was undertaken to compare the costs and benefits of conventional railroads, busways, paratransit, and LRT. The technology that best satisfied the policies and goals of the region was a modern LRT system that promoted the development of houses and apartments in a manner that provided balance between green space and urbanization, while linking these new communities with the older city.

SUMMARY

The five cities reviewed here are by no means unique in their use of LRT technology. Unlike new systems, such as monorails or people movers, the operation and technical successes of LRT are not restricted to a few sites. In more than 300 cities in about 30 nations, the significance of LRT is shown daily. There are different options and objectives for the world's various societies, but there is a question as to whether we can continue to rely so much on the automobile. We need a combination of urban transport technologies in which each contributes positively. When we consider costs, accessibility, pollution, and adaptability to setting, there are many strong arguments for the use of LRT technology. LRT services can be combined with the use of private vehicles through peripheral parking lots.

However, it must be remembered that the choices available to urban planners and officials must be based on what the community and nation will permit the technology to do. One clear example of this relates to the amount of peak-hour capacity that is desired. If the transport capacity is to be provided by elevated expressway, the amount of land required and the impact of the structure will be several times greater than those for an LRT structure. In Cologne and Rotterdam, LRT installations exist and provide high-capacity transport with minimal impact on the residential and historic areas of the cities.

The materials, equipment and vehicles required for LRT use are available worldwide. New rolling stock is being supplied for Helsinki and for LRT operations in Fort Worth. The Boeing Vertol LRV is being built in Philadelphia for revenue service in Boston. This vehicle has been in revenue service since December 1976. The Pullman-Standard Car Manufacturing Company of Chicago has designed a new four-axle vehicle. In Ontario, there are in production both four-axle and six-axle vehicles currently slated for use in Toronto. An indication of the versatility of LRT technology for adapting to new social objectives is seen in Boeing Vertol's proposal for handling wheelchair patrons by providing a hydraulic lift within the vehicle.

When innovative planning in urban transport is encouraged, the difference between the design and cost of LRT equipment and those of heavy-rail equipment becomes very apparent. LRT technology combines design and equipment that adjust easily within the existing urban fabric and operate through the historic, recreational, residential, governmental, and business communities with ease. The idea that a railbound vehicle, operating in its own reserved or private right-of-way, must be expensive and overbearing on its surroundings is found not to be true in light of existing applications.

The planners and engineers interested in the use of this technology should review the methods used in other nations. However, such interest should not envision total and strict importation of another city's operation but rather should examine innovation in the urban transport planning process. In this manner, LRT will be feasible for expanded installation within many cities of North America.

REFERENCE

1. A. M. Wellington. The Economic Theory of the Location of Railways. Engineering News, New York, 1893.

Current Trends: Problems and Prospects of Light-Rail Transit

Vukan R. Vuchic, Department of Transportation Engineering, University of Pennsylvania, Philadelphia

The difficult task of rescuing our urban transit systems from several decades of neglect has only started. Among the obstacles to transit improvements is our deeply rooted double standard for different types of expenditures: Purchase of wasteful items by consumers is considered to move the economy but the use of public funds, even for the construction of very useful projects, is often criticized as wasteful. Another serious obstacle to the development of rail transit in our country has been a lack of expertise in the planning, technology, and operation of these modes. We have virtually invented a new mode: unreliable rail transit. A concerted effort must be made to apply the technical skills that this technology requires to fully realize its great potential. A major step toward that goal would be made if the Urban Mass Transportation Administration would redirect some of its efforts from the development of exotic modes (some of which have little potential) toward the modernization of standard rail and bus technologies. In spite of these obstacles, light-rail transit (LRT) has recorded significant advances. It is now broadly recognized as a serious contender for major transit improvements in many medium-sized and large cities. Its modernization in Europe is continuing, new LRT systems are under construction in Canada, and several U.S. cities are actively planning or designing new LRT systems. There is also a major potential for extensive deployment of LRT in the large cities of developing countries that has not been fully recognized yet. President Carter has promised to pursue three important goals: to revitalize cities, to decrease unemployment, and to increase energy efficiency; if he takes a correct path toward these goals, we should see construction of LRT in a number of our cities in the near future.

Few areas incorporate and symbolize as many of the problems, conflicts, and challenges of modern society as urban transportation does. Among the most complex problems of our society is finding the right balance between the interests of individuals and society—the dilemma of where, how much, and in what manner to introduce public control over planning, development, and operation of systems that consist of private and public

components; the serious problems of reconciliation of functional requirements with environmental protection and excessive energy consumption are also found in urban transportation in very acute forms. Moreover, the interdependence between urban transportation and the strength and character of cities is so strong that we often debate the merits of different modes (such as automobile versus transit) on the basis of the differences we have in our concepts of what cities should look like or, even more fundamentally, how prosperous and how livable cities should be. Public transportation is particularly closely related to the prosperity of cities. Its analysis must therefore be done in the light of an analysis of the general trends that affect cities.

RECENT TRENDS AFFECTING URBAN TRANSPORTATION

There has been a growing consensus that the private automobile, when favored over other modes and used indiscriminately as has been done for decades, is not compatible with an attractive urban environment and that some means of regulating and limiting its use are absolutely necessary if we want to have livable and healthy cities.

The first results of this changing attitude can be seen in the openings of numerous pedestrian malls and automobile-restricted areas in various cities. However, the more comprehensive measures, such as increased taxation for parking, limitation of automobile entry into certain areas, monitoring of traffic flows on various facilities, and extensive limitation of through traffic in cities, are still found only in theoretical discussions. The fact is that the greatly underpriced use of the private automobile in cities remains the key obstacle to efficient urban transportation. Until that problem is resolved, we will be facing financial crises in all urban transportation systems. We will also continue to have serious environmental problems and extremely high levels of energy consumption.

After a slowdown during the energy crisis, automobile ownership has continued to increase in virtually all countries. But it is highly significant that, despite this trend, many cities that undertook transit improvements have had a stable or increasing transit ridership. This has clearly shown that the automobile does not have an unexplainable magic but that urban travelers choose among modes with very rational judgment. Transit ridership has been stable or has increased in many European cities, as well as in Toronto, Edmonton, and several other Canadian cities. Relatively modest improvements of transit have also resulted in drastic increases of ridership in such cities as Pittsburgh, San Diego, Honolulu, and Minneapolis.

Most of these recent trends have contributed to an improved image and a greater recognition of the vital role of public transportation. In most countries, investments for construction of new transit lines and for operations have increased, and treatment of transit vehicles has been improved through various priorities. These improvements are significant, but the difficult task of recovering from several decades of total neglect of public transportation in our cities has only been started.

Several of these recent general trends have had a direct impact on the role and potential of light-rail transit (LRT) in cities in many countries. A particularly strong impact has been made by the tendency to improve the utilization of existing facilities, primarily through provision of various types of transit rights-of-way on the surface. We are finally beginning to recognize the fact that transit vehicles should be given priority over other vehicles at least in proportion to their higher capacity and efficiency. Provision of separate right-of-way and transit priorities at intersections have made LRT feasible and desirable in many cities in which only a few years ago rail technology was considered to be unacceptable.

The recognition of the potential of LRT has been aided by the success demonstrated in cities that gradually improved LRT for a number of years. They have now upgraded their most critical network portions and have clearly shown that medium-sized cities can effectively use rail transit on an extensive network. LRT is thus filling the wide gap between the low level of service and low investment required for buses and the high level of service and high investment required for rapid transit.

The relationship between LRT and modes adjacent to it in the spectrum of transit modes has been clarified somewhat, but it remains a subject of many discussions for specific applications. The discussions about the merits of LRT versus rail rapid transit (RRT) have been lively and often unnecessarily confused by two extreme points of view. On one side, there are those who believe LRT is so seriously impeded by its grade crossings or surface operation that it can never give satisfactory performance; RRT is therefore the superior mode. At the other extreme are those who believe that LRT has a greater flexibility of alignment and that, with proper design and regulation of crossings and street running, this mode can virtually match RRT performance; therefore LRT is superior to RRT in virtually all applications. It is rather easy to prove that both of these extreme views represent incorrect overgeneralizations.

It is interesting that there has recently been a tendency to develop systems that use many good characteristics of both modes: ability to have grade crossings or street operation of LRT and operation in trains of three or four cars on grade-separated tracks of RRT. Line A-1 in Frankfurt, line 8 in Gothenburg, the planned Buffalo line, and the second line of the Rotterdam Metro belong in this category. Thus there is a nearly continuous spectrum of modes from LRT to RRT. However, the fact remains that there is abundant experience to show that, despite the large overlap between the domains of the two modes, each one also has a large domain in which it is clearly superior to the other.

It should be pointed out that the desire to make all LRT systems as much like RRT as possible to avoid having an inferior LRT system has often been shortsighted and damaging. It is now rather widely recognized that the extremely high standards for LRT represent overdesign for many applications. For example, a recently developed, well-publicized European light-rail vehicle (LRV) has proved to have excessively complex electronics, cannot negotiate many existing curves, is much heavier than earlier models, and is inconvenient for low-platform boarding. Successful application of this LRV model in a couple of cities does not mean that such a large vehicle is applicable on most LRT systems.

The problem of overdesign (or goldplating) and the technical complexity of vehicles and infrastructure represent damaging factors; they actually decrease the domain of rail modes, which may be unnecessarily priced out of some applications. However, there are indications that a more economical design is now regaining its importance.

OBSTACLES TO LRT DEVELOPMENT

The slow development of LRT, particularly in this country, can be explained by a number of serious obstacles that we are facing. Let us again start with a review of the major general problems in our society that impede revitalization and modernization of our cities and thus also impede improvement to public transportation and LRT.

We have very deeply rooted double standards for different types of expenditures. We tend to consider all private expenditures desirable consumer behavior that moves the economy, while we tend to regard all public expenditures as suspicious investments that are often a waste of taxpayers' money. A popular view is that, if a person purchases an automobile that has a vinyl roof, push-button windows, power brakes, and so on (which consumes a great deal of fuel), this represents a desirable expenditure, while the construction of new public facilities, such as transit lines, is an investment that should be minimized by all possible means. Does that really make sense? Should we consider the automobile industry the most vital and desirable basis of our economy? Should we not include many public works for constructing permanent, efficient, and extremely useful facilities as an even more attractive mover of our economy? Let us not forget that a major factor behind the law that instituted the Interstate highway system was the creation of jobs and stimulation of our economy. We should now focus our forces on similar types of public works, but primarily on the projects that permanently benefit our cities and society. Improved mobility, stimulating development of desirable urban environments, and energy conservation are some of the potential major benefits rail transit offers.

Our country is obviously in a state that could be described as "closed-eyes happiness." It is quite unpleasant to think about the worsening energy problem, so we choose to totally ignore it. President Carter's energy program, which is rather modest and probably inadequate if his description of the seriousness of the problem is correct, has been attacked as too drastic. If the problem were not so serious, it would be quite amusing to observe many representatives in Congress declaring that, under the proposed additional 1.3 cents/L (5 cents/gal) gasoline tax, people will not be able to get to their work places. The same representatives do not express such concern when communities run out of funds to support minimal bus service to large segments of our cities. This let-them-eat-cake approach is hardly a sign of enlightened leadership.

A major oversight in the delineation of the energy program has been a virtually total omission of consideration of transit as a major factor in energy efficiency. President Carter's program takes a popular but incorrect view that contends that we cannot get people out of their automobiles and that the role of transit is not significant. The former has been proved wrong in many instances, while the latter is incorrect in its basic approach. It is neither the present volume of transit use nor its present role that should be considered. The potential of transit lies in its ability to serve a much larger share of urban travel if it is properly financed, designed, and operated. If ridership is increased, transit can effect a much greater energy saving than is now the case.

Organizational deficiencies in our cities also represent a major obstacle that has not gotten adequate attention so far. The multiplicity of governments in metropolitan areas makes a functional approach to such problems as transportation very difficult to achieve. Many organizations, such as the National Conference of Mayors, represent only central cities instead of metropolitan areas. How long can we ignore this deficiency?

An extremely serious specific problem is the very high degree of major errors made both in the design of rail transit systems and in the manufacture of rail vehicles, control systems, and other components. Due to the serious incompetence in these fields, we have actually invented a new version of transit modes: rapid transit with low reliability. This is directly contrary to one of the basic characteristics of rail transit. In dozens of cities around the world this mode has been operating with reliabilities very close to 100 percent for many decades. The new rapid transit system in Munich had two significant delays during its first year of operation. Some of our new systems have that many delays in a week or even in a day.

This problem is explainable by the lack of competence that results from decades of neglect of rail transit technology in this country, but it is not excusable, and it cannot be tolerated. The cost of this problem is extremely high. Frequent technical problems increase operating costs and cause user inconvenience and loss of riders. Moreover, they generate totally incorrect opinions among laymen about the characteristics of rail transit. The news media have recently displayed a shocking lack of basic knowledge and have contributed to confusion, with diligent assistance from the traditional opponents of rail transit.

Let me point out that, if the telephones in Albania do not work well, it is hardly proof that the telephone system as a means of communication is inefficient and unreliable. Yet the opponents of rail are trying to say that because some of our new rail systems have frequent breakdowns, rail transit in general is ineffective and unreliable. Not only transit operators but millions of rail transit users in New York, London, Berlin, and many other cities know very well that high reliability is one of the basic inherent characteristics of properly designed and competently managed rail transit. They also know that rail transit is a major asset of their cities.

While debates and criticisms of urban transportation planning can be useful and productive, this is only the case with constructive criticism. We do have, unfortunately, a vocal group of professional critics who are usually opposed to all improvements not only of public transportation but of cities in general. Because rail transit plays a major role in cities, this mode is their primary target. Most of these critics explain all conceivable problems very simply: They are due to rail technology. They are like the Luddites in England who, about 150 years ago, blamed machines for their unemployment and tried to solve the problem by destroying them. According to these critics, rubber-tired vehicles on highways, ranging from buses down to jitneys and car pools, would offer better and cheaper service. While this is true for some cities or areas, no responsible and knowledgeable professional can make such a categorical statement.

The fact that separate right-of-way is both the key to transit performance and its ability to compete with the automobile (regardless of transit technology) and the main element in investment cost (again regardless of technology) is completely ignored. Successful rail systems, such as the Lindenwold Line, are not mentioned.

It is unfortunate that the planning for the year 2000, which was based on extrapolation of past trends and often produced the unrealistically large plans that were typical of the 1960s, has now been replaced (at least in the United States and Great Britain) by an ultraconservative philosophy of no investment—a philosophy of thinking small and not far ahead. We have now been bouncing between the unrealistic, imaginary future and vague, irresponsible proposals that we should return to the free competition and primitive organization of urban transportation that was actually superseded at about the turn of the century. There has also been, however, an encouraging event in this area recently. Public Transportation and Land-Use Policy (1), a study performed by the Regional Plan Association of New York, is a major contribution toward better understanding of this impor-

tant aspect. More studies of this type are needed.

REVIEW OF LRT PROGRESS

By far the best progress in actual development of LRT has continued to take place in a number of European countries, particularly West Germany, the Netherlands, Switzerland, and Belgium. The number of new systems, lines, and extensions has not been great, but the work on upgrading existing networks has been intensive and has had excellent results. Brussels, the Hague, Hannover, Cologne, Zurich, and many East European cities have introduced new sections of lines on separate rights-of-way, LRT in pedestrian malls, many innovative traffic-engineering measures for LRT priority, and so on. These cities have good coordination of LRT with buses and rapid transit, as well as park-and-ride systems and numerous new technical inventions, designs, and operational concepts. There are indications that this trend is now also spreading to those countries that had abandoned streetcar systems long ago, e.g., France and Great Britain.

A major problem of urban transportation is beginning to appear, or at least to be fully appreciated, in the developing countries. The number and sizes of their cities are increasing at a rapid pace and transportation is becoming a serious bottleneck in their development. Most of them have used low-cost solutions that result in only temporary relief. To even begin to create an adequate transportation system, most of these cities, such as Cairo, Bangkok, Teheran, Caracas, and Bogota, will have to have high-capacity modes. The potential for the use of LRT in these cities is great, but it has not been fully recognized by many planners. At the present time there is operation or construction of LRT in Brazil, Egypt, India, and several other countries. There is also rapid-transit construction in several cities in these countries.

Closer to home, LRT in Canada certainly deserves careful attention. Not only have Edmonton, Calgary, and Toronto made excellent progress in planning, but the approach and organization of their project implementation sets a good example for many U.S. cities. Indications are, however, that these developments of LRT are only the beginning of using the large potential this mode has in these and several other Canadian cities.

Progress in the United States during the 2 years since the first conference on LRT has been particularly successful in Buffalo and Pittsburgh, but other cities, such as Portland, Oregon, Dayton, San Diego, and Hartford, are also in the process of considering or planning LRT systems. However, this progress falls short of the needs of our cities and the potential of this mode to meet them. The new role that LRT has assumed was very noticeable at the meeting of the International Union of Public Transport in Montreal in May 1977. Not only was there an extensive discussion about this mode, but preparations are now under way to establish a committee on LRT within this organization, the largest on public transportation in the world.

PROSPECTS FOR FUTURE DEVELOPMENTS

In reviewing and summarizing the developments and various factors influencing the development of LRT, we can see that its potential is now very strong, certainly far stronger than most of us could have predicted several years ago. This potential is often underestimated. There is a continuing tendency to use the maximum (and often exaggerated) capacities as the required criteria for introduction of a mode. First, it is not true that we must have 40 000 persons/h for RRT, 20 000 for LRT, 10 000 for a busway, or 3000 for a surface bus line. These figures represent the maximum capacities of the modes—the upper limits of their applications. Each one of these modes can be justified at much lower volumes. LRT can effectively serve 2000 to 3000 persons/h, and bus lines can operate with a few hundred persons per hour. Further, peak-hour volume in one direction is not the only criterion: System performance and service quality are often the dominant factors. If this is properly understood, it is then obvious that a great number of our cities have corridors or entire networks that are suitable for LRT.

Unless we remove the serious obstacles to transit improvements and accelerate our progress in that direction, we will not be prepared for the worsening energy crisis, for the increasing economic and social problems in our cities, for recovery of our deteriorating urban environment, and for all the problems that extreme private affluence and public poverty bring with them.

President Carter, among others, has expressed three important goals: to revitalize cities, to decrease unemployment, and to increase energy efficiency, in which transportation is a major item. Improved public transportation, including construction of new rail transit lines, is certainly an obvious and logical method of achieving all three of these goals. More off-street parking is the last thing most of our cities need.

Our progress in urban transportation will accelerate considerably if the Urban Mass Transportation Administration (UMTA) focuses more intensely on two basic objectives: (a) to prevent or at least minimize the probability of major failures, such as technical problems and excessive costs, and (b) to undertake more programs of very practical, operational, and tangible improvements in our transit systems. The first goal will be achieved by fostering much better expertise in planning and design of transit systems, vehicles, and other components. UMTA has made valuable efforts in LRT system planning and design concepts, but its research and development efforts in vehicle development of all conventional modes have been less than successful. While many exotic technologies, some of which clearly have no future, have been given a lot of attention, several versions of UMTA-sponsored prototype vehicles using conventional technology (e.g., the Transbus and the rapid transit state-of-the-art car) have produced excessively complex, heavy, unreliable vehicles that are, in many respects, less advanced than the latest vehicle designs in Europe.

UMTA must monitor vehicle specifications and design of transit systems more closely. It must prevent a vehicle manufacturer that made numerous design errors on one rapid transit system from getting another order for cars in the future. We simply must reacquire the lost ability of building and operating reliable and efficient transit systems. Additional, stable financing and better training of technical personnel are required for that.

Another potential failure lies in the downtown people-mover program. If we look back over experiences with new modes, we can see that virtually each one caused major problems, extensive criticism, and often lawsuits after its opening. Installations in Dallas-Fort Worth, Morgantown, and Toronto were not bright moments in transit innovation. Short-haul transit service is a missing link in many downtown areas but, if we learned very bitterly in Morgantown that testing a new transit mode on a line that is supposed to perform a regular revenue service is highly risky and usually damages the entire transit program, why are we now planning to use various combinations of new technologies, planning, and operating

concepts in as many as 7 to 10 cities at the same time? Does it make sense that we take this serious risk in so many cities while the proven mode of LRT has been approved in only 2 of them?

The second goal, to make real progress in transit improvements, will be achieved if we not only provide transit systems with reliable hardware but also develop economical design and efficient operation. Our transit systems suffer from obsolete fare-collection methods, inconvenient scheduling, inadequate (or nonexistent) information for passengers, rampant vandalism, and strikes from which, often, no one benefits. Focusing on solutions to these problems may not be a highly glamorous task, but solutions to these problems are necessary if we are to offer reliable, comfortable, and economical transportation that passengers will accept and appreciate. We should never forget that it is the urban traveler for whom we are designing our systems and our urban population for whom we must provide better cities. The developments in Boston and San Francisco, which had difficult beginnings after years of neglect, show that LRT is one of the modes that, with the cooperation of various concerned agencies, can lead to major improvements at moderate costs. The need in many other cities is great, and urgent action is required.

REFERENCE

1. B. S. Pushkarev and J. M. Zupan. Public Transportation and Land-Use Policy. Indiana Univ. Press, Bloomington, 1977.

Issues in the Implementation of Light-Rail Transit

Gerald B. Leonard, Los Angeles County Board of Supervisors

A conference on light-rail transit (LRT) invariably seems to draw out a highly explicit discussion about car design, the existence of rights-of-way for construction, and the great disparities between European advances and those in the United States. This paper suggests that, despite the high degree of competence that the technical community can claim in advocating LRT implementation, it is all little more than an academic exercise if the local, state, and national political realities are not recognized as integral aspects of implementation. The discussion in this paper is based on a survey conducted on a national scale of the key political figures in those states or areas considering LRT, as well as many key members of the agency and consulting staffs. The paper calls attention to the essential weaknesses inherent in current efforts to revitalize LRT as a primary element in urban transportation.

I intend to single out in this paper two issues I believe are extremely important to the implementation of light-rail transit (LRT), even though I am dealing with one of the least developed aspects of LRT implementation. I hope that this particular orientation may serve to channel our efforts in the most productive way conceivable so that we all might improve our efforts to implement LRT across the country.

In preparing this paper, I examined the planning and engineering studies of all the cities in North America involved in the development of LRT. Noticeably absent from these abundant descriptions of rights-of-way and technical specifications of cars is an attempt to identify the political climate in which this work is taking place. Ultimately, most if not all of the studies are at least temporarily sidetracked because the plans do not fit into the political environment or because they have run into problems in receiving funding from the local community, the state or province, or the federal government.

Those of us involved in the planning of LRT systems, although we are professional in our standards, are invariably buffs on the subject and consequently talk mostly to each other. In our planning and engineering studies, we use slides and diagrams to illustrate all the virtues of a technology that we have already acknowledged is part of our justification for pursuing the implementation of LRT systems. But in this talking to ourselves, I think we have somehow missed a far more critical issue involved—that of using our combined expertise in talking to the public or its political leadership.

The fruition of our technical skills—the building of an LRT line or network—in some city or a number of cities depends not so much on whether the vehicle is articulated or the vestibule can be entered from both high-level and street-level platforms or on the number of trucks that the vehicle has but whether such a scheme to build an LRT system is compatible with the wants of the general public and with the political priorities for the expenditure of limited public funds as seen by the various political jurisdictions. The competition for funds with which to construct LRT systems has never been keener than it is at present in our mildly depressed economic environment. It therefore remains for us to recognize that the public's perception of government and its current levels of expenditure are primary concerns to the public and consequently primary concerns of our elected officials. Keeping this in mind, it is highly advantageous to recognize not only the ability on our part to design the most efficient and fastidious system conceivable for the public good but also to take clearly into account an accurate reflection of the existing economic conditions at all levels of government.

In trying to assess the best means by which to assemble an accurate statement on the political and institutional problems associated with the implementation of LRT systems, the obvious and easiest means by which to do so would have been to identify from one's own experience and research what such impediments are and how a rational program to resolve these roadblocks to implementation might be established. In the case of this research, however, I have chosen to recognize that the strongest sources for identifying the problems associated with the implementation of LRT are the political leaders and planning technicians involved in the planning, design, construction, and operation of the various systems currently in operation or proposed for operation in