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SCIENTIFIC CONCEPTS FOR CITY PLANNERS

A THESIS

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by

Bruce Donald McDowell

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SCIENTIFIC CONCEPTS FOR CITY PLANNERS

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PREFACE

Originally the title of this thesis was to have been "Scientific Techniques of City Planning," but when the research and writing were begun in earnest it soon became evident that introducing basic concepts would require all the time available for the study. The author regrets that some of the subjects could not have been treated in more detail. The task of outlining specific step-by-step techniques will have to be left for the future.

Throughout the thesis there are two themes. The first theme is the argument that scientific treatment of city planning problems can be of great value. The second theme is an effort to present informative material about various techniques which show promise of becoming useful to city planners. It was not possible to include all scientific techniques which might conceivably have a bearing on city planning, nor was it possible to give both sides or the argument about using the scientific approach to solve city planning problems. There are still many problems in city planning which are very difficult to treat scientifically. The author recognizes the limitations of present-day science, but the position taken in this study is that the scientific treatment of city planning problems can be the most successful treatment in the long run. Even though it takes a great deal of effort to develop an adequate scientific technique, once developed, its usefulness repays the effort.

The author wishes to thank everyone who has contributed to the successful completion of this thesis. Special credit is due the following persons:

Mr. Harvey J. Cheston, Jr. and Dr. Julien A. Ripley gave the author his background in mathematics while studying at Montgomery Junior College in Montgomery County, Maryland.

Dr. James H. Fox introduced the author to statistics and social research in courses given at The American University in Washington, D. C.

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Mrs. Ann Price typed the final copy.

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SUMMARY

The increasing size and complexity of urban areas within the United States brings the need for more efficient and more thorough analysis of city planning problems. This study applies scientific concepts to city planning in order to show their potential usefulness.

The scientific concepts presented in this study are described within the framework of five city planning functions: (1) survey and analysis of data, (2) maintaining a continuous reporting of data, (3) clarifying policies on which plans are based, (4) making detailed plans to implement policies, and (5) evaluating the effectiveness and desirability of results emerging from the planning program.

The development of operations research and systems engineering, during and following World War II, has prepared the way for the use of science in city planning. Several operations research techniques which show promise of being useful to city planners are described.

The present lack of well developed city planning theory makes it necessary to rely upon empirical data to a high degree. Thus, statistical concepts are emphasized. The relationship which industrial quality control and electronic computer techniques bear to city planning is briefly discussed. The process of making decisions is discussed along with the two major problems facing decision makers: (1) measuring

social values, and (2) determining probabilities of occurrences. A few techniques of problem solving are also discussed.

Because the social effects of city planning innovations are so great, every effort should be made to gain maximum knowledge from each one. The concept of telemetering is shown to be useful in preserving data which is often lost because of lack of forethought, and the concept of feedback is shown to be useful in improving the effects of planning programs.

City planners can expect scientific concepts to play a growing role in their programs of research and planning. Consequently, it is recommended that people with scientific training be encouraged to participate in the process of city planning. It is also recommended that the team approach, wherein a number of specialists work together on a study, should be used as a method of marshalling the required amount of knowledge to carry on thorough analyses. Finally, a number of topics for further study are listed and the compilation of a city planning handbook is recommended as a means of making the scientific knowledge of city planning readily available to a large proportion of the professional city planners.

CHAPTER I

INTRODUCTION

"Concepts previously known only in a given field may spread far beyond its boundaries, notably in recent times."[1] With this bit of experience as background, this study is an effort to spread a few selected concepts of the social, natural and mathematical sciences to the field of city planning.

The function of planning.--It is first necessary to set down a definition of city planning in order that the relationships between scientific techniques, introduced in the study, and city planning can be seen. The following definition of city planning is not meant to be the last word on the subject. It is merely meant to give a context in which this study can be read and understood.

Though in most cities current city planning practice is largely confined to making physical plans, the leading thought among theorists is that city planning should be "as broad in scope as city government."[2] City planning is conceived as an advisory service to the chief executive, and through him it is advisory to the legislative body. City planning is a staff function in the sense that ideally it is devoted exclusively to the knowing, thinking and planning activities of government as opposed to the line function which is chiefly concerned with the "doing" activities of the operating departments. "As an integral part of an administrative structure the functions of a planning staff are broadly twofold: (1) to carry on research and to make recommendations on the basis thereof and (2) to [synthesize] departmental policy [into an overall city plan]."[3]

The real test of planning is not only how sound it is from a technical point of view. It depends also on whether and how it influences official action. "Planning, of whatever character and no matter how good, is useless unless it influences official action."[4]

Planning is a process available to anyone who will use it. It is available to totalitarian governments as well as democratic governments, political bosses as well as professional public administrators, groups of private citizens as well as official government, and private enterprise as well as public enterprise. In a democracy, planning for the public good is "the process by which we make a continuous, organized effort to gather all the facts about and bring all the scientific insight to bear upon any problem which may require the adoption of a public policy."[5] In essence the idea has been expressed as "to put the experts on tap rather than on top." Planning is the process which makes available to the political domain of public decision expert research and synthesis.

This study stresses scientific concepts for good reason. "The importance of science is less in its material boons than in its universality, in the large area of agreement that it has achieved; the fact that it has risen above particular languages to a form of discourse that may become common to all, and be incorporated into them. Modern theory is well adapted to estimating the degree and extent of the validity of propositions, and perhaps even of giving them direction."[6]

Need for new methods.--Although city planning has been practiced since cities first appeared, this practice developed into a conscious procedure as cities became complex. Finally city planning developed into a profession and has been practiced as a profession (though an ill defined one) for more than half a century.

The need for new methods is a natural requirement for any profession, but there are special reasons why the profession of city planning is ripe for the application of new methods at this particular time. Underlying these reasons is the rapidly increasing complexity of man's existence. One bit of progress does not merely add to another; it multiplies. For instance, world population graphed with respect to time starts slowly but gains momentum until at the present time it exhibits a very rapid rate of growth. Inspecting a graph of the average speeds of transportation year-by-year, the number of telephones in use, or the number of persons supported by one farm worker, the same trend is noticed.[7] One type of progress after another follows the trend of the growth curve.

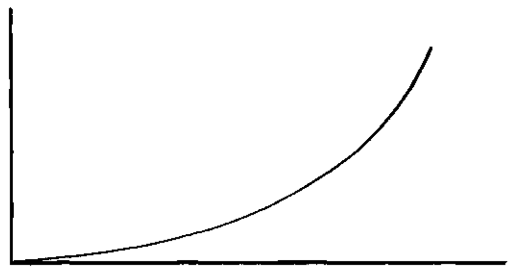

Fig. 1 Typical Growth Curve

Source: H. H. Goode and R. E. Machol, Systems Engineering. New York: McGraw-Hill Book Company, 1957, pp. 2-3.

City planners have worked with these phenomena long enough that no more needs to be said to them about increasing rates of growth.

Until recently the effects of science upon the people of the world were very largely restricted to a *laissez faire* character. When a scientific laboratory turned out a new principle, private enterprise picked it up and turned out a new product. The public reacted in a natural way, with each person exercising his individuality. This lack of any government policy to guide the use of new products of science was in the tradition of eighteenth century *laissez faire* in which a policy of non-interference in economic affairs was deemed appropriate for government.

The depression of the 1930's and the Second World War which followed dramatized the inadequacies of such a procedure. Social planning began to come out of its academic home into public service. The requirements of war stepped up scientific research and development unbelievably. Of course, secrecy surrounded much of what was done, but in the 1950's some of the secrecy disappeared, revealing astounding progress. It is at this point in history that this study was undertaken. The depression gave city planners a prominence they never enjoyed before and scientific research is offering the city planner new tools more powerful than any he has ever had before. The time is opportune for the application of new methods to city planning.

Scientific methods.--Before new methods or concepts which can be applied to city planning are described, it will be helpful to say a few words about scientific method. Although it is not new, scientific method is still accepted as the basic philosophy behind present-day scientific concepts. Scientific method developed over a period of many centuries, as a result of the thoughts of practical as well as theoretical philosophers.

The earlier philosophers concentrated on logical systems of thought, thinking that reason was a sufficient proof of their ideas. However, more recent philosophers have realized that logic cannot prove anything to be true of the real world unless the assumptions on which the logic rests are correct. In an effort to make sure that their logic does not lead them astray, modern scientific philosophers take pains to compare their logical conclusions with occurrences in the real world. Thus, the addition of the philosophy of empiricism to the philosophy of logical reasoning has resulted in the philosophy of science.[8]

Scientific method has several steps, but its distinguishing characteristic is observation. No study is scientific unless it is based upon carefully observed data which are used to empirically test hypothetical propositions. The six steps of scientific method are as follows:

1) The problem under study and all words used in the study which do not have generally accepted meanings are defined; assumptions and conditions under which the problem is studied are made explicit.

2) All knowledge on the subject made available by previous studies is analyzed as the basis for forming an hypothesis about the problem.

3) The hypothesis is used to predict occurrences.

4) The hypothesis is empirically tested by observing occurrences and comparing the actual occurrences with the predicted ones.

5) Results of testing the hypothesis are used to revise it in an effort to make it consistent with the actual occurrences.

6) More tests and revisions are run on the hypothesis until a satisfactory hypothesis, which can be successfully used to predict occurrences, is developed.

At the end of this six-step method the hypothesis, which to begin with was a tentative proposition to be proved or disproved, emerges as a theory that can be used, for all practical purposes, as a fact.

The scientific method requires that whoever uses it must be objective in so far as possible. The results of tests must be arrived at according to rules which other scientists could follow to arrive at the same results. These rules should be made explicit so that there is no mystery about how the results were attained. Only under this condition of objectivity can the meaning of the test results and the value of the theory based on them be clear.

Coupled with the development of precise measuring devices, equipment which can be used to control experiments, and mathematics, the scientific method has been used to great advantage in the study of many kinds of phenomena. This study will show how some of the concepts used in scientific investigations can be used to make city planning more effective than it normally is at the present time. The first such concept to be discussed is that of systems engineering.

Systems engineering.--Systems engineering is one method of scientific investigation which has been meeting with success in finding new solutions to the increasingly complex problems of modern life. Originally developed to handle military problems of unprecedented complexity, it is now becoming important also in peace-time applications.

Systems engineering is mainly concerned with the design of equipment systems, but social, biological, and ecological systems have many points in common with equipment systems.[9] Many systems engineering techniques may be applicable to city planning problems in the future.

In defining a system the first important thing to consider is that there is always a singleness of purpose which the system works to accomplish. For instance, an automatic traffic signal system would have as its single purpose to enable traffic to move quickly and efficiently through a city or part of a city. The components of such a system would be a sensing device to record the movement of traffic, a transmitting device to relay the record of traffic movement, a computing device to process the traffic data, a second transmitting device, and finally the signal itself which controls the traffic. It would be the job of the systems engineer, not to design each of these devices, but rather to write functional specifications for them so that they will be designed in such a way that they will work well together to accomplish the single purpose when the system is assembled. The similarity to a city planning job is obvious. Just like the systems engineer, the city planner should not be responsible for designing each road or intersection or park; rather it is his job to write the functional specifications for the park system or the road system or whatever system he is working on. The systems engineer and the planner are specially trained to take the broad view of the system as a whole. It is impossible for them to learn all that would be necessary to see the system as a whole and still be able to do an expert job of designing all the components of the system.[10]

One example of a system with which all city planners are concerned is the land use control system. City planners have a systems engineering responsibility for the land use control system just as industrial engineers have the systems engineering responsibility for a communications system, a weapons system, or some other system. A few of the well known components of a land use control system are zoning, subdivision regulations, official maps, public acquisition of land, and tax policies. Planners have a tendency not to treat these components as parts of a system. They are more likely to treat them as independent tools. Consequently, zoning, subdivision regulations, and the other components are not always made to work together for common purposes. When a planner works to improve a zoning ordinance and map without reference to the other land use controls, he is doing what a systems engineer would call "suboptimization." Suboptimization is not the job of a systems engineer. Instead, his job is to optimize the whole system. As a matter of fact suboptimization, without regard for the limits set by optimization procedures, may ruin the chances for optimization because the two may be incompatible. The city planner who works on a zoning plan without always being mindful of the other land use controls could very well be damaging the overall land use control system.[11]

The team approach is the obvious method of attack for a systems engineering problem. The systems engineer directs the team so that they work with the single purpose of the system in mind. City planners might very well benefit by studying the methods of systems engineering and applying the system engineer's approach to their system design problems.

Operations research.--Another new approach to increasingly complex, modern problems is operations research. Operations research has been defined many ways, but essentially it is the application of scientific methods and techniques plus the team approach to operational problems. Operational problems are difficulties arising from a certain way of doing a job or a certain way of using a piece of equipment. Implied in the term "operations research" is the existence of an operation. Though such an implication may have been correct when operations research first began to be used, it is no longer strictly correct. The findings of operations research are not limited to suggesting better operating procedures using existing equipment or systems. Operations research studies sometimes lead to proposals for new equipment and systems to be designed. Also, to avoid the limitation of studying existing operations, mathematical simulation has been taken over as a very important part of operations research methods. Using the simulation techniques, operations research workers are able to test hypothetical operations thoroughly before they are actually established in use.

Operations research was developed during the Second World War by the United States and Great Britian for the express purpose of aiding military decision making. Its record during the war was highly distinguished, and thereby established operations research as a new profession with something unique to offer. The advisory position enjoyed by operations research leads to the following well known definition of operations research. "Operations research is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control."[12] Notice the similarity of this definition of operations research with the definition of city planning already given!

Another more recent definition is similar but adds the point that "The concern of OR with finding an optimum decision, policy, or design is one of its essential characteristics . . . it seeks the best solution."[13] Operations research takes the systems approach and "is concerned with as much of the whole system as it can encompass."[14] But that does not necessarily mean it starts with analysis of the system as a whole. "Most OR problems begin with familiar problems of restricted scope,"[15] and then broaden the scope as much as circumstances permit. As this process takes place, the solution of each problem uncovers new problems. "Consequently, OR is not effectively used if it is restricted to one-shot projects. Greatest benefits can be obtained through continuity of research."[16]

Operations research is an applied science. It uses all known scientific techniques as tools in solving a specific problem. One major contention of this thesis is that city planning is to a large extent operations research. It is an applied science which should use every applicable scientific technique at its disposal. City planning should make use of the most recent discoveries in any field of study whenever they are applicable in any way. This is to say that if city planning hopes to keep up with the tremendous growth of complexity of problems and technological change, it must avail itself of a multiplying technology of its own based on the advance of all sciences.

Operations research emphasizes quantification of factors in the process of decision making. Those factors which cannot be quantified are not stressed. Management is always left with the ultimate responsibility for making the final decision based on subjective judgments in addition to facts presented by operations research studies.

Operations research has drawn most of its workers from the basic sciences (i.e., physics as opposed to engineering, biology as opposed to medicine, sociology as opposed to public administration, etc.). Thus, a real emphasis on research has been attached to operations research studies. The product of an operations research team is a research report. One of the most experienced operations researchers in the United States lists as "the important characteristics of operations research" the following:

> Research on the operations of the whole organization;
>
> Optimization of operations in a manner that brings about greater assurance of both short and long range health for the organization;
>
> Application of the newest scientific methods and techniques;
>
> Synthesis and extension of the methods and techniques of the older management sciences;

> Development and use of analytical models in the manner common to the basic sciences;
>
> Design and use of experimental operations that give an insight into the behavior of actual operations;
>
> Use of integrated and creative multi-disciplinary team research to solve complex operational problems.[17]

It is not the purpose here to give a lengthy account of the success of operations research. That has already been superbly done elsewhere by people much better qualified than this writer.[18] But even so, it is appropriate to give a short account. The account illustrates the point that as operations research has developed it has become capable of solving increasingly complex problems.

During the war, operations research developed from the point of considering weapons problems to the point of considering broader tactical questions and finally to the point of tackling complex strategic problems. One interesting weapons problem was that of increasing the percentage of submarine sinkings resulting from air attacks. After study of many attacks, a solution was found which increased the number of sinkings between 400 and 700 per cent without the use of any new equipment. In addition the study revealed that a slight change in the design of depth charge triggers would further improve the effectiveness of the air attacks.[19]

Numerous tactical problems were solved. Losses of ships in convoys were substantially reduced[20] and bombing raids were given surprising effectiveness.[21] A new mine laying tactic was developed which enabled less than six per cent of the XXI Bomber Command's effort, which was devoted to the new tactic, to do as much damage to the enemy as the remaining 94 per cent effort concentrated on conventional operations was able to do.[22] Another tactical problem was presented by the Japanese kamikaze attacks. In this case operations researchers worked out a solution which saved from damage half of the ships which would have otherwise been hit.[23]

Strategic problems are likely to cut across a larger number of scientific disciplines than are the weapons and tactical problems. It is primarily as a result of tackling some of these broad problems that operations research teams have come to include social scientists as equal partners. Postwar military operations research in the United States has naturally been asked to assess Russian capabilities. "One result of this type of research has been codification of those principles of action which appear to underlie the Politburo's calculations; such codification is now available as one factor to be considered in making analytical predictions of Russia's future actions."[24] Another strategic question given to operations researchers was whether the Army should recommend economic and military aid to Western Europe. The resulting report formed the basis for the Army's recommendations concerning this problem.[25]

Non-military applications of operations research have been evident mainly in industry, but there is one example of operations research in national planning. Under the guidance of an operations research consultant, Puerto Rico has been transformed "from an impoverished agricultural island to a thriving, semi-industrialized community with a standard of living which compares favorably with that of other Latin American countries."[26]

As suggested in one of the first books written on the subject of operations research, city planning can benefit from the use of operations research. To paraphrase the authors, initial opposition can be expected from governmental administrators, but once this is overcome there is no reason why operations research should not be as fruitful in aiding the solution of governmental problems as it was in helping to solve military problems. Of course, some operations will be more fruitful of results than others. Traffic problems, for instance, are highly amenable, for data are easy to obtain, and changes in conditions (if not too drastic) can be produced to study the effects. On the other hand, the design of city housing and municipal facilities requires data that are difficult to obtain, the solution is strongly dependent on individual circumstances, and operational experiments are difficult if not impossible. Nevertheless, the field of housing and city planning is an extremely important one and operations research in this field could be started whenever an adequate administrative authority is set up to whom the scientist could report and which could insure that research is more than idle academic exercise.[27]

One of the most recent and authoritative text books in the field of operations research makes the following statement in the course of summarizing the applicability of operations research to various types of problems. "We also realize that it [operations research] has an enormous potential application to community problems as is evidenced by Chapter 15 [Traffic Delays at Toll Booths]. . . . We feel that the future development of Operations Research should occur in all areas of administration."[28]

<u>A trend in city planning.</u>--Recently city planners have been thinking in terms of some of the same scientific concepts used in operations research. In 1954, Richard Neutra argued for the team approach in planning and even went so far as to say that "This [mixed team of technical specialists doing city planning] might be beneficially chaired by an expert in applied biology."[29]

A year ago, Melville C. Branch, Jr. sketched the status of city planning and operations research, indicating that the two professions are growing closer together. He concluded his article by stating "It should be possible to intercommunicate the state of the art in each approach, . . . examine their interrelation, and determine what further study and types of coordination will advance the knowledge and technique of comprehensive planning."[30]

This year one of the policy committees of the American Institute of Planners lists as a goal to be sought the more effective use of scientific techniques by city planners.[31]

Perhaps the influence that scientific advancement has had on planners can best be seen in a 1956 speech by Martin Meyerson in which he uses the new ideas of continuous information flow and feed-back.[32] Meyerson felt that city planners were either bogged down in petty detail or caught up in making long-range plans which had little chance of being realized because they failed to show specific steps to be taken in the present. To correct these shortcomings, Meyerson proposed what he called the middle-range bridge for comprehensive planning. This proposal was not to be substituted for long-range planning; it was to supplement it. The purpose of the proposal was to introduce a method for producing short-range plans (for ten year periods or less) which would solve current problems in accordance with the long-range plans. The short-range plans would have immediate effect and would be constantly revised to meet changing needs.

Meyerson outlined five functions of the planning agency which are necessary in the process of producing the short-range plans he envisages. The five functions are as follows.

1. Central Intelligence Function
   (analysis of relationships and values)

2. Pulse-Taking Function
   (periodic alert to danger signs)

3. Policy Clarification Function
   (regular revision of development objectives)

4. Detailed Development Plan Function
   (specific projects furthering the long-range plan)

5. Feedback Review Function
(analyze consequences of past as guide to future)

As will become apparent later, the five planning functions have a striking similarity to a theoretical model for decision making. The attempt of this thesis to indicate the application to city planning of selected scientific concepts as techniques is organized around the five planning functions in the hope that this organization will add meaning for city planners.

CHAPTER II

INVENTORY AND ANALYSIS OF A CITY'S RESOURCES

The first of Meyerson's community planning functions is called the central intelligence function. As Meyerson describes it, this function is market oriented. That is, in carrying out the central intelligence function the planner's job is to seek an understanding of the various markets in the community; housing markets, industrial markets, real estate markets, and consumer markets, among others; for it is the market processes which are of primary importance as a method of allocating resources in the United States. The market process Meyerson is speaking of is the bringing together of producer and consumer, supply and demand. Meyerson goes on to say that by carrying out the central intelligence function planners should be preparing to develop public policies to improve the operation of community markets by keeping perpetual inventories of market characteristics. Summing up the proposal, it is the purpose of "a central intelligence function to facilitate market operations for housing, commerce, industry and other community activities through the regular issuance of market analyses."[1] What Meyerson is saying, then, is that city planners should seek to know the resources of their communities and the market relationships which distribute the resources. This study assumes a broad view of the terms "resources" and "markets." Not only are natural resources and the economics of their distribution referred to, but also referred to are social resources and the distribution of them.

While the central intelligence function is not limited to statistical analysis, statistics plays the most important single part in the planner's job of resource and market study. This chapter is concerned with basic studies of resources, market analysis studies, methods of presenting the findings of these studies, and the idea of supplementing statistical studies with case studies. Then to unify the chapter it is summarized by anology to a typical data processing system using electronic computers.

Information is the basis for all planning. Good plans are based on huge quantities of pertinent, up-to-date data. At every stage of the planning process from the earliest investigations to the final reappraisal, gathering of data is the key to success. Thus, information gathering and processing is central to this chapter as it is to every other chapter in the thesis.

In getting to know the resources of an area, there are four important points to consider. First, what kinds of basic studies need to be undertaken and what is the best way to undertake them? Then, assuming the necessary data have been gathered, what are the relationships which can be found between facts uncovered in the basic studies? Third, how can the facts and relationships be presented so that they are most meaningful to those who have to use them? And fourth, how can weaknesses in the statistics and generalizations be overcome? It is with these four questions that this chapter will be concerned.

Basic Studies (the Inventory Function)

The two-pronged question which introduces this section is, What kinds of basic studies need to be undertaken and what is the best way to undertake them? To answer the first part first, it should be said that modern city planning literature is unanimous in recognizing the need for basic studies which include investigations of social, economic, and political characteristics of urban areas as well as the more standard physical studies of land use, natural resources, and so on.

Probably the most complete study ever undertaken for an urban area is the Regional Survey of New York and Its Environs.[2] It included detailed studies of:

the important industries

wholesale markets

retail shopping districts

financial districts

population

land values

government

highway traffic

transit and transportation

public recreation

buildings: their uses and the spaces around them

physical conditions: such as geography, climate, water, sanitation, refuse disposal, and pollution, power, heat and light

public services.

The Regional Survey did not slight physical or economic aspects of New York's many problems, but it gave unprecedented emphasis to social factors. One especially outstanding example of emphasis on social factors is in Chapter XII of the public recreation study entitled "Children's Play in Twelve Congested Districts."[3] Children were observed as they played on the playgrounds and overflowed into the streets and alleys. It was noted where children came from to each of the parks or playgrounds. From these and other factors a percentage of adequacy was established for each park and each playground in the twelve areas. Thus, an index of adequacy was established as a guide for recreation planning. The Regional Survey pioneered this and other techniques.

The Regional Survey of New York and Its Environs was possible only because of sponsorship from the Russel Sage Foundation. It took seven years and $1 million to complete the studies. As valuable as such studies would be to the average city planning agency, a project of this magnitude has never been undertaken in other cities. Nevertheless, piecemeal approximations to the Regional Survey type of project are becoming increasingly common and new chapters are being added. In cities where planning is progressive, it is not unusual to find (just finished, in progress, or about to be undertaken) projects for investigating economic base, employment factors, population trends, land use patterns, housing conditions, transportation systems, and various community facilities. In addition, any particular city is likely to have a number of special projects relating to current problems which flare up from time-to-time (and may have significance only at one time or one place). For example one project might be for the purpose of improving the tax structure and another might be aimed at determining whether the city could be eligible to benefit from a certain Federal or state program of assistance. An alert planning agency will always be finding new problems to solve which will require new kinds and sources of information.

The needs for several new types of studies are currently being widely circulated in social science and planning literature. Attitude surveys on subjects ranging from home ownership and taxes[4] to neighboring, redevelopment, and the journey to work[5] have been called for many times. Some other studies commonly being called for are geographical studies to identify the extent to which natural areas exist and the characteristics which they exhibit.[6] Then there are population problems which need attention, such as estimating daytime populations.[7] Flood plain surveys also need to be made in many areas[8] and improved studies of economic base are frequently urged.[9] All of these studies are essentially statistical. There is no end to the list of proposed studies which could be given here.

Now that an answer has been given to the question concerning the types of basic studies city planners should undertake, the next step is to answer the question concerning the best way to undertake the studies.

It goes almost without saying that the use to which data are to be put should be carefully thought out before the data are collected. This is an economy measure, plain and simple. City planners have limited time, money and effort to put into almost unlimited possibilities for basic information studies. Not only that, but it is a conceptual economy also. By collecting only data for which there is a use the planner avoids confusion. (These statements are not intended to apply to the fundamental research situation in which "extraneous" data may turn out to be the key to a new discovery.)

After the data have been carefully selected, they should be collected in such a way that they will be available quickly and inexpensively for many different kinds of analysis at any time. One of the most common occurrences in offices which deal with large quantities of data is the extreme difficulty of access to data soon after they arrive in the office.

Special provisions should also be made for keeping the data up-to-date. In the United States, today, everything (population, land use, technology, economic conditions, etc.) is changing so rapidly that even while a city planner is working on a new set of date, the data become out-dated.

By now problems of how to undertake studies designed to gather information are familiar to most city planners, but methods of solving them are not so familiar.

Modern machine methods are the only practical solutions to handling huge quantities of data quickly and with flexibility of access, analysis, and up-dating. IBM systems for handling land use data have been established to meet growing demands for up-to-date information in Providence, Rhode Island;[10] San Mateo, California;[11] and Tulsa, Oklahoma;[12] and other cities such as Wichita, Kansas, are proposing to establish such systems as quickly as possible.[13]

Other municipal functions are also being aided by the use of modern machine methods of data handling. In Los Angeles, where the city operates 16 IBM systems and the county operates 17 more electronic systems, accounting, billing, filing operations, analysis of crimes, traffic violations, and accident reports, computations for construction projects, and handling of voter and tax rolls are all done by machines.[14] Budget control is another phase of municipal operation in which machines can aid.[15] And in New York City, the transit authority is using a UNIVAC system to make daily inventories of its $20 million worth of supplies in 16 scattered warehouses.[16] Almost any job of handling large quantities of data in a repetitive fashion where speed is an important factor can be done advantageously by machine methods.

Basic studies can be designed so as to permit the use of economical methods of collecting, recording, and assembling information.

Market Studies (the Analysis Function)

Without some sort of analysis it would make no difference how many individual pieces of data could be collected. An individual piece of information, or even a large group of individual pieces of information, is nothing more than idle description of the past if it cannot be analyzed to provide generalizations which can be applied to new situations. Thus, the analysis of data is essential to planning for the future.

City planners have long been analyzing data of various kinds. Analysis of data is basically a statistical procedure, so naturally, frequency distributions and graphs of one kind or another appear commonly in planning literature. However, most of the time, data analysis is taken no further than simple tables and graphs. Tables and graphs are valuable as far as they go and are the obvious first step in analyzing data, but they remain tied to a specific set of figures--a specific situation. Consequently, the kind of generalization which yields universal laws is not highly developed in the field of city planning.

Complicated problems are difficult to solve in generalized ways because of the number of factors involved. City planning deals with complicated problems because social factors have to be considered as well as physical factors such as topography and construction techniques. In dealing with complex problems, generalizations can be made most easily if the most significant factors can be identified and studied intensively while relatively insignificant factors are "weeded out" for the sake of avoiding confusion. After a generalization is finally seen, it may be possible to refine it by using some of the previously discarded, less significant factors. This process of generalization and refinement is impossible without the use of quantitative data.

A few generalizations have appeared in planning literature though refinements are much more rare. One such generalization is the gravitational attraction law.[17] The theory, derived from the analogy of the gravitational theory of physics, was first stated in the early part of the 19th century and revived from time-to-time until at the present time it is well enough thought of to be used as one factor in delineating retail market areas. The form of this theory used for delineating retail market areas is known as Reilly's law of retail gravitation. It states that the ratio of population centers in inverse to the ratio of the distances of market dominance between the centers exercised by each. In other words:

$$\frac{P_i}{P_j} = \frac{d_j}{d_i}$$

where P_i = population of center "i"

P_j = population of center "j"

d_i = distance market dominance of "i" extends toward "j"

d_j = distance market dominance of "j" extends toward "i"

Since one or the other of the centers is assumed to be dominant over all the distance between the two centers

$$d_i + d_j = D$$

where D is the total distance between the centers. Taking center "i" as the one for which a market is to be delineated, d_i can be computed from equations (1) and (2), the total distance between the two centers, and the populations of the two centers. The derived equation is simply

$$d_i = \frac{D}{1 + \frac{P_i}{P_j}} .$$

By applying this formula between one retail center and each of a number of surrounding centers, it is possible to delineate the market area of the one center. Since factors of "friction" such as road conditions between the centers, intervening political boundaries, etc. have not been incorporated into the formula, the formula must be used with discretion. But even so, the formula is useful as a guide and may be refined for more precise use in the future.

In the absence of more and better refined generalizations, the analysis of city planning data is, at the present time, dependent almost entirely on specific case materials. Analysis of this type requires that all pertinent factors involved in a problem be measured directly each time the problem is studied, whereas if generalized relationships could be said to exist between the factors, relatively few measurements would have to be made to determine a solution to the problem.

Analysis of relationships among data in specific cases is familiar to all experienced city planners. A simple example is the comparison of data on types of apartments and number of school children living in the apartments. When such data are tabulated, results might show that, for instance, one type of apartment yields nine tenths of an elementary school child per unit while other types might yield seven tenths, five tenths, or three tenths. Such figures, once arrived at, can be applied in the city to which the data refer for the purpose of predicting the number of elementary school children who will live in new apartments which are to be built in the future. But in a few years the data become so out of date that they have to be revised and retabulated. Obviously such a procedure would be costly and time consuming if done manually.

Data analysis, both for purposes of generalization and case studies, requires machine methods, at least in middle sized and large cities. This is a question of sheer possibilities as well as economy. Generalization, in particular, cannot be based on a small group of facts because it represents all of a certain kind of experience. Therefore, generalization should be based on as much experience as possible if it is to be realistic.

Many of the simpler techniques of data analysis such as ordinary frequency distributions and simple graphs have been available to planners for a long time. These statistical techniques are valuable, but statistics has more to offer than city planners have been prone to use. Statistical analysis is one of the most important kinds of scientific analysis. As a matter of fact, even the physical scientists have recently come to realize the fundamentally statistical nature of their problems.[18]

Planners have use for two broad types of statistical analysis: descriptive analysis and analysis of relationships. The two situations which require different types of statistical analysis are static and dynamic. Descriptive analysis describes a whole universe (or population), as it exists at one point in time, either by summarizing data about a sample of units in the universe and then predicting universe characteristics based on the sample. Analysis of relationships is concerned with finding relationships among variable characteristics which can then be used to predict future data. For the sake of example, a housing condition survey is brought to its conclusion by descriptive analysis of statistics while population forecasts are arrived at by analyzing statistical relationships of variable characteristics.

Descriptive Analysis

Descriptive analysis is discussed here first because it is simpler and more fully developed than analysis of relationships. Several common techniques are used in descriptive analysis. Ratios, percentages, and proportions describe simple comparions of data. Measures of central tendency (mean, median, mode, etc.) are used as the single most descriptive measure; they are measures which give a general description of a whole universe all in one number, such as average income in a community or average educational level in a community. For a more complete description of the universe, however, measures of dispersion also have to be used. These measures are designed to show the range over which the statistics vary, or at least they give some estimation of the range in which the major portion of the data lie. Skewness, a measure of departure from symmetry in ordered data, is also important to statistical description. Progressing to even fuller description, graphical representation is the next step; followed by description in the form of mathematical equations. Carrying descriptive statistics one step further, it is possible to describe, with a fair degree of accuracy, a whole series of data after examining only a sample (sometimes very small) of the data.

Descriptive statistics facilitates thinking about and conversing about data. It also facilitates simple and complex comparions between one set of data and another. It is no wonder, then, that descriptive statistics has already become an everyday tool of city planners who deal with long series of data.

The same techniques of descriptive statistics just mentioned can be used with data from actual situations to test hypotheses. Based on a group of assumptions, hypothetical relationships, and specified conditions, predictions of expected data can be made. If the actual data are then described by descriptive statistics, they can be easily compared with expectations. If a comparison confirms expectations the hypothesis is strengthened; if it does not, the hypothesis is weakened. Setting up hypotheses and testing them with descriptive statistics is a job requiring considerable skill and has, understandably, not come into common usage among city planners. Nevertheless, the useful possibilities are evident.

Analysis of Relationships

Analysis of relationships, like descriptive testing of hypotheses, requires considerable statistical skill. Basically there are two things to be accomplished in the job of analyzing relationships: establishing relationships among data and generalizing on the relationships as a means of predicting future data. Four aspects of relationship or association can be investigated by statistics. The first aspect is existence--whether or not there is any relationship. Next, the question of whether the characteristics are positively or negatively related can be investigated. Then, statistics can indicate how close the association is (i.e., how reliably the statistical relationship describes the actual data). And finally, statistics can measure the change in one characteristic associated with changes in other characteristics.

A number of statistical techniques have been developed for use in the analysis of relationships. Some of the techniques, such as contingency and analysis of variance and covariance, are suited to treatment of nonquantitative data, one example of which is the problem of analyzing the relationships between race (white and Negro) and type of public welfare relief (direct relief or work relief).[20] Other techniques such as total, partial, and multiple correlation are suited to analysis of quantitative data, an example of which is the problem of anlyzing the relationship between the percentage of net change in a population due to migration and the average annual rate of natural increase in the population.[21] As might be expected, nonquantitative data and the techniques for analyzing the relationships among them are not as precise as are the quantitative data and the techniques for analyzing them. Nevertheless, the statistical methods of analyzing nonquantitative data (the analysis of which is often lacking) are better than ordinary common sense. Methods of correlating quantitative data are, to an even higher degree, superior to ordinary common sense.

Correlation analysis.--It is in the realm of correlation analysis that frontiers are being extended. Recent developments in electronic computer systems are largely responsible. Only because computers are available is it possible to process large quantities of data with complex statistical techniques. Before the use of computers, limits of time and expense prohibited many statistical analyses which are now becoming commonly accepted practice. As more and more problems become stated in quantitative terms, correlations heretofore impossible will appear.

The most simple type of correlation is total correlation. It is used to analyze a relationship between two series of data. For instance, the relationship between cost of sewer lines and length of sewer lines could be analyzed by correlation as follows. Records of installation of a number of varying lengths of four foot trunk sewers could be examined and lengths and costs shown on each record could be plotted on a graph. The resulting graph might look similar to the one below which is called a scatter diagram.

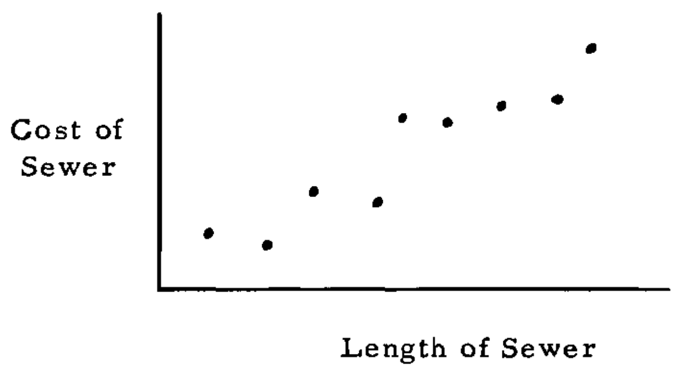

Fig. 2 Scatter Diagram

The scatter diagram can be analyzed mathematically to determine the line which represents the relationship between length and cost most accurately on the average. Such a line (called a regression line) would have the mathematical form $y = a + bx$

in which y = cost of sewer

a = point at which the line described by the equation crosses the y axis

b = the slope of the line (ratio of y to x)

x = length of the sewer.

In the case of the scatter diagram above, the regression line would appear as follows:

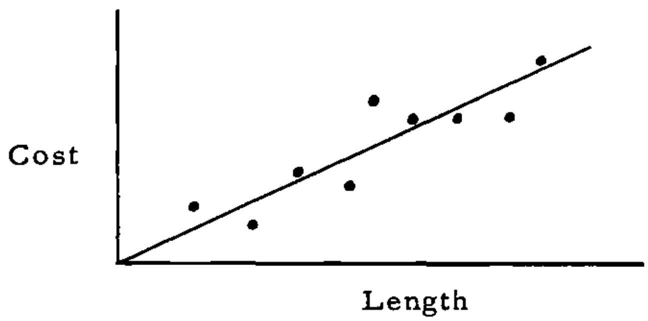

Fig. 3 Regression Line

After proper refinements an estimated trunk sewer cost could be computed by the simple procedure of substituting the proposed length into the formula. This total correlation procedure is the basis for other, more complex types of correlation.

Partial correlation is used to separate analysis of relationships when more than two characteristics are involved. For example, the correlation problem stated above was to fine the relationship between length and cost of sewer lines. Without narrowing the problem further, the total correlation would be one between cost and length records of all types of sewers. However, in working out the above example, the problem was narrowed to consideration of four foot trunk sewers only. Thus, the example given, while it is a total correlation of the four foot trunk sewer problem, is only a partial correlation of the broader sewer line problem which included all sewer lines.

Within the more narrow problem further breakdowns can be made, so as to consider separately, for example, four foot trunk sewers which have been constructed in rocky soil and four foot trunk sewers which have been built in sandy soils. In the total correlation problem only two variables were considered; cost and length. Then by the use of partial correlation the size of pipe, a third variable, was held constant for the purpose of removing its influence in the relationship between cost and length. And finally, the type of soil (another variable) was held constant so that its influence would not affect the relationship between cost and length. Another possibility, using partial correlation methods, would have been to hold length and soil type constant and investigate the relationship between cost and size. The next possibility would be to hold constant length and size while the relationship between cost and soil type was analyzed. Thus, a whole series of correlations can be found between various isolated characteristics within the bounds of the total correlation.

After partial relationships have been analyzed, there is often reason to recombine them in such a way that the conditions of a new problem can be simulated. Carrying out the sewer line example, the cost of a sewer line is to be estimated. The partial correlations between cost and length, cost and size, and cost and soil type enable the cost for the proposed sewer line to be estimated. The process of combining partial correlations is known as multiple correlation.

Statistical correlation is not limited to straight line relationships. Curved relationships have been found to exist and they can be correlated statistically.

To summarize the uses of correlation, it can be said that there are three. First, correlation can be used to establish control over experimental conditions, as was explained with the examples of partial correlation. Second, it can suggest and test hypotheses about relationships between variables. And third, the correlation relationships can be used to predict conditions in practical situations in order to solve problems.

Trend analysis.--Analysis of relationships involving time as one variable is called trend analysis. Since time is not normally thought of as a cause of variation in characteristics of other data, correlation coefficients, tests of significance, and similar statistical tests of relationship are not usually applied to the analysis of time series. Nevertheless, regression lines are fitted to time series data to indicate trends of variation which take place over periods of time. Time is an important factor in much of the work city planners do. It is important, for instance, in predicting population growth, economic growth, and traffic growth.

Since trend analysis is such an important part of market studies (because of its role in predicting supply and demand) an example of market trend analysis is appropriate at this point. In trying to use sales trends established from past records of a company, some researchers have found that monthly estimates by salesmen were twice as accurate as predictions based on the trend. They also noticed, however, that sales tended to vary in a random manner around the trend prediction while salesmen's estimates exhibited a constant bias. From these two observations a new method of trend analysis was suggested. First, sales figures for the past twelve months were used to determine a trend line (by the regression line method used in correlation analysis). Then the standard deviation of the twelve sales figures as they varied randomly around the trend line was computed and two lines were plotted parallel to the trend line at a distance (one above and one below) of two standard deviations. Since chances of sales varying more than two standard deviations are only 32 out of 100, these parallel lines were used as the limit of expected random variation of the sales figures. Whenever a new sales figure fell outside the limits, a forecast of change in the market trend was made. Until a new trend was definitely established, the trend line was recomputed each month as new information became available. But so long as the sales figures fell within the limits of an established trend, no trend change was forecast. Within the trend limits, salesmen's monthly estimates (adjusted for their constant bias) were used for short term forecasts. Using this analysis retrospectively over a seven year period, each trend change was correctly forecast before it would have been using other methods, and the method proved itself in current use as well as in retrospect. Subsequently, the method has been further refined.[22]

The value to city planners of this method of trend analysis is that it can be used to check on predictions. If, for instance, a plan adopted by a city, programs a number of physical improvements based on a specified rate of growth, a record of new building or occupancy permits could be plotted on a graph showing the growth trend and the limit lines and could be used to predict changes in the assumed trend. As a result, the program of construction projects could be adjusted more realistically to needs.

New Methods of Analysis

There are a number of analysis techniques which have not been generally available to city planners, a few of which are explained in the following paragraphs.[23]

The new profession of operations research has repeatedly been concerned with five recurrent types of problems, and consequently it has some well developed techniques for handling these problems. The five types of problems are:

1. inventory
2. allocation
3. waiting-time
4. replacement
5. competitive.

Each type of problem has a relevancy to city planning and the operations research methods of solution could become valuable techniques to be used for planning problems.

Inventory problems.--Inventory problems grow out of industrial applications of operations research where questions involved are primarily concerned with how much of an item should be ordered for production or purchase and when the order should be given. The object is to balance inventory costs against administrative, production, and shortage costs so that the most profitable situation is enjoyed by the company. Such a problem is analogous to the city planning problems of market analysis and proposal of policies to stimulate or slow down certain market processes in the city.

Two examples of city planning problems which can be treated as inventory problems can be given. The first involves zoning and taxing policies. These policies can be adjusted from time to time so as to regulate the amount of land available for urban development of one type or another according to demands for it made by economic, social, and other pressures. When the demand for urban land is low or when it is desirable to limit the extent or urban development, zoning the land for agriculture or very low density residential use will help to hold the land in open use. A decision to hold certain lands open could be reenforced, in addition to using the zoning policy just mentioned, by assessing the land for tax purposes at a low value which reflects the fact that the land is limited to non-intensive uses. Analysis as an inventory problem would be directed toward determining when and where it would be most advantageous to the community for land to be discouraged from free circulation in the urban land market.

The other side of the problem involving the land market is to determine when and where land should be encouraged to circulate freely and seek to be put to urban use. When it is determined that certain land should become urban, zoning and taxing policies could be used to encourage this. The land would be zoned for an intensive urban use and assessed for tax purposes at relatively high values on the basis of its potential urban use.

In addition to regulating the supply of land, problems of water supply could also be treated as inventory problems. Inventory analysis applied to the planning of water supply projects would benefit the community by indicating when it would be most economical to build additional facilities. On the basis of this analysis water projects could be recommended for inclusion in the capital budget with some degree of confidence that the recommendation was sound economically. The extent and timing of other public projects, as well, could be analyzed scientifically if treated as an operations research inventory problem. In both land supply and public works problems the most economic over-all timing and extent of projects would be the ideal sought.

Allocation problems.--Allocation problems "arise when (a) there are a number of activities to be performed and there are alternative ways of doing them, and (b) resources or facilities are not available for performing each activity in the most effective way. The problem, then, is to combine activities and resources in such a way as to maximize over-all effectiveness."[24] The city planning application which comes to mind here is in the preparation of the capital improvements program.

Capital improvement programs are the programs through which many of the resources of a city are made usable. Consider the problem of allocating the water from a limited supply to a number of different uses. Since water is ordinarily distributed through a public system of dams, canals, acquaducts, pipes, and so forth, the construction of these facilities is at least a partial determinant of water allocation. Part of the water could be directed to irrigation canals, part to large industrial users, and part to the general domestic system of the community. This is clearly an allocation problem with no obvious answer, but it can be scientifically analyzed by mathematical and other methods which have been developed by operations research.[25] Other resources, as well as water, present similar problems of allocation. An important point to remember is that there are many kinds of resources in addition to natural resources, and whenever there is a limited resource of any kind its allocation may become a critical problem which could be best analyzed by the allocation methods of operations research.

Waiting-time problems.--Waiting-time problems "involve the arrival of units which require service at one or more service units."[26] Either service or served units or both may often be required to wait at various costs to the waiting units. "The problem is to control arrivals or to determine the amount or organization of service facilities which minimizes the sum of these"[27] waiting costs. Traffic problems are among the concerns of city planners which could benefit by application of operations research waiting-time techniques.

Traffic problems may seem more the responsibility of traffic engineers than the responsibility of city planners and to a degree this is true. But the planner's interest is a broader one than the traffic engineer's. In order to be able to recognize the need for new trafficways and in order to recommend the type of trafficway needed, the city planner must know, at least in a general way, what capacities can be achieved on any given type of street, road, or highway. The experience gained from waiting-time analysis will determine these capacities to a large extent, and it may also lead to the discovery of new types of highways which city planners will be able to recommend for improved traffic carrying characteristics.

It should be recognized that problems of traffic capacity involve more than engineering considerations. They involve basic policy questions about how long people in the community are willing to wait in lines of traffic, and they involve also economic questions in the nature of cost and benefit analysis. Such questions place limits on improvements to trafficways which affect capacity computations.

Since city planners have the over-all responsibility of planning adequate systems of trafficways for communities, they should make sure that waiting-time analysis is used to assess capacities of the trafficways in the community. Without such analysis a city planner cannot predict the need for new trafficways or the effects new trafficways will have on the community, except in a rough rule of thumb fashion.

Any other service facility of a city could conceivably benefit from analysis by waiting-time techniques. Mass transit systems, swimming pools, parks and playgrounds, auditoriums, the central business district, and employment centers all serve people, but the people often must wait to be served. There is doubt that these facilities are giving service in the most efficient way. Consequently, waiting-time techniques are suggested as appropriate means of analysis with which to seek improvements in service.

Although the city planner may very well find himself unable to carry through such detailed waiting-time analysis as would be necessary, his basic interest in creating a city which can serve its people efficiently should lead him to seek waiting-time analysis of his community. The important thing for city planners to realize is that waiting-time techniques do exist and that they are indispensable to the kind of analysis which will lead to design of efficient cities. The city planner should satisfy himself that this type of analysis is being applied to the problems of his city.

Replacement problems.--Replacement problems are problems which are concerned with replacement of deteriorating or obsolescing items in a way which will minimize the sum of the costs of maintaining old items, the costs of loss of efficiency of old items, and the costs of replacing old items. The current planning problems which could benefit most if treated as operations research replacement problems are urban renewal problems.

In order to gain full benefits from urban communities, old sections must be continuously brought up to date. Otherwise they become blighted and their condition influences nearby sections of the community like a rotten apple affects other apples in the barrel with it. It is a real problem to know when it is best to use techniques of conservation, or the techniques of rehabilitation, or the techniques of clearance. In city planning literature, comparative cost estimates demonstrating which treatment of an urban renewal project would be most profitable in the long run to the community never appear. It must be assumed, therefore, that such estimates are not made. The magnitude of the urban renewal program is large enough to suggest that millions of dollars may be wasted each year in the process of rebuilding cities. Treating urban renewal problems as replacement problems could conceivably lead to large savings.

Maintenance problems are special cases of replacement problems since they usually involve replacement of a component of a facility rather than the whole. To give one example of possible city planning applications, the street maintenance program of a city might serve the people considerably better if the planning agency were to study it as an operations research replacement problem, giving emphasis to the broad problem of efficiency, including such factors as automobile repair costs incurred due to bad roads, and shifts of traffic to other routes, as well as public maintenance costs.

Competitive problems.--Competitive problems are ones "in which the efficiency of a decision by one party is capable of being decreased by the decision of another party."[28] Two types of competive problems have been studied. 1) Game problems, in which the number of competitors, rules of action, outcomes, and benefits of outcomes are all capable of being specified, have been studied enough so that a general "theory of games" has been developed. 2) Bidding problems differ from game problems in that the number of competitors is not usually known, the possible actions are generally unlimited in number, the outcome of actions can usually only be estimated, and the benefits of outcomes are not known with certainty; but nevertheless the beginning of a theory of bidding has been started and already some useful tools are available.

The realm of city planning in which competitive analysis might be useful is in testing the effectiveness of proposed methods of implementing public policies. In this problem the competitors might be of three types: (1) governmental units, (2) special interests such as builders, bankers, retailers, or industrialists, and (3) the general public. Any public policy which is enforced competes against special interests, certain members of the general public, or both in an effort to protect the rights of the community as a whole. In other words, government seeks to set up rules and strategies which will enable the community at large to win benefits in the competition with individualistic interests conceived without thought of the community interest.

To give a simple example, a builder may see his chance to make an unusually big profit using inferior construction methods. Since the profit motive is often the most important motive of a businessman, it is natural for the builder to seek this profit. In doing so, however, he causes the community to suffer. The community retaliates with building regulations.

This is the beginning of a competitive situation, and it leads to a sequence of questions. What will be the builder's reaction to the regulations? Are the building regulations giving the community the desired protection? Is the government defeating some community goals, such as economical construction, by insisting on building regulations which are more restrictive than necessary? How does the public react to the regulations? Can people afford to pay for buildings constructed in accordance with the regulations? Is it possible to enforce the regulations?

Game theory and bidding theory are appropriate tools with which to investigate such questions. City planners should take the responsibility of seeking scientific answers to the above questions.

Summary.--Real systems of problems usually involve more than one of these five problem types. The usual procedure in operations research at the present time is to handle a system of problems as a mere sequence of problems. But even so, operations researchers recognize the need for developing models which incorporate different types of problems. There appears to be no other way to arrive at true optimum solutions to a system of problems.

The problem solutions which operations research is able to produce very often are the results of applying especially powerful mathematical techniques. To name a few of these techniques, linear, dynamic, and quadratic programing are the mathematical techniques used to solve inventory and allocation problems. Waiting-time problems require the use of queueing theory, sequencing theory, and line-balancing theory. The mathematical techniques of game theory and bidding theory have already been mentioned in connection with competive problems.

Operations research is not limited to solving the five problems mentioned here nor are the techniques mentioned necessarily limited to use with a single type of problem. The success of operations research lies with its ability to adapt techniques from one type of problem to another. Imagination is the key.

City planners should keep abreast of new developments in operations research and of applications of its methods to city planning and related problems so that they will be able to take advantage of the promising techniques listed in this section of the thesis. But beyond this, city planners should encourage research projects specifically aimed toward developing city planning applications of the techniques.

Presenting Data (the Communication Function)

Presentation of data is more important than ordinarily realized. Visualization in the mind of a city planner does not always come easily, and especially is this true when new ideas are being explained or sought. Flexibility, economy, and speed are all important parts of effective presentation of data. Flexibility is important because it allows presentation to take any form the mind can conceive. Economy is important because it removes the mental block (and administrative block) against "wasteful frills" of presentation. And speed is important because it helps the planner to reenforce his thinking as thoughts come to him, instead of finding it necessary to slow his mental processes (and perhaps forget good ideas) at a crucial moment of creativity. Thus it is that effective presentation of data stimulates planning ideas while ineffective presentation slows creative processes.

Experimentation in ways to present data, so they can be interchanged, compared, and contrasted with freedom, is an extremely important tool of conceptualization. Ways of presenting data which give planners a high degree of freedom could lead to very productive thinking and even accidental discoveries.

In addition to aiding planners with their creative tasks, effective presentation of data aids planners who are concerned with the everyday operations of assessing the progress toward implementation of a plan and keeping track of crucial market conditions which might call for public policy adjustments. Since planners are not able to have first-hand knowledge of all occurrences having a bearing on planning decisions, they must depend largely on the data presented to them. They may need accurate data only annually or semi-annually, or they may need it weekly, daily, or hourly, depending on the stability of the situation and the ability to predict the future. The way in which data are presented to planners concerned with everyday situations determines the planners' concept of the situation. Thus, it is important that the data presented to them be easily understood and up-to-date. Again flexibility, economy, and speed are important factors in the scheme of presenting data.

The above considerations have led to the design and installation of a "planning control room" by the Ramo-Wooldridge Corporation.[29] The room is used primarily to give executives a clear overall concept of the company's progress so that they have accurate, up-to-date information on which to base decisions. But, in addition, the room's potentiality as an aid to the company's planning staff is recognized.

The planning control room is lined on three sides with 26 sliding panels of various types and five fixed panels. All of these panels are specially adapted to one kind or another of visual presentation of data. Most of the panels are four and one half by six feet. Altogether there are "711 square feet of representation surface, any part of which is immediately available."[30] Twenty additional panels can be substituted for other sliding panels in a matter of several minutes.

Five different types of panels are used in the planning control room. Specially finished masonite panels are the basic unit, comprising about three-quarters of the total number of panels. They can be marked with grease pencils and other devices, and can be easily erased. The masonite panels are used for numerical tabulations, graphs, and many other kinds of visual representation.

Changeable-letter "menu boards" are used to present tabular data composed of many frequently revised numbers.

The magnetic boards which are used are especially well suited to presentation of bar graphs, organization charts, irregular forms, and other special objects which can be held to the board by a magnet. One unique advantage of the magnetic boards is that whatever is displayed on them can be moved easily to a different position.

Chalk boards are another type of panel used.

Transparent panels are used when overlays are needed as a method of direct comparison of information, and a projection screen is provided for the showing of photographic films.

Beaver board panels, though not used in the Ramo-Wooldridge room, would be useful for displaying maps.

Most of the planning control room panels at Ramo-Wooldridge are inconspicuously marked with a grid system to aid in setting up displays in a hurry. Generally, all the displays are graphically produced, in the planning control room directly on the panels, at great savings in time. All the displays can be revised or erased easily and quickly. Also, all the displays are made so that black and white photographs of them will be readable. Such photographs can be distributed for detailed study by individuals without great expense or delay in time.

The cost to Ramo-Wooldridge for installing the planning control room in its offices was $6,500 and its monthly operation, exclusive of salaries, is about $50. Such a small cost is hardly indicative of the great value of a planning control room. City planning agencies would do well to put more emphasis on these valuable methods of data presentation.

Case Studies (a Supplement to Statistics)

Statistics do not always give the kind of information that is needed. It is the purpose of statistics to summarize data in such a way that meaningful generalizations appear. But there are times when a generalization is not sufficient. Details have their importance also. It is often true that the meaning of a generalization is not apparent until the details behind it are fully understood. At other times, only an intimate knowledge of details can suggest any generalization at all. And then again, there are subjects about which so little is known that there are not nearly enough facts available for a generalization; only a study of particular details is helpful. In all these instances, case studies are needed.[31]

Case studies are individual studies, describing situations in great detail, and focusing, not on the description itself, but on the problem being studied. Of course, the degree to which the case can be focused depends on how well the problem has been formulated. Facts are selected objectively and the description is made as realistic as possible. Accuracy in reporting is extremely important to the usefulness of case studies. Often case studies are undertaken in situations where the reliability of different sources of information is not known. In such cases cross checking of information, using several sources, is required. Cross checking is also highly desirable among the personnel conducting the case study to see that their biases are not damaging the objectivity of the study.

A number of methods are used for conducting case studies, and combinations of them are also used.[32] In some situations written materials such as newspapers, diaries, letter files, etc. are the only sources used. In other situations interviews are used extensively. In still other situations observers at the scene of action are used. If the observers participate in the action as members of the group being observed, the method is called the participant-observer method; otherwise the method is called the nonparticipant-observer method. In some case studies untrained members of groups have been asked to record their observations of the situations they have been in. Other studies have used only trained observers in the use of participant-observer methods. Anthropology, sociology, business and public administration scholars have made the most use of case study methods.

Summary

Summarizing this chapter on "Inventory and Analysis of a City's Resources" can best be done by presenting a short sketch of a typical data processing system. In diagrammatic form the data processing system appears as follows.

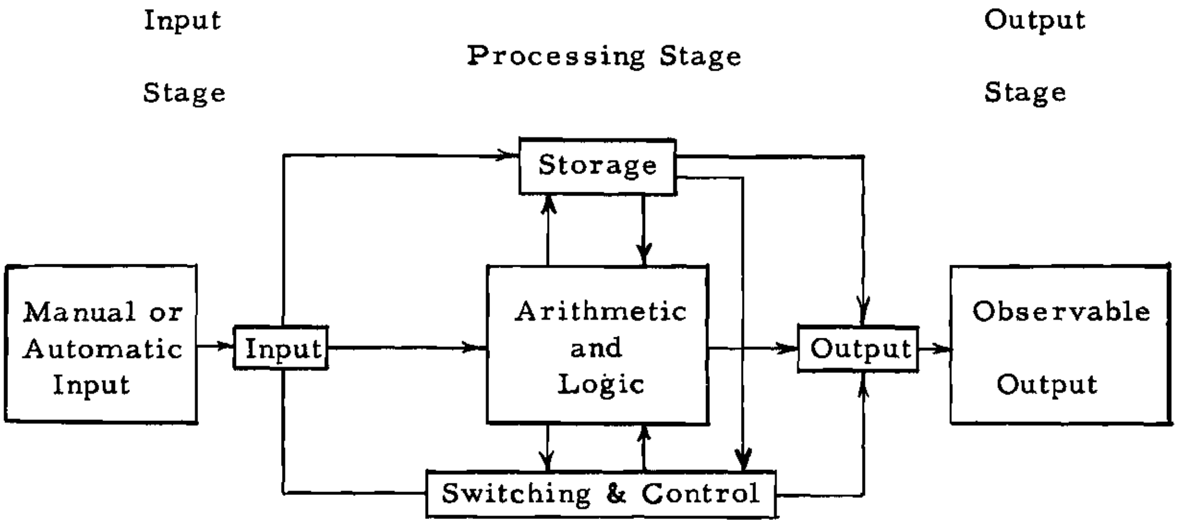

Fig. 4 Typical Data Processing System

Source: G. Kozmetsky and P. Kircher, Electronic Computers and Management Control. New York: McGraw-Hill Book Company, 1956, p. 19.

More will be said in Chapter II about the details of how components of an electronic computer operate in the various parts of the block diagram above. Only a general idea will be given here. Input components vary all the way from keys similar to those of a desk calculator to completely automatic machines which record data directly at its source and transmit it to the computer in a code the computer can understand. The computer itself stores information for use at a later time, performs arithmetical and logical operations, and operates in accordance with built-in controls. Output components transmit the results of the computer's work from the computer to a machine which decodes the information into an understandable report which is then displayed.

In this chapter the three major sections (basic studies, market studies, and presenting data) correspond to the three stages of the data processing system just described. The basic studies section is concerned with getting data together and ready for analysis or processing. The market studies section is concerned with analyzing the data to find comparisons and relationships and to solve problems. And finally, the data presentation section is concerned with making the results of analysis available to city planners, administrators, and others in useful ways.

CHAPTER III

CONTINUING INVENTORY AND ANALYSIS

"The planning agency should perpetually scan the community for indications of maladjustment."[1] With this statement Martin Meyerson sums up his idea of the pulse-taking function. It is his idea that city planning agencies can recognize problems in the operation of community markets, before they gather momentum too great to stop, by making quarterly or other periodic reports on such subjects as "Failures of firms, increased congestion, incipient changes in land use, [and] new demands for services."[2] In addition to determining needed alterations in the community, the purpose of investigating these subjects would be to focus attention on public policy for remedial action. The pulse-taking function would spearhead policy as well as technical decisions. Through the pulse-taking function, city planners ought to anticipate problems so that they are able to correct situations before a crisis confronts them.

As in Chapter II it is assumed here that the term "community markets" refers to the means of distributing all kinds of resources in the community. Also it is assumed that the pulse-taking function is more of a warning device than a device for final diagnosis and analysis of problems. In some cases the pulse-taking data may be so well incorporated into certain market theories that no additional analysis will be needed. But normally pulse-taking will only supply data which indicate that more study is needed on the problem. Specifically, in cases where it is not economical to keep inventories of resources completely up-to-date, trends might be established for the varying status of a resource and extended into the future with the idea that rough indicies of the resource be kept perpetually for comparison. Plans based on the established trends would continue to be executed so long as the indicators confirmed the trends, but as soon as the indicators began to disagree significantly with the trends, a complete revision of the inventories involved and reappraisal of plans would be called for. With a system like this in operation many cities might need complete inventory surveys no more frequently than at ten year intervals, and perhaps these surveys could be done as part of regular census enumerations.

Analogy of Quality Control

The pulse-taking function of city planning is analogous to the quality control function of industrial engineering in that both are processes of measuring repetitive events, as they happen, for the purpose of evaluating the events and controlling them in so far as possible. A brief description of quality control is given below. The description is intended to introduce this potentially useful concept into city planning literature in order to help clarify the purpose of the pulse-taking function and to stimulate further study of the concept and development of techniques applicable to city planning.

Industrial quality control is based on statistical sampling procedures which have been simplified to an easily applied routine.[3] A device called the control chart graphically depicts production samples in a way which makes it easy to see when production goes out of control or is about to do so. The control chart idea is very similar to the market trend analysis procedure described in Chapter II, except that control charts depict samples instead of complete records of sales. Similar to the trend line of the market trend graph, the mean line of the control chart specifies expected occurrences. Above and below the mean line (three standard deviations for most industrial applications) limit lines are placed to warn of poor control in quality. When production samples fall outside the control limits or when a number of consecutive samples fall on one side of the mean line, it means that something is causing loss of control which will result in deviation from production specifications. A production operation which is under control is one in which deviations from the mean are random, that is, caused by chance. Thus, the distribution of samples around the mean should approximate the normal distribution curve when production is under control. If the distribution is skewed, a preventable cause is assumed to exist.

Following are two control charts. The first depicts controlled production and the second depicts production which is out of control.

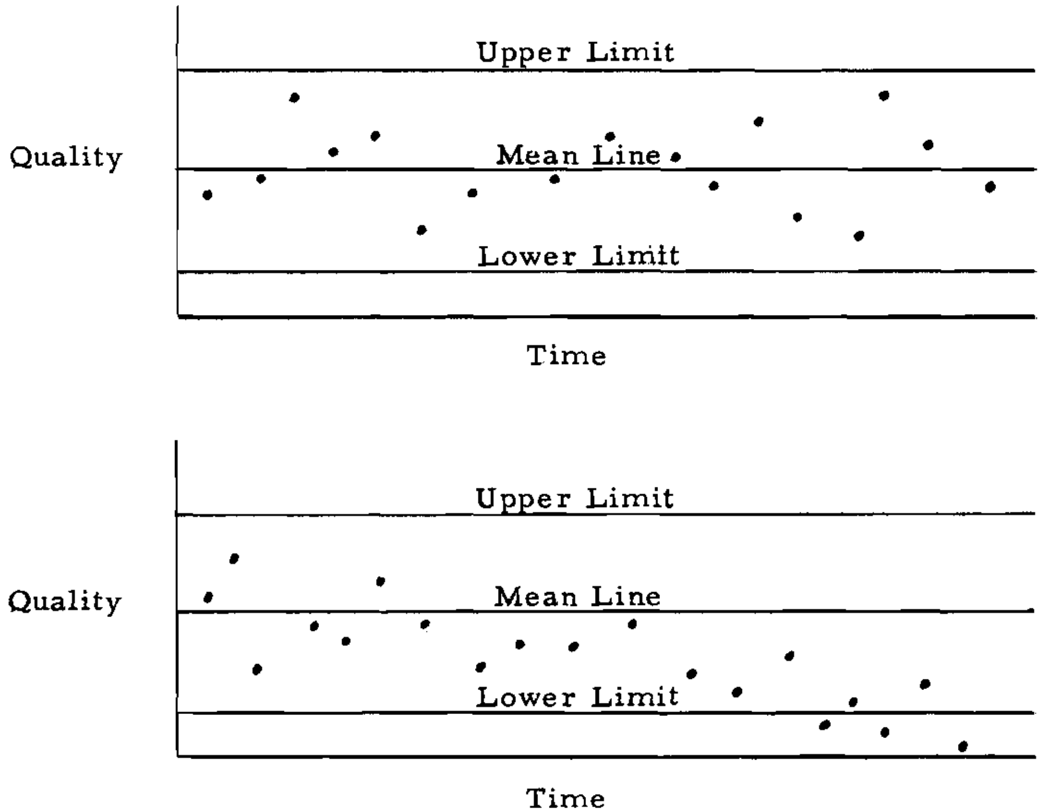

Fig. 5 Control Charts Used in Industrial Quality Control

Applied to the broad field of market analysis described in Chapter II, the control chart idea could be used as a convenient method of graphic analysis to show when samples of market characteristics indicate the presence of causes bringing about change in market trends. Each sample of market conditions gathered could be plotted on a control chart, the mean line of which represents an adopted standard of lot size, floor area per dwelling unit, parking space per retail establishment, or some other specified item which the planning agency wished to control. The standard could be either a formally adopted one (an ordinance) or merely an experimental specification used for comparison with uncontrolled occurrences. Presumably the formally adopted standard would be enforced, as for instance minimum lot size is enforced under zoning regulations. However, if forces in the community were effective in raising or lowering the average size of lots (or other specification) the samples would be recorded in a skewed pattern on the control chart. Whereas random variations would indicate only normally expected exceptions to the specification, skewed variations would indicate specifications having standards too low or too high, poor zoning administration, or other causes of bias against the specification. Thus the control chart could be used to evaluate how realistic or how effective planning controls are. The analysis could then be used as a guide to improving enforcement of control measures or readjusting the standards of control. On the other hand, if standards specified on the control chart are merely experimental rather than adopted policy of the city, control chart analysis could be used as an aid in establishing realistic standards to be included in new ordinances.

Conceptually at least, industrial quality control methods may provide an important tool through which the pulse-taking function of city planning can become effective.

Selection of Data Series

Suitable data series form the basis of the pulse-taking function.

As in the quality control example of pulse-taking mentioned above, the whole analysis depends upon the sample data, because without data there can be no analysis. The problem to be considered next is the problem of selecting suitable data series which can be used in the pulse-taking function.

Data series to be compiled in the pulse-taking function must be manageable. If they cannot be kept up-to-date and always available, there is no real pulse-taking function in the community.

The cost of compiling data for pulse-taking purposes could become prohibitive if the most economical sources are not used, because it is a cost which adds up day after day, year after year. Fortunately there are a number of sources of information, in most communities, available for the asking. Considering the housing market alone, the following types of data are being compiled in various communities and are likely to be available to planning agencies free of charge.[4]

From government sources there is information available on new construction as indicated by building permits, VA and FHA loan applications, and recorded subdivisions. Public deed records show real estate sales and public housing records give information as to vacancy rates in public housing units. Public records show economic and population trends in school enrollments, employment and unemployment figures, births, deaths, and marriages. Sales tax records also contain valuable economic information. Electric power companies are usually willing to supplement the above information with figures on electric meter connections, installations, and idleness to indicate housing construction and vacancies. Newspapers reveal information on prices of existing homes advertised for sale, and apartments and homes advertised for rent. Real estate boards and telephone and gas companies can also supply useful information. Other sources of information available to planning agencies without charge can be found in most communities and they are worth looking for.

Although it may not be practical to compile a large number of different types of data, an inadequate data handling system should not be allowed to handicap the city planning agency unnecessarily. It is almost inevitable, however, that all the data desired cannot be compiled. In this situation it is important to decide on the most meaningful data and the most economical way to compile them. A good example of this can be drawn from the realm of housing market analysis where the single most important factor to keep track of is vacancy rates. The most meaningful type of information, then, is information about vacancies. Vacancy information can be gathered by census procedures or sample surveys, but one of the most economical ways to gather it is by using electric power company records of idle meters. Thus, for the sake of economy, vacancies as indicated by idle meters could be substituted for the entire list of information types and sources described above.[5]

Indicators of conditions in markets other than housing markets can be found and added to the list of pulse-taking data series. By adding to and revising this list from time-to-time, the planning agency can develop an effective routine for pulse-taking.

Indices

Indicators of market conditions are called indices. The basic concept of indices is not difficult to grasp. As a matter of fact it has already been illustrated in the discussion about using idle electric meters as a measure of housing vacancies. An index measures one thing, and from it can be inferred the measurement of another. The housing vacancy index, for example, measures the number of idle meters and from this measure an inference is drawn as to the number of vacant houses or dwelling units.

All indices are not as simple or direct as the idle meter index. The idle meter index uses only a single factor, but many other indices use a number of factors to make up compound indices. Economic indices, for example, often have compound structures. The cost of living index considers, as factors, current retail prices of a number of different items of food, clothing, household supplies, and other commodities which the "average family" is believed to use. The index is arrived at through combining the factors into a single number which is the index.

Index factors may be combined by simple addition, by weighted addition, or by simple or weighted averaging. To illustrate, consider the index factors 1.0, 1.5, and 1.6. Combining these three factors by simple addition, the result is an index of 4.1. Simple addition is used as a method of combining index factors when each of the factors is felt to be as important to the total index as the others.

However in cases in which the facotrs have differing degrees of importance to the total index, a percentage weight can be assigned to each factor before they are combined into the total index by addition. For instance, if the first factor is taken as a standard, if the second is considered to be only half as important, and if the third is twice as important as the first, the weights would be 100 per cent, 50 per cent, and 200 per cent respectively. Multiplying each factor by its weight and adding the three weighted factors together, the total index is found to be 4.95.

If it is desired to express the total index in a number of the same general magnitude as the factor indicies, the total index can be expressed as an average of the simple or weighted factors. To accomplish this all that is necessary is to divide the addition indices, found above, by the number of factors included in the total index. Carrying this through the simple average is found to be 1.37 and the weighted average is 1.65.

Further variations can be obtained by expressing indices in standardized or relative forms as well as in the units in which the data are collected. For instance, if the idle meter index were to be expressed in standardized form its units might be number of idle meters per 100 installed meters. Whereas if expressed in relative form its units might be the ratio of percentage of idle meters in one area compared with the average percentage of idle meters in all areas. Of course, the unit of measurement in which the idle meter data are collected is simply the number of idle meters. The form in which indices should be expressed depends upon how they are to be used.[6]

An adequate set of indices, properly expressed, is a basic requisite of the pulse-taking function, but their real usefulness depends upon data collection.

Data Collection

Some methods of data collection have already been mentioned in Chapter I including questionnaire, interview, participant observer and non-participant observer, and document or records examination methods. The field survey, usually referring to observation of inanimate objects or agricultural crops or animals, is another method. It is a standard method of collection for such data as those pertaining to mapping and land use. All these methods and similar ones are manual, and, therefore, they are costly and time consuming.

With the advent of electronic data handling equipment, new methods of collecting data automatically are becoming available. A few automatic data collection methods will be described in this section. First, however, the idea of compatible data deserves attention.

Since the prime purpose of data collection is to make data available for analysis, it is important to assure that data are compatible with easy compilation techniques. Data which are collected with a single use in mind often are very hard to use in other ways. A great deal of effort may have to be expended to ready the single purpose data for another use, and it may even be necessary to collect the data again from their source. Frustration and waste of time and money result.

A case in point is the normal method of recording land use data. The type of use, the amount of land, the location of the property, and other pieces of information are normally recorded only on maps. The type of use may be generalized in order to fit nicely into a convenient color code on the map while the amount of land may be expressed only graphically instead of numerically. Location may be given only by position on the map rather than by neighborhood, census tract, and parcel numbers. This means that if a tabulation of land areas devoted to a certain type of use in some particular area of the city is desired, it would be a major undertaking to get it. First of all suppose the type of land use being studied is more specific than the general type shown on the map; a new field survey may have to be made. Assuming, however, that land use categories on the map are satisfactory, the areas of all the properties in proper categories will have to be measured, computed, and added up. To make sure all properties used in a certain way in a certain part of the city have been included in the classification is not always easy either. Even supposing that the map shows neighborhood, census tract, and parcel numbers, careful checking and cross checking are required to prevent mistakes. Information recorded on maps is not compatible with quick, efficient tabulation requirements, and data gathered with nothing more in mind than map making do not encourage experimental tabulations. The only tabulations made of these inconveniently expressed data may very likely be those which are absolutely required. This situation stifles research and leads planners into relatively unproductive routines which produce stereotyped plans.

Another familiar example of data incompatability is evident in areas which include several political jurisdictions. Any analysis of land use controls in a metropolitan area would lead naturally to a desire to tabulate land according to types of zoning districts. Unfortunately, it is very seldom that any two different political jurisdictions will have comparable districts. Consequently, the natural desire for this type of analysis has to be abandoned, or, at best, carried out under a handicap which seriously damages any conclusions which may be reached.

Social scientists have already recognized the need to have compatible data from city after city clear across the nation.[7] Only under such conditions will it be possible to derive scientific generalizations about urban phenomena. Thus, there is another demand on data collection.

To assure useability of data, they should be collected in comparable units of measurement and in versatile media. This is a matter of measuring and recording data in convenient units so that they will have the greatest possible usefulness in the data handling system which will process them.

Establishing comparable units of measurement is argued for by Robert M. Sparks in his article titled "The Case for a Uniform Land Use Classification."[8] The main points in the argument are as follows. Current land use research is handicapped because of incomplete and incompatible data. More adequate land use research depends upon a uniform land use classification which will enable data from the various urban areas of the United States to be compared. Comparative research between cities cannot be put off forever; and, this being the case, a uniform land use classification must be adopted.

Versatile media for recording data are available primarily as input records for computers. IBM cards, paper tapes, magnetic tapes, and even microfilm media may be suitable for recording city planning data in readiness for processing by the computers. IBM cards are the most widely used of these media and they are easy to use. In the problem of tabulating areas devoted to various land use types, IBM cards would be a much more suitable media for data records than maps. A few instruction cards could be fed to an electronic computer along with cards containing the use, area, and location data and in a matter of minutes the desired tabulation would be complete. Many types of information could be entered on the cards and various tabulations and cross tabulations could be made available any time they were desired. This ease of tabulation obviously holds an advantage over the typical method of tabulating information which must be painfully drawn from an ordinary land use map.*

The Tulsa Metropolitan Area Planning Commission has recorded basic data on a series of IBM cards with a "separate card for each parcel of land under separate ownership or that portion of the parcel in one zoning district in the Tulsa Metropolitan Area."[9] The data recorded include location, parcel dimensions and area, land use, information about buildings, assessed value of land and improvements, homestead exemption, and zoning. The Tulsa experience shows that an IBM system of recording data is practical.

Sampling[10]

Data collection is very often done on a sampling basis to save cost. From a well chosen sample of appropriate size the whole universe, which the data samples, can be described with a high degree of confidence.

Two major types of sampling are used and both assume random choice of data at one stage or another so that chance can be said to be in operation and probability theory will be applicable in the analysis of the data. The applicability of probability theory is important because

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*Even though maps are inadequate for purposes of statistical analysis, it is not meant to deny the advantage maps have in terms of visual presentation. Other media merely supplement maps.

the accuracy of the sample can be assessed by probability theory. Without probability theory the accuracy of the sample remains unknown.

Random sampling and supplementary techniques for eliminating bias in samples constitute the major problems in sampling. There are a number of ways to make random choices of sample units. The simplest and most obvious is by flipping a coin. Two other methods available involve the use of tables of random numbers or electronic random number generators. If a high degree of confidence is needed in a sample, the use of technically trained personnel is required.

Random sampling.--The simplest type of sampling is that in which all the data are chosen at random from the universe as a whole. This is called, simply, random sampling. The basic requirement is that each unit in the universe has an equal chance to be chosen as part of the sample, thereby ruling out bias. Random sampling is most appropriate to small universes or large universes about which little is known.

Stratified sampling.--The second major type of sampling, called stratified sampling, is useful primarily with large universes which are relatively well understood. The chief value of stratified sampling is that it can use a smaller number of data to match the accuracy of random sampling. In other words, stratified sampling is more economical than random sampling.

The differentiating characteristic of stratified sampling is that the total universe can be divided into subuniverses which are fairly homogeneous in significant characteristics. Selection of valid subuniverses requires a considerable knowledge of the total universe because it must be shown that the subuniverses are meaningful in relation to the problem about which the sample is to gather information. Stratified sampling can be used only when the validity of subuniverses can be demonstrated.

By taking random samples from each subuniverse the total sample can be reduced in size because there is no chance of the total not including data representing each subuniverse. If a random sample of the universe as a whole were taken, the size of the sample would have to be enlarged to increase the chances of including representatives of the subuniverses.

Within the subuniverses there is need to take only small samples because the subuniverses are homogeneous with respect to their significant characteristics. The more homogeneous the subuniverse, the less need there is for a large sample to be taken from it to represent it adequately. Nevertheless, even a subuniverse sample cannot be reduced below ten cases if it is to remain reliable. This is one reason for applying stratified sampling only to large universes. Another reason for applying stratified sampling to large rather than small universes depends upon the number of subsamples. Too many subsamples, even at the minimum size, would require a large total sample which might no longer hold an advantage over the size of the corresponding random sample.

The point to remember is that stratified sampling is only a device for reducing sample size without damaging the reliability of the sample. If the resulting sample cannot meet this test random sampling should be used.

Integrated Data Processing Systems

As soon as data are collected, the problem confronting city planners is to process the data efficiently. To meet this problem an integrated data processing system should be prepared to accept the data and process them.[11] The integrated data processing system performs three types of activity:

1. direct transfer of information,
2. combination of information into reports
   and
3. decision.

The flow of data through all parts of the system is the critical element of design in the integrated system. Efficiency depends upon routing data (expressed as simply as possible) most directly among the least required number of users. There should be a definite use of data made by each recipient. Otherwise there is lack of efficiency. Capacities and processes of the integrated data processing system should be adapted to the ability of the originator of information, to the form of the message, and to the need of the user. Combination of information and decision activities should not be allowed to interrupt the flow of data unnecessarily. Decision activities take more time and attention than information activities which can normally flow rapidly. As a result, if information flow is tied to decision making, the information flow may be slowed considerably. On the other hand, unneeded information flow through decision channels tends to slow decision activities by increasing the work load in those channels. Designing an efficient integrated data processing system is another highly technical job on which city planners need the aid of specialists.

Three types of integrated data processing systems are possible: manual, partly mechanized, and automatic. Manual data systems are the type normally used. All of the data are gathered, reported, and analyzed for decision content by people. In the partly mechanized systems one or a few phases of the data processing are handled by machines. And in the automatic systems all phases of the data processing are handled by machines. Automatic data processing systems are the basis of automation.

Regardless of the advantages of automatic systems in speed and accuracy, manual data processing systems may still be the most economical systems in situations where the number of data is small and the required personnel are available at reasonable salaries. Manual systems can be augmented with such devices as adding machines , desk calculators, and McBee Keysort cards.

The Keysort cards are designed to be punched around the edges to allow them to be sorted more quickly than otherwise. Each card has a row of numbered holes near its edges. Using a numerical code, information can be recorded on the cards by punching the edges of them to open the holes to the edges. Then, when a needle is inserted through a hole of the desired code number in a deck of cards, those cards which have been punched at that hole can be shaken out of the deck. The cards which fall out all have the characteristic indicated by the code and the process can be repeated to yield complex classifications of characteristics.

A partly mechanized data processing system is reported by the Baltimore City Health Department.[12] As part of its record control system for housing law enforcement activities, the Health Department uses two series of IBM cards. The first series records daily inspection and clerical activites so that they can be quickly tabulated as a progress report of the Housing Bureau. The second series records such things as identification of the property, value, use, occupancy, zoning and housing violations, and actions taken by the Bureau and the owner to abate violations. Information from these property inventory cards is tabulated semi-annually for the purpose of assessing housing conditions and progress of the law enforcement program, and to serve as a basis for urban renewal planning.

The purpose of the record control system for housing law enforcement activities is to maintain a continuous flow of information directed toward abating housing law violations. The flow of information begins when there is a complaint about a violation or a decision to start an enforcement program. Field inspectors then investigate the designated premises and record appropriate information. Notices are issued in several ways, hearings may be held, and court proceedings may be used. All of these actions add to the flow of information concerned with abating housing law violations and most of the information is processed manually. Since the two IBM series in this data processing system are not used directly in the abatement process itself, they are supplementary to the main purpose of the system. Nevertheless they are important supplements because they enable continuing appraisal of the whole data processing system.

A completely automatic data processing system for city planning problems is still far in the future, but the form one might take can be suggested. A simplified example of housing market analysis affords possibilities. Assuming that housing demand can be indicated adequately by vacancy rates derived from idle meter counts and that housing supply can be adequately indicated by building activity rates derived from issuance of building permits, the number of idle meters and the number of building permits could be recorded automatically and fed to an electronic computer which would find the totals of each, convert them by multiplication to supply and demand figures using statistically derived conversion factors, add the supply figure to previously existing inventory records, subtract the demand figure from the sum to arrive at a new inventory figure, compare the inventory figure to a set of criteria which indicate the best policies to adopt at various different levels of supply and demand, and print out a report of the final result plus any or all of the intermediate steps in this involved computation.

To record idle meters automatically for the planning agency's data processing system would require that a copy of electric power company records be made as a by-product of the original power company record. Such a record could be made in the form of punch cards, punch tapes or magnetic tapes, which ever could be adapted most easily to power company and planning agency data processing systems. Building permit approvals could be similarly recorded on tape or cards as the applicant's notice was typed. If both types of data were recorded on magnetic tape, the data could be radioed to a central computer at pre-arranged times similarly to the way space satellites radio their data back to earth. The computer would then process the data arithmetically and logically according to its pre-arranged program and issue the desired printed report which would be waiting for the city planner at a pre-arranged time. After setting up such a system, the city planner would need do no more in the way of housing market analysis than to read periodic computer reports and his time would be freed to devise policies to cope with the conditions indicated in the report.

An automatic data processing system as described above is not practical at the present time because the expense of radio transmission could not be justified and the theory of market analysis is not highly enough developed to permit idle meter and building permit data to be used with confidence as the sole indicators of the housing market. But by adding a few more easily recorded types of data and by transferring the data manually from the recorder to the computer, a data processing system almost as automatic as the one described is already practical.

Some automatic data recording is in use already. A recent article in the American City magazine describes a recording system used by Oakwood, Ohio. The operation of water pumps in the city water system, the operation of traffic lights and fire alarms, and the occurrence of police call-box check-ins, among other things, are all recorded by a single device called a time printer, which has a capacity large enough to record data from forty separate stations. The printer is "the end mechanism of an intricate system that provides an accurate and authentic printed record of all the electrical and mechanical functions the city must deliver to its 11,000 citizens at specific times."[13] Each time one of the stations being recorded operates, the printer records the station identification symbol, date, hour, and minute. This system is a good example of automatic data recording even though it does not record data for research and planning activities.

Just because the Oakwood example deals with electrical and mechanical services given by the city does not mean that other transactions cannot be recorded also. Accounting records are often made automatically as a by-product of issuing checks. This technique enables the United States Treasury to handle the accounting for one million government checks each day.[14] Inventory records can be automatically recorded as a by-product of processing invoices. Sales orders can be automatically prepared as a by-product of preparing ordinary paper copies for a salesman's files.[15] Airline reservations can be automatically recorded and tallied during the process of checking uncommitted seat space.[16] On the basis of experiences such as these, there appears to be no reason why records important to planning, such as the number of building permits issued and characteristics of the authorized buildings, could not be automatically recorded also.

Automatic recording of comprehensive business data has been proposed on a national scale, and the proposal has been worked out in enough detail to show that it is possible.[17] The proposal calls for recording the data mechanically at the point of origin. It would be recorded in standard units and standard codes, so that similar types of information from any number of business firms could be processed mechanically without any need for manual recopying. If such a procedure were ever adopted on a national basis, almost unlimited business data would be made available for automatic analysis by type of business, by state, by region, or by the county as a whole. The wealth of information made available in this way would be a boon to economic research. Benefits of similar magnitude could be expected in government research if transactions in governmen offices were to be automatically recorded.

Available Electronic Computers and Accessories

A steadily increasing number of electronic computers and accessories for them are available for rent or purchase. The three major types of electronic computer systems are large-scale, general purpose; medium-size, general purpose; and special purpose.

Large-scale, general purpose computers cost in the neighborhood of a million dollars and rent for $20, 000 to $50, 000 per month. They can handle large, complex problems at high speed but their size and speed are not needed for most city planning problems. The Sperry Rand Corporation and the International Business Machines Corporation are the leading producers of large-scale, general purpose computers.

Medium-size, general purpose computer systems are more numerous and less expensive, but smaller in capacity and slower in some operations. This group of computer systems is most likely to be applied to city planning problems. Computers in this group can perform mathematical, statistical, and logical operations. Prices of the medium-size computers run as high as several hundred thousand dollars with rents around $6,000 to $10,000 per month. Companies such as Sperry Rand, IBM, Electro-Data, Marchant Calculators, National Cash Register, Underwood, and Burroughs, among others, have medium-size, general purpose computers on the market. The Datatron medium-size computer, made by the Electro-Data Company, was used in the 1956 traffic analysis of Chicago.

Special purpose computer systems might be appropriate when there is no need to handle a variety of problems and when there is a requirement for a special capability such as, for instance, extra large memory capacity. For example, a special purpose computer could be used to compare applications for building permits with the requirements of a zoning ordinance. The computer would be designed especially for this task and would be suited only to this task, whereas if the task was assigned to a general purpose computer it would be only one of many tasks handled by the general purpose computer. The advantage of a special purpose computer is that it costs less and gives better performance in its special field than a general purpose computer. It costs less because it is less complicated, and it gives better performance because less compromises of design are required in it. Both of these advantages arise from the fact that the special purpose computer has only one job to do whereas the general purpose computer has many.

In addition to the computers themselves, computer systems have accessory input, output, and storage components. The medium-size computer known as the UNIVAC File Computer has "the ability to link as many as 24 input-output units, and as many as 10 magnetic [storage] drums, to the central processor . . . [enabling it to] reach any one of several hundred thousand short records in a fraction of a second."[18]

Translating devices are available to convert one form of input to another. The information on tape inputs can be transferred to punch cards and vice versa. FOSDIC, one of the most advanced devices of this sort in use, will be used in the 1960 census to convert microfilm copies of original hand written data sheets to recordings on magnetic tapes ready for analysis by computing machines.[19] Also available are typewriters which punch information on IBM cards or paper tapes as they are used to type ordinary material. Such devices are indispensable parts of automatic data processing systems because of their contributions to the rapid and smooth flow of information.

The introduction of electronic computer systems into a city planning agency presents many technical and administrative problems which can be solved only by detailed studies of actual city planning requirements and available equipment.

As the Modern Age proceeds, bringing huge metropolitan areas, automation, high labor costs, complex urban problems, and even more complex solutions to urban problems, the necessity for city planning agencies to use electronic computers will become more and more obvious. In Chapter II, it was mentioned that computers can be used to maintain inventory records and analyze market conditions as required by the central intelligence function of city planning. In this chapter the role of computers in maintaining the continuous flow of indices required by the pulse-taking function has been emphasized. In the following chapter the use of computers in helping to make decisions for the policy clarification function is described.

It is hard to say exactly what the role of electronic computers will be in the future of city planning because the application of computers to city planning problems is in the embryo stage. However, the evidence shows that the complexity of problems which can be handled by computers is rapidly becoming very great.[20] It can reasonably be expected that electronic computers will become a major tool of the planning profession in the not too distant future.

Summary

This chapter has emphasized the need for maintaining a continous recording of data in all fields involving vital planning decisions. To meet this need only the most useful series of data should be selected to be maintained, and it may be desirable in some cases to sample these data series instead of recording them completely. Otherwise, cost may become prohibitive. A number of economical sources of data were discussed briefly and the need for efficient systems of handling data was emphasized. Automatic data recorders and electronic computers seem to be indispensable aids in handling the tremendous quantities of data which are necessary to apprise adequately all the factors affecting planning in a medium or large size community.

CHAPTER IV

DECISION MAKING
(the Synthesis Function)

Laying the groundwork for establishing public policies is theoretically the major task of city planners. The central intelligence function of planning supplies information needed to propose policies and the pulse-taking function indicates when and where policy changes are needed, but these two functions alone do not lay sufficient groundwork for establishing new public policies. Therefore, Meyerson proposed a policy clarification function for planners.

The policy clarification function, as Meyerson sees it, is the function in which city planners take initiative in proposing suitable policy measures "to halt undesirable changes and promote desired ones in the community."[1] Acceptance or rejection of the policies is in the realm of political processes, but planners should be able to give politicians "detailed information on the advantages and disadvantages of alternative courses of action to achieve desired goals."[2] Here is where the concept of "decision makers" is useful.

Decision Makers

The concept of decision makers can be grasped most easily from a diagram like the following one.

Decision Maker

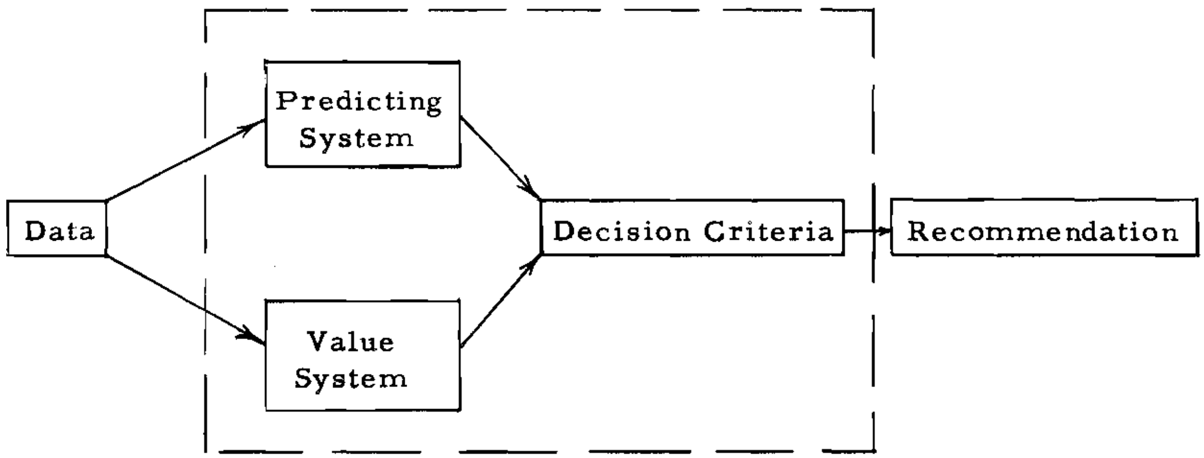

Fig. 6 Block Diagram of a Typical Decision Maker

Source: I. D. J. Bross, Design for Decision, New York: The Macmillan Company, 1953, p. 29.

This diagram of a decision maker represents nothing more than the functions which constitute the process of making decisions. The actual decision maker may be a person, a group of people, an electronic computer, or a combination of people and computers.

In the diagram the data block represents the information which describes the particular situation on which a decision must be made, and the recommendation block represents the final decision. Between the data and recommendation blocks there are three other blocks which represent three different kinds of information that can be used to supplement information from the data block before a final decision is arrived at. The predicting system represents a collection of information on relationships and trends, together with probabilities and levels of confidence. The value system represents a collection of judgments which can be used to assess the desirabilities of occurrences which are predicted from the trends and relationships found in the predicting system. The decision criteria block represents rules for choosing between outcomes. One simple example of such a rule is to choose the outcome with the highest desirability indicated by the value system.

The diagram is useful because it draws attention to the kinds of reasoning which take place in the process of making decisions and identifies the points at which subjective value judgments must be made. Whether the decision making process is carried out by people, by electronic computers, or by a combination, it is always wise to draw a decision maker diagram. The diagram can be drawn in detail to show how each step is carried out. This detailed diagram will help to reduce confusion about how decisions are made, and it will also help to point out the extent to which the decision is not founded on scientific analysis.

When a decision is to be made, pertinent data are given to the decision maker. The predicting system supplies a list of outcomes and their possibilities of occurring, while the value system supplies a list of desirabilities associated with each outcome. Then the data, outcomes, probabilities, and desirabilities are evaluated in terms of decision criteria to arrive at a recommended decision.

Electronic computers not only can be used in decision makers, but complex decisions demand the aid of computers. An electronic computer can analyze all the facts of a situation if the facts are known and if relationships between them are understood. Nevertheless, there are many situations in which all the facts and relationships are not known. Electronic computers cannot be expected to make valid decisions when the facts and relationships are not known. In such cases human judgment must be used, but it should be remembered that human judgment may not always make valid decisions in these cases either. Electronic computers, in effect, extend man's ability of the mind somewhat as a telescope extends man's visual ability. When need for a decison arises and the situation is too complex for the human mind to grasp unaided, an electronic computer may be able to give the assistance which is required.

The adaptability of electronic computers to decision makers is easy to see when the diagram of a typical decision maker (on page 86) is compared with the diagram of a typical data processing system (on page 55). The data processing diagram has been formulated largely as a result of work with electronic computers and the same is true of the decision maker diagram. In the decision maker diagram the data block corresponds to the input blocks in the processing diagram. Continuing the comparison, the predicting system, the value system, and the decision criteria in the decision maker diagram correspond to items in the storage block of the processing diagram. The recommendation block in the decision maker corresponds to the output of the data processor.

To illustrate how a decision maker works in a city planning context, the process of making decisions concerning land use can be described. A simplified description of decision making concerning land use in central Boston follows.[3] The data consisted of land areas, land uses, and the locations of the areas. In the predictive system, known economic relationships indicated that if economic market conditions were allowed to prevail there would be a high probability of the Beacon Hill and Boston Commons areas being used for expansion of the business district. On the other hand, colonial traditions in the value system indicated that the areas held great historical significance. Evaluation in terms of the decision criterion that historical sites should be preserved, even at the expense of economic pressures, yielded the decision to forestall business expansion into Beacon Hill and the Boston Commons.

Models

City planners, in their roles as advisors to public decision makers, are often in a position to use decision maker models as a means of developing proposed policies to be used under various different assumptions, conditions, and desires. Just as engineers and scientists build models of their designs before a large investment is made in the real thing, so that they can find out whether the designs will work all right, city planners can use decision maker models to test decisions before the real question is decided.

Models, as they are spoken of here, are symbolic substitutes for reality. They may be graphic, verbal, or mathematical. Models are used because they are economical and convenient for use in simulating real situations. In the decision making model it is easy to think in terms of changing the contents of the boxes in the block diagram. That is, different data can be substituted to describe new situations; different trends and relationships can be used to predict outcomes; different judgments can be used to assess desirabilities of outcomes; and different criteria can be used to choose between outcomes.

In the Boston case described above, for instance, the data could be changed to represent an area many miles from Beacon Hill. The predicting system could be adjusted to indicate greater or lesser probabilities of outcomes depending on the magnitude of economic pressures. The value system could be changed to place historical significance only on types of buildings different from those on Beacon Hill. And the decision criterion could be changed to favor economic development rather than protection of historical sites. Various contents might be tried in the decision maker model, resulting in various decisions, whereas in real life it would be impossible to experiment with all possibilities in a similar way.

Mathematical models.--Mathematical formulas are the most precise kinds of models normally used. The convenience of using mathematical formulas to solve problems, as an alternative to compiling tables of all possible answers, is well known in many fields of science. This convenience can be illustrated by considering Reilly's law. If the populations of two cities and the distance between them are known it is only necessary to put these values into the formula given by Reilly's law and do the simple computations indicated. In a few minutes the point between the two cities at which each city attracts retail trade with equal force is found. The alternative to this type of approach would be to conduct an interview or questionnaire survey of a sample of the people who live in the area between the two cities. Just constructing the questionnaire would take considerably longer than the whole process of using Reilly's law. The convenience of using formulas is often great.

Symbolic logic is an extention of mathematics which makes it possible to translate ordinary language more fully into mathematical language. Up to the present, symbolic logic has found practical application primarily in the field of electronic computer design, but it is expected that symbolic logic will extend the mathematical advantages of precise and convenient manipulation to widening circles of experience in the future.[4] Progress toward developing a universal scientific language, which would mean the same thing to everyone, has been prophesied for the future.[5] The advantages of such a language should be obvious. The universal scientific language would banish endless semantic arguments and confusions of words and ideas which obscure many public issues today. Further development of symbolic logic will have the effect of enabling models to be applied to the solution of greater numbers of problems.

Statistical models.--Since a certain amount of uncertainty exists in almost all, if not all, situations found in the world of experience, an effort must be made to express uncertainties as part of decision making models. A model in which uncertainties are expressed is called a statistical model. Mathematically, uncertainties are expressed as probabilities. Mathematical models become statistical models when they include probability expressions.

Measuring Social Values

Two major problems arise in the use of decison making models. The first is the problem of measuring social values, and the second is the problem of determining probabilities of occurrences. Consideration of determining probabilities of occurrences will be left to the next section of this chapter, while the measurement of social values is considered in this section.

Measuring social values is a problem especially when people whose social values are being measured do not consciously realize what their values are. The job is still more difficult when the people doing the measuring unconsciously let their own values influence the measures of other people's values. As yet there is no completely satisfactory way of measuring social values, but several techniques have been developed gradually to the point where they are useful even though not perfect.

Measurement is the process of evaluating something in relation to a standard. The standard may be nothing more than a subjective group of characteristics against which items are compared intuitively with no clear idea of what relationship one characteristic has to the others. On the other hand, measurement may consist of determining the value of a thing by comparing it with a continuum of values,* each related to the others in a very definite and precise way. As might be expected, subjective comparison of characteristics is a weak method of measurement in comparison with the usefulness of the continuum method.

A number of techniques of measurement have been used in many different situations. Best known and most highly developed are the methods of measurement used by the physical sciences. Measurements of distance, area, volume, and other characteristics of the physical world are familiar to almost everyone and useful to city planners in many ways. However, measurements of social values rather than physical values are the measurements to be treated in

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*A continuum of values is a standard which divides varying degrees of a single, continuous characteristic into discrete units representing increasing degrees of the characteristic.

this thesis because they are less well understood and less frequently used by city planners, notwithstanding the crucial role they play in decision making.

Ranking.--Several techniques have been developed by the social sciences for measuring social values. The simplest of these techniques is called ranking. Ranking is the process of placing items in some order by comparing each item with the others. The result is that with respect to some characteristic each item is assigned a position relative to all the other items. Ranking techniques are laborious and less useful than other measuring techniques, but in cases where standards of measurement are not available ranking techniques are useful and even allow "a fair amount of statistical treatment, including rank correlation."[7]

Rating.--Rating is a second technique of measurement. It is a process by which items can be assigned to a position on a continuum of values. The continuum of values is a standard which divides varying degrees of a single continuous characteristic into discrete units representing successively increasing degrees of the characteristic. The position of an item on a continuum represents the value of the item in terms of the characteristic measured by the continuum.

An example of a rating instrument is the APHA apprisal method for measuring the quality of housing.[8] Although this instrument measures types and sizes of dwellings, housing quality including water facilities, sanitary facilities, heating and lighting, general maintenance, nature of occupancy, and the surrounding physical environment rather than purely social factors, the APHA apprisal technique illustrates, very well, measurement by rating. The technique calls for inspection of housing and neighborhood conditions and specifies a system of giving penalty points for deficiencies in the several characteristics measured. Penalty scores are then added up and classified as follows to indicate quality of housing.

Graduation of Quality	Neighborhood Environmental Score	Housing Condition Score	Total Housing Score
A-Excellent to good	0-19	0-29	0-49
B-Acceptable	20-39	30-59	50-99
C-Questionable	40-59	60-89	100-149
D-Substandard	60-79	90-119	150-199
E-Unfit for habitation	80 & over	120 & over	200 & over

Fig. 7 Classifications of Rating Scheme for APHA Technique of Measuring Housing Quality

Source: F. S. Chapin, Jr., Urban Land Use Planning. New York: Harper and Brothers, 1957, p. 236.

The differences between ranking and rating are that rating makes it possible to compare items to an unchanging set of criteria rather than to other similar items, and the criteria define the characteristics of items in a much more specific way than do rank comparisons. Statistical treatment of ratings is more reliable than statistical treatment of rankings, but not as reliable as statistical treatment of scaled measurements which are described next.

Scaling.--Scaling is the third method of measureing social values. It is similar to rating except that the items are rated in such a way that the intervals between divisions on the continuum are all equal. Thus, the difference between scaling and rating is a technical difference only, rather than a difference in concept. Scaling is a refined form of rating. The basic concept behind both is comparison with and objective standard.

"By a scale in the strict sense is meant an instrument which is divided into a number of equal and equivalent units, with the zero point at that point where the amount of the quality under measurement may correctly be assumed to be zero."[9] Such an instrument has the advantage that measurements made with the use of it can be freely manipulated mathematically and statistically. Scales of this type are the ideal instruments for measuring social values. Since ranking and rating instruments are actually imperfect substitutes for scales, no distinction will be made between the techniques in the following discussion of constructing instruments for measuring social values.

Construction of scaling and rating instruments.--The construction of an instrument for the rating or scaling of social attitudes or social characteristics has many problems, but they are being gradually overcome. Technical literature in the social sciences includes long passages concerning criteria of scale construction, techniques for testing reliability and validity of scales, and efforts to assure equal units of measurement in scales. The most important criteria governing scale construction is the requirement that only logically related items should be combined into a scale and the relationship should have an explicit rationale.[10]

Realiability, meaning the ability of a scale to produce the same results every time it is applied to the same measurable item, is determined by any of a number of techniques such as the test-retest technique which simply consists of administering a test twice to the same population, or the multiple form technique in which two different forms of the same scale are administered separately to the same population, or the split half technique in which a single test is administered with alternate items considered as belonging to separate forms of the same scale. (Separate forms of the same scale would be made up of slightly different questions or perhaps the same questions phrased in different ways.) In all cases, reliability is determined by the degree to which the first and second measures agree.

Testing the validity of a scale relies upon knowledge of the characteristics being measured. Validity can be determined logically, by opinions of experts, by measuring known groups, or by comparing the scale measurement with measurements made using independent criteria (criteria other than those used in the scale itself).

Assuring equal units of measurement on the scale also requires knowledge of the characteristics being measured. If the end points of the continuum measured by the scale are definitely fixed, percentage units might be constructed. Otherwise a more arbitrary unit might be established such as a money value or simply a numerical quantity similar to the penalty point system in the APHA housing quality instrument. The mere attachment of numerical values to scale measurements does not assure that units of measurement are equal, but it helps to express the equality of units if it exists. Equality of units is a hard thing to achieve, but remembering that units of measure are arbitrary to begin with, they can be equalized gradually through familiarity with the phenomena being measured and comparisons with known units of measure. The passages in social science literature dealing with scoring and weighting techniques describe attempts to establish and express equal units of measure.

Constructing scaling and rating instruments is an extremely technical undertaking. Except in elementary applications of the rating and scaling concept, city planners should seek the help of social scientists when social values are to be measured.

Application of scaling and rating techniques.--Since index numbers indicate positions on a continuum of values, the indices mentioned in Chapter III are measuring instruments of either the rating or scaling types. However, the examples given are more in the realm of physical and economic measurement than in the realm of social measurement. The application of rating and scaling techniques to measurement of social values is best exemplified by attitude surveys.

The Detroit Area Study illustrates one use of attitude ratings in a context familiar to city planners. Among other attitudes, the 1956 survey gathered data on racial relations attitudes. One of the survey questions set up a hypothetical situation which was responded to by a sample of the white population of Detroit as indicated in the following paragraph.

> One day a six-year-old asks her mother if she can bring another girl home to play. The mother knows that the other girl is a Negro, and that her own daughter has only played with white children before. What should the mother do? (1) She should tell her daughter that she must never play with Negroes; (2) The daughter should be told that she may play with Negro children in school, but not at home; or (3) The Negro child should be permitted to come to the home.[11]

The three alternative answers set before the respondents were designed to measure degrees of prejudice. Presumably, permitting the Negro to come home would indicate lack of prejudice, while letting the children play only at school would indicate moderate prejudice, and refusing to let the daughter play with the Negro would indicate strong prejudice. These alternatives are characteristic of a rating continuum rather than a scale since it cannot be said that they indicate 0, 50, and 100 per cent prejudice as would be necessary to define a scale of prejudice in the strict sense. It can be seen, however, that the rating continuum gives a useful measurement of the prejudice whites feel against Negroes. Such a measurement could be used by city planners charged with the responsibility of recommending relocation plans in connection with urban renewal projects in Negro areas, to cite one example.

Scales have been developed in the late 1940's and early 1950's to measure characteristics of neighborhoods and other social areas.[12] They are composite scales made up of objective percentile indices. Percentile indices denote, as a percentage, the position of an item or occurrence in relation to the statistical distribution of all such items or occurrences. For example, the 90th percentile of educational status denotes the level of education which only 10 per cent of all people in the community have surpassed. The other 90 per cent of the people are at or below the 90 percentile level.

The first scale measured social rank by combining percentile indices of educational status, income, and occupational status. The second scale measured degree of urbanization by combining percentile indices of fertility, women in the labor force, and the density of housing. And the third scale measured segregation of racial groups by combining percentile indices of the ratio of size of minority groups in the social areas compared with the total size of the minority groups in the larger area being analyzed.

These measures could be used by city planners to indicate other characteristics of the measured neighborhoods if correlations could be established. Such values would be important for decision making in relation to the neighborhoods and the city as a whole.

Determining Probabilities of Occurrences

Even though measurements may indicate trends and social values there still remains uncertainty about future occurrences. Various predictions can be made on the basis of measurements. However, what is needed in addition to measurements is some way of expressing degrees of certainty about predictions.

Determining probabilities of occurrences is of key importance to decision making because, in effect, decision making is often a gamble in which the outcome of the decision is by no means certain. City planners, in their roles as both decision makers and advisors to decision makers, are successful in so far as the decisions they are involved with result in outcomes favorable to the public. These decisions will have favorable results most often when they are made in accordance with the best chances for favorable outcomes. To answer questions about confidence in predictions, the mathematics of probability has been developed.

Predictions.--Before probability theory is discussed, a few methods of prediction should be described. Persistence, trajectory, cyclic, associative, and analogue techniques of prediction are common. Persistence prediction simply holds that there will be no change, and the future occurrence is predicted to be the same as the present occurrence. Trajectory prediction assumes a trend in which no change is foreseen. The trend is assumed to continue and alter future occurrences by successive increments. Cyclic prediction foretells future occurrences in accordance with a repeating cycle of events. All three of these prediction techniques are simple extensions of past and present occurrences.

Associative prediction differs in that it foretells the occurrence of one type of event by extending records of another associated type of event. For example, the total amount of retail selling space needed in a community could be predicted to rise if the population were to rise. In other words, associative prediction is based on records of indices rather than on direct measurements of the phenomena to be predicted. In the example given, population is an index of retail selling space. Prediction which takes into account causes of change is associative prediction. Covariance and causation may both be used for making predictions.

Analogue prediction foretells events by analogy. Mathematical analogy is the preferred type. Notice that analogue prediction depends heavily on models, defined earlier in the chapter as symbolic substitutes for reality. As well as symbolic models, real situations might also be used profitably as in the case of predicting a city's population by comparing its growth to a similar growth period in the history of another city of a similar type. Nevertheless, there are great difficulties with using real situations for analogy. Thus, mathematical and statistical models may be better suited to analogue prediction in many cases.

Multiple correlation equations avoid the disadvantages of using real situations for analogy. Several different causes of the occurrence which is to be predicted can be isolated and related to the occurrence with the aid of partial correlation analysis. Then which ever of the causes is found to be influencing the occurrence in a particular case can be combined, selectively, into a multiple correlation equation which can be used to make the prediction. Using real situations it is often impossible to find the same set of causes operating to influence an occurrence in both a past situation and a present situation for which a future prediction is to be made.

Probability theory.--Having briefly reviewed prediction techniques, the next subject to consider is probability theory. There are two types of probability, equal chance probability (such as the enactment of an ordinance when forces for it and against it are evenly divided) and unequal chance probability (such as the enactment for an ordinance which is favored by the political party with the most votes). When no evidence can be found that one outcome is any more likely than another, the outcomes are expressed with equal chance probabilities of occurrence. In this case, the probabilities of these outcomes are equal. On the other hand, if there is evidence to show that one outcome is more likely than another, the outcomes are expressed with unequal chance probabilities showing the relatively greater or lesser chances of occurrence. If one outcome has a twenty-five per cent chance of occurring and another outcome is twice as probable, the probability of occurrence for the second outcome is fifty per cent.

Probabilities are ratios in which the number of outcomes for which probability is being expressed is compared with the total number of cases in which there is a chance of this particular outcome occurring. Stated as a formula,

$$\text{Probability of outcome} = \frac{\text{Number of occurrences of outcome}}{\text{Total number of cases}}$$

Probabilities are usually expressed in the form of decimal numbers, or they may be expressed as a percentage chance (i.e., there is a 95 per cent chance of a certain outcome). Just as percentages add up to 100 for the total number of cases, the sum of decimal probabilities of all possible outcomes is equal to one.

In complex situations probabilities can be combined. For instance, if two independent outcomes are possible, the probability that one or the other will occur is the sum of the probabilities of each occurrence separately. In the case of flipping a coin, the probability of one or the other is 1/2 + 1/2 or one. On the other hand, the probability of both occurring is the product of the separate probabilities. Flipping a coin twice, the probability of heads appearing both times is 1/2 x 1/2 or 1/4. Other manipulations of probabilities are possible, but the details of probability theory cannot be gone into in this thesis. The point made here is only that probability theory is a useful mathematical tool for expressing degrees of certainty or uncertainty.

Probabilities can be used in two ways. First, they can be used with statistical tests to establish degrees of confidence in comparisons among data series designed to show the presence or absence of random (equal chance) variations. And second, probabilities can be used to express, directly, the chance of a prediction being true. Actually these two ways of using probabilities both amount to the same thing because they are both expressions of confidence in a prediction. The distinction meant to be made here is that probabilities may be used as a theoretical tool of research and also as part of a useful mathematical model developed by research. Mathematical models of decision makers cannot be constructed without the use of probability theory.

Social Control

An additional factor to consider in the construction and use of decision makers is social control. Many different types of social control are in operation or available for use. Social controls can be thought of in two major categories. The first category is natural; the second is formal.

Natural social controls are what sociologists would call folkways. They amount to unwritten agreements of custom or social pressures toward conformity. As such they would probably appear as part of the value system of the decision maker after being measured on some sort of scale. For instance, the Detroit Area Study measured the folkways of prejudice using an attitude rating scale. These measurements of prejudice indicated the value placed upon racial segregation by white people in Detroit. If any kind of significant change in the makeup of folkways could be seen taking place so as to influence decisions within the period of prediction, it would be appropriate to inject such changes into the predicting system. The value system of a decision maker only holds constants.

Other natural controls on society, such as economic forces, are similar to natural social controls in that they operate spontaneously. They should be taken into account in the decision maker in a way similar to the way natural social controls are taken into account.

Formal social controls are laws. They are officially sanctioned and enforced by government. Trends of development can be detected in laws. Laws, trends of law, and innovations in law should take their proper places in the decision makers as constant social values if they are unchanging or as prediction trends if they show signs of change.

When populations grow in size and density formal social controls become more important. Given certain conditions, it may be impossible to achieve desired results without formal controls. This is well illustrated in city planning history. Prior to this century, in which the United States has changed from a rural country to an urban one, formal planning controls were of minor importance. Such controls as were in effect were nuisance controls to protect neighbor from neighbor and very little was available in the way of controls to enable governments to carry out comprehensive programs of city improvement. Zoning, subdivision regulation, and official map powers have all developed, primarily in this century, in response to haphazard city expansion and uncontrolled city decay. Any decision maker which fails to take into account formal social controls will not meet present day demands.

Presenting Facts and Alternatives

The purpose of a decision maker used by city planners is not to reach the final best answer, but, rather, to act as a model for analysis of alternatives. Notwithstanding the fact that city planners have traditionally acknowledged that their task should be to present alternatives, they seldom followed the acknowledgment with alternative plans. In most cases city planners have had neither the time nor resources to make more than one plan. The time has come to think in terms of actually preparing alternative proposals.

As mathematical models, measuring techniques, and automatic data processing systems gain wider use, alternative planning proposals can be made more readily. It is now becoming possible for city planners to realistically strive for their ideal of presenting facts and alternatives in the best tradition of performing a staff service.

The Final Analysis

Final decisons of how a city should develop are properly left to the public, acting through their political representatives. But city planners can influence final decisions by presenting facts and alternatives in an objective way. Planners have the opportunity to inject rational thinking into political processes by making available expert research and synthesis of facts and ideas. It is in this way that city planners have most to offer in the process of planning for the public good.

CHAPTER V

DETAILED PROBLEM SOLVING

Once the major policy decisions have been made, the task of the city planner narrows to the design of definite projects for implementing those policies, and the detailed solution of specific problems comes into primary importance. This is the planning function which leads directly to action. Long-range plans which were adopted as an expression of major policy decisions are, at this point, translated into short-range plans calling for specific action in the near future. This chapter is primarily concerned with methods which can be used to solve the specific problems that must be solved in the course of making specific, short-range plans.

The detailed development plan function which Meyerson describes would serve as a "compromise between immediate problems and future expectations which will permit coherent policy effectuation. This type of plan preparation will require detailed, timed and localized programming of governmental policies for private as well as public actions. Detailed cost estimates of private as well as public development, and specific administrative and legal measures to carry out the programs will have to be worked out."[1] These short-range plans would cover a period of five to ten years and would be revised each year to "indicate the specific changes in land use programmed each year, the rate of new growth, the public facilities to be built, the structures to be removed, the private investment required, the extent and sources of public funds to be raised, the tax and other incentives to encourage private behavior requisite to the plan."[2]

Thinking of designs for development as specific, short-range plans for implementing policy, the problem is well defined and the question becomes how to solve it.

How to solve it.--In 1629 a mathematician and philosopher by the name of Rene Descartes, who incidentally was the inventor of analytic geometry, wrote a treatise called Rules for the Direction of the Mind[3] in which it was his intention to give a universal method to solve problems. This treatise is one of the most successful early attempts to build a system of heuristic. Heuristic is simply the study of methods and rules of discovery and invention. It overlaps the fields of logic, philosophy, and psychology. As a unique field of study, heuristic has not gained much prominence or application in the modern world even though it is the basis for scientific reasoning. Modern heuristic does exist however.

In 1951 Rudolf Flesch contributed a popularized version of heuristic in his book by the title of The Art of Clear Thinking.[4] Previously in 1945, G. Polya introduced a somewhat more technical book called How to Solve It. Since then Polya has contributed two other volumes and a second edition of How to Solve It.[5] It is Polya's intention to revive the study of heuristic and present a modern heuristic seeking to develop "a better understanding of the mental operations typically useful in solving problems."[6]

Since heuristic is a basis for scientific thought and problem solving, it is appropriate to present a brief summary of heuristic principles at this point in the thesis.

To begin the summary, here is a list of major points from The Art of Clear Thinking. They are presented first because they are broader in scope and more fundamental than are the major points of How to Solve It.

1. Thinking is manipulation of memories.

2. Discovery is the result of using memory to see new situations in different ways.

3. Classification of items or possibilities is a powerful tool with which to seek discovery.

4. Discovery may result from accident and hunch. The accidental clue is recognized by a receptive mind, while the hunch becomes evident from a study of facts.

5. The ability to solve problems is the ability to spot the key factor in a confusing situation even though the key may be hard to distinguish from the background it is against. In other words, to solve a problem, look for the key in seemingly irrelevant factors of a situation and seek to associate the key with a meaningful, but perhaps seemingly unsuitable, memory.

In addition to these five major points, Rudolf Flesch offers fourteen tips to improve thinking. They are worth repeating here as a transition from the preceeding list to a summary of How to Solve It.

1. Write the problem down.
2. Translate the problem into plain English.
3. If possible, translate the problem into figures, mathematical symbols or graphs.
4. Don't rely on your memory but use written or printed sources.
5. Know how to use a library.
6. Take notes and keep files.
7. Discuss the problem with others.
8. Use a check list of categories, adding new ones from time to time.
9. Try turning the problem upside down.
10. Don't be afraid of the ridiculous.
11. If you feel frustrated, don't worry. Relax; turn to other work; rest; sleep.
12. Take time to be by yourself. Free yourself of trivial work. Shut out interruption.
13. Know the time of day when your mind works best and arrange your schedule accordingly.
14. When you get an idea, write it down.[7]

There is not space to explain the validity of Flesch's list of tips or the validity of his five major points. Even if there were it would be superfluous to do so because it has already been done in The Art of Clear Thinking.

Turning now to G. Polya it should be said that the emphasis in How to Solve It is placed on examples of the technique of problem solving. Explanations of why these techniques work are hardly considered. It is for this reason that How to Solve It and The Art of Clear Thinking should be read together.

The importance of How to Solve It is that it proposes a series of questions which can be used to stimulate a person into reaching a solution to his problem. The questions are asked for four purposes. The first questions are asked in the interest of producing an understanding of the problem. The next group of questions is asked in the interest of devising a plan to solve the problem. The third group of questions monitor the carrying out of the plan. And the last group of questions checks the correctness of the solution, assesses the usefulness of the solution, and strengthens the imprint of the solution on the useful experience of the problem solver. The questions follow.

Understanding the Problem

1. What is the unknown?
2. What are the data?
3. What are the conditions?
   (What restrictions must the solution reckon with?)
4. Is it possible to satisfy the conditions?
5. Are the conditions sufficient to determine the unknown?
6. Are the conditions redundant?
7. Are the conditions condradictory?

Devising a Plan of Solution

1. Do you know a related problem or an analogous problem which has been solved before?

2. Do you know a problem having the same or a similar unknown?

3. Can you use its result or its method for the problem at hand?

4. Can you introduce some auxiliary idea in order to make its use possible?

5. Can you restate the problem?

6. Can you restate the problem as a more special problem, a more general problem, or a more accessible problem?

7. If you cannot solve the problem right away, can you solve part of the problem?

8. Can you solve a related problem?

9. Did you use all the data?

10. Can you think of other data which could be used to determine the unknown?

11. Did you use the whole condition (all the restrictions)?

12. Can you separate parts of the problem?

13. If you keep only a part of the condition and drop the other part, how far is the unknown determined?

14. Can you change the unknown or the data, or both if necessary, so that the new unknown and the new data are nearer to each other?

15. Have you taken into account all essential notions involved in the problem?

Carrying Out the Plan of Solution

1. Can you see clearly that each step is correct?

2. Can you prove that each step is correct?

Looking Back

1. Can you check the result?

2. Can you check the argument?

3. Can you derive the result differently?

4. Can you see the result at a glance? (Is it obvious to you?)

5. Can you use the result or method for solving some other problem?

For the careful problem solver who studies his problem with patience, devising a plan of solution is likely to be the crucial step. It is in this step of problem solving that thinking, as Flesch defines it, takes place in its most creative form. All the questions in the second group are asked with the purpose of creating association between the current problem and memories. Going back to The Art of Clear Thinking, it is found that the definition of thinking is "manipulation of memories" which enables new situations to be seen in different ways. Problem solving is dependent on discoveries resulting from this kind of thinking.

Memories, which are so vitally important to finding solutions for problems, can be thought of as additional data. Memories are a collection of facts or impressions taken from experience more or less at random. Certain memories may reenforce others or, in other cases, detract from them. Memories can be grouped together and related to each other. What is suggested here is that memories can be treated statistically. Statistics are a kind of memory. This suggestion is treated in more detail in the following section.

Statistics as a basis for design.--The importance of statistics as a basis for designing specific plans lies in the fact that probabilities and mathematical constants are developed through use of statistics. In other words, measurements are statistically determined. Since the design of specific plans depends upon measurements of past experience and available resources, the importance of statistics to design is great.

All engineers recognize the importance of mathematical constants and they normally allow for probabilities of error by using safety factors. Engineering handbooks supply engineers with list after list of typical safety factors and mathematical constants which they might need to apply in the course of their work. In the field of traffic engineering, for instance, statistics are available which give capacities per hour on various different types of roadways and along with capacities correction factors are supplied for conditions such as width of lane, types of vehicles in the traffic, intersection controls, percent of turning traffic, speeds of traffic, and others.[8] These traffic statistics are examples of mathematical constants which can be applied to specific situations.

Structural engineering gives a good example of the use of safety factors. Normally a structure is designed by computing the forces which produce stresses and strains in the building materials, multiplying the forces by a safety factor of 1.5, 2, 5 or whatever has been found desirable, and then specifying building materials and methods which will withstand the stresses and strains computed with the desirable safety factor. Even if the assumptions made in computing forces in the structure were not absolutely correct, use of the safety factor increases the probability that the structure will withstand the forces to which it is subjected after it is built. Thus, unforseen forces will not likely be large enough to destroy the structure.

A series of mathematical constants and of correction factors is urgently needed for application to city planning problems. Without them each problem will have to be handled in each city as a brand new research problem. Needless to say, separate research on each problem is inefficient and likely to give poor results because adequate attention cannot be given to each problem on this separate basis.

Some progress is being made toward developing statistical tables which city planners can use. Two major contributions come to mind immediately. The first is Harland Bartholomew's compilation of land uses in American cities, in which an effort was made to give percentages of land in various types of land use by types of city.[9] The second major statistical contribution to city planning was recently issued under the sponsorship of the American Institute of Planners and the Federal Reserve Bank of Boston. It is a compilation of municipal costs and revenues resulting from community growth in small to medium sized New England communities.[10] More tables of this sort need to be developed and put into circulation so that the maximum amount of design material will be conveniently available to city planners. A city planning handbook which would be kept up-to-date periodically is needed to fulfill this need.

City planning handbook.--A city planning handbook would be a book in which all tables containing information applicable to general city planning problems could be displayed. This, in itself, would be worthwhile because at the present time important tabular information is widely scattered in any number of publications, some of which are relatively well known and some of which are obscure. The tabulations of land use and municipal costs and revenues, cited above, are among the well known, as are census publications and tabulations in the reports of the Planning Advisory Service. In contrast, many valuable tabulations appear only in publications of individual cities and are consequently unavailable to a large extent. Until these latter tabulations are assembled and averaged with others from similar communities, they will not have wide use outside the areas for which they were developed. The editors of a city planning handbook would be in a perfect position to consolidate data, which are largely going to waste today, into important tabulations useful to city planners all over the country.

Beyond tabular presentations, a city planning handbook should contain formulas and standards in all branches of planning. An example of formulas which might be included is the one expressing Reilly's law of retail gravitation, described in Chapter II (see pp. 27-28). There are many examples of standards which should be included; for instance, there are subdivision standards and National Recreation Association standards which planners use a great deal. To bring these formulas and standards together into a city planning handbook would greatly simplify many parts of the job of city planners.

Another type of information which should be included in a city planning handbook is a group of generalized outlines for the major types of city planning studies.

A city planning handbook including tables, formulas and standards, and study outlines would go a long way toward satisfying questions of how to solve it. It would efficiently refresh memories, give methods of solving typical problems, give reliable information, and provide check lists for basic studies. These are all aids to the art of clear thinking.

Design decisions.--As mentioned at the beginning of this chapter, the design stage of planning in which specific short-range plans of action are made, is a stage in which the major purpose is to fit active city development to long range goals. Often this leads to the need for compromise. The design stage is primarily technical rather than political.

but when significantly important compromises in design are called for and there are acceptable alternatives, a public decision is in order. Major shifts in public opinion, economic conditions, and design standards are each likely to lead to the need for new public decisions. In city planning, standards from a handbook may never be flexible enough to apply directly to each local situation. Design standards are helpful and they should be used by city planners, but in many cases they will have to be adjusted to the particular community in which they are used.

In effect, design standards give to a city planner the solution to a related problem. It reamins for the planner to ask himself how he can use the solved problem to help in solving the unsolved problem. If he still cannot solve the problem at hand, he might ask himself how he might change the problem in order to arrive at a solution. In this way he will develop alternatives, and in so doing he may raise policy questions which will need to be decided in the political structure of government.

What is illustrated here, by the question of how to adapt detailed activities in a city to long range policy goals, is a constantly changing process of interdependent occurrences. In acting upon itself, the process of city development exhibits what has come to be known as feedback. Feedback is the subject of the following chapter.

CHAPTER VI

REAPPRAISAL

The feedback review function Meyerson suggests describes "the planning agency as analyzer of the consequences of program and project activities in order to guide future action."[1] Unintended as well as intended consequences are to be appraised. ". . . questions must be asked and answered so that we can learn from our experience and can adjust our future programming and planning."[2]

"The more such a review function is performed, the more easily it can be performed. As a body of review knowledge is built up [as for example] on the parking effects of highways, on the use made of playgrounds, on whether public housing and redevelopment projects achieve their objectives, on the impact of off-street loading ordinances, the more simply can new measures be gauged."[3]

Before going further, it is appropriate to consider the basic concept of feedback.

Feedback.--Feedback is the term used to refer to the process which makes two or more things mutually interdependent. If feedback is operating, each of the two or more things is both cause and effect. The effect on one thing caused by another becomes the cause of change in the other, and so on. The distinguishing characteristic of feedback in a system is the presence of a closed loop in which information is circulated from one part to another, enabling self-excitatory behavior in the system. A typical feedback loop is illustrated in the following diagram of an ordinary heating system for a building.

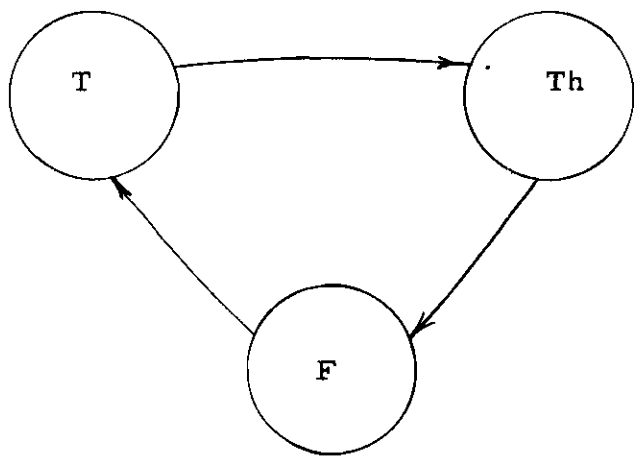

Fig. 8 Diagram of a Typical Feedback Loop

Source: The Editors of Scientific American, Automatic Control. New York: Simon and Schuster, 1955, p. 12.

The room temperature (T) causes the thermostat (Th) to regulate the furnace (F) and the regulated furnace causes a change in the room temperature. This is a constantly adjusting system of cause and effect which is self-regulating.

The great advantage of feedback control is that it is actuated directly by the quantity to be controlled, "and it corrects indiscriminately for all kinds of disturbance. Thus, detailed theory of all possible conditions affecting the quantity to be controlled, and predictions of when each condition will occur, is not needed. This greatly simplifies the control system and avoids the gross errors which might occur and go unnoticed in a control system without feedback.

Feedback control has one disadvantage which can range anywhere from being negligable to being ruinous. There must always be some error in feedback control because it is the error which is depended upon to bring about the correction. The smaller the error allowed, the more accurate will be the feedback control.

There are three major requirements which must be met in order to enable successful feedback control. First, there must be a means of effecting changes needed to maintain control. In other words, there must be a capable regulating organ of some sort. Second, the quantity to be controlled must be measurable and there must be some sort of device for measuring it. "Third, both regulation and measurement must be rapid enough for the job in hand."[4]

Nothing further needs to be said, at this point, about the first two requirements, but the third requirement needs some explanation. The speed with which feedback control operates is important because too slow regulation and measurement let errors become large and overcorrection results, leading to increasing oscillation in the control process rather than to settling down. When oscillations grow, control is lost and errors become so large that the control system becomes useless.

The key to progress in feedback control has been in finding ways to prevent oscillation. Three ways to reduce oscillation are to reduce time lag by:

(1) increasing the speed of transmitting the feedback signals,

(2) introducing a time-lead, anticipating the time-lag,

and

(3) introducing other feedbacks, besides the main one, designed so as to reduce time-lag.

"Modern achievements in automatic control are based on the use of combinations of such devices to obtain both accuracy and stability."[5]

A great deal of progress has been made in recent years toward understanding feedback and toward producing machines capable of controlling themselves. The increasing use of electronic computers and the advent of automatic factories indicates this progress in bold terms. These particular applications of automatic feedback control, however, are not the only use of the feedback concept important to city planning. Semi-automatic applications of the feedback concept will also be useful. Since an understanding of telemetering is needed to further explain feedback control and its semi-automatic applications, this important link in feedback systems is described in the following section.

Telemetering.--The term telemetering refers to "the practice of remote measurement."[6] That is, the thing being measured is some distance away from the point at which the measurements are recorded for use. The telemetering system includes the measuring device, a transmitting device, and a registering device.

When feedback systems use information or measurements which are made at one point but registered at another point some distance away, they are using telemeter links. In a semi-automatic feedback system, the telemeter link may be all that is automatic. After the desired measurements are made, transmitted, and registered, the feedback loop may be closed only by the action of a human being. In the heating system example, a semi-automatic feedback loop would operate as follows. The room temperature would be measured by the thermostat and the thermostat would register the measurement by turning on a light in the furnace room. At this point the janitor would take over, operating the furnace to raise room temperature while the light was on and withhold heat while the light was off.

A more realistic example is given in the case of the automatic data recording system used by Oakwood, Ohio (see pp. 78-79). One type of data recorded is police call-box check-ins. So long as routine check-ins are made at regular intervals no action is taken. But if the policeman on the beat misses a check-in, an investigation is started to determine the trouble. After the cause of the missed check-in is eliminated, routine check-ins are again made at regular intervals.

The most familiar example of telemetering is probably the telemetering of test rockets in the weapons and satellite development programs of the United States and Russia. These rockets are instrumented with devices to send back huge volumes of data concerning how the rockets perform and what condtions they find in their paths. Because of the telemetering instruments, even rockets which do not complete their planned flights produce valuable information. The information gained through rocket telemetering is used to improve rocket design, though this process is not automatic. This is why even rockets which do not complete their planned flights are not considered failures.

The unique trait of telemetering is that it enables otherwise inaccessable data to be gathered. To gain this benefit, however, requires forethought. Telemetering must be built into the thing to be measured so that a more or less continuous set of measurements can be derived over the whole history of that which is measured. This requirement for forethought in telemetering is a critical idea which needs to be taken seriously in city planning.

City planners should instrument activities for which they have responsibilities and interests. By making provision to measure these activities as they take place, the activites will have research value no matter how they affect the city. This concept is all the more important because of the difficulty, even impossibility, of carrying out controlled laboratory experiments in city planning like those often possible in the physical sciences. The social effects of city planning innovations are so great that every effort should be made to gain maximum knowledge from each one.

The record control system for housing law enforcement reported, in Baltimore, is an excellent example of how city activities can be designed for continuous measurement from start to finish (see pp. 75-76). Other demonstration grant projects sponsored by the Housing and Home Finance Agency in connection with urban renewal programs encourage activities to be assessed at every step. These programs are by no means small in importance.

The reappraisal function of city planning is a function in which all the other functions are combined, and consequently it will very often lead to change in the original plans. Thus, there is a need for flexible plans.

The need for flexible plans.--Only in simple and unchanging situations are single decisions adequate.[7] Most situations are either complex, so that there is uncertainty about what the best decision is, or they are changing, so that what is the best decision at one time may not be best at a later time. Thus, there is usually reason to make a sequence of decisions depending on new conditions and results of previous decisions.

By definition a plan which is not flexible is hard to change. If a plan cannot change to keep step with new decisions which become necessary, there will be conflict between plan and decision and one will damage the other. Either the plan will force inferior activities upon the city or it will become ineffective and brand the planning program as a waste of time.

A certain amount of stability in plans is needed because it is hard for a city and its people to adjust to a long series of rapid changes. In fact, one of the major tasks of city planning is to stabilize changes so that they take place at a rate which can be adjusted to without hardship. Only if city planning manages to stabilize the city's development in this manner will it gain public favor and support. From this the principle arises that plans and decisions should be changed only when a major benefit will result. If little is to be gained by the change it may not be worth the disruption it will cause. Benefits to be gained from a change should always be weighed against the disadvantages of change.

The advantage of flexible plans is that small changes and changes which are normally expected to occur do not disrupt them. Commitments should not be made unnecessarily and details should not be added to plans until they are necessary to achieve the goals of the plan. If commitments and details are adopted before necessary, plans become rigid and are laid open to reversal. However, whenever a real need for decisions and establishing firm plans can be demonstrated there should be no hesitation.

Carrying out a program in phases is a frequently used method of keeping plans flexible. Properly used, it is analogous to the pilot project concept often used by scientists. All the details of the first stage of a project are worked out with great care and the first stage is put into operation. Meanwhile, however, plans for later stages of the project are kept tentative in so far as possible. The later stages are detailed only after experience from the pilot project becomes available. The pilot project concept "accepts the fact which has been documented thousands of times in scientific research--that no amount of intuition, native talent, or systematic thought will substitute for the careful recording, tabulating, and analysis of the research facts. These facts must be obtained before the final investment of much time, money, and energy in a full-scale project."[8] Generally speaking, a program can be carried out most smoothly and economically if it is done in phases, using the pilot project concept.

In summary, several advantages of flexible plans can be listed.

1. They reduce conflict between plan and action.
2. They help create a feeling of confidence in plans.
3. They keep plans realistic.
4. They allow the best solutions to be found and applied smoothly and economically.

The reappraisal function of city planning is the last of the five functions recommended by Meyerson to enable city planning to become more effective. Consequently at this point in the thesis, consideration of planning functions is completed. Beyond this point there remain to be said a few words about organization of planning staffs. The following chapter contains a few notes on organization, followed by a few brief conclusions and recommendations.

CHAPTER VII

NOTES, CONCLUSIONS, AND RECOMMENDATIONS

In preceeding chapters selected scientific concepts have been described within the framework of five city planning functions: (1) survey and analysis of data, (2) maintaining a continuous reporting of selected critical series of data, (3) clarifying policies on which plans are to be based, (4) making detailed plans to implement policies, and (5) evaluating the effectiveness and desirability of results emerging from the planning program. An effort was made to show how the selected concepts may be applied to the five functions.

Scientific concepts can actually be applied to the planning functions only by an active planning agency. Thus, the question arises: how should planning agencies be organized to apply scientific concepts effectively? Following are a few thoughts on the subject of organization.

Notes on Planning Organization

In the context of this thesis urban research and city planning are inseparable. Though all research and planning in a city will not be done in a single agency, it makes sense to centralize the basic responsibility for all research and planning in one agency.[1] "The principal duties of such an agency would be to serve as a clearing-house for municipal investigations, plans, and information; to assist the chief administrator in the correlation and integration of the studies and plans of the various municipal departments and agencies; to conduct certain research and planning activities which cannot be assigned to the regular city departments; and to provide advice and assistance to the departments in their regular research and planning work."[2]

An agency in a position to operate in a city as just described is a true staff agency. It would be the "right hand man" of the city's chief executive. Its position would be favorable to effective research and planning activites on a broad scale.

Considering the staff function of research and planning to be operations research, clues of effective organization can be expected to come from experiences of existing operations research agencies, especially those serving governmental clients.

Three conditions need to exist in order for operations research to be productive.[3] The first condition requires detachment of operations research personnel from direct responsibility for the operation under study. It has been found essential to protect operations research personnel from the harassment of operational responsibilites in order for them to be able to study problems scientifically and impersonally.

The second condition is that operations research personnel must be given sufficient time for research. This is another reason to separate operations research from operating responsibilities.

The third condition needed for operations research is that operations research personnel must have the confidence of the executive who has the responsibility for the decision. Confidence of the executive is essential because only through that confidence can operations be applied.

It is evident that operations research groups should be attached to a high echelon of management. The ideal situation would be, of course, to establish the operations research group as a staff arm of the chief executive reporting directly to him. This is not absolutely necessary however. Experience with existing operations research organizations has proved that the operations research group can work effectively either as an integral part of the agency it works for or as an outsider, working through contract.[4] Of course, in either case the operations research group must have contact with upper echelon management.

In addition to upper echelon contacts, operations research workers must have contacts at lower echelons where data are to be gathered. It has been found necessary for the operations research worker to become familiar at first hand with operations involved in his research and he must get close enough to the action to be able to help formulate the problem as well as to work on its solution.[5] By taking an advisory role reporting directly to immediate operating management at the level of investigation as well as reporting to upper echelons, operations researchers gain the confidence of operating personnel and enjoy their cooperation.

Internally, operations research requires the use of a mixed team type of organization in which various specialists complement each other to reach a balanced solution to their problem. Operations research typically requires so many different specialists from time to time that most permanent staffs are not large enough to supply all the specialists. Consequently operations research groups use consultants freely as members of their mixed teams.

Three implications of operations research experience for city planning organization can be pointed out here.

(1) City planning studies should be reported directly to the city's chief administrator. Whether this reporting is accomplished through direct organizational channels, contract agreements, or informal arrangements would seem, from operations research examples, to make little difference. It is not so important whether the city planning agency has departmental status within the government or whether it is a separate commission as long as the city's chief administrator is kept in close contact.

(2) The city planning agency should respect operating departments of the city and not make them feel as though the planning agency is about to sabotage them. Work done by the planning agency which will affect a city department should be reported to the affected department(s) as the work is being done. It may even be good policy to loan

planners from the planning agency to operating departments when special research and planning jobs need to be done within the departments.[6]

(3) The city planning agency should use specialists whenever and of whatever type required by the projects undertaken. Sometimes the specialists will be available within the agency itself. Other times specialists from the various city departments might be used. When these two sources fail, the required specialists can be acquired by contract as consultants. Specialists should be used as members of a team. They should not be permitted merely to attack a problem from their own point of view and turn out their own separate reports. Instead, they should be required to work, with the whole group of specialists, toward a combined solution to the problem.

Beyond these three principles, generalizations about city planning organization are hard to make. Because city planning and research work is done largely project by project, organizational changes within the planning and research agency are likely to become necessary at relatively frequent intervals. For this reason rigid internal organization probably cannot be made to work well. The best way to keep an organization effective, while at the same time keeping it flexible, is to keep it small enough so that informal relationships will afford adequate control. Smallness in an agency also has the advantage that proportionately less time will have to be spent on internal administrative matters. Thus, to the three principles discussed above, a fourth and last might be added: it is best to keep a research and planning agency relatively small, possibly even to the point of depending on consulting specialists to a considerable extent.[7]

Conclusion

The fact that city planning is, at least in part, an applied science means that it is concerned with solving problems. Results are paramount. Consequently the methods used and the fields of knowledge drawn upon depend on what the problems require. Any method or field of study capable of offering aid to the problem solving city planner should be exploited to the fullest extent possible. A number of concepts, developed in the fields of physical and social sciences, mathematics and statistics, have been described in this thesis in an effort to bring them to the attention of city planners. In so far as possible, specific applications of the concepts have been indicated. It should be realized, however, that these concepts have not been widely used in city planning applications up to the present time. Therefore, it is hard to say in just what form these applications will be made.

The inescapable conclusion of this thesis is that in the future city planners can expect scientific concepts to play a growing role in their programs of research and planning.

Recommendations

I. Use scientifically trained planners.--It is recommended that people with scientific training should be encouraged to become city planners or at least to work for city planning agencies. As a corollary, it is recommended that the education of city planners should include the fundamentals of scientific thought. City planners will need to be able to work with scientists in order to take advantage of what science has to offer. For this they will need an understanding of science. The world of today is a scientific world and the world of tomorrow will be more scientific. City planners cannot be expected to be leaders in a scientific world without being familiar with the basis of that world.

II. Use the team approach.--There is much to be gained by applying scientific concepts to city planning though it is not always obvious just exactly how the concepts can best be applied. The team approach will be required to furnish the needed amount of specialized knowledge.

This thesis has sought to give city planners enough information about scientific concepts and techniques so that they will be able to recognize when it is appropriate to use scientific specialists to help them solve their problems.

The experience of operations research have shown the value of using a team approach. When a city planner is faced with an inter-disciplinary problem, he would do well to consult with experienced operations researchers for help in organizing the necessary team.

If the problem has an economic facet the team should include a qualified economist. If the problem calls for measurement of social values a qualified sociologist or psychologist should be included. Problems involving data processing require the specialties of electronic engineers and computer programmers. Problems in heuristic might require philosophers, mathematicians, or computer experts. Engineering problems require engineers. Whatever facets a problem has, the city planner should see to it that the team which is working on it includes the specialists who are qualified to contribute toward a solution.

The important thing for city planners to grasp is the scientific attitude that problems can be analyzed objectively using reliable and valid means of measurement and logical systems of thought. It is not nearly so important for a city planner to be able to apply all the latest scientific techniques himself. He can hardly be expected to be knowledgeable enough to master all the useful techniques. City planners should use teams of scientific experts to help them.

III. Topics for further study.--The final recommendation concerns topics for further study. Innumerable topics for further study could be developed from the material introduced in this thesis. A few of these topics, presented below, might be used as possible thesis topics for the future. It is recommended that further study of these topics should be actively encouraged by city planners. The topics follow.

1. Application of Electronic Data Processing Systems to City Planning Problems.
2. Mathematical Models Useful to City Planners. (Econometrics might be a good field to investigate in this connection.)
3. Application of the Control Chart Technique to City Planning Problems.
4. Development and Use of Devices for Measuring Social Values of Interest to City Planners. (This topic could be broken down into any number of more specific topics, each dealing with one specific measuring device or type of device, or dealing with one specific set of social values.)
5. Preparation of a City Planning Handbook. (This topic could be broken down into three sections--preparation of tables giving design data, compilation of formulas and standards, and preparation of study outlines for the major types of basic studies.
6. Techniques of Keeping City Plans Flexible.

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