RESEARCH NEEDS IN TRANSPORTATION PLANNING AND MANAGEMENT

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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PREFACE

In 1974, legislation was enacted by the General Assembly to establish the Virginia Department of Highways and Transportation. In essence, the legislation expanded the responsibilities and duties of the former Virginia Department of Highways, with the main new assignment being in the area of planning. The Department was charged with the responsibility of developing and coordinating a unified planning process taking into account the advantages, potentials, and needs of all modes of transportation — highway and street, rail, air and water. Subsequently, the activities of the Research Council were broadened to assist the Department in meeting its new responsibilities.

The purpose of the study reported here was to survey the research needs in Virginia in the broad field of transportation planning. All of the needs have not been delineated; however, many are enumerated in the report. Hopefully, this overview will serve as a catalyst for discussion between the members of the Planning Research Advisory Committee and the researchers, that will result in the selection of specific projects.

SUMMARY

In this report, the research needs have been divided into two categories — long-range and short-range planning. The long-range needs relate to the procedures and methodologies of the planning process, while the short-range requirements focus upon the management of transportation systems.

Recent experience with the implementation of transportation plans has revealed many deficiencies in the planning process. Among the basic criticisms that have been made about the existing models and methodologies are that they cannot be readily used on subregional and project levels; they lack multi-modal planning capabilities; the plans are not responsive to the policy issues that planners are being asked to address; expensive, large travel surveys are required for model calibration; and a full account of the impact of transportation facilities on the general quality of urban environment is not evaluated. Planning models have been developed for large urban areas; however, they cannot be applied to the development of a statewide plan, which is one of the initial tasks assigned to the Department by the General Assembly. On the other hand, these models are not suitable for forecasting the transportation demand in small urban areas.

Most of the future mass transportation needs in Virginia must be accommodated by rubber-tired vehicles such as buses, because the populations of the metropolitan areas are not large enough to support other mass transit modes. Much of the planning in the urban areas has centered around automobile transportation and has not adequately considered new technologies and other rubber-tired vehicular modes. Consequently, the research needs in this area are numerous and range from improved modal choice models to bus shelter guidelines.

The General Assembly stated that the transportation system would facilitate the flow of commerce. Although the movement of goods and the provision of services by the transportation sector account for approximately 20% of the gross national product, only limited effort has been expended to develop guidelines for moving freight. The term "goods movement" needs to be defined and a determination of data requirements for freight planning should be made. Master plans for movements of goods should be developed, and demand models are required in order to estimate the effect of policy and system changes on the movement of freight by various modes and carriers.

The long-range planning process should consider the impact of non-motorized vehicular modes such as bicycles upon the urban transportation problem. Research is required to determine if the bicycle is a legitimate urban transportation mode. The same is true of walking. If bicycling and walking should not be considered as modes, then planners need assistance in measuring their potential effects on urban transportation.

Urban transportation planners recognize that long-range planning is not a panacea for all transportation problems, and that it should be supplemented with short-range plans which are responsive to immediate transportation needs. Through transportation systems management there are many options that can provide improved urban mobility. These options can be implemented quickly at a low cost, and they can provide environmental and energy conservation benefits.

Short-range techniques to improve the people-moving capabilities of streets and highways are of two basic types: Those that improve the efficiency of passenger vehicles by increasing the number of people carried per vehicle, and those that improve the flow of vehicles. When considering the average occupancy and the abundance of unoccupied seats in private automobiles, carpooling is one of the most efficient means of increasing the productivity of existing transportation facilities. Other organized forms of pooling commuters such as vanpools and buspools can improve the people-moving capabilities of the streets and highways; however, all of the ride-sharing programs have a common problem, i.e., most Americans enjoy the personal mobility provided by the automobile and they are not willing to share a ride with their neighbors and co-workers.

In an effort to improve ride-sharing programs, research studies should be undertaken in the areas of top management and union support, promotion campaigns, incentive programs, and marketing.

Federal, state, and local governments can promote ride sharing by granting high occupancy vehicles preferential treatment in using streets and highways. Through the provision of exclusive lanes, high occupancy vehicles can be allowed to bypass traffic congestion and delay to achieve travel time savings. These lanes have the capability of accommodating large volumes of passengers and a potential for substantially increasing the total capacity of a facility. The provision of fringe parking lots offers a means whereby "lone" motorists can group into pools and utilize preferential facilities.

There are several areas where significant contributions can be achieved by research. Each preferential technique should be warranted on the basis of its people-moving capabilities, and guidelines should be developed to ensure the selection of the optimal technique. Additional studies in demand forecasting and potential user motivation are essential in future proposals for preferential treatment and control facilities. Other areas of research include the institutional, financial, social, energy,

and environmental aspects of preferential facilities. Also guidelines should be developed for the proper evaluation of the effectiveness of such facilities.

Finally, the short-range techniques capable of increasing the efficiency of a street or highway system by improving the flow of vehicles have been presented in the report. It has been concluded that through traffic management, many improvements such as better channelization, one-way streets, parking regulations, and signalization can be made to relieve congestion and promote smooth traffic flow. It appears that the application of systems concepts has merit in the traffic field, and should enable the engineer to view the traffic problem in its total environment rather than merely considering it in an isolated or fragmented context.

It also has been concluded that traffic signals is one area in traffic management that should receive top priority in Virginia. The signalized intersection continues to be the point of minimum capacity on a street or highway; therefore, it is necessary to bring traffic signal operation to the highest possible level of efficiency. Educational tools should be developed and workshops conducted to assist field technicians in understanding the basic characteristics and functions of signal equipment, and new procedures of establishing signal timings should be developed. The benefits of signal systems should be documented, and considerable research is required to develop control logic that can utilize the capabilities of the digital computer.

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INTRODUCTION

One of the most difficult problems facing the Commonwealth of Virginia is providing for the transportation of people and goods to, from, and within the central business districts of its cities and throughout its expanding suburban areas. In 1974, the members of the General Assembly of Virginia were cognizant of this problem and enacted House Bill H667 establishing the State Department of Highways and Transportation. The bill stated that

> It is hereby declared to be the policy of the Commonwealth of Virginia that the present and future welfare and mobility of the citizens of Virginia require a balanced transportation system, consisting of coordinated private and public facilities and services, provided and administered to assure adequate, safe, economical and efficient transportation, which will stimulate economic growth, provide convenient access to employment, health, educational, recreational, and other activities for all its citizens, facilitate the flow of commerce, encourage efficient allocation of human and economic resources, and preserve the inherent advantages of each mode, while utilizing intermodal advantages to the fullest extent, all taking into account the needs of the public, users, carriers, industries, labor and the civil authorties. It is further declared that this policy shall be carried out by the State Department of Highways and Transportation through continuous, comprehensive, coordinated transportation planning with other agencies of the Commonwealth having transportation responsibility, local governments, regional planning and transportation commissions, and private transportation facilities.

Thus, the term "balanced transportation" has come into common use, but without a clear definition of the word "balanced". Most commonly it seems to imply a balance between modes with the corollary that there should be a balance in funding, with no clear statement of or even basis to decide what the balance should be. However, it appears that the Assembly's intent is clear; it recognized that available resources should be allocated among the various modes of transportation in whatever manner might be necessary to achieve a balanced intermodal system supporting the greatest good of all segments of the population and economy.

The Department has responded to the General Assembly's charge by increasing the emphasis on improved public mass transportation in and between urban areas, and additional money has been appropriated for urban transit aid. The main new assignment for the Department, however, and the one which will have long-term benefits for the state's citizens and its economy, is the responsibility for planning. The Department is responsible for developing and coordinating a unified planning process which will take into account the advantages, potentials, and needs of all modes of transportation — highway and street, rail, air, and water.

Organizational changes have been made within the Department to meet the additional responsibilities. Primarily, the size of the State Highway and Transportation Commission has been increased from nine to eleven members, and a new position, director of planning, has been established. Two new divisions have been formed to help meet responsibilities assigned to the office of the new director.

On July 1, 1974, the Research Council's activities were expanded to assist the Department in meeting its expanded responsibilities, and, with the concurrence of its other cosponsor, the University of Virginia, the Council's name was changed to the Virginia Highway and Transportation Research Council.

PURPOSE AND SCOPE

The purpose of the study reported here was to survey the research needs in Virginia in the broad field of transportation planning, with the end product being an overview of new research activities to support the Department in meeting its new responsibilities. Because of manpower, and time constraints, and the fact that the population of most metropolitan areas in Virginia can support only highway-related modes of transportation, the scope of the study was limited to highway transportation and the coordination of plans for the other modes with the highway modes. The research needs relative to the other modes will be addressed in another report.

Many meetings and conversations with state and local transportation officials and university personnel delineated numerous problem areas which require research and these are presented in this report. Since the study focused upon broad types of research activities, specific projects are not delineated. The research areas have been divided into two categories — transportation planning and transportation management — and these are discussed in the following sections.

TRANSPORTATION PLANNING

Transportation planning studies have been conducted in a large number of urban areas throughout the world during the past 25 years. The process developed for conducting these studies, which is still evolving, attempts to provide a systematic procedure for solving urban transportation problems. The most commonly used planning process had its origin in the studies performed in Detroit and Chicago during the 1950's and 1960's. While more recent studies have made significant contributions to the development of land-use prediction models, travel-demand forecasting models, and evaluation procedures, most of them have been organized within the type of framework developed for the Chicago study.

In the typical transportation study, the most probable pattern of land development is predicted for a "horizon" year (usually 20 years ahead), and the transportation demands to be created by that land use are estimated. A set of alternative transportation plans are then developed which incorporate highway and public transportation facilities. The operating characteristics of each alternative at the prescribed future year are then estimated in the form of travel flows on each link of the transportation networks, and the maximum benefit-cost ratio is the usual criterion for choice among the alternatives. Furthermore, the present planning process requires a continuous review because there is no orderly sequence of public investment that can be instituted to yield the exact conditions for which a plan has been devised.

Recent experience in the United States and other countries with the implementation of plans developed through this type of planning process, commonly known as the urban transportation planning (UTP) process, has resulted in some disenchantment. Most urban transportation planners recognize that the process cannot produce plans which are a panecea for all transportation problems; however, the basic criticisms that have been made are

that the existing models cannot be readily used on the subregional and project level; the models lack multimodal planning capabilities; the plans produced are not responsive to the policy issues that planners are being asked to address; expensive, large travel surveys are required for model calibration; and a full account of the impact of transportation facilities on the general quality of the urban environment is not evaluated.

In the following sections a few problem areas within the transportation planning process are reviewed and discussed.

Statewide Planning

One of the initial tasks of the Virginia Department of Highways and Transportation is to develop a statewide transportation plan. Generally it is felt that a statewide plan should not be developed within the conventional framework whereby specific improvements for a 20-year period are designated; but rather the long-range transportation plan should establish goals and objectives, and should provide for direction and coordination of efforts for interfacing between the modes to meet the total transportation needs of the state. Much emphasis should be given to short-range planning in the statewide process so as to determine the transportation demands for a short time period such as five years, and to delineate studies, projects, and technologies to meet the demands.

The procedure and methodology developed and applied for the UTP process is not necessarily adequate or acceptable for use at the statewide level. In fact, given the present state of the art, caution must be used in even considering the use of the UTP models on the statewide level, unless major modifications are undertaken. When considering the diversity of the geographic and time scales that must be addressed in the statewide process, a variety of methodologies must be developed which are tailored to best fit the scale of the situation. The methodology must be oriented to address the questions of the economic and land use impacts of transportation alternatives as well as the more traditional user-oriented impacts; and it must be capable of providing information for multiple time horizons, i.e., for short-term and long-term periods. Existing models are not flexible enough to predict the impacts of alternatives for changing conditions such as the fuel shortage, nor do they have the capabilities to consider the probabilities of events that may or may not occur and the impact of those events on transportation decisions.

In short, much research is needed in the development and implementation of statewide planning models. At present, the planners do not have the tools to enable them to accurately estimate the statewide needs and the services required to fulfill those needs.

Small Urban Areas

Transportation planning studies for small urban areas have evolved as miniature versions of the transportation planning process in larger urban areas. These studies are time-consuming, costly, and have inordinate data requirements.

As mentioned earlier, most of the models commonly used in large transportation studies are not always reliable for use in small cities. Consequently, there is an increasing concern among transportation officials about the small urban planning process, as they are required to establish continuing plans to accommodate these urban areas.

In Virginia, the majority of metropolitan areas fall within the small city category and a transportation policy relative to the planning process should be developed. Two of the most difficult tasks will be problem definition and city identification. The definition of the small urban area must be developed and a list of the locations in Virginia that meet the definition criteria must be made. The small urban area planning program should also include procedures for inventorying the transportation services and travel demand, analyzing transportation needs, developing system alternatives, and the formulating of plans.

In the small areas there appear to be many types of services available, although they are not coordinated to provide optimum usage. An example is the individual services provided by the various social agencies. The acquisition of data on travel demands is expensive and time-consuming, and there are no techniques that accurately predict latent demands. Methodologies should be developed whereby the alternative systems can be defined, designed, and evaluated to determine how adequately they fulfill the transportation needs of the community.

There are many problems in the planning process for the small urban areas, and much research is needed in the development and implementation of planning models which can predict and estimate the transportation services required to achieve the quality of life desired by the community.

Rural

It has been only in recent years that formal attempts have been made to determine the need of the rural people and provide them with public transportation. The federal government, through the 1973 Federal-Aid Highway Act, authorized $30 million for use by localities in funding rural transportation demonstration projects. In Virginia, the Department has been charged with coordinating this program with the Federal Highway Administration. The major responsibilities are reviewing and commenting upon proposals to be submitted by the state.

Since the planning and design of rural transportation systems are of such recent concern, most planners involved with them have little experience or literature upon which to base their decisions. Many states, including Virginia, have conducted "need studies" in an effort to develop demand forecasting techniques, and, although several have been developed, they all seem to have many faults. Some ignore the effects of the level of service on economic demand, while others make questionable assumptions as to needs. A few are expensive to implement, and for some there is no proof that the methods are viable. As evidence to the crudeness of these techniques, Burkhardt used three demand forecasting models in the Berkley, West Virginia, study and came up with three considerably different values for need.

Methodologies should be developed which would have the capabilities of estimating the needs in different rural areas without major modifications and thus provide the planner with a basis for the selection of alternative systems to meet the needs of the rural people. Different types of demonstration projects should be encouraged to allow the development of evaluation procedures for the respective systems and to increase the mobility of the persons in the rural areas. Furthermore, the results of demonstrations can be developed into a useful guide for rural planning and provide the framework for the establishment of technical, organizational, and economic information needed for decisions regarding programs for rural transportation.

Travel Models

As mentioned earlier, the models being used for forecasting travel demand have been criticized as being inadequate for analyzing today's public policy alternatives. Much work has been done in the development and modification of models; however, the void has not been filled. Continued research is recommended in the development, calibration, and implementation of models for the urban areas in Virginia. To alleviate further disenchantment with the planning process on the part of policy and decision makers, it is important that future model development have a sound theoretical basis. Perhaps much of the present criticism could have been avoided if the move from the research laboratory to full field applications had not been so rapid and premature.

Now that the Department is charged with the responsibility of coordinating all modes of transportation, additional emphasis will be placed on travel choice, with greater use of models. In the past, choice models have been inadequate; however, recent research indicates that models based on individual and household level data can be formulated to show how travel is influenced by changes in policy. These "disaggregate models", which use a much smaller and more selective data base, appear to be applicable to subregional and project planning and may be transferable among urban areas. Research should be conducted to determine the application of these models in Virginia. Furthermore, research is needed to extend the approach of disaggregate behavioral travel demand models to trip purposes other than work and to travel decisions other than choice of travel modes.

When developing and modifying travel demand models, the researchers should be cognizant of the need for simplified techniques which are useful, economical, and quickly responsive to the policy issues that planners are being asked to consider.

Rubber-Tired Transit

The discussion relative to planning for rubber-tired transit is separated from modal choice because of its importance in fulfilling the transportation needs of the urban and suburban areas in Virginia. The majority of transportation studies conducted in the larger metropolitan areas in Virginia centered around automobile transportation and lacked the review of new technologies in other highway modes.

Land use development in suburban areas is resulting in a "crisscrossing maze" of transportation patterns and only rubber-tired vehicles have the flexibility to supply this demand. There is a need for alternative rubber-tired modes, because the social consequences of modal choice decisions are such that it is not possible or desirable to provide the highway capacity needed to accommodate the commuters who want to use the one person-per-car travel mode. However, at the same time many bus companies are declaring bankruptcy because of increased operating costs and lagging patronage and revenues.

Many studies have examined trends in urban transportation and transit usage, while few have dealt with diverting persons from private automobiles to other highway modes. Research is needed on the convenience of service, increased speed, elimination of the need to transfer, enhancement of passenger comfort, increased patronage, and so forth.

A methodology for determining the form of transit required in metropolitan areas and the minimum facilities needed for representative type communities would be beneficial to the planner. When determining the form of transit and the facilities required to meet the demands, the types of vehicles should be considered. The use of small buses as a form of public transit can be justified in many cities in Virginia; however, limited information indicates that the vehicles have many undesirable mechanical characteristics. In fact, the service life cost of small buses may be greater than that of the conventional size bus. Cost data from several demonstration projects should be analyzed to determine the potential use of small buses in Virginia. Furthermore, the design of all types of buses should be reviewed. Narrow front doors that allow passage of only one person at a time, manually operated rear exit doors, high floors above the street requiring steep steps, windows which open from the side, and inadequate destination signs are among the physical features which inconvenience passengers and discourage ridership.

There is a need to quantify the parameters that define the quality of transit services on both rural and metropolitan systems and the relationship of these parameters to each other. Techniques and methodologies for improvements of rubber-tired transit such as incentive ridership programs, management of economics and marketing, fringe parking, index of levels of service, bus shelters, preferential traffic treatments, and interface with other modes should be designed, evaluated, and implemented in an effort to relieve existing highway congestion and gain efficiency in the use of energy resources.

Data Requirements

One of the major problems of all studies — urban, regional, and statewide — is the lack of an appropriate data base for calibrating models. In a number of studies the mistake of relying on previously collected data apparently has been made, and in many cases data bases have been constructed without a full knowledge of the models for which the data were intended. In urban studies, approximately 60 percent of the cost can usually be attributed to data collection and processing costs; therefore, it is in this area that careful design and collection can result in high savings.

Research is needed to develop a simplified transportation planning process, especially for the small urban areas, that is sufficiently flexible so that travel forecasts can be based on a small sample, home interview survey or on simulation. Even the manner in which the home interview is conducted should be reviewed.

Costs of the typical processed urban home interview range between $20 and $30; therefore, alternative forms such as mail-back questionnaires and telephone surveys should be investigated. Consideration should be given to both the planning process requirements and the data requirements in an effort to take full advantage of recent advances in the understanding of travel behavior, dwelling unit analysis, and new census procedures that make increased amounts of data available. Obviously, there is a need for a carefully designed data collection program by which data can be reviewed and cataloged in terms of sources, availability, format, relevance, and reliability. The program should identify and acquire data needed to fill gaps in existing data and should address the problems of updating the data base.

Goods Movement

Although the movement of goods and provision of services by the transportation sector typically account for approximately 20 percent of the gross national product of this country each year, it has been only in recent years that many state departments of transportation have been concerned with preparing, or assisting in the preparation of, "master plans" for highway, rail, air, pipeline, and water facilities to serve existing and future freight flows. Because this is a relatively new focus, agencies often do not have a clear definition of the term "goods movement", and are not familiar with the kinds of freight data needed for planning. Furthermore, little is known about available data, their reliability, the compatibility of data from different sources, and the temporal continuity, aggregation, and costs of the data. Such information is believed to be necessary in the planning processes.

There is a need to define and rank essential data and to begin building a core of knowledge and understanding about goods transport. There is an especial need to identify sources of freight data upon which future transportation plans can be based and to develop methods for assembling basic freight data. The deficiencies in existing data should be identified and alternative strategies for remedying such deficiencies should be developed and evaluated.

Guidelines for planning the movement of freight should be developed to assist the local planners in determining their needs and identifying opportunities for improvements. These guidelines would allow the incorporation of goods movement into the transportation planning process and consideration of goods flow as well as people flow in transportation plans.

Goods demand models are required in order to estimate the effect of policy and system changes on the movement of freight by various modes and carriers. The models should have the capability of estimating flows of given commodities on competing transportation modes as a function of line-haul characteristics such as costs, levels of service, dependability, and variables that can be altered by public actions.

Bicycle

The bicycle is another vehicle which utilizes highway facilities, but it is not usually considered in the transportation planning process. As a mode of transportation the bicycle has a number of things to recommend its use. It is efficient in terms of power requirements and it is nonpolluting. It offers door-to-door accessibility and convenience, and on congested streets it actually offers a travel time advantage over the automobile and bus. It is very inexpensive and requires a minimum amount of space both in transit and while stored.

Unfortunately, bicycling has some undesirable characteristics. When not operating on a heavily congested street it is generally slower than other vehicular modes. Because of the physical endurance of the bicyclist the maximum one-way commuting trip is usually limited to 5 or 6 miles. Bicycles operating in mixed traffic are highly susceptible to traffic accidents. Then there are always the problems created in inclement weather. On a balmy day the bicycle has the potential of reducing the demand on other modes, but very few bicyclists are willing to commute on windy, wet, snowy, or icy days. Thus it may be argued that bicycling should not be considered in transportation plans, because the other modes must have the capabilities of accommodating the bicyclists during adverse weather.

Research is needed to determine if the bicycle is a legitimate urban transportation mode, and planners need assistance in determining the impact that bicycles have upon other modal facilities such as highway, transit, and pedestrian. If the bicycle should not be considered as a mode, then planners need assistance in measuring the potential effect it has on urban transportation. Additional research into the attitudes of present and potential bicycle commuters is desirable to gain insight into the effectiveness of potential policies and programs aimed at encouraging bicycle commuting. Warrants should be established for bicycle facilities and operational controls should be reviewed to ensure the safety of the bicyclists.

TRANSPORTATION MANAGEMENT

In many quarters, both official and unofficial, it is believed that mass transit is a panecea for all transportation ills and that there is no need to build more highways.

Fixed rail mass transit is a viable solution to the commuter problem only in a very small number of very large cities with high densities of population. The Urban Mass Transportation Administration has concluded that there are only ten or twelve cities in the United States where fixed guideway transit is a viable solution to the problem. The suburbs of Washington, D. C. are the only areas in Virginia that can support this type of transportation mode and a system is under construction there.

In the other metropolitan areas in Virginia and in all the small cities and rural areas, the transportation of people, whether it be for commuting to work, for shopping, for pleasure, or in commerce, can and must be provided by the highway passenger car-bus combination.

Figure 1 reflects the importance of highways in the United States. In 1974 the highway mode accommodated 93.2 percent of the passenger miles in this country and approximately 23 percent of the cargo moved. The personal mobility provided by the automobile is essential to the social and economic structures of this nation, and this personal mobility has improved the quality of life for the people as much as any social or technological phenomenon in the last 50 years. Therefore, the suggestion made by many people to get rid of automobiles and move everyone by mass transit is invalid.

The performance of the highways, e.g. the ability of the system to provide safe and efficient transportation and reduce pollution and congestion, has deteriorated since the beginning of World War II. At no time in the postwar era has top performance been achieved from the highway network, and the situation is getting worse. To further compound this problem, many states are having considerable difficulty constructing new highways in both urban and rural areas, primarily because of environmental and social concerns. These problems will most certainly be magnified by the lagging economy and fuel shortage. Therefore, it is imperative that the mobility of people and goods be improved through the implementation of transportation management techniques.

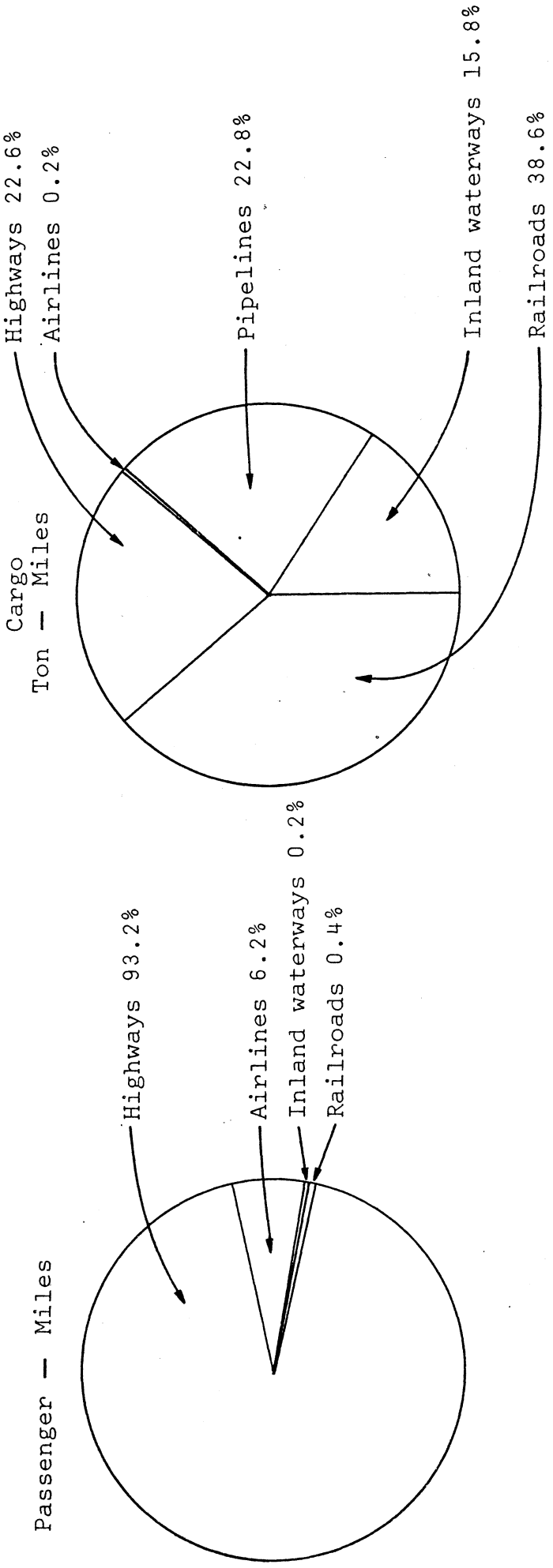


Figure 1. Transportation trends in the United States in 1974, by mode.

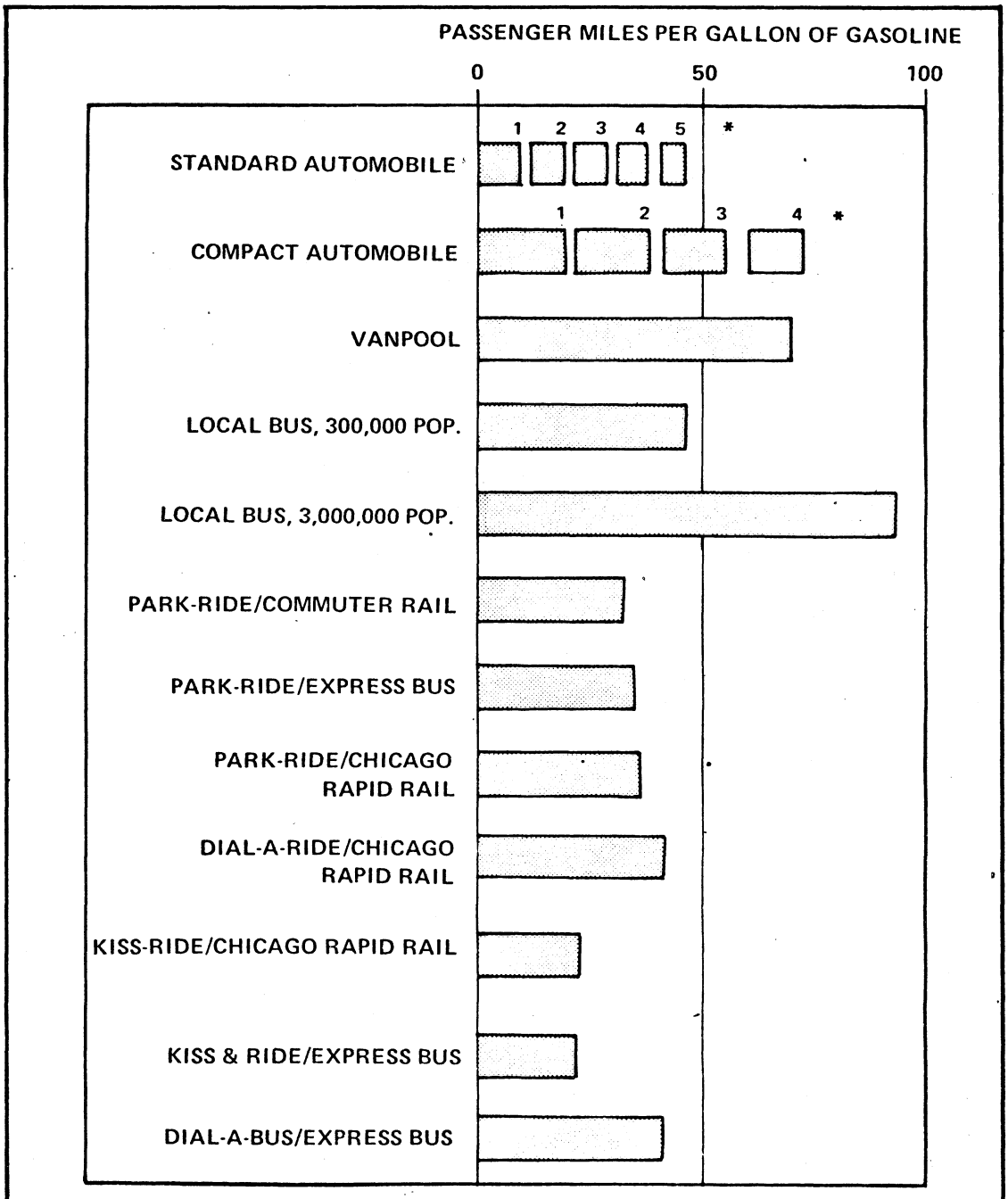
There are many available options that offer improved mobility which can be implemented quickly at a low cost and which can provide environmental and energy conservation benefits. Some of these techniques concentrate on improved utilization of the automobile through ride-sharing programs, while some attempt to improve transit operations, and still others focus on improving the people-moving efficiency of the existing highway system through more effective management, and still others attempt to reduce the demand of motor vehicle transportation services and facilities.

Carpools

Among the most promising concepts for improving the performance of highways are those that increase the average occupancy of vehicles utilizing the facilities. When considering the average occupancy and the abundance of extra seats in private automobiles, carpools are one of the most effective means of increasing the productivity of existing transportation facilities. The present average occupancy for all automobiles commuting to and from large cities in this country has been estimated at 1.6 persons per car. If the occupancy would be increased through carpooling to just two persons per car, there would be an amazing 20 percent reduction in rush hour traffic. Another way of revealing the potential benefits of carpooling is the consideration that a modest 10 percent increase in the average number of persons per automobile for urban work trips would be equivalent to a 60 percent increase in public transportation ridership.

In contrast to other approaches which require years of time and billions of additional dollars, carpools can reduce air pollution and energy consumption immediately and economically. If commuters were persuaded to use carpools, there would be an immediate savings of 430,000 barrels of crude oil per day, and this may increase to an estimated 790,000 barrels by 1990. The October 18, 1973, issue of the Congressional Record revealed that if among public employees alone the automobile occupancy were increased to 2 persons per car, almost 600 million gallons of gasoline would be saved per year.

Even though the preceding statistics relate that substantial benefits can be anticipated by increasing the occupancy of the standard automobile to 2 persons, Figure 2 shows that it is still an inefficient mode of transportation in terms of energy consumption (passenger miles per gallon of gasoline). Furthermore, many Americans enjoy the personal mobility provided by the automobile and they are not willing to share a ride with their neighbors and coworkers. It has been estimated that 25 percent of all lone drivers would not carpool unless severe travel restrictions were imposed, and such restrictions are not likely to be applied except on a temporary, emergency basis as a result of severe fuel shortages.



ENERGY EFFICIENCIES OF TYPICAL WORK TRIP BY MODE AND MODE COMBINATION

(10 Mile total trip length; 2 miles access distance to express transit and composite automobile for mode combination trips; peak hour occupancies.)

* Number of passengers

Figure 2. Energy efficiencies of typical work trip by mode and mode combination. Source: Highway User Quarterly, Summer 1974.

Research needs relative to carpools are many, especially in the areas of encouraging the "loners" to share a ride in their automobiles. Techniques and methodologies for improvements in carpools such as top management and union support, promotion campaigns, incentive programs, and marketing, should be designed, evaluated, and implemented in an effort to relieve the existing highway and parking congestion, conserve fuel, and improve the quality of life for all citizens of the Commonwealth by reducing vehicular pollution.

Vanpools

One form of transportation using streets and highways that appears to have a high potential for success is the vanpool, an organized form of carpooling that serves trips between home and work, generally to the large industrial concentrations poorly served by public transportation. The system replaces the usual one-driver-per-auto system with a fleet of company furnished, 7 to 15 passenger vans, each driven by an employee of the company. The employee who drives the van can also use it as his personal vehicle. Vanpools have been successfully implemented in several states, most notably in Minnesota (3M Company). The program could provide benefits to workers through lower costs and less personal driving; to employers through fewer parking spaces required; and to the state in less traffic congestion, air pollution, and energy consumption. As shown in Figure 2, the vanpool is an energy-efficient mode of transportation, especially in small metropolitan areas.

Although several studies have been completed on the applicability of the vanpool concept in Virginia, additional research should be conducted to seek answers to questions relative to public policy and the role of the state in seeking implementation of the concept. Attempts should be made to determine the characteristics of industries (e.g., size, location, and type) that would make them suitable for vanpools and the savings to the state that would accrue from vanpool programs (e.g., reduction in traffic volume, less need for conventional transit, less fuel consumption, and less air pollution). Promotional guidelines should be developed, and sites for possible implementation of programs should be suggested.

Preferential Treatment and Control

The efficiency of a highway system can be improved by increasing the number of passengers each vehicle carries. One way this can be done is to grant high occupancy vehicles preferential treatment in using the highway. In the following sections several research needs relative to preferential treatment and control are presented.

Bus Lanes

In most Virginia cities, buses transport the vast majority of people who choose not to travel by private car and they are considered the foundation of public transportation. During the past three years, many programs have been initiated to lure people out of the automobile and into buses in an effort to relieve street congestion and promote the efficiencies in the use of energy resources. Benefits of such a program are denoted in Figure 2, where it is shown that for a ten-mile work trip, an energy savings would result if automobile users, even four-occupant carpools, were to decide to ride local buses. In terms of energy, the local and express bus modes of mass transit compare favorably with rapid rail transportation.

Many programs have failed simply because the bus did not provide service (comfort, convenience, privacy, reliability, travel time, etc.) comparable with the automobile. Normally, a trip by bus requires a longer travel time than by auto and few commuters are willing to accept this factor even though the cost may be less. Through the use of exclusive lanes, buses can bypass traffic congestion and delay, and thus achieve a travel time savings. There is strong evidence that commuters can be attracted to public transportation such as provided via an exclusive lane if travel time is reduced. Bus lanes have the capability of transporting large volumes of passengers and the potential for substantial gain in total capacity to move people in a corridor.

Several techniques can be employed in providing bus lanes. The construction of exclusive rights-of-way for buses offers the highest type of service. These roadways can be constructed on an existing highway right-of-way or on its own right-of-way. In either case, these facilities assure the separation of vehicle classes and thereby allow high speed operation of the buses. Another advantage is that the efficiency of the existing highway is not reduced. The provision of this type facility requires high capital investments and major construction, which necessitate a long time for implementation.

Reserving an existing traffic lane for buses is an effective technique that can be implemented quickly and involves only changes in traffic operations and control devices. The reserved lane traffic can travel either with the normal flow of traffic or against it. In several cities it has been feasible to reserve all lanes of a street for buses. These streets are commonly known as bus streets.

Another facility that has been successfully used is a special bus bypass lane around locations such as entrance ramps to freeways and toll plazas where traffic congestion exists.

Even though all of these techniques have been applied, there are several areas where significant good can be achieved through research. Each technique should be warranted on the basis of its people-moving capabilities, and guidelines should be developed to ensure selection of the optimal technique. Associated with the warrants for bus lanes is the need for data and forecasting techniques. Consistent volume data are lacking, and more accurate information on peak-hour bus and passenger volume data are needed. The type of data as well as the collection processes should be reviewed. Additional research studies in demand forecasting and potential user motivation are essential in planning new projects. Additional field testing and design studies should be conducted to determine the optimal roadway parameters, i.e. cross section, lane width, type of separation barriers, and grades. Legal and enforcement considerations should be reviewed and evaluated. Liability, especially that for contra-flow bus lanes, is a subject of significant concern. Research is also needed on the institutional, financial, social, energy, and environmental aspects of bus lanes. Finally, guidelines should be developed for properly evaluating the effectiveness of the bus lane techniques implemented.

Carpool Lanes

The techniques for accommodating express bus service and the related needs for future research may be noted for other types of high occupancy vehicles such as cars and vans used in ride-sharing pools. In addition to the items mentioned in the previous section, public and private organizations can provide ride-sharing incentives for their employees. Employers can initiate programs that will assist in the identification and grouping of employees into pools. If the company or agency provides parking for employees, spaces near the building can be reserved for pooled vehicles. Other incentives range from subsidizing parking fees to allowing the employees who are participating in ride-sharing programs to leave work several minutes early in order to avoid travel delays in the parking areas.

Many techniques of preferential treatments for high occupancy vehicles have been developed, however, they should be reviewed and those applicable in Virginia should be compiled in a research report. Much research is needed in the areas of promotion and marketing of the various priority techniques and programs. In a report prepared by the Virginia Energy Office it was noted that the promotion of ride-sharing offered the greatest potential of energy savings of all those proposed in the transportation field.

Transit Priority at Intersections

A further increase in street capacity is achieved through a variety of traffic control techniques which can benefit buses and other transit vehicles. Bus travel times can be improved by providing preferential treatment at signalized intersections. Equipment can be installed on buses that allows them to preempt normal traffic signal time patterns.

One strategy, which is under experimentation in Washington, D. C., provides special transmitters on buses that activate detectors in the pavement. The detectors send signals to the controls, which in turn extend the green time to allow the approaching bus to pass through the intersection without stopping.

Intuitively, a bus priority system appears to have a high probability of success in improving bus travel times; however, the Washington project should provide valuable results. If the project is successful, studies should be conducted in the state and demonstration projects should be initiated. The effectiveness of the technique as a means of improving the mobility of people in urban areas should be evaluated.

Park and Ride Facilities

The park and ride technique for providing mass transportation has demonstrated its applicability in Virginia. Facilities provided in Northern Virginia and Richmond have been successful in reducing the total vehicular travel on the streets and highways and thus conserving energy, reducing vehicle emissions, and relieving traffic congestion. The park and ride mode is unique in that it utilizes the private automobile to collect trips in low density residential areas and then allows the trips to be made along existing transportation corridors via transit. Through the use of standard transit buses on freeway lanes or reserved bus lanes, the efficiency of the highway in terms of moving people per lane can be increased. Through the use of the automobile as a collector of trips and the provision of a change of mode facility with ample parking, the service area of the transportation for the particular subset of passengers utilizing the park and ride mode is effectively increased. Increased service areas may allow greater station spacing, which in turn may allow greater efficiency within the transportation system.

The benefits from the park and ride mode are not limited to the transportation network alone. Land use efficiencies may be realized due to a decentralization of parking demand. Park and ride facilities in fringe areas reduce the demand for parking in the downtown area and thus allow the land to be used for high density development.

Fringe parking appears to offer promise as a component of an integrated transportation program and it is important that research in this area be continued. A major concern for the future is the ability to reasonably predict the demand for park and ride facilities. Although several demand models have been developed, they should be applied in demonstration projects and should be evaluated. Additional study is required on the diversion of auto trips to the park and ride mode and the effect of a number of park and ride facilities operating in the same corridor. The environmental and economical impacts created by the facilities upon the neighborhood should be evaluated, and guidelines should be developed for the location of fringe parking lots. Design standards are needed to ensure that facilities are constructed so as to provide maximum service for the user and minimal impact on adjacent land use. Finally, studies should be conducted on the social, economic, and travel characteristics of the users.

Staggered Work Hours

To meet the peak hour demand, transportation officials have generally concentrated on increasing street capacity and vehicle fleet size. However, in many urban areas the reconstruction of streets to improve capacity is no longer practical because of economical and environmental concerns. Adding more buses to the fleet will help substantially, but this is costly since there is no demand for most of the buses during off-peak hours.

One solution to the problem is staggered working hours. Programs that stagger employee arrival and departure times attempt to spread the peak demand over a longer period of time and thus relieve traffic congestion and permit efficient use of street space and transit vehicles.

There are several methods of staggering hours. The traditional eight to five work day can be adjusted to stagger employee arrival and departure times over a short time period. In Washington, D. C., six federal departments have allowed their 50,000 employees to arrive at their offices at fifteen-minute intervals from 7:00 a.m. to 9:00 p.m. Many other organizations have adopted the same policy in an effort to help the employees avoid traffic jams and to improve punctuality.

Staggered working hours can also take the form of flexible hours, commonly known as flextime or gliding hours. This arrangement generally consists of a prescribed period of time during which all employees of an organization must be present while allowing employees to select their own starting and quitting times to accommodate their individual needs and preferences. In an eight-hour working day some employees would desire an early schedule of 7:00 a.m. to 4:00 p.m. while others would find a late pattern more suitable.

The above methods try to stagger the working hours within the traditional five-day work week. Another option available to adjust the demand for transportation facilities is the shortened work week, often called the compressed week. The forty hours per week are retained but are condensed into fewer days. The most common compressed week consists of four ten-hour days. In theory, the adoption of the four-day work week would reduce the demand for commuter services and facilities by 20%.

All of the staggered work-hour techniques have advantages and disadvantages. The staggered hours over a short period of time could have a negative effect on ride-sharing programs and public transit service, whereas the flexible hours could make carpooling easier for the employees. Another negative effect could occur if the program, designed to conserve fuel, resulted in the employees spending the extra time off from work driving the private automobile for recreational and pleasure purposes. The benefits and disadvantages of each system should be outlined in a research project, and guidelines for a successful program should be developed. Evaluation techniques should be developed to measure the effectiveness of implemented projects.

Information relative to the impacts of the compressed work week is limited, therefore many questions remain to be answered. Among these are:

1. What are the effects of such a program in terms of production costs, including energy consumption?

2. What type of employment activities can effectively support the program?

3. What do employees do with the extra time off from work? and

4. What are the impacts upon the public transportation system?

Traffic Management

Most of the previous discussions have dealt with techniques to improve the people-moving capabilities of streets and highways by increasing the number of people carried per vehicle. Another option is to improve the flow of vehicles. Through traffic management many improvements can be made which will relieve bottlenecks and promote smooth traffic flow. The range of improvements include better channelization of traffic, one-way streets, effective parking regulations, exclusive lanes for turning vehicles, improved signalization, progressively timed traffic signals, and computerized traffic flow control.

The traditional approach to a traffic problem has been to view it as an isolated problem and alternative solutions have been considered in this context. Certainly, this approach has been appropriate and quite successful in many cases, because usually the traffic flow on a street or highway is governed by a deficient section or intersection. Continual studies and remedial measures should be made on an individual or isolated location basis; however, they should be supplemented with evaluations of the entire street system. An improvement at one intersection is of little benefit if the traffic flow is restricted at an adjacent one. An attempt should be made to view the problem in its total environment rather than merely to consider it in an isolated or fragmented context.

The application of systems concepts appears to have merit in the traffic field, and research in this area is recommended. The systems concept can yield a better understanding of traffic and transportation problems and thus provide the engineer with direction to rational solutions and insights in dealing with his complex problems. The traffic and transportation engineers should be provided an introduction to the philosophies, concepts, and analysis pertinent to systems problems. Furthermore, training techniques and workshops should be provided to present examples which illustrate the application of systems concepts to traffic and transportation problems.

Traffic signals is one area in traffic management that should receive top priority in Virginia. The majority of urban street and highway systems incorporate signalized intersections and the intersection continues to be the point of minimum capacity. To improve system capacity, without sacrificing safety, it is necessary to bring traffic signal operation to the highest possible level of efficiency.

Communities in Virginia have traffic control systems consisting of numerous types of equipment from various manufacturers, and, not surprisingly, technicians in the field are not always familiar with

the controls that they must operate and repair. Without a clear understanding of the basic characteristics and functions of signal equipment, they cannot make the fine timing adjustments necessary to maintain efficient signal operations, therefore training should be provided.

Standard methods of computing the time allocations on signal controls require extensive data collection, manpower, and expenditures. Most procedures require a 12-hour directional traffic count, and in Virginia these are rarely secured; therefore, the signal timings are based on intuition and visual observations. New procedures utilizing sample volume data should be developed.

Traffic flow along a street can be greatly improved by interconnecting the signal control equipment. Interconnection or coordination of two or more signals into a system provides positive time relationships between the signals and ensures an orderly progression of traffic. Traffic engineers frequently have difficulty in obtaining necessary funds for the installation of a costly signal system, simply because management is not aware of the benefits derived from coordinated traffic flow. Before and after case studies of signal systems should be conducted and the motorist and community benefits documented. In addition to assisting in the decision-making process for future proposals, this information would be of great interest to the general public.

Through the use of a computer it is possible to coordinate every signal in a city or locality. In many cities, systems have been installed, with resulting benefits and advantages. One striking potential advantage of computer control is flexibility, and considerable research is required to develop control logic that can utilize the capabilities of the digital computer for data processing, decision making, and control command functions.

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