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ABSTRACT

This document dates from 1966 and is thought to be primarily useful in allowing the reader to trace the evolution of this model from its earlier stages to completion. M.E.T.R.O. is a gaming simulation which uses techniques of war gaming as a tool for coping with current and anticipated urban problems. At this stage in its conception, M.E.T.R.O. was designed to have 16 or 17 players, plus a staff of six to 10 more people (composed of team advisors, a judge, and technical personnel). Each player belonged to two types of teams: 1) a team representing a central city, suburb, or urbanizing township, and 2) a team representing particular important urban roles that discuss metropolis-wide policies (politicians, planners, school people, and land developers). It was part of M.E.T.R.O.'s intention to illustrate typical interaction patterns and joint-problem solving among urban decision-makers. In such dual roles, a player would be subject to contradictory pressures, depending on the teams he was on. The rules and techniques of the simulation, which used a computer, are described here. Extensive documentation on the later stages of M.E.T.R.O. is available through the Environmental Simulation Laboratory at the University of Michigan. (JK)

M.E.T.R.O.

A GAMING SIMULATION

Toward a New Science of Urban Planning

M.E.T.R.O.

Report on Phase I

M.E.T.R.O. Project Technical Report #5

January 1966

Tri-County Regional Planning Commission

Lansing, Michigan

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". . .There is a play of possibilities and probabilities, of good and bad luck, which permeates every thread, great or small, of its web and makes war, of all branches of human activity, the most like a game of cards."

Karl Von Klausewitz *

* Quoted in Abt, Clark C., *War Gaming*, International Science and Technology

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

I. INTRODUCTION

The M.E.T.R.O. project "effectuation model" described in this report is unique in its use of the ancient technique of operational gaming (war gaming) as a tool for coping with current and anticipated urban problems. As with its military antecedents, it is intended to serve as a training device, a research tool, and, ultimately, as a decision aid under operational circumstance. The importance of gaming to the military is highlighted by the following quotation:

> "Today's games, models, and simulations of war deal with most operational and functional aspects of the military establishment. From games originally developed to train officers in infantry tactics and logistics, war gaming has now expanded to include R & D, production, deployment and operation of ground, naval, air, and space weapon systems, command systems communications, intelligence, and logistics. *It may not be an overstatement to say that no technical and operational evaluation of a weapon system, military tactical doctrine, or national strategy will be complete without including some form of gaming and/or model simulation.*" [1]

During the past few years, there has been an upsurge of interest in analyzing, improving, and teaching decision-making techniques by using systems approaches to expand operational gaming. This combines computer simulation with gaming. Both diplo-military and business gaming are intended to help administrators, politicians, and scientists better understand extremely complex social systems and then develop efficient problem-solving strategies and research strategies. It is time to extend these techniques to urban problems and basic urban research. Many can profit from gaming simulations of urban areas: a) urban planners; b) the various professionals concerned with health, education, welfare, housing, transport, or civil rights in urban areas; and c) social scientists concerned with different aspects of urbanism.

Formal city plans have evolved through several generations: (1) initially, "Master Plans" were prepared by professionals using internalized heuristics or "rules of thumb." These were characterized by a concentration on physical

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[1] Abt, Clark C., *War Gaming*, International Science and Technology, August, 1964. (emphasis ours)

growth and a basic generality of presentation; the goals, objectives, criteria, standards, or underlying models were seldom explicit. Further, they were for "ideal" or optimal growth at some specific future time. (2) The "Comprehensive Plan" approach evolved from this and has been in vogue since World War II. This has tended to be more "scientific" in that it is less the visceral reaction of any one individual; more oriented to social and economic considerations than purely physical design; and, finally, more likely to be the product of a coherent and visible set of goals, procedures, and specifications applied against some coherent model of the urban structure. (3) Most recently, the Comprehensive Plan has evolved to include policy plans, formal models and simulations, the preparation and testing of alternative plans, and the provision of some mechanism for frequent review and updating. In many cases, rudimentary "data banks" are employed in this regard. This latest generation of plans is characterized by high levels of cost, great complexity, limited flexibility, and the same difficulty in enforcement that has plagued all generations of plans.

Plan effectuation, or the implementation of specific proposals, has always been a weak link in the planning chain. The first generation of "Master Plans" failed, by and large, because they did not present realistic alternatives; second generation "Comprehensive Plans" similarly were of restricted value, more because their increased sophistication and complexity resulted in recommendations which could not readily be transmitted to the decision-makers of the community. The latest generation of plans has vastly increased the gap between the urban "plan-makers" and the "decision-makers" they attempt to serve.

> "Similarly, we are edging toward the notion of posing *alternatives* for future metropolitan structure, as a practical planning and research principle. Two of the most famous current planning efforts have applied this principle in entirely different ways: the Penn-Jersey Transportation Study, in order to provide a framework for utilizing the most advanced model-making computer techniques; and the Year 2000 Plan for the Washington region, to give the public a persuasive image of what the future could be like. What may be needed is some combination of these approaches, if we are to cope with the metropolitan wilderness. Our models will be hypotheses, not Utopias, but they will help us to assemble the bits and pieces of knowledge in a way that is meaningful, not only for expert understanding and judgment, but also for public communication and decision." [2]

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[2] Wurster, Catherine Bauer, *Summary Remarks*, Urban Expansion - Problems and Needs - Papers Presented at Administrator's Spring Conference: April, 1963.

The same gap (between formal analysis and introducing changes) also exists for urban researchers who want good use made of their findings and for federal administrators who want to introduce new programs in given urban areas. The extremely complex tasks of translating concepts to policies and then to effective action in urban areas can better be investigated by these persons as well, via gaming simulations. In the same fashion, the budding professional can be introduced to his field far more effectively with these same techniques.

The M.E.T.R.O. project will attempt to close this gap, utilizing operational gaming techniques to develop a plan effectuation instrument. The instrument will have the capacity of demonstrating to appropriate human decision-makers the consequences of alternative decision chains on metropolitan growth patterns. This will be accomplished through the use of a simulated, abstracted environment, employing a reduction of time span and dynamic inter-play of current decisions with fixed policies. The instrument is intended to simulate growth patterns which should occur naturally and enable their comparison with planned growth patterns. In addition, M.E.T.R.O. will be designed to: (1) illustrate the kinds of information which are available to decision-makers (*e.g.* data banks), (2) inform the decision-makers about the techniques which are available to evaluate and implement decisions (*e.g.* mathematical growth models and capital improvement programs), and (3) provide information concerning the implications for urban development which are associated with alternative courses of action.

This technique will introduce a dynamic quality into urban "plan-making" activities and allow for a structured interplay between those concerned with plan design and the "decision-makers" upon whom the plan's ultimate implementation depends.

2. THE NEW SCIENCE OF URBAN PLANNING

Urban plan-makers have turned to the technique of simulation with increasing frequency in recent years. Their efforts have ranged from the identification and modeling of some relatively simple components, such as shopping-center locations and the design of detailed traffic facilities (queuing problems in bus terminals) to sophisticated efforts at modeling complex groupings of components, as is represented by the linking of transportation models with land use, employment, and population models in an attempt to simulate complex urban growth patterns.

The conceptual basis for these efforts at urban simulation is borrowed in large part from systems theory, a comparatively recent but rapidly emerging field which allows rigorous inquiry into phenomena associated with physical systems. The basic approach used is the identification of all components, or sub-systems, of the system under consideration; the modeling of each of the sub-systems in mathematical format; the linking of these sub-systems by a macro-model stated in similar terms; and finally, application of those formulations for problem solution, normally with the use of a computer.

The transference of these notions to social systems presents many obstacles. An urban center, for example, is extraordinarily complex, and considerable difficulty is encountered in the prime step of identification of components. Abstraction to a minimum number of components is mandatory and requires subjective selection, presenting great difficulty in evaluating the appropriateness of the selection which has been made. In physical systems studies, the components are tangible and lend themselves to consistency of measurement, a function which has become institutionalized in the Federal Bureau of Standards. The components of a social system, particularly the ubiquitous and troublesome homo-sapiens, are nowhere so convenient to deal with. True, when working with large groups, significant generalizations can be drawn (witness the success in forecasting the results of the recent election), but many urban phenomena are greatly influenced by individuals or comparatively small groups. Unfortunately, the modeling of individual human behavior, even under extremely simple circumstances, has only begun. This implies that a man-machine linking may be mandatory for the effective modeling of certain components.

Data requirements also differ considerably. In social systems, many types of data (attitudes and values for example) are not easily stated in quantitative terms. True, there are many physical manifestations from which these can be deduced (vehicle preference, housing styles, mode of living), but currently this requires the accumulation of vast quantities of data (demographic housing, socio-economic) because no coherent theory of the urban phenomena exists which allows the acquisition of minimal critical data required for an efficient control system.

Physical systems are comparatively simple to replicate since the components are tangible, and this allows for repeated controlled experiments. Social components are frequently intangible, always dynamic, precluding comparable control situations.

Finally, there is an increasing gap developing between the plan-makers and the decision-makers. The plan-makers, in attempting to develop more sophisticated techniques, find communication with decision-makers reduced to the presentation of alternative solutions for their choice. Decision-makers, confronted daily with expanding urbanization, must make a choice either in the context of gut-level logic or abstract and vaguely understood plans, with the prior consideration winning out all too frequently.

2.1 OPERATIONAL GAMING

Operational gaming is one technique which might be developed to alleviate this situation. This involves the utilization of typical real-world role players placed in a simulated, abstracted environment and linked to the sophisticated simulations in some realistic context. This technique enables the decision-makers to experiment with alternative strategies, to interact in a dynamic fashion, and consequently, to more effectively replicate a social system. The plan-makers can, in return, study the responses of these decision-makers under varying conditions. This may prove to be an effective calibration technique, with the subjective judgments of "real-world" decision-makers being substituted for a "Bureau of Standards." Finally, by creating a structured man-machine link, a much richer simulation may result.

It should be emphasized that there is no theory of optimal solution that can be derived from operational gaming. Rather, the technique serves as a learning environment, a substitute for an expansion of experience. It is of potential empirical value particularly because it enables the player to experiment with a new set of heuristic procedures. Operational gaming becomes increasingly possible as the various efforts at urban simulation advance.

The operational gaming technique itself, in at least rudimentary form, is as old as recorded history in the form of war gaming excercises and was a critical element in developing the strategies of some of the major campaigns of World War II.

Since World War II, the business world has made extensive use of gaming, both for training and for operational purposes. This rather dramatic increase in the use of gaming has been given impetus by several factors:

(1) The advent of electronic computing and data processing equipment capable of handling the tremendous volume of data at the necessary speeds.

(2) The development of a variety of cross-disciplinary techniques which have made possible a more sophisticated instrument.

(3) The critical need to develop improved management techniques if highly competitive, complex businesses are to survive.

A parallel need has developed in the management of our urban regions. These highly complex, rapidly growing areas are a major national resource, and large sums of federal money have been allocated in recent years to improve metropolitan planning. Two products of this effort have been: (1) the vast improvement in urban data handling techniques, such as the so-called urban "Data Banks," and (2) the development of increasingly sophisticated "growth models" for transportation and land use planning. As a result, for the first time, the professional is potentially able to present alternative plans to the decision-making body.

In spite of these improvements, these plans are not entirely satisfactory: first, because they unrealistically restrict the real alternatives available, and second, because they do not give adequate recognition to the variety of impacts which are possible from different decision chains by the various sectors of the community which influence physical growth patterns. For example, categories of private households are assumed to have certain characteristics in terms of levels of service desired, expenditure patterns for housing or transportation, etc.; and these patterns are, in effect, projected as being applicable in future years. This use of operational gaming allows the introduction of persons from appropriate community roles, whose decisions are fed back into the model each cycle. This dynamic model allows a continually changing response as environmental conditions are altered, and as private selections for expenditure of time or money alter impacts on public service systems.

It is not suggested that this technique will tell us the precise growth patterns of various decision chains. The technique should be more accurate than conventional growth model techniques (the models employed will be the same in either case), because in the operational gaming approach, certain inputs will be generated each "year" by human decision-makers. Further, it should give improved insight to the various decision-makers involved in the evolution of each alternative growth pattern, since the assumptions and variables involved will be made more explicit. Also, these decision-makers will be personally involved in the process.

A basic premise on which this proposal rests should be explicitly stated: Those who presume to formally control the destiny of an urban community by guiding the physical development must know both the probable pattern of growth and the desired "plan" before a reasonable effectuation strategy can be devised.

Another inherent assumption is that the processes under consideration are intra-metropolitan. Competition *between* different metropolitan areas and their relative rates of growth *is explicitly excluded* as a consideration in this research. Rather, an attempt will be made to simulate the distribution of a given level of growth within the metropolitan area (as generated by the growth models developed for the regional plan).

2.2 "METROPOLIS" - A Prototype Urban Game

Extensive experience has been gained with "METROPOLIS I," which was designed for use in training students in urban planning. This "game" familiarizes the student with some of the more significant community decision-making roles as they relate to community growth patterns in the context of public and capital improvement expenditures, since these decisions are critical to urban growth patterns. Emphasis is placed on the roles of the major players, the importance of capital improvements on the physical development pattern of a community, the effects of various community issues, and the linkages between the players, the capital improvements, and the issues. Timing also is stressed, both in terms of a typical sequence of events and particularly in the long-range consequences of individual or group decisions.

The setting for METROPOLIS is a hypothetical, abstracted community (Lansing, Michigan) in which players are placed in a dynamic setting and forced to choose a course of action from various alternatives. Simultaneous decisions are required on a two-level basis at each cycle: The first level of decision is private and involves personal gain; the second involves some public issue, generally a capital improvement. Resources are limited for each level of decision, and each decision results in deterministic consequences at a later date. The second level of decisions evolves around the capital improvement program with each player able to influence, and be influenced by, the program. In effect, this technique results in three separate games linked into one play. This permits a greater potential for synthesis by the student and allows a more complex institution to be simulated. This pattern will permit the development of future sub-games which can, in turn, be linked to the parent simulation.

METROPOLIS has been run in excess of thirty times, with the participants varying from undergraduate students (5 runs) to graduate students (9 runs)., professional planners (6 runs), lay citizens (4 runs), and experimental (6 runs). This experience has been useful in designing the current decision exercise.

2.3 THE M.E.T.R.O. PROJECT

M.E.T.R.O. (Michigan Effectuation, Training, and Research Operation) is an integral part of the overall regional planning program. A continuous effort has been maintained to insure that the final product will serve the intended purpose--to facilitate the implementation of the regional plan. This coordination of effort has been achieved through:

(1) Integration of personnel (many staff members have worked on both the Effectuation Model and other work elements of the Regional Plan).

(2) Joint scheduling efforts (close liaison has been maintained to insure that the timing of both projects is coordinated).

(3) Mutual development of growth models and related work elements (sustained effort in the joint development of growth and distribution models has been maintained).

(4) Joint development of data sources (the development and maintenance of necessary data files has been closely coordinated--example includes land use information, census data, record plats, Dun & Bradstreet listings, etc.).

(5) Continual review of M.E.T.R.O. activities by appropriate Tri-County personnel.

Once the basic regional studies have been completed, plans have been developed and consensus on a particular course of action has been agreed upon, the prime task facing the Tri-County Regional Planning Commission is that of plan effectuation. Since this agency is restricted, more or less, to methods of persuasion, as opposed to methods of absolute control, the available strategies and techniques for influencing local decision-makers must be thought through in detail. The effectuation model is specifically designed toward this objective. The M.E.T.R.O. operational game will be essentially a highly specialized educational instrument oriented toward physical planning. A large part of a plan effectuation effort can be legitimately described as an educational process. Several specific examples may help to illustrate the point:

1. The actual physical pattern which emerges in any metropolitan area is the result of many actions by private and public decision-makers. A prime purpose of the Regional Development Plan is to influence these key personnel to mold their decisions in the public interest. This requires more than casual communication of the essence of the plan. The technique employed in the Effectuation Model--operational gaming--is of proven ability in parallel situations. The "environment for learning" places the decision-maker in a simulated environment where he can be exposed to the plan's structure in context.

2. The Effectuation Model is designed to demonstrate the effects of a series of individual decisions on the urban growth pattern. This can be done in conjunction with, or isolated from, the plan's objectives; in either case, the resulting congruence or disparity can be effectively highlighted.

3. Through the use of operational gaming, individual decision-makers can pursue a particular course of action, altered on subsequent trials, to explore possible outcomes of different approaches to a problem.

4. Of prime importance to any plan effectuation effort is communication with elected officials. Even if it were possible to convey the necessary essence of any regional plan to such a group, there still would exist the difficult and continuing problem of disseminating this information to newly elected officials. Operational gaming is a technique which can be used to quickly develop rapport while conveying basic plan elements and concepts.

The broad objective of the M.E.T.R.O. project is to develop an instrument which has the capability of demonstrating to professional planners, and to appropriate human decision-makers, the consequences of alternative decision chains on the metropolitan growth pattern. This will be achieved through the use of a simulated, abstracted environment, employing a reduction of time span and dynamic interplay of current decisions with fixed policies. The technique is intended to simulate growth patterns which would occur naturally and enable their comparison with planned growth patterns.

Specifically, operational gaming techniques will be of value in plan effectuation and as training aids. In the area of plan effectuation, operational gaming will evaluate the relative "fit" of various alternative plans--land use, transportation, and public facilities--proposed by a metropolitan planning agency to the probable growth pattern resulting from typical decision patterns of local governmental units, with respect to formal development controls and both implied and explicit policy decisions. The extent and nature of the discrepancies can be utilized as a guide in the selection of alternate plans, and as an indication of the specific areas of local governmental control which must be altered to insure decisions in keeping with the selected plan. In addition to testing which alternative has the greatest relative likelihood of success, the technique will be useful in suggesting modification of alternatives.

As a training aid, operational gaming can enhance the understanding of metropolitan growth processes by the professional planning staff, local governmental officials, and planning interns. Professional planners, by being placed in various local government roles, can gain insight through this new perspective; specific functional processes can be demonstrated to local officials in the expectation of gaining greater acceptance of a given policy or particular facet of the plan; and finally, neophyte students can more readily acquire a perspective of important metropolitan processes by participating in the simulation.

To encourage innovation, both by planners in the development of alternative plans and effectuation programs, and by officials in their administration of these plans and programs, the M.E.T.R.O. simulation is intended to be sufficiently flexible to allow low-cost experimentation with the effects of alternative policies on growth patterns, including alternative mechanisms for land use controls, such as a regional authority and, perhaps, alternative methods of taxation.

2.4 COMPUTER ORIENTED PLAN EFFECTUATION

The M.E.T.R.O. project is designed as a parallel operation to the regional growth models which are modified to permit the impact of gamed decisions to be injected into each iteration, as well as to output appropriate feedback at the end of each cycle. (See Figure 1).

A specific "game" will be constructed for each team, with sufficient detail to obtain realistic behavior on the part of the players. These will have to be linked into an overall game to effectuate a realistic interaction among the teams. (See Figure 2).

Typical decisions required of each team (different in detail and scope as appropriate to the particular unit of government under consideration) will be of three main types--budgets, issues, and policies. The rationale for this is briefly described below:

1. Budgets - Each unit of government is accustomed to making an annual commitment of funds. Many policies are implicit, or revealed in the distribution of funds by a unit of government, and these decisions can represent a more meaningful revelation of actual policy than can more explicit statements drawn from these office holders. In the budget function, the distribution of formal funds--governmental expenditures--as well as that pressure exerted on or by informal funds (influence on or by private investment capital), will have to be recognized.

2. Issues - Each governmental unit will have to be confronted with various issues in the form of specific projects, a referendum, or simply a secret poll on opinions. These will be translated into an index by a conversion program.

3. Policies - Each governmental unit has a series of policies under which it operates. Some of these are explicit; many more are implicit, based on tradition or custom for that particular unit. In either case, these policies are the standards, or decision rules which control the behavior of that unit of government under certain circumstances.

Figure I

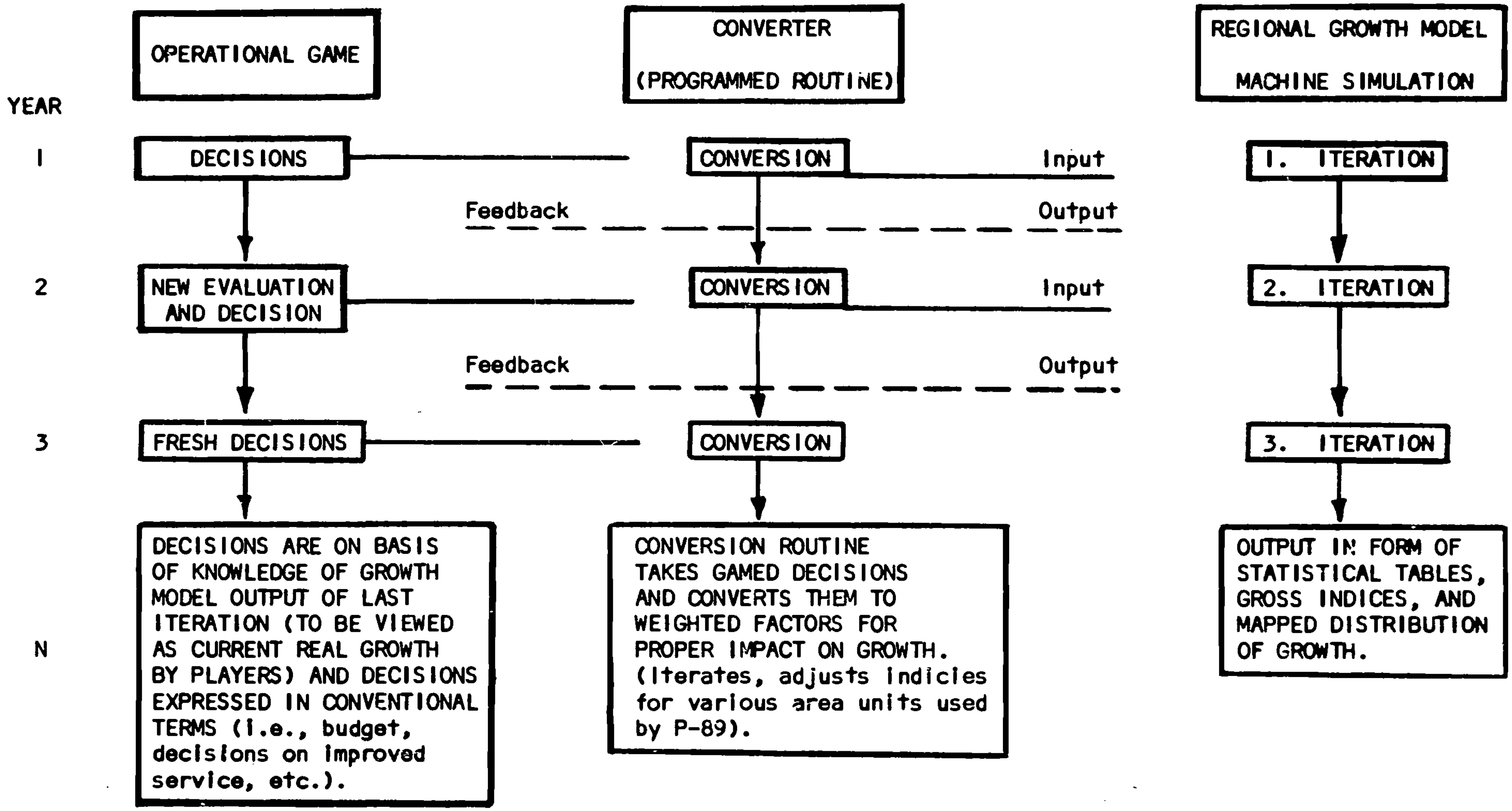
OPERATIONAL GAME
CONVERTER (PROGRAMMED ROUTINE)
REGIONAL GROWTH MODEL MACHINE SIMULATION
YEAR
1
2
3
N
DECISIONS
CONVERSION
Input
1. ITERATION
Feedback
Output
NEW EVALUATION AND DECISION
CONVERSION
Input
2. ITERATION
Feedback
Output
FRESH DECISIONS
CONVERSION
3. ITERATION
DECISIONS ARE ON BASIS OF KNOWLEDGE OF GROWTH MODEL OUTPUT OF LAST ITERATION (TO BE VIEWED AS CURRENT REAL GROWTH BY PLAYERS) AND DECISIONS EXPRESSED IN CONVENTIONAL TERMS (i.e., budget, decisions on improved service, etc.).
CONVERSION ROUTINE TAKES GAMED DECISIONS AND CONVERTS THEM TO WEIGHTED FACTORS FOR PROPER IMPACT ON GROWTH. (Iterates, adjusts indicies for various area units used by P-89).
OUTPUT IN FORM OF STATISTICAL TABLES, GROSS INDICES, AND MAPPED DISTRIBUTION OF GROWTH.

Figure 2

GAME OPERATIONS

Gamed

1. Decisions
2. Structured Interaction
    a. Politicians
    b. Land People
    c. Planners
    d. School People
    e. Judge
    f. Central City People
    g. Suburban People
    h. Urban Township People

Operator

1. Staging
    a. Strategy
    b. Tactics
2. Player Briefing
    a. Pre-game information
    b. Post-game debriefing
3. Translation for machine of gaming outputs
4. Interpretation of machine output for players

Automated

1. Data Bank
    a. Newspapers
    b. Projections and Surveys
    c. Public Opinion Poll
    d. Etc.
2. Sub-routines
3. Processing
4. Input
5. Output
6. Accounting
7. Simulated
    a. Households
    b. Industries
    c. Commerce

Explicit Policies are evident in the form of zoning regulations, subdivision controls, utility extension policies, and recorded opinion on issues such as annexation vs. incorporation. There are, of course, many other examples.

Implicit Policy is evident in more subtle and perhaps more revealing ways. The ratio between actual and assessed value of property; types, levels, and costs of services provided; extent of professionalization of public employees; and many other factors are indicative of the general state of management which might be expected. The reaction to contrived, but typical issues, may also be revealing (*i.e.*, the suggestion of some innovative approach for coping with a problem, as the creation of a regional authority).

In each case--budgets, issues, and policies--the results of fresh decisions (annual budget) or of changed policy (change in ratio of assessed value to real value) must be recorded for each cycle, converted to an appropriate index, and applied, through the use of the growth models, to all geographic units having similar characteristics, thus setting the stage for a new machine iteration of the appropriate growth model. This iteration may represent a higher level of accurate prediction than the models presently being synthesized.

The main characteristics of the model are the interaction of typical teams representing the more significant forms of local government. These will represent such units as counties, townships, villages, towns, cities, school boards, and possibly special districts and state agencies. These "teams" or "roles" will be required to make decisions normally expected of the unit of government they represent, according to the major functions provided by government (education, provision of utilities, and other services--fire and police protection, road construction, health services, etc.).

At the end of each cycle (a simulated year), these decisions will be input into the converter, isolated by function, and converted to adjusted indices for each of the geographic units used by the growth models. The output will, in turn, be fed into the models, where it will be iterated until the conclusion of the cycle when fresh output will be generated.

At this point, another concept inherent in the project must be introduced. First, the essence of any successful simulation is abstraction at an appropriate level; if we duplicate precisely, we are no longer simulating, but recreating in the real world. In this case, we abstract to convenient geographic units--minor civil divisions or census tracts for example--which are in some sense modular. Second, we game for each typical modular unit (suburb, township, city, etc.) and attribute the gamed results to all like units, using a technique similar to that made popular by the "vote profile analysis" conducted by the major networks on election nights.

A difficult problem at this point is to develop a meaningful set of indices which describe each modular unit. One example is an accessibility factor, which indicates the convenience of the area to the transportation net and which will be developed as part of the land use and transportation study. Other indices will indicate availability of land, the desirability of land for the various land uses, and the probable attractiveness of the land for development purposes. These are based on the decision patterns of the different units of government, as for example, in the general aggressiveness of a particular area in providing public services for new growth. The "growth attractiveness" index will be designated to compensate for central place tendencies and other clustering phenomena.

The model is designed to assist the professional in plan implementation through making explicit the impact of public policy decision on urban growth patterns in a simulated community. The objective, in one sense, is an "instant plan"--a dynamic, continuing plan which can be revised periodically in lieu of a formal, static, traditional "plan" for some future time period.

2.5 APPLICABILITY OF THE MODEL TO OTHER URBAN AREAS

It now appears that the model will be more abstract and generalized than was initially anticipated. The instrument is likely to be useful in testing alternative plans at fairly abstract levels, and it should be readily transferable as a technique to other communities (where local data and circumstances could be used).

The casual observer of the empirical basis for the M.E.T.R.O. model is likely to remark that choosing the Lansing-East Lansing metropolitan area does not leave any scope for generalization to other areas. It is a truism that any urban area is a product of its economic base, which is shaped by its major firms; and after all, how many urban areas have an automobile plant, a state government, *and* a major university? However, this misses the point of our analysis. Those characteristics essential to the economic base, which are generated by dominant firms, are:

1. The spatial patterns and location economics resulting from growth.
2. The character of the demands for urban services made by the firms' employees.
3. Those employees' household consumption patterns.
4. The ancillary businesses generated by activity of firms in the local area.

The dominant firm is an exporter to the "rest of the world"--the national, or extra-regional, economy. Hence, its actual product is nearly irrelevant to the local urban region, so long as its employees are paid. What counts is the inherent stability of its industrial or commercial type, its growth rate, and the type of employees it hires.

From this viewpoint of the generalized urban impact and character of nationally, or extra-regionally oriented firms, there are strong advantages to choosing Lansing. (Let us note that the Lansing area is a middle-sized urban complex and can therefore cast some light on both the problems of the small city and the major metropolis; also, the Lansing area is relatively autonomous--it is not a mere satellite of a major metropolis as are so many cities of its size). The impact of Lansing's basic firms on the urban area gives a picture that is almost proto-typical in its representativeness:

1. A large firm in heavy industry, with employment and business growth that fluctuate violently around the trend of the national economy and a very large blue-collar work force (Oldsmobile), can be seen as typical of what steel, transport, and machine tool manufacturers do to the local urban scene.

2. A fairly large "firm" whose business is essentially clerical and other white-collar transactions, with a slow-growing and highly stable employment and business outlook that is a muted reflection of the national economy (state government), can be seen as representative of the minor administrative, clerical, and sales branch offices of national commercial firms, of insurance and banking firms, etc., in their effect on the local urban scene.

3. A high-growth, technologically-oriented "firm" whose major product is usually innovative, and is oriented to research and development contracting with the Federal government; which will hire primarily technical, professional, and administrative personnel, oriented to national and world markets and highly sophisticated in their demands for urban culture and services (Michigan State University), can easily represent the "information, research and innovation" industries such as aerospace firms, electronics and computer-oriented firms, and others making a living from the new technologies.

We thus have each kind of social class of employee and each major form of modern industry and business represented by these three economic dominants of the Lansing metropolitan area. We also have a heterogeneous "other" category for our nationally or extra-regionally oriented firms and for those too small to be individually represented in this model. This category will have characteristics intermediate to types (1) and (2) of our basic firms. It should, therefore, be quite clear that a gaming simulation modeled on the Lansing metropolitan area has a very strong potential for generalization to other areas. Whether one's goals are to have a good heuristic model for teaching professionals and laymen about urban processes, or to try out typical planning alternatives on a representative urban area, Lansing's economic base has the essential elements for a satisfactory gaming-simulation.

One can extend the argument, in fact, to suggest Lansing's suitability as a model for *future* cities, in that the relative proportion of workers oriented to modern technology is *larger* in Lansing than most other present-day cities. It is obvious that planners want urban models that stress the impact of modern technology on growth and decision processes, and to a certain extent, the Lansing area has an unusual suitability for such purposes.

3. THE M.E.T.R.O. MODEL

3.1 <u>THE PEOPLE</u>

As now conceived, M.E.T.R.O. would have 16 or 17 players, plus a staff numbering from 6 to 10 persons (composed of Team Advisors, a Judge, and Technical Personnel....See Figure 3). The large number of players derives from the fact that each player belongs to two types of teams: (1) a team representing an areal unit (Central City, Suburb, or Urbanizing Townships), and (2) a team representing particular important urban roles that discuss metropolis-wide policies (Politicians, Planners, School People, and Land Developers). For example, a player's dual role might be Central City Planner, or Suburban Politician, or Township Politician, etc. This is part of M.E.T.R.O.'s intention to illustrate typical interaction patterns and joint problem-solving among urban decision-makers. As a member of a metropolis-wide team of professionals, the player represents his area's interests in policy discussions. As a member of an areal team, he performs this specialized urban role in standard policy decisions and represents his profession's views, if any. In such dual roles, a player is *cross-pressured*; the decision-rules and rewards appropriate to his professional role may be in conflict with the particularistic requirements of his own area (or government) team.[3] Perhaps the Land Developers are an exception here, since whether to assign particular land players to particular areas is optional with the players. The Land Developers may choose to be as flexible as possible so that each serves all, or varying parts, of the entire metropolitan area.

A few words are in order on the characteristics of our urban roles and our areal government teams. The roles have been decided on after prolonged

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[3] Appendix I contains a player payoff matrix illustrating this: On the outcome of any given issue, a role (*e.g.* that of *planner*) may be rewarded across the board, but an entire areal team is punished (*e.g.* the suburb) so that the player who is the suburban planner is ross-pressured. Many game issues work this way. A player may use any of a large number of "payoff" indicators to evaluate his success in the gaming run. Whether any given payoff is a "success" or a "failure" is up to him.

Figure 3

TEAM MATRIX

Areal Teams

	Central City	Suburbs	Urban Townships	Team Advisors
Politicians	2 or 3	1	1	1
Planners	2	1	1	1
School People	2	1	1	1
Land People	3			1
Judge	1			--

Personnel: 16 or 17 Players
+ 4 Advisors
+ Operating Staff

evaluation of the manner in which the prototype METROPOLIS operated. The choice of four roles represented the maximum number that is workable in the face of using different kinds of governments and the minimum number of roles that gives a reasonable verisimilitude in the decision processes. The key roles of Politician and Planner are obvious in their inclusion. The business community is represented by the Land Developer, whose decisions symbolize those affecting patterns of land use. There are *simulated* business firms in the category of "basic industry," *i.e.* nationally-oriented firms, discussed above, and the category of "endogenous" firms, selling in the local market. M.E.T.R.O. adds the role of "School People"--professional educators and their school boards, lumped into one. This occurred because professionals who played in METROPOLIS argued that so large and rapidly growing a public service as the school (which demands over half the taxes collected and a larger share of the tax dollar every year) should *not* be pre-programmed or simulated in the game. Moreover, school locations affect urban growth patterns. Given these arguments, School People should be brought in for argument and bargaining to see the impact of their policies on urban life.

Interpretation of the various roles is left to the individual player. Players are to be given "stereotypes" of their various roles at the beginning of the game.[4] They are informed that these are derived from analyses of historical behaviors of role holders in the Lansing area but that players may choose to be as liberal or conservative, as speculative or cautious, as aggressive or passive, as they think appropriate. Players may, in fact, wish to lay out a policy for themselves ahead of time and then see how well they can stick to it under pressure of time and circumstances, as well as what impact it has on promotion of the goals they would wish to achieve (*i.e.*, a maximum urban growth rate, personal profit, public welfare, etc.). For this paper, the nature of each functional role (Politician, Planner, *et al*) is best described by the kind of game decisions and activities required of it and by the interaction it has with other roles. Such will be the focus of section 3.5 PLAYER INTERACTION.

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[4] See technical reports referring to player roles.

Choice of the three areal (governmental) teams was conditioned by our concern to represent the heterogeneity of metropolitan areas, *e.g.* differentiating between the concerns of central cities and suburbs. At the same time, since each government needed minimally a Politician, a Planner, and a School Person, it would have multiplied the number of players beyond reason to have more than three areal teams.

However, the game design is flexible enough to encompass one or more additional areal teams, if desired. For the present, we have settled on three kinds of urban areas: the large, densely settled, industrial *Central City*, with its roots in the Nineteenth Century and with growing problems of congestion, blight, and welfare; the upper- and middle-class *Suburbs*, with many comparative advantages, but suffering growth pains and perhaps some difficulties in balancing taxes and demands for public services; and finally, the *Urbanizing Townships*, just beginning to face the advantages and responsibilities of the spread of urbanism into their basically rural areas, with their governments and public services still unadapted to modern life. Each of these differs strongly from the others in terms of governmental organization, political habits, settlement pattern, socio-economic and demographic population composition, and the problems and decisions these conditions generate.

The purpose of M.E.T.R.O. is to set up the three areal teams in a stylized pattern that is of considerable generality for extension of the ideas and problems they generate beyond the specific data of Lansing and its environs. The areal teams' activities represent sub-games that must be integrated into a metropolis-wide game. Hence, considerable effort will be spent in calibrating the M.E.T.R.O. instrument, on the problems of how much weighting to give each team, and on how different the decisions must be between areal teams. As in the real world, the areal teams make the final decisions, while the metropolis-wide functional teams, that meet late in each cycle to represent professional groupings and to discuss regional problems, will have only discussion and advisory roles. The use of "functional" teams allows the emergence of new metropolitan regional pheonomena to be brought home to the players, introducing possibilities of strong advantages from region-wide cooperation of normally competing local interests, and showing how some problems can *only* be tackled region-wide.

The *Operator* is the manager of all gaming functions. This starts with his introduction of the game to the players in a pre-gaming briefing and in his explanation of the game structure in cycle one. Though he is supported by the Team Advisors, (whose functions will be discussed) he is the main coordinator of activities and is the floor manager. Not unlike a director of a play, he supervises continuity of action, choreography of problem presentation, and the evolving pattern of the gaming run. There is a certain "staging" effect in making the issues and decision-constraints seem realistic to the players, and it is this which conditions his interventions into the play of the game. In this context, he adds his explanations to the issues and outcomes reported in the newspaper and interprets the film strips and other visual support materials that are used to introduce new programs and problems. In addition, he receives all forms generated by player decisions, inspecting them for completeness and accuracy before they are submitted to the computer. He supervises the computer processing operation and prepares all computer output for presentation and interpretation to the players.

The Operator also keeps gaming records, putting all player decision forms, information requests, etc. into a file coded by cycle. He receives and collates records of informal player bargains and interactions given him by Team Advisors, and all these are combined with the computer records of the game that are on tape. These give a basis for later research on decision-making and give the background materials for the critique session interpretations at the end of the game run. The Operator gives a post-game review of what happened to the metropolis as a whole as a result of team activities and simulated development patterns. He points out the alternatives that confronted the players (including some decision possibilities they may have missed), indicating the probable course of the game, had something else been done. He moderates discussions of the game by players themselves, and finally, he explains the metropolitan growth trends that the game model projects for the future on the basis of the pattern established by this particular gaming run. He phases out the day's activities by a brief comment on the role of planning programs in the long-run growth of the metropolitan region.

Team Advisors are provided by the Operator as extensions of his function, to smooth the flow of the game by assisting players, and to perform the less obvious function of keeping records of any significant informal interaction patterns between players. They provide the players with technical gaming information throughout the gaming run, such as how to use and fill in decision forms, and they check to see that players make all decisions required of them each cycle. They aid in interpreting computer output and also transmit all decisions and forms to the Operator for encoding and submission to the computer at the end of each cycle. In general, they should retire into the background after the first three instructional cycles and must take care not to bias the game by affecting decision-making.[5] Their record keeping on "informal" interaction is intended to supplement the records kept on the computer. By "informal" we mean interaction or decisions that are not actually punched on cards. Such brief records are used as an aid in the critique session at the end of the game.

The *Judge* is available as a neutral arbitrator of disputes, since players normally develop a strong emotional involvement in, and identification with, their gaming roles. In addition to these active participants in gamed activities, there are several purely technical persons, not visible to the players, who do card-punching, computer runs, and all the other minutiae required to run a successful gaming simulation.

3.2 THE PLACE (See Figure 4).

A room for gaming simulation must be very carefully arranged to facilitate interaction among players, giving them appropriate degrees of access to one another. If one chose, the arrangement of tables for teams could aid in the dominance of one team, merely by placing that team in the center of the traffic flow at the most accessible location. We have chosen a neutral,

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5 Clearly, the team advisors must be skilled personnel, not just clerks: (1) They must know the gaming operations thoroughly; (2) they must understand the real-world counterparts of gaming functions and players' roles; (3) they must be sophisticated enough to accurately record interpersonal interactions; and (4) they must be sensitive enough to group dynamics so that they do not bias player interactions or supply too much information, even if players ask for it.

Figure 4
ROOM LAYOUT

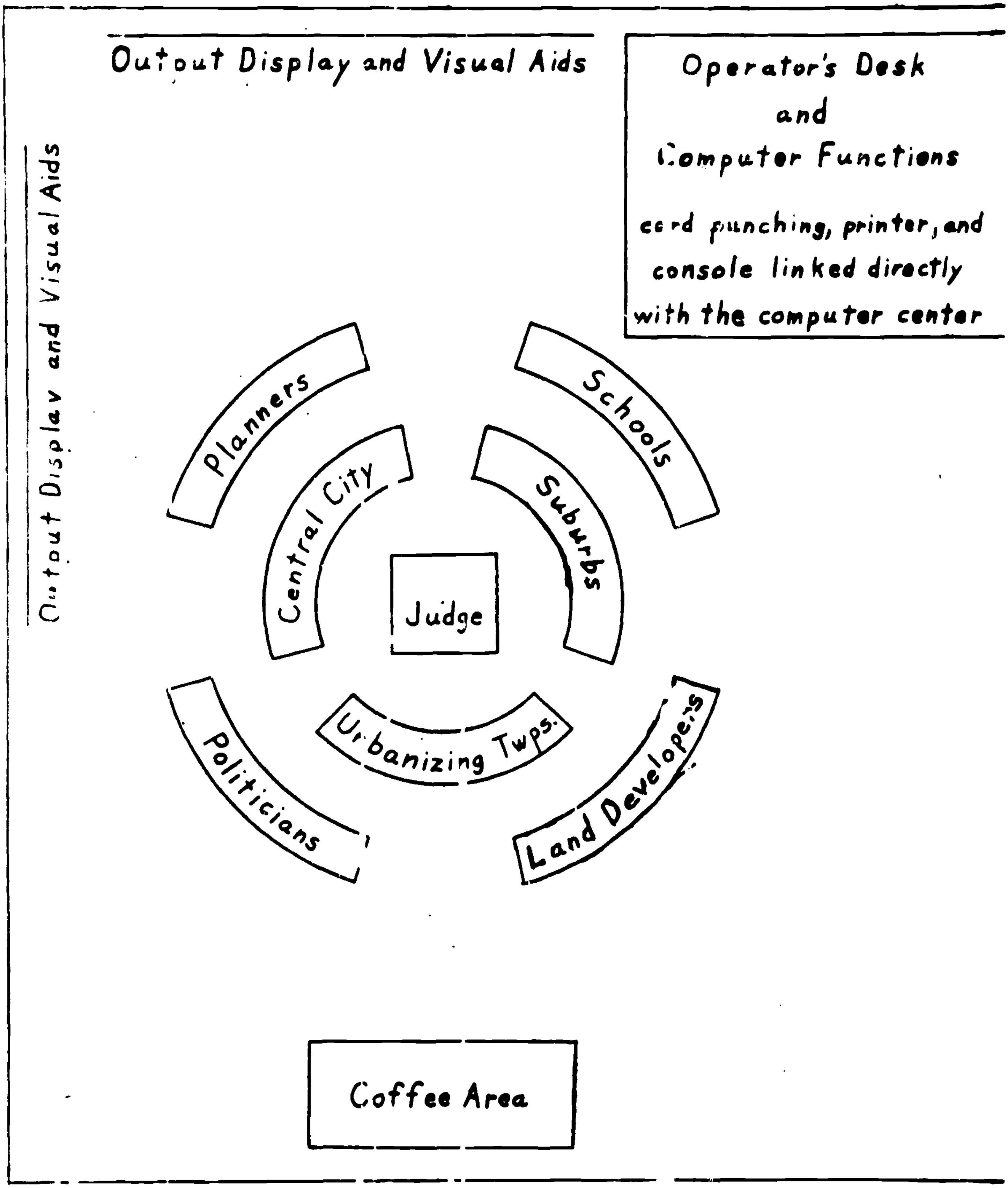
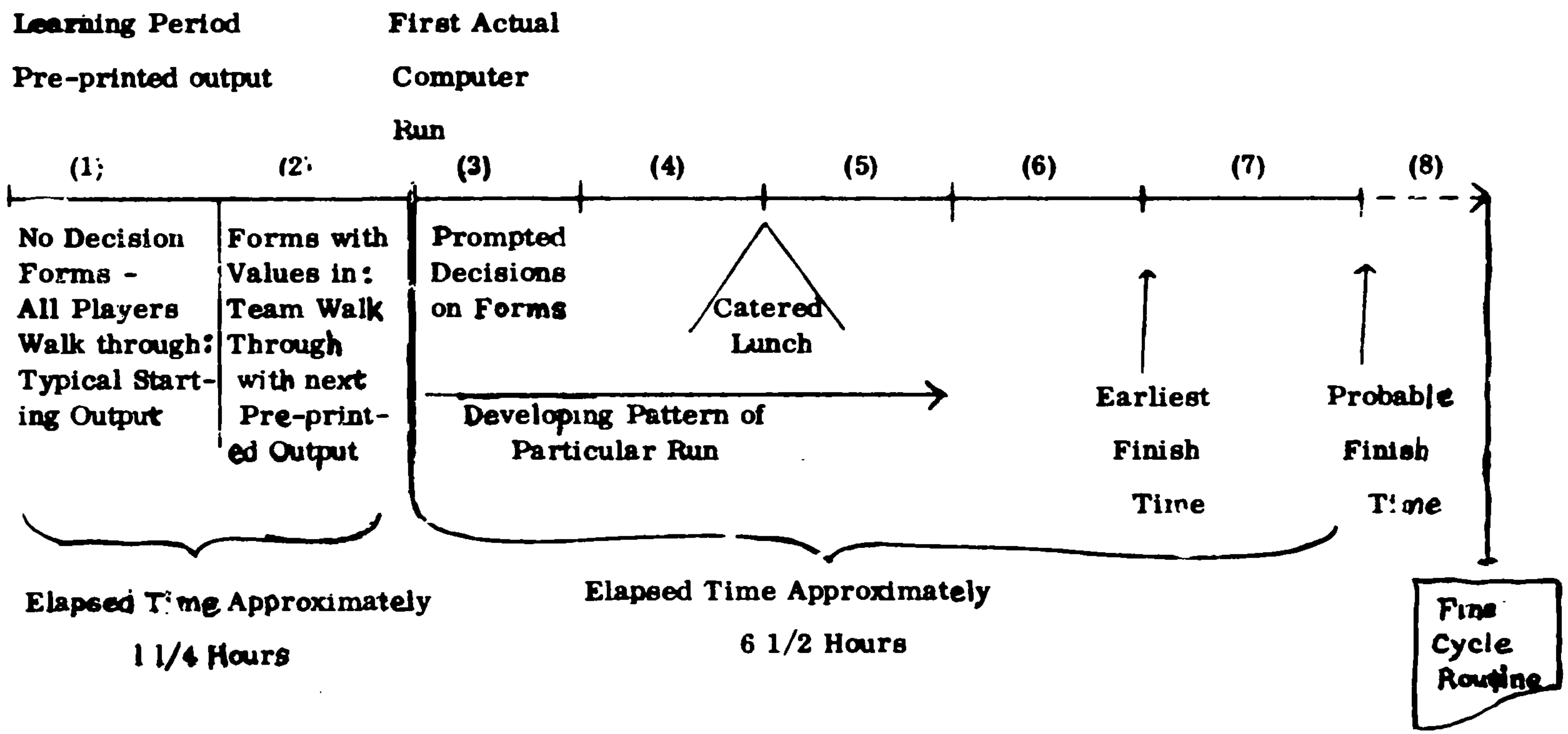


Figure 5

M. E. T. R. O. RUN SEQUENCE

(Activity Types for Introduction, Play and Evaluation of Run)



INPUTS FOR CRITIQUE

A. If session is not successful, we can have an immediate 1 hour critique (4 P.M. - 5 P.M.)

B. If session generates marked enthusiasm, then more extended critique can follow dinner.

Print-outs:

1. of previous cycle
2. 5 year projection (happy ending)
3. 10 year projection (high, medium, low alternatives for teaching purposes, critique, etc.)
4. 20 year projection
5. Gives what long-term policies are required for each areal and functional team.

December 1965

equally weighted pattern, so that any dominance must come from activity patterns of players. In the inner circle of tables are the three decision-making teams of the Central City, Suburbs, and Urbanizing Townships. These are the effective power wielders, for the functional metropolis-wide teams around the outer circle (Politicians or a "Metropolitan Council;" Planners or a "Regional Planning Association;" Educators or a "Metropolitan Educational Association;" and Land Developers or a "Metropolitan Real Estate Board") all have essentially discussion, consulting, and advisory functions. At the utmost center, casting a benevolent eye upon all, is the Judge, ready to perform arbitration functions.

Displayed on one or more walls are such computer outputs as: (SYMAP) maps showing special aspects of the city; statistics on city growth patterns of the last few cycles; the newspaper generated for each cycle; and the personal standing of each player in the game. In addition, various capital improvement projects will be illustrated on a slide screen each cycle. Off to another side of the room is located the computer apparatus used by the game Operator.

3.3 <u>M.E.T.R.O. RUN SEQUENCE</u> (See Figure 5).

The time required for an average M.E.T.R.O. game is estimated at about 9 hours, including pre-game introduction and post-game critique. The average time for a cycle of play (representing one year in the game) will likely be around 90 minutes, depending on the tempo of decisions by the players. If the players have not played in M.E.T.R.O. before, then the first two cycles will be for the purpose of giving a thorough introduction that avoids confusion. The two will last about 75 minutes, leaving time for about five cycles of play in the course of a normal workday. [Experience with the prototype gaming simulation METROPOLIS indicates that players who are wrapped up in the game (a large majority) are quite willing to put in a 10-hour day so extra cycles may be possible].

The two-cycle introduction for beginning players is staged play and walk-through, in addition to broad descriptions of the nature of the game. The pre-game introduction includes a history of the metropolitan region and recent growth trends. The basic gaming roles, teams, and operations are described to the players *en masse* in the first cycle, with stress on a broad overview of the flow of the game and the structure of player interactions. The use of game data and computer printouts of maps (via the SYMAP technique) and the rewards and punishments for players also are described. In essence, the whole of this cycle is displayed and described in conceptual and abstracted form. The first cycle outlines the game, introducing the concept of overall metropolitan-area welfare.

By contrast, the second cycle introduces each player to the roles he will have to play. Players examine their player handbooks for specifics of the decisions they make and how their team is to function. They go over, in detail, the forms that they will use. These are forms still filled in with a pre-programmed cycle. Each player will have a desk-pad type of check list for the activities within the cycle (see the prototype desk pad in Appendix I). Each area team gathers separately with its Advisor to go over the specifics of what factors are taken into account on decisions, how decisions are put onto forms, and how to interpret the results of the previous cycle's output for the next decisions. Individual player payoffs are foreshadowed from examination of output from the first cycle. The use of the data bank will start to become apparent as an aid to decisions, as will the nature of the constraints upon decision-making, including the need for bargaining and tradeoffs between interests. The roles of the metropolis-wide functional teams are discussed briefly, but a demonstration is held off until the third cycle.

It is very important in these first two cycles to keep from unduly confusing players in a complex game, hence the step-by-step staging of an introduction. Naturally, if the players are already experienced in the play of the game, the introduction can be held to a minimum, and play quickly begins. Note that the computer is not actually running in these introductory cycles; rather, pre-printed materials will be used that have been specially selected for their heuristic value.

The third cycle uses the first actual computer run, simulating growth and redistribution of the urban population, the activities of business firms and households, and the response of voters to candidates and issues. Players make their first actual decisions (with limited prompting by Team Advisors) and start investigating possibilities for informal bargaining and interchanges. All further play is conditioned by game contingencies and is the gaming simulation proper. Players are beginning to learn that they must live with the effects of decisions of many years earlier and that they will live with this year's (this game cycle's) decisions for many years hence. The value of compressing several years' experience into a few hours becomes especially apparent, for feedback on decisions comes within a few minutes' time.

Lunch is brought in (catered) to the playing area around the fourth or fifth cycle, and players may take a short lunch break or eat on the run. (In successful runs of METROPOLIS, they were immersed enough in the game to choose the latter). Play continues. The elections are held on alternate cycles (first, third, fifth, and seventh) so that some of the rhythm of the game is produced by these alternate periods of crisis for Politicians and School People. A further shift in the play of the game can be obtained by introducing some special metropolis-wide issues that are calculated to illustrate some basic relationships or problems (*e.g.*, as in a short, sharp national recession). The fifth cycle is probably best, for by then the players have gotten into the swing of the game, yet the consequences of their decisions are clear before the end of the run.

The finish time of the game can be adjusted according to the speed of the cycles and the interest of the players. The earliest finish time (due to slow play or an unsuccessful run) is cycle five, and the most probable finish time is cycle seven, for which M.E.T.R.O. is presently designed, with as many as eight or even nine cycles possible. Unsuccessful runs will then conclude around 4 p.m. (assuming an 8:00 or 8:30 a.m. starting time) with some time left for critiques. The normal runs will end at about 5:30, with a dinner break planned to last around two hours and a critique session scheduled for 7:30 or 8:00 p.m.

The final run will differ from the others in that it will generate machine output of several kinds. First will be the normal résumé of the previous cycle results. Then a special sub-routine will be used to calculate a five-year projection of growth for the metropolitan area, based on the position attained by the final cycle of play. Following that will be a ten-year trio of projections: high, medium and low trend estimates, useful for the critique session. From the middle estimate trend of the previous projection, there will be calculated the long-run twenty-year projection, designed to finish in perspective. The logic of the projections is fairly straightforward: In their five to seven cycles of decision-making related to the simulated sector of businesses and households, the players established a trend. The projections carry the implications of that trend to its logical conclusion. In addition, the computer printouts can be programmed to generate long-run policy alternatives for areal and functional teams (though the form of this has not yet been worked out in the M.E.T.R.O. project).

3.4 CYCLE PHASING (See Figure 6).

Cycle phasing is important to the flow of the game in the sequence described above. A problem is posed by computation. The computation of game operations is enormously shortened by computerization; but even so, the allocation of time to encoding, submission, running time, output, and necessary corrections, cannot be less than a half-hour, and up to an hour must be allowed for unforeseen problems. What to do with the game activities during this period is solved by having the metropolitan functional teams meet to discuss problems. The main body of calculations can be prepared during this second phase of a cycle. Though not all computer operations are likely to be completed during the second phase, the division of output into four self-contained packages permits a continuous flow to the game. By the time a player reaches a given decision, the materials are at hand. There is good interconnection of cycles, for in each beginning phase, an areal team takes up the outcomes of the previous cycle and the metropolitan issues generated by functional teams. Functional teams carry on their consideration of metropolitan problems on the basis of new data output about the changing metropolis. The above intertwining of interaction and computer phasing allows a maximum of gaming activity with a minimum of wasted time. The actual stage sequence involved in the computer operations, as in the four kinds of output, will be discussed in Section 4.

The above phasing of activities in cycles affects the interaction

Figure 6

TYPICAL CYCLE PHASING FOR M. E. T. R. O.

(A) TIMING OF METROPOLIS-WIDE ISSUES

CYCLE N		CYCLE N + 1	
AREAL TEAMS MEET	METROPOLITAN FUNCTIONAL TEAMS MEET	AREAL TEAMS MEET	METROPOLITAN FUNCTIONAL TEAMS MEET
	Raise issue as mandatory discussion item -- each functional team makes recommendations to respective areal teams	Areal teams vote on issues on basis of own interests and functional team recommendations	

(B) TIMING OF COMPUTER OPERATIONS

input N of gaming results	output #1	output #2	output #3	output #4	input N + 1

|------------1 hour----------|

--------60 min. — ---	-----30 min. ----	------60 min. -------	---30 min. -----

(C) MASTER PROGRAM SEQUENCE

Output #1 = Polls, Issues, Referenda, Elections, etc. (4-ply output)

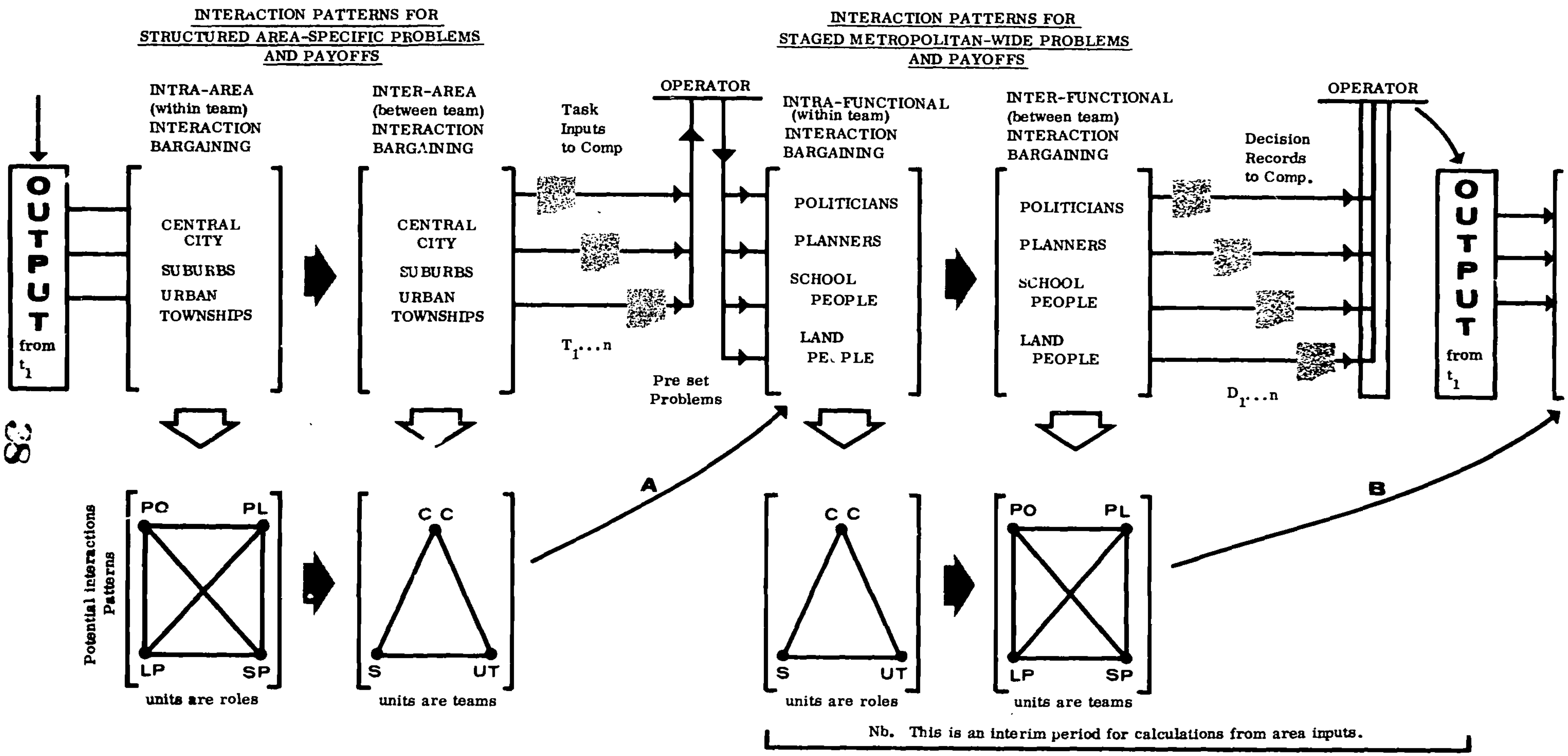
Output #2 = Cyclical Team Interaction Results (4-ply output)

Output #3 = Newspaper and Issue Generation (4-ply output)

Output #4 = General Data (1-ply output)

Figure 7

GENERAL PARADIGM FOR INTERACTION AND DECISION PATTERNS within a Gaming Cycle (time "t")



A Areal Teams may generate problems for Metropolitan Functions (not pre-programmed by Operator)

B Metropolitan Functional Teams may set up new programs for Areal Teams to decide upon.

patterns of players, so the impact is diagrammed in Figure 7. Each phase of a cycle has two characteristic patterns of interaction, and each naturally gives way to the one following. The effect is to give a close-grained, tightly timed, formal structure, within the bounds of which there is still great player initiative.

3.5 PLAYER INTERACTION

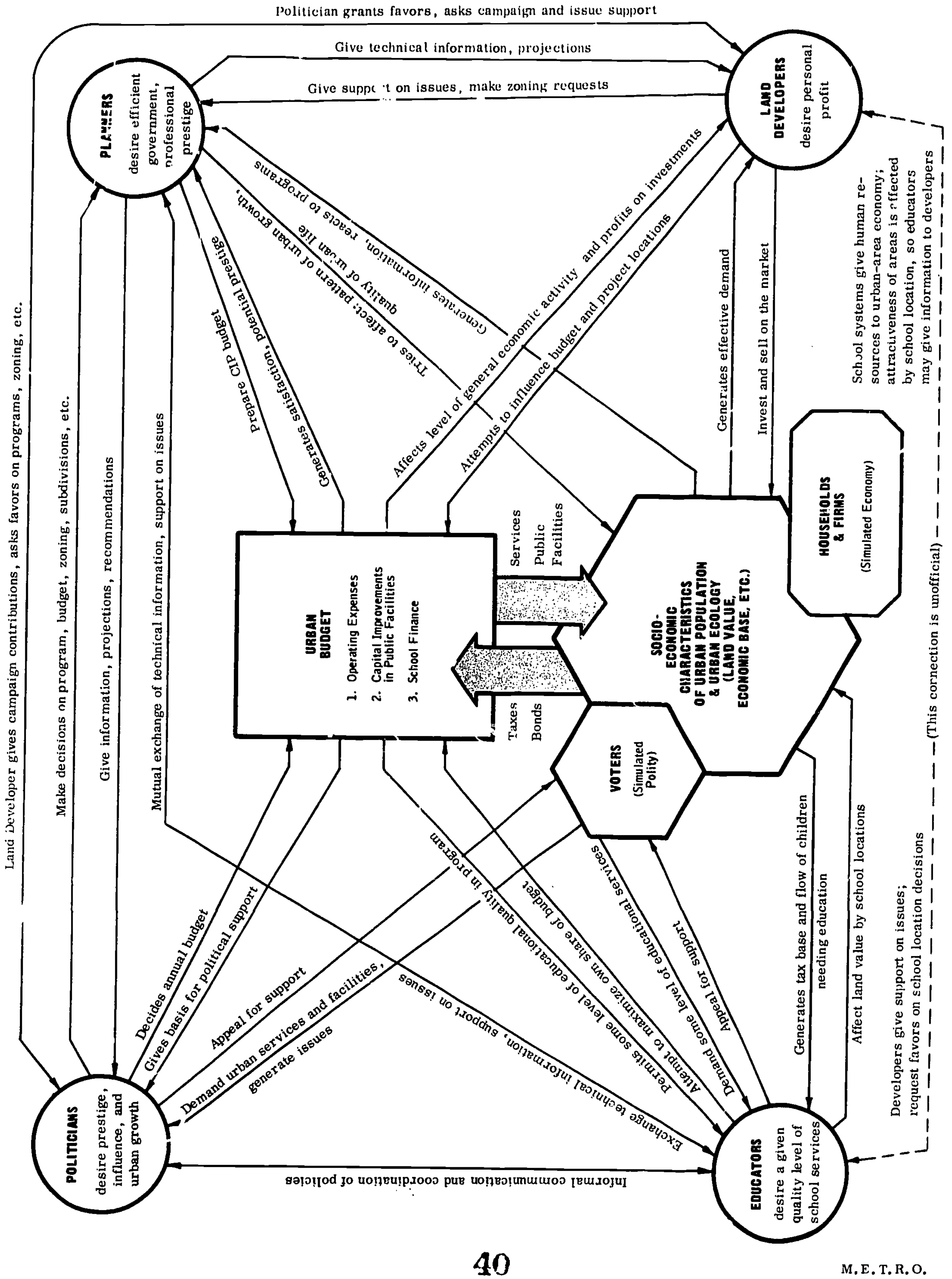
Player interaction patterns deserve close scrutiny, because the demands for interaction, implicit or explicit, tend to condition the roles that are taken. Players have the freedom to push their roles in any direction but must be willing to take the consequences for their acts and to put up with their fellows in the game. Few unilateral decisions are possible; most plans and enterprises are highly interdependent. Players can even get near veto power over others in certain circumstances. Furthermore, the world bites back: players interact, in a sense, with the simulated businesses, households, and voters, and the activities and decisions that these make, respectively. Much of a player's personal standing (*e.g.* likelihood of winning an election or profit position) depends on his accurate estimation of how the world will move next year and his ability to modify, or to take advantage of, the course of events. His prediction is aided by data bank output from the computer and by the "expert" opinions of his player colleagues. But in the long run, the decision process is not one of simple optimizing of choices; it is also one of strategy and bargaining and of balancing off power equations in a social system.

Interaction patterns are crucial, because therein lies the exchange of *quid pro quo*. They inevitably focus on the urban budget, for that is the biggest factor open to manipulation by the players. Even the Land Developer finds that his investments are affected. Player payoffs, whether in votes, dollars, or likelihood of holding one's job, are directly conditioned by the short-term feedbacks built into the model. But they find also that their welfare as a whole depends on how they interact to promote growth and urban amenities. If all contribute to growing the pie, each can have a bigger piece next round. (See Figure 8).

Politicians are the key deciders on the budget, since Planners only

FIGURE 8

M.E.T.R.O. Functional Interactions



recommend, though School People share the decision honors. A Politician builds prestige, influence, and ability to get reelected by the bases for political support he can engender in the voters through providing something for everybody. Should he fail to meet voter demands (as made known in the newspaper), or satisfy pressure groups, or promote economic growth, he probably will be defeated. The Politician uses the yardstick of political practicality to evaluate programs and recommendations by the Planner. He is free to make deals with Land Developers (favors and information for campaign contributions). He consults informally with the School People, since a big and growing bite is taken out of the tax dollar by growing school needs.

Land Developers are also key decision figures, since their decisions plug into the economic pattern of the metropolitan area. Informal deals may be made with School People and Planners, but the main use of interaction is to exchange information. Mutual support on the budget and on issues are the key exchanges. Market-oriented operations consume most of the decision space of Land Developers, so that is their key interaction. Like the Politicians, their success symbol is clear cut, but in dollars rather than votes.

School People would like to increase the schools' share of the budget to improve school services, but they face rising opposition from some quarters; in addition, they need to bargain with the other players. Information and policy exchanges are standard interaction with Politicians and Planners, and the same is possible *sub rosa* with the Land Developers. Any deals that are made are strictly up to the players, but indirect pressures on other players should force some form of dealings. Though it is easier for the School People to get reelected, they must still face the voters every other year.

Planners (those similar to the ones for which this game was devised) have tough problems in the game, for they have the largest goals and the least formal power to achieve them. Hence, they must interact and bargain strenuously with the other players to accomplish their purposes. To promote a plan, all they have is data and persuasion--no money and few favors. Planners make capital plant and zoning recommendations to Politicians who do the deciding, and since the outcomes affect the Land Developers, an interesting triad is formed.

These interactions take place within the context of areal team decision-making in the first phase of any cycle. We must not forget that the outcomes of these sub-games affect other areal teams. Hence, there may well be unstructured bargaining between the Central City, Suburbs, and Urbanizing Townships. We expect this to emerge rather late in the game as an awareness of common fate dawns on the players.

Interaction between functional role holders in the second phase of a cycle, such as among the Politicians or the Planners, will be primarily problem oriented and have little scope for bargaining. Players will represent the interests and viewpoint of their areal teams, but the main point will be to consider issues and clarify alternatives and possibly to make recommendations to their respective areal teams for action. Since no direct rewards or punishments are forthcoming, we expect these interaction patterns to be quite loose and unstructured, less fraught with the high tensions of the others.

4. MAN-MACHINE INTERACTION

The player interactions summarized above are always centered upon the urban budget and the simulated economy and polity. The purpose of this section is to describe how player concerns and decisions are linked to machine-processing functions. Reality is recreated in abstracted form within the computer by use of mathematical and logical operations. Not unlike simulations of space flights where astronauts sit in a mock-up capsule, the player is in a closed-off place receiving signals about an outside world. And if the messages about the world are artfully enough concieved and are similar enough to player expectations and experience, *then* the messages he gets from the "black box" could represent either simple translations of *real* events or simulations out of a machine, and the player couldn't tell them apart. This is possible, because the machine operates upon historical data drawn from the same world as the player's experience and because some expert has formalized commonsensical and scientific generalizations enough to give the computer some rules for handling that history-based data.

The man-machine link is therefore problematic in two ways, each corresponding to a direction of message flows. On the one hand, the players' decisions must be fed into the machine to add to historical data; this has to be a translation that "works": *i.e.*, the player decisions, of whatever kind, based on whatever considerations, must be expressed in the same format that holds the historical generalizations and rules of operation within the computer. This is no mean feat. On the other hand, the machine language is a highly artificial one, so that machine output, representing the simulated world and showing outcomes of player decisions, must be translated back into meaningful and realistic human terms. In order that players can make efficient use of this machine output, there are necessary interpretation functions to get from the technical to the language of the workaday world. Both of these translation tasks fall under the Operator's main concern: to keep the gaming and decisions going smoothly and realistically. Hence the game Operator is the key intermediary in the man-machine linkage. It is quite literally true that M.E.T.R.O.

will not function without an efficient linkage of player interactions and computer simulation, so it follows that this Operator function is quite indispensable for the M.E.T.R.O. instrument.

It should always be borne in mind that the machine end of the linkage is a *tool*, not an end in itself. *Unlike most tools man has invented, however, it is an extension of his thought processes rather than of his hands, arms, or legs.*

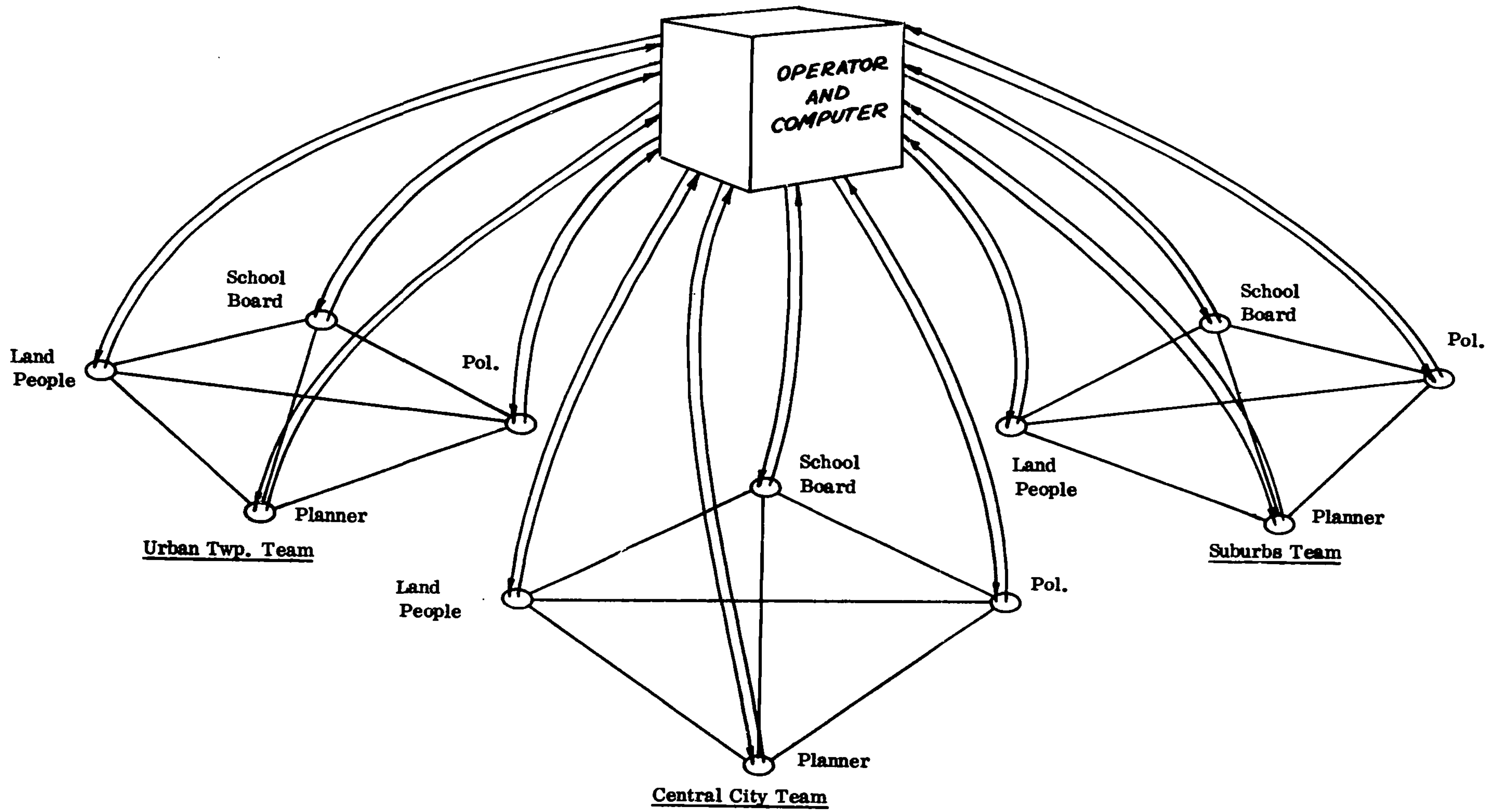
Players are given a chance to "exercise" their decision capabilities, to try out new strategies and tactics, to investigate new technologies (such as the data bank, or computer printing of maps in one thousandth of the time that planners could draw them) and to gain experience in dealing with typical or probable future problems. The output they receive from the computer is itself a phenomenon of their futures, in that computers will soon become an indispensable arm of urban government. Hence, it is important that players perceive the game's computer output properly and learn to make use of it to supplement the decision-making skills they have already acquired.

The computer output that players use is in the following formats: a tabloid newspaper reporting outcomes of previous positions and new issues that players should be sensitive to; tables of figures; charts; graphs; and maps. These describe (1) the current state of the metropolis as a whole, of jurisdictions, and of small areas; (2) the results of the last cycle of gaming for player positions; (3) special data called for by players to supplement decision-making; and (4) new issues or problems generated by past play. It is useful for players to familiarize themselves with such computer output formats, because they are not unique to this gaming simulation but are good prototypes of the output of computer-based data systems of the future. (See Figure 9).

The man-machine interaction concept is, then, a basic matter for proper operation of the game. During the course of the game, players must assume responsibilities which require that they take specific actions so that the game can progress properly. Many of these actions take the form of decisions, requests, and activity reports, all of which must be related to the accumulated data that describe the state of the M.E.T.R.O. area. A new state of the M.E.T.R.O. area is generated when this data is fed into the machine, operated

Figure 9

MAN - MACHINE INTERACTION



upon by the converter functions and transferred to the appropriate segments of the data bank. There is then a feedback of information to the players describing the new state of the M.E.T.R.O. area which is used as the basis for a new cycle of actions. Figure 10, the M.E.T.R.O. Information Feedback in Man-Machine Interaction, represents the pattern of these interacting operations as the gaming sequence proceeds.

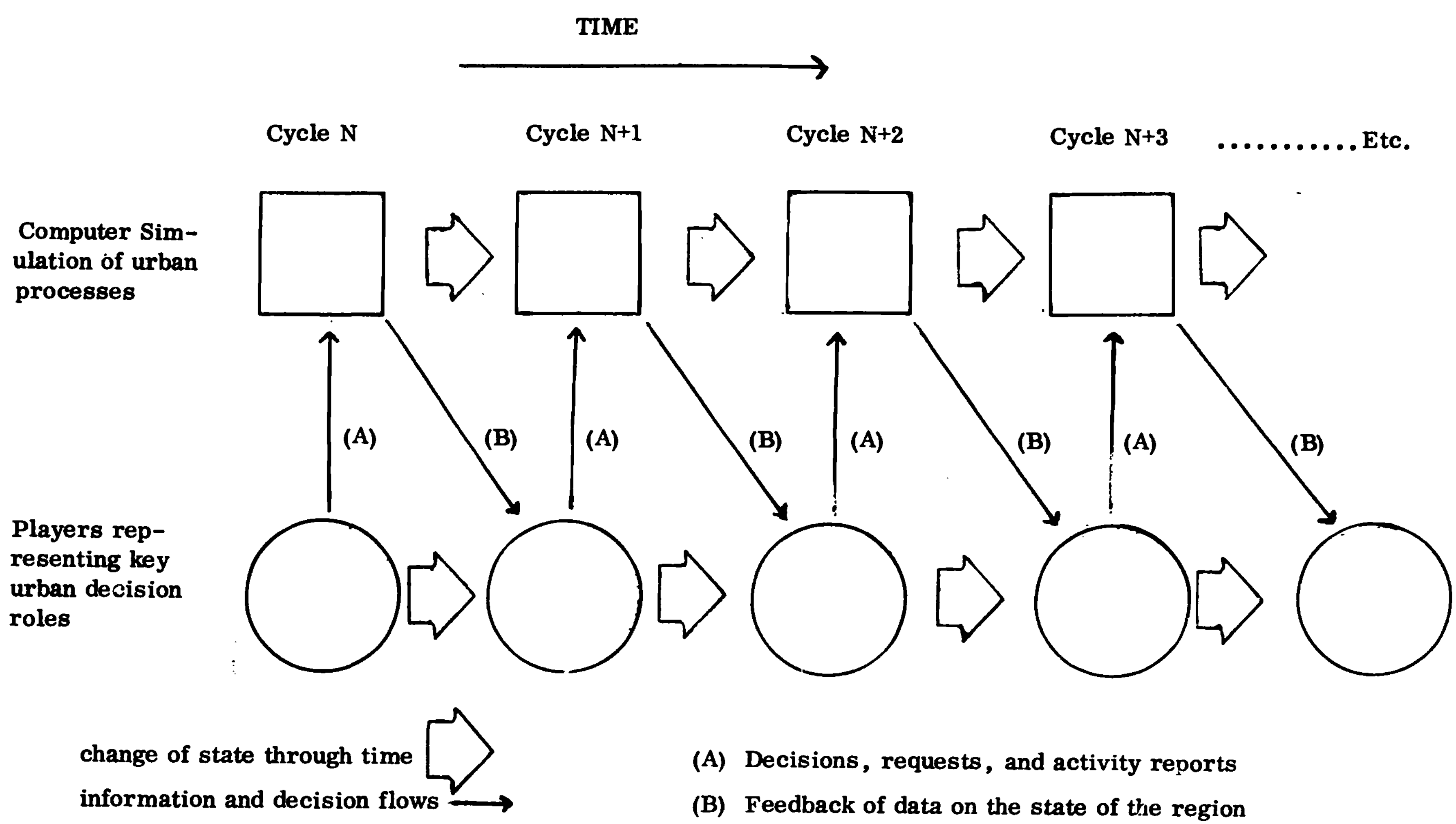
There are a variety of reasons for establishing and exploring the man-machine relationships described above. First, there is a large set of important ideas concerning the so-called rational decision-making requirements for improved efficiency and effectiveness in arriving at optimal decisions in all phases of urban government, business, and private transactions. Second, and more specifically related to the operation of the gaming instrument itself, is the requirement for a compression of time if the most vital objectives of the gaming simulation are to be met. Let us expand on both of these elements.

The essence of rational decision-making is entrenched in the notion that the basic character and validity of decisions which have to be made can be improved by providing the decision-maker with more adequate information at a time and place which *will make it possible to be directly applied to formulating required decisions*. Adequate information usually implies more data, which has a high level of reliability, and which is maintained and manipulated in such a manner as to permit the rapid transmission of the data to the decision-maker. Conversely, the system must permit feedback from the decision-maker to the data set. The design of any data support network must encompass these basic characteristics if it is to provide the sought-after "high quality levels of decision." *In structuring the machine-based operations for M.E.T.R.O., this specific phase, a highly efficient man-machine interface, is a primary objective.* The computerized data bank in the game (representing a prototype of the urban data-banks that may be in common use in urban government and planning a decade from now) can be used to acquaint players with new types of decision-making based on up-to-date scientific data about their city.

The second phase, referred to above, was that of the importance of compressing the time span of the real world in order that the objectives of the gaming simulation instrument could be met...for example, for evaluating

M.E.T.R.O. INFORMATION FEEDBACK IN MAN-MACHINE INTERACTION

Figure 10



M.E.T.R.O. 1-11-66

the alternative courses of action that might be pursued in coordinating urban development. The advantage of the gaming approach over the others rests in the fact that it allows a sequential evolution of the course of such development pressures, including the continuing intervention of players to evaluate their strategies and alter their courses of action, with the opportunity to follow up the results of these decisions and evaluate their effect on the overall course of the emerging urban area. It is essential to this objective to be able to fully utilize the rapid data manipulative capability of the computer.

This type of objective is of utmost importance because it is aimed at the problem which faces all decision-makers who must often make decisions which in the short run appear to be entirely valid, even under the tests of rational, scientifically based requirements, but in the long run turn out to be otherwise, because other people making simultaneous decisions actually changed the conditions of the scientifically based best decision choice. This should emphasize to the player the need to be well aware of, and coordinate his actions with, other decision-makers acting to adjust the character and course of development of the urban area.

Of prime importance, then, for all the reasons stated above, is the need to arrive at a well devised man-machine interface system which will capitalize upon the data manipulative capabilities of the computer but that is fundamentally devised to effectively serve the player in his decision-making capacities. In no way do the machine-based operations substitute for player decision functions; rather, the variety of computer-based data manipulation, visual display, and record-keeping activities adds realism to the game, provides an opportunity to experience and experiment with highly intricate data-based analyses, and adds considerably to the continuity and flow of the game by maintaining a time compression of "real world" years into a few gamed hours.

5. THE M.E.T.R.O. DATA SYSTEM

A critical element in the operation of the M.E.T.R.O. gaming instrument is the effective and efficient operation of the data support network. This network includes the organization of the computer-system procedures, the data input/output capability, and the internal processing of the variety of data items necessary for information support for players and record keeping for the game Operator. The problem of the system as a whole is a complex one; therefore, in devising the system, attempts are being made to think of it as a series of sub-operations, each of which fits into a niche within the larger set.

While the notion of sub-operations appears so obvious as to be trivial, it still provides a useful ordering device to keep track of the many minute operations. Even more important, if the system can be devised as a series of sub-operations, the actual testing of the system should be a less hazardous (and expensive) process.

5.1 M.E.T.R.O. ANALYSIS AREAS

The design of M.E.T.R.O. has been based upon the characteristics of the area served by the Tri-County Regional Planning Commission. As a result, the final instrument will have direct applicability to the Lansing metropolitan area and will be primarily oriented toward the urban planning needs of this region. (See Figure 11).

The instrument, as currently conceived, will be concerned with a 12-township area around the City of Lansing. For the purpose of the game, this area has been grouped into three basic political units which approximate three types of urban settlements. These are a Central City, Suburb, and adjacent Urbanizing Townships. Their counterparts in the Lansing area are the City of Lansing, City of East Lansing, and surrounding townships, respectively.

The selection of three types of areal units (Central City, Suburb, and Urbanizing Township) assumes three different levels or types of players within each functional team (composed of a Politician, Planner, School Person, and Land Developer). The rationale here is that the responsibilities, values, and

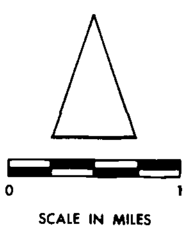
M.E.T.R.O.
ANALYSIS AREAS

Jurisdiction Boundary

Ward & High School District

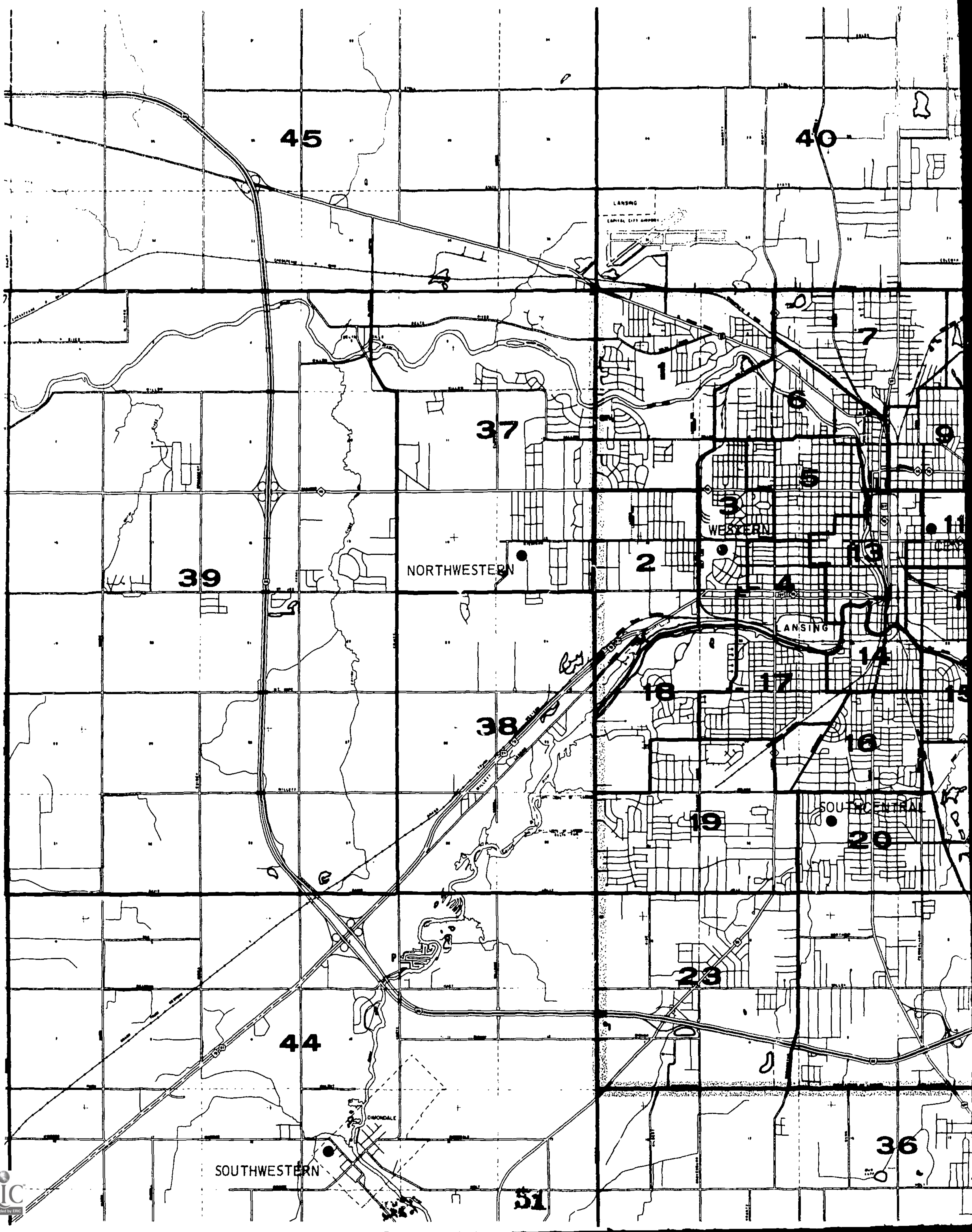
Analysis Area Boundary

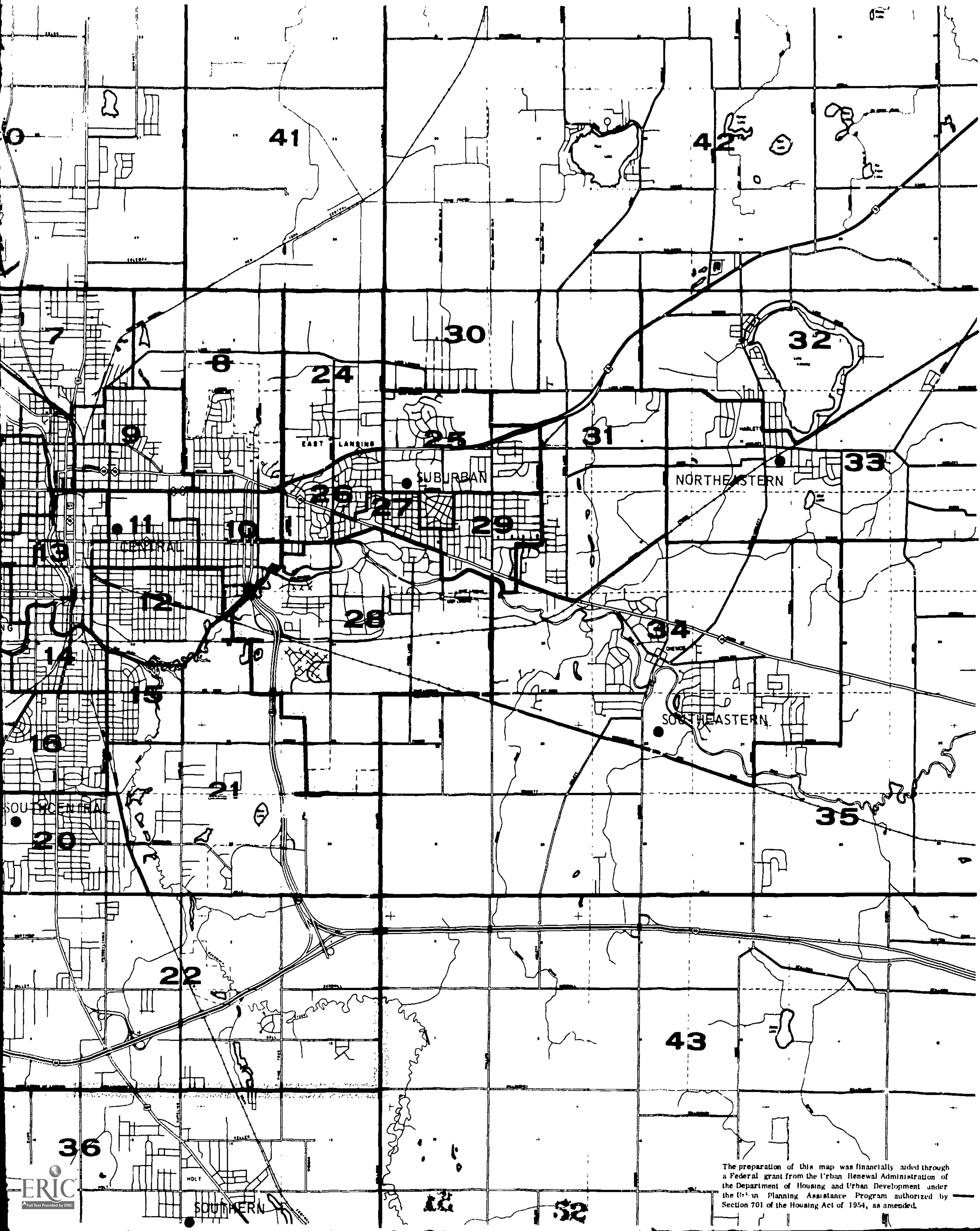
HIGH SCHOOL



M.E.T.R.O. PROJECT

TRI-COUNTY REGIONAL PLANNING COMMISSION
535 N. Clippert, Lansing, Michigan 48912
Telephone 517 372-1810


45
40
LANSING
7
1
6
9
37
5
3
WESTERN
11
NORTHWESTERN
2
13
39
4
LANSING
14
17
18
15
38
16
SOUTHCENTRAL
19
20
23
44
DIMONDALE
36
SOUTHWESTERN
51



The preparation of this map was financially aided through a Federal grant from the Urban Renewal Administration of the Department of Housing and Urban Development under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended.

actions of a given team member within one areal unit will differ significantly from those of a similar functional team member within a different areal unit.

Each of the three political areas has been subdivided into units composed of one or more census tracts. These sub-units are commonly referred to as analysis areas. There are 22 analysis areas in the Central City, 5 in the Suburb, and 17 in the Urbanizing Townships.

In selecting the census tracts which were combined to form an analysis area, the following variables were considered in an effort to consolidate 2 or 3 adjacent census tracts having similar characteristics:

1. Total population.
2. Percent non-white population.
3. Percent under 21 years of age.
4. Total number of acres.
5. Mean number of people per acre.
6. Total number of residential structures.
7. Percent of dwelling units which are deteriorating or dilapidated.
8. Percent of structures built prior to 1930.

The process of combining census tracts into analysis areas involved several optimizing criteria. A *minimum* number of tracts is needed for areas to be sufficiently homogeneous for good inference in models and in urban planning, and we need to represent accurately the major variations in the urban area. A *maximum* is set jointly by computer limitations and player comprehension, hence we used analysis areas rather than individual census tracts.

The problem of data storage within a computer is largely a function of the number of areas for which data is recorded. By using analysis areas, it is possible to greatly reduce the total number of areal units and, therefore, computer storage requirements. Players also have a similar problem of human data storage. In order to reduce the complexity of the game from the player's perspective, it is desirable to have as few geographic units as possible. Therefore, rather than inundating the players with statistics for every census tract in the region, information will be presented in a more comprehensible form for a relatively few analysis areas within each areal unit.

5.2 GAME OPERATIONS - INFORMATION SUPPORT RELATIONSHIPS

The gaming simulation activities generate the need for five types of operations in the data support network. These are (1) input of gamed-role decisions and cycle-unique data changes; (2) actual data record update in the data bank; (3) cycle-unique item generation and processing; (4) record operations for game Operator and game history; (5) output of information to role players and Operator. Each of these functions will be discussed separately in order to specify what they entail. The "programmed routine system" described in the next section represents the operating elements which provide the computational logic for accomplishing the tasks of these five operations.

The game is devised around a base of information representing a typical urbanizing region (a representative portion of the Lansing Tri-County Region), abstracted in such a manner as to make the time-constrained operation of the game possible. This data base is initialized at a given point in time from observed information on the region. From this point on, the data base is updated according to actions and activities in the game. Certain data is maintained upon a metropolitan-wide basis or by the three jurisdictional levels. However, the primary data base is maintained uniquely for each of the 44 analysis areas established for use in the game.

The general characteristics of the types of operations in the data support network are as follows:

1. Inputs - These game-based actions and activities change the initialized values in the data bank. They include such things as changes in land ownership, additions to capital plant, changes in zoning, and a range of items describing changes in the social and economic characteristics of the M.E.T.R.O. area. After being generated by players in the game, these items must be put in machine processing form (punched cards) and submitted as data inputs when the computer processing run begins. It can be readily seen that this procedure must be designed to incorporate the most streamlined, abbreviated form possible in order to be manageable. The game Operator is responsible for collecting these items from the players and insuring that the proper input form is accomplished.

2. Data Record Update - The record file is maintained in two parts. First is a general record for items summarized by the three jurisdictional

levels (Central City, Suburb, Urbanizing Township) or by the metropolitan total. This portion of the file can be visualized as a matrix of dimensions 4 by n (number of items to be maintained) where the 4 represents one row vector for each jurisdiction, and one for metropolitan-area totals.

Figure 12

DATA FILE LAYOUT - GENERAL

DATA ITEMS

ANALYSIS AREAS	1	2	3	4	5	6	7	8	9.....n	
Central City										
Suburb										
Urbanizing Township										
TOTAL										

Second are the specific records maintained for each analysis area on a separate basis. This can be represented as a matrix of dimensions 48 x n (number of items to be maintained) where the 48 row vectors are the 44 analysis areas, plus a total for the metropolitan area, plus a summation sub-total for each of the three jurisdictions. (See Figure 13).

Items in the file are updated by input, internally keyed updating routines, and routines which combine input items and the results of several updating routines. Since not every cell need be updated every cycle (only a small segment of them will be) the physical constraints in updating are not as great as the matrix size might indicate.

3. <u>Cycle - Unique Item Generation and Processing</u> - A series of items must be output for game use, and these are generated by various routines which derive these items on a probabalistic or other algorithmic-based selection process. The growth and distribution models and voter response model are among the cycle-unique set. Items provided from these include the growth and

Figure 13

DATA FILE LAYOUT - ANALYSIS AREAS

DATA ITEMS

ANALYSIS AREAS		1	2	3	4	5	6	7	8.....n	
Central City	1									
	2									
	3									
	4									
	etc.									
Subtotal										
Suburb	21									
	22									
	23									
	etc.									
Subtotal										
Urban-izing Town-ship	41									
	32									
	33									
	etc.									
Subtotal										
TOTAL										

distribution of population, the results of elections, bond issues, referenda, and newspaper items. The players have the option of asking for various additional types of information beyond the scope of that provided in the typical cycle output. Various projections, summaries of data, trend analyses, etc. can be produced in response to such requests. An index of available information will be provided to the players, and they may request items from it on the basis of certain game conditions (possibly with a cost to the player per request). Figure 14 indicates the general format of the index to such available information.

4. Record Operations - A continual record of the history of the game (patterns of update, actions, etc.) is maintained on a record tape which records these from certain key indices of game actions. Cycle-by-cycle totals are maintained and recorded. In addition, continuing cycle-by-cycle records necessary for the Operator's game manipulation and control are provided for output each cycle.

5. Output - At the end of each computer pass, the results relevant to each player are output to him by a series of output-oriented routines. These include the routines for newspaper generation and player output sets. Figure 15 summarizes the major components of the output set.

5.3 PROCESSING CONFIGURATION AND SEQUENCING

The computer-oriented processing network is envisioned as shown in Figure 16. It is composed of a master data tape with the initialized values for the data bank (with permanent copies on reserve to reproduce this initial set for each game), a master executive tape which contains all the control routines and the permanent library of processing routines (also a permanent copy on reserve), a duplicate data tape on which the updating is done each cycle, a record tape to retain a history of the progress of the game, and an output tape for purposes of output format preparation for interface with the printer.

Each cycle the input is submitted for processing at the end of the areal team-meeting portion of the cycle (60 minutes). Output is planned in four segments, the sequence and timing of which are indicated in Figure 6, Section 3.3. A different perspective on the same sequence is outlined in Figure 17, which focuses upon the steps involved in the actual computing sequence.

12/13/65

Figure 14

M. E. T. R. O.

INFORMATION REQUEST FORM

Item No.	Check Desired Item	Title	Description	Cost	Code
1	☐	Population Projection	Cohort-Survival by Planning District, Five -5 year increments	$ 500.00	T-7
2	☐	....	....	$	G-2
3	☐	....	....	$	...
4	☐	....	....	$	...
•	☐	....	....	•	...
•	☐	....	....	•	...
•	☐	....	....	•	...
N	☐	....	....	$	...
		(List Alphabetically by Subject)	(Content Clarification for Players)	(Item Cost = function of computer time)	(Operator's IBM Code Number)

NOTE: All requests generate discrete or "canned" units of output; content and areal units are specified in the output.

Figure 15

M. E. T. R. O.

TYPICAL COMPUTER OUTPUT PER CYCLE

I. General
   A. Identifying Data (date, location, cycle #, title, etc.)
II. Newspaper
   A. Budget (one for each areal team)
      1. Tax Rate
      2. Equalized Assessed Value
      3. Revenues
      4. Expenditures
      5. Estimated Budget for Next Cycle
   B. Growth (by areal unit and total)
      1. Population -- total, change, rate
      2. Median Family Income
      3. Exogenous Growth Factors
      4. Infrastructure Accumulation
      5. Cummulative Investment Totals
   C. Public Opinion Poll
      1. Referendum (by whom initiated, amount, nature, outcome)
      2. Bond Issue (by whom initiated, amount, nature, outcome)
      3. Payoff Matrix on Public Opinion Poll
      4. Issue Outcome
   D. Election Section
      1. Voter Response Output
         a. Referendum
         b. Bond Issue
      2. Present Probability of Reelection
      3. Campaign Expenditure Commitments
III. Graphic Output (Charts, Maps, Matrices, Graphs, etc.)
      1. Requested Information (format determined by calling subroutine)
      2. Projections
      3. Land Characteristics Matrices (e.g. zoning, land use, value)
      4. SYMAP showing improvements since 1st cycle
      5. Data Bank Table Updated
IV. Output for Players
   A. Politicians
      1. Capital Improvement Budget (projects carried, not carried, multi-year projects)
      2. Payoff Matrix
      3. Operating Budget (by %)
      4. Projects (location, type, $, duration)
   B. School Board
      1. Payoff Matrix
      2. Accreditation Data
         a. Average Teachers Salary
            (1) National Trend
            (2) Local Status

Figure 15 (continued)

b. Children / classroom
   (1) National Trend
   (2) Local Status
c. Operating expenses / pupil
   (1) National Trend
   (2) Local Status

3. System Data
   a. Number of Teachers
   b. Number of Classrooms
   c. Number of Students
4. Tax Rate -- Current and change
5. Revenue -- Property Tax, bond issue, referendum, state, federal
6. School Room supply - demand by grade vs. areal units

C. Land People
   1. Matrix by areal unit including acres owned, zoning, acres subdivided, public improvements, construction (# and $), and asking price.
   2. Payoff Matrix
   3. Promotion Expenses
   4. Net Worth
   5. Credit Rating
   6. Cash on Hand
   7. Investments this Cycle
   8. Interest on Cash and Loans
   9. Contributions
   10. New Construction, Quanitity and Cost
D. Planners
   1. Payoff Matrix (planner override, CIP error, P.O.P. response, C.P.I. discrepency, political confidence scale)
   2. CIP -- by Project
   3. Operating Budget -- by %
   4. Discrepency Index (planned use vs. zoned use x areal unit)
   5. Planning Budget % Distribution Matrix by year for operating expenses, research, data bank, long range planning, current planning and public relations.

V. Administrative Output
   A. Computer Details (e.g., timing diagnostics, etc.)
   B. Next Cycle Data
   C. Run Records
   D. Areal Team Data
      1. Central City
      2. Suburbs
      3. Urbanizing Township

Figure 16

M. E. T. R. O. PROCESSING NETWORK

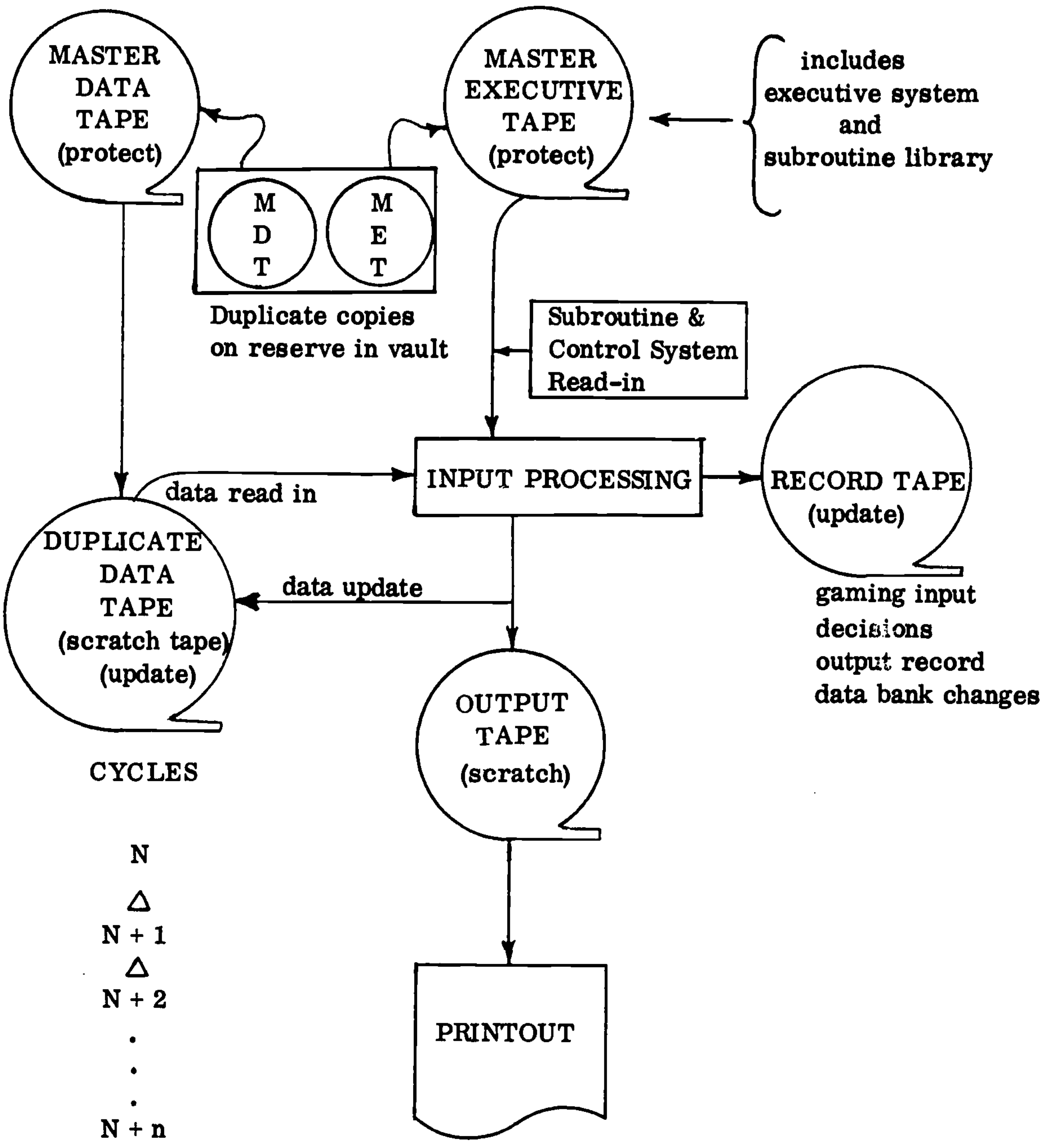
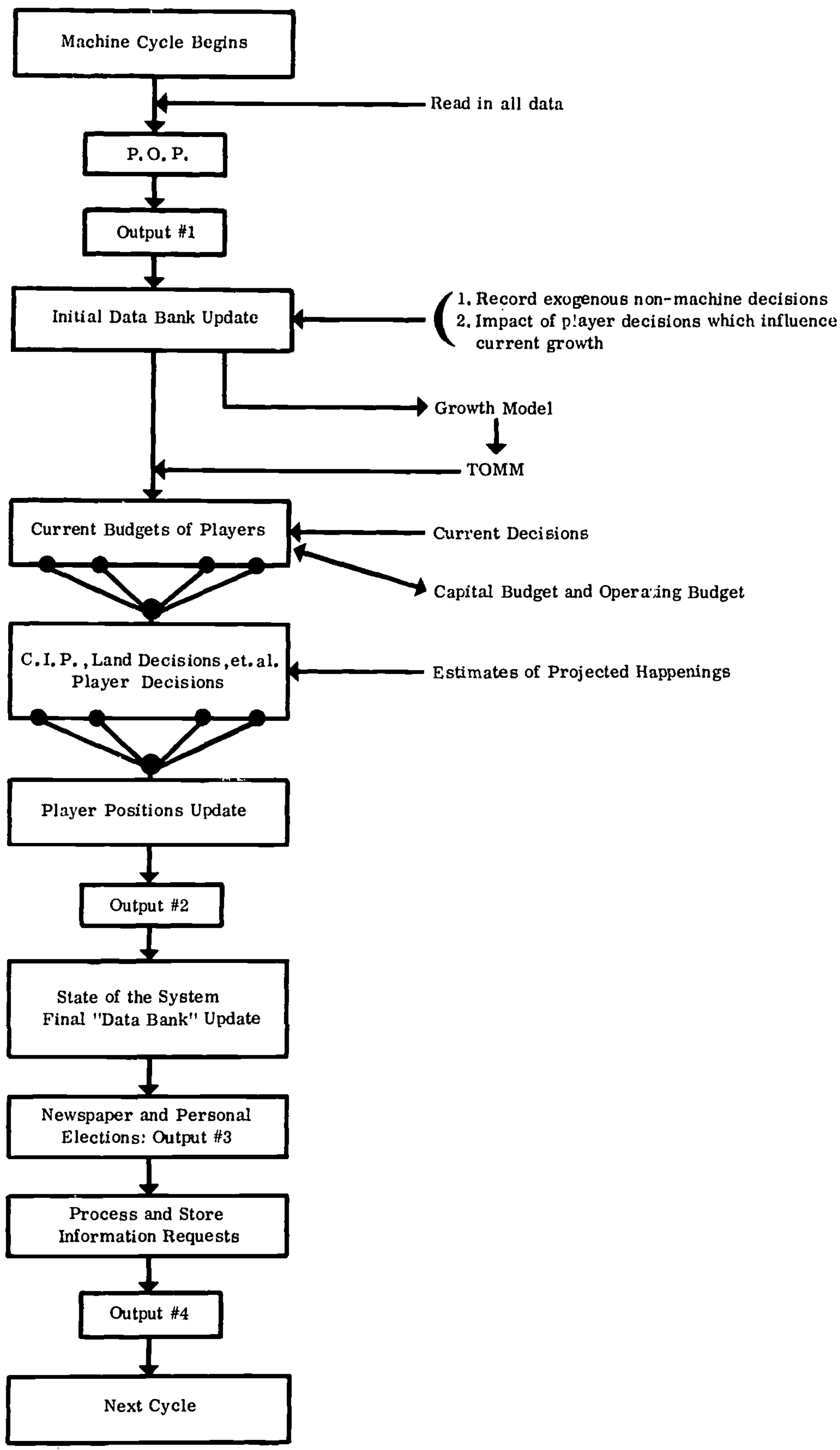


Figure 17

M. E. T. R. O. TYPICAL COMPUTING SEQUENCE



5.4 DATA NETWORK SOFTWARE

Data Network Organization - The data network is conceptually a six-section system. Two of these sections are purely programming components. The first is the executive system of control routines, and the second is the set of library routines for use in processing and updating. The remaining four sections are data elements. These are shown below in Figure 18.

Figure 18

DATA NETWORK ORGANIZATION MATRIX

EXECUTIVE SYSTEM

SUBROUTINE LIBRARY

Metropolis Wide Data	I	II
Analysis Unit Data	III	IV
	Data Bank	Data Support

The data item elements compose a 2x2 matrix. "Data bank" items are defined as data which are specifically maintained for output as descriptive data quantities. The items labeled "Support Data" describe those types of items which are classified as indices or factors for use in computational aspects of the data processing network. Normally, data support items would not be for printed output purposes except possibly to the Operator. Quadrant I implies metropolitan-wide data items of the data-bank type. Quadrant II includes metropolitan-wide data items of the support-data category. Quadrants III and IV are segments of the data bank and support data files recorded on the basis of analysis units.

Precedence System for Data Bank Operations - Since there are a variety of types of operations which involve the overall updating system for the data bank, a definition of the rules for sequencing these operations will aid the structuring of the processing network. Figure 19 indicates the ordering precedents for five segments of the data bank.

Type I operations represent that set which provides growth projections and distributions which are to be used as the bases for cycle updating.

Type II comprises that group of routines which operate independently of any data from the data input set submitted by the Operator each cycle (*i.e.*, counters, and automatic updating operations).

Type III is that set of routines which update, on the basis of the input each cycle, by the Operator. These include both data items and computed indices for game use.

Type IV represents the category of updating routines requiring data for updating purposes which come from the data bank and which must be updated for the current cycle prior to input to the Type IV routines. These might include any number of Type I, II, and III based updates occurring prior to Type IV operations.

Type V routines are those remaining updating routines which require any combination or number of Type I, II, III, and IV routines to fulfill their updating procedures.

Processing and Updating Routines - The compendium of routines which operate to accomplish all of the various computational, updating, and control requirements of the information support system for the game are grouped into four primary groups: (1) the Executive System, which provides the overall controls on the computer operations for the game; (2) the Growth and Distribution Models; (3) the Data Bank Update Routines; and (4) the Output Generation Routines.

The first of these categories, the Executive System, is designed as a master calling program which is structured so that it calls upon appropriate sub-routines to perform the various computations necessary for processing operations in that cycle. This calling type of format will utilize two particular programming techniques. Control cards will be prepared by the Operator each cycle prior to the submission of the program to the computer. These control cards will be punched by the Operator according to the predesigned format. The occurrence of a punch in a control card column represents the need (or lack of need) to perform given types of operations. For example, if new data is submitted which requires an updating of the Land Developer's holdings in the analysis areas, the appearance of a punch in the control card column delegated to control operations required for this updating will trigger the calling of the necessary sub-routines.

The second category, the Growth and Distribution Models, operates each cycle prior to most data bank updating procedures. Macro growth for the M.E.T.R.O. area is generated and distributed to the sub-areas. For the present, these models are being considered in the data system primarily from the perspective of what data items are necessary for input to the models, and what outputs are generated by them to be used specifically by updating and processing routines. A further discussion of these is included later in this report.

Third, the Data Bank Update routines include all the routines defined earlier in this report as Type II, III, IV, and V updating procedures. Each of these is to be spelled out in detail, based upon an initial delineation of the routine requirements specified in the M.E.T.R.O. Programmed Routine Index forms. (See Appendix I).

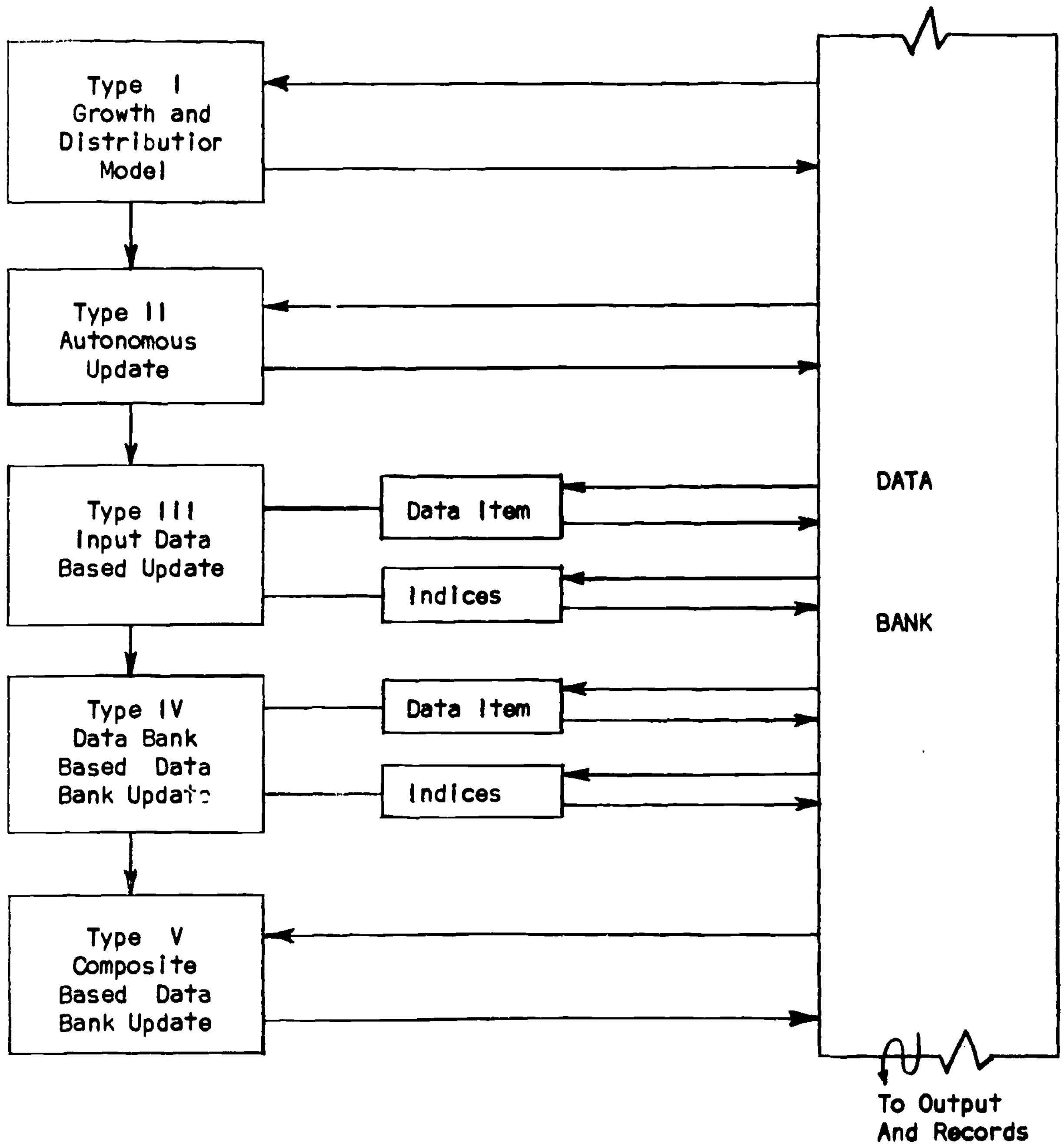
The fourth category includes those routines designed for generating output each cycle in the form of printed matter, cards, or possibly graphic display, if cathode ray tube display equipment is included. Each segment of output material will require an operating set of routines which provide sequencing and formating for the output. For example, the newspaper, voter response model results, and player output sets are among the major portions of the output category of routines.

5.5 SPECIAL M.E.T.R.O. MODELS

There are four computer routines which are uniquely important to the M.E.T.R.O. operation. This unique status requires a special description of the general character of the programs. Three of these routines, the Growth Model, the Distribution of Growth routine, and the Voter Response Model, are distinct

Figure 19

DATA BANK UPDATE PRECEDENTS



from the others, because each serves as a priming device for all other operations of the gaming simulation. The fourth special routine is SYMAP, a computer mapping routine which provides a necessary link between the large volume of data in the data bank and the users of this information. Each of these routines is considerably more complex in its structure and manner of operation than the others in the set of programmed routines.

Growth Model - A primary element for the simulation is the staged growth of population, employment, and income for the M.E.T.R.O. area. Each cycle, some increment of growth for these elements is defined to enable the carrying out of the various planning and management functions required for the simulated urbanizing area. Each role depends upon results from this growth process.

The growth model is devised as strictly a macro growth generator of area-wide totals. The distribution of the population over space is accomplished through the distribution model discussed in the next section.

Basic variables which operate in the growth model are populations, exogenous employment, endogenous employment, income, property value, public facilities, and a series of welfare indices composed of ratios of the income, property value, and public facilities to population. These variables are altered over time by the simulating forces of the players' actions, manual allocations (exogenous industry), and certain programmed routines. A series of equations is derived through multiple regression analysis to relate the variables, and these are solved simultaneously to output the required data necessary for the distribution model.

Distribution Model - The requirements for a staged simulation of growth, through time, necessitates the use of a special model to distribute the growth generated by game conditions and the macro-growth model. This task is typically one of the most difficult to accomplish in planning efforts in an on-going planning agency. Numerous approaches to this problem have been proposed in the various transportation studies, Community Renewal Programs, and a variety of other research efforts.

The needs for distributing growth in M.E.T.R.O., however, have certain basic and very important differences. Primary among these is the difference in the need for a firm prediction of what will happen in the real world. Usually, the efforts to simulate must involve a considerable effort to validate this capability to reproduce reality. The requirements for validation are less demanding in M.E.T.R.O., since we are trying only to provide some representative growth process which exhibits the characteristics and problems of a growing region. This need not be a "precise" prediction of what will happen in the future.

The characteristics which a distribution model must exhibit for the M.E.T.R.O. application are: (1) a relatively simplified input form, and (2) a sensitivity to actions taken by players during the stages of the simulation. A distribution model devised for the Pittsburgh Community Renewal Program efforts provides these capabilities. This model, T.O.M.M. (Time Oriented Metropolitan Model) is being adapted for use with M.E.T.R.O.

T.O.M.M. operates with variables which are used as determinants for the allocations of employment, land use types (retail, service, and residential), and the breakdown of household types within this allocated total for each analysis area. New exogenous manufacturing (those firms dependent on markets exogenous to the region) is allocated manually during the game sequence under certain conditions and constraints established by the play of the game. The input includes those projections of growth from the distribution of land uses in the previous cycle. T.O.M.M. is designed as a marginal allocation model, distributing new growth on the basis of the already-established patterns of growth in the previous time periods. The model depends upon multiple regression analysis to establish the relation of the independent variables and the solution of the derived equations to output the dependent solutions.

The Voter Response Model - M.E.T.R.O. uses a Monte Carlo type of simulation of voter response to candidates and to various kinds of issues. By "voter response" we mean the voter turnout at the polls, the vote cast on various issues presented for a vote, and the number of "yes" and "no" votes on any given issue or candidate. The candidates running for office are players, and therefore are incumbents. The characteristics of the opposition candidate(s) are not specified.

A simulated voter is faced with a sequence of choices: whether or not to vote, whether or not to vote on a particular issue (if more than one is offered), and whether to vote "yes" or "no" for a particular candidate or issue. Any "no" decision drops a voter out of this branching tree of possibilities, and the next voter is taken up. (For purposes of economy, several hundred voters are taken up at a time). Each decision point is a randomized generation of alternatives, binomial in nature, whose probabilities are affected by a number of social variables.

Factors affecting the voter response model are: the population size, the relative wealth of the population (*e.g.* median family income), the kinds of issues being presented, the kind of election being called, (*e.g.* special, local, state, or national), the support of pressure groups (simulated) for the issue or candidate, the consensus of players on whether or not to support a given issue, and a candidate's behavior in the past few cycles (*e.g.* whether he met public demands for services in a satisfying way, whether he balanced taxes with services, and whether or not he implemented such necessary, but unpopular, policies as zoning changes in residential areas).

Both politicians and school people run for office every other cycle. This is to let reality bite back, in the sense that office-holders must be concerned both with popularity of programs and promotion of the welfare of enough voters to stay in office. If an area of town is neglected, or proposed programs that are deemed necessary have been historically unpopular, then candidates will feel the weight of public opinion. Short-run appeasement of interests is not enough; things have to work well for our office-holder to survive. To this end, we computed numerous regression equations on support levels for different issues in the Lansing area, and we are analyzing an opinion poll of public preferences (by class, area, and ethnicity) for various public goods. These give the parameters of the model.

Computer Produced Maps - During the course of the game, each player's decisions will produce simulated physical, social, and economic changes in the Tri-County Region. The majority of these changes will be reported to the players in the form of tables and charts relating to specific data items. However, the player's perception and comprehension of these changes will be greatly facilitated if he has available graphic representations or maps which depict the extent and location of changes in the region each cycle.

Since the time constraints of the game preclude the manual preparation of maps each cycle, it is necessary to produce the desired maps directly on the computer. This will be accomplished by use of a computer program known as SYMAP, originally developed by Professor Howard T. Fisher of Harvard University.

SYMAP (Synagraphic Computer Mapping Program) is capable of producing three types of maps. "Areal flat tone maps" are similar in appearance to maps which have been prepared by placing different symbols (*e.g.* zip-a-tone patterns) over each areal unit on a map, where the patterns shown are a function of the data value assigned to each areal unit. Since SYMAP can accommodate up to ten different "levels" or groups of data, there is a different pattern associated with each level (*e.g.* 0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-100). Each of the ten patterns is produced by printing with different characters available on a computer printout.

"Linear flat tone maps" are similar to areal flat tone maps, except that each flat tone area is only one character in width or height. Such maps are useful for portraying variables associated with channelized flows (*e.g.* highways, streams, etc.).

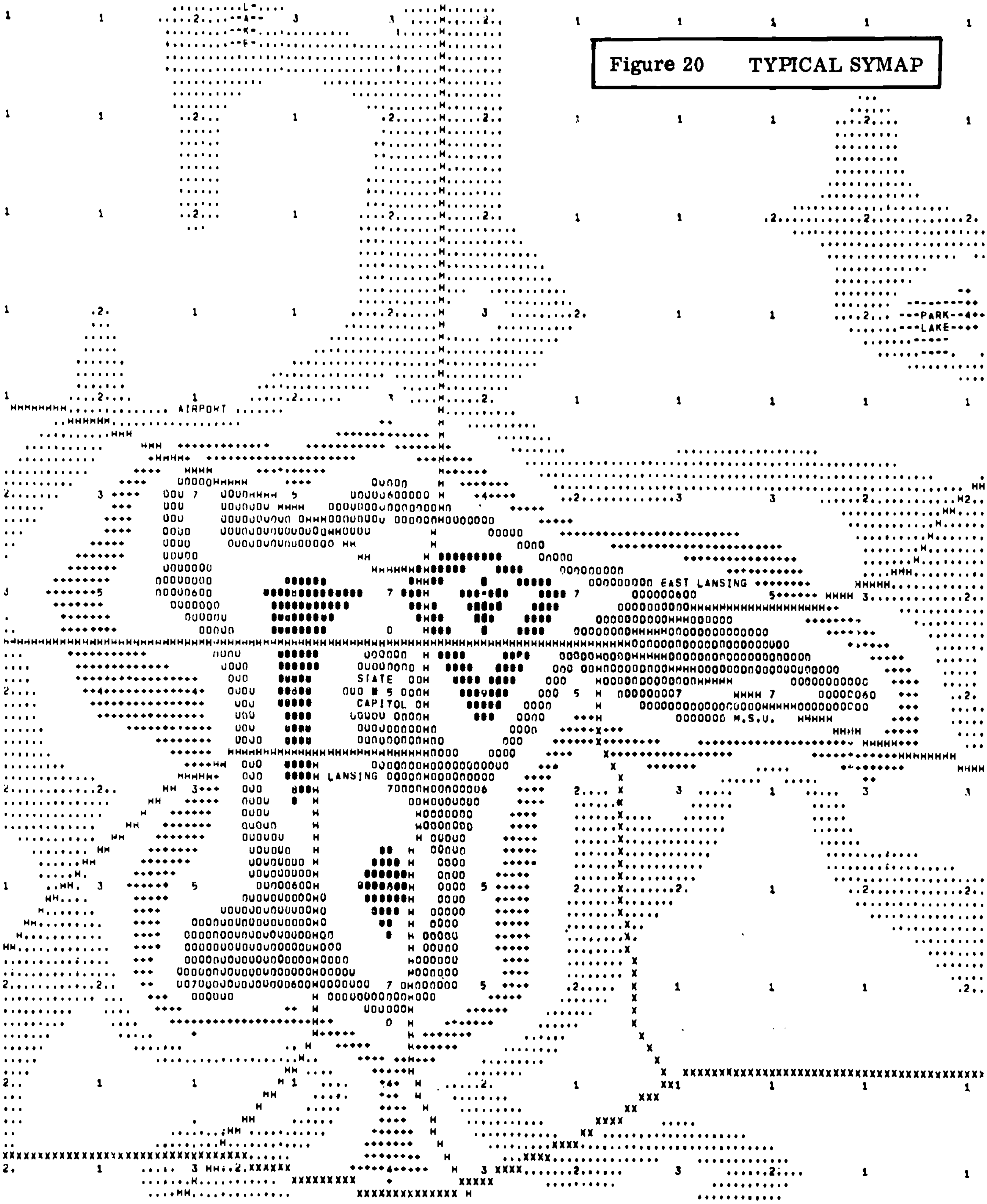
The most significant characteristic of SYMAP is its ability to produce "contour maps" (see Figure 20). The location and value for each contour are calculated by the computer by means of linear interpolation between known data values. A contour map will at times be a more accurate representation of reality than a flat tone map. This is particularly true if the values of the phenomena being mapped are expressed in terms of a continuous scale rather than being of discrete types (*e.g.* population densities *vs.* land use categories).

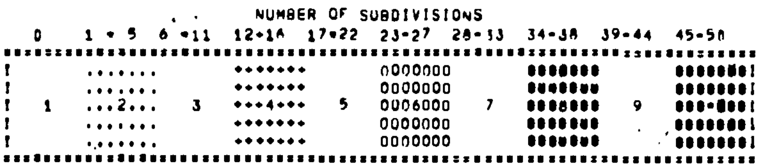
The preparation of SYMAPs will be completely automatic, with the data being drawn from the data bank each cycle. Certain SYMAPs may be optional and produced at the discretion of the game Operator. In both cases, all required information to produce maps in response to control card inputs will be contained on magnetic tape or drum storage.

The specific examples of maps which might be produced in a given cycle include the quantity and location of new households, new jobs, new subdivisions, public improvements, dilapidated housing, polluted streams, voter regions, school needs, land use, zoning, etc.

In addition to SYMAP, the possible use of a 30-inch Calcomp Digital Incremental Plotter is being explored. A 30-inch Calcomp Plotter is currently on order at Michigan State University's Computer Laboratory.

Figure 20 TYPICAL SYMAP





SUBDIVISION ACTIVITY IN THE TRI-COUNTY REGION, LANSING, MICH.
NUMBER OF SUBDIVISIONS PLATTED WITHIN EACH SECTION OF THE NINE TOWNSHIP AREA AROUND LANSING, 1870 TO 1965

6. ANTICIPATED USES OF M.E.T.R.O.

As urban planning has slowly evolved from purely physical planning with engineering and architectural tools, toward political-socio-economic analysis, it has become clear that new decision-making capabilities need to be developed. In the past, decisions about social change, about public goods, and about the nature of the public welfare have been left largely to market forces or to the privileges of powerful interest groups. Modern urban life has become complex and interdependent to the point where a transit strike, a power failure, a water shortage, and problems *ad infinitum*, can paralyze any metropolis. We must actively anticipate the future and bend its course to our goals and our needs, merely to survive. But these decisions have few precedents in whom they affect, in the scope of their impact or in their complexity. Many such decisions are not, even in principle, susceptible to analysis by presently known mathematical tools, such as statistical decision theory or operations research. They are more often in the form of n-person strategic games, with strategies, conflicts, coalitions, bargaining, payoffs, etc. so complex that the game-theorist in mathematics throws up his hands in horror at the mere prospect of analyzing

Urban planning of the new type is therefore a twofold process whenever it is oriented to scientific procedures: (1) On the one hand, it is concerned to discover *rational means of allocating resources* to optimize the attainment of diverse public goals. It attempts to evaluate the way in which various public policies, public goods, and gross economic activity patterns will respectively affect (positively or negatively) rational goal attainment. It even compares the short-run policy goals to their long-run effects and the long-run goals of society. (2) On the other hand, planning becomes, in this context, very much of an *educational process*. Many of the best procedures of national resource allocation are still being discovered and may exist, if at all, only as heuristics in the minds of practitioners. Urban policy-making is complex enough that planners educate themselves merely by the process of exploring the range of decision-making tools. They are educators also, not by presenting full-blown plans, but by constructing and explaining a good rationale as a basis for a plan. This introduces concepts of how to think about our urban future and how to think about planning. It sensitizes the public to the alternatives we face in the future. This is the best hope of planners, since having little personal power, their only chance of success is to persuade others - an educational task.

The M.E.T.R.O. project is illustrative of one of the most efficient techniques for quickly conveying this very complex subject without the problems of a language barrier. Operational gaming involves people in the excitement of a game, but one that is relevant to *real* problems they face, so that problems of motivating the learner are lessened. It also gives direct experimental contact with prototypical decision situations, realistic problems and constraints, and prototypical power and conflict relations, all merged into the same framework. Given these advantages, the remaining advantage is possible - that decision-makers can experiment with new ideas and techniques at a very low cost. Unlike their real-world decisions, there is not so much riding on an outcome that the tried and true, what once worked, is there to exert a conservative bias. The stage is set for bold innovative solutions, such as will soon be required for urban areas, but with feedbacks in the game to show where the dangers and complexities lie. It allows social science concepts to be systematically illustrated in a concrete form that is very relevant to policy personnel. Such ideas as the concept that the short-run rational decision may be disastrous in the long run are lost on policy makers if stated as the "prisoner's dilemma" of game theory[6]; but the concept is well illustrated in a M.E.T.R.O. type of game where this year's opportunistic decision must be lived with for the next decade.

The beauty of operational gaming is its flexibility. A gaming simulation of the M.E.T.R.O. type may be modified to illustrate a galaxy of urban places,

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6 If both players cooperate on low payoff outcome, they both do well in the long run; but there is a high payoff to the one who "cheats" or refuses to go along; and if *both* learn not to cooperate, as is short-run rationality, then *both lose* every round.

with universes of problems, thereby clarifying whatever social science has to offer on the subject of urbanism. Operational gaming keeps social science from being dull and pedantic. It allows the non-academic an insight into the connection of complex situations and complex explanations. It warns the academic that the world he wants to explain has a richness and variety that cannot be ignored. As an educational tool, it has value, because it is close to experience; but it is a condensation of experience, and its lessons are infinitely less binding and final.

It is obvious from the above that gaming simulations of the M.E.T.R.O. type will serve educational functions for many populations:

(1) Planners - both professional training for planning students and the refurbishment of skills for professionals in the field, as an introduction to new technologies and the meaning of applied social sciences. For example, training in the use of urban data banks and the array of social statistics they provide.

(2) Politicians and Public Administrators - as a link between planners or technicians and policy makers, it makes professional abstractions and jargon more concrete and pertinent. As an educational tool, it exposes the array of choices actually available and the contributions of some of the new technologies, and it gives the beginnings of rationales for evaluating plan alternatives. Under the heading of elected officials, we must distinguish between the updating of decision-skills of established officials on the one hand, and the familiarization of new officials with the complex problems of urban affairs on the other hand. Relative to this point, M.E.T.R.O. models can provide a fairly good "reality shock" to newly elected officials who come to office with strong ideological convictions. Plans can be readily evaluated.

(3) Social Scientists - concerned with urbanism, in political science, economics, sociology, geography, and public administration, can use the M.E.T.R.O. type instrument to investigate sytematically the effects of hypothetical decision patterns on the urban scene. They can run different kinds of models in the simulation sector and examine player reactions. They can examine such gaming simulation instruments for ideas on where data or explanatory concepts are missing; and they can utilize their own M.E.T.R.O. type instruments to

explain their disciplines to planners, to students, and to lay persons. When the planning rationale is made more public in this way, better students can be attracted to urban problems and to urban planning.

(4) The Linkage of Planners and Local Officials to Officials of the Federal Government (*e.g.* in HEW and in the new urban and transport department) - problems at the local level can be illustrated by the play of a sample game representing an urban area. M.E.T.R.O. type models can, in the long run, be built around the particular parameters of any given urban area. They could become standard artifacts of future urban planning offices, if only to easily demonstrate to all what planners are doing.

APPENDIX I

OPERATION FORMS

12/13/65

M. E. T. R. O. PLAYERS CHECKLIST*

ROLE: ______________ AREA: ______________

1. AGENDA: a. What is your standing? b. What is the area's standing? c. What are your teammates' standing?	4. Actual budgeting a. operating expenses b. capital improvements	Cycle # Time Player's Name
2. Prepare public opinion poll positions.	5. Operations to improve current standing	7. Note Taking a. Information needed b. Bargains made c. Pending actions (Applications) d. People checked with
3. Budget Preliminaries __________ __________ __________ __________	6. Memo to check on information needed.	

* Forms to be preprinted in desk pad format

PAYOFF MATRIX FOR ANY GIVEN ISSUE

	CENTRAL CITY (+1 / -1)	SUBURBS (0 / -1)	URBAN TWPS. (+1 / 0)
POLITICIANS (+1 / -1)	∑Pass CC∩Pol. (+2) ∑Fail CC∩Pol (-2)	∑Pass Sub ∩ Pol. (+1) ∑Fail Sub.∩Pol. (-2)	∑Pass Twp∩Pol. (+2) ∑Fail Twp.∩ Pol. (-1)
PLANNERS (0 / -1)	∑Pass CC∩Plan (+1) ∑Fail CC∩Plan (-2)	∑Pass Sub.∩Plan (0) ∑Fail Sub∩Plan (-2)	∑Pass Twp∩Plan (+1) ∑Fail Twp.∩Plan (-1)
LAND PEOPLE (-1 / +1)	∑Pass CC∩ LP (0) ∑Fail CC∩LP (0)	∑Pass Sub∩LP (-1) ∑Fail Sub∩LP (0)	∑Pass Twp. ∩ LP (0) ∑Fail Twp.∩LP (0)
SCHOOL PEOPLE (+1 / 0)	∑Pass CC∩SP (+2) ∑Fail CC∩SP (-1)	∑Pass Sub∩SP (+1) ∑Fail Sub∩SP (-1)	∑Pass Twp∩SP (+2) ∑Fail Twp.∩SP (0)

M.E.T.R.O. INDEX FORM -- PROGRAMMED ROUTINES

PROGRAM# ______________________ CATEGORY # ______________________

NAME ______________________

PURPOSE ______________________

____

DESCRIPTION ______________________

____

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PROCEDURES FOR USE ______________________

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INPUT ORIGINS ______________________

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OUTPUT DISTRIBUTION ______________________

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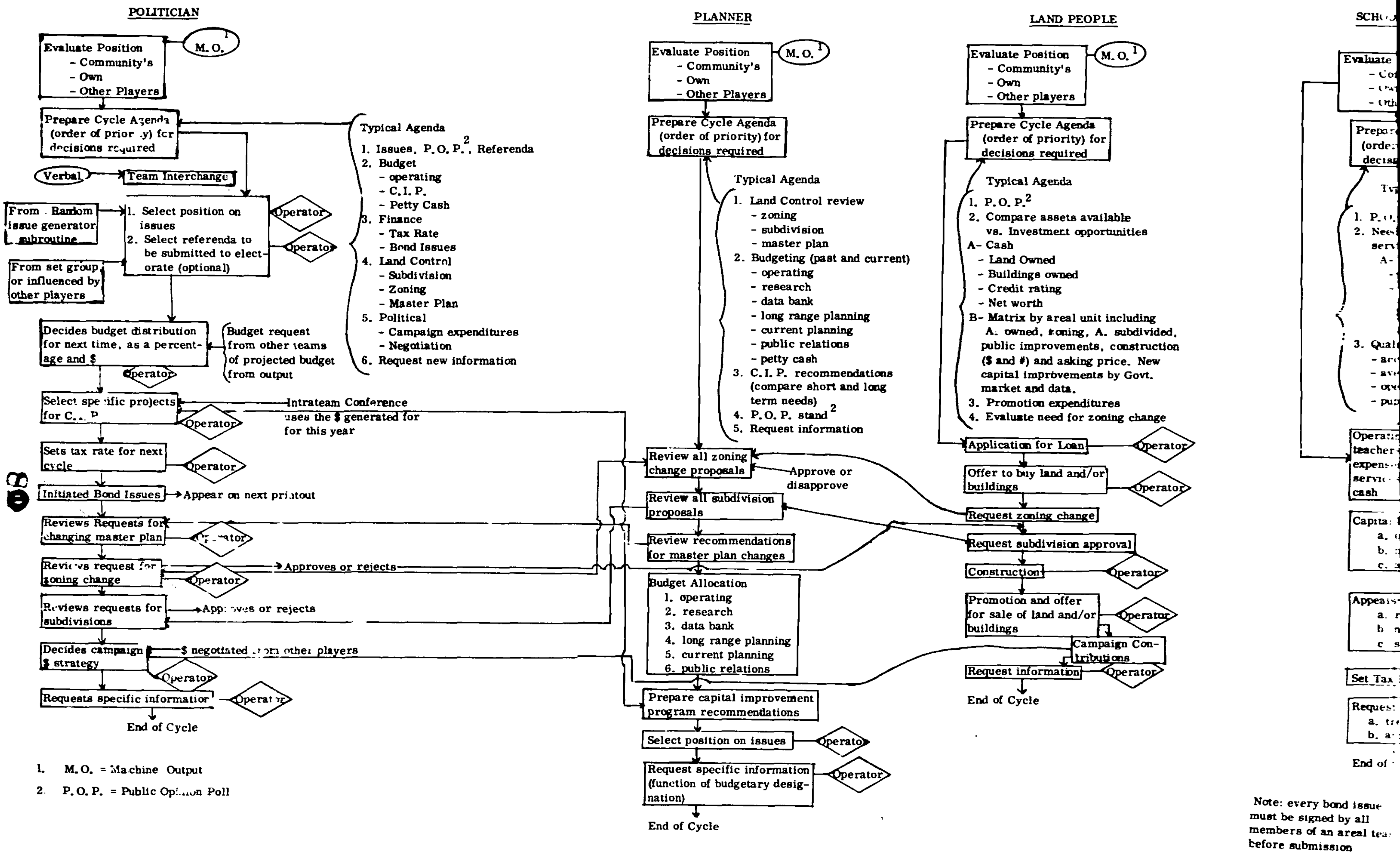
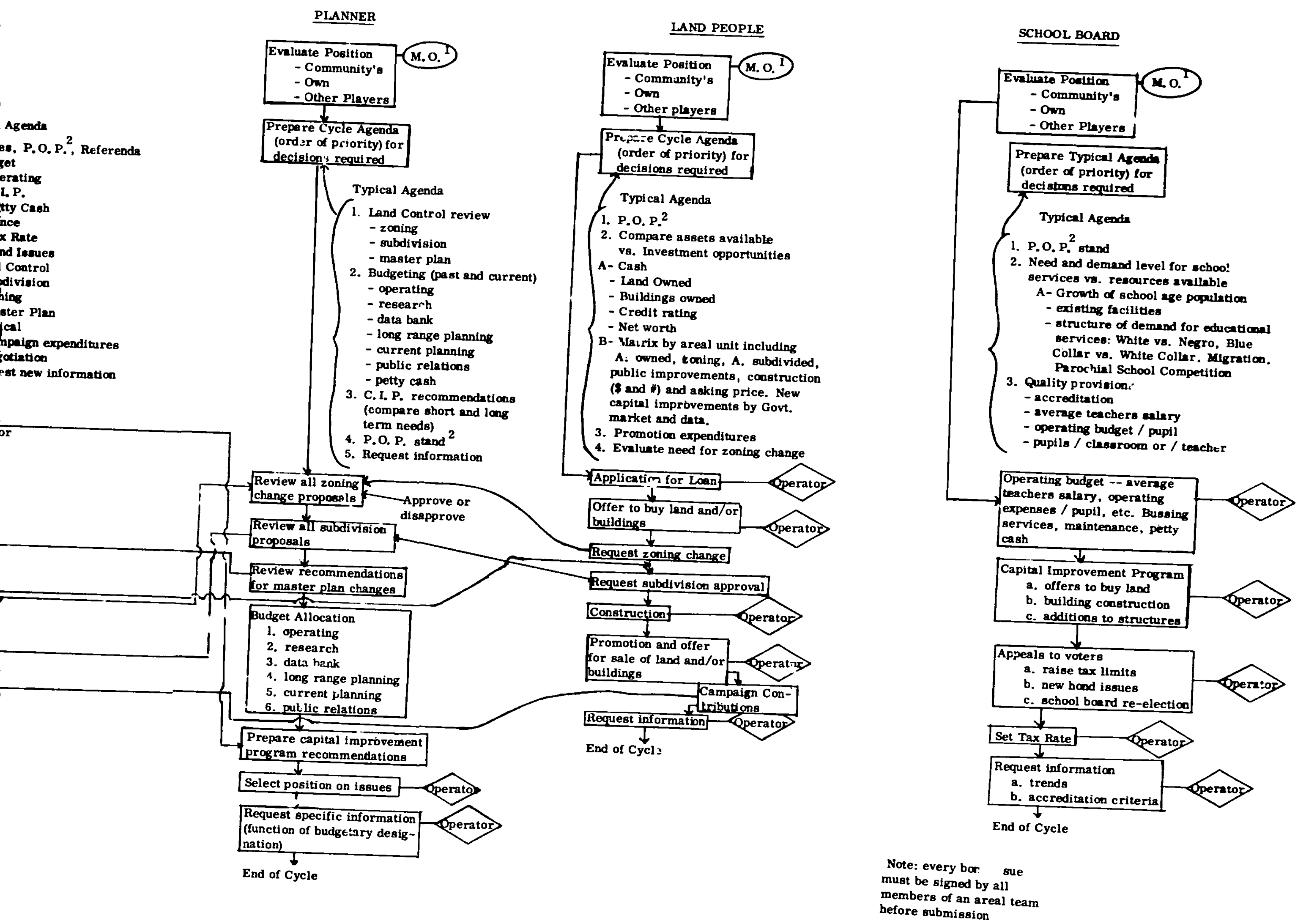
APPENDIX II PLAYER ACTIVITY FLOW CHART



1. M.O. = Machine Output
2. P.O.P. = Public Opinion Poll

APPENDIX II PLAYER ACTIVITY FLOW CHART



APPENDIX III PROTOTYPE DATA BANK LAYOUT

M.E.T.R.O. DATA BANK

LAND CHARACTERISTICS — LAND USE / SITES OWNED / LAND PEOPLE; PLANNED USE; ZONING CHANGE INDEX; CAPITAL IMPROVEMENTS — CAPITAL PLANT INVENTORY

DATA / CENSUS TRACTS	GROSS ACRES	NET ACRES	PUBLIC	VACANT (ZONING A, B, C)	RESIDENTIAL (ZONING A, B, C)	COMMERCIAL (ZONING B, C)	INDUSTRIAL (C)	SCHOOL BOARD (ACRES)	LAND PEOPLE 1 — CATEGORY 4, 5, 6, 7, 8, 9	LAND PEOPLE 2 — CATEGORY 10, 11, 12, 4, 5, 6, 7, 8, 9, 10, 11, 12	LAND PEOPLE 3 — CATEGORY 4, 5, 6, 7, 8, 9, 10, 11, 12	LAND VALUE INDEX	PLANNED USE: PUBLIC, OPEN SPACE, RESIDENTIAL, COMMERCIAL, INDUSTRIAL	ZONING CHANGE INDEX: POLITICIAN, SUPPORT, OVERRIDE (PLANNER)	BLIGHT INDEX	ACCESSIBILITY INDEX	LAND-USE INTENSITY	UTILITIES	ROADS	PUBLIC RECREATION	TOTAL	SCHOOL AGE	DEPENDENCY	%
CENTRAL CITY 1-25								# SCHOOL ROOMS	# SUBDIVIDED LOTS; # UNITS FOR SALE	# UNITS FOR SALE; # UNITS FOR SALE; # SUBDIVIDED LOTS; # UNITS FOR SALE; # UNITS FOR SALE; # UNITS FOR SALE; # DIVIDED LOTS	# UNITS FOR SALE; # UNITS FOR SALE; # UNITS FOR SALE	GENERATED BY DISTRIBUTION MODEL		(ZONING IMPACT VALUE) x (NO. OF ACRES) x (LAND VALUE INDEX)*; POLITICAL ** APPROPRIATE COLUMN	AGE, LAND USE INTENSITY, CENTRALITY	ARBITRARY VALUE RELATED TO MASTER PLAN	ARBITRARY VALUE BASED ON OBSERVATION OF CURRENT FACILITIES							
SUBTOTAL																								
SUBURB 31-36																								
SUBTOTAL URBAN TOWNSHIPS																								
41-56																								
SUBTOTAL																								
TOTAL														Ch	Ch									

* Z.I.V. IS DERIVED FROM OVERPRINT OF ZONING CHANGE FORM

** THREE SC…

APPENDIX III PROTOTYPE DATA BANK LAYOUT

.O. DATA BANK

LAND CHARACTERISTICS

SITES OWNED

LAND PEOPLE

- SCHOOL BOARD
- 1 — CATEGORY 4, 5, 6, 7, 8, 9
  - # SUBDIVIDED LOTS
  - # UNITS FOR SALE
- 2 — CATEGORY 10, 11, 12, 4, 5, 6, 7, 8, 9, 10, 11, 12
  - # UNITS FOR SALE
  - # UNITS FOR SALE
  - # SUBDIVIDED LOTS
  - # UNITS FOR SALE
  - # UNITS FOR SALE
  - # UNITS FOR SALE
- 3 — CATEGORY 4, 5, 6, 7, 8, 9, 10, 11, 12
  - # SUBDIVIDED LOTS
  - # UNITS FOR SALE
  - # UNITS FOR SALE
  - # UNITS FOR SALE

- LAND VALUE INDEX — GENERATED BY DISTRIBUTION MODEL
- PUBLIC
- OPEN SPACE

PLANNED USE

- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL — (ZONING IMPACT VALUE) x (NO. OF ACRES) x (LAND VALUE INDEX)* — 4
- POLITICIAN
- SUPPORT — POLITICAL ICE IN APPROPRIATE COLUMN
- OVERRIDE

ZONING CHANGE INDEX

- PLANNING
- BLIGHT INDEX — AGE, LAND USE INTENSITY, CENTRALITY — 4
- ACCESSIBILITY — ARBITRARY VALUE RELATED TO MASTER PLAN
- LAND-USE INTENSITY INDEX — ARBITRARY VALUE BASED ON

CAPITAL IMPROVEMENTS

- UTILITIES — OBSERVATION OF CURRENT
- ROADS — FACILITIES
- PUBLIC RECREATION
- CAPITAL PLANT INVENTORY — TOTAL

SOCIO-ECONOMIC

- SCHOOL AGE 5-18
- DEPENDENCY RATE -15, 65+
- % NON-WHITE
- CRIME RATE
- MEDIAN FAMILY INCOME
- MEDIAN EDUCATION
- HOUSEHOLD TYPE — 1, 2, 3, 4, 5 — % OF D.U.'s IN EACH CATEGORY
- MEDIAN HOUSING VALUE
- [illegible]
- # D.U.'s
- [illegible]

* Z.I.V. IS DERIVED FROM OVERPRINT OF ZONING CHANGE FORM

** THREE SETS: ONE FOR EACH PLAN OPTION

APPENDIX IV

M.E.T.R.O. DATA SYSTEM PROGRAMMED ROUTINES

(1) Population Equivalent Totaler - Calculates the total number of population equivalents in each analysis area for input to capital plant index routine.

(2) Capital Plant Deterioration Model - Depreciates the value of the capital plant investment each cycle for each analysis area.

(3) Capital Plant Index - Each cycle, the new capital plant investments are added to the depreciated capital plant giving a new total value for each analysis area. This total is established as a ratio to the population equivalent to obtain a reference index value.

(4) Capital Plant Adequacy Check - Checks the present value of the capital plant index against a standard of adequacy value to determine the current "standing" of the capital plant of any analysis area.

(5) School Accreditation Routine - Tests the current adequacy for each school district on the basis of four parameters used in accreditation and assessment procedures. These are capital plant investment per student, teacher salaries, operating expenditures per student, and the pupil-teacher ratio.

(6) General Adequacy of School Plant (G.A.P.) - Depreciates previous school plant investments each cycle for each analysis area and adds to this any new investments. Checks the ratio of the investment per pupil with a standard ratio to determine the adequacy of the present investment level.

(7) Average Teacher Salary - Computes an average teacher salary for use in the school accreditation routine based upon the dollars budgeted for salaries and the number of teachers in each district.

(8) Operating Expenditure per Pupil - Calculates the ratio of the current operating expenditures to the number of students for each school district.

(9) Pupils Per Teacher - Calculates the ratio of pupils per teacher for current time period for each school district.

(10) School Room Update - Accounting routine for the number of school rooms, including a check of those rooms reaching an age-inadequacy threshold.

(11) Total Number of Teachers Needed - Calculates the discrepancy between the number of teachers presently in each of the school districts and the number required to reach the acceptable standard pupil-teacher ratio.

(12) Teacher Salary Demand - Increments the teacher salary level demands each cycle during the course of the game.

(13) Total Cost of Teacher Salary Demands - Calculates the total cost of meeting the teacher salary demands if the standard teacher-pupil ratio is maintained.

(14) Land Developer Loan Evaluation Routine - Checks on the financial eligibility of any Land Developer for a loan by testing whether or not it falls within the maximum limits set for him.

(15) Land Developer Taxes Owed - Each cycle, based upon the location and volume of land holdings of each developer, the taxes owed are computed.

(16) Campaign Expenditure Influence - Calculates the adjustment in reelection likelihood for politicians, based upon campaign funds expended for current election.

(17) Zoning Change Index (Planner) - Computes a position index for the Planner each cycle based upon zoning change requests which he has permitted or rejected. Included factors are the agreement of the Planner's choice with the master plan, agreement of his recommendation with the politicians' ultimate choice, the discrepancy of the recommendation (if any) with present development types in the area, and the changes in land value derived from the change.

(18) Zoning Change Index (Politician) - Computes position index of Politician relative to his action in zoning request matters. Based upon agreement with master plan, correlation with present land use patterns, agreement with Planner's recommendation, number of changes and land value changes derived from rezonings.

(19) Master Plan Discrepancy Routine - Checks zoning changes with land use distributions provided for in the master plan, for changes which exceed the permitted land use volumes in the plan. Excessive occurrences of discrepancies may affect the voting patterns in the voter response model generating election results for politicians.

(20) Land Sales and Purchase Accounting - Running accounts for the land holdings of players, by analysis area, updated each cycle.

(21) Buildings' Sales and Purchase Accounting - Running accounts for the land holdings of players, by analysis area, updated each cycle.

(22) Net Area Formula - Updates the net area available for development in each analysis area (area not in streets).

(23) Land Value Index - Maintains an index value for land which may be used in operating in other information routines or can be converted to a dollar value for land (land value routine) for specific reference purposes, such as for assigning purchase prices for land transactions. Factors include present value of building improvements on the land, demand for

units in the analysis area, the capital plant index, the land currently available for the particular type of land use in the analysis area, and the old land value index.

(24) Land Value Routine - Converts land value index to actual dollar values when this is required by land transaction procedures.

(25) Land Value Totaler - Sums improved and unimproved land values for analysis areas to derive total value for the areas.

(26) Tax Levels for Schools and Political Jurisdiction - Updates the millage levels for each of the taxing units. Checks for discrepancies of millage levels with the state millage limits.

(27) Tax Base Update - Collates total value of land in each analysis area with assessment level of the taxing jurisdiction within which it is located, then accumulates by jurisdiction the total assessed value levels.

(28) Tax Revenue Routine - Computes the tax revenue, by jurisdiction, on the basis of current tax base and the tax millage levied by each jurisdiction (minus a certain proportion of delinquency).

(29) Petty Cash Update Routine - Maintains a cycle-by-cycle accounting of the petty cash of each player. Serves as a device for checking the flow of these funds in the game.

(30) Traffic Accessibility Update - Each cycle, the traffic accessibility factors are updated for each analysis area (factors are inputs from growth model).

(31) Output Control - Provides format and structure for certain lead in information for the output each cycle, such as leading, cycle number, and certain print statements.

(32) Newspaper Generator - Each cycle, generates newspaper describing the variety of community conditions and information concerning activities or actions that are relevant to the game. Includes a generation of random headlines as well as those of explicit importance to the game. Sections include national, state, and local information portrayed in tabloid and computer graphic form.

(33) Player Standing Output Set - Separate set prepared for each player. Composed of various information relevant to the individual player's role, some of which is presented routinely each cycle; the rest is produced as the result of specific requests for information by the player at the beginning of the cycle.

(34) Player Budget Routine - Compiles the financial statements relevant to each of the individual roles (

APPENDIX V
HOUSEHOLD TYPES

THE DISTRIBUTIONS OF SOCIO-ECONOMIC STATUS TYPES (OR HOUSEHOLD TYPES) BY ANALYSIS AREAS

For the M.E.T.R.O. gaming simulation, it is essential to be able to characterize the life styles, political importance and voting habits, general consumption behavior, and preferences for public goods, of the families who live within certain fairly homogeneous areas. For this purpose, we have decided that a five-class system appears to describe the Lansing Metropolitan Area with enough precision for our purposes. It is the *shape* of the distribution for each analysis area that is important for our purposes, not the actual numbers on any given variable. We wish to characterize central tendency and dispersion about that tendency for socio-economic levels. Hence, the percentage distribution by tract for SES levels will be found from an averaging of the percentage distributions by levels on certain objective indicators of class position. The data are derived from the 1960 Census, Report PHC(1)-73, and will be validated from the Home Interview sample survey conducted by the Tri-County Regional Planning Commission.

As Schumpeter noted long ago, the real unit of social class analysis is the family or the household. All members of a familial unit share the socio-economic status, or if you prefer, the social class position, of the head of the household. So, to say that we are talking of the SES composition of census tracts or the kinds of households in analysis areas, is to refer to precisely the same phenomena. Hence, the easiest way to classify households is to refer to the objective indicators generally agreed upon by sociologists as encompassing the most important aspects of social class position: occupational types, residential types, income levels, and educational levels of heads of households. Defining class position of a household, or defining the class composition of a census tract, using a combination of these variables rests on an explicit assumption about each variable. First, the occupation of the head of the family reflects the skill, power, and prestige of his productive niche in society; second, a family's mode of living is mirrored in its home; third, the family's income determines its ability to get what it wants in the marketplace; and fourth, the level of the formal education of the head of the household indicates the tastes and preferences for public goods of the whole family. Combining these into a weighted index gives a status score for families and comparison of the percentage distributions by levels of each indicator gives an idea of the general status level of an analysis area and of its relative heterogeneity. We expect most census tracts to be dominated by one or two status groupings as a rule, and sometimes three.

Since Lansing is a middle-sized midwest city, it seemed reasonable to suppose that five classes would most adequately describe its class structure. No census tracts will be identified as "upper class" in the classic sense. There are too few households that could fit such a definition. We do not propose to do any extended and rigorous research to verify the five-class suppostion, for preliminary evidence suggests no direct conflict with this usage. The five classes will be referred to in this report as household types from here on. In addition to the above-listed indicators of class composition of census tracts, the percent of non-white residents will be listed alongside of the distribution of our stereotyped household types in the playing of the game.

In Social Class and Mental Illness by Hollingshead and Redlich, A. Hollingshead and J. Myers found that expert judgments of the social class position of carefully interviewed respondents could be predicted with a probability of (Pearsonian r) .93 by use of a combined index of residence and occupation. Use of education in a 3-factor index raised the correlation to .94. While it may not be valid to extrapolate directly from the New Haven class structure of five classes to Lansing, it is possible to assign roughly the same order of priority to the variables in our characterization of census tracts: occupation is first, residence second, education third. Just to be sure, income will be added as a fourth indicator, if only as median family income.

What follows is a series of stereotypes that shows our combination of variables.

Household SES Type I - Is upper middle class and upper class combined. Occupations of head of households are: professionals, technical workers, managers, officials and propriators. One-half of the family income levels are in excess of $15,000, and the other half are in the $10,000-$15,000 range. (There is a substantial overlap of income levels for all status groupings, hence income is a weak indicator for characterizing households in census tracts). Value of housing is in excess of $20,000, and if they rent, rentals are over $150 per month. Education of the head of the household is at least college graduate, often with postgraduate study.

Household SES Type II - the typical middle-class household in which the head's occupation is clerical, sales, or kindred types. Income of the family is primarily in the $7,000-$10,000 range. Education of the head is some college or high school graduation. Housing value is primarily in the $15,000-$20,000 range, and gross rentals would be from $100 to $149 per month, though they may be somewhat lower.

Household SES Type III - is characterized by a mixed membership of very low white collar workers, skilled craftsmen and foremen, though the latter two predominate. Family income is primarily in the $4,000-$7,000 range. Head of household's education is typically high school graduation. Housing value is usually from $10,000 to $15,000, and rental in the $80 to $100 per month range.

Household SES Type IV - is composed of semiskilled occupants, operatives and non-household service workers. Family income is in the lower portion of the $4,000-$7,000 range. Housing values are in the $5,000-$9,900 range, with gross rentals being $20 to $59. Education of the head of household is 8 to 11 years for the most part.

Household SES Type V - is the lowest stratum of society and heads of households are laborers or household service workers. Family income is less than $4,000, and the value of housing is less than $5,000 and rentals primarily less than $20 per month.

There are stereotypes, it must be stressed, for any given household may fall within an SES type on one variable (say income) and within a different SES type on another variable. What this approach *is* legitimate for is giving the approximate composition of an analysis area by comparing and summing the *patterns* of the distributions on three of the four variables: occupation, housing, and education. Income is redundant here.

APPENDIX VI

A Bibliography of
Reports Supplementary to
the M.E.T.R.O. Project

THE MICHIGAN EFFECTUATION, TRAINING, AND RESEARCH OPERATION PROJECT (M.E.T.R.O.)

I. M.E.T.R.O. Project Description

   A. One Page Abstract

   B. M.E.T.R.O. proposal to the U.S. Housing and Home Finance Agency

II. M.E.T.R.O. Logic Model

   A. Typical M.E.T.R.O. game sequence

   B. Generalized M.E.T.R.O. logic model

   C. Detailed Pittsburgh C.R.P. logic model

   D. M.E.T.R.O. population, household, and income distribution model (tent.)

   E. M.E.T.R.O. World Interaction Matrix (M.W.I.M.)

III. Supporting Studies

   A. Study Outlines

      1. A History of land subdivision activity

      2. An analysis of subdividers and builders

      3. An analysis of land and builders

      4. A study of public referenda decisions in the Tri-County Area

      5. A profile of local government types in the Tri-County Region

      6. Stages in the development of the tax proposition study

      7. Public expenditure study

      8. A preliminary investigation of the sequence of land use by local government decision-makers

      9. Home interview questionnaire

      10. An analysis of the effect of zoning changes upon land development patterns

      11. 3 maps of the Tri-County Region

   B. Technical Papers

      1. Iterative P.E.R.T. (Hamdi Akfirat)

      2. Voter Response Model (Hamdi Akfirat)

IV. Related Urban Games

   A. Operational Instruments

      1. Gaming Simulation in Urban Research - Metropolis (Richard D. Duke)

      2. The Cornell Land Use Game - C.L.U.G. (Allan G. Feldt)

3. Planning Operational Gaming Experiment - P.O.G.E. (Francis Hendricks)

B. Proposed Instruments

1. Computer Simulation of a Community for Gaming (Nathan Grundstein)

2. The Community Model Game and the Workable Program Fundamentals (Nathan Grundstein)

3. Toward the Advancement of Comprehensive Planning Technique (Alvin Lewis)

V. Related Literature

A. Gaming Urban Systems (Richard D. Duke)

B. Operational Gaming in Planning Education (Allan G. Feldt)

C. The World Crises in Dedham, Mass. (Peter C. Brooks)

D. Social Science and Social Control (John Dewey)

E. Organizing the Use of Models in Metropolitan Planning (Britton Harris)

F. War Gaming (Clark C. Abt)

VI. Bibliographies

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*Advisory capacity

**Not currently with the project