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Compte Rendu
de la Conférence
Internationale
sur la Recherche
en Matière
de Transport

Proceedings
of the
International
Conference on
Transportation
Research

PREMIÈRE CONFÉRENCE

FIRST CONFERENCE

**Bruges, Belgium
Juin, 1973**

**Bruges, Belgium
June, 1973**



THE CHALLENGE for transportation systems analysis today, as it has been since its beginning, is the necessity to cope with the real world in all its complexity. The problem seems to have become more difficult recently, in spite of the advances in computers, theory and analysis techniques which are now at our disposal. The difficulty occurs, in my estimation, because of the growing uncertainties facing society.

Transportation institutions are deeply rooted in the economic, social and political fabric of our society. Situations which provoke change also tend to threaten established institutions, their mode of operation, and the people who depend upon them. The result is sometimes labelled a "crises." But crisis, or not, the uncertainty generated by the situation may make the future difficult to predict.

A number of "crises" have appeared upon the transportation scene recently. One is that faced by the Eastern Railroads in the U.S. as the result of the bankruptcy of the Penn Central Railroad and other railroads in that region. Not only has the Penn Central been unsuccessful at reorganizing within the presently existing institutions but it has slipped steadily into a deepening financial situation. It now appears that the trustees will be unable to make it go as it is presently constituted and that they will submit a plan for its liquidation. Liquidation, however, has tremendous economic implications not only for those shippers which use it, but also for viable railroads elsewhere and thus, for the railroad industry as a whole. The situation will come to rest on the general public. Liquidate or not, it is clear that the railroad will not be allowed to disappear. There is talk of nationalization, but no enthusiasm for it. An accurate assessment of the situation is difficult to obtain since misinformation is everywhere. Some institutions are bound to change. The question is which ones?

For transportation as a whole the shortage of petroleum looms large as a source of uncertainty. Some say we are running out of oil; others that we are only experiencing a temporary shortage of refinery capacity. The situation, however, seems destined to produce both rationing and short-term price increases. Depending upon the magnitude of the increases and their duration the whole future of automotive technology could hang in the balance.

At the same time the standards for ambient air quality which have come out of the 1970 Environmental Protection Act have heightened the uncertainty surrounding the future of automo-

biles in cities. The plans submitted by the states on how they intend to reach the required standards by 1975 in each of the metropolitan areas have produced some very startling results, including proposals for 80% reductions in vehicle miles travelled in Los Angeles by gasoline rationing and \$5 parking charges in Boston. If, after careful examination, it appears that less drastic measures cannot be found, then society will be faced with a tough question of priorities.

For a number of years congress has threatened to fund a program for urban mass transportation. To-date, however, this effort has received little more than token funding. The highway program, on the other hand, continues to generate Trust Fund revenues at a time when construction of the urban portion of the interstate system has been brought to a virtual halt because of public opposition. Though the use of Highway Trust Fund monies for the transit program has been proposed and has gained supporters, it has not yet passed Congress.

For the urban densities found in the suburban areas of most cities transit is grossly uneconomical. A possible reason for congressional resistance to mass transit is the lack of support by the state and local government officials and transportation planning professionals who would be responsible for securing from the local public the substantial operating deficits that would be generated as the consequence of building these systems under present conditions. The sizable capital cost of the systems proposed is undoubtedly an input as well.

Another factor generating uncertainty is the increase in public sentiment for "no-growth" land use policies. Communities opposing developers rights granted under the fifth amendment to the constitution are seeking to overcome this impediment to public planning. If upheld in the courts, these communities will have set a precedent leaving the right of planning to the community. If supported by federal legislation supporting and encouraging community planning, denser urban housing, or changes in the tax laws, another major determinate of urban change would be cast against the automobile.

These factors combined could spell trouble for the automobile in urban areas. However, it is well to note that the land-use densities currently prevailing in our urban areas are those that have for the most part developed during the automotive age and adjustment would be necessary. This probably could not take place quickly. No-

Education for Transportation Systems Analysis

by

Paul O. Roberts*

growth zoning policies might tend to complicate matters further.

Even air travel is faced with uncertainty. The recession which slowed air travel two or three years ago has now been replaced by a resumption of growth. The air congestion which had grown to crisis proportions before the recession has not yet reappeared. Some argue that it will soon be back with us. In the meantime it becomes increasingly clear that public opposition to the construction of new airports almost eliminates this as a way of accommodating new growth as it occurs.

Thus, transportation institutions face an extremely uncertain future. Yet, society appears reluctant to abandon the notion of improving transportation. This appears to be as much a goal now as it ever was. However, transport must restructure its institutions to fit the changing situations. The question is how should transport institutions be structured? This is essentially a normative question, a question frequently asked of system analysis. The answer obviously has very important implications for education in transportation systems analysis.

THE NATURE OF TRANSPORT INSTITUTIONS

Despite the fact that the question we posed—"How should transportation institutions be structured?"—is a normative question, the answer cannot be viewed from a strictly normative point of view. There are a lot of participants who stand to gain or lose from a restructuring of the institutions. The problem is typically a political one. Formal or informal processes exist in society by which most routinized decisions are made (or not made) laws, funding mechanisms, regulatory boards, appeal boards, and the like, all exist within which decision makers with given constituencies make limited sets of decisions. Restructuring institutions is, in effect, changing this process by which decisions are made.

Changing the process is necessarily and properly political. There is however,

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a role for systems analysis and during periods of uncertainty it can be especially useful. A crisis may, in fact, bring a complete restructuring of the institution. The fact that the Penn Central cannot survive in its present form gives hope for much needed institutional change. Transportation systems analysis approached properly can contribute to the restructuring that will take place in response to crisis.

Transport systems analysis is also useful in a period of non-crisis though the scope of possible actions may be more proscribed. Restructuring which will make someone better off without hurting others (so called Pareto solutions) are frequently the only ones that can be implemented. Adopting this approach in project appraisal and evaluation might make it easier to implement individual projects as well.

THE ROLE OF EDUCATION

As I see it the role of education in transportation systems analysis is to prepare the professional to understand transportation systems so that he can solve problems. The first amounts to the fundamental charge "Improve Understanding." I can see four areas in which this should be done.

- 1) Understanding the role of transportation in man's endeavors.
- 2) Understanding transportation and societal institutions and their workings.
- 3) Understanding the transport system itself and the interactions and impacts that will result when changes are made.
- 4) Understanding technology and its economies.

This is done primarily by carrying out an active program of research. We need to know more about the role of transport in: economic development, preventing environmental degradation, urban change and land use, resource development, transport in foreign trade and as well as a host of other topics.

To solve problems the professional should know how to manipulate an existing transportation system to improve its operation, how to design a transportation system to serve a specific purpose, or how to manage a system for profit. To do any of these he must know

what improvements can be made socially, economically and politically to an existing or proposed system. That is, he must be able to predict the impacts of a specific system on: the transport system and its components, the various actors in the system and the economy.

His knowledge of the system should be such that he can suggest improvements. This could be in the area of technology or in the area of public policy. This implies that the educational process have subjects in both areas.

I would argue that it is difficult to acquire the professional skills needed without focusing on real-world systems and their problems. Only then can one learn to abstract from the complexity which characterizes most situations to focus on those issues which are most meaningful. Our students are being taught a three step process: 1) Raise important issues, 2) Prepare the background for their resolution, and 3) Advance a plan of action.

The first step, raising important issues, requires that one be able to identify probable futures and their implications. This includes identifying a variety of possible futures and their choice and chance elements. It also demands an understanding of the possibilities of achieving a given future including a knowledge of the process, the institutions, the actors and the politics of the situation, including its dynamics. Finally, it requires some knowledge of the implications of each future for the system as a whole and for the important actors.

An issue may involve knowing of an undesirable future in time to take evasive action. It may involve selecting from a list of desirable futures. Or, it may involve searching from all possible futures for one which can be most easily tolerated since the probable futures are not desirable. Typically, an issue involves tradeoffs between goals or between the goals of different segments of a population.

Resolving an issue is a laborious task. An individual or a firm faced with an important issue must decide on his tradeoffs. This means thinking about goals. For a government the resolution may be even more difficult, requiring debate, compromise, even conflict between coalitions of actors each with a different set of goals and their possible tradeoff. A great deal of time may be spent in understanding the uncertainties and the tradeoffs as well as who is being impacted. Facility in the knowledge of how to manipulate the controllable variables in the system can be of inestimable use in searching for solutions with "Pareto" qualities. The abil-

ity to quickly and accurately determine the impacts of another course of action can help to remove the uncertainty associated with some outcomes. This can facilitate debate but it can also sharpen the issues in those cases where negative impacts can be clearly identified.

Advancing a plan or a strategy for action is the ultimate consequence of being able to predict the probable impacts of a plan's choice actions and evaluate them. Evaluation can only occur once goals are identified. Thus, a point of view must be selected. For a government administration the selection of a point of view (even a public point of view) may not satisfy all interested parties and may result in conflict or opposition thereby frustrating the decision maker. A game situation may result.

THE ACADEMIC PROGRAM

The key to applying an increased understanding to the solution of issues in transportation including the restructuring of transportation institutions themselves requires three things: knowledge, framework, and analytical tools.

The knowledge must include an understanding of all aspects of transport ranging from the physical and economic to the social and political. Recently, environmental knowledge has also become important. Since our traditional knowledge of physical systems has been greater than that in economic, social or the political arena it has meant an increasing interest in these areas. An understanding of history is helpful in placing these factors into context and establishing the time constants.

In the framework area, a variety of theoretical constructs have begun to evolve. The framework for problem solving in systems analysis has led to the more general notion of a public decision-making process. Slowly, an approach to determining the equilibration of supply and demand functions over networks has developed and been put to work. Analytical tools, computational methods and model building techniques have made great strides over the past few years. Economic theory has contributed greatly with production functions, demand theory and econometric methods for establishing these approaches numerically. Model building of supply and demand models has advanced rapidly. Much remains to be done but we have made a start.

All three of these major elements are included in our educational program in transportation systems analysis at MIT. The newest elements are in the area of framework and in the emphasis on social and political processes.

At MIT we have recently formed a new Center for Transportation Studies. It is, however, merely a formalization under one organizational structure of the activities in transport that have gone on for some time. It builds on the strengths of large groups in Civil Engineering, Ocean Engineering and Aeronautics and Astronautics in the School of Engineering which have had a co-operative program for some time. It also integrates the work of faculty from Mechanical Engineering, Electrical Engineering, Urban Studies and Planning,

Economics, Humanities, Political Science and the School of Management.

The Center has approximately 40 faculty and staff and approximately 100 graduate students in transportation. Our research budget is almost 2 million dollars a year spread over the entire spectrum of modes and disciplines.

The educational program includes graduate degrees at both the Masters and Ph.D. level. The subject offering is broad, with more than 50 subjects directly of interest.