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ABSTRACT

This paper argues for the use of systems analysis as a basis for building urban complexes to depart from current duplication of effort in some cases and lack of adequate effort in others. By consolidating effort with the judicious use of computers, systems analysis can provide better analysis out of an equivalent effort. Comprehensive planning models using systems analysis would allow urban planners to create public utilities and services designed to meet the near and distant needs of urban areas. (RA)

FEASIBLE SYSTEMS ANALYSIS

FOR

COMPREHENSIVE PLANNING

OF

PUBLIC WORKS

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"If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it." Abraham Lincoln.

Our basic problem has not changed since the above quotation was used in 1858. It is generally recognized that most metropoitan areas are in various degrees of serious trouble. Our general attack on the problem is heavily weighed toward planning procedures, but as yet it appears that administrators, engineers and planners are not able to "get a handle on" the situation. Great sums have been spent in preparing comprehensive plans, general plans, functional plans and capital improvement programs and still all too often there is something lacking. Some examples illustrating this point are these:

Item: Scuttlebutt has it that about two-thirds of the required comprehensive and continuing transportation plans are not "continuing" in a meaningful way.

Item: Only a few transportation studies have evaluated alternatives which were significantly different from the first configuration studied.

Item: Few metropolitan areas have documented the implications of alternative patterns of urban growth, and fewer yet have been able to adopt a set of consistent development policies based on a choice of alternative patterns.

Item: Many metropolitan areas have not developed a unified and official set of specific design criteria to be used in all facility design to the end that the adopted development policies will be carried out.

Item: Often the regional planning organizations do not in fact plan for the entire area, but in reality exist for complying with Federal regulations in order to obtain funds for a specific need of the initiating governmental unit.

The reasons for such problems with the efficiency of the planning function are numerous, but a dominant one is the complexity of urban development.

One way to handle such complexity is to simplify consideration of policies by operating the administrative and planning function in the systems mode of thinking and by using computers to handle the routine tasks of data manipulation so that there will be time and mental energy left to face broad issues and continually test alternatives.

Systems Analysis Not Yet Accepted

Despite widespread recognition of its advantages, the systems approach to the overall function of city planning and management has not been exploited. Local administrators are generally aware of the desirability of being able to perform in this mode, but they have reservations which tend to dampen their enthusiasm; some of which are these:

First, many urban analysis models are deterministic in their operation and do not adequately represent the real world. For instance, data are fed into the computer and operate in any unyielding mathematical formula to provide a representation of an urban design. The planner can recognize this operation as a valuable research tool, but he cannot accept the output as representin an approvable plan. This is to be expected, because it is virtually impossible to model all of the variations of factors which can be involved in creating a politicially acceptable urban form design.

Secondly, systems analysis work is thought to be unusually complicated and expensive. Indeed, there are known models which only those who constructed them seem able to operate. Then too, the work is often based on an ideal of sophisticated input data seldom found in real life municipal administration. The computer programs are often not designed for operation on the available equipment and rewriting and debugging a program for a different computer is a considerable undertaking on the municipal level where money is invariably scarce.

A third problem has nothing to do with systems analysis per se, but deters its use. Most planning and engineering organizations undertake those activities for which there is ready funding (often Federal funding) and not necessarily those activities which would be most desirable to fill out a well organized planning and analysis program. Fundamental work such as economic analysis and land use planning is often accomplished only as a by-product of fundable studies. The advent of revenue sharing will place a new responsibility on localities to more carefully evaluate and justify the priorities in which such funds are to be spent. If the receiving agency so desires, it can establish a single and efficient analysis base without reference to uncoordinated requirements, as at present.

Fourthly, a most serious problem with complex analytical procedures, even when undertaken, is that the lack of funds, time and human persistence leads to a minimal number of alternatives being evaluated and vital feedbacks being ignored. This is a human or financial limitation and is not caused by any limitation inherent in the available machinery. Its cure may lie in an optimum amount of simplification.

Problems of these types need not deter the progressively greater use of systems analysis in local public activities if the subject is approached from the standpoint of fundamentals. A primary step is to use a systems oriented method of thinking and operation. A core framework of models and computer programs can be easily and inexpensively integrated into the agency operation. As time and resources permit, additional and more sophisticated analysis procedures can be added.

Systems Analysis Steps for Planning Analysis

Systems analysis in local government is the activity of planning and designing for people and the physical facilities they use, all of which can be identified as operating as an interrelated system. A metropolitan area would be such a system. The objective of the analysis is to create significantly better plans than can be produced by other methods. Various authors have called it an art, a science, a procedure and an attitude. As an attitude and procedure, it is closely allied with the notion of comprehensive planning.

The vehicle upon which the analysis is organized is called a "model". This title is relatively new to general usage, but the concept is as old as engineering and planning. A model can be defined as a reasoned outline, diagram or formula of a process of thought or of a representation of a real life situation. Mathematical precision and computerization was added with the advent of the comprehensive transportation plans accomplished after 1950. Current generations of high speed computers has simplified and reduced the cost of formerly complex operations. While doing this they have increased the opportunity to lose track of logic through intricate procedures. This must be avoided. These responsible for the analysis must at all times fully understand the manner in which the results are being achieved. Poor logic or spurious correlation are not improved by computer processing.

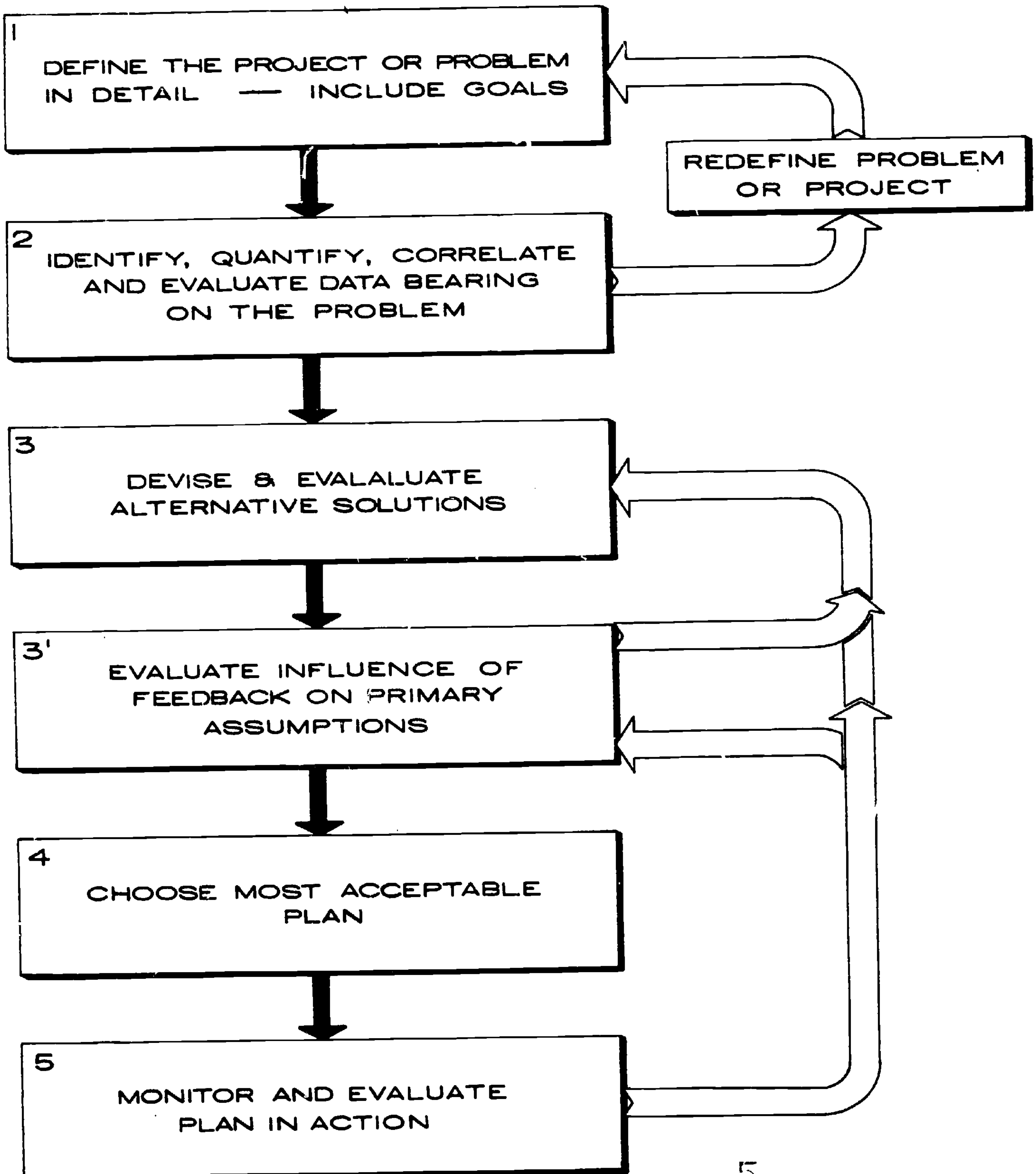
To the planner or public works official, systems analysis should be thought of as involving all of the feasible factors which he perceives to influence comprehensive planning. The word "feasible" can be variously interpreted, but it should not be construed to include more factors than can be handled on a continuing basis. It is much better to handle planning in a systems mode at a scale which can be accomplished, than to remain on an ad hoc basis. Similarly, it is much easier to later modify first approximations than to face a pile of blank paper or a mountain of unassimilated data. Systems analysis models must be simplified as much as possible, but not to the extent that the key elements are simplified away.

To the project planner or engineer, systems analysis means the use of the systems procedure, but not treating in detail the comprehensive urban system in which the project will function. In the minds of many, any computer assisted analysis is systems analysis. This is definitely not true.

The steps which make an analysis a systems analysis, when applied to the work urban planners and public works officials do, are shown in the flowchart of Fig. 1 as these:

1. Critically define the problem. This is more than stating the obvious, such as "prepare a plan for....". Since subsequent steps require the assembly

FIG. I
SYSTEMS STEP FLOWCHART
FOR
COMPREHENSIVE PLANNING ANALYSIS



of data, economy and even feasibility demands careful though as to which data to gather and how to format it. On a metropoitan level, several groups of parameters are a common basis for the design of most public works. These design parameters should be consistent with each other when applied to different classes of projects. For instance, domestic water consumption is calculated from the same small area population base as are home based trips in a transportation analysis. Preplanning should include consideration of the widest multiple use of data. Basis-for-design data are not just bare statistical findings, but are founded upon assumptions as to future conditions and upon official policies designed to shape the future condition. The comprehensive land use planner should be aware that a plan can never be carried out as long as it remains in the form of colored maps. The ideas so portrayed must be translated into numbers usable in engineering and architecture and the planner should see that the adopted policies are properly translated into these numbers.

2. Identify, quantify and correlate factors bearing on the problem. Here the research is pointed squarely at the problem. Data should not be collected in the hope that most of it will be useful. The further use of each data series should be clearly in mind, and these data should be formatted for smooth transition to the next step. An encyclopedia of facts about a planning area in itself is of marginal use. The implications of the data must be discovered and the problems and opportunities clearly recorded. Insights revealed by the data may well suggest a redefinition of the problem.

3. Devise and evaluate alternative solutions. In many cases this step involves devising and calibrating a model representing the operation of the system. This is the case in transportation planning (Step 2 is merged with this step in most transportation modeling). The use of systems analysis implies that all of the more promising solutions will be evaluated. It also makes such multiple evaluations feasible. If political and social considerations are not worked into the model they must be applied at the end of the evaluation and in many cases will be the controling issues in the selection of the adopted course of action. Put another way, this latter process resolves itself into deciding what engineering and financial penalties will be acceptable in satisfying social and political objectives.

3'. Feedback influences must be evaluated. When complicated systems are studied (and metropolitan areas are complicated systems), the analysts and policy makers discover new insights which make it desirable to modify the analysis with revised assumptions and limitations. As an example, the provision of excellent highway access to a lesser developed portion of a metropolitan area is almost sure to cause a change in the relative development rates in the metropolitan area. Because of this, the traffic generation data used in the first series of analysis runs may need to be changed. A clean systems approach makes this feasible. Often less than optimum plans are self fulfilling. This is illustrated by the case where an area is not developed because there are poor facilities, therefore, being not developed, the area does not need facilities. In a good systems program, such areas would be tested at a simulated condition of optimum development.

4. Choose the recommended plan. The analysis may reveal more than one acceptable plan and a policy choice is controlling in the final determination. If social and political factors are not handled in the analysis, they may be the keys to deciding the adopted course of action.

5. Continue to monitor the basic factors and assumptions used in the analysis. If there is significant change, rerun the analysis with revised data. Even modify the analysis model if experience indicates this should be done. To make continual monitoring practical, it follows that systems analysis models must be as simple as is consistent with adequate results. The input data should be based on statistical programs which are likely to be continuing. An application of this last principle is to depend heavily on census tract data and the Federal economic censuses rather than develop unique arrangements, of marginal additional value, which depend on continuing local funding. Establishing multiple important uses for the same data is a good device for assuring its continued currency. For example, the data prepared for a transportation plan update should be formatted so that it can also be used for utility planning. Above all, data must be summarized in an orderly manner so that updates are uncomplicated.

Parcel based urban data banks make the use of systems analysis much easier by reducing the number of parameters which must be estimated. However, trying to evaluate the implications of various urban forms through the direct use of parcel data is like operating a bank with only pennies in the tills. To put detailed information to efficient use in urban problem solving requires its consolidation into an easily manageable form suitable for manipulation. Although parcel based data banks are very helpful, they are not a prerequisite to the use of the systems mode of planning.

Computer use becomes important in systems analysis on a metropolitan level due to the implied successive manipulations of large amounts of data. Under these conditions, hand manipulation would be so expensive and so time consuming as to discourage or eliminate the evaluation of a sufficient number of alternative solutions or of feedbacks.

General Plan Translation to Project Plans

General development plans and governing body policy plans must eventually be translated into numbers representing demand criteria before detailed design or construction of any public facility can proceed in carrying out such general plans. These numbers must be provided for small geographic areas (such as sub-drainage basins or O & D zones) and the forecasts must be projected for long periods into the future. Many public works are expected to serve in the magnitude of fifty years and longer. A long range outlook even though hazy in its accuracy, can prevent costly design and location mistakes. It can also enhance the reliability of middle range forecasts by identifying changing and emerging trends. For example, a very long range view may cause a waste water treatment plant to be located farther down stream so that it can intercept one or more additional drainage basins, thus avoiding a duplication of facilities even in the middle range future.

Presently, studies to provide a basis for facility design are commonly carried out anew for each project and as a result the same general data are superficially reworked many times. This is not only costly, but often interdependent facilities are designed on the basis of differing assumptions as to level of service to be provided and the geographic priority in which funds should be spent. An example is a water utility preparing to provide very large advance capacity to an area where the traffic engineers are hard pressed to find ways of handling traffic from the land already receiving water service. The new water service is almost sure to cause more serious traffic problems before any relief can be provided.

People and their needs provide a common denominator for design criteria for all facilities. People need various environments for their activities which means the allocation of land space and structure space. This fundamental thread runs through planning disciplines such as economic planning, social planning, utility planning and transportation planning. The characteristics of this use of space which must be recorded for each type of planning are somewhat different, but these differences are minimal. The land use and population data needs are similar when planning for transportation, for sewers, for recreation, for schools, for protective services, as examples.

Systems analysis can promote local governmental efficiency by providing a set of interrelated design factors which are derived from an agreed base grounded in the overall policies of the responsible governing bodies.

A Sample Set of Urban Systems Analysis Models

If the real world is visualized as an infinitely complex system with an infinite number of possible subsystems, how then is it possible to apply systems analysis to achieve useful results? The answer is to choose a skeleton set of compatible subsystems as shown on Fig. 2, which deal with the elements commonly thought of as constituting the comprehensive plan. Additional subsystems can be added as the agency is able to work out analytical techniques and organize data on a continuing basis.

FIG. 2

RELATIONSHIP OF URBAN SYSTEMS ANALYSIS MODELS TO THE REAL WORLD

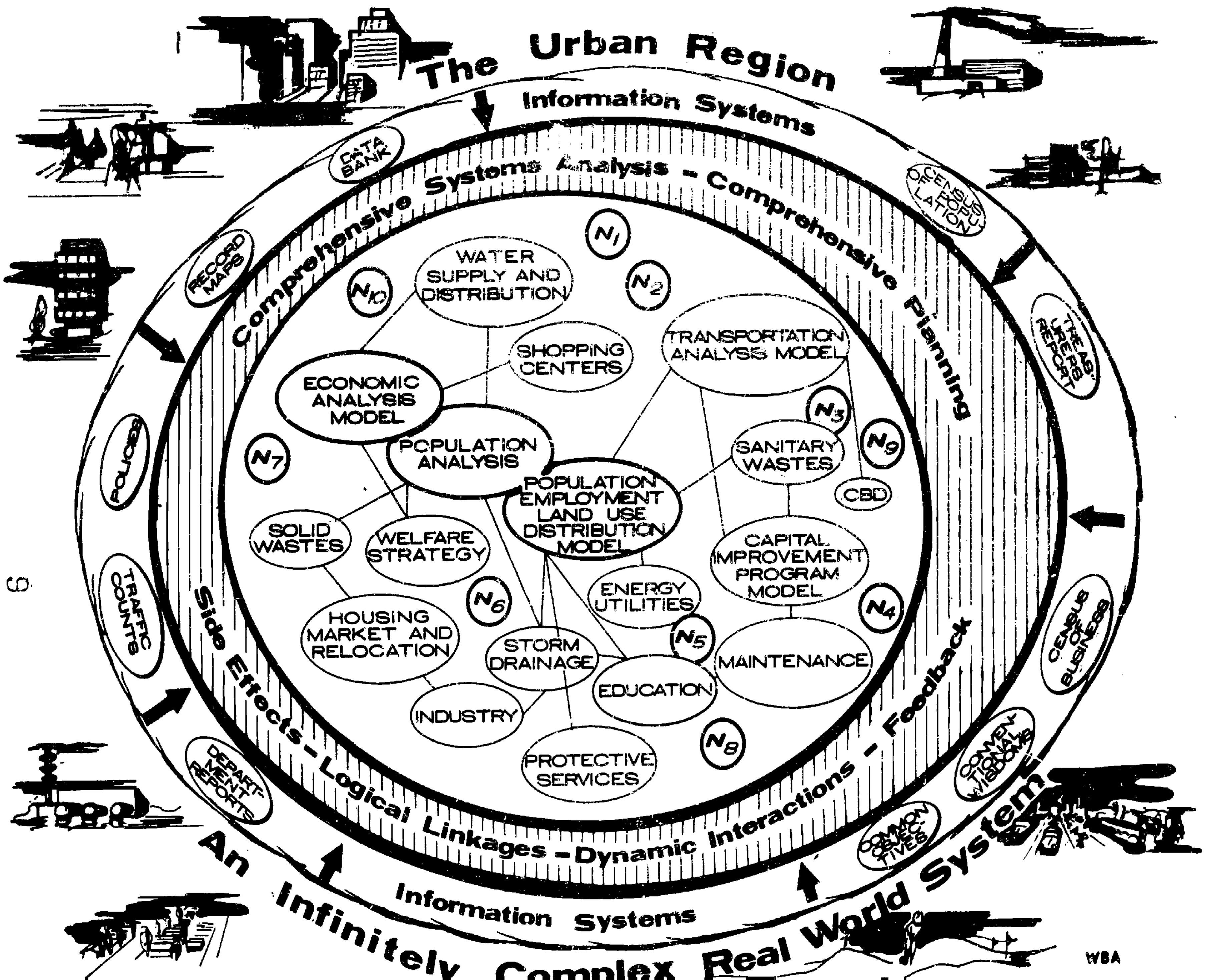
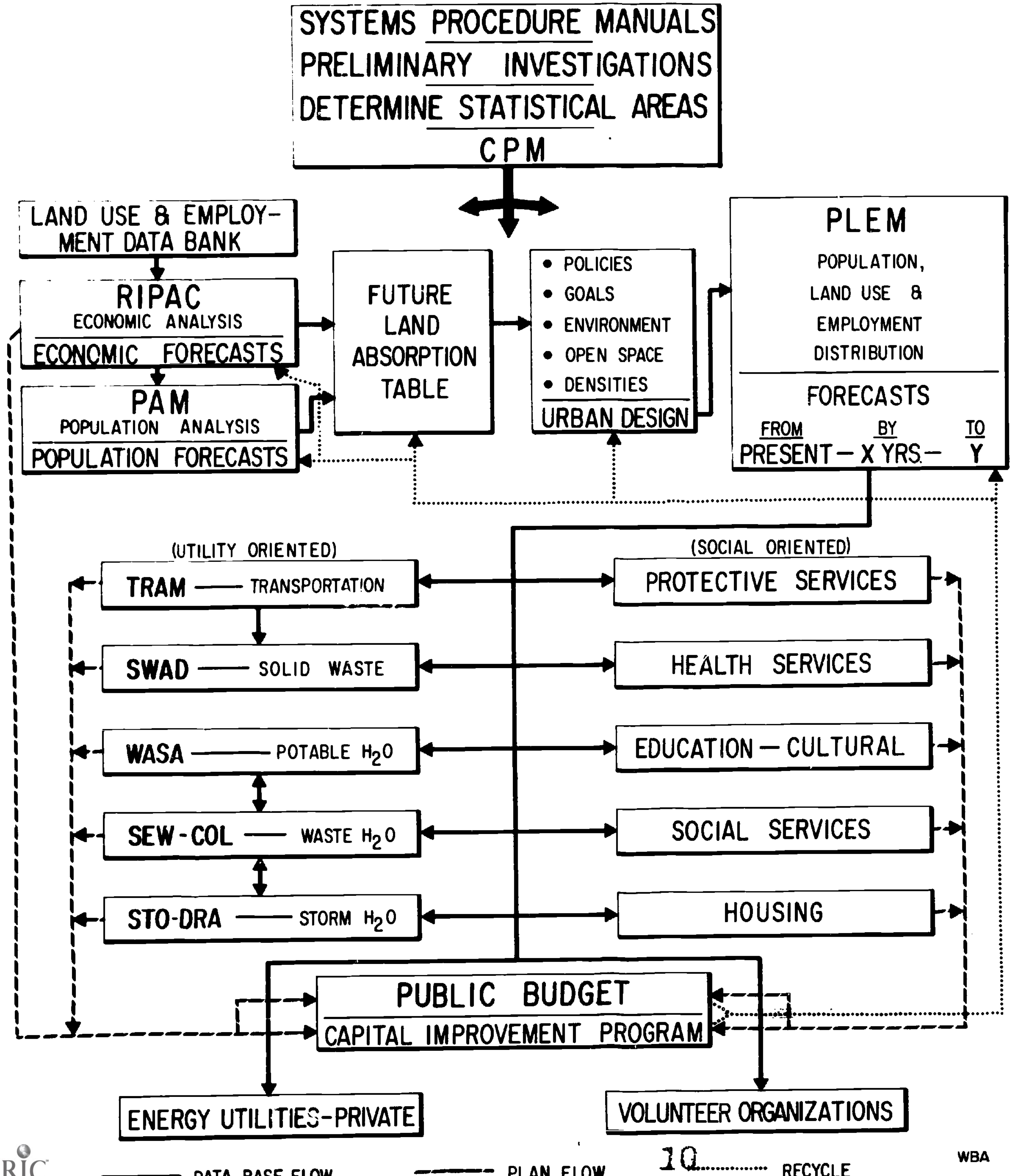


FIG. 3

COMPREHENSIVE URBAN SYSTEMS ANALYSIS

FUNCTIONAL RELATIONSHIP OF SUB-SYSTEMS



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Planners are likely to vary in their preferences as to what constitutes a minimum set of subsystems, but the following with their interrelationships shown in Fig. 3, could form a starter set:

1. Economic Analysis System Model. Regional Income and Product Accounts (RIPAC). Most planning and engineering design criteria are based on an estimate of the future economy of the study area. The most serviceable economic model for general planning at the metropolitan level is based on a regional adptation of income and product accounting coupled with multiplier analysis. It has proved effective in continued municipal use.

Of most interest to planners is the accounting for value added by industrial origin. Employment forms the best proxy for estimating value added while concurrently providing essential input for the transportation, population and utility analysis models. Forecasting is aided by accounting for export and indirect export value added which in turn supports a local sector. The outlook for each industry is estimated with the aid of industry leaders.

2. Population Analysis Model (PAM). For most metropolitan areas, growth or decline in population correlates with economic opportunity and therefore total population (with some sociological inputs) is primarily a function of the economy portrayed by the RIPAC model.

3. Population, Land Use and Employment Distribution Model (PLEM). The geographic distribution of activities (land use) within the metropolitan area is the key plan element which supports the design criteria for almost all other functional elements of planning and engineering. The RIPAC and the PAM models yield data for the construction of land absorption tables. The PLEM model is an accounting framework for the assignment of land uses to small geographic areas. Data about the present and judgements about the future are recorded for each small area. The model quickly summarizes the results. It keeps human expert judgement "in the driver's seat" but takes the drudgery out of the operation, so that several different points of view can be easily tested. In order to be of most use for engineering, the future for each small area is carried to a state of maturity or forward for 50 years (y=50). Intermediate year forecasts are developed by selecting a development pattern curve and allowing the computer to prepare the forecast tables. Design engineers usually want intermediate forecasts on five year intervals (x=5).

4. Transportation Analysis Model (TRAM) (could be TRANPLAN or FHA package). All metropolitan areas, if they are to receive Federal transportation funds must be involved in continuous and comprehensive transportation planning. The output of the preceding subsystems, along with inventory

type subsystems, provide direct input to the transportation model. If the preceding models are current, then this element can also be kept current.

5. Water System Analysis (WASA) (could be FLOWNET). Outputs of PAM and PLEM, along with inventory data, form the basis for analysis of the flow characteristics of a water system. Computer assisted models can be used to optimize the operation and construction of a water supply system.

6. Sanitary Sewerage Collection and Treatment Analysis Model (SEWCOL). Sewerage analysis models have as their primary input, the results of the PLEM model plus inventory information. Collection lines are sized and optimization features indicate the most favorable locations for treatment.

7. Storm Drainage (STO DRA). The sizing of the storm drainage system closely follows the procedure used for sizing the sanitary sewerage system. If an agency is set up for one, only inventory inputs and minor program adjustments are needed for performing the other.

8. Solid Waste Collection and Disposal Analysis Model (SWAD). Many aspects of solid waste collection are analogous to transportation planning problems. Data prepared for transportation analysis can be used directly for solid waste analysis.

9. Capital Improvement Programming (CIP). The orderliness and science made possible in public administration by the use of the systems analysis mode of operation will be greatly diminished if the work is not carried through to an orderly capital improvement programming procedure. This activity should be thought of as consisting of two parts: 1) organized project lists with costs, and 2) fiscal capacity. Every facility which is finally retained as an identifiable project in a comprehensive plan should be costed and entered into the capital improvement program project file. This should be done even if the project is not contemplated for immediate construction. The inclusion of such projects in the program analysis will assure that the comprehensive plan is realistic. This does not mean that planning organizations should refrain from considering highly innovative approaches. After all, who in the 1940's would have taken seriously the probability of an Interstate Highway program? Systems analysis makes possible the evaluation of these alternatives and the setting in motion of a search for currently nonexistent fiscal capacity to carry out innovative programs. Costs should be segregated at least into 1) land, 2) improvements (construction), 3) recurring operation and maintenance and 4) relocation responsibilities.

The second aspect of capital improvement programming, fiscal capacity, can be handled expediently with the use of RIPAC.

Housing and potential relocation workload analysis should be another continuing activity. The land use model and the capital improvement program form a good basis for this analysis.

Conclusion

This paper has presented a plea for the use of the systems analysis mode of operation in providing a common basis for building urban complexes. It implies that current practice is inefficient due to duplication of effort in some cases and a lack of adequate effort in other cases. An orderly consolidation of effort and the judicious use of computers can allow for better analysis with the same amount of effort.

Detailed data banks and sophisticated procedures are not necessary to obtain this improvement. If current projects are based on informed judgement with a minimum of factual data, then the use of these same judgements in a systems framework will be an improvement over present procedures.