Coordination of Intermodal Transfers at LRT Stations

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Effective intermodal coordination can significantly enhance the attractiveness and productivity of a combined light rail transit and bus transit operation beyond the potential of either mode operating alone. The coincidence of bus and rail services at a station, however, does not constitute coordination. Effective coordination can also represent a economical means of improving the expanse and frequency of bus services while simultaneously reducing bus operating costs. Operational planners should take certain considerations into account when planning intermodal coordination at light rail transit (LRT) stations. Evaluation criteria for intermodal coordination have been developed and are discussed here in light of a case study involving intermodal operational planning accomplished in conjunction with the St. Louis Metro Link LRT system.

From a passenger's perspective, the ideal transit service would link all potential origins with all potential destinations without ever requiring a transfer. This idealistic level of service was actually provided, more or less, by the electric railway systems operated between the late 1890s and the 1930s. The old streetcar and interurban lines often preceded commercial and residential development in their service areas and for a time represented the only reasonable means of transportation access to the areas that they served. Patterns of urbanization and suburbanization followed the alignments of the early electric railway lines and the resultant communities were developed on a "pedestrian scale," surrounding stations and car stops. The practical limits of development during this era were effectively defined as the distance that a passenger would walk from a rail transit route.

Public transportation services today, in contrast, must contend with a predeveloped environment where land use has been oriented to an "automobile scale" with little regard for transit access or the pedestrian. Decades of development based on the private automobile as the predominant mode of transportation have resulted in low-density residential communities and dispersed employment centers. In the modern urban and suburban environment, meeting automobile competition with a "one-seat transit ride to anywhere" is a fantasy that would be neither practical nor cost-effective for a transit operator to implement.

The concept of the "one-seat ride" is all the more difficult to deliver with the new light rail transit (LRT) systems. A new LRT line is superimposed on a predeveloped landscape and—although LRT is the most flexible of the rail transit modes—it can be physically constrained by its alignment. The perfect right-of-way within walking distance of major concentrations of residential, employment, and commercial activities is seldom standing vacant, idly waiting for tracks to be laid. Economy often dictates the use of abandoned railroad alignments through old industrial areas that may form a barrier—real or perceived—separating nearby neighborhoods and activity centers within a reasonable walking distance of LRT stations.

As a practical reality, however, relatively few of a region's households, worksites, schools, and commercial activities are actually within a reasonable walking distance of LRT stations. Access planning at LRT stations is a major consideration in the design and evaluation of a proposed LRT system. Park-and-ride and kiss-and-ride provisions represent important means of access for modern LRT stations in our automobile-oriented society, particularly on the home end of a transit journey. Automobile-dependent access can be restrictive, however, to potential passengers without an automobile or to families with only one vehicle. Automobile-dependent access is also of little utility at the work end of an LRT commute or when vacant land is not available for parking development. For these reasons, the effective coordination of intermodal transfers at LRT stations is an important consideration of access for modern LRT systems.

TRANSFER MOVEMENTS

The Traveler

Discarding the concept of the "one-seat ride," a greater number of current trips would be compatible with transit if travelers would consider making transfers enroute. But the necessity to transfer can discourage patronage even for a single-mode transit operation. Most transfers introduce walking, waiting, and other activities that can add time, inconvenience, and anxiety to a traveler's journey. A poorly coordinated transfer can require long, irregular waits for infrequent connecting services in unpleasant surroundings, especially at night or during inclement weather.

The normal aversion to transfers can be worse, however, in a multimodal transit environment. The change of mode reinforces the differences between bus and rail operations and fosters the impression—real or not—that each mode is a separate and distinct entity that operates independently. Planning an intermodal journey involves working with at least two service timetables, possibly published in different formats. Information is rarely available at intermodal transfer points regarding schedules and connecting services. Many transfers further inconvenience the traveler by requiring payment of

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an additional or a new fare. The addition of institutional gaps apparent in the marketing, service planning, scheduling, or operational management of each mode can leave the traveler with the sense of stepping into an undefined void in the transportation planning process, exacerbating the fear of being stranded. As such, travelers' aversions to intermodal transfers can represent a major obstacle to the effectiveness of a multimodal public transportation system.

The Operator

In contrast the introduction of transfers enhances the utility and cost-effectiveness of a fixed-route transit system from the perspective of the transit operator. Transfers permit reasonably direct access to the maximum number of destinations with the minimum number of specific routes and services. Transfers also enhance operational efficiency by segmenting an overall system into a number of smaller intersecting operational components, each of which can operate at a level of service appropriate to the variations in traffic demand and physical characteristics experienced on the specific segment over time.

The flexibility to independently adjust the level of service on each operational component of a multimodal system is an important consideration to the economy of an LRT system. Connecting bus transit services can function more economically as local distributors when properly matched with the line-haul service provided by LRT. Conversely, a high-speed LRT service operating trains on exclusive right-of-way with close headways and long station spacing can function more economically as a regional line-haul service than buses in mixed traffic. But, although LRT operates effectively as a line-haul carrier, it makes a poor local distributor for multiple low-density activity centers (such as a suburban office park). The convoluted nature of such local services retards performance advantages of the mode and makes LRT unattractive for through passengers. The alternative of multiple, single function spur lines would be economically unfeasible to construct and difficult to operate. LRT can effectively function as its own local distributor for a major concentration of activity centers (such as a central business district [CBD]), however, especially when located at or near a terminal.

The point of balance between the traveler's demand for direct service and the transit operator's need for economy often lies with the level of attention given to the details of the transfer movement. Transit operators excel in safely transporting passengers *within* their vehicles in a reliable, timely, and cost-effective manner. Equal attention needs to be given to the planning and operation of that part of the transit journey that take place outside their vehicles. Well-planned, convenient transfers can offset a traveler's apprehensions about making transfers and promote a more effective transit system.

ST. LOUIS EXPERIENCE IN INTERMODAL PLANNING

The effectiveness of intermodal coordination at LRT stations was a particular concern for the Bi-State Development Agency, the predominant transit operator for the metropolitan districts of Missouri and Illinois that surround the city of St. Louis. Bi-State chose to undertake the construction of a 16.9-mi LRT line extending from East St. Louis, Illinois, through downtown St. Louis to Lambert St. Louis International Airport. The ready availability of more than 12 continuous miles of unused railroad facilities—extending from Illinois, across the Mississippi River, beneath the heart of the downtown business district and through the northwestern suburbs—permitted the economical construction of a new line-haul rail transit service that could effectively compete with the automobile to attract new riders to public transportation.

It should be noted at this point that the original 17.5-mi, 20-station Metro Link LRT line was temporarily reduced to 16.9 mi and 18 stations, primarily as the result of FAA concerns regarding the alignment of the Berkeley spur near the airport. The ridership projections and analysis discussed hereinafter are based upon characteristics of the *original* line; the relative proportions quoted remain relevant for the reduced line. Bi-State intends to complete the Berkeley spur when reengineering is complete.

The alignment of the new LRT line—locally referred to as Metro Link—is fortuitously located to attract riders by directly serving the downtown business district and a number of the major employment, commercial, cultural, and recreational centers for the region, including Busch Stadium, Laclede's Landing, the Jefferson National Expansion Memorial (the Gateway Arch), Union Station, Keil Auditorium, Forest Park, St. Louis University, University of Missouri, and the aforementioned airport. Based on the strength of these trip attractors "linked" by a uniquely suitable alignment for fast, frequent LRT service, Metro Link has been projected to carry about 16,800 passenger trips per weekday during its initial year of operation (*1*). Ridership is anticipated to further increase to about 37,100 passenger trips per weekday by the year 2000 (*2*).

Bi-State recognized early in the planning process that an LRT service alone could not realize these potential levels of ridership. Although Metro Link passes through a number of residential communities, a relatively limited number of households are actually within walking distance of a Metro Link station. Furthermore a number of suburban employment centers and other trip generators are also nearby but beyond a reasonable walk. Bi-State realized that the effective integration of LRT and bus operations was key to achieving the level of ridership projected for Metro Link. This opinion was supported by the alternatives analysis, which projected that an independent LRT service in same alignment without effective intermodal support would only attract about 16,300 weekday passenger trips by the year 2000—only 44 percent of the ridership projected for an integrated LRT-bus system (*2*).

The importance of the bus network to the success of Metro Link is borne out by the projections regarding morning peak period station access. The largest portion of Metro Link passengers were projected to arrive by bus (44 percent), compared with those who park-and-ride (33 percent) or walk (24 percent). At the opposite end of the trip, 35 percent of all morning peak period passengers were projected to transfer to buses to complete their journey. The rate of bus egress from stations during the morning peak period was projected to be significantly greater at stations outside of the CBD: an average 56 percent bus egress with a high of 83 percent at one particularly productive site (*3*).

Restructuring existing Bi-State bus routes as feeder and distributor services for the line-haul LRT service was determined to be the most cost-effective way for Bi-State to increase overall transit ridership. These "rubber-tired extentions" of Metro Link will effectively connect the LRT service with residential communities, employment centers, and other significant activity centers outside the CBD that are not within a reasonable walking distance of a station.

ROUTE RESTRUCTURING AND THE LOYAL RIDER

Restructuring existing bus routes as feeder and distributor services subordinent to the line-haul LRT service introduces another aspect of the predeveloped landscape that a new LRT line must contend with: existing constituencies.

The routes and services of the existing transit system have evolved to effectively serve this sprawled, automobile-oriented environment without consideration of LRT. The existing transit system probably includes routes that parallel the LRT alignment and provide roughly similar service oriented around the same trip generators that the proposed LRT is targeted to serve.

Likewise the transit system has an existing clientele with riding habits developed without consideration of LRT. Despite the enthusiasm of the LRT designers, the LRT service and station locations may be inconvenient, irrelevant, or contrary to the specific needs of a significant number of existing transit riders. Service planners must be sensitive to the fact that the introduction of LRT service—although representing a significant improvement from a systemwide perspective—can also represent a significant disruption and deterioration in bus service from the perspective of a particular individual who relies on the existing system.

EVALUATION CRITERIA FOR INTERMODAL COORDINATION

The Bi-State Development Agency took advantage of the availability of special funding to develop a more detailed evaluation of its bus route restructuring plan for Metro Link. The funding was from the Exxon Oil overcharge settlement through the U.S. Department of Energy and the Missouri Department of Natural Resources Division of Energy. Sverdrup Corporation of St. Louis, in association with Manual Padron & Associates of Atlanta, was commissioned to conduct the evaluation under the guidance of the Bi-State's service planning and scheduling department.

Bi-State provided the consultants with the evaluation criteria with the overall goal of making cost-effective changes in Bi-State bus routes and services to enhance regional mobility for the greatest number of passengers. The following objectives, as spelled out in a 1990 internal Bi-State memorandum, governed the development of the plan:

- Provide transit routes and services that are responsive to identified passenger travel patterns.
- Minimize overall travel time for the most passengers.
- Simplify the overall route structure.
- Avoid unnecessary disruptions of present routes and services without clearly demonstrated benefits.
- Maintain consistency with Bi-State transit service standards.
- Improve the overall operating efficiency of the Bi-State transit system.

Overall, LRT is intended to be the predominant line-haul carrier in the corridor it serves. Bus routes would be redesigned to function as complimentary and coordinated local feeders and distributors for the line-haul service provided by LRT. The process of redesigning an existing bus system to coordinate with LRT needed to be carefully undertaken on a station-by-station, route-by-route basis, however, to avoid needless disruption of the existing bus transit system. The planning process attempted to balance concerns for extending travel time for through passengers with the need to minimize the walking distance and wait encountered by intermodal transferees. Broad-brushed generalities were avoided. For example, although the general orientation of the process is to eliminate inefficient duplication of bus and rail services, parallel bus and rail routes may not necessarily be duplicative considering that the high-speed, limited-stop style of service that makes LRT an attractive line-haul carrier is not as effective serving a myriad of minor local destinations located between station stops.

General Considerations

Bus and rail transit routes and services should be designed to maximize system ridership, consistent with the following three guidelines. First, overall travel times and travel opportunities should be maintained or improved for the majority of passengers on any route changed to accommodate the LRT service. Second, overall bus and rail operating costs should be minimized. Third, any route changes proposed should have reasonable expectation of being implementable in light of local public and political considerations.

Note how these guidelines translated into evaluative terms. The degree of coordination between connecting services at a transfer site can significantly influence passengers' perceptions of discomfort. Because an *uncoordinated transfer* enroute can have the most pronounced effect on ridership, it was proposed to weight such transfers in a travel time calculation at a rate equal to half of the headway of the connecting service multiplied by a factor of 2.5. *Passively coordinated transfers*, in contrast, would be weighted at a rate equal to the scheduled waiting time multiplied by a factor of 2.5, whereas *dynamically coordinated transfers* would be penalized at a rate equal to the scheduled waiting time alone.

Scheduling Considerations

Schedules for bus and rail transit routes should be coordinated to minimize the out-of-vehicle time experienced by transferees and for maximum passenger convenience consistent with the following two guidelines. First, extraordinary measures to coordinate schedules should not be considered necessary for transfers between connecting routes operating at head-

ways of 10 min or less. Under these circumstances, service frequencies would be sufficient to ensure timely connections for intermodal transferees.

Second, one of three transfer coordination strategies should be considered when one or more connecting routes are operating at headways greater than 10 min:

- Passive schedule coordination synchronizes the headways of connecting routes with the line-haul route and adjusts the operating schedules so that the connecting route passes through a station prior to or following the scheduled arrival of the line-haul route, depending on the predominant flow of transfer traffic.
- Dynamic schedule coordination provides an enforced delay of connecting transit vehicles (typically the buses) until the line-haul route arrives (typically the train). Headways on connecting routes are also synchronized with the line-haul route.
- Timed-transfer ("pulse") coordination schedules all routes to meet simultaneously and dwell at a station for a period of time sufficient to ensure connections for transferring passengers. Under most circumstances this strategy is not technically applicable to rail transit, except at terminal stations (such as the Southeastern Pennsylvania Transportation Authority's Norristown Transportation Center). Rail transit can effectively participate in timed-transfers at intermediate station, as in the case of the Gateway Transit Center on Portland's Tri-Met LRT system, where the LRT trains are scheduled to pass through the timed-transfer site in both directions while buses dwell.

Routing Considerations

Routing considerations begin with the LRT designers, who should provide an effective path for buses through a station environment that is direct and will not add significant travel time for through bus passengers. Direct access through the station environment and to the station boarding area should be prioritized based on the capacity of each mode and the length of time a vehicle will remain in the station. As such, the most direct access through the station environment to a point as close as possible to the boarding platform should be afforded to bus transit, followed by paratransit, kiss-and-ride, taxicabs, and—last, albeit most popular—park-and-ride.

The design of LRT infrastructure notwithstanding, bus transit routings should be designed to minimize convoluted routings and for maximum passenger convenience consistent with the following five guidelines. First, an existing bus route that parallels the LRT line should be considered for rerouting, truncation or elimination if

- Overall travel time for the majority of passengers currently using the parallel bus route (including transfer time) would be reduced;
- The majority of passengers currently using the parallel bus route have origins or destinations within a quarter mile of an LRT station; or
- The parallel bus route would not function as a local distributor along the LRT alignment, synergistically complementing the express service provided by LRT.

When a parallel bus route is truncated at an LRT station, its headways should be synchronized with the LRT service, and an appropriate degree of schedule coordination should be considered. Parallel routes may be segmented at LRT stations to provide better bus-to-bus connections, to discourage competitive through-riding on the bus, and to improve service reliability.

Second, an existing bus route that crosses an LRT line in the vicinity of a station site and is expected to be carrying a significant number of through bus passengers beyond the LRT station should be considered for rerouting to the LRT station consistent with these points:

- Through bus route/low orientation to rail—If the majority of the passengers on board the route at the LRT station are not anticipated to transfer to LRT service, that bus route should not be rerouted to the LRT station if that action would significantly prolong travel times for through passengers. When a through bus route can be rerouted to the LRT station without prolonging travel times for through passengers, bus headways should be synchronized with LRT and passive schedule coordination should be considered.
- Through route/high orientation to rail—If the majority of the passengers on board the route at the LRT station are anticipated to transfer to LRT service, that bus route should be routed as close as possible to the station platform to accommodate transfers. In such cases bus headways should be synchronized with LRT and passive schedule coordination should be pursued to the maximum extent possible. Some form of dynamic schedule coordination should also be considered to a degree that would not prolong travel times for through passengers aboard the bus and that would not significantly reduce service reliability for passengers elsewhere on the bus route.

Third, an existing bus route that terminates at or near an LRT station site, or an existing bus route that crosses an LRT line in the vicinity of a station site and is not expected to be carrying a significant number of through bus passengers beyond the LRT station, should be considered for rerouting to the LRT station or truncation consistent with these points:

- Terminating route/low orientation to rail—If the majority of all passengers using the route are not anticipated to transfer to LRT service, bus headways should be synchronized with LRT and passive schedule coordination should be considered to the maximum extent possible without disrupting service reliability for passengers elsewhere on the bus route. These buses should also be routed as close as possible to the station platform to accommodate any intermodal transfers that do occur.
- Terminating route/high orientation to rail—If the majority of all passengers using the route are anticipated to transfer to LRT service, such a route should be considered a dedicated feeder route for LRT service. In such cases bus headways should be synchronized with LRT service and dynamic schedule coordination should be provided to enforce connections in a positive way. These buses should also be routed as close as possible to the station platform to accommodate transfers.

Fourth, where an existing bus route terminates in the general vicinity of a LRT station but does not currently cross the

rail line and a significant number of passengers are anticipated to use the LRT service, that route should be considered for rerouting to the station if such an extension was determined to be cost-effective. In such cases, the appropriate degree of schedule coordination should be consistent with the preceding guidelines.

Fifth, the potential for concentrating bus routes at key stations should be considered, if possible, to maximize bus-to-bus transfers. The use of timed-transfer ("pulse") coordination for some or all of the bus routes at a particular station should be considered wherever feasible.

Service Expansions

If significant net reductions in operating costs are identified through the integrated operation of a revised, intermodal transit network, a portion of those savings can be reallocated to improve transit service in the LRT corridor as follows:

- Cost savings in bus operations would cover part of the rail operating costs;
- Consideration can be given to adding off-peak service in areas that currently have peak period service only;
- New service could be added to respond to demands from developing suburban areas; or
- Some resources could be used to facilitate timed-transfer coordination at LRT stations, which would require better reliability, improved headways, or additional layover time on some bus routes to be effectively implemented.

The consultants separately evaluated Bi-State bus routes operating in the Missouri and Illinois tributary areas of Metro Link. Although guided by the evaluation criteria developed by Bi-State, the consultants and Bi-State staff agreed that the full set of evaluation criteria just presented was more detailed than necessary to support the preliminary planning activities defined in the study scope of work. An abridged set of guidelines was agreed upon for the consultants to employ for route evaluation. The full set of evaluation criteria was reserved for subsequent use in more detailed service planning, developing actual timetables, and working out operational priorities.

The consultants concluded that Bi-State could improve and expand transit service, plus realize a significant reduction of bus operating costs by rerouting existing bus routes consistent with the evaluation criteria. Bus service duplicated by Metro Link would be scaled back or eliminated, and timed-transfer centers were proposed for five outlying Metro Link stations in Missouri and Illinois. In Missouri some of the savings were redeployed to provide extensions into new service areas and longer service hours on existing routes. Two new dedicated feeder bus routes would link the LRT line with the city of Clayton in suburban St. Louis County. In Illinois the plan proposed to truncate several local routes that currently operate through to downtown St. Louis at the LRT terminal in East St. Louis (*4*).

Under the consultants' route restructuring plan, weekday bus miles in the Metro Link service area would be reduced by about 8 percent (nearly 1 million mi annually), while the number of weekday bus trips would increase almost 11 percent. This apparent contradiction reflects that very long line-haul bus routes would be truncated or eliminated, whereas most of the new feeder routes would be relatively short. The peak bus fleet would decrease by 38 buses in the morning peak period and 51 buses in the evening peak, although the midday service requirement would increase by 9 buses. Weekend service would also increase under this plan. The recommended service plan is projected to reduce annual bus operating costs by $1.7 million (*4*).

CONCLUSION

The coincidence of bus and rail services at a station does not constitute coordination. The benefits and effectiveness of a new LRT line can be significantly improved by restructuring existing bus services on a comprehensive basis. To achieve these benefits, however, operators and designers need to look beyond their vehicle and plans and consider every aspect of a passenger's trip via transit from the customer's perspective. Particular attention is necessary to the details of coordinating any transfer movements en route. In the rush to develop new and more effective services, the impact of service changes and reroutings on the current ridership needs to be carefully considered.

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