URBAN SYSTEM ANALYSIS AND MODELING

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Electrical engineers, aerospace engineers, physicists, chemists, and other engineers and scientists with skills developed in the defense and space effort have begun gropingly to seek to apply their expertise to the solution of social problems. Key among these are problems of our urban environment. In this tutorial talk we focus, with examples, on some areas of city life and government in which engineers and scientists have already begun to play a role, or in which they might eventually become involved. This implies engineers working closely with lawyers, economists, planners, government officials, consumer groups, community groups, and others, in developing acceptable solutions to the problems.

We first discuss briefly applications from the areas of instrumentation, communication and telemetry, data processing, and control technology, to the urban setting. For example, we note in the talk the need to develop instruments for pollution measurements and control, environmental sensing, traffic control, transportation, etc. Absorption and reflective (i.e. radar type) techniques involving infra red, laser optics, etc., have been suggested for instruments required to measure and monitor various pollutants in the air and water, in situ and dynamically. Traffic instruments that sense car flow, velocities, density of traffic, types of traffic, etc., are needed.

Efficient transmitter-receiver systems are needed to telemeter the environmental, traffic, and other data measured to central processing stations. The expected increase in data traffic due to increased use of telemetry plus widespread commercial data flow, projected home and individual user data needs, computer utility requirements, and the like, makes vitally important the development of comprehensive and efficient urban data networks. Add to this increased requirements for mobile communication systems that accommodate all types of emergency communications (fire, police, health and medical), public carrier (taxi), radio telephone, and others, and one has some extremely difficult problems relating to urban communications that will have to be solved. Public, private, and technological constraints will all have to be considered in their solution. As an example, it is apparent that work is urgently needed on the question of more efficient spectrum allocation and usage in crowded urban areas. The concept of Spectrum will of necessity have to be broadened to include time and space (geographical) allocations as well as frequency allocations. Radio and cable systems, data and voice networks, will have to be mixed in some equitable fashion. Should there be regulation of these? Should there be one communications utility for a given region, should there be competitive private systems? What is the public's interest in all of these questions and how would it best be served? Urban regions, particularly in the case of communications, cover many political jurisdictions. Should the Federal government, state, and municipalities involved all play a role in the resolution of these questions? This is obviously one area in which technology and public policy questions are highly interrelated and in which engineers will have to work closely with public officials, representatives of user groups, public interest groups, etc.

In the next and major portion of the talk we consider the newly-arising area of urban system analysis. This area ranges broadly from operations research analyses for more efficient allocation of resources, to urban modeling for planning purposes, to traffic and transportation studies. In all of these, systems analysts, systems engineers, computer specialists, etc., are playing significant roles.

Examples include the application of systems techniques to such public systems as education, public welfare, housing, waste disposal, police, the criminal justice system, fire, hospital, and medical care. Here systems analysts and engineers work with the public agencies involved to more efficiently allocate resources, set up performance standards, develop methods for monitoring performance, develop models of the systems involved for forecasting and data gathering purposes, develop more realistic planning and programming procedures, etc.

Some case studies available for fire, housing, police, and sanitation, among others, and actual implementation of some of the approaches suggested by systems analysts indicate that significant improvements in service may be obtained at no or very little additional cost. There are difficulties in implementing some improvements or changes suggested because of entrenched bureaucracy. The natural suspicion aroused by "new-fangled" ideas and concepts often slows down the introduction of new approaches to fire fighting, crime detection and prevention, or to waste disposal, as does the very natural scepticism of experts in the field that such newcomers as the analysts can contribute to solutions of real-life complex problems. But those examples of the successful introduction of systems concepts show that it is possible to develop a close working relationship between analyst and expert in the specific public system under study. Cooperation and working together is in fact necessary since the performance objectives and real constraints on solutions suggested are often best known by the officials involved.

Traffic and transportation are of course fields that have been well developed by engineers over the years. But here too systems approaches are proving themselves important in improving the capability of both private and mass transportation systems. The systems concept broadly considered includes interaction with all aspects of city living and the city environment. Future transportation systems must be developed not solely for the purpose of coping with the projected traffic requirements effectively and efficiently, but must have minimal effect on the environment Modern transportation studies consider the effect of alternative approaches on population movement, on the possible dispersal or relocation of industry. They incorporate projections on changes in living habits, working conditions, leisure-time activities. They include as important factors esthetic considerations, minimal dislocation of people, jobs, and neighborhoods, questions of noise and air pollution, etc.

We conclude the talk with a discussion of the area of urban modeling and planning. Here engineers are beginning to work with urban planners urban geographers, urban sociologists, urban economists, and political scientists, among others, in developing quantitative models of the overall urban system. This includes studies of the dynamics of population and employment growth (or decline), of the movement of people and jobs, of changes in the population mix (age, income, class, race), of the interaction between city and suburbs. There are two important reasons for these studies. First is the fact that basic understanding of the dynamic processes underlying the urban system is still lacking. The modeling involved in attempting to quantitatively study the dynamics of the urban system can only lead to increased knowledge about this extremely complex process. It is in the setting up of quantitative models of the urban system, in the solution and interpretation of the systems of equations involved that the systems engineer, working closely with the planners and other specialists, can play a key role.

Secondly, it is apparent that the systems activities noted earlier--public systems analysis and transportation studies for example, rely heavily on forecasts of the distribution of population, housing, and employment, throughout an urban area.

Two contrasting examples of urban models are described in this talk. The Forrester approach to modeling seeks to describe the dynamics of a self-contained small urban community. The model is completely ad hoc, non-spatial, and quite complex (128 nonlinear difference equations). Computer experimentation is used to explore the ramifications of the model. Applications to specific communities would presumably require checking the appropriateness of the various equations, or modifications to accommodate specific data. The Lowry Model of Metropolis on the other hand was originally conceived as a static, spatial model. (It was developed over a decade ago as a first approach to modeling Pittsburgh). It attempts to find the equilibrium distribution of population (housing) and jobs(industry) in a large metropolitan region. The model is very simple to understand, using a market potential and trip-distribution approach to relate jobs and housing. Some further extensions have incorporated aspects of the time element into this model.

Both models are deterministic in nature. The possibility of developing stochastic formulations is considered in this talk. Examples are given of simple approaches that are both dynamic and spatial, connecting the two contrasting aspects of the Lowry and Forrester models. Under stationary (equilibrium) conditions the solutions here, in an average sense, should agree qualitatively with those found by using Lowry-type models.