INTERNATIONAL ACTIVITY IN PERSONAL RAPID TRANSIT DEVELOPMENT AND ASSESSMENT

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This study reports on developments in the rapidly emerging field of personal rapid transit in western Europe, North America, and Japan. It deals with conflicting notions of the basic system concept as perceived in various nations and reports on the nature and the sources of financial and technical support for research programs in each country. Application studies in specific urban environments and technological research and development efforts are reported. Personal rapid transit is analyzed in the several evaluative contexts of transit services provided, social and environmental impacts, and institutional constraints to implementation. The study was carried out for the Organization for Economic Cooperation and Development as part of a larger study into a wide range of public transport service innovations in operations, planning, and technology.

•THE SURVEY of activities in the personal rapid transit field reported in this paper was carried out for the Organization for Economic Cooperation and Development during 1971-72. It represents but a portion of a larger study that sought to scan the status of a variety of innovations in urban public transport ranging from administrative reforms to new technologies (1). OECD is an international organization made up of member countries from western Europe, North America, and the Pacific and devotes its efforts to research, policy analysis, and mutual exchange on a variety of matters having to do with economic growth and common problems of urbanized, industrialized nations. It has been engaged in road research questions among other interests for a number of years, but the particular study reported here had its origins in more recent interests of the organization in environmental and urban matters.

On an ad hoc basis, a 2-year study of the "impact of the motor vehicle on the environment" was undertaken early in 1971 under the direction of an international committee drawn largely from the pollution-control agencies of the participating countries. My own study of innovations in the urban public transport field was viewed as exploring alternatives to the private automobile for urban mobility, in the context of policy discussions of urban environmental quality that might involve varying degrees of restraint on private motor vehicles in major world cities. Other studies that were carried out as part of the same inquiry have dealt with air and noise pollution caused by motor vehicles, traffic limitation techniques in urban areas, and natural resource demands of the automobile for fuels and metals.

A number of short-term improvements to the functioning of existing forms of transit were identified, particularly in the area of planning and administrative innovations. Although many of these might be carried out at relatively low cost and without long development or construction delays from conception to realization, the institutional resistances to implementation were found to be significant in many cases, Just getting the highway planning agencies and the transit planning agencies in a given metropolitan area to work together on common aims is an example of such difficulties, which vary widely from one city to another or from one country to another. What may be common practice in one country today will have to wait for political and institutional changes in another before it is feasible there.

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In a more middle-term perspective there were also found to be a number of promising operating concepts, evolutionary technologies, and investment opportunities that had both a technological component and an organizational component necessary for successful implementation. Examples of this kind of public transport improvement were the construction of new highway facilities exclusively for bus operations, placement of central city tram lines underground, application of medium-sized automated vehicles in simple airport or downtown shuttle services, and computer-directed management of traffic priorities in complex street and highway networks. Applications of this nature already exist in selected cities, at least in the demonstration stage, but the realization of their potential will take some time to be communicated into policy on a widespread basis.

On a longer-term basis there are both significant opportunities and significant uncertainties in new transit concepts employing major technological advances. Personal rapid transit is perhaps the best example of these, but dual-mode systems and high-speed trains are others. But, despite the many and varied attempts at such technological innovations observed in the course of this survey, the prospects for realistically implementing much of their promise at present seem quite marginal. Too little governmental and public concern has thus far been expressed in defining the nature of the problems that these new technologies should help ameliorate and the processes by which they might be tested and selectively introduced to gain acceptance as a long-range alternative to existing transport modes. Thus the primary concern of this paper, beyond simply reporting current research and development activities in the field, is with the institutional factors that may limit the future applicability of such an advanced technology concept before it has ever been adequately developed and demonstrated.

CONFLICTING DEFINITIONS OF TRANSIT SYSTEM CONCEPT

Personal rapid transit here is intended to refer to small automated vehicle systems in area-wide service. Such a concept, and its technological realization in reliable and economical hardware, would offer a major advance in the service characteristics of urban public transport as experienced by the traveler. If it is possible to develop such a new technology system it would add a new personalized alternative to the present choice of transit modes, most of which are mass transportation devices, whether buses, trams, or trains. This is a potential quality of transit service of interest in relatively affluent cultures where the private automobile exercises much of its appeal in its highly flexible and personal use. It does not seem to be obtainable through any of the short- and medium-term innovations mentioned earlier, which can improve mass transportation over present standards but never attain the high level of service that may well be desired of public transportation in the future. Therefore it seems important to single out the potentials and the institutional pitfalls of this particular advanced technology concept for review.

Observing the national programs of several countries in this research and development area allows one a certain perspective on institutional problems that is not possible by observing efforts in the United States alone. As promising as the possibilities are for a new form of transit service through the development of a more personalized, yet public, mode of urban travel, the potentials in all countries for undue delay and embarrassing failures in application are significant, given the present array of organizational and political factors bearing on the whole structure of institutions involved in urban transit development. These dim prospects do not seem to lie so much in technological problems but in the gaps of communication and responsibility between those institutions with specific transportation missions and those with differing but intimately related tasks, such as enhancing the quality of the urban environment or promoting the application of science and technology to human affairs. The pattern may be different in Germany, France, Japan, Great Britain, or the United States, but certain common features of these communication failures and fragmented responsibilities are present in all existing national programs dealing with personal rapid transit.

Perhaps the most frustrating communications failure involves a definition of what personal rapid transit, or PRT, really is meant to be in transit service terms. There is frequent abuse of the term, which serves to confuse technology with service. The abuse is twofold and consists of describing as PRT (a) moderately large-vehicle, line-haul technologies because they are automated and can, incidentally, bypass stations; and (b) small-vehicle shuttles, loops, and networks in airports and other major activity centers because they are small and on guideways. Although both these types of systems are innovative in their own right and are immensely valuable as precursors to truly personal rapid transit systems, they do not embody the service characteristics that are central to the original concept of PRT.

Each of these alternatives has been discussed extensively in the report from which this paper is excerpted. As is also discussed there, the staging of research, development, and demonstration as we advance from these precursor systems to fully characteristic PRT networks and vehicles is critically important to the whole process of establishing technological and political feasibility for advanced transit systems.

Reportage in the popular press, and even in the technical literature, to the effect that PRT is already here must be treated with some skepticism. The pressures on industrial firms and government agencies to make such a claim are quite understandable in the short run, yet potentially very dangerous in the long run.

The need to demonstrate civil technological programs to the public in forms that they can readily understand, to overcome widespread doubts in the transit industry that anything technologically innovative in urban transport is possible or even desirable, to begin to spend real money in this field to keep industrial interest alive, to improve the image of a tired and dull public service in its political competition for scarce resources are all valid and important reasons for a bit of boosterism to spur interest, support, and future expectations. And for these reasons (as well as others less understandable), efforts are being made to simplify and to shortcut expensive research and development programs and to bring PRT systems—or their less exacting cousins—to limited performance demonstration soon.

But the importance of recognizing a thing for what it is—not for what it is called or wished to be—needs to be brought to current discussions. Therefore much of what is currently being said publicly about PRT in a variety of countries is in need of critical analysis to clear the air about a subject of immense importance to the future of urban transportation.

Without such critical review early in the process, the potential for disappointment and political backlash when costs rise, complexity increases, and failures occur becomes a very real and great danger, perhaps unrealized in many technical quarters today. A few such disappointments in the not-so-distant past have already occurred. It is with this perspective in mind that we offer the following optimistic yet critical interpretation of recent developments in the field of personal rapid transit.

Minus its current abuse, the term PRT originally referred to the concept of a public transport system featuring small automated vehicles that would operate on exclusive guideways, traversing extensive and complex area-wide networks in response to the origin and destination desires of individual passengers. The term seems to have been first used in the U.S. government report, "Tomorrow's Transportation" (2), to cover a range of such systems concepts, of which more than 20 had been proposed as early as 1967. (Other general terms then in use included "area-wide individual transit" or "network transit".) A longer and more precise definition appears in that report and is well worth reviewing by those seriously interested in the field (2, pp. 60-62). It serves to restore a focus on the importance of this systems concept, which has become so obscured in the past few years in the United States yet which has been adapted directly from American work as the central concept of both the Japanese and German research and development efforts in high-technology urban transit.

Perhaps the key point to be emphasized about PRT, as thus defined, comes in a paragraph from the 1968 federal report (2, pp. 61-62):

> The guideway network covering the metropolitan area is the essential ingredient of the personal rapid transit system. Without a network of guideways the system could hardly avoid conventional heavy dependence on work trips and a radial orientation to existing central business districts. Thus it could not provide adequate transportation alternatives in large metropolitan areas

> with a wide dispersion of trip origins and destinations. No matter how sophisticated the technology, transit which operates without some sort of network service pattern almost certainly will remain a marginal service in the movement of urban populations.

Thus the central issue and advantage of personal rapid transit as an innovative transit service with major, not minor, potential influences on urban transport is represented in the last sentence of the quotation above: "No matter how sophisticated the technology, transit which operates without some sort of network service pattern almost certainly will remain a marginal service in the movement of urban populations."

Although elements of the advanced technology that can lead in the direction of PRT are already under development in research laboratories around the world, it is less the technology and more the overall systems concept that is at issue now. It is a harmless enough expediency for an automated tram such as will operate at Morgantown, West Virginia, to be called a PRT, while development continues toward more sophisticated networks, vehicles, guideways, and operations. But if it becomes widely believed that such an installation truly represents personal rapid transit, and further research and development is thus curtailed at a relatively low level of service capability, then the mislabeling represents a major disservice to all of those who hold out some hope for major technological and service improvement in urban transport.

Instead, it should be possible to keep the concept of PRT intact while incrementally bringing the technology to higher and higher levels of sophistication. The Dulles Airport "Transpo" demonstrations could have some influence in that regard. But the crucial question there is, Which kinds of characteristics of the small-scale transit systems will be emphasized in the next demonstrations, if any, and possibly be slated for real cities, following technical tests and public trials at the exposition?

At some more distant, evolutionary point in system development, the sophistication of the needed control technology—perhaps the efficiency of the power-consumption requirements, the maintainability of the constituent system components, and other factors—will be central technological issues that must be resolved before really major commitments can be considered for PRT systems. But for the present and very near term, existing technologies are being utilized for as much of system hardware as possible by many of those companies promoting capabilities in this area. That is, rubber tired, automotive-type suspensions, conventional electric motors for on-board propulsion, small-scale computers for controls, and other such existing components are being lashed together in relatively crude but imaginatively adequate first-generation personal rapid transit systems. These will probably be adequate for small-scale, cheap public demonstrations soon that can be used—or misused—to powerfully convey an image of potential and progress in urban transit research and development.

Keeping a perspective on the differences between where PRT is today and where it must develop in the future to become more than an exposition or test track novelty will be crucially important in the next few years for industry, governments, and the public. It will be, that is, if initial visibility is to be turned into adequate political and financial support to carry out the necessary research, development, and demonstration work to make real urban PRT installations possible in the long run.

COMPARATIVE NATIONAL PROGRAMS OF RESEARCH AND DEVELOPMENT

The research and development activities that must precede the actual delivery of an extensive, complex, safe, reliable, and unobtrusive system of personal rapid transit in an important urban environment have recently begun to get under way in several advanced industrial countries.

United States

In the United States, where it is generally acknowledged that serious interest in personal rapid transit began, a variety of relatively small industrial firms began doing their own systems design and prototype development, following the systems analysis performed for the "Tomorrow's Transportation" report in 1968 and refined elsewhere since. Most visible among these are Alden, Transportation Technology, Dashaveyor, Monocab, Carveyor, and Uniflo. But operating at relatively low levels of financial investment and in a climate of skepticism at both urban and federal levels of government, these firms generally failed to establish sufficient credibility to move their designs beyond their own test tracks into serious consideration for urban applications. And without the prospects of either production contracts for their relatively rudimentary initial systems efforts or substantial infusions of public or private investment to increase the complexity of the designs, the whole field seemed stymied. There was no way that a small, private firm could, by itself, break through into a field that must, by its very nature as a public service, be supported by public funds.

Only with the agreement of the Urban Mass Transportation Administration to sponsor demonstrations of 4 such systems at a special public exposition did these individual firms obtain the opportunity to establish the needed public credibility to move privately initiated, small-vehicle transit systems forward in the United States. Even at that, the relatively cheap investment of $6 million to $8 million was divided equally among the 4 systems that were selected from some 13 applicants. Much of the cost that then went into design of the systems for demonstration at Transpo was private investment, leveraged by the federal involvement and "seed" investment.

A significant change in the industrial composition of the private firms now active in the PRT field in the United States has followed. Almost immediately following the sorting-out process involved in the Transpo competition, Dashaveyor was purchased by the Bendix Corporation, the Monocab division of Varo was purchased by Rohr Corporation, and the Ford Motor Company became a serious entry in the field. The other final participant, Transportation Technology, had already been affiliated with the Otis Elevator Company for some time. Thus, with this qualitative shift in the financial makeup of the private sector and the federal credibility afforded to the overall enterprise, it can be expected that the pace of development of new transit technologies will increase in the United States.

Another recent variation on the processes involved in developing a new small-vehicle transit technology—one that recruited and employed high-technology laboratories of government and the aerospace industry—is also being carried out in the United States as part of the Morgantown demonstration project. In this instance the systems analysis was first carried out, not by a producer company or a government systems laboratory, but by a university and local government that together had a specialized transit problem in need of solution.

Once given the national importance now afforded the Morgantown system, the Jet Propulsion Laboratory (one of the quasi-governmental systems facilities with a good record in managing space programs) was brought in by UMTA to do the systems design and to direct the overall implementation of the project. Awards for actual development of the vehicles and controls were subsequently awarded to the Boeing Company, a major aircraft manufacturer, and the Bendix Corporation, another aerospace and electronics enterprise (3).

None of the 3 proprietary systems that had been studied by the joint university-city team in their own initial systems analysis and systems design studies was selected for development as had been originally envisioned, although the Alden Self-Transit Systems Corporation, which had been the preferred choice of the university-community team, was included as a subcontractor to Boeing on vehicle development. After the systems design phase had been completed, the Jet Propulsion Laboratory withdrew from further managerial responsibilities. Project management, in addition to the continuing vehicle development work, was awarded to Boeing.

It is still too early to tell the ultimate value of the project. Costs have risen, the system has been cut back in extent, and the date for ultimate public use of the system is still somewhat unresolved. The system has begun to operate in a test track configuration, however, as of October 1972.

The Transpo and Morgantown demonstrations are recognized as measures to at least start the whole field of new technology moving, without necessarily delivering a workable PRT technology (as it has been defined for this paper). An additional program that it is hoped will lead to more advanced PRT systems is under discussion by presidential advisors and the Department of Transportation. The outlines of this program are still unclear, but it was given prominent mention in a background briefing held in conjunction with the 1972 State of the Union message and in a special presidential message on research and development.

The program is likely to involve a considerable contribution of skills from the National Aeronautics and Space Administration (NASA), the Aerospace Corporation, and other high-technology laboratories. Some of these groups have already been hard at work for several years now on systems aspects of the concept (4). Analyses, simulations, and model configurations of networks have been variously sponsored in ad hoc circumstances.

Germany

In Germany the PRT situation is less ambiguous, organizationally more advanced, and technically progressing at a somewhat steadier pace than in the United States. There, a consortium of firms has been funded by the central government to carry out an entire research, development, and prototype demonstration program leading to an initial version of a PRT technology, all at a relatively low cost and within a tight time schedule. The two industrial firms participating in this program are of considerable technical diversity and financial strength. Demag is a producer of heavy machinery and steel products located at Duisburg in the Ruhr, and Messerschmitt-Bölkow-Blohm is an aerospace and aviation-based firm headquartered near Munich.

These firms had separately been surveying previous work in the field of transit technology as a potential market opportunity in 1970-71 and had been carrying out preliminary systems analysis of PRT-type concepts when they discovered their overlapping activities. They subsequently decided to join forces in exploring the potentials of small, automated-vehicle technology for urban transit applications.

Demag's interest can be broadly identified with the energy and steelwork aspects of such systems, whereas those of MBB run to the controls and vehicles. Together, they are identified with a substantial systems study performed in 1971 with the city of Freiburg, Germany, as the example application used for data and detailed analysis (5). Since that initial study they have continued their systems analysis and design work with travel data and urban environmental constraints from a variety of real settings, including portions of Munich and the town of Hagen in the Ruhr.

The project—called Cabin Taxi or Cat for short—is sponsored by the German Ministry of Education and Science in conjunction with in-house funds of MBB and Demag. A letter of intent to this effect was transmitted to the firms early in 1972 indicating that some DM 15 million would be available for an initial 2 years, with 80 percent government funding and 20 percent from the individual firms themselves. A development schedule announced in 1972 (6) has the following targets:

1. Testing of all essential components of this personal rapid transit system on test stands in 1972;
2. A test track for the prototypes to commence operation in 1973;
3. Completion of a first larger experimental network to study user acceptance in 1974; and
4. The first public network to start operation in 1976.

A decision on whether or not to go ahead with installation of a public network, as opposed to merely an experimental one, will have to be made after the results of the first 2 years of the project are evaluated. The 1976 date for opening operations of an installation in a real urban setting is thus contingent on successful performance in the next 2 years and on additional funding becoming available beyond that now committed.

France

In France, the single firm of Engins Matra—an aerospace, automotive, and communications conglomerate of sizable proportions, headquartered in the Paris suburbs at Velizy—has been selected by the national government to examine the prospects of

PRT-type technology from systems analysis on to prototype demonstration. The origin of French interest in such technology stems both from domestic innovations, such as the novel coupling/decoupling concepts in an earlier proposal called AT 2000, and from the general level of activity in the field elsewhere in the world.

A 28-month contract that commenced in March 1971 was negotiated between Engins Matra and the French government. As a research and development grant, it carries Frs 7.3 million of government commitment and calls for another Frs 2 million of investment by Matra itself.

Systems studies of a range of technologies having somewhat different performance characteristics but all having small-vehicle systems that are generically called ARAMIS are being carried out. The emphasis is on quick delivery of a system using off-the-shelf technologies for its components. Data for analysis and designs have been obtained from a variety of French urban settings, such as medium-sized communities like Nice and Strasbourg and the suburban communities ringing Paris to its south. A test track was initially scheduled for operation by the summer of 1973.

Public reporting of the status of this work has been minimal, and unfortunately no references seem publicly available at this time. It is thus impossible to say accurately whether or not schedules will be met or what the performance characteristics of the system will be.

United Kingdom

British efforts in developing PRT technology were well along on a system called Cabtrack by the spring of 1971 but were slowed by the Department of the Environment, which oversees transport in the United Kingdom. The decision came just short of a contract award to the industrial firm of Hawker-Siddeley to carry the systems studies closer to hardware production (7). The effect of this position is to take Cabtrack back to the drawing boards for comparative study with minitrams and more conventional technologies, with an admonition to watch carefully the costs and environmental impacts of each alternative.

Japan

In Japan, serious efforts to develop a PRT system under the name CVS (computer-controlled vehicle system) are well advanced under the sponsorship of the Japan Society for the Promotion of Machine Industry (JSPMI) and the technical guidance and instructions of some faculty members of the University of Tokyo and the Ministry of International Trade and Industry (MITI).

A New Machines and Systems Development Center was set up in April 1972 within JSPMI. Through this center the project team, consisting of university scholars and technical representatives of a variety of participating industrial firms, is now designing and testing the first full-scale vehicles, tracks, and control systems for an automatically controlled small-vehicle system.

Previous to this effort, feasibility analyses, systems studies, and construction and operation of a 1-to-20 scale model of a CVS network were carried out in 1970-71 to ascertain whether the project warranted significant support. The model, with some 60 vehicles operating over a simulated portion of the central Ginza area of Tokyo, was prominently displayed at the fall Tokyo Motor Show in 1971.

With financial support assured for the next stage of research and development in 1972-74, plans have been made to construct a test course for the CVS at the automotive test course of MITI at Higashimurayama, Tokyo. An initial 200 m of this track was opened in September 1972, and test runs of the first CVS cars were performed from October to December 1972. A full test course of 4,700 m is due for completion in 1973, and full computer operation of a 100-vehicle test system will be carried out from February to October 1974 (8).

No plan nor schedule has yet been announced for an urban demonstration. That will probably have to await successful completion of test under the present 2-year research and development phase of effort.

Summary of Programs

In the European countries and Japan the PRT research and development has been sponsored by science and technology ministries or special agencies, not by transport ones. This appears to be related to a difference in aims regarding the short and long term. Transport ministries and departments in every country mentioned are skeptical about uncertain, high-technology transit systems. This has to do not only with the technical risks and development costs involved but also with the desires of the constituencies that transport agencies rely on for political support. These constituencies often have short-term goals relating to current problems or the maintenance of existing industries or institutions such as rail transit suppliers and operators, highway builders, urban mayors, transit employee unions, automobile manufacturers, and trucking companies. Few of such groups could be expected to take a long-term view, particularly if it appears threatening to their interests later on or drains resources away from current programs of financial interest to them. Science, education, or technology ministries, on the other hand, typically have constituencies with high-level research interests, such as universities and advanced-technology laboratories and firms. Such groups, in seeking research opportunities and new markets, could naturally be expected to support innovative ventures with less regard to whether or not they solved a valid transportation need of cities.

Any one, or all, of the research and development programs discussed in this paper could be curtailed by 1974, when they run out of financial support for the relatively low-cost phase of initial prototype development. Most programs are now budgeted at a few tens of millions of dollars until then and can be carried out with only minor threats to existing urban transportation programs. But hard decisions will have to be made in each country soon on whether or not to spend sums at least an order of magnitude greater on development and demonstration of more complex systems with low headways and network configurations. By at least 1976 these choices will lead to severe political and budgetary conflicts with priorities for existing urban transport modes. My own feeling is that unless PRT systems can be demonstrated to be clearly technologically feasible and politically sensible as a major portion of the transportation investment priorities for cities in the 1980's they will not be continued past the next few years.

To find out whether or not such systems make political sense as other than technological novelties it would seem imperative now that application studies be carried out to find out how such systems would be applied in real urban environments, what effect they would have on the quality of urban mobility, and how they would specifically relate to the several ecological and economic stresses now approaching urban transportation in terms of air quality and increased fuel costs for private automobiles. This job has been poorly done in the past and often ignored. It can hardly wait much longer if PRT applications are to begin to make major claims for transportation funds in any of the countries now involved in such research.

APPLICATION STUDIES AND SYSTEM EVALUATION

The technological aspects of the research and development, at least as far as getting a single prototype into simplified operation, probably appear quite simple and straightforward to industries comfortable with meeting the high-technology challenges of aerospace and electronics systems. Indeed, individual firms and government laboratories with strengths in these areas are quite noticeable in the present flurry of technological activity surrounding PRT concepts in every country now taking an active interest in the field.

But to existing urban transit operators and to the lower technology, mass-market-oriented automotive industry, as well as to other skeptics of whatever stripe, the issues of mass production, reliability, maintenance and operating costs, and consumer acceptance are among the major concerns. And these issues cannot be grasped well at the early stage of prototype demonstration.

In addition to the technological aspects of research and development, there are a host of political, social, and environmental issues that will appear only at the stage of actually attempting to demonstrate a system in an urban setting. Then other values also will be at stake, and failure could be costly to the community as well as to the transport system proponents themselves. Dealing with such issues requires a different type of research, and a different view of development and demonstration, than that used to deal with technological, or even economic and production, concerns.

Most of the research and development now under way is of the technological prototype sort, or its analytic precursor, systems analysis. But a limited effort is also being devoted to application studies that seek some indication of the general functioning and acceptability of such PRT systems in real urban situations. In addition, simpler types of systems that have some of the PRT features and can be readied now or in the very near future are serving as partial tests of the technological components, operating requirements, production costs, urban design requirements, and consumer acceptance of the more complex and extensive systems that should gradually follow.

In some ways it is certainly too early to attempt to predict or assess the consequences of a major commitment to an innovative urban transport mode such as this one, but it is exactly because of the unexpected social and physical consequences related to the implementation of another urban transport technology—the private automobile—that interest was initially aroused in PRT as an alternative. High-quality application studies of the potential effects of personal rapid transit systems in widespread use are thus a desirable and important part of any nation's research and development activities in this field.

Urban studies have been made by virtually all industrial firms and technological laboratories with programs in new transit system development, but the types of studies carried out are almost always of the nature of a travel demand forecast, for later use in designing the location and capacity of hypothetical system vehicles, guideways, and stations. Although such studies are valuable inputs to the design process, they fall far short of the types of social, architectural, and planning studies that would be beneficial to cities, citizens, and national governments in appraising the merits and demerits of these technological research activities.

Three recently suggested actions placed before the U.S. government by a special committee of the National Academy of Engineering (9) are extremely pertinent to this point:

1. Federal urban transportation programs should focus increasingly on providing better quality of urban life, not just better transportation.
2. The increasing focus on the quality of urban life clearly calls for a better understanding of the interactions and relationships between urban transportation systems and the functions of metropolitan areas. This, in turn, requires an enhanced program of analysis and real-world experimentation.
3. The proper design of urban transportation experiments and the implementation of more effective investment programs also call for an increase in supporting social science thinking and analysis.

The thrust of these suggestions would appear to be (a) that a good deal more attention needs to be paid in the future to the roles of transport service in urban life, not just to its engineering and economic features; (b) that conscious thought about how, when, and where technologies are applied in demonstration and initial application deserves additional emphasis; and (c) that broader areas of professional competence ought to be drawn upon early in the systems analysis and design process and on throughout the demonstration and implementation phases of transport system development. Although these points were meant to apply to an entire spectrum of urban transport-related programs, they are especially important in the case of a service concept as significant as personal rapid transit could become.

Three recent application studies are worth mentioning, because they have gone somewhat outside the limited engineering perspective of industrial laboratories. As such, they are indicative of additional sources of evaluation for new industrial products like PRT and of application studies of slightly broader scope.

In Gothenburg, Sweden, a study of possible application of personal rapid transit to the future needs of that city of approximately 500,000 has been under way for several years now. It began as a separate study of one alternative to the proposed rail rapid transit program for the city, but it has become an integral part of a comprehensive town planning study of several transport alternatives and their potential influence on city development.

Here, the city government is itself carrying out the study. And because there are no potential PRT system suppliers active among Swedish industries today, the inquiry has been able to look worldwide for comparisons of potential technologies. Final results are not due for several years yet, but interim progress has been reported (10).

A somewhat similar study—this one carried out by a university research group—has been undertaken in Minneapolis-St. Paul with the partial support of the Minnesota legislature. Although not part of a comprehensive study of alternative modes of transport for the Twin Cities, it has played a part in transit decision-making there along with studies of rail rapid transit and bus improvements (11).

And in the United Kingdom, an architectural study performed for application of Cabtrack has been the most detailed environmental assessment of PRT yet attempted (12). The results of the study showed such a system to bring mixed blessings in a complex urban environment such as central London. But it has provided a valuable contribution to the assessment of transit system impacts in certain architectural surroundings and has raised some warnings as to the manner in which such interdisciplinary collaborations will have to be conducted in the future.

But most of these study efforts aimed at broader evaluation of the costs and benefits of PRT investment in real urban environments have failed to effectively recognize and deal with a sizable clientele of users—city governments, environmental agencies, potential travelers, and so on that could generate the political support for implementing PRT systems if they were indeed found to be technologically and economically feasible. Without such support, and a fairly clear notion of how one proceeds politically from where we are today to the transport investments of the 1980's, personal rapid transit is not likely to contribute much to urban transport improvement but will be buried by prior commitments to rail transit systems and further highways.

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