Urban Information Systems and Transportation Planning

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The rapid evolution of multipurpose urban information systems along with emergent changes in census technology will provide opportunities for a new generation of transportation analysis and planning studies. This paper outlines the logical bases of new systems under development, discusses applications to general urban analysis and relates these application potentials to urban transportation research, analysis and planning. Particular emphasis is given to the relationship between new information handling capabilities and the needs of urban transportation planning.

•URBAN area transportation planning studies of the past decade have been required to develop a new technology of information-automation not shared by the urban planning field in general. The impetus for this technological development has stemmed from three major factors. First, the studies have been financed at a high enough level and have had sufficiently specialized objectives to permit the application of computer technology. Second, the teams of professionals undertaking the studies included relatively more members with data processing capabilities than found on the coexistent urban planning and renewal staffs. Finally, there has been a more sophisticated level of assistance from the federal supervising agency in relation to urban transportation planning studies than from the federal agency relating to community planning and renewal activities.

These generalizations are not presented to discredit one group of professionals as compared with another, but simply to recognize facts and circumstances that are fairly obvious to those with long-term contacts in the two fields. In all fairness to the Department of Housing and Urban Development, its antecedent agencies were too sparsely staffed to mount the kind of attack which the U. S. Bureau of Public Roads has done in developing computer programs, training a large number of state and local officials in the traffic assignment process, and maintaining some sort of an organization to service requests for information on computer programs. Although the influence of the highway engineer has been substantial in moving the urban transportation planning studies in the direction of automated systems, it is only fair to give a great deal of credit to many professionals in the transportation planning studies who have not come from this field but who have exercised strong leadership in adapting to information-automation, such as the technical leadership of the Detroit and Chicago area transportation studies of the 1950s.

In reflecting on the developments of the past decade, it is interesting to note that the information systems developed in the urban transportation planning field have been essentially the ad hoc systems needed to produce data for urban transportation planning models and to meet the predominantly single-purpose needs of these studies—traffic forecasting. The systems naturally have not addressed themselves to the across-the-board aspects of urban and regional planning. There has been very little spin-off in

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utilizing the information gathered, not only for this reason, but also because of the organizational systems in which urban planning, urban renewal and transportation planning studies are conducted. Examples of payoffs in information systems developments for general planning purposes are scarce. Occasionally, planning and renewal agencies have found it practical to contract the processing of specific data reports from the transportation area study agencies, but in these instances the cost of data reduction has been relatively large because files have been organized in ways primarily useful for the purposes of the transportation planning groups.

Today, approximately the tenth year of man's general capability to communicate with the computer by using a general programming language, let us take stock of where we are in regard to the needs of the spectrum of users of urban information.

1. Strong pressures have emerged for the coordination of urban planning activities, transportation included, at least on the level of professional studies if not within a coordinated political framework. The transportation planning studies are no longer conceived as being ad hoc studies, but as continual ones with ongoing staffs and resources. There have been joint efforts from several sources on the federal level to pool resources to conduct urban analysis and planning.
2. Strong interest has now emerged both on the political and administrative level toward the establishment of urban and regional information systems for a broad variety of purposes which cut across the responsibility lines of a number of agencies.
3. The climate for information assembly and manipulation in the planning and renewal agencies is rapidly changing in favor of automated systems and ones which are as equally sophisticated in their demands as the foregoing transportation studies.
4. We are at the fulcrum point in the transition from one generation of computer technology to another, a time in which the value of stock in programming and systems development is relatively low because of the new capabilities in the emerging technology, and we have on hand a full decade of programming that will have a rather rapid depreciation.
5. There is a substantial increase in the sophistication of professionals in a growing number of fields in computer applications and computer operations, and we can expect a substantially different climate and professional capability in the emerging planning agencies.

All of the these facts point to a new climate, new attitudes, new capabilities, new methods of attacking the problems and new problems. They tell us in effect to take a closer look at integrated urban information systems for multipurposes as well as for a higher level of utility and capability for the various categories of users, including the transportation and planning segment of the urban planning area.

How will more sophisticated multipurpose urban information systems change the nature of the urban transportation planning process? To assist in answering this question, I have outlined in the following section what I believe are a handful of basic urban information systems needed for multi-projects.

BASIC URBAN INFORMATION SYSTEMS AND APPLICATIONS

This part of the paper describes tools and processing systems for handling data for an urban area information system and some of the more apparent applications. The material is concerned with the planning, development, testing and refinement of tools which are needed for the total spectrum of urban planning activity. Six basic components of the system are outlined as follows:

1. A geocoding system designed to convert data input by street address location identifiers to geographic coordinates, allowing information retrieval by arbitrary areas of interest as well as traditional areas of record, such as census tracts.
2. A query system designed to facilitate querying and manipulation of large data bases.
3. An automated graphic display system for map making and data display.

4. A plan test system for testing, by simulation, alternative proposals regarding employment distribution, residential densities, transportation facilities and the effect of capital expenditures and priorities on the planned growth of various sectors.

5. A planning operations system designed to assist in internal agency day-to-day routine information processing needs, such as document retrieval, report generation and the production of statistical reports for fixed-time series intervals.

6. A capital improvements and work scheduling system based on critical path methods of analysis, designed to integrate the planning and programming of all public works development in the area.

The first three components are parts of a continuum and are complementary. The first enables location of data, the second manipulation of these data, and the third data display. More will be said about their relationships as they are discussed in depth.

Before proceeding to describe each of the subsystems, some general remarks are in order concerning the choice of system components. The components recommended here stem from three requirements: (a) they are the most basic needed in terms of developing a data-handling capability; (b) they relate to the most fundamental questions which planning agencies must answer in terms of its programs; and (c) they will upgrade planning and programming capabilities. With the exception of the query element, the other systems proposed have already proved operationally feasible from test applications or experience.

Geocoding System

A geocoding system automatically relates a data observation, event or happening to a mapped location. A geocoding system of the type developed by Dial (1) and implemented by Calkins (2) is suggested as an essential tool for positioning data observations in two-dimensional space as well as retrieving data in highly flexible ways. Many data of concern in urban analysis are only locatable by street address identifiers or more easily coded by such identifiers. However, street addresses are very cumbersome to use in data retrieval. Coordinates, or X and Y spatial references, are far more powerful location identifiers from the standpoint of information retrieval capability.

To accomplish the translation of street addresses to grid coordinates, it is necessary to compile a street-address-to-coordinate directory.[1] Once compiled for a city or an urban area, the directory serves in the translation of any data having street address locational identifiers. Assistance in compiling directories is provided by a computer program that allocates entire lengths of streets into segments created by intersecting streets. Associated with street segment records are address range limits for each block, and grid coordinate values of the street segment ends or street intersections. The addresses of input data are systematically compared to the street segment records of the street-address-to-coordinate directory to accomplish the translation. Thus, any record of interest, such as a housing unit, incidence of communicable disease or the location of an economic activity, has a grid coordinate value automatically assigned to it if the input record has its street address coded.

If the conversion is to grid coordinates rather than areal unit codes, such as census tracts, the coordinated data observations may be assigned later to arbitrarily delineated areal units by a query system. This is done through a procedure that tests whether the coordinates of data observations queried are within polygon boundaries describing the areal units. This capability utilizes geocoded data. The assignment of coordinates to polygons is part of the query system that is proposed and described here.

As stated earlier, the geocoding system permits the conversion of data entities whose locational identifiers are street addresses to grid coordinate identifiers. This

[1]An operational test of such a system is now under way as part of a National Capital Commission—Dominion Bureau of Statistics test in the Ottawa, Ontario region, using 1966 Census data for retrieval analysis.

conversion opens the door for the use of many kinds of data that were previously unusable because they were not readily locatable. Many data exist, related to persons or properties, that are coded only by street address. Data such as building permit applications, employee address records, charge account records, pupil residence records, and hospital patient discharge records may be made amenable to spatial analysis by this system.

Monitoring subsequent population change by utilizing building permit application data is necessary to maintain current population estimates. Typical questions that building permit data are able to answer relate to time, location and magnitude of new construction. Coordination of building permit data enable their automatic allocation to any arbitrary analysis area of interest or traditional enumeration districts such as census tracts, traffic zones or school attendance areas. If building demolition records are entered into the system as well as the record of population movement from utility connection information, then a permanent system is available to monitor population change with very small error.

Besides monitoring population change as discussed, a geocoding system may assist in studying the spatial distribution of a great many urban phenomena important to planning analysis. These include, but are not limited to, the following:

1. The trade area of shopping centers;
2. The tributary area of hospital patients;
3. The location of commercial or industrial land uses;
4. The location of different land-use adjustments;
5. The tributary area of employment centers;
6. The location of federal employee residences;
7. The location of dwellings by types and values;
8. The location of communicable diseases of various types;
9. The location of traffic accidents by various classifications; and
10. The location of welfare cases of different types.

In each case, address records must be obtained from source documents such as public records, commercial directories or especially contrived sources which involve the cooperation of people and business establishments.

The applications of geocoded data have virtually no limits of utility for regional and local planning agencies, a variety of municipal departments, and both public and private welfare agencies. Once geocoded data have been developed, a project which is not to be underestimated in scope, these data are amenable to visual inspection by automated graphic display or for various types of statistical analysis or to arrive at notions of the urban ecological processes, including concentration, dispersion, clustering and time changes in the settlement patterns of people, households and economic activities. These changes should be relatable to planning policies.

Query System

A query system connotes a means or tool to access data on spatially distributed phenomena in a variety of combinations and with relative economy. The emphasis must initially be upon the system development rather than a collection of data. Without such a philosophy, each specific planning task will require its own specific data retrieval systems and no general flexible processing capability will be gained.

The query system is designed not only to handle data with street address identifiers, but also to combine the entire spectrum of data collected by different identifiers as well as for differing time spans and spatial boundaries. The spatial data query system essentially consists of a user-oriented computer programming language and schemes for organizing spatial data. This system is conceived to give planners a great deal of flexibility and power in handling and preparing data for analysis and reports.

The query system described requires that data be locatable in space by means of coordinate identifiers or areal unit codes. Geocoding, or the automatic assignment of spatial coordinates to entities, and the query system are complementary. Geocoding assigns coordinates and the query system manipulates or handles coordinated data. The existing Dial-Calkins geocoding system has some elementary, although important, query capabilities, e.g., capability to assign polygon identifiers to data observations.

To illustrate the query system better, assume the existence of elementary school student residence records in machine-processible form. Also assume these data have been geocoded by a street-address-to-grid-coordinate program. Various school enrollment areas may then be tested using the query system. This system is capable of selecting entities based on satisfaction of specified values for properties of these data. For example, students could be assigned to school service areas by testing whether their locational coordinates are within polygons describing these areas. In addition, students of a particular grade may be specified for selection. These kinds of queries may aid in the allocation of teachers to specific grades in specific schools.

Similarly, travel behavior data from interviews of households may be queried. Typical queries relating to data from household travel behavior studies are (a) select household entities with incomes exceeding $10,000 and who own more than one car; (b) select household entities owning no cars and whose family size is more than two; and (c) select household entities that make more than 10 trips per day.

Examples such as these use all three of the complementary systems—geocoding, query, and graphic display. Geocoding is used for ease of inputing spatial data, a query system to enable manipulation, and graphic display for spatially positioning the output.

Emphasis is placed here on the requirement for building a general query system, much as an assembly line must be built either to produce one or a thousand fabricated products. When attention is not given to the general development of a process to handle miscellaneous queries, common situations arise in which it may take several hours of computer time and the input of many reels of tape to answer relatively simple questions, much as it would require considerable time and cost to fabricate a car without the existence of an assembly line.

Ongoing agencies that envision using a large data base must develop a generalized data-handling facility. Such a facility is necessary to organize, store, retrieve and report all kinds of data on spatially distributed phenomena. Whether these data are used to assist in the evaluation and control of a process of operation, or whether they are to provide a basis for planning and to evaluate alternative plans, generalized processing expertise is essential, and, in fact, equally important as the data itself.

The central function of a query system is to facilitate the query and search of data and to simplify programming instruction for the desired output. It is important that a query system be designed for ease of use by persons with minimal computer experience, but who are skilled in planning analysis. A data-handling procedure designed for ease of use is the single most important element of an information system. Without a flexible system, many data are effectively locked in due to the time and cost of retrieval or manipulation.

To develop an effective automated information operation, an agency must generate an efficient means of reaching magnetically stored data, manipulating it and reporting results. This may be accomplished in several ways. One way is to develop and acquire package programs that perform all anticipated desired functions. By specifying parameters, or limits, the package programs can meet specific needs; but unfortunately, all the desired needs are not initially known. One step above acquisition of separate package programs is a system or collection of user-oriented package programs operated by English-like instructions that perform a spectrum of frequently desired tasks, such as the production of time-series statistical observations or graphic display. At a higher level, task-oriented programming languages enable compilation of more flexible and powerful instructions for highly specific tasks.

A most promising data-handling means is being developed by IBM for the System/360 (3). It is called GIS (Generalized Information System) and provides great power for storing, manipulating, retrieving, and presenting data. GIS enables storage of and retrieval from complex and linked data sets. In addition, the syntax of GIS is very flexible and in English-like language. However, GIS is not particularly oriented to handling spatial data. It is necessary to develop a subset of GIS, or an independent system to handle spatial data.

Alternatively, an agency could utilize existing data programming systems such as SPAN (4) or MARK III (5). However, each of these systems was designed and implemented on specific computer configurations and is independent of a flexible spatial coding system. Their dependence on second generation hardware also proves limiting. Second generation is the term generally applied to the computer hardware configurations in use in the first half of the 1960s, such as the IBM 7000 Series, GE 235, and CDC 3600. Third generation includes the IBM Series 360, GE 645, and CDC 6600.

Unlike commercial and scientific fields, computer programming systems for urban regional analysis needs are relatively underdeveloped. Of the systems described thus far, only the geocoding system is highly operational. Clearly, it is not specifically the purpose of an agency to become engaged in information systems research. To solve problems and assist in operations, it is nevertheless important for all organizations with large-scale information needs to contemplate advancing the state of the art of information systems operations consistent with the scope of their responsibilities.

Automated Graphic Display System

Automatic graphic display of information is essential for the presentation of a spatial pattern in the form of maps. Map imagery is presented via automated plotting hardware or cathode ray tube photographic output. In addition to displaying data through map imagery, there is a need to reproduce maps themselves at varying scales and with varying information according to the specific project at hand. This type of graphic output is now fully developed in the aerospace industries. The technology must be adopted to urban area planning and analysis needs, if manpower requirements are to be kept within reasonable limits as work demand grows.

Whereas the information system component discussed previously is concerned with spatial retrieval, it requires a graphic display subsystem to carry through in terms of a visual reporting of the information retrieved. For example, a general spatial query system could retrieve from large data files the number of people living in housing units 50 or more years of age within 5 miles of a projected employment center, assuming such data to be part of the base. The knowledge of this number itself would be only partially significant. Significance of much greater importance would be attached to a visual display of these housing locations interpreted through a map screen of the urban area. Such imagery could give some highly visible clues as to the geography of rehabilitation needs.

An automated graphic display system is essentially the application of computer programming to the ordering of data for display on output equipment. These data are ordered in such a way that the output of the system will be in the form of a map or a graph.

Output devices are of three types: (a) the high-speed impact printer, which is found at almost every large-scale computer installation; (b) the inkline plotter of either the plane table or platten type, wherein the motion of a pen is programmed to produce the image much as it would be produced by hand; and (c) the cathode ray tube (CRT) which looks like an oscillograph and for all practical purposes may be likened to a television image. Of the three graphic output modes, the CRT is the most efficient because it produces the image at electronic speed; the only production time limitation is in the photographic equipment which records the image produced on the scope. Impact printers are relatively quick and have the advantage of being very handy, but their output resembles that produced by a typewriter. The inkline plotter is probably the best tool for cartographic simulation of conventional map production. Highly efficient package programs have already been developed for graphic display via the impact printer (6).

A special adaptation of the CRT is the "light pen," which is a stylus-like instrument connected to the CRT by a cable and held in the hand. The user can apply the light pen to images displayed on the CRT either to enter data or retrieve data for ground locations which are visually evident by the display of a street line map. It is a short step from the present technological capabilities described in the query system to adapt to a system whereby the user can describe a perimeter of ground space by light pen outline in reference to a map image of the city programmed to appear on the CRT and call for data to be retrieved or summarized for that area. Practical examples of such use would be obtaining a feedback on the number of people living within an arbitrarily designated area, the value of land within some perimeter, and the number of cases of a communicable disease in a given area.

Perhaps the most immediate need for automated cartography is in the production of maps superimposed with information selected to meet the demands at hand. In this regard, a by-product of the geocoding system is a digitized record of all street segments. These segments may be displayed in any scale, either by inkline plotter or by CRT scope.

Digitized street segment records may be immediately valuable in displaying information of relevancy to municipal engineering and public works analysis as well as transportation planning. For example, if a file of traffic-volume counts is developed for street lengths, an adaptation of the display program permits the streets to be shown at varying widths corresponding directly to the traffic volumes. Similarly, a file of street lengths can be produced showing only streets of particular widths or pavement conditions. Current CRT technology even permits colored imagery and photographic reproduction, which could display roads of one type in red, those of another in green, and so forth.

Before leaving the subject of computer graphic systems, it is worthwhile to note that systems are now available to assist in the urban design process by constructing perspective drawings from very basic plan and elevation data. The conventional procedures of urban design require, at some stage of planning, a substantial expenditure of time and effort in the development of perspective drawings and the preparation of models for both design analysis and lay evaluation. Recent developments in computer output systems, such as the refinement of the inkline plotter and CRT display, now permit new tools of three-dimensional analysis which give the design team a multitude of perspective views stemming from the one-time coding of the spatial location of corresponding points of the given object (building, building groupment, or other spatial arrangement) with reference to the orthogonal distance from the picture plane and ground level.

A simple analogy would be the production of a multitude of perspective views of a building from a single set of coded information capable of production by a nonprofessional design aide. The viewing position could be made to vary in height and azimuth position, or various combinations. Views can be projected on a CRT recorder at speeds limited only by photographic requirements (60 frames/minute for practical considerations). In fact, motion pictures can be produced easily from the output which simulate moving around the building in space or walking through an urban spatial setting. This process may not preclude the need to build a model for public relations purposes, but it can substantially aid the design team in the predetermination of the spatial elements of the solution.

In summary of this section, an automated graphic display system will not only have a substantial impact in upgrading graphic study capabilities of the planning agencies, but also should ultimately give them the capability of information retrieval in a real-time sense for decision-making purposes.

Of all of the systems proposed in this section, no doubt the graphic display system could be the most utilitarian in both the savings of drafting time and the provision of services to other agencies in the region. For an agency continually involved in the production of maps, it is an economic certainty that before more than a few years pass there will be justification for the rental of in-house plotting equipment. Virtually all major transportation studies in the United States have already attained this level of in-house need. An automated graphic display system is not only necessary to upgrade map production, but to produce output reports which use a visual format to convey the meaning of the information. This type of output facilitates both technical, management and policy decisions.

Plan Test System

The effectiveness of plans, policies, and alternate proposals may be tested in a variety of ways ranging from simple visual observations to complex mathematical models. Contemporary planning places considerable hopes on a capability to monitor or test the plans and policies.

A distinction should be made between the testing of alternate proposals in the planning process as compared with the testing of the plan or policy itself in regard to events which occur after its inception. In the latter case, plans and policies can often be tested by relatively simple information feedbacks. For example, a system which reports on land-use changes or adjustments, not strictly in compliance with the planned land-use policy, may be a valuable tool in determining whether or not the policy is honored in general or breached in day-to-day adjustments. In this regard, it is common to encounter land-use adjustments that are substantially contrary to plans and which, while conceivably within the legal framework of adjustment, display the inoperation of a plan or the unwillingness of an administration body to implement it. These statements are not meant to imply that the adjustment of a plan in contradiction to its policy is necessarily illogical, but merely to indicate that feedback systems can give a fairly good indication of policy success, whether it is dealing with land use, prison paroles, welfare programs or other matters.

Time-series data of historical nature can further shed light on the effectiveness of plans and policies. An example here is the evaluation of urban areas which have been considered timely for rehabilitation through housing code enforcement. If records indicate that housing codes are not enforceable and that rehabilitation money is not being generated for an area, then it is probable that the housing stock is beyond rehabilitation status in general.

Information feedback systems can go a long way toward evaluating the impact of plans and policies in an ex post facto way. Their value should not be underestimated. On the other hand, the problem of pre-evaluating planning alternatives from the standpoint of social and economic justification, impacts and potential success is a much more sophisticated exercise, and calls for the use of models in which the input variables can be altered and the estimated results studied for different mixes of inputs. In the traffic planning and shopping center planning fields, gravity and accessibility models are typically used for preplan testing purposes and have been found to be substantially successful. It is the purpose of this section, however, to present the dimensions of at least one major plan test system as an example.

The plan test system described here is an illustrative model.[2] Its utility is in answering questions of the impact of decisions on the location of new employment centers in an urban region. This model presumes employment inputs can be anticipated 3 to 5 years in advance, both in the government and private service sectors.

Because the model-building state of the art is relatively crude, partially because of limited data-handling capabilities, only a simple model is formulated. Initially, the emphasis should be on analysis of data for calibration or estimation of parameters for the model. This slow and deliberate approach to model building is based on experience in other model-building efforts where too much was attempted or promised without sufficient data base or data-handling capability to effectuate it.

Among the most important determinants of urban patterns are employment locations and transportation facilities. Thus, the suggested model allocates increases in area employment at specific loci to residential areas. Such a model is deemed useful to test alternative proposals of large employment center locations in terms of impacts on travel facilities and residential densities. It is felt that a linear programming model, which distributes population, given inputs of employment and travel times, enables policy makers to evaluate decisions as to locations of large national government employment centers. In addition, needed transportation improvements may be shown as a result of model application, and potential pressure for development may be anticipated.

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[2]This model rationale has been proposed by Kenneth J. Dueker in a study for the National Capital Commission of Canada, forthcoming.

A linear programming allocation process or solution method is proposed. Linear programming formulation enables optimal allocation of persons to residential areas based on minimizing the aggregate work travel cost for the new employees being allocated. This allocation is subject to constraints of transport capacity, housing supply, and employment demand.

Only incremental employment changes are to be allocated. The model is designed to allocate new employment to existing or new housing. Thus, the concern is not in replicating existing patterns, but in allocating future population growth to residential areas. This incremental approach creates some difficulties, however. For example, transportation capacity between employment zones and residential areas must be expressed as remaining available capacity, and housing supply as available housing supply. Another problem, that of generating many variables within the model, is partially circumvented by a short planning horizon of 5 years and by an iterative solution to achieve a balance between employment, available residences and transport capacities. In a long-range model, variables such as service employment must be endogenously generated. In a short-range model, service employment can be exogenously estimated and considered input to the model. If the model does not allocate sufficient population for that area, the employment inputs must be modified and the model rerun. Similarly, the model must be rerun until travel times and capacities are properly related. Subsequent refinements of the model might be to make these iterations internal to the model or automatic.

Planning Operations System

Inherent in large planning offices are high costs in accessing records and developing documents, reports and graphs by hand. Also, much repetition of office operations is required because of document updating requirements, such as the periodic production of statistical reports. Automated retrieval systems are mandatory if large manpower inputs are to be avoided. Such systems will reduce the amount of nonproductive work and provide more current and extensive information on available documents, records, reports and graphs.

Document retrieval systems, such as KWIC (Key-Work in Context), SDI (Selective Dissemination of Information), and "peekaboo" retrieval systems should be operationally investigated. These systems need to be evaluated in terms of being able to retrieve documents by subject, author, agency location, and in terms of specific agency needs.

Administrative records, such as property management data, that may be of value for planning are recommended for investigation, although organization of property data for management purposes is necessarily different than for planning. For planning, these data must be geographically ordered. Though the ordering and data-handling systems for management and planning are different, one system should rely on the other to collect and update that part of the data base relevant to its own needs. Ideally, the planning system should be designed to utilize data from the management system, but must be a separate system itself because of its differing requirements.

Critical path planning accounts for the restraining interrelationships between the various improvements. Within the restraining framework, the various improvements must be scheduled. At this point resource limitations are considered. Resources, such as finances, manpower and equipment, are allocated and the improvements scheduled to level resource fluctuations over time. The key is to make the entire process systematic and partially automated to enable rapid reevaluation for testing alternative capital improvements proposals.

Elements of the capital improvements program go through several cycles of budgeting, programming, and scheduling as they pass from the conceptual stage to realization. Within the overall budget, projects are in various stages of planning, moving from long-range planning to design investigations, to preliminary design review, to final design, and finally to construction. At each stage in planning an improvement, new information is added to the programming, scheduling, and budgeting process. Incorporation of these cyclic considerations into the Capital Improvements Program system will offer a great deal of monitoring and control capability.

RELATIONSHIP TO TRANSPORTATION PLANNING

Not all of the systems described have equal implications for urban transportation planning. Some, such as the graphic display and work scheduling elements, are part of the urban transportation planning technology that has evolved to date. Likewise, the plan test system is inherent in the transportation planning modeling work that has gone on for at least a decade, and therefore poses no uniquely new concept to the transportation planner. These systems have been described in somewhat broader terms, however, as part of the total spectrum of urban information systems needs.

Of far greater importance to the transportation planning process are the geocoding and general spatial data query systems. These are not part of the conventional technologies of urban transportation planning studies, and they are perhaps the one phase of the transportation planning process that is in most need of attention from the technological development standpoint.

The significant contribution of the geocoding system is that it eliminates reliance on preconceived notions of region, such as the traffic enumeration zone, and at the same time permits the aggregation of information from many sources for query areas that may constitute an analysis spectrum of areal configurations. For example, traffic enumeration district zones traditionally increase with distance from a central focus, and thereby mask out the true nature of trips to subfoci. A regional shopping center complex, for example, along with associated commercial and industrial land uses, may be found at the intersection of four traffic enumeration zones in such a way that a unique activity focus is not observed at the destination end of the trip. Further, the size of the traffic analysis zone at that location in the region may be such as to mask the importance of destinations to the shopping center because both origins and destinations fall within only one zone.

The importance of the specified spatial query system for transportation planning lies in the capability of matching the characteristics of specific households with their specific travel generating characteristics, rather than using the average values for enumeration districts themselves. At the existing level of technology, the averaging of characteristics for areas masks out the true characteristics of the regression of one variable upon another. At present, we also infer that the characteristics of selected samples cover their areal entities, whereas with the general spatial query systems it should be possible to link the properties of entities at the basic level of enumeration.

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REFERENCES

1. Dial, Robert B. Street Address Conversion System. Urban Data Center, Univ. of Washington, 1964.
2. Calkins, Hugh W. Operations Manual for Street Address Conversion Systems. Urban Data Center, Univ. of Washington, 1965.
3. Generalized Information Systems: Application Description. International Business Machines Corp., 1965.
4. Almendinger, Vladimer B. SPAN: A System for Data Management. Urban Information and Policy Decisions (C. D. Rogers, Ed.). Inst. of Local Govt., Graduate School of Public and Internat. Affairs, Univ. of Pittsburgh, 1965.
5. Postley, John H. A General Purpose Urban Management Data System. Proc. Third Annual Conf. on Urban Information Systems and Programs, Amer. Soc. of Planning Officials and Northwestern Univ., 1965.
6. Using Computer Graphic for Community Renewal. CRP Guide Number 1, U.S. Govt. Printing Office, Washington, 1964.