

Central Corridor Light Rail Transit Project; Minneapolis-St. Paul, MN

The Central Corridor Light Rail Transit (CCLRT) project added a second line to the light rail system in the Twin Cities. The 9.7-mile addition extends from a junction with the initial light rail line just east of downtown Minneapolis to a terminus in downtown St. Paul. The project emerged as the Locally Preferred Alternative (LPA) from an Alternatives Analysis/Draft Environmental Impact Statement prepared by the Ramsey County Regional Railroad Authority in 2006. The Metropolitan Council formally adopted the LPA and became the federal grantee and sponsoring agency for the project's development and construction.

The project entered Preliminary Engineering in December 2006, entered Final Design in May 2010, and was awarded a Full Funding Grant Agreement by the Federal Transit Administration in April 2011. The project opened to service in June 2014.

Metro Transit, a service of the Metropolitan Council, now operates the Green Line on the project as part of its regionwide bus and light rail system. Figure 1 is a map of the Central Corridor, the Green Line, and its junction with the Blue Line – the metro area's initial light rail line completed in 2004 as the Hiawatha Corridor light rail project. The Green Line shares the 1.2 miles of tracks and five stations in downtown Minneapolis that were built as part of the Hiawatha Corridor project. In this Before-and-After Study of the project, sections documenting its physical scope, its capital costs, and economic development in the corridor focus on the new 9.7-mile light rail facility. Sections on the project's impacts on transit service, operating costs, and ridership consider the entire 10.9-mile Green Line service, both on the project itself and on the shared tracks through downtown Minneapolis.



Figure 1. The Central Corridor and the Green Line

Physical scope

The CCLRT project is a 9.7-mile, double-tracked light rail line that runs entirely at-grade on arterials streets from just east of downtown Minneapolis to, and through, downtown St. Paul.

From its junction with the Blue Line, the CCLRT project proceeds to the east on Washington Boulevard through the West Bank campus of the University of Minnesota (UM) and uses the Washington Boulevard bridge to cross the Mississippi River. The alignment continues through the East Bank campus, in part through a 0.4-mile pedestrian mall established as part of the project on a segment of Washington Boulevard. After passing the UM stadium, the alignment uses the exclusive UM transit-way and an arterial street to reach University Avenue where it turns east for the next 5.5 miles. Tracks and stations are in the median except for the last half mile as the line approaches downtown St. Paul where it transitions to an alignment along the south side of University Avenue. Past the State Capitol and other government buildings and into downtown St. Paul, the line runs on arterial streets in former traffic lanes now reserved for transit. On the east side of downtown, the line's terminal station is at the multimodal center in Union Depot. Tail tracks extend two blocks further to the Operations and Maintenance Facility (OMF).

Throughout the CCLRT project, the tracks run in reserved rights-of-way, encountering traffic only at cross-street intersections. Except for a few short segments on ballast, the tracks are embedded in pavement with only the tops of the rails exposed. The alignment crosses four bridges – a new bridge built by the project over I-35W in Minneapolis; the existing Washington Avenue bridge over the Mississippi upgraded structurally as part of the project; and existing bridges over State Route 280 and I-94 in St. Paul.

The CCLRT project has 18 stations: one in the UM West Bank campus, two in the East Bank Campus, 11 on University Avenue, and four in the capitol and downtown areas of St. Paul. Station platforms are 270 feet long to accommodate three-car trains and are low-level to permit level boarding of trains without any special accommodation. Station platforms provide passenger shelters and off-board fare-collection equipment. None of the stations has a park-and-ride lot. Bus transfers at rail stations generally rely on sidewalk bus stops at cross-street corners.

The project encounters 43 signalized traffic intersections. All traffic signals give some level of priority to trains, ranging from full traffic pre-emption to extended green times for approaching trains, depending on the intersection and the time of day. A block signal system governs train spacing. Traction power is supplied to trains by overhead wire suspended from catenary supported by poles located between the tracks and 14 traction power substations spaced along the length of the corridor.

The OMF at the St. Paul terminus is a converted 183,000 sq. ft. warehouse building that provides for daily maintenance and storage of light rail vehicles as well as administrative offices.

The Project acquired 133 parcels for right of way, of which 70 were temporary easements for construction, 46 were permanent easements for transportation uses, and 17 were permanent acquisitions for stations, signal bungalows, traction power substations (TPSS), and the OMF.

The 47 vehicles acquired as part of the project are 90 feet long and double-articulated. Each vehicle is low-floor, provides 66 seats, and has a crush capacity of 196 passengers.

The anticipated scope identified at each project-development milestone was consistent with the as-built project in terms of its length and general alignment. At PE-entry, the anticipated scope was different from the as-built outcome for six elements of the project: (1) through the UM East Bank campus, a tunnel and two stations under Washington Avenue instead of the at-grade pedestrian-mall alignment actually built; (2) no structural modifications to the Washington

Avenue bridge versus the structural upgrades that were needed to support the introduction of train traffic; (3) the omissions of the stations that were built at Hamline Avenue, Victoria Street, and Western Avenue after litigation brought by the affected neighborhoods and a modification to FTA funding policy; (4) the absence of mitigation measures that were later added to the project scope to address vibration and electronic emission impacts on facilities at UM and Minnesota Public Radio (MPR) after litigation brought by both institutions; (5) a vehicle storage yard that omitted a vehicle maintenance facility and was located at a different site several blocks from the actual OMF location that provides for both storage and light maintenance; and (6) 31 light rail vehicles rather than the 47 actually purchased as part of the project scope after a post-FFGA decision to operate the Green Line on 10-minute peak-period headways with three-car trains rather than the earlier plan for 7.5-minute peak-period headways and two-car trains.

Preliminary engineering addressed most of the issues that caused these differences so that, at FD-entry, the only remaining differences in the anticipated scope were the mitigation of UM/MPR impacts and the number of rail vehicles. By the FFGA award, the mitigation elements had been added to the scope and only the number of vehicles was different from the actual outcome.

Capital cost

The actual cost of the project was \$926.5 million in year-of-expenditure (YOE) dollars – 56 percent for construction, 4 percent for land acquisition, 19 percent for rail vehicles, and 21 percent for professional services – with no expenditures for finance charges. Total YOE cost per mile was \$95.5 million, \$77.6 million per mile excluding the vehicles.

At PE-entry, the predicted cost was \$932.2 million in YOE dollars, less than 1.0 percent different from the actual cost. This YOE estimate derived from a 4.9 percent overestimate of baseline (constant dollar) costs -- equivalent to \$43 million YOE – offset by a similar underestimate of inflation costs. The baseline cost estimate was high because underestimates of the costs of site-work and special conditions, the OMF, and vehicles were more than offset by an overestimate of station costs and a 16 percent unallocated contingency allowance that was only partially needed to complete the project. Projected inflation effects were marginally low because of small underestimates of annual inflation rates (equivalent to -\$25 million YOE) and the length of the project-development schedule (-\$12.4 million YOE).

At FD-entry, the \$956.9 million cost estimate in YOE dollars overstated the actual project cost by \$30.5 million (3.3 percent). An overestimate of baseline costs by the equivalent of \$30.4 million YOE was the entire source of the difference. The estimate of inflation-related costs accurately matched the actual outcome (again, partly the result of small and offsetting differences, in this case an underestimated schedule and overestimated annual inflation rates). These baseline cost differences were the direct consequence of scope differences in the individual project elements along with a favorable bid climate in the early 2010s that helped to keep construction costs under control. The FFGA, awarded 11 months after FD-entry, relied on the same cost and schedule projections.

Transit service

The Green Line operated 24 hours per day with 10-minute headways across most of the day, seven days per week for the first five year after it opened in June 2014. (In August, 2019, Metro Transit ended Green Line service between 2:00am and 4:00am.) Headways are 20 to 60 minutes in early mornings and late evenings, again seven days per week. Trains consist of three cars on

weekdays and two cars on weekends. End-to-end runtime is 46.5 minutes at an average speed of 14.2 mph. Green Line schedules are coordinated with Blue Line service to facilitate the merge of the two lines at the junction into downtown Minneapolis.

Other east-west transit service in the Central Corridor includes: local Route 16 on University Avenue operating on 30-minute headways for most of the day between downtown St. Paul and the eastern edge of East Bank campus; local Route 6 operating through downtown Minneapolis and then on University Avenue to the eastern edge of the East Bank campus on 4-10 minute peak headways and 10-15 minute headways off peak; and express route 94 operating on I-94 between the Minneapolis and St. Paul downtowns on 4-to-10 minutes peak headways, and 10-15 minute headways off peak.

In both downtowns, bus connections to the Green Line are available to a large fraction of the transit system's routes, reaching out to most of the metro area. In the midway segment of the Central Corridor between the UM East Campus and downtown St. Paul, north-south bus routes on one-mile spacing (connecting to every other Green Line station) generally operate on 20-30 minute headways except for the A-Line Bus Rapid Transit service that offers 10-min headways.

Metro Transit made several changes to bus routes in the Central Corridor to reduce/eliminate service made redundant by the opening of the Green Line into the transit system, dropping the limited-stop Route 50 on University Avenue between the two downtowns, truncating local Route 16 at the East Campus, and reducing service on the Route 94 express between the two downtowns. Metro Transit increased service on the north-south streets in mid-corridor, adding new routes, rerouting some existing routes, and tightening headways. The service added on the north-south routes more than offset the service reductions on east-west routes, resulting in a five percent net increase in bus revenue-hours and an eight percent increase in bus revenue-hours.

The Central Corridor service plan in place through most of the project-development effort was generally representative of actual rail and bus service outcomes with some exceptions largely caused by revised operational decisions made after the FFGA award. The service plan anticipated rail service to: (1) operate on 7.5-minute peak-period headways rather than the 10-minute actual headways; (2) run two-car consists on weekdays versus the three-car consists now in service; and (3) require only 40.6 minutes to run its full length (benefitting from aggressive traffic signal priorities for trains) compared to the actual runtime of 46.5 minutes resulting from less aggressive signal priorities. The net effects of these differences are that the service plan marginally underestimated Green Line peak-period capacity, average passenger wait times at stations, the number of vehicles required, and the round-trip time for each train, and, therefore, the number of train-hours and train sets needed to maintain headways. The bus component of the plan anticipated substantial reductions in east-west service and little change in north-south service – in contrast to the modest east-west reductions and substantial north-south improvements that were in fact made. These differences were the product of a Central Corridor transit service study done after the FFGA in which public input showed significant support for improved north-south bus service.

O&M costs

The Green Line's fully allocated operating and maintenance costs in 2015, the first full year after opening, were \$30.2 million – 30 percent for vehicle operations, 18 percent for vehicle maintenance, 9 percent for other maintenance, and 43 percent for administration. Actual O&M

costs for bus service in the corridor increased by \$2.96 million (inflation adjusted) from before (2010) to after (2015) project opening – the net result of a \$13.6 million reduction for east-west routes and a \$16.5 million increase for north-south routes.

Predicted O&M costs throughout project development underestimated actual light rail costs by 20-29 percent – a direct result of the underestimates of the number of vehicles, train-hours, and train sets needed for Green Line service. This direct relationship was confirmed for this study by re-application of Metro Transit’s O&M cost model with the actual service requirements. The revised estimate of O&M costs was 6.6 percent higher than actual costs – a small difference that perhaps reflects modest economies of scale with the large expansion of all aspects of the light rail system. Analogously for bus O&M costs, cost predictions underestimated actual O&M costs in direct proportion to the underestimate of net bus service increases that occurred in the corridor.

Ridership

In April 2016, nearly two year after the Green Line opened to service, weekday ridership on the line averaged 40,400 trips. This count includes all trips that entered or exited Green Line trains at any of the 18 new stations or the five pre-existing stations in downtown Minneapolis shared with the Blue Line. Excluding the 2,000 trips on Green Line trains that are made entirely within downtown, ridership on the CCLRT project itself is 38,400 trips per average weekday.

A survey collected at that time provides insights into the characteristics of Green Line riders and their trips. Thirty-four percent of all Green Line trips are made between home and work, 17 percent are made by students between home and a college campus, 29 percent are made between home and other activities, and 20 percent are between two non-home locations. The large shares of non-work trips reflect both the diverse mix of land uses in the corridor and the multiple functions of Green Line service – as a commuter line for workers and college students in the Central Corridor, as a distributor of trips to the Corridor from outlying areas connecting to the Green Line in downtown Minneapolis or downtown St. Paul, and as a circulator for both residents and non-residents of the Corridor among its various activity locations.

Fifty-one percent of riders lived close enough to a Green Line station to be able to walk directly from home to the station while 40 percent used bus or train connections to travel between home and the line. Only six percent used park-and-ride. Some 84 percent of the park-and-ride trips used “hide-and-ride” parking near Green Line stations – at commercial lots or other parking facilities that were not part of the CCLRT project or specifically for transit users.

Responding to a 2016 survey, 72 percent of Green Line riders report that they were making a trip to and from the same locations as before the line opened to service. Nearly two-thirds of these riders previously made the trip on another transit route while one-third used a different travel mode – driving, ridesharing, walking, or biking. Of the 28 percent reporting that they are making an entirely new trip, more than a third have changed residence location and more than half are traveling to new activity locations. A large majority of these riders report that the opening of the Green Line influenced their choices of new residence and/or activity locations.

Four individual travel markets together represent nearly 80 percent of the 40,400 trips on the full length of the Green Line. By far, the largest comprises the 12,000 trips attracted to the University of Minnesota, 30 percent of the total. Trips in this market come from residence locations throughout the metro area, with the largest shares from areas in the Central Corridor

east of UM (34 percent), from locations within or near the UM campuses (19 percent), from downtown Minneapolis (13 percent), and from outlying areas connecting to the Green Line from buses and trains in downtown Minneapolis (18 percent). Half of the trips in this market are made by students and nearly a quarter by faculty and staff.

The 7,800 trips (19 percent of all Green Line ridership) attracted to downtown Minneapolis represent the second largest market, again drawn from residence locations throughout the metro area including the eastern end of the Central Corridor (37 percent), the UM campuses (17 percent), and other locations in St. Paul (15 percent). This market comprises 50 percent work trips, 23 percent circulation trips among non-home locations (notably within downtown and between downtown and the UM campuses), and from residences to non-work/non-school activities (19 percent).

Some 6,800 trips (17 percent) on the Green line are attracted to work and other activities in the eastern segment of the Corridor between (but not including) the UM East Campus and the state Capitol area. Nearly half of these trips are made by residents of this segment of the corridor and another quarter were made by residents of other areas in St. Paul. Fully half of these trips are to shopping and other non-work locations and one quarter are commutes to workplaces.

Finally, 5,400 trips (13 percent) are attracted to the Capitol area and downtown St. Paul, nearly half commuting to work, a third traveling to non-work activities, and the remainder circulating between non-home/non-work locations. Half of these trips are produced in residential neighborhoods in the eastern end of the Corridor but nearly one-fifth come from outlying areas via trains and buses to connect in downtown Minneapolis to the Green Line and then riding its full length to downtown St. Paul.

Ridership forecasts prepared for the FFGA milestone predicted 32,400 weekday trips on the Green Line in its opening year, an underprediction by 8,000 trips (20 percent) of the actual 40,400 ridership. This prediction was low even though the Green Line service characteristics on which it was based were turned out to be optimistic: running speed was faster and peak-period service was more frequent than in the outcome.

The underprediction had two principal causes. First, the forecast largely missed the significant numbers of Green Line trips produced by, attracted to, and made within the midway part of the corridor – the segment between the UM East Campus and the Capitol area in St. Paul. Second, the forecast did not anticipate the large numbers of non-work trips on the Green Line for travel from home and to shopping and other activities, and between non-home locations. To a large extent, these two difficulties overlap; for example, much of the ridership that the forecast missed in the midway segment is for non-work purposes. And they distort the predicted characteristics of Green Line riders, missing many of the lower income and carless riders actually using the line.

The underpredictions for these markets were partially offset by too-high forecasts of Green Line trips by (1) students traveling to UM and (2) residents of areas outside the Central Corridor, particularly riders from outlying areas predicted to rely on park-and-ride access to the transit system.

These findings highlight the importance of testing and refinement of ridership forecasting tools against transit rider data, particularly where the regional transit system includes fixed guideways. The regional travel model used to prepare the Green Line ridership forecasts was based on rider data obtained before the opening of the Twin Cities' first rail line in the Hiawatha Corridor –

since renamed the Blue Line. Rider data collected after the Hiawatha Line opened came too late to support model refinement before the CCLRT forecasts were needed. Given that forecasts from the same regional travel model prepared for the Hiawatha Corridor project also turned out to be low, tests of the model against Hiawatha ridership outcomes might have led to useful model refinements and a closer forecast for the CCLRT project.

In any case, the Metropolitan Council now has comprehensive rider data that provide details on system-wide transit trips using buses, light rail and commuter trains, and bus rapid transit lines. Based on the analysis of the Central Corridor ridership forecasts completed in this study, the Council's priorities for possible refinements to the travel models and forecasting applications include: non-home-based (circulation) trips on fixed guideways; special markets, including university students and the unique parking policies and transit fares that affect their travel decisions; the prediction of household auto-ownership choices; the extent to which hard-to-measure fixed-guideway characteristics (visibility, reliability, comfort, etc.) not specifically represented in travel models affect ridership, particularly for non-work travel; changes in origin-destination travel patterns in response to major changes in the transit system; the prediction of underlying travel patterns for all travelers, not just transit riders; and closer attention to opening year forecasts, particularly demographic changes that may occur by the opening year.