The impact of computers on urban transportation

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Dr. Ramo has said that one of the purposes of this series of talks was to try to "close the gap" between the information technologists and the applications of their technology in the real world. If this is one of our primary objectives, I don't believe there is a field in which the gap between the technologist and the application is so great as in the area of urban planning, of which transportation is a part. There's definitely a gap between the person who knows the problem and the person who knows how to solve the problem. The reasons for this gap are historical and complicated. There's no need to go into them at this time, but the gap, I think you'll discover from this talk, very definitely exists and needs to be closed.

When one considers the concept of the impact of computers on urban transportation, he is almost forced to remark, "Impact, what impact? Change, what change?" Looking around today in urban areas, you see crowded freeways, decrepit, decaying transit systems. It somehow all seems the same except that it's getting worse. The automobile is certainly not a product of the computer. Our old rail and bus transit systems are certainly not a product of the computer. So why should we blame it on the computer? Just what is the impact? What has it been? What is it going to be?

At the other extreme, the Sunday supplement articles recite the wonderful hopes of the future: automatic highways, completely controlled freight terminals, exotic transit systems. What is the real truth? What kind of impact has there been and what type of impact seems to be coming?

The true situation is somewhat between these two extreme views. The first indications of an impact are now apparent. More precisely, a dual impact of computers on urban transportation has become evident in the last few years. The first impact relates to the use of computers in the planning and design of transportation systems. And inevitably this design application results in an involvement with the whole problem of urban design because it is impossible to separate the transportation or circulation system in a city or a metropolitan area from the spatial pattern of the city itself. The second impact is more direct and involves the use of computers as part of the transportation system itself. Today in transit systems, and in the future even in individual vehicle-type transportation systems, this second impact will be felt.

Now I believe very strongly that the first of these applications is by far the most important: the influence of computers on the whole urban environment. The technologist might disagree and consider the other application far more interesting. Thoughtful consideration, however, may cause him to alter his views. Next to the issues of war and peace, themselves, the problem of whether we can create a livable urban environment is certainly very high on the agenda.

There is also reason to be very pessimistic. Looking at our traffic-choked, polluted cities, for all of our advanced technology, for all of our wealth, we live in kind of a squalor. Frank Lloyd Wright once said that America seems to have an unrestrained, impassioned lust for ugliness. I don't like to be unkind to our host city, but if you walk around Las Vegas at night—even a person who has very little aesthetic sense can't help but question what our wealth and technology have done to our urban environment.

The reasons behind this decayed environment will make it obvious that the computer is not just a vehicle for the automation of existing operations. Its role rather is so fundamental because our urban environment has gotten out of hand.

The causes for this unfortunate situation are two: First of all, the urban environment, the metropolis, has become so complex that it's impossible for any person, architect, planner, economist, or anyone else to really grasp and to create a design to fill the objectives that everybody seems to desire. Secondly, even if he were able to design such a city as the grand master planners of old envisioned, even if he were able to comprehend this complexity, he could not do anything about it because urban decision making and control have also deteriorated to the point where no individual or group can really influence the shape of the changing environment. It isn't just a question of political power. Even if this power was given to those people urging metropolitan government, it really couldn't be used intelligently because of our sparse knowledge of the urban growth process. The computer has arrived none too early. Let us examine its current role in urban design.

Transportation and the urban land pattern are intimately related. At the subdivision level or in a great metropolis, common sense logic supports the idea that the location of activities and the circulation between these activities is interrelated so that the problem of urban transportation planning is really a problem of total urban design. Attempts to solve this design problem have gathered together an interesting group of people in metropolitan transportation studies. City planners, traffic engineers, highway engineers, systems and computer specalists have formed a multidisciplinary team. Some progress has been made. To understand the reasons for this progress, a discussion of the methodology of these studies is appropriate.

The first task in the urban transportation planning sequence is one of data collection, processing, and analysis. A large quantity of information is a prerequisite for intelligent planning. The land use pattern must be determined in great detail. The detailed land use pattern has never been measured in most urban areas. So it is usually necessary to start a new data acquisition program. Data on the travel habits of people are also needed. This data is obtainable only by actually interviewing individual people to find out the origins and destinations of their trips in order to establish a pattern for projecting travel patterns into the future. Other data on resources such as soil and water must also be collected because of their limiting effect on the final plan.

An idea of the scope of this data collection may be inferred from experience in Southeastern Wisconsin, an area with about 1.6 million people, which is actually one of the smaller metropolitan areas. The basis planning information in this area involved 200 to 300 million characters of data. The area served by the Tri-State Planning Committee in New York City requires a data bank of 2 to 4 billion characters of data.

That computers have made it possible to even consider handling this vast quantity of data at all is a truism. But serious problems in the form of data processing "bottlenecks" have appeared. Typically these studies start with high hopes. A large scale data collection is the first step. Some areas never have been able to successfully digest the data collected and the planning process slows to a halt. Although the computers have raised bright hopes and fostered high ambitions, the weakness of current information retrieval and analysis software has tended to dim these hopes and discourage excessive ambition.

Data handling in these urban transportation studies has the disadvantages of both business data processing and scientific computations. Extensive computations are accompanied by a large quantity of input. The lack of sophisticated information retrieval and analysis techniques has led to the use of crude "brute force" processing practices.

The second task in the planning sequence is that of forecasting. In order to make a plan for an urban area it is necessary to look at least 20 to 30 years into the future. The problems of future land commitments and the life of transportation facilities extend the time horizon of urban plans. Forecasts of land requirements reflecting quantity and quality are also needed to provide for future transportation facilities.

In forecasting, the role of the computer has been in support of economic forecasting models. In fact, next month I will be a member of a panel in Washington, D.C., where the question will be asked: "Have mathematical models and the computer solved our forecasting problems?" The answer will very definitely be no, but a start has been made. These models, although far from perfect, have forced a rethinking of the economic variables and relationships related to forecasting.

The next phase of the planning process is that of design. Very little has been accomplished to date in this area, but it is here that the most important role for the computer probably lies. After all of the information has been collected and processed, after the forecasts have been estimated, the central problem of transportation planning or, more inclusively, urban design still remains.

The urban design problem may be defined as follows: Given certain objectives (the varied needs of the urban population), given certain constraints (technological constraints and human constraints) and given the related costs, how do we design an urban pattern and related urban transportation and utility facilities? Despite the large amount of data collected by urban planning agencies, this data is rarely used in a direct manner in urban design. It is not possible with existing analytical techniques to use the data directly in plan synthesis. The relationship between urban design and systems analysis has been very indirect. It would seem that all of this data collection analysis and forecasting will do little good unless it can be integrated into plan design. I, and a number of other urban system analysts in the United States and Europe, are now involved in an effort to develop mathematical programming type models in which it will be possible to quantify objectives, estimate costs, insert constraints and provide urban design patterns to aid the planner in the critical function of urban design.

The last function in planning where computers have had effect and have made great progress is that of plan simulation or test. Simulation models of highway and transit networks have reached a high state of development. Models exist for forecasting the number of trips that will be generated by residential, industrial, or commercial areas. Other models will then distribute this traffic by origin and designation using certain gravity-type formulas. Still other models will assign this traffic, both with or without a capacity constraint, to certain freeways or arterials in an intuitively conceived system. These kinds of traffic models have been applied in urban areas. I think this is greatly to the credit of certain federal agencies, mainly the Bureau of Public Roads, that have developed very comprehensive program packages for the application of these models. Despite these noteworthy advances, these simulation models can only test intuitively conceived networks and do not aid directly in the design process itself. Future development of design models will probably eventually obsolete this class of simulation test models.

So much for the application of computers to system planning and design. The other function of the computer, and up to this time not a very important one, but one that has great promise, is the use of the computer as part of the transportation system itself. In both types of urban transportation, transit systems and individual vehicle systems, the role of the computer is becoming more apparent. Computers are being tested in the roles of vehicular controllers as well as traffic controllers. The roles in planning and design are not independent areas. An example of their interaction in transit is illustrative.

There's a very strong political and even emotional pressure in the United States to persuade cities to adapt rail transit systems. That a traffic problem exists in most large cities is obvious. There's a great tendency, however, for people, not only politicians and the general citizens, but even people with technical qualifications to ignore the nature of the overall problem of the city and its needs and to question whether these transit systems are even economically feasible much less socially acceptable or aesthetically desirable. Some studies in Southeastern Wisconsin have indicated that the free market has already provided an economically sound solution for urban transportation. Fancy rail transit systems, automated or not, often encounter market difficulties because they do not fill any previously neglected market need. For a new transit market to emerge, the pattern of the city or the metropolitan area itself much change. So there's a very strong interaction between the basic design of the urban pattern and the role of the computer in transportation systems. Operating applications of computers in the system may be discussed in two time-sequenced phases.

Looking at the here and now, the first applications in transit systems are under way in the Bay Area Rapid Transit System (BARTS) near San Francisco. Four separate companies are testing control systems, all of which involve computers to a greater or lesser degree. The most complete system includes all three separate uses: in vehicular control, in transit scheduling from a series of satellite computers, and finally in overall control from a centralized computer. The second application, in dispatching, schedules the transit system in such a way as to provide service with minimum cost, and the third is in the more conventional areas of business data processing extended most noticeably into fare collection. These systems are now being evaluated. Only one of the four systems actually involves using a digital computer for all three of these roles. Two use analog computers for vehicular control. Two of them use an additional computer for dispatching, and one of the systems applies analog computers to vehicular control dispatching, and a digital computer only for business data processing. BARTS is very definitely a feasible application. There's no question about it, and the real question here is only which is the best system from an operational as well as a maintenance point of view. It is easy to exaggerate the importance of the economic effects of transit automation. Automation does play a role in the transit economics, but it is becoming pretty well understood that this role is not economically decisive. In other words, if a profitable transit market does not exist in an urban area, automation is not going to change the situation. There was a great excitement a few years ago over monorail systems. There are various other emotional flurries at times towards other transit system proposals, but even with the aid of the computers and automation, the limiting factor is still an adequate market demand in most urban areas. A minimal level of transit demand is required to support a transit system. The computer is not likely to influence this basic market demand.

Another important "here and now" application of computers is in traffic control systems. Some years ago, the first attempt at traffic control using computers was initiated not in the United States but in Canada. Traffic Research Corporation developed a system in Tòronto. This system has been extended to the control of 300 intersections. These traffic control systems, by controlling traffic signal cycling in response to volume and spacing of traffic, can actually increase the capacity of systems as much as 50 or 60 percent. High hopes exist for a system being developed for New York City. The basic limitation in such systems does not lie with the sensing equipment, the communication equipment, or the computer, but, as in most process control applications, with the knowledge of the process characteristics. Little is known about traffic flow as a process. Although it is possible to simulate transportation systems in an aggregate sense, knowledge of microscopic traffic flow is still very slight. The success of the traffic control system in Toronto has been dependent, I think, on experimental knowledge not based on a theoretical model of the traffic flow process.

Looking into the future in the light of present accomplishments, it is evident that applications to date, except in urban design, will probably not revolutionize urban transportation because they really do not relate directly to the basic problem of urban transportation. There is much concern about this urban transportation problem today. The HHFA (Housing and Home Finance Agency) has been raised to a cabinet-level department. The HHFA has sponsored a number of transit demonstration grants. The success of these programs has been somewhat questioned. President Johnson has recently placed great emphasis on transportation with his recommendation of a cabinet post for this function. New studies are aimed at the formulation of a National Transportation Policy. A major program has been initiated for the northeast section of the U.S. known as Megapolis. The Department of Commerce has recently sponsored a series of studies at Cornell and MIT. The Bureau of Public Roads is also developing studies in this same area. Finally, all of these studies must solve the one basic problem. Amidst all of the hand-wringing and arm-waving, it really reduces down to one fundamental problem: urban areas. The way such areas are developing is fundamentally toward very low-density, sprawling-type development. With this type of development, the automobile, however horrible it may seem to some planners and other people, is actually an ideal form of individualized transportation. It may not seem desirable at times for the community, but it is for the individual. People can complain about congestion, air pollution and other ills, but until some alternative to the automobile is suggested (and it certainly will not be in the area of rail transit), until some system is developed which has flexibility, which faces the problem of air pollution, and which is able to provide something equivalent to the automobile, the situation is probably not going to change much.

Urban transportation studies have now analyzed a large amount of data to discern the nature of transit-riding. They have discovered that many of the people who utilize transit have no other choice. They are known in the trade as "captive riders." Given a free choice, many of these riders would not choose transit most of the time. Some of the new transit systems being suggested do not seem to face the captive nature of transit riders. Future increases in transit ridership must come from the noncaptive, who must be sold on the benefits of transit travel.

Some of the new designs are not only technically weak but psychologically unattractive. Vehicles, that for all of their automation technology still resemble a New York Subway Car (with standees during the rush hour) are probably not going to convince many people that they should abandon their automobiles for the transit car.

If there is a solution, what role will the computer play? Although no generally acceptable complete solution has yet been forthcoming, the general consensus seems to involve an individual electric vehicle that can operate in these low-density areas. The Cornell Study suggested an Urbmobile. The Urbmobile could be driven locally for pickup and distribution and also on automated freeways for travel over longer distances within the urban area. Although this system is still at a very conceptual stage, it at least has the potential for the solution of the basic urban transportation problem that involves high volume traffic in certain areas at certain times, and simultaneously low-volume travel to a wide dispersion of trip origins and destinations. A system such as the Urbmobile will obviously require computers for vehicular control and for traffic control.

In other areas of transportation, only partially urban and mostly intercity, the computer will also play a major role. The automated highway for intercity transportation will probably come along in the next 20 or 30 years. The problem is not as overwhelming as the urban one and probably not as critical, but is much easier to solve with existing technology. The problem of terminal operations and freight transportation will also very definitely involve the computer.

In summary, the role of computers in urban transportation systems will be important and sometimes crucial. This role will definitely not be peripheral. People now seem to desire a better urban environment, but the complexity of the urban patterns has need of the computer to solve the problems of urban design. The computer will also have a role in the operation of transportation systems. To realize this potential of the computer in urban development, two needs are apparent. There are some subsidiary technical needs in data collection and data processing of computer software for information retrieval and analysis, but I think these are very minor compared to the major problem, the problem we have addressed ourselves to today, namely, the marriage of analytic and substantive knowledge. The greatest technology can be very sterile unless it is combined with substantive knowledge. I think the experience of operations research and management science in industry testifies to this need. Many operation's research projects have failed in application from a lack of substantive reality. In urban problems the need for this marriage of the professional, who is not information technology-oriented, of the politician, and of the information technologist is even more critical. This marriage is the central problem that must be solved if we are to realize the potential of the computer into the field of urban planning and transportation systems.