vice. This factor may become increasingly significant.

A final constraint, and the one that has proved to be the most significant in Dayton, is the amount and types of federal assistance available and the delays met in processing applications for this aid. UMTA's programs for LRT do not have sufficient priority to provide a workable and timely source of funding. As was previously pointed out, Dayton's regional transportation planning agency is today back at the point reached in 1973—justification of a choice of mode. This is now our most severe constraint to the implementation of LRT.

Analysis of Transit Alternatives

R. Craig Hupp, Southeastern Michigan Council of Governments, Detroit
Donald N. Weisstuch, Leonard S. Wegman Company, New York*

The planning and implementation of major public works projects require the consideration of many engineering, social, environmental, political, and fiscal issues. In particular, the 1970s have seen nonengineering issues take precedence over engineering considerations in project planning and implementation. These issues are highlighted in a conceptual approach based on six tests of feasibility—physical, operational, institutional, social and environmental, financial, and economic feasibility. This paper describes the application of this approach and the nonengineering issues that were identified as having an effect on the planning of a light-rail transit system in Harrisburg, Pennsylvania. The feasibility tests were found to constitute a valuable approach because they lead to a formal or explicit recognition of several planning issues that are usually only implicitly recognized in planning studies. Once they were explicitly identified, these issues could be analyzed in terms of their impact on the planning process.

The planning and implementation of major public works projects require the consideration of a number of engineering, social, environmental, political, and fiscal issues. It once was the case that, if the need for the particular public works project was particularly clear, public support was unambivalent, and fiscal resources were adequate, the major thrust of the planning and implementation effort could be limited to the identification and resolution of the engineering issues. The process moved smoothly from planning through preliminary and final engineering studies to construction and operation. The conception, planning, design, and initial decade of implementation of the Interstate highway program (1956 to 1966) illustrates a situation in which only the engineering issues required detailed analysis. But times have changed. The completion of the Interstate system is now often challenged in many communities on social, environmental, and fiscal grounds. Few, if any, major transportation capital projects in the 1970s can be said to have unambivalent public support or adequate fiscal resources and, while the need for a solution to an identified problem may be clear, the best solution is not always self-evident. We believe that social, environmental, political, and fiscal issues are now taking precedence over engineering considerations in project planning and implementation and are generally proving to be far more difficult to resolve.

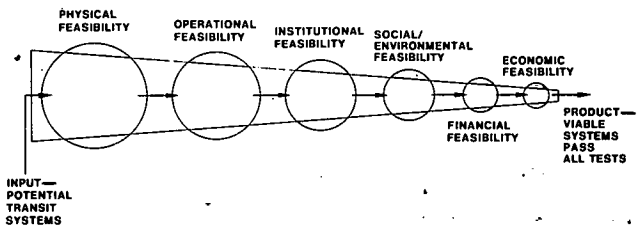
The attractiveness of light-rail transit (LRT), as evidenced by the success of TRB's conference on LRT in 1975 and many active LRT proposals in cities throughout the United States and Canada, is that it offers some hope of a compromise solution to the conflicting requirements of the nonengineering issues. An LRT alternative falls between a do-nothing alternative, which offends few interests but satisfies few needs, and a very capital-intensive transit alternative such as conventional rapid transit, which has the potential to satisfy many travel needs but carries a high cost in social, environmental, and fiscal resources. For example, LRT at grade or in a shared right-of-way represents a transportation compromise between the inefficient existing automobile and bus transportation system and the very efficient (from a transportation point of view) rapid transit subway operation. At the same time, it offers a fiscal compromise because the cost of building an LRT system at grade or in shared rights-of-way is often less expensive than a completely grade-separated or subway system and hence is more likely to be fundable. Thus, the revival of interest in LRT indicates a growing awareness of the need to address the nonengineering issues involved in the planning and implementation of a major transportation project or program.

We have developed a conceptual approach to the planning of major transportation projects that is intended to explicitly identify and highlight all of the issues involved in the planning and implementation of a new transportation system. The emphasis of this approach is to identify the implementability of a proposed transportation or transit alternative through tests of its physical, operational, institutional, social and environmental, financial, and economic feasibility. An alternative that passes the first five tests and outperforms other alternatives in the test of economic feasibility should have the best chance of being carried through to implementation. These tests are presented schematically in Figure 1.

The tests of feasibility are summarized briefly below in the context of a rail study recently conducted by Tippetts-Abbett-McCarthy-Stratton (TAMS) in Harrisburg, Pennsylvania. The test of physical feasibility addressed the question of whether it was physically possible to construct new rail services in a candidate travel corridor. Physical constraints were identified, engineering design criteria were established, and rough capital cost estimates were prepared. The test of operational feasibility was intended to identify operational conflicts with other transportation modes. If new facilities were required to permit operational feasibility, cost estimates were prepared. The test of institutional feasibility was intended (a) to identify all federal, state, or local agencies; private companies; public or semi-public authorities; and labor organizations and unions whose responsibilities, ownership, legal rights, and so on would affect or be affected by the inauguration of rail transit services and (b) to determine, as required, the agency or agencies that should own, operate, and manage the new transit service. A large part of the maneuvering between the Federal Railroad Administration (FRA),

private railroads, and affected labor unions during the recent formation of the Consolidated Rail Corporation (Conrail) illustrates the great influence institutional considerations can have. To a certain extent, institutional issues are more flexible constraints than physical, operational, or fiscal factors because institutional positions or factors can often be modified through negotiation. The test of social and environmental feasibility identified the social and environmental aspects of the project, e.g., disruption, mobility, noise and air pollution, accidents, and energy consumption. The test of financial feasibility was basically a cold, hard look at the magnitude of federal, state, and local financial resources available to meet anticipated capital costs and operating deficits. No matter how favorable the cost/benefit ratio of a transit alternative, if it is not fundable it will not be built, and its benefits will never be realized. An alternative can be dropped from further analysis at any time it proves to be physically, operationally, institutionally, financially, or socially and environmentally infeasible or unimplementable. Surviving alternatives should be compared by using conventional techniques of economic analysis in the test of economic feasibility.

Figure 1. Schematic representation of the tests of feasibility of transit alternatives.



HARRISBURG LONG-RANGE TRANSIT PLAN

TAMS recently completed a 3-year study of the feasibility of various long-range transit options for the Harrisburg area as part of the Harrisburg Area Transportation Study (HATS). The nature of the study performed and the transit alternatives considered are described in this section. In a subsequent section, the application of the tests of feasibility is described.

Harrisburg, the capital of Pennsylvania, is strategically located in a three-county metropolitan area of 300 000 in the south-central area of the state. Harrisburg's location is important as a rail hub, the railroad gateway to the West, and the western terminus of railroad electrification. The rail network in the Harrisburg area is nearly ubiquitous; it extends in six spokes to and beyond the nearby communities of York, Gettysburg, Carlisle, Duncannon, Dauphin, Hershey, Elizabethtown, and Columbia. The location of these rail lines is shown in Figure 2.

Most of the railroad facilities in the Harrisburg area were taken over by Conrail, the quasi-public freight railroad formed by the federal government to take over the bankrupt railroads in the northeastern United States in April 1975. Conrail subsequently passed to the National Railroad Passenger Corporation (Amtrak) the control of the former Penn Central Transportation Company's main line extending from Harrisburg through Elizabethtown to Philadelphia. Amtrak also acquired the railroad stations at Harrisburg, Middletown, and Elizabethtown. In this paper, the railroad lines in the area will be referred to by their pre-Conrail designations.

Most of the rail lines in the region are fairly active. The Penn Central line between Harrisburg and Mechanicsburg serves primarily as a 14.5-km (9-mile) freight siding for the many industries between Harrisburg and Mechanicsburg. The Reading Company's line from

Figure 2. Railroads in the Harrisburg area.

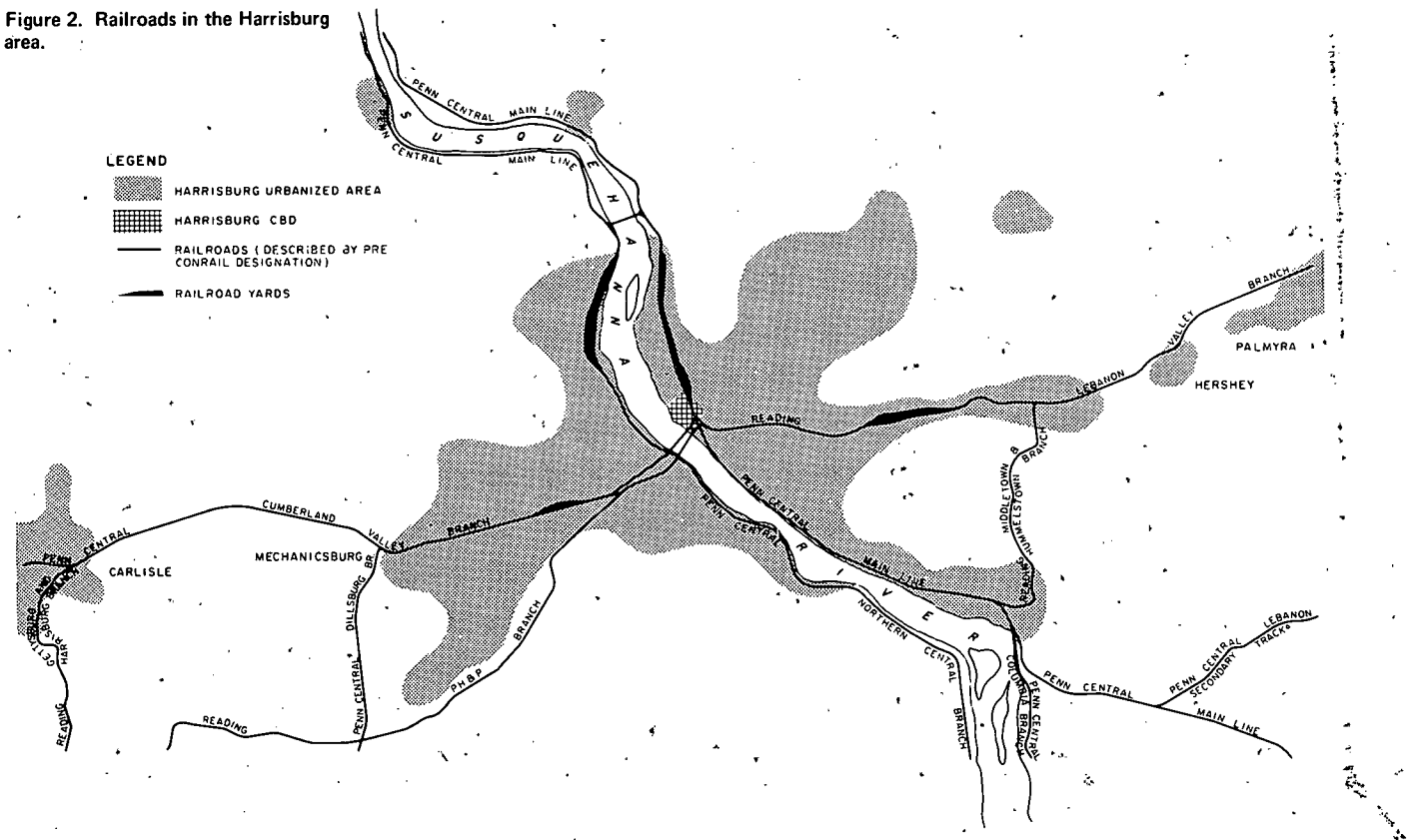
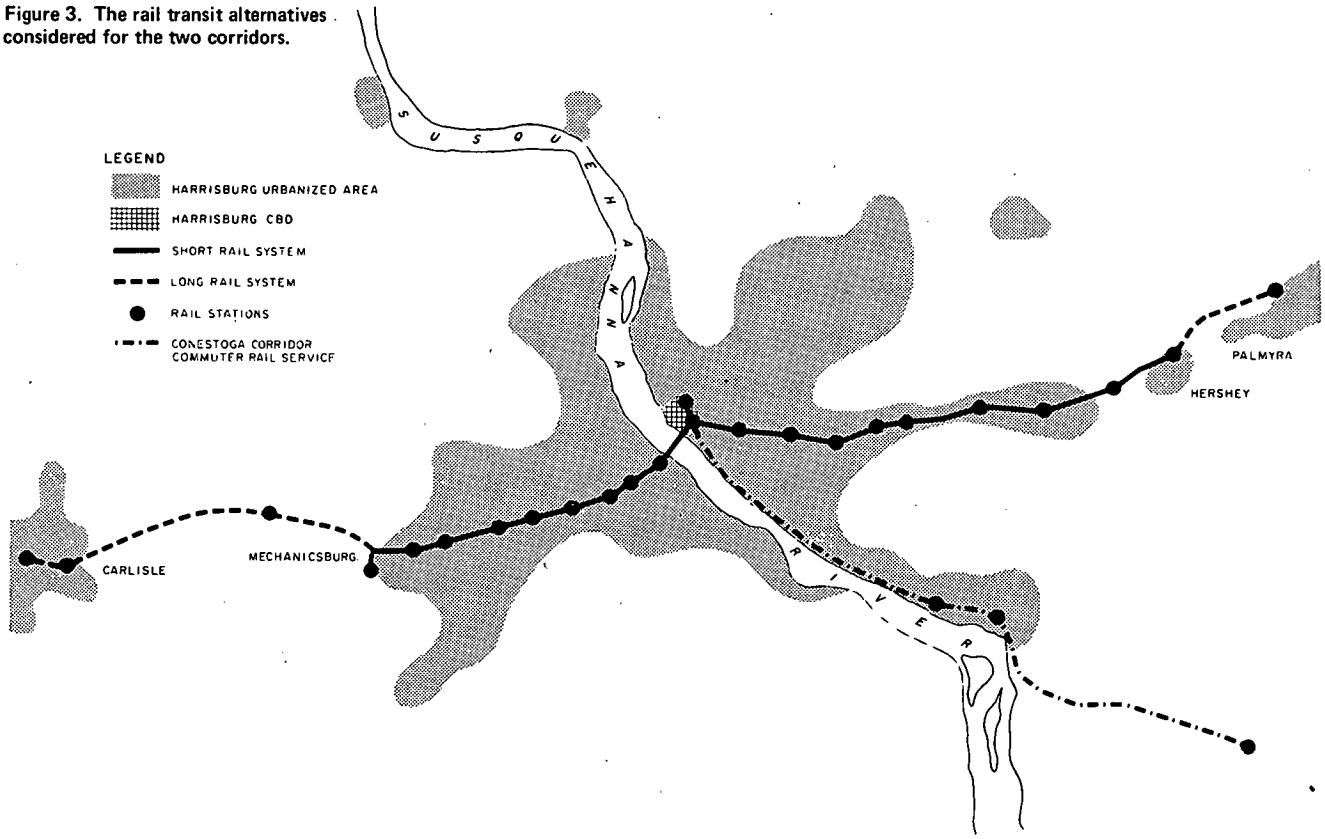


Figure 3. The rail transit alternatives considered for the two corridors.



Harrisburg through Hershey and points east is an important main-line connection to New York that will see increased use under Conrail. The Penn Central main line from Middletown through Harrisburg and north along the Susquehanna to Pittsburgh is the main artery for east-west rail freight traffic and long-distance passenger service in Pennsylvania. Other freight lines in the region are also frequently used.

For a number of years, there have been several groups in the Harrisburg community that promoted capital-intensive transit service improvements. They urged that the existing railroad facilities in the Harrisburg area be examined to determine whether they were suitable for use by rail transit services. As a result of controversy over several highway projects in the adopted highway plan for 1990, the fuel crisis in 1973, and increased public concern about an effective mass transit system, the HATS coordinating committee decided to explore the potential for rail transit services in the Harrisburg area. The long-range transit study was begun in 1973 to explore these possibilities. Its primary focus was the exploration of the feasibility of initiating new low-cost rail transit services within existing railroad rights-of-way. Several options for rail transit services were developed and analyzed in terms of patronage attracted, construction costs, operating and maintenance costs, revenues, operating deficits, and time and cost savings to affected travelers. The scope of the study was expanded in 1974 to include an analysis of long-range improvements to the existing bus system as well.

RAIL TRANSIT ALTERNATIVES

The rail transit alternatives developed for the Harrisburg region considered options for both routes and vehicles. There are nine travel corridors or subcorridors that contained railroad rights-of-way and were thus potential corridors for rail transit services. A preliminary evaluation of these corridors in terms of their tributary population and accessibility identified five corridors that were suitable for further analysis. Preliminary estimates of capital and operating costs and transit patronage revealed that only two corridors could justify serious consideration for frequent, all-day transit services. These were the Lebanon Valley corridor, which runs east from Harrisburg to Hershey and beyond and is centered on the former Reading Company's Lebanon Valley branch, and the Cumberland Valley corridor, which runs west from Harrisburg to Mechanicsburg and Carlisle and is centered on the former Penn Central Cumberland Valley branch.

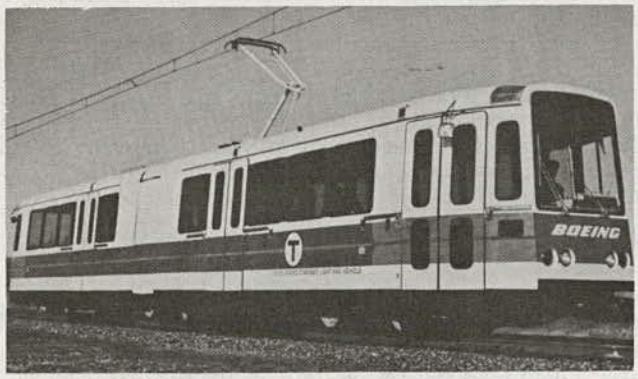
Rail transit alternatives were developed in some detail for these two corridors; see Figure 3. Two options were considered for rail services in these corridors. One, referred to as the rail and bus short system, consisted of a 38-km (23-mile) system between Trindle Spring in the west and Hershey in the east, operating through Harrisburg Station and a new rail station north of the State Street Bridge and serving the Capital Complex, which has 15 000 employees. The second option, the rail and bus long system, consisted of services between Carlisle and Palmyra, operating through the Harrisburg and Capitol Complex stations during peak periods—a distance of 58 km (35 miles)—and between Mechanicsburg and Hershey during off-peak periods. To complement the proposed rail services, several bus routes in both corridors were developed to act as feeders to the rail lines.

In addition to the tests of feasibility that are the prime topic of this paper, an interesting feature of the long-range transit study was the evaluation of existing transit vehicles for use on the rail transit services. Two types of rail vehicles were considered for service in the Leb-

Figure 4. Examples of rail vehicles considered for service.

SILVERLINER CRV OPERATED BY SEPTA IN PHILADELPHIA

PCC LIGHT-RAIL VEHICLE
REBUILT BY ALLEGHENY TRANSIT-PITTSBURGH



NEW STANDARD LIGHT-RAIL VEHICLE

anon and Cumberland valleys: commuter rail vehicles (CRVs) and light-rail vehicles (LRVs); both types are shown in Figure 4.

CRVs are typically designed for relatively long commuter trips—8 to 50 km (5 to 30 miles)—and for higher operating speeds, lower acceleration rates, and a higher ratio of seats to passengers carried than typical LRVs or rapid transit vehicles. The CRVs under consideration for Harrisburg would be self-propelled electric cars like the Silverliners, which are used by the Southeastern Pennsylvania Transportation Authority (SEPTA) in the suburbs of Philadelphia and on the Philadelphia to Harrisburg services. Although these vehicles are intended primarily for routes whose stations are at least 1.6 km (1 mile) apart, Silverliners are operated successfully on routes in the Philadelphia area that have low-level stations spaced less than 1 km (0.6 mile) apart. This is possible because of their relatively high acceleration rate of 10 m/s^2 (33 ft/s^2). The Silverliner, like a number of the CRVs that operate in the New York area, draws its electrical power from 11-MV alternating current in overhead wires and has on-board rectifiers and transformers to convert this power for its direct-current electric motors. Both new and used Silverliners were considered for service in Harrisburg. New Silverliners currently cost about $800 000 each. It was estimated that used Silverliners or New Haven 4400s could be purchased and rehabilitated for about $150 000 each. Since new and used Silverliners have approximately the same number of seats, the capital-cost advantage of used vehicles is readily apparent.

Two LRVs were also considered, the Boeing Vertol Standard Light-Rail Vehicle (SLRV) and the Presidents' Conference Committee (PCC) car. These vehicles differ in two important respects. The SLRV has a greater passenger capacity than the PCC car. It can seat more than 70 passengers and carry a total of more than 100, as opposed to 50 or 60 seated passengers and 80 total passengers for the PCC car. The cost of SLRVs is now more than $600 000, whereas a PCC car costs $160 000 including rehabilitation.

The tests of feasibility were applied to these vehicles. Another important factor, besides the differences between CRVs and LRVs in vehicle size and electrification systems, had to be taken into account in system design. FRA regulations state that all rail passenger vehicles that come under its jurisdiction must meet several collision-strength standards. Any rail transit vehicles that operate on active freight trackage come under the FRA's jurisdiction.

Because CRVs meet federal standards for collision strength, they would be allowed to share active freight trackage; CRV services between Harrisburg and Philadelphia do so today. Rail transit alternatives were therefore developed for both the short and long systems that assumed maximum use of existing trackage as a result of track sharing between CRVs and freight cars. On the other hand, LRVs must be operated on separate trackage because there are no LRVs that meet FRA collision standards. Alternatives developed for these vehicles would require less cooperation with Conrail and freight users since scheduling conflicts would be minimized (but not eliminated entirely) because of the required separation of trackage. The construction costs associated with the LRV alternatives represent a reasonable maximum for rail transit services in Harrisburg that use a shared right-of-way.

Headways for all three kinds of vehicles considered (Silverliners, SLRVs, and PCC cars) were sufficiently long to permit some extended single-track operation even though this was not reflected in the alternative track layouts that were developed. The alternatives developed for both LRVs and CRVs were primarily double-track systems. Single-track operation would be used only in several short sections in which construction of an additional track would require expensive earth cuts or fills or a new bridge. This approach left some flexibility in the system concept so that, if detailed engineering analysis revealed that Conrail would not be able to share or yield trackage or right-of-way to permit double-track operation in certain locations, single-track operation would be feasible, even if it were less desirable.

TESTS OF FEASIBILITY

In order to examine each alternative in terms of the tests

of feasibility, basic information about each system was developed. Data on the rail system (location of tracks, switchyards, stations, and so on) were collected in field surveys. The field surveys and interviews with railroad employees provided information on existing railroad operations. Requirements for additional facilities were identified, and cost estimates were prepared. Patronage estimates were prepared as a basic input for the tests of financial and economic feasibility. They were used to identify the fleet size required, the level of service to be provided (and hence the operating costs), the fare-box revenues to be generated, and the overall system travel and time costs. The financial feasibility test also required that funding sources and their probable level of support be identified. To this end, existing levels of local, state, and federal transit funding were analyzed. The economic feasibility tests required information on highway travel as well. Estimates of 1990 highway traffic were carried out for this reason. No data base existed or could be developed within the scope of this study to permit more than a general analysis and evaluation of the indirect economic and the environmental considerations.

This study was carried out in a transitional period. Conrail took over the railroads in Harrisburg less than 6 months before the conclusion of the long-range transit study and was in no position to make long-term planning commitments regarding rail transit services and properties it had just acquired and begun to operate. Consequently, a number of important issues identified through the tests of feasibility were not resolvable within the time frame of the study.

Physical and Operational Feasibility

The tests of physical and operational feasibility are treated together here because in this study they largely overlapped. These tests required both the identification of constraints and the development of a design or design approach for overcoming them and an estimation of associated capital and operating costs. The stated intention of the long-range transit study was to develop low-cost rail alternatives for Harrisburg. Thus the tests of physical and operational feasibility were directed toward alternatives that made maximum use of existing facilities.

The test of physical feasibility basically involved whether a rail transit system could be built within available Conrail rights-of-way. To answer this, the rights-of-way in the Cumberland and Lebanon Valley corridors and the railroad facilities they contained were identified. Information was gathered on the extent and boundaries of existing rights-of-way; the location of existing bridges, structures, embankments, and other civil engineering works; the location of existing trackage, yards, stations, electrification, and other railroad facilities; and adjacent land use and topography. The test of operational feasibility dealt with whether existing freight and passenger services could be maintained and whether rail transit services could be successfully integrated with them. Several factors were considered, including present track use, frequency and characteristics of freight and passenger operations, and likely trends in railroad operations.

On the basis of a physical and operational inventory of Conrail facilities and operations in the two travel corridors, a number of constraints and facility requirements were identified. Of primary importance was the conclusion that existing rights-of-way could accommodate both existing freight and new rail transit services. Over much of the length of each corridor, vacant roadbed and unused or little-used trackage could be easily converted to rail transit use, although existing freight operations would impose a number of constraints on rail transit services. These constraints would depend on the type of vehicle, since CRVs would be allowed to share trackage with freight services, while LRVs would not.

The operational challenge entailed in track layout for an LRV system lay in developing a double-track transit system that interfered with a minimum of freight sidings and left sufficient trackage available for existing freight operations. A major rail overpass was found to be required in one location in the Cumberland Valley to switch the LRT alignment from the north to the south side of the main-line freight right-of-way in order to avoid a major yard and several important sidings. Bypassing another freight yard required more than 3.2 km (2 miles) of new roadbed that used, in part, an abandoned interurban right-of-way that had been taken over by the Reading. Fortunately, most of the active sidings are located on the south side of the right-of-way and have adequate track space or vacant right-of-way on the north side for LRT services. Over the 58-km (35-mile) length of the long system, 15 sidings and four through tracks would be crossed at grade. Protective devices would be included as part of the LRT signalling system to prevent LRVs from entering sections of track that have at-grade or flat junctions if the junction were in use by freight trains. The use of these sidings would be limited to night hours when transit services would not operate.

A CRV alignment was developed that made maximum use of existing trackage, a significant portion of which would be in active use by freight trains. New construction was minimized. As a result, construction costs for the CRV system were one-third less than those for the LRV system. However, because much of the trackage would be shared, freight operations on the shared track would be totally restricted during peak periods (4 h) and somewhat curtailed during the remainder of the transit operating day. Such operating restrictions could only be imposed with the consent of Conrail. As noted earlier, it was impossible to resolve this question at the time of the study. Without Conrail's consent, only the LRV alignment is operationally feasible.

Capital-cost estimates for both LRV and CRV alignments were used to develop a range of costs that were carried through the tests of financial and economic feasibility. It was found that the cost of providing facilities for rail transit services could vary by as much as 50 percent depending on the amount of track sharing that would be possible and the type of rail transit vehicle operated.

Institutional Feasibility

The test of institutional feasibility involved the issue of the ownership, operation, and management of new rail transit services. This required an analysis of the interaction between existing institutions and the proposed rail services and the identification of possible institutional arrangements for the new rail services.

The regulatory institutions affected are those public bodies at the federal, state, or local levels of government charged with ensuring that those involved in the transportation of people and goods operate in the public interest, i.e., both with ensuring public safety and ensuring that there is competition between carriers at a level that maximizes public welfare.

At the state level, the Pennsylvania Public Utility Commission (PUC) bears both of these responsibilities. The PUC had several actions under way that affected the proposed rail line because they related to the safety of several crossings. In general, the PUC's concerns for public safety would be the same as those of the rail transit operating authority. Cost estimates included allowances for upgrading the warning devices at the at-grade street

crossings along the rail lines of interest. In the area of the regulation of competition, the PUC awards carriers franchises that permit the carriers to offer a defined service to a specified geographic area. With the exception of the terminus of each line, the proposed rail services did not conflict with existing franchises held by transit operators other than the Cumberland, Dauphin, and Harrisburg Transit Authority, generally known as Capital Area Transit (CAT), and its contractor, Capitol Bus Company.

At the federal level, the agencies with the most pertinent regulatory powers are the Urban Mass Transportation Administration (UMTA), FRA, and the National Transportation Safety Board (NTSB), all part of the U.S. Department of Transportation. UMTA's regulatory powers generally stem from the strings that are attached to federal capital and operating assistance grants. Provisions in the Urban Mass Transportation Act of 1964 as amended require that transit projects that receive federal funding assure the protection of affected transit employees (section 13c), prepare an environmental impact analysis, and draw up a program to accommodate the elderly and handicapped. In addition, the act empowers UMTA to investigate the safety conditions of any of the projects it funds. The FRA's regulatory authority has been discussed earlier in this paper. The NTSB has been actively involved in developing system safety plans for rapid transit systems now in the design or construction phase. It would be involved in the planning of any rail transit system in Harrisburg. In addition, the NTSB is responsible for investigating rail transit accidents, except in the case of commuter operations controlled by the Interstate Commerce Commission.

The operating institutions that would be affected by new rail transit services include Conrail, Amtrak, Septa, and other railroads that have trackage rights on the Conrail or Amtrak systems, as well as the intercity bus services that serve Harrisburg and CAT. Amtrak owns Harrisburg Station and the Penn Central main line between Harrisburg and Philadelphia. Conrail owns the remaining lines of interest. There is every possibility that Conrail and Amtrak, the operating organizations most affected by the rail transit proposals, will agree to permit new local rail transit services to use part of their facilities, but no negotiations have taken place at any level with either. This made it impossible within the scope of the study to unequivocably state that rail transit service was institutionally feasible.

There are three operating institutions that could operate or own new rail transit services either singly or jointly with one or more other institutions—Conrail, CAT, or a new rail transit authority that could be formed. Conrail purchased the rail lines of interest from the bankrupt Penn Central and Reading railroads at essentially their scrap value on April 1, 1976. Conrail would apply the "dominant-user" criteria to determine whether Conrail or the rail transit authority should own the facilities to be shared. In this case, it could be argued that the rail transit service would be the dominant user in terms of the number of trains per day. In realistic terms, however, considering the function of the rail lines of interest, there is no question that Conrail would be the dominant user and should own the facilities. Our study assumed Conrail would retain ownership and lease the trackage rights to the rail transit authority. The value of the lease would be negotiated. If Conrail were the operating agency under a purchase-of-service agreement, part of the fees would cover the economic value of the trackage rights. The plan that outlined the structure of Conrail (1) set down guidelines for the lease of rail properties and suggested the lease value should represent a fair return on the value of the property used.

A totally new agency, independent of CAT and Conrail, could be set up to operate rail transit services. The only advantage to this approach is that the new agency would start with a clean slate. It would not have any of the operating biases or political and union commitments that CAT or Conrail have inherited or evolved through time. Administratively, however, it would make little sense to develop a new agency when there are existing agencies that could provide the same services.

An alternative operating institution considered was the local transit authority, CAT. New rail services could be operated under its control either directly or through a purchase-of-service agreement with Conrail. The type of rail vehicle affects this analysis. CAT is the best institutional alternative to operate rail transit services that use LRVs. The union work rules under which LRVs are typically operated are similar to typical union work rules for buses. For example, LRVs are operated in Newark, Pittsburgh, Boston, and New Orleans by locals of the Amalgamated Transit Union, which also represents CAT's employees. CAT would also carry out vehicle maintenance. There is no advantage in this case to having this function performed by Conrail. For administrative reasons, it would be advantageous to form a rail operating division within CAT. This would allow policy decisions to come from a common source while the day-to-day transit operations of the two modes would be carried out independently.

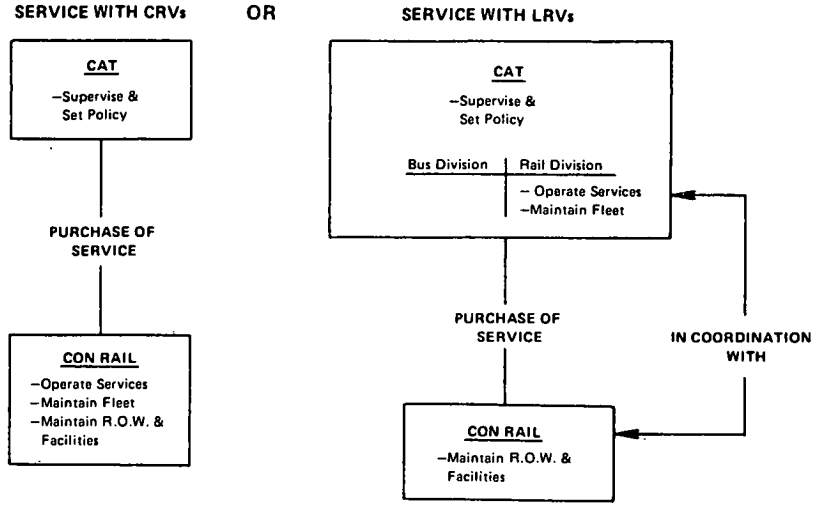
The third alternative is Conrail, which currently performs the operation and maintenance functions for rail transit services in Philadelphia and New York. In realistic terms, it is the only agency able to perform maintenance of facilities and way in Harrisburg, particularly under the track-sharing option that would use CRVs. Conrail would also be the logical agency to operate the services and maintain the vehicles. Conrail now operates and maintains a fleet of several hundred CRVs, including Silverliners, in Philadelphia.

If LRVs are selected, vehicle operation and maintenance would be somewhat more complicated. LRVs are typically operated under transit work rules that are quite unlike those that ordinarily apply to CRV operations. The transit work rules by which CRVs are operated, if applied to LRVs, would make LRV operation particularly uneconomic. It was concluded that Conrail would not be the most suitable operating agency if LRVs were selected.

The operation of rail transit services also requires close coordination with the freight services operated by Conrail. In the case of CRVs that would share tracks with Conrail, Conrail would surely need to have overall dispatching control of all trains moving on the same facilities. It would therefore be logical under these conditions that Conrail operate the rail transit services. If LRVs were used, the need for coordination is less because no track sharing occurs; it would be more reasonable for an agency other than Conrail to operate the transit services.

In summary, practical institutional arrangements for the implementation of rail transit services in Harrisburg were identified. The ownership of rail facilities would remain with Conrail, which would levy annual charges for trackage rights. Rail services would be operated under the general authority of CAT. No matter which type of rail vehicle were selected, Conrail would carry out maintenance of facilities and way under a purchase-of-service contract. If CRVs were selected, Conrail would also carry out vehicle operation and maintenance. If LRVs were selected, CAT would carry out the same functions. Figure 5 shows these relationships schematically.

Figure 5. Options for the operation of rail transit services.



Financial Feasibility

The test of financial feasibility analyzed the amount and availability of funds required to construct and operate transit services in Harrisburg. This test was not intended to determine whether the funds would be well spent on any or all of the various alternatives or whether the funding sources would agree to commit the funds over which they have control. Its purpose was to identify the possible funding sources and their resources and to estimate the level of capital and operating funds required to implement the two rail alternatives under consideration.

At the federal level, UMTA is the primary source of funds. The details of UMTA's funding programs are well known and will not be discussed here. There is an additional source of federal funds. The Federal-Aid Highway Acts of 1970 and 1973 permit the use of federal urban highway system funds for the construction of fringe parking facilities associated with public transportation facilities and for bus lanes, bus priority treatments, and fixed-rail facilities. The HATS coordinating committee could request that some urban highway system funds be diverted to mass transit. This funding source was rejected because, in light of the currently restricted level of highway funds available in Pennsylvania for construction, such a diversion would be the end of most highway improvements in the HATS study area.

The state department of transportation, through its Bureau of Mass Transit Systems, has been providing both capital and operating assistance. Thus, the state share of the total assistance required will vary according to the federal share. If federal funding provides the maximum 50 percent of the operating deficit, the state share could be as much as $33\frac{1}{3}$ percent and the local share as low as $16\frac{2}{3}$ percent. Capital and operating assistance grants are included in the state budget. Their total varies from year to year and has generally increased with time, but there is no regular funding program equivalent to UMTA's section 5 program; funds are approved by the state legislature on an annual basis. Requests for operating assistance now exceed the legislature's level of appropriation. Unless the state legislature increases its level of funding for operating assistance, the department of transportation will be unable to provide a full one-third share of each transit authority's operating deficit.

Cumberland and Dauphin counties and the city of Harrisburg provide the local share of capital and operating assistance funds out of general revenues, splitting it 25, 45, and 30 percent respectively. These local sources now spend about 1 percent of their total budgets on CAT.

Capital costs include all capital expenditures that must be made between 1976 and 2000, including the replacement of the existing bus fleet when it wears out, expansion of the bus fleet, purchase of rail vehicles as required, and purchase or construction of all of the necessary capital facilities. Operating costs include the total cost for operating and maintaining the transit system. Since the operating costs will obviously vary from year to year, the estimate for 1990 was used to indicate the likely level of overall funding required. Total system costs for each alternative are presented in Table 1.

At the federal level, the capital and operating assistance funding requirements can be met within existing levels of funding. At the state level, while capital funding requirements can probably be met, it is unlikely that the state will be able to provide its full share of operating assistance. The local governments that support CAT will probably find that the combined requirements of capital and operating assistance funding will be greater than can be conveniently met from their general budgets. The rail transit alternatives could easily require more than 5 percent of their gross budgets if the state is unable to provide its one-third share of operating assistance funds. For the rail transit alternative to be considered financially feasible, therefore, additional revenue sources at the state and local levels must be developed.

Economic Feasibility

The test of economic feasibility included a complete summary of the costs and benefits of alternatives under consideration in order to determine whether all of the economic, social, and environmental benefits arising from the proposed alternatives outweigh their costs.

For the HATS long-range transit study, the all-bus alternative was selected as the base alternative because it represented a logical evolution of transit services in the Harrisburg area. The economic comparison of alternatives was limited to the travelers affected by the rail transit alternatives proposed for the Cumberland and Lebanon Valley corridors. Approximately 3 800 000 passengers/year would use the rail transit services in the rail and bus long system in 1990. Fewer rail passengers would be attracted by the rail and bus short system; the difference would be attributable to automobile drivers. Under the all-bus system, fewer still would use buses;

the difference would again be made by automobile drivers. In effect, the three alternatives represented different ways of carrying the 3 800 000 passengers and are compared below on that basis.

Mode	All-Bus System	Rail and Bus Short System	Rail and Bus Long System
Automobile	2 090 000	500 000	–
Bus	1 710 000	–	–
Rail	–	3 300 000	3 800 000
Total	3 800 000	3 800 000	3 800 000

Tables 2 and 3 compare the alternatives on the basis of quantifiable (in monetary terms) and nonquantifiable economic factors. The all-bus alternative was found to be the least cost alternative in quantifiable economic terms by a margin of 10 to 15 percent. This alternative would, however, entail higher levels of fuel consumption, accidents, and air pollution. No attempt was made to put a monetary value on these factors. The differences between the three alternatives are small in comparison with the total figures for the area.

This discussion has not dealt with the indirect economic benefits that might follow the construction of a rail transit system. The region as a whole may reap benefits from these induced changes in several ways. Intraregional changes in land use represent a benefit when they lead to increased efficiency in the use of public and private facilities. The shifting of residential growth per se is not a net benefit. The same is true of an intraregional shift in economic growth or vitality. Community values enter this analysis because the community may deem a given land use or economic pattern preferable to all others. Where the transportation improvement supports the preferred pattern, the community will realize a net benefit. A revitalized downtown, as exemplified by the Harristown project in Harrisburg, may be a community goal. In this case, a rail transit system, which would indeed add to downtown vitality, would lead to net beneficial changes in land use and economic activity. Clearly, the indirect intraregional changes resulting from a transportation improvement, e.g., rail transit services, must be evaluated within the context of community goals and values.

At the interregional level, there are several possibilities of economic activity flowing into the Harrisburg region. One form of economic growth that is easily identified is the flow into the area of state and federal funds to construct the rail transit system. A large part of the funds to finance construction of the rail facilities could be expected to remain within the area. Less easily identified is the extent to which industries would be attracted to the region from outside because of the presence of a high-capacity rail system.

This discussion of indirect economic benefits has been a general one because their identification and analysis were outside the scope of the work performed by TAMS for the long-range transit study. The magnitude of indirect benefits is influenced by public policy and community desires. Only when these policies and desires run parallel to the advantages an improved transportation facility offers will the community reap significant indirect economic benefits.

SUMMARY

The six measures of feasibility represent a systematic way of taking into consideration the nonengineering factors that all successful transportation planners consider. The six-test approach is a coherent and explicit way of identifying the important issues. Its intent is to distinguish the most implementable alternative from the most economic alternative (which may not prove to be implementable). During the Harrisburg study, the approach served as a logical framework for conducting an issue-oriented planning approach by identifying the many issues and factors not under the control of the transportation

Table 1. Funding requirements for the three transit alternatives (in 1975 dollars).

Item	Percentage	All-Bus System ($000s)	Rail and Bus Short System ($000s)	Rail and Bus Long System ($000s)
Capital cost				
Federal share	80	3200	28 000	40 000
State share	10	400	3 500	5 000
Local share				
Harrisburg	3	120	1 050	1 500
Dauphin County	4.5	180	1 575	2 250
Cumberland County	2.5	100	875	1 250
Total		4000	35 000	50 000
Total annual operating cost		1550	2 750	3 500
Total annual fare-box revenue		850	1 500	2 000
Annual operating deficit				
Federal share	50	350	625	750
State share	33.3	233	417	500
Local share				
Harrisburg	5	35	63	75
Dauphin County	7.5	52	93	112
Cumberland County	4.2	29	52	63
Total		700	1 250	1 500

Table 2. Comparison of the monetary costs of the three transit alternatives (in 1975 dollars).

Item	All-Bus System ($000s)	Rail and Bus Short System ($000s)	Rail and Bus Long System ($000s)
Annualized capital cost	160	2 470	3 480
Annual operating and maintenance cost			
Transit	1570	2 740	3 640
Automobile (gasoline, oil, parking)	2770	1 020	–
Total	4340	3 760	3 640
Annual cost in passenger time			
Transit	2800	4 200	5 200
Automobile	2600	900	–
Total	5400	5 100	5 200
Total annual cost	9900	11 300	12 320

Table 3. Comparison of nonmonetary economic effects of the three transit alternatives.

Item	Cumberland and Lebanon Valley Corridors Only			Whole HATS Study Area
	All-Bus System	Rail and Bus Short System	Rail and Bus Long System	
Annual gasoline consumption, L (000s)[a]	3750	2200	1480	303 000
Annual accidents				
Persons killed	1.4	0.6	0.6	50
Persons injured	59	36	28	4 200
Property-damage accidents	308	140	28	26 000
Annual air pollution, Mg[a]				
Carbon monoxide	170	71	3.6	16 960
Hydrocarbons	38	14.5	4.5	2 270

Note: 1 L = 0.26 gal, 1 Mg = 1.1 tons.

[a] These figures reflect an allowance for the improvements that are being made to automobiles.

planning process. When the Harrisburg rail transit study began, it was viewed by elected officials, local planners, and the general public as strictly an engineering exercise of fitting new railroad tracks within an existing right-of-way, turning the power on, and beginning transit service. Through the feasibility test approach, TAMS was able to identify other important factors influencing the construction of new rail transit service, some of which required community action and some of which (particularly institutional issues) were outside the community's control. The attraction of the feasibility-test approach is not that it offers a methodology for resolving planning issues but rather that it leads to their formal or explicit identification.

ACKNOWLEDGMENTS

We wish to acknowledge the constructive criticism received from the Bureau of Advance Planning and the Bureau of Mass Transit Systems of the Pennsylvania Department of Transportation during the long-range transit study and the important role that Harley Swift and Gordon Thompson played in promoting and developing the concepts of shared right-of-way transit for Harrisburg.

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Joint-Development Potential for Light-Rail Systems

Stephen A. Carter, Stephen Carter and Associates, Columbia, South Carolina

In recent years, many cities have begun to question the universal application of conventional rapid transit (CRT) systems but have indicated a need for a fixed-guideway solution to their transit problems. During this period of technological reexamination, light-rail transit (LRT) systems are being evaluated in greater detail to determine their capacity to meet operational specifications. This paper isolates for discussion the potential of LRT systems to inspire joint-development opportunities like those that have been attributed to CRT systems. Current incentives are evaluated in terms of the similarities that exist between the development of CRT and LRT systems. LRT's operational flexibility is widely recognized. This flexibility also provides new dimensions for station-area development; the small scale (compared with CRT stations) provides opportunities for initiating development within areas that normally would not be considered to have development potential. The barriers to joint development for LRT systems are essentially the same as those for CRT systems. The most significant barrier to a full realization of joint-development potential is the lack of adequate private capital to realize the full opportunity of the public investment. Under the new policy directives for urban revitalization, several new financial assistance programs have been developed. The urban design action grants appear to have a significant potential for use in expanding the joint-development potential of LRT systems. Value-capture options for stimulating private investment in joint development are currently being given considerable attention in demonstrations of LRT and downtown people movers. Each rapid transit system currently under consideration must conduct an assessment of the value-capture potential as part of the requirements for federal funding. Implementation techniques are discussed in terms of development incentives and the control mechanisms that are necessary to guide development along the lines of community objectives.

Since there is a general professional consensus regarding the physical and economic merits of joint development, one wonders why so few valid examples exist today. Federal agencies have invested millions of dollars in joint-development research, yet the private development community's reaction remains tepid at the hour of implementation. While the number of examples of joint development increases with each kilometer of transit, freeway, or waterway development, there remains a gap between the public and private entrepreneur.

In recent years our nation has refocused on light-rail transit (LRT) as a valuable transportation resource, the infrastructure for which already exists in many urban and suburban environments. Since the cost of conventional rapid transit (CRT) sometimes exceeds $30 million/km ($50 million/mile), both the federal and local governments are looking at existing LRT rights-of-way and considering adding to them for new or expanded systems. No one is suggesting that LRT is a panacea for solving transportation and urban development problems, but LRT is considerably less expensive to construct and operate than CRT and has greater functional flexibility.

This presentation attempts to analyze the joint-development potential that LRT systems offer in a variety of patterns of urban density and land use. The same rationale that has encouraged cities to look more closely at LRT for urban transportation systems is applicable to the joint-development opportunities. Several components of the planning process for LRT and joint development will be isolated for analysis, including (a) current incentives for joint development, (b) current liabilities affecting joint-development potential, (c) federal assistance for joint development, (d) value-capture financing options, and (e) implementation opportunities.

Since very few examples exist in the United States to illustrate the joint-development potential of LRT systems, the case studies presented here will generally be taken from CRT systems. Most of the developmental and financial techniques are transferable and the effects may be quite similar.

INCENTIVES FOR JOINT DEVELOPMENT

A turning point in the recognition of joint-development planning as a workable component in the transportation planning process came in a memorandum on the role and responsibilities of the federal highway system in Baltimore written by the late Charles Abrams in 1967 (1).