crime reported, but also for eight major categories of crime: Auto Theft, Theft from Auto, Purse Snatching, Robbery, Assault, Daytime Residence Burglary, Night Residence Burglary, and Business Burglary. Figure 4 is a flat-tone map illustrating Night Residence Burglary in the Ninth District for January of 1967. This map is obviously much different than the Total Index Crime map; it can be seen immediately that the center of activity has shifted drastically. In this way, the district command is apprised of where its specific needs lie in the area of crime prevention, and is given information which the Total Index Crime map does not indicate at all. Thus, the command is given still another tool to assist in the allocation of resources. This information also is given in terms of ten different levels, with the total number of incidents and their distribution clearly indicated.

There is a deficiency in the flat-tone mapping procedure. It assumes that activity is constant throughout each Pauly Area, and so fails to consider the interrelationship of all the areas within a district and gradations between centers of activity. For crime analysis, especially, a mapping technique would be preferred which shows the interdependence of the Pauly Areas within the district. Contour Mapping does just this (see Figure 5).

Contour mapping embodies densities, rather than mere statistics. As in flat-tone mapping, the program for contour mapping receives data by Pauly Area. However, instead of merely illustrating the average level within each Pauly, it illustrates the gradation from area to area. The data for each Pauly Area is associated with the center point of each. The program then estimates the level for each point on the map from the data it has about the nearest Pauly Area. For example, if the program were trying to find the symbol to put at the point halfway between two Pauly Areas, it would find the average of the values for the center points of each, and place the symbol for this level there.

The difference between the flat-tone and contour maps can perhaps be best seen by comparing examples of each. Figures 3 and 5 do this. Each gives the same statistical information: Total Index Crimes reported for the district, highest number reported for any one Pauly Area, and distribution of Pauly Areas throughout the ten levels. The flat-tone map, however, chops the district up into absolute value Pauly Areas, while the contour map gives an overview, showing interrelationships of Areas, and showing the over-all pattern of incidents reported. This unified-view approach of district activity, as has already been stated, is especially helpful in indicating trends over a period of time. A comparison of Figure 5, Total Index Crime for January, 1967, with Figure 6, Total Index Crime for December, 1966, brings this out rather well. Although there were three distinct locations where reported activity was almost equally heavy, by the close of the next month, incidents had become concentrated in a single location. A quick glance at the statistics at the bottom of the map indicates that this concentration was due to a marked increase in the occurrence rate reported in the high location area, not because of a diminution in the other locations.

An important distinction concerning the use of these maps should be made. The contour maps show crime shifts over a period of time better than the flat-tone maps—thus the crime analyst will find the contour maps more useful than the other type. A district commander, however, may be more interested in

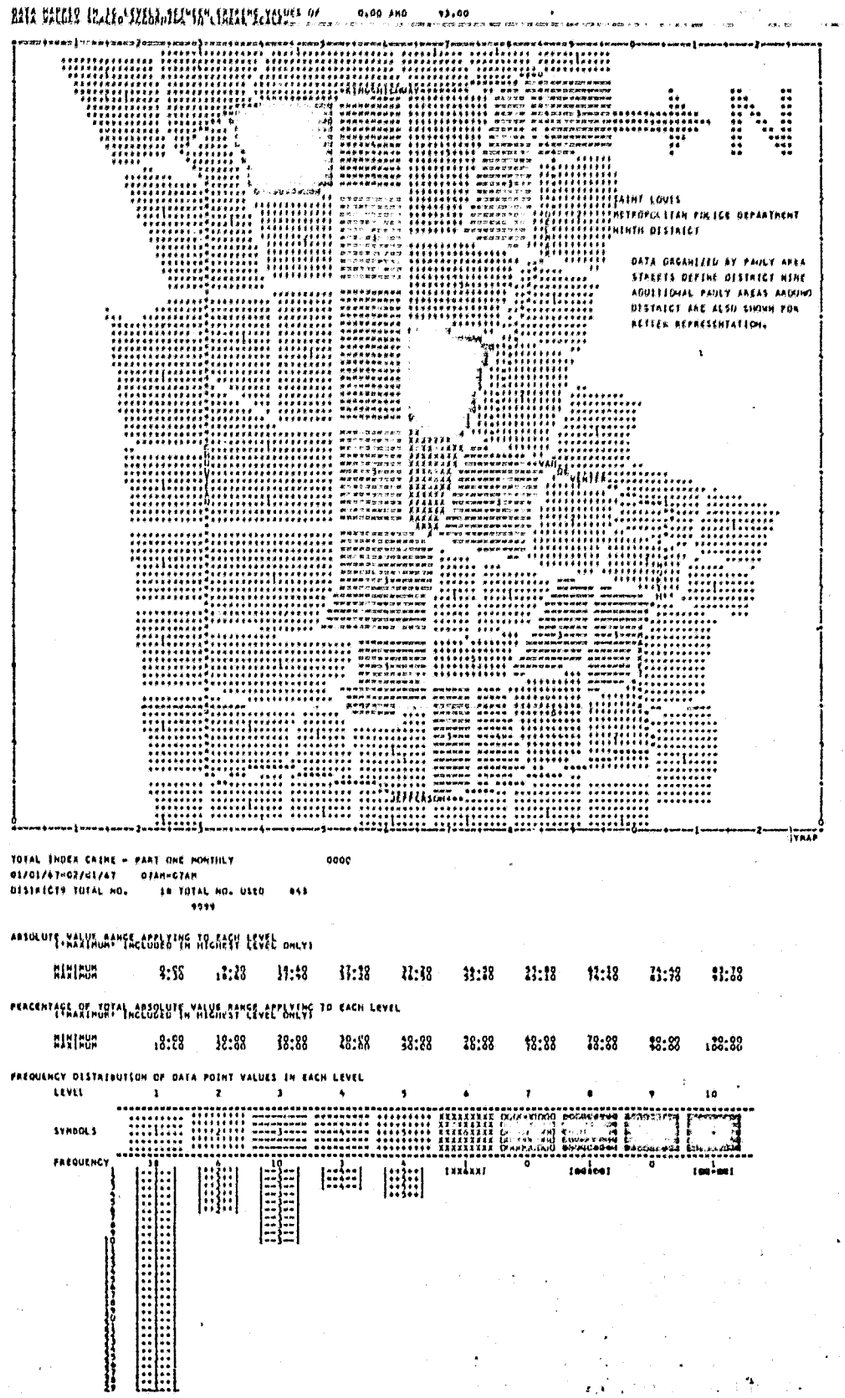

Figure 3—Flat-tone map for total index crime—part I—January 1967

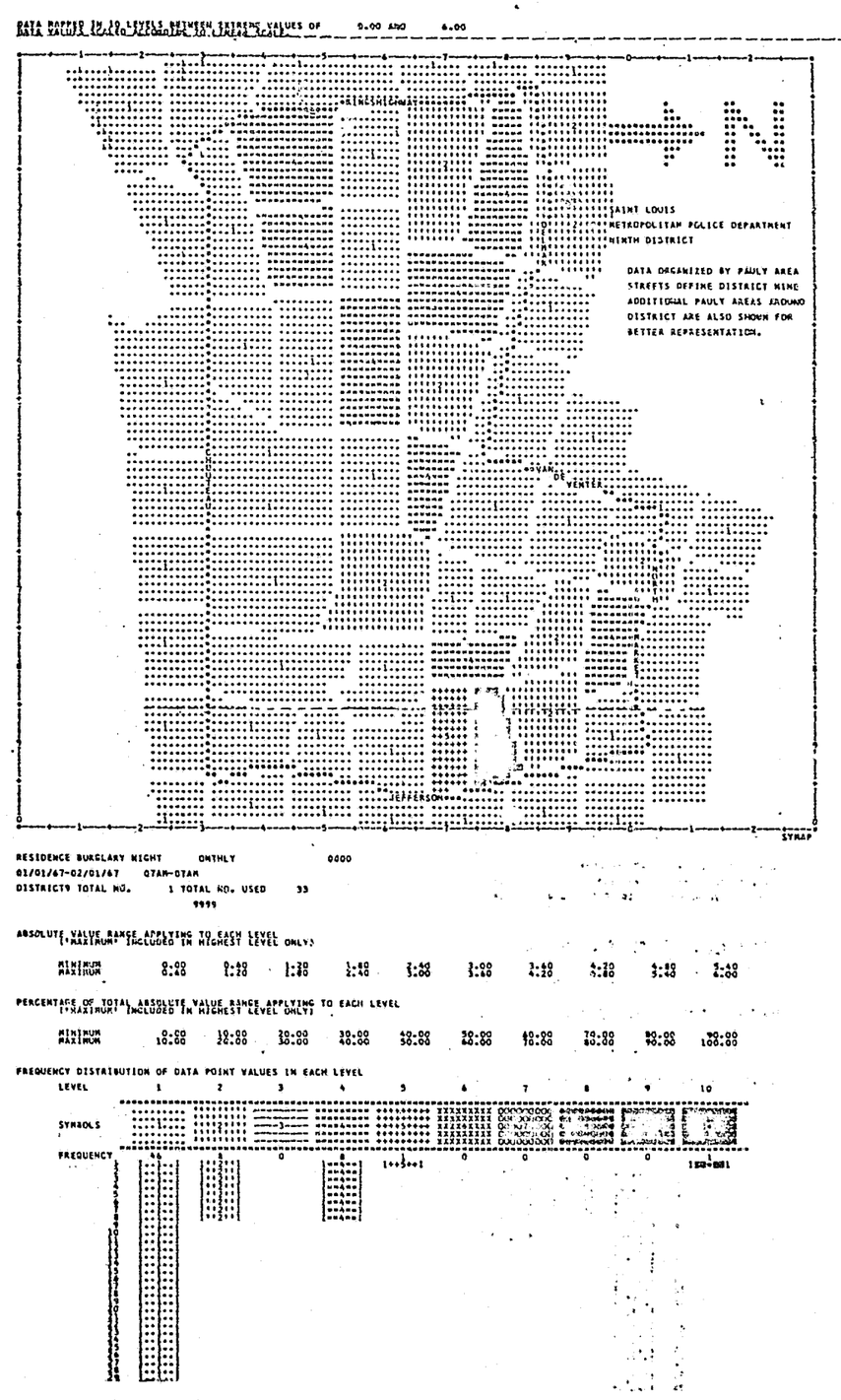

Figure 4--Flat-tone map for residence burglary—January 1967

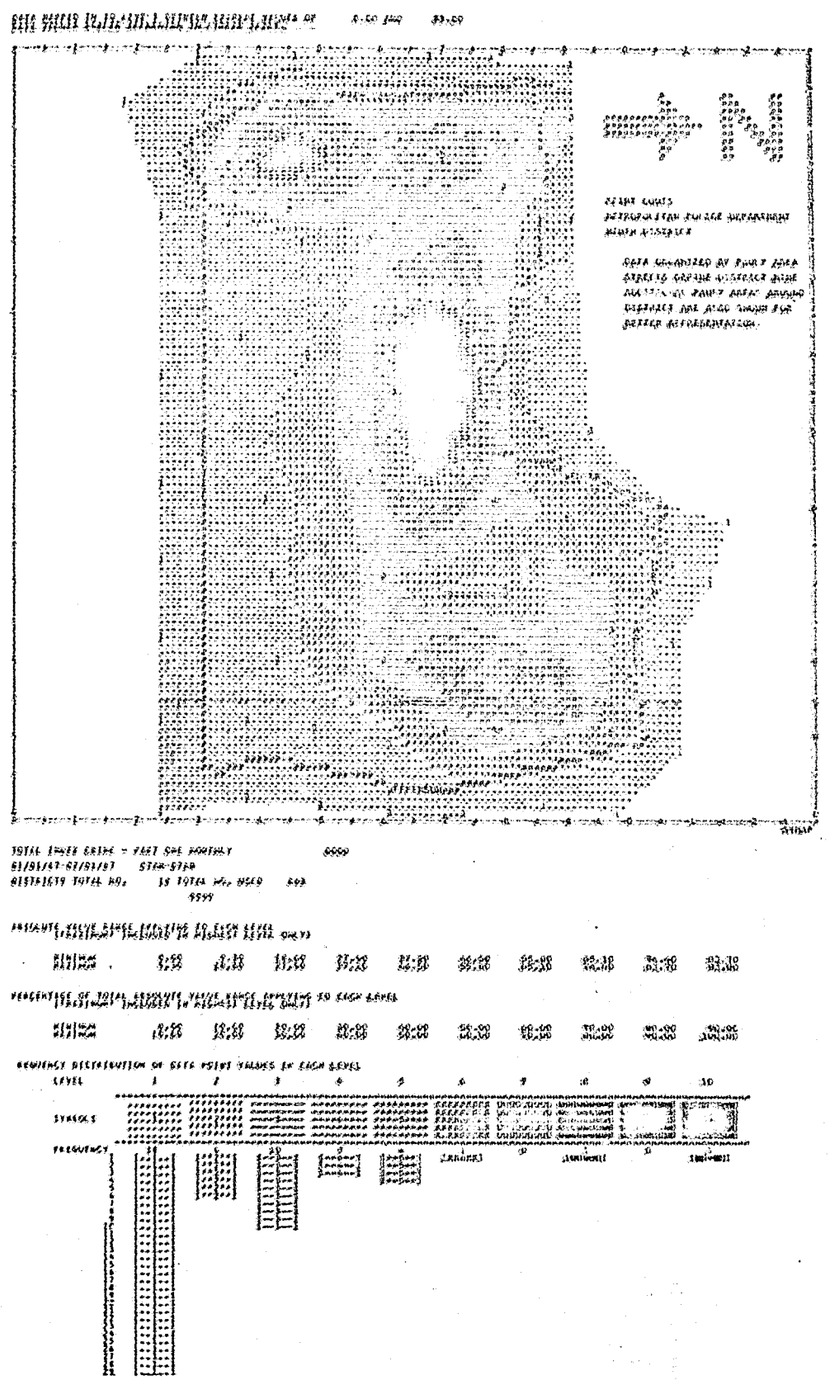

Figure 5—Contour map for total index crime—part 1—January 1967

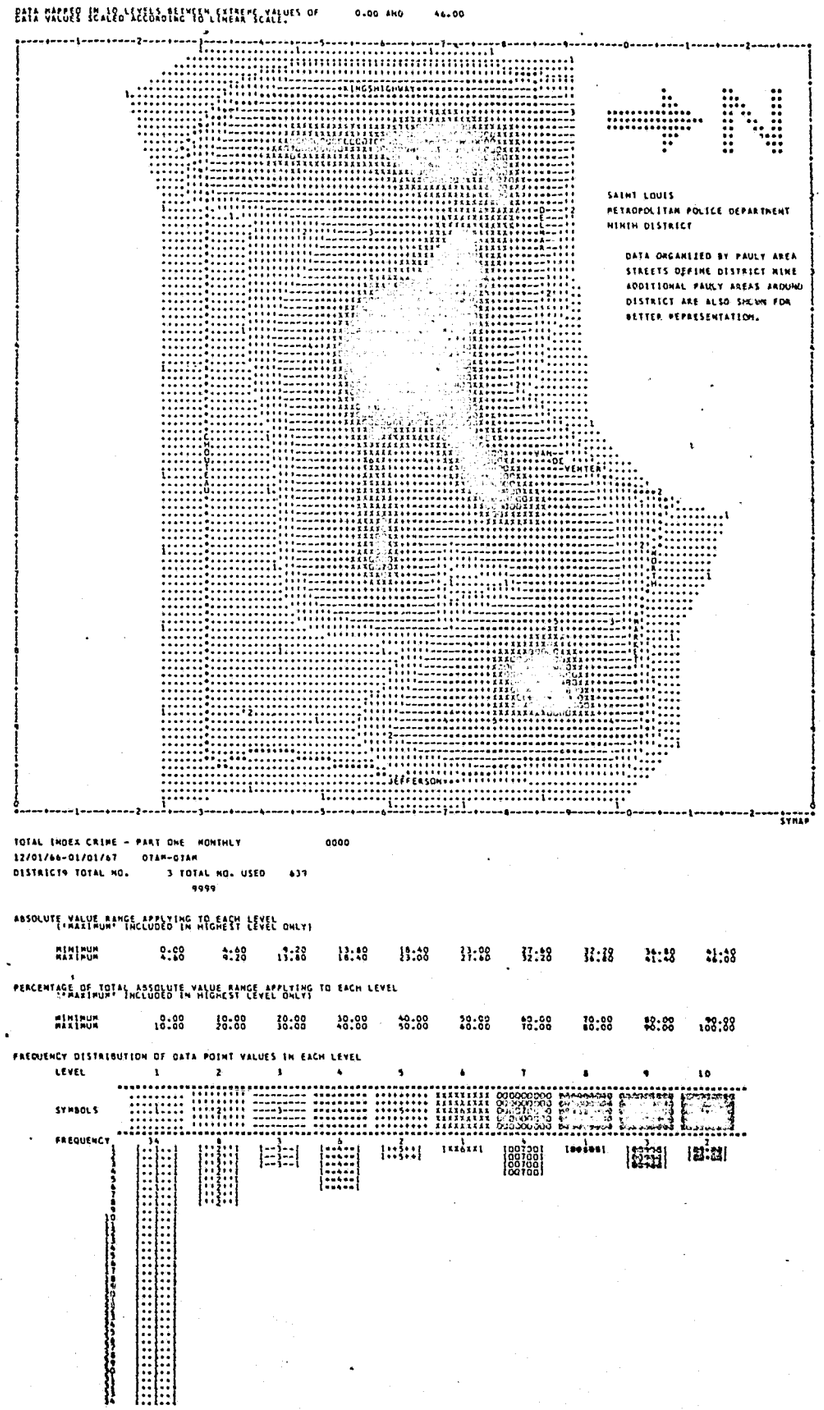

Figure 6—Contour map for total index crime—part 1—December 1966

where crime is presently occurring rather than in the shifts which have occurred. The flat-tone maps, then, can be very important tools for the district commander. They not only provide statistical data on the number and kinds of crime reported, but also represent on a map the density and location of reported incidents. The district commander is thereby enabled to make quick, but well-founded, judgments as to where to concentrate his preventive patrol and how to structure his preventive beats.

As a summary, it might be helpful to review the over-all framework into which these new mapping techniques were fitted. First of all, before any maps could be produced, it was necessary to construct a permanent geographical subdivision whose basic unit was of a fixed and workable size, both large enough to be meaningful and small enough to permit differentiation and gradation. The units finally decided upon were the Pauly Areas. It was further necessary to code these areas into language which the computer could use, and then to develop a location code which could convert reported data into data in terms of Pauly Areas. This involved not only the writing of computer programs to perform the translations, but also the construction of a New Location Code, which enabled reports to be made quickly and efficiently in a code which the Street File System could easily translate into Pauly Area computer data.

Traditionally, the patrol had been one unit, whose members answered calls, patrolled to prevent crime, and were available for any need which might arise. There were, however, patent inefficiencies in this method of operation. Therefore, when the St. Louis Police Department received the previously mentioned Law Enforcement Assistance Act grant of $170,000 to develop efficient methods of allocating unit patrol forces, the first step taken was the division of these units into two entirely distinct units, the one to be concerned solely with answering calls for service, the second to function in crime prevention. The rationale for this division is that calls for service and preventive patrol are directed at two distinct goals, and their needs are governed by different factors. Under the old system, in order to insure that there would be enough men to meet the needs which might possibly arise at any given time, it was necessary to have at hand more men than were needed most of the time, with the result that often men had nothing to do, or there were too many men in the same area, and too few in another. It was obvious that the division into two separate functions would mean more efficiency could be achieved in each.

The calls for service function includes all patrol activities taken in direct response to calls and complaints received from the public. This function employs in general the same computer data collection procedure—the Pauly Area, the New Location Code, the Street File System—as does the preventive patrol. The source data, however, are radio tickets and not all the incidents of crime reported to and by police. These calls for service are predictibly constant, taking into account the time of day, day of week, and season of year. Thus, needs are always heavier in the hot summer months, than in the cold temperatures of December and January; at four in the afternoon, than at four in the morning; and on Friday evening than Sunday evening.

Procedures were therefore developed to predict the patrol manpower needed to answer calls for service, taking into account the constant factors just mentioned. Using the ready-access disk file and the updated information kept on calls for service occurrence in the Pauly Areas, future calls and the time needed to service them are predicted, and beats are designed. The changing needs during a twenty-four hour day are taken into account by having more men on duty during the day and evening watches, and fewer during the early morning hours. By a process called exponential smoothing, the rates of occurrence of calls for service in Pauly Areas take into account seasonal factors in such a way, for example, as not to cause predictions for cool October to be overly influenced by the high occurrence rate of August and early September. The factors used in this smoothing process are themselves smoothed, i.e., the actual rates immediately preceding them are given more weight than those which held several weeks or months before. On the basis of all this, predictions of the number of men and the time needed to service these calls can be made and appropriate called for service beats designed.

The importance of these predictive abilities for crime prevention and the calls for service function in general, is that all those men not needed to answer calls for service can be assigned and used in preventive patrol. In this way, there is almost no possibility of a situation occurring in which all patrol men are tied up answering calls, and none are available to patrol. Beats can be separately designed to achieve the maximum prevention of crime and to adequately handle calls for service. If an emergency should arise, the preventive patrol can of course answer calls for service; and when the calls for service unit is not answering calls it also patrols its beat. By and large, however, the functions remain separate, and this separation permits a substantial concentration of police manpower to crime prevention.

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