Infrastructure Rehabilitation and Technology Sharing in Bringing LRT to St. Louis

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Metropolitan St. Louis, after 19 years of planning, is developing a dual-mode, cost-effective public transportation system integrating light rail technology with a vastly improved regional bus network. The light rail transit component, known as Metro Link, is an 18-mi continuous fixed-guideway rail line connecting the St. Louis, Missouri, central business district with the Lambert International Airport and McDonnell-Douglas complex to the northwest and with East St. Louis, Illinois, to the east across the Mississippi River. Complementing Metro Link are shuttle bus operations to major employment centers, and realigned routes that form an extensive feeder bus network in the corridor. The initial rail line will directly connect the principal retail, office, recreational, educational, medical, and transportation activity centers with the densest urban population areas. Existing infrastructure is being used, including right-of-way, structures, and facilities to be acquired from two railroads. Nearly all the railroad property is abandoned, but will be revived for this light rail system. Additionally, street and highway right-of-way and other public lands will be made available for permanent Metro Link easements. The capital expense budget for building Metro Link is $287.7 million, covering design and engineering, construction and procurement, testing and start-up, and project management. As a federally funded project, this capital expense is matched with railroad property and facilities acquired separately by the City of St. Louis and donated to the project with a value in excess of $100 million.

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FOR NEARLY THREE DECADES most American cities have relied on the conventional urban bus as the primary form of public transportation. Whether riders are transit dependent or riders by choice, their alternative to the private automobile has been and still is, principally, a bus—a form of public transit that must ply the same congested highways, downtown streets, and intersections as the automobile. In larger cities, where population densities and ridership justified a significantly higher level of public transit service, rail rapid transit and commuter rail have continued to serve as major modes of travel in key corridors. Since the 1960s many cities—for example, San Francisco, Washington, Atlanta, Miami, and Baltimore—have developed new rail rapid transit systems.

St. Louis metropolitan-area decision-makers and planners have searched unceasingly since the late 1960s for an ideal solution to the public transit needs of their region. A chronology of events and activities over 17 years led to preliminary engineering for the current project. As the record reveals, St. Louis had its share of false starts and reconsiderations, and St. Louis officials found themselves caught in the ever-changing federal policy maze.

OVERVIEW OF ORGANIZATIONS INVOLVED

In the St. Louis (Missouri-Illinois) metropolitan area two primary organizations are involved in transit planning and programming: the regional council of governments, East-West Gateway Coordinating Council (EWGCC), and the regional transit operator, Bi-State Development Agency (BSDA). In addition, the City of St. Louis and the County of St. Louis (which are completely separate political jurisdictions) are active participants in all transit-related matters.

EWGCC was formed in 1965 as a metropolitan association of local governments. Its two-state jurisdiction includes the City of St. Louis, four counties (including St. Louis County) in Missouri, the City of East St. Louis (Illinois), and three Illinois counties. EWGCC serves as the metropolitan planning organization for the region. The council's board of directors is composed of 14 chief elected officials from local county and municipal jurisdictions; 6 citizens from the region, appointed by elected officials; and the board chairman of the regional transit operator, BSDA. EWGCC is financed by cash contributions (based on a per capita assessment) from member jurisdictions, state contributions, and federal grants.

BSDA owns and operates the regional mass transit system. It also owns and operates the general aviation Bi-State Parks Airport, operates the Gateway Arch tram system, and serves as the regional coordinator for the Port of Metropolitan St. Louis. BSDA was created in 1949 through a compact between Missouri and Illinois ratified by the U.S. Congress. It was given broad powers to plan, construct, maintain, own, and operate specific public works facilities and services. BSDA serves the City of St. Louis, three counties (including St. Louis County) in Missouri, and three counties in Illinois, an area that covers nearly 3,600 mi^2. BSDA is governed by a 10-member board of commissioners appointed by the governors of Missouri and Illinois (five members by each) to 5-year terms. BSDA has no taxing powers, but is a quasi-public agency authorized to issue tax-free industrial revenue bonds, collect fees, and receive funds from federal, state, and local governments.

In 1963, in an effort to stabilize mass transit service in the St. Louis metropolitan area, BSDA was empowered to take over and consolidate 15 separate transit providers. Subsequently, in 1973, a ½-cent sales tax for transit/transportation purposes was authorized by the Missouri General Assembly in the City of St. Louis and County of St. Louis. The city and county annually appropriate these funds in whole (for the city) or in part (for the county) to support BSDA transit operations. BSDA receives support for transit services in Illinois via a downstate transit tax allocation and ¼-cent sales tax in areas of two counties served; both sources of funds are tied to purchase of service agreements annually.

PROJECT HISTORY

In 1983, funding was approved for an alternatives analysis study for the central/airport corridor, which had been shown to be a prime target for major transit investment since 1971. This new alternatives analysis study encompassed five primary alternatives. In July 1984, culminating the alternatives analysis process, a public hearing was held on the draft Environmental Impact Statement (EIS). After receiving all public comments, the EWGCC board adopted a modified light rail transit (LRT) alternative for implementation.

This preferred alternative included LRT between East St. Louis and the University of Missouri's St. Louis (UMSL) campus, all via abandoned or underutilized railroad right-of-way and facilities. The lines then extended to Lambert International Airport and the McDonnell-Douglas headquarters and manufacturing complex at Berkeley (Missouri) via either mixed traffic operation along an existing collector street (Natural Bridge Road) or an exclusive light rail alignment using the Interstate 70 right-of-way. This preferred alternative included a conceptual set of bus service and realignment provisions to effect a feeder bus system to light rail stations and regionwide bus improvements. The estimated capital cost of the light rail component, including more than 18 mi of line, 24 or 25 stations, and 34 vehicles, was put at $250 million in escalated dollars.

The innovative financing developed for funding the preferred alternative was critical to the project's acceptance. The City of St. Louis explored with affected railroads their willingness to provide right-of-way at zero or minimal capital outlay by local government. Compensation for the railroads would entail a swap of the city-owned, and still very much operating, MacArthur railroad bridge across the Mississippi River, public assumption of maintenance responsibilities for railroad bridges in the alignment, and provision of operating rights for one of the railroads on a portion of the acquired line to allow limited freight switching to continue. With an agreement in principle from the railroads to consummate such a transaction, these potential assets were appraised and determined to have a value, if donated to the project, sufficient to cover the 25 percent local-share matching requirement for UMTA capital grant funds under the new start category of the discretionary capital program (Section 3, Urban Mass Transportation Act of 1964, as amended).

UMTA, meanwhile, was expressing considerable reservations about the local decision to pursue the preferred alternative, light rail, rather than the transportation system management (TSM) alternative. Further, although UMTA had provided guidance on the appraisal of railroad assets value, they were not prepared either to accept the appraisal results or to commit to ruling that such assets were indeed eligible to meet local-share matching requirements. But the project's logic, financial feasibility, and uncanny adaptation and reuse of existing infrastructure had now surfaced unmistakably at the local level and in Congress. Through earmarking, Congress designated $2 million in Section 3 funds for a preliminary engineering effort on light rail. Locally, another $1.5 million was allocated from the region's formula allocation of UMTA Section 9A funds, and local cash was raised to provide the match for both UMTA program monies. An application to UMTA for these grant funds was filed by EWGCC in August 1984.

What ensued thereafter was a fairly typical iterative process of application reviews and comments by UMTA. Evidenced in the application review cycle, however, was continued reluctance by UMTA to accept the local decision to pursue light rail. Fortunately, the new budgeting cycle at the federal level was advancing through Congress simultaneously. In anticipation that the St. Louis light rail project would continue to prove its merits through the preliminary engineering analyses and design, Congress acted to again earmark new-start monies for it. The fiscal year 1985 budget earmarked another $10 million for St. Louis; these funds were to be used to initiate final design and construction.

In February 1985 the EWGCC received approval of its grant application to proceed with preliminary engineering on the locally preferred alternative. UMTA, in approving the grant request, stipulated that St. Louis must also evaluate further the no-action and TSM alternatives at the same level of detail as light rail. The EWGCC also agreed to review its demand forecasting, assuring UMTA that the models would be validated (and recalibrated using 1984 on-board survey data from the transit operator) and entirely new travel projections used for preliminary engineering. A final EIS and the UMTA-required cost-effectiveness analysis would also be prepared. The stage and financing for advancing transit improvements were set.

On July 1, 1985, consultants were hired, an EWGCC light rail project office was established, and the preliminary engineering phase was begun—including the additional alternatives analysis and a third demand forecasting techniques assessment.

Demand forecasting techniques were assessed and found to be satisfactory, models were recalibrated and validated, networks for each alternative—including three subalternative lengths of the preferred LRT alternative—were prepared, and travel projections were made. In response to the direction given by the EWGCC board as a result of the draft EIS public comment, analysis of the alternative alignments to reach the airport and Berkeley concluded in the selection from six options of a route that would use Interstate and airport rights-of-way, avoiding any mixed traffic operations on existing thoroughfares and eliminating one or two passenger stations that optional alignments would have required. The initial design work also determined that a major improvement in the alignment in East St. Louis could be made, eliminating in-street trackage and one proposed passenger station. Initial operational analysis also led to a reduction in light rail vehicle (LRV) fleet requirements from 34 to 31 cars, and major changes in the preferred alternative in the downtown St. Louis portion of the line. Detailed modeling work on patron access and egress, and productions and attractions by traffic analysis zone, revealed little negative impact on ridership but substantial positive impact on travel times, and capital and operating costs from the elimination of two underground passenger stations downtown.

All of the preliminary engineering phase activities were augmented and enhanced by third-party oversight. In addition to locally staffed technical, policy, and design review advisory committees that met at least monthly to critique the work constructively, a peer review group and value engineering workshop were convened. The peer review group, composed of seven transit industry professionals from across North America, met at the end of January 1986 in St. Louis to consolidate and tender their critique after several weeks of individual reviews of technical documents. Similarly, a consultant team was given an independent contract to perform a value engineering assessment. This culminated in a week-long value engineering workshop on-site in April 1986.

After 12 months of analysis and design, the preliminary engineering phase was completed. The refined LRT alternative proved through environmental assessment and cost-effectiveness measurements to be the most feasible and prudent course to follow. Engineering and architectural plans were completed to an aggregate 30 percent of design level, with decisions solidified on station locations, track geometry, vehicle requirements and design, construction and procurement contracts and schedules, financing plan, and other deployment details. The initial system of integrated bus services and routes with LRT was defined, detailed, and costed. The time, the option, and the opportunity to deal effectively with travel needs in one key corridor in the region had arrived.

METRO LINK ROUTE

The St. Louis metropolitan area rail transit system, known as Metro Link, is an initial 18-mi continuous fixed guideway rail line from East St. Louis (Illinois) through the St. Louis (Missouri) central business district to the Lambert International Airport and McDonnell-Douglas complex at Berkeley (Missouri). Complementing Metro Link are shuttle bus operations to major employment centers and a realigned regional bus system. The initial line will directly connect the principal retail, office, recreational, educational, medical, and transportation activity centers (see Figure 1).

Metro Link will make maximum use of existing infrastructure. Adaptive reuse of infrastructure is, through rehabilitation of freight railroad rights-of-way and structures, the backbone of Metro Link's feasibility. Included are the historic 113-year-old Eads Bridge (which spans the Mississippi River), the Washington Avenue-Eighth Street railroad tunnel (which runs from the Eads Bridge under the St. Louis central business district), the historic St. Louis Union Station baggage tunnel, a former rail passenger car repair facility and yard, and nearly 14 mi of continuous railroad trackage and right-of-way. Additionally, street and highway right-of-way and other public lands will be made available for permanent, exclusive Metro Link easements. The initial Metro Link alignment will be on a reserved right-of-way, exclusive except for 16 to 18 low-volume street crossings that will be accommodated using common railroad at-grade crossing protection devices.

Because of the availability of existing railroad, highway, and other public rights-of-way, the Metro Link project requires very little real estate acquisition and associated relocation. Near the airport a total of nine single-family residences, all of them under the airport's principal flight path, will be acquired. Elsewhere, only four business properties, three of them at-grade parking lots, will be acquired.

Table 1 displays the Metro Link alignment type and route miles of right-of-way. The existing railroad rights-of-way are being donated by the City of St. Louis to the project after the city has innovatively acquired ownership from

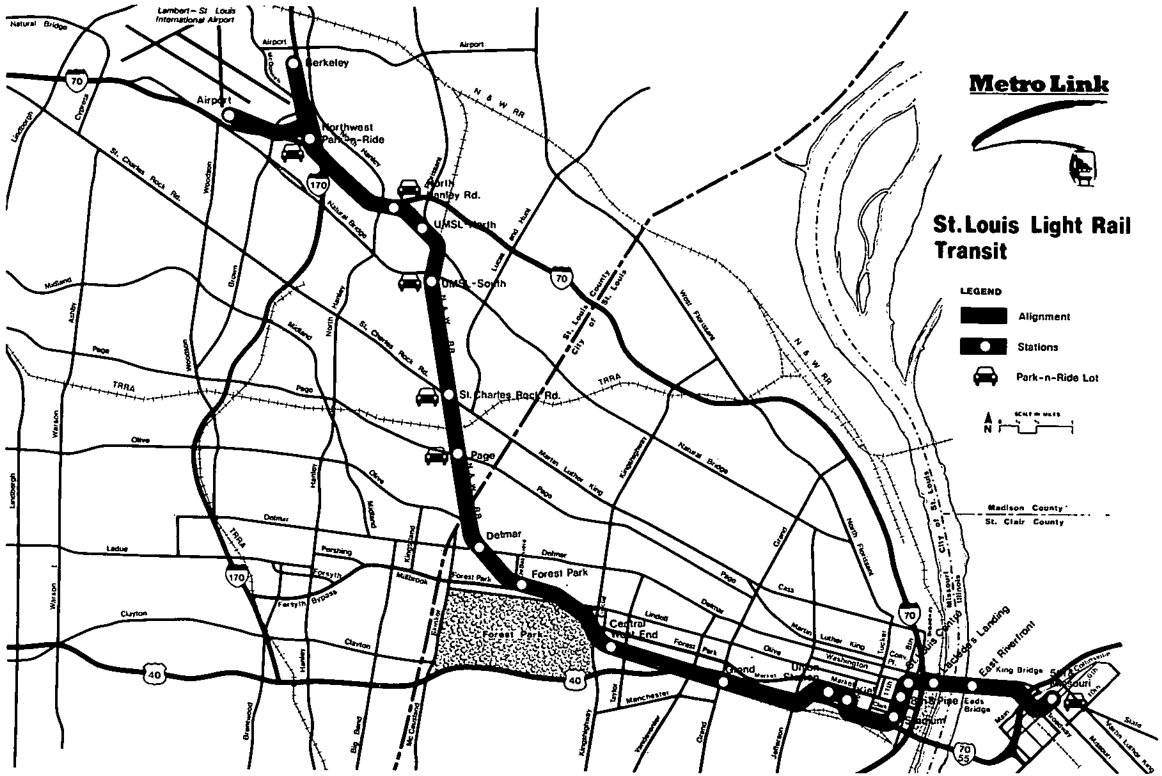


FIGURE 1 Metro Link route map.

TABLE 1 METRO LINK ALIGNMENT/RIGHT-OF-WAY

Alignment Type	Existing R.R. ROW (mi)	Other ROW (mi)	Total (mi)	Percent
At grade	11.8	3.4	15.2	84
Elevated	0.9	0.9	1.8	10
Subway	0.8	0.2	1.0	6
Total	13.5	4.5	18.0	100

the railroads. In the "other right-of-way" category, less than 1 route mile must be acquired from private landowners; the remaining mileage will be made available for exclusive Metro Link use by public entities through permanent, no-cost easements.

DESIGN PHILOSOPHY AND CRITERIA

Not unlike circumstances in the vast majority of its counterpart urban centers across the country, St. Louis had no existing LRT system of its own from which officials could garner practical, local design requirements. The last streetcars in St. Louis ceased operating in May 1966. Consequently, and for better or for worse, the Metro Link managers had to develop a design philosophy without current home-grown experience with light rail. Fortunately, St. Louis came to the preliminary engineering phase with reasonable and pragmatic plans, and at a time when other cities that had already completed a like journey could be tapped for guidance.

At the outset of preliminary engineering the governing charges to staff and consultants were made clear and definitive. Metro Link would be designed based on off-the-shelf equipment, proven technology and construction practices and techniques, strict adherence to budget and schedule, and conscious consideration of every opportunity to incorporate provisions for future system enhancements and extensions. Part and parcel of each of these charges were the overriding goals that the end product be safe, reliable, maintainable, effective, and efficient. Philosophically, then, the initial 18-mi Metro Link system would be capable of being implemented quickly and would provide at least basic rail service that constituents would find immediately successful.

From that rather fundamental and clear project genesis, preliminary engineering proceeded to meet its 1-year completion schedule within its $4.5-million engineering budget and to design a system that, with little risk of overrun, can be deployed for approximately $288 million (escalated dollars) in capital expenditures.

The design philosophy had to be translated into design criteria. To that end, criteria were liberally adopted or adapted from other systems. Because nearly 14 mi of the initial 18-mi alignment are railroad right-of-way with structures built for freight traffic, trackway and trackwork design criteria were fashioned along American Railway Engineering Association (AREA) standards without notable deviation or applicability issues. Systems engineering elements and operational principles were shaped using the San Diego Trolley as a model. Metro Link design criteria for the yard and shops were in large measure an adaptation of Portland's MAX criteria and physical plant.

If there are any elements of the Metro Link design that suggest variation from the U.S. norm for similar projects, they would most likely be station platforms and design implications for contract packaging. After considerable review of what other systems were doing to address the issue of accessibility, and weighing that issue with station dwell times, vehicle dynamics and track geometry, fare collection options, and accident liabilities, Metro Link's designers opted for high-level loading platforms at all stations. Regarding contract packaging, the decision was reached to limit construction and procurement contracts to the smallest number possible—18 contracts at most. Hence, design could proceed in terms of plans, specifications, and estimates in a manner that was conducive to placing the majority of coordinative responsibility on general contractors, not on the Metro Link staff and consultants. Further, the design work carefully disaggregated civil and systems elements so that contract units could be assembled that had the highest likelihood of achieving economies of scale, disadvantaged business enterprise (DBE) goals, optimum equipment, material and labor resource allocations for contractors, etc., within the context of the implementation critical path and right-of-way constraints.

METRO LINK SYSTEM

Stations

Twenty stations will be built along the initial 18-mi Metro Link route. Two will be in East St. Louis, 10 in St. Louis, and 8 in St. Louis County. (The City of St. Louis is a totally separate political jurisdiction from St. Louis County, a century-old circumstance that is not without its negative consequences on fiscal and areawide cohesiveness.)

With the alignment encompassing the reuse and rehabilitation of nearly 14 mi of excellently situated railroad right-of-way, including tunnels and a major bridge, the character of stations was uncontrollable in many respects.

Fifteen stations are at-grade, for the most part accessible without substantive vertical circulation features except for minimal stairs and ramping; one of these stations will be built at the airport to achieve platform interface with the airport terminal's planned people mover system. Three stations are in subway: two in the Washington Avenue-Eighth Street tunnel, and one in the Union Station baggage tunnel. The remaining two stations are on existing elevated bridge structure, one at each approach to the Eads Bridge, where they are enclosed by approach superstructure.

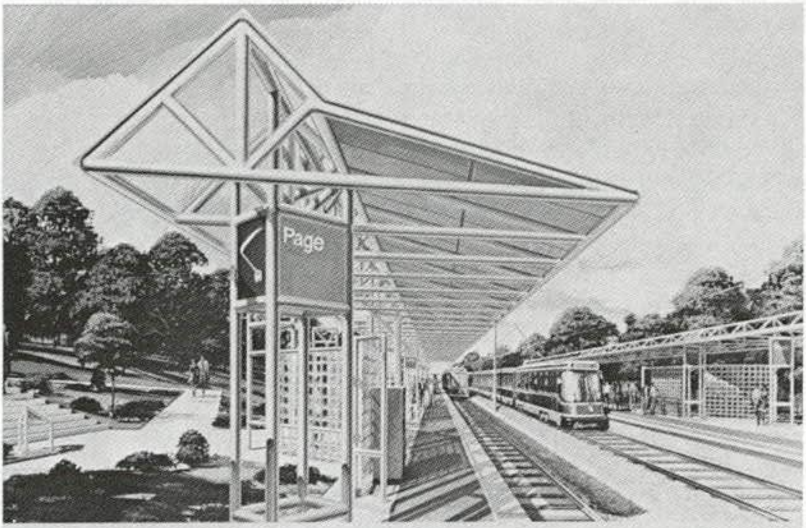
All station platforms are high-level loading to provide full accessibility and to minimize boarding time for all patrons. Platform lengths are typically 200 ft long to accommodate two-car trains. Depending upon the functional and physical location of each station, elevators and escalators will be provided (see Figure 2).

Metro Link stations will be built with materials and finishes chosen with several key criteria in mind. Materials are to be readily available, to have optimal life-cycle costs, and to require only common construction or installation techniques. Station finishes are designed to be resistant to vandalism and to mitigate weathering impacts. Platforms exposed to the elements will have space-frame steel pylon canopy structures with roofing material of copper and glass. Canopies are modular and sized to accommodate 100 percent of each exterior station's peak hour patronage per headway at a minimum of 5 net ft^2 per patron and to cover the complete platform width.

Only essential wall requirements to protect patrons, fare collection equipment, and other elements from crosswinds will be provided, using glass block, free-standing wall segments. The structural elements will be used to support and integrate canopy, lighting, graphics/signage, platform security and communication, and seating requirements. Landscaping will enhance appearance, control and passively direct the movement of patrons within station sites, and enhance or improve microclimates at the stations.

Patron access and egress at stations varies, of course, by location. Six stations will be built with integral park-and-ride lots, providing an initial capacity of nearly 2,000 parking spaces. Kiss-and-ride as well as bus drop-off provisions are incorporated at all station sites except those in downtown St. Louis, where existing thoroughfare provisions adequately perform these functions.

Access and egress treatments are hierarchical. First priority is given to bus patrons using the drop-off lanes, second priority to short- and long-term parking for handicapped patrons and kiss-and-ride patrons, and third priority to long-term commuter parking patrons. Patrons accessing or leaving stations on foot are provided the most direct circulation available to the adjacent land uses.



Page Station

Eighth & Pine Station

FIGURE 2 Metro Link renderings of outdoor and indoor station platforms.

Light Rail Vehicles

As with other federally funded projects, the engineering for Metro Link LRVs has proceeded using a generic car. Conforming to the overall design philosophy, the LRV design used in preliminary engineering was for off-the-shelf, service-proven technology and components.

In this section the generic LRV used in preliminary engineering is generally described. But from this point forward the LRV final engineering will proceed toward completion of a performance specification within a period of 6 to 8 months. That is to say, Metro Link staff and consultants will not design the LRV. Procurement will be based on general and technical conditions that can best ensure proven vehicle and vehicle subsystem performance, leaving detailed design to the manufacturers. Testing at the component level, integrated subsystem level, and, finally, the system level, coupled with pre-revenue and revenue performance criteria, will provide the primary means of product assurance. Also, an on-site maintenance component is planned for inclusion in the procurement to permit the supplier to use his own forces during the first years of revenue service to monitor actual conditions and correct problems that might otherwise cause deficiencies in contracted reliability, availability, maintainability, and other intrinsic threshold levels.

The LRV procurement will use a one-step competitive bid process or, pending further analysis of market conditions, competitive negotiation. In either case, the contract specifications will be aimed at sharing the procurement risks between owner and supplier. Performance criteria, payment provisions, incentives, and damage clauses will be structured to provide owner protection. Supplier control of maintenance for up to 5 years, supplier-detailed design of their off-the-shelf, proven LRV, and the payment and contract incentive provisions will be structured to provide bidder protection.

This procurement philosophy should save scarce resources and time. It will eliminate costly detailed engineering by the owner, whose generic vehicle design constraints under current procurement regulations tend to void much of the work anyway upon bid. Likewise, potential suppliers are given greater latitude in offering a design that they already have and are willing to bid to the performance criteria. They also can avoid costly negotiations over substitutions or equivalents. Being willing to admit that most owners and their engineering consultants are not skilled in manufacturing can pay dividends by reducing final design project costs while simultaneously freeing resources to concentrate on end-product assurance.

This is not to suggest that any and all LRV procurement problems will be avoided, let along mitigated by the Metro Link approach. There are no illusions, only proactive policies that have their roots in the design and procurement experiences of Metro Link project staff and the shared wisdom of colleagues in other transit agencies.

Patronage estimates and the service design require an initial fleet of 31 LRVs. Double-ended, six-axle articulated vehicles with passenger capacity for 64 to 76 seated and 160 to 200 standing at crush load conditions are planned. Dimensionally, the LRV will be between 8 ft 8 in. and 9 ft 3 in. wide, no more than 93 ft long (over couplers) or 12 ft 3 in. high, and equipped with four gangways per side for floor-level boarding.

LRV performance characteristics include maximum operating speed of 55 mph; random and synchronous spin/slide detection and correction control; negotiation of minimum flat horizontal curve radius of 82 ft and minimum vertical (crest or sag) curves of 1,640 ft; and maximum superelevation of 6 in.

Metro Link LRVs will be fully climate controlled, have a normal operating condition interior noise threshold for acceptance of 67 dBA, and general watertightness. Fully automatic, self-centering couplers will be provided for all mechanical, electrical, and pneumatic train connections.

The preceding data are included in preliminary engineering documents distributed in February 1987 to LRV suppliers for an industry review. Very informative and constructive comments were received from every supplier with an LRV currently in service at, or in production for, a U.S. transit agency. These review comments will be revealed at the outset of final engineering. Every performance-oriented criterion or contract condition will be given independent evaluation and reevaluation in the context of both the LRV product requirements and the requirements for interdependent Metro Link project elements. Among other early final engineering tasks, thorough and vigorous integrated value engineering, life-cycle cost, human factors, operations and maintenance cost, and implementation schedule analyses using the largest and longest lead-time contract unit (i.e., the Metro Link LRV) as the catalyst will provide an invaluable project focus.

Yard and Shops

In the planning of yard and shop layouts, thorough consideration was given to all aspects of LRV maintenance, car cleaning operations, operation of the shop with respect to mainline operations, internal operating characteristics, and all other facets of Metro Link-related operating activities. The importance of establishing a clear maintenance and repair philosophy provided the designers with general parameters for a functional, efficient design.

Basic system philosophy consideration and analysis were given to the following requirements to generate specific design solutions:

- Levels of maintenance and repair;
- Work activities;
- Shop loading;
- Contract maintenance;

- Inventory requirements;
- Work flow;
- Space requirements;
- Equipment requirements;
- Personnel requirements;
- Scheduling;
- Routine inspection and preventive maintenance;
- Records, procedures, and method;
- Cost restriction, budget limits;
- Future expansion; and
- Interaction with operations.

An abandoned passenger car maintenance facility and yard on a 10-acre site in the Mill Creek Valley railroad yards area just west of downtown St. Louis, together with two acres from an adjoining city-owned lot, will be Metro Link's yard, shops, and central control location. This site, at the intersection of Scott Avenue and 22nd Street, is approximately one-third of the distance along the initial 18-mi alignment. An existing metal car shed 160 ft long by 67 ft wide by 34 ft high with inspection pit will be rehabilitated and incorporated into the Metro Link shops.

The Metro Link yard and shops facilities will include a three-story maintenance and office building providing approximately 56,500 ft^2 of floor space; a materials storage yard; storage tracks and LRV movement trackage, including a run-around track with a loop; arterial service roads; and parking lots. The yard and shops will handle 24-hr operations.

Three fundamental levels of LRV maintenance, repair, and overhaul will be handled by the shops, i.e., routine maintenance, periodic maintenance, and major repair. Inbound trains from revenue service will be routed to a track or tracks where the following routine maintenance functions will be performed: visual inspections, maintenance technician sign-off, and interior and exterior cleaning. Outbound trains will be inspected by their operators prior to departure. Periodic maintenance will be performed in service and inspection areas, and will include scheduled inspections, correction of deficiencies, scheduled preventive maintenance, and lubrication and testing. Major repair will be done in the shop, including major scheduled maintenance, change-out or complete repair of major LRV components, wheel truing, and collision repair functions. An environmentally separated blowdown facility will be located on a track not normally used for daily inspections.

Space will be provided for the storage of the following types of equipment and structures: electrification poles, signal apparatus, lighting poles, rail, ties, special trackwork, other track materials, ballast, and reels of wire.

Storage tracks initially will provide for 31 LRVs; in the future space will be arranged to accommodate up to 50 LRVs. LRVs will be stored on level tangent track, with both longitudinal and lateral access aisles. Storage tracks will incorporate reused railroad rail salvaged from the existing trackage in the acquired rights-of-way.

Trackwork

The initial Metro Link alignment includes approximately 34 track miles of double-track mainline and one track mile for the airport branch single-track spur. All construction plans and specifications comply with the current edition of the AREA Manual for Railway Engineering and Portfolio of Trackwork Plans, modified as necessary to reflect the physical requirements and operating characteristics of the Metro Link system. Where the system operates across a public street, applicable design requirements of the American Association of State Highway and Transportation Officials (AASHTO), the Missouri Highway and Transportation Department (MHTD), the Missouri Division of Transportation (MDOT), the Illinois Department of Transportation (IDOT), the Illinois Commerce Commission (ICC), and the local counties and municipalities also are utilized.

The track meets or exceeds the minimum requirements of the Federal Railroad Administration (Title 49, Part 213: Track Safety Standards for Class 3 Track). Class 3 track limits freight trains to a maximum operating speed of 40 mph and passenger trains to 60 mph.

The standard gauge of Metro Link is 4 ft 8½ in. Wider gauge will be used in some curves, depending upon the degree of curvature, in accordance with the following: gauge of 4 ft 8¾ in. for curves with a degree of curvature greater than 160, but equal to or less than 240, and a gauge of 4 ft 9 in. for curves with a degree of curvature greater than 240.

Primarily ballasted track will be used, meeting the requirements of AREA's Specification for Prepared Stone Ballast. Mainline cross ties will be pressure-treated oak and mixed hardwood 8 ft 6 in. long, conforming to AREA specifications for 7-in. grade ties spaced 20 in. center-to-center on the joint trackage, 24 in. center-to-center in yard track. A ballastless track system will be utilized on the Eads Bridge approach and main river spans and on the floor of the maintenance building at the yard and shops.

All Metro Link mainline track, turnouts, and yard lead tracks will be constructed of continuous welded rail, welded into continuous strings by the electric flash-butt process. Field welds will use the approved preheat thermite process in accordance with AREA specifications.

New rail will be procured for all mainline track, turnouts, and yard lead tracks. Rail will be 115RE section new prime rail, while rail for paved track will be 128RE 7A new prime girder rail. Heat-treated or alloy rails will be used in all special trackwork (i.e., turnouts and crossings) and on all curves where the degree of curvature is greater than 40. The rail for the yard and storage tracks and exclusive freight tracks will be Number 1 relay 115RE rail.

All mainline track with a center line degree of curvature greater than 150 will have an inner restraining rail adjacent to the low rail; rail for this purpose will be Number 1 relay 115RE rail. Emergency guard rails will be installed on tracks on all bridges; for this purpose relay 115RE rail, extending 50 ft beyond each end of the bridge, will be used.

Special trackwork will be manufactured and installed in accordance with AREA specifications and plans. Single crossovers will be used in lieu of double crossovers unless space restrictions dictate otherwise. All special trackwork will be located only on vertical and horizontal tangents; it will not be superelevated. The minimum length between any facing switch points will be 45 ft. The minimum horizontal or vertical tangent distance preceding a point of switch will be 10 ft. Special trackwork is to be located as follows (and includes use of geotextile fabric): Number 10 and Number 8 turnouts with 19-ft 6-in. curved switch points as the standard mainline turnout; Number 6 and Number 4 turnouts with 11-ft straight switch points as the standard yard turnout.

Appropriate measures will be evaluated during the final design of trackwork to minimize stray currents to ground resulting from the use of rails as the negative return for the traction electrification system.

Operations

A track and signal schematic diagram of the mainline route for the St. Louis Metro Link system is shown in Figure 3. The schematic is a simplified representation of station locations, special trackwork junctions, emergency crossovers, pocket tracks, tail tracks, and other operationally important features such as yard locations and railroad junctions.

Trains on the Metro Link system will be operated manually. Signaling and control subsystems are basic and confined to those functions required for safety (i.e., train protection and at-grade street crossing protection) and for the oversight and management of operations at terminals, turnbacks, and transfer zones between yard and mainline areas (i.e., train supervision).

For mainline operations, train protection and supervision are accomplished by these means:

- Train movements will operate by line of sight on Fifth Street in East St. Louis;
- Wayside block signals providing automatic train protection (ATP) will be installed beginning at Fifth and Broadway in East St. Louis and continuing across the Eads Bridge, in the Washington Avenue-Eighth Street tunnel, on

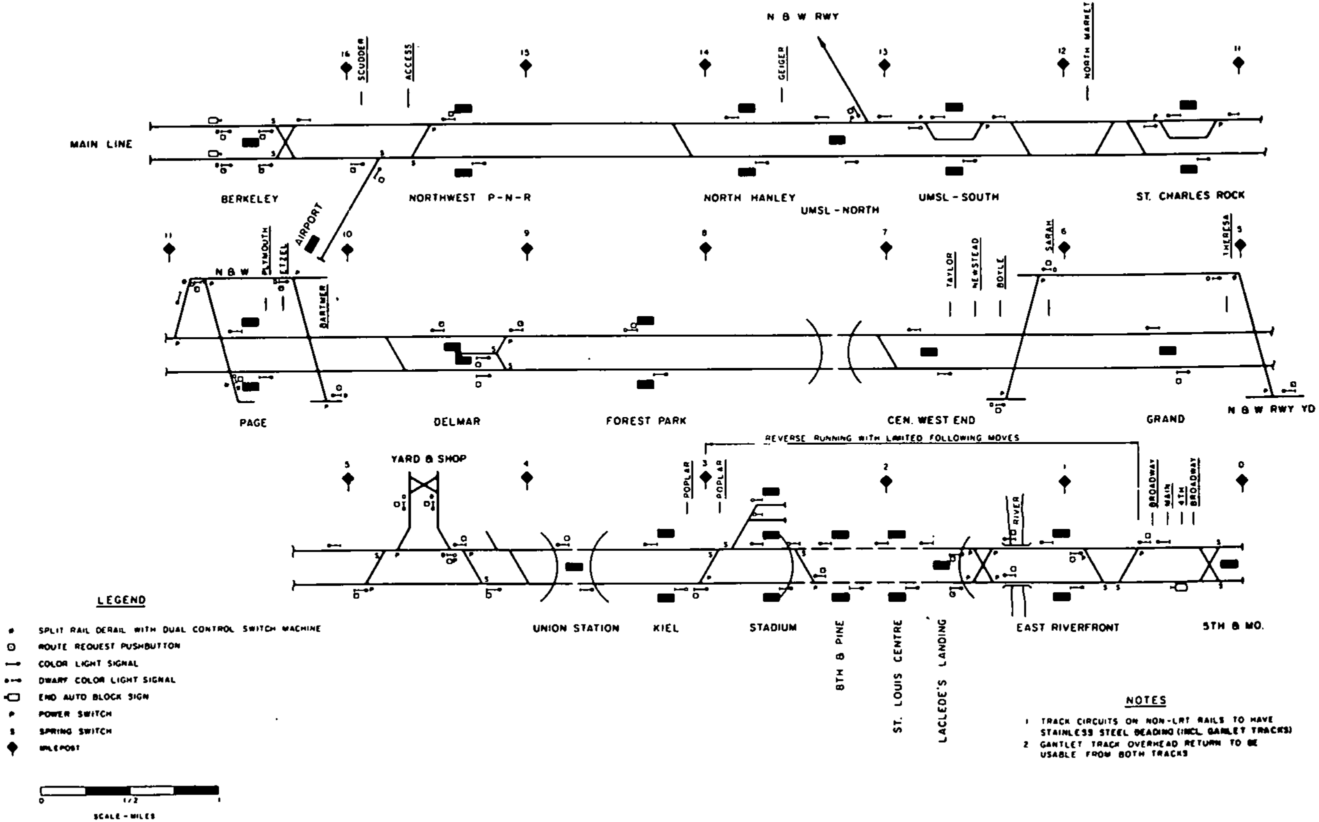


FIGURE 3 Single line diagram of the signal system.

the TRRA/new right-of-way/Norfolk & Western segments from Busch Stadium to UMSL, and on the new right-of-way from UMSL to Berkeley to protect following movements on these high-speed line sections; and

- Signals will be provided on the airport branch to control movements on the single-track section.

Track switches will be controlled in one of three ways. Switches located at junctions where frequent through and diverging facing train movements are made will be power operated, with routes requested by operator-controlled wayside pushbuttons. Switches located in low-speed territory and used primarily for through facing movements and trailing movements from the diverging route will be spring-operated. Infrequently used switches will be thrown by hand.

The 18 street grade crossings along the initial Metro Link line will be protected with railroad-style flashers and gates. Where necessary, crossing protection will be coordinated with adjacent street intersection traffic signals (e.g., at Scudder Road near the airport).

Operations (whether normal or abnormal) will be directed, controlled, and monitored by central control personnel operating out of the shops and office building at Scott Avenue and 22nd Street. Central control will supervise all mainline train operations, maintenance and storage activities, and traction power distribution in accordance with established operating schedules, rules, and procedures. It will implement any corrective actions required to maintain service schedules and to minimize adverse effects of equipment failures or emergency situations. Central control will also monitor station operations to provide for the safety and security of passengers, employees, and system facilities and equipment.

Central control will have several systems at its disposal. The route schematic display system will provide a complete visual indication of the mainline tracks, special trackwork layouts, signal block visual indication limits, and passenger station and substation locations. Radio communications with train operators will permit dispatchers to plot specific train locations manually. The radio communications system will provide channels for train operations, security supervisors, maintenance, and management. Two channels will provide two-way communications between central control and all trains and security personnel. Maintenance and management personnel will have exclusive channels. The telephone system will provide dedicated voice channels for use as telephone extensions from central control to selected sites along the right-of-way, primarily at passenger stations. Telephone service will be provided for passenger assistance and for administrative and maintenance purposes. Emergency telephones will be provided at each passenger station.

The closed-circuit television system will include cameras at selected points in stations and other facilities connected to monitors at central control. The public address (PA) system will be used to issue systemwide announcements (or selective announcements) in all stations. A PA system will also be provided on each LRV so that train operators can make announcements to riders and, via roof-mounted speakers, to people on the wayside. The tape recorder system will provide a record of all dispatcher radio transmissions and phone conversations.

The cable transmission system (CTS) will provide the backbone communication link between central control and various field locations. Terminals located at central control and at each major node of the LRT system will be interconnected by the CTS. The supervisory control and data acquisition (SCADA) system will operate over the CTS. Supervisory alarm and control circuits will connect each fare vendor and each electrical substation with central control. Electrical and support data related to intrusion and field equipment status alarms also will be transmitted on this system.

Trains will reverse direction at Fifth and Missouri in East St. Louis, at the western ends of the line (Berkeley and Airport), and at Delmar and Union Station (21st Street) for turnback service. Train operators will change ends and reset the vehicle destination signs. In addition, at both Delmar and 21st Street, it will be necessary to make diverging moves through the turnback tracks. Turnaround times have been allocated for these tasks.

Speed limits for the Metro Link line are shown in Table 2. These speeds generally reflect performance capabilities, station spacing, adjacent development, and traffic interference. In some locations, sharp radius curves further reduce speeds for relatively short distances.

Normal weekday service (see Figure 4) will begin at 5:30 a.m. and end at 1 a.m. (2 a.m. in East St. Louis to or from Union Station). Commuting peaks will occur from 6 to 9 a.m. and from 3 to 6 p.m.

The number of cars per train is a function of headways, platform lengths, vehicle limits, and street block lengths. The limiting factor for the line is the initial 200-ft platform length, which restricts train lengths to two cars. Two-car consists will be operated on several peak hour, peak direction trains, but

TABLE 2 METRO LINK SPEED LIMITS

Segment	Speed Limit (mph)
East St. Louis to Eads Bridge (East Approach)	20
Eads Bridge (East Approach) to 21st Street	20 to 55
21st Street to UMSL—South	55
UMSL—South to UMSL—North	40
UMSL—North to North Hanley	30
North Hanley to Berkeley	40 to 55
Airport Branch	40 to 55

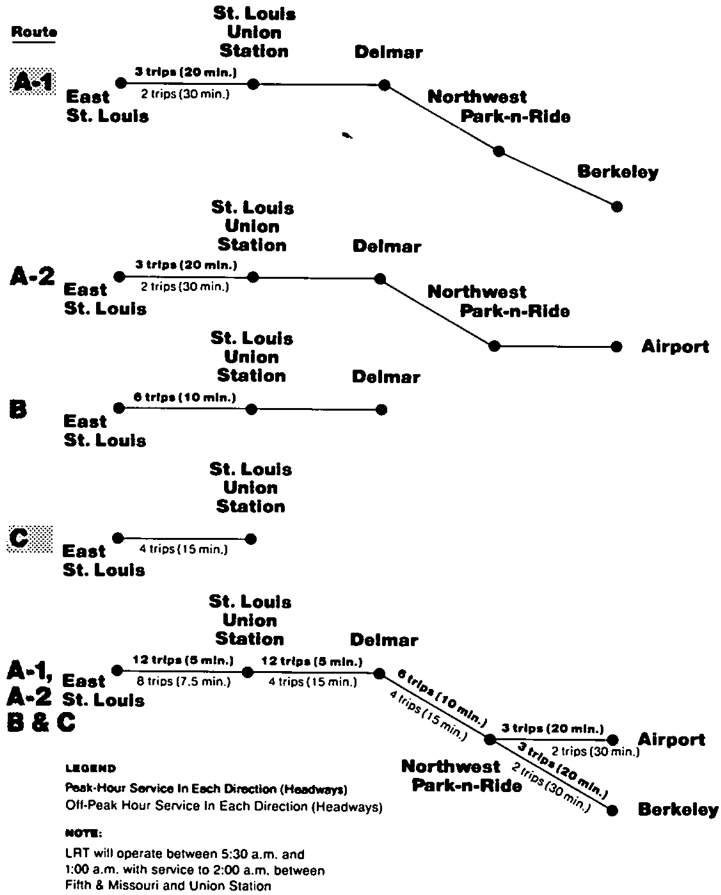


FIGURE 4 Metro Link year 2000 service and headways.

single-car consists will suffice for other peak and all or most off-peak services.

Based on the Metro Link operating plan, including a network of bus routes and services revised to interface with the LRT stations, ridership is projected at about 37,000 daily for the year 2000 (after some seven years of revenue service).

As with other new LRT systems in the United States, Metro Link will utilize a self-service proof-of-payment fare collection system. Fare inspectors will patrol the operation on board vehicles. The San Diego Trolley policy has been proposed in St. Louis as the model legal base for evader citation and enforcement (using the criminal versus civil code).

For system security, a metropolitan transit police force is under review. This police force could work directly for the bus and light rail operator, BSDA, and be augmented by local police departments through interagency agreements.

IMPLEMENTATION AND BUDGET

This section describes the schedule development for the Metro Link project for the final design, bidding, procurement, and construction of all elements of the project. Seven line section construction contracts provide for the basic construction of the 18-mi alignment, the structural elements of the 20 passenger stations, and 6 park-and-ride lots. One station-finish construction contract will provide for the architectural, mechanical, and electrical finish work for the 20 stations. The one yard and shops construction contract will provide for the vehicle maintenance, central control, and storage facility for the system. Four systemwide construction contracts will provide for the trackwork, signals and communications, traction power, and utility relocations. Three procurement contracts will provide for the LRVs, fare vending equipment, and service and maintenance equipment. Other contracts will provide for the consultant assistance for engineering, construction and procurement management, start-up, risk management, and legal counsel.

The schedule gives the sequence for construction and procurement efforts to complete the work, allows 6 months for vehicle and system testing and start-up, and targets revenue service for the end of 1992.

Acquisitions and easements of private properties, railroad properties, and other properties have been or are being finalized early to avoid delaying the construction efforts. Adequate time has been scheduled for long-lead procurements and for the coordination and work of contractors that must complete work within areas of other contracts.

UMTA funding to meet the cash-flow needs of the project to complete work and begin revenue service as scheduled is contractually delineated in a full funding grant agreement, subject only to congressional appropriations under the budget authority contained in the Federal Mass Transportation Act of 1987 (P.L. 100-17).

The final design effort has been organized, and will be completed, in accordance with milestone review and approval dates for 40, 60, 90, and 100 percent submittals for each individual construction contract. Preliminary engineering provided an aggregate 30 percent design level for all work. Therefore, the designated 40 percent review and approval milestone will serve as a midcourse correction checkpoint.

The bidding and award of construction contracts have been timed to provide sufficient time for necessary long-lead procurements and construction activities. The most critical are the design, manufacture, delivery, and acceptance of the LRVs. Other long-lead items have also been considered for their fit into the final design schedule planning. Detailed schedules for the various contracts will be completed early in the final design phase. The anticipated levels of other construction in the St. Louis metropolitan area during Metro Link project construction have been reviewed, revealing no problems in the construction labor market in terms of meeting the project's construction needs.

The systemwide contracts must be completed in partial segments that will coincide with the line segment contracts and their respective schedules, which have staggered starts and time periods. While it will not be possible to start systemwide contracts at one end and progress to the other within the time constraints necessary to meet the anticipated completion date of the project, the general availability of right-of-way will permit these contractors almost unrestrained intermediate scheduling.

The anticipated allocation of funds and the commitment of design and construction dollars based on the contract schedules have been evaluated. The awarded contracts require obligations slightly in advance, on average, of the UMTA grants. However, actual dollars paid out will be well within the UMTA grant cycles each fiscal year. Section 306 of the Federal Mass Transportation Act of 1987 specifically authorizes such advance obligations.

UMTA funds for federal fiscal years 1985, 1986, 1987, and 1988 have been appropriated. The funds for 1989 and beyond are delineated in the full funding grant agreement. This future funding provides a reasonable cushion for cash flow to continue construction to its scheduled completion. Obviously, if the anticipated funds for 1989 to 1991 are significantly varied or delayed, the completion date may be delayed and additional costs may be created for the total project due to continuing inflation additives and other delay costs. Figure 5 shows the capital cost to complete the Metro Link project, $287,699,046. That plus noncash assets contributed at the minimum local-share matching requirement level of 25 percent, or $95,899,682, brings the total to $383,598,728. For comparison purposes, Figure 6 distributes the capital expenditures by common LRT cost elements.

CONCLUSION

St. Louis has attracted nationwide attention by imaginatively recapturing the past and recreating it in modern and exciting fashion. Along the restored riverfront and in the rehabilitated commercial districts and in-town residential neighborhoods, new growth and prosperity have been created by a partnership between public and private interests. A transportation system that sets high standards of quality is needed to continue this revitalization. An LRT system is seen as the cornerstone of this new transportation system.

METRO LINK CAPITAL EXPENDITURE BUDGET

	In Millions
General Construction, Systems and Rights-of-Way	$136.0
Stations and Parking Lots	28.7
Light Rail Vehicles	57.1
Design, Construction Management and Administration	40.7
Contingency	25.2
Total Escalated Costs	*$287.7*

Dec. 1987 estimate

FIGURE 5 Metro Link capital expenditure budget.

In step with cost-conscious times, designers of the LRT system have crafted a practical plan for building this line by maximizing the use of existing bridges, tunnels, and track. This approach on an initial 18-mi line will meet several goals:

- Reduce construction cost by at least two-thirds;
- Virtually eliminate the social, economic, and environmental disruption that typically accompanies large-scale construction;
- Allow for a grade-separated rail operation with higher speeds and fewer delays;
- Reduce or eliminate negative transportation-caused environmental impacts;
- Rehabilitate the historic Eads Bridge and an ideally located downtown tunnel and reuse abandoned and underutilized railroad lines; and
- Ensure an effective core alignment from which prudent extensions can be efficiently deployed to serve every major travel corridor.

The St. Louis LRT project, Metro Link, is on the verge of being built and put into the planned dual mode (bus/LRT), fully integrated mass transit system. Urban rail transit in the region has been a long time in coming back. By simply adopting and adapting proven technical and operational experiences of other LRT systems to the unique alignment opportunity in St. Louis,

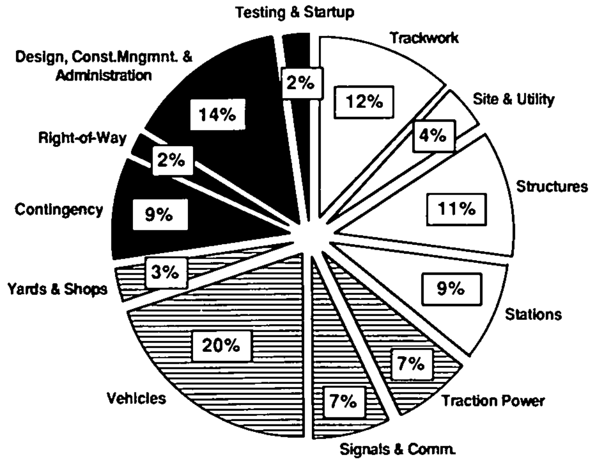


FIGURE 6 Metro Link capital cost breakdown.

Metro Link is feasible and cost-effective. In turn, LRT is the catalyst for a comprehensive restructuring of bus routes that produces a new start for improved public transportation service to the region.

ACKNOWLEDGMENTS

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