

Technical Memorandum: Evaluation of Proposed Downtown St. Paul LRT Loop

DRAFT



December 7, 2006

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Evaluation of Proposed Downtown St. Paul LRT Loop

Executive Summary

Any light rail alignment is a compromise based on ridership, costs, economic development impacts, community desires, and federal cost-effectiveness requirements. This technical memorandum provides an assessment of a loop configuration for the Central Corridor light rail transit (LRT) project in downtown St. Paul. It also compares the loop alignment with the approved Locally Preferred Alternative (LPA) for the project, as summarized in Table 1.

In summary, the loop has the following advantages and disadvantages when compared to the Cedar and 4th alignment for the LPA:

Advantages

- Reduces walking distance to some major generators and special event venues throughout downtown area
- Reduces utility relocations and impacts
- Eliminates impacts on Cedar and 4th
- Only Second Street is closed to vehicular traffic
- Parking issues on streets where loop operates are less severe due to single-track operation in mixed traffic
- Provides access to track level of Union Depot.

Disadvantages

- Increases walking distance to major employers in downtown core area
- Since loop only operates in one direction, round-trip travel times are longer for all downtown passengers since they must back-track in one direction or the other
- Has higher capital (+\$49 million) and operating (+\$1 million per year) costs
- Decreases Central Corridor LRT ridership by 5,000 to 6,000 boardings per day
- Impacts more streets than LPA alternative due to longer route
- In order to maintain schedule reliability, a layover needs to be included in the loop that will delay customers
- More difficult to extend other LRT lines from Union Depot and limits commuter rail capacity of the Depot
- Not as cost effective as LPA.

Conclusion

The loop alignment raises FTA's Cost Effectiveness Index (CEI) from \$24.84 to between \$26.42 and \$27.27. The project needs to be under \$23.00 to receive a recommendation for federal construction funding. The loop alignment provides some benefits, but does not perform as well as the LPA from a ridership and cost perspective.

Table 1: Summary of LPA versus LRT with Downtown Loop

	LPA	LRT with Loop
Characteristics		
Length in Downtown St. Paul (feet)		
• One-way route	8,580	17,360
• Single track	17,160	17,360
Number of Curves Less Than 25 MPH	8	11
Number of Stations in Downtown St. Paul	5	9
Peak Weekday Headways (minutes)	7.5	7.5
Operating Run Times (minutes)		
• End-to-end for entire LRT line (one-way)	39.5	41.5
• Rice St. Station to Union Depot (one-way)	9.5	11.5
Layover Times (minutes)		
• Minneapolis Multi-modal Terminal	6	6
• St. Paul Union Depot ¹	12.5	8.75
Average Weekday Boardings (with / without layover)		
Downtown St. Paul Stations	6,430	1,940 / 2,770
Entire LRT Line	43,330	37,460 / 38,180
Systemwide Bus and LRT	65,100	65,900 / 66,150
Passenger Travel Times (with / without layover)		
Travel Time Savings (hours of user benefits)	7,805	7,503 / 7,746
Travel Times to Minneapolis from: (minutes)²		
• Rice Street Station	46	46 / 46
• Union Depot	48	52 / 52
• 6th and 7th streets (just east of Mears Park)	47	46 / 46
Travel Times from Minneapolis to: (minutes)²		
• Rice Street Station	46	46 / 46
• Union Depot	48	55 / 55
• 6th and 7th streets (just east of Mears Park)	47	69 / 60
Costs (in millions)		
Annual O&M Costs (2006 \$)	\$52.3	\$53.2
Total Capital Costs (2006 \$)	\$818	\$860
Total Capital Costs (year of expenditure 2014 \$)	\$932	\$981
Cost Effectiveness (with / without layover)		
Incremental Cost per Hours of User Benefits³	\$24.84	\$27.27 / \$26.42

¹Loop layover at St. Paul Union Depot is at mid-loop, causing a delay for passengers continuing on their trip; LPA layover at Union Depot occurs at the end-of-the-line, with all passengers deboarding.

²Includes travel time on train, as well as wait time at stations and walk time to ultimate origin and destination.

³FTA's threshold to enter preliminary engineering is \$28.99 and \$22.99 for final design and construction.

Source: DMJM Harris, AECOM Consult and Connetics Transportation Group, 2006.

Evaluation of Proposed Downtown St. Paul LRT Loop

Overview

This technical memorandum evaluates an alternative loop alignment in downtown St. Paul for the Central Corridor light rail transit (LRT) project. It assesses ridership and travel time impacts in comparison to the approved Locally Preferred Alternative (LPA). Conceptual level operating and capital cost estimates also were developed and compared to the LPA. This information was then used to determine the cost effectiveness of LRT with the proposed downtown loop. Key issues associated with the proposed LRT loop alternative are also described, leading to a summary of the findings and overall conclusions of the analysis.

Description of Alternatives

This section provides a brief description of the Central Corridor LRT project for the LPA in downtown St. Paul, as outlined in the Draft Environmental Impact Statement (DEIS). The downtown St. Paul loop is then defined, including the alignment, stations, and operating assumptions. This information was used to calculate the operating and capital costs, as well as the ridership of the loop. For comparison, the LPA's costs and ridership projections were derived from the DEIS and New Starts Report for the Central Corridor LRT project.

Alignment and Stations

Locally Preferred Alternative

The LPA alignment in downtown St. Paul from the Rice Street Station to the Union Depot is 8,580 route feet or 17,160 feet of single track, as delineated in Figure 1. It is a linear, bi-directional alignment that contains five stations within the downtown St. Paul central business district (CBD). Generally, the LPA alignment follows University Avenue from Rice to Robert Street; Robert Street from University to 12th Street; 12th Street from Robert to Cedar Avenue; Cedar Avenue from 12th to 4th Street; and 4th Street from Cedar to Wacouta Street. LRT trains would run in a dedicated right of way for the LPA, with a loss of most of the on-street parking along the route in downtown St. Paul.

To accommodate dedicated running of LRT on University Avenue from Rice to Robert streets, the roadway would include one or two traffic lanes in each direction with no on-street parking. On Robert and 12th streets, the LRT guideway would be placed between the traveled way and sidewalk. All existing cross streets would remain open to automobile and pedestrian traffic movements through the intersection. On-street parking would be eliminated on both streets. On Cedar Avenue, LRT is in the center median from 12th to 10th streets. South of 10th Street, the LRT guideway would be located on the east side of the street, remaining in this configuration to 4th Street. Cedar Avenue would be reduced to one lane of traffic from 10th to 5th streets and

would be closed between 5th and 4th streets to allow the LRT tracks to transition into a curve at 4th Street. On 4th Street LRT would be on the south side of the street with one lane of traffic. Fourth Street would be closed between Minnesota and Robert streets to accommodate station platforms.

The configuration and location of the five LPA stations in downtown St. Paul would be as follows:

- Capitol East: Two side platforms on 12th Street west of Robert Street
- 10th Street: Two side platforms in median between 11th and 10th streets at Cedar Avenue
- 6th Street: Two side platforms between 7th and 6th streets at Cedar Avenue
- 4th Street: Two side platforms on 4th Street between Robert and Minnesota streets
- Union Depot: Center platform with pocket track and an additional platform at 4th Street in front of the Union Depot

Downtown St. Paul Loop

The proposed LRT alignment is a one-way loop in downtown St. Paul, as shown in Figure 2. It is 17,360 feet or 3.3 miles in length and contains nine stations. More detailed plan and profile drawings of the downtown loop are found in Appendix A, with the typical cross sections in Appendix B.

In general, the loop alternative would follow existing streets from the intersection of University Avenue at Rice Street circulating around the St. Paul CBD in a counterclockwise direction. The alignment would be single track, with the exception of a double track at the Union Depot Station. The second track at this location would serve as a layover area for trains. LRT operations would be a combination of running within the street right of way in mixed flow with automobile traffic and in dedicated lanes. The shared running operating scenario is proposed in locations of limited right of way and where there is a need to preserve curbside parking. On the other hand, potential impacts to traffic and on-time performance of LRT trains could be incurred with shared running. For the dedicated lane portion of the alignment, there would be a need to eliminate curbside parking, reduce the number of traffic lanes or widen existing streets, which would be more disruptive and more costly. A detailed traffic and parking assessment would need to be conducted to determine the exact locations of the two operating scenarios.

The downtown St. Paul loop also provides greater geographic coverage, with more direct walk access to some major activity centers such as the Cathedral, Xcel Energy Center, Science Museum, Regions Hospital, etc. However, travel times and walking distances to other job concentrations in the center of downtown are much further with the loop than the LPA. Other operational challenges exist that impact the efficiency and effectiveness of the LRT system with the loop. These trade-offs are further analyzed and described in this report.

Figure 1: Locally Preferred Alternative LRT Alignment and Stations

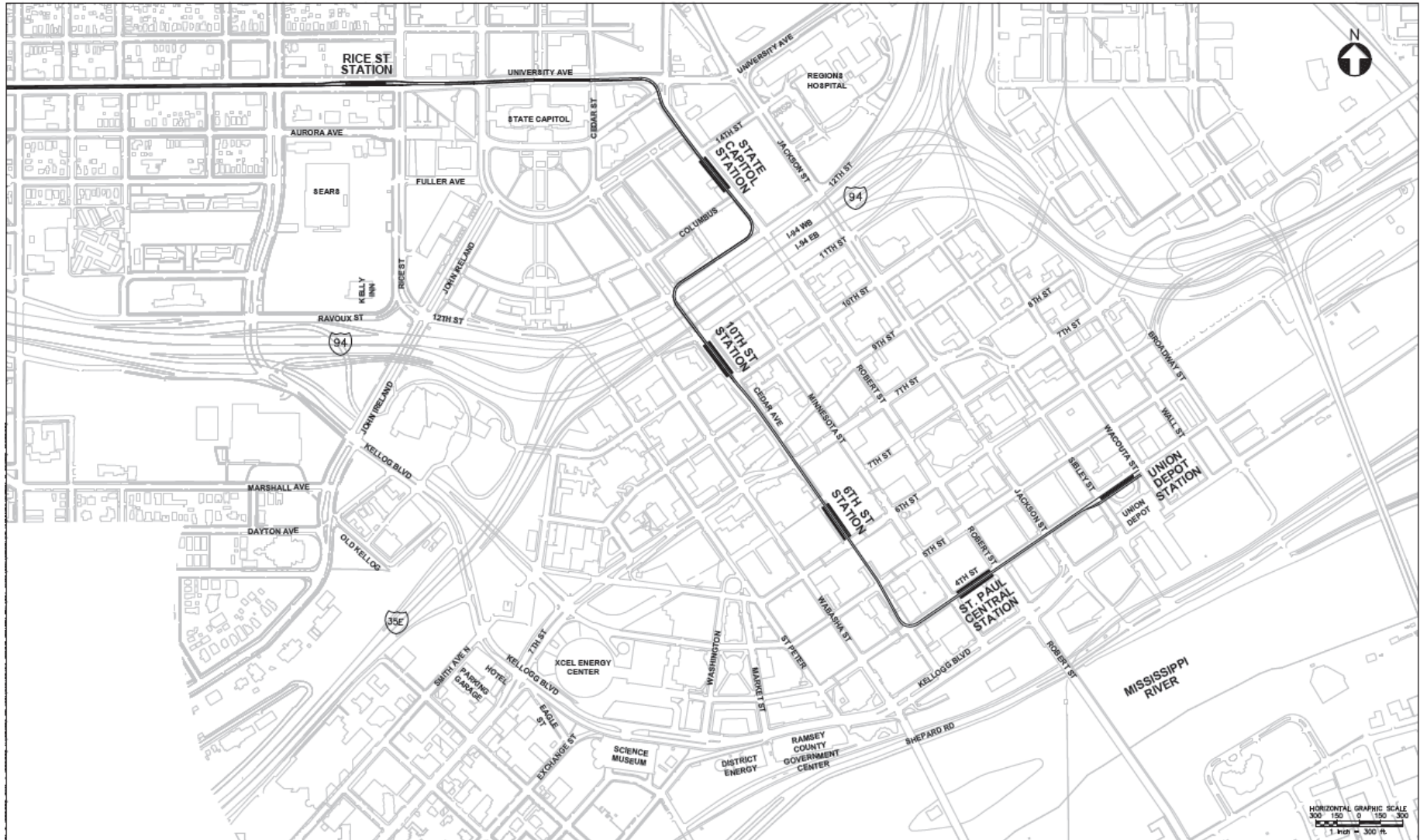
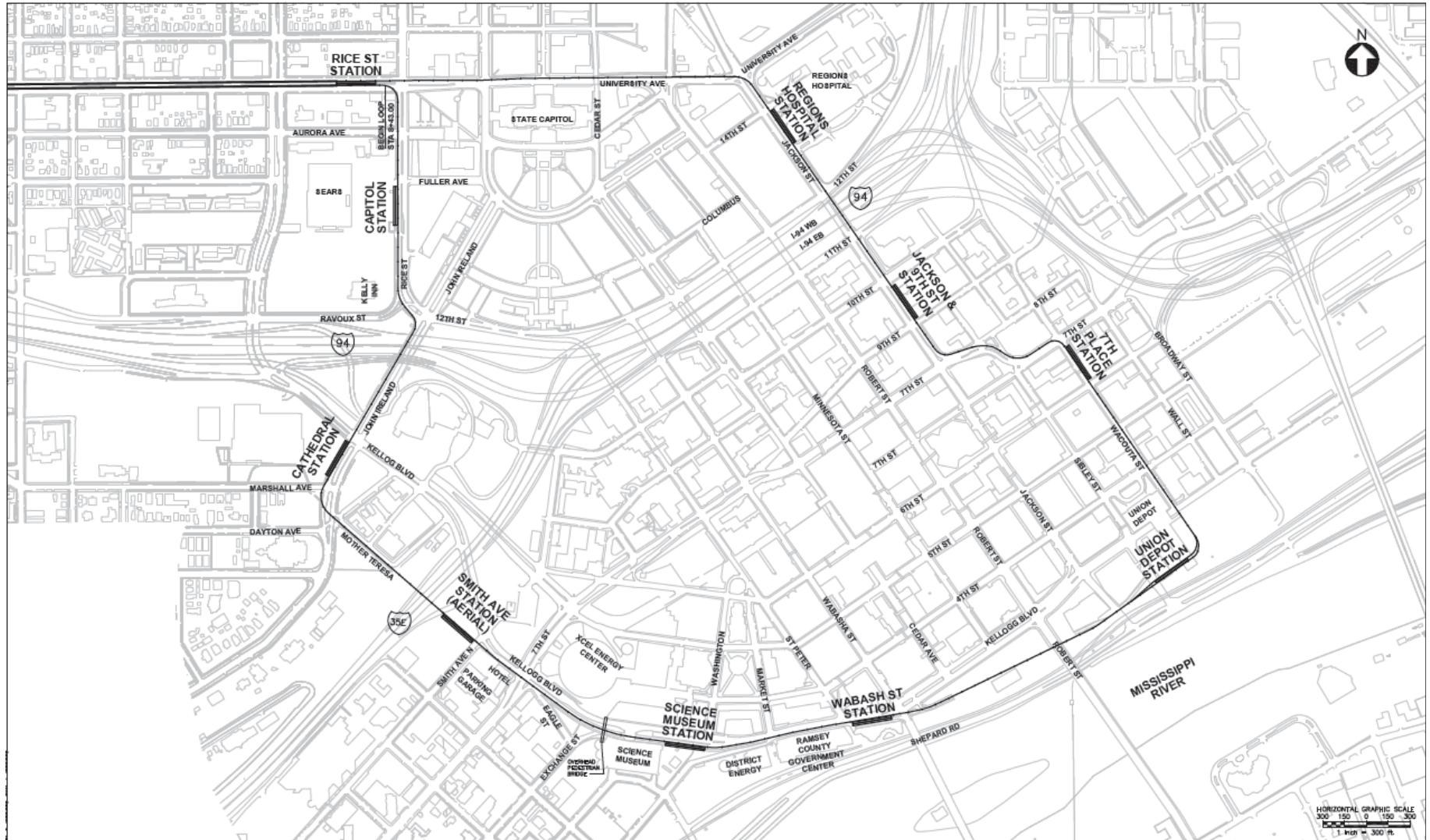


Figure 2: Downtown St. Paul LRT Loop Alignment and Stations



The one-way loop would operate as follows:

- East of the originally proposed station at University and Rice, the eastbound track would turn right onto Rice Street, deviating from the approved LPA alignment. As shown in the Typical Section A in Appendix B, the LRT track would be situated in the right travel lane, leaving sufficient room for parking or passenger drop off along the curb. A platform for the Capitol Station would be located just south of Fuller Avenue, adjacent to the Sears department store. The platform would be an extension of the sidewalk modified to allow boarding on the low floor light rail vehicles (LRV), as shown in Typical Section B. Beyond this station at Fuller, the line would continue south on Rice, then turn right (southeast) onto John Ireland Boulevard.
- The LRT track would then cross over Interstate 94 on the existing structure. Further study would be needed to determine if the existing bridge could be modified to accommodate embedded track, which allows motor vehicles to drive on the track. If this is not feasible, other options are available including elimination of one lane, conversion of the median to a traffic lane, or placing the track on top of the deck within the bike lane. The Cathedral Station would be located just past Kellogg Boulevard. Beyond this station the line would turn to the left, crossing John Ireland, and follow along the south side of Mother Teresa Way. In this section of the line, the track is situated along the back side of the exiting sidewalk because the right of way is relatively narrow (Typical Section C).
- East of College Avenue, the LRT track would be placed on a structure to cross over Interstate 35E (Typical Sections D, E and F). Just east of the I-35E off ramp, the line would enter a Smith Ave. Station, located within an existing parking lot that serves United Hospital. This station would be aerial because of the proximity to the freeway off ramp, which requires the line to be grade separated. The aerial station would require two means of egress as well as ADA accessibility (ramps or elevators). The aerial alignment continues east, crossing over Smith Avenue, 7th Street, and Eagle Street. Columns supporting the aerial structure would be placed along the edge of curb, allowing two lanes of street traffic on Kellogg Boulevard in each direction.
- Just east of Eagle Street the line would drop down over a distance of approximately 600 feet at approximately 5 percent grade, which is the minimum distance required to meet the regional LRT design criteria. The existing pedestrian bridge serving the Xcel Energy Center would require relocation because of conflicts with the aerial structure. The track would drop down to the street surface in front of the Science Museum, entering a station just west of Washington Street. The line would then continue east along Kellogg, entering a Wabasha St. Station just east of the Ramsey County Government Center West.

- Just past Wabasha Street the line would veer to the right, entering the 2nd Street right of way. The embedded LRT track would be located along the right side of the street, which allows parking to be maintained along the left side. The line would continue east into the covered portion, passing under Robert Street (Typical Section G). Just west of Jackson Street, the track would veer to the right, transitioning onto a structure to cross over Jackson Street (Typical Section D). After crossing Jackson, the track would be placed on the existing deck that was built as part of the Union Depot complex (Typical Section H). A Union Depot Station would be located between Sibley Street and the old overhead concourse. It would include two tracks so that trains entering the platform area can alternate between each, thereby allowing them to layover for short periods of time (Typical Section I). This station layout would reduce the number of through railroad tracks and platforms that the Union Depot could accommodate in the future.
- Beyond the Union Depot Station, the line turns north to align with Wacouta Street. The track would be placed on an aerial guideway from the edge of the Union Depot deck along Kellogg Boulevard to just south of 4th Street (Typical Section D). The line would transition to embedded track at 4th and continue north within the Wacouta Street traffic lane. Curb side parking would be maintained along this segment (Typical Section J). A 7th Place Station would be situated between 6th and 7th streets. This station would be similar to other stations where the sidewalk is extended and raised to allow low floor boarding (Typical Section K).
- The line would turn west onto 7th Street and then north onto Jackson Street. A Jackson & 9th St. Station would be located between 9th and 10th streets. The line then continues north over the existing I-94 bridge. The same issues with the existing John Ireland Bridge apply at this location as well. Continuing north past 12th Street, the alignment enters a station just past the main entrance to Regions Hospital.
- North of the Regions Hospital Station the track would veer west at University Avenue, occupying the curb side traffic lane (Typical Section A). There may be a clearance issue at the Cedar Street over crossing, which may require a shift in the track alignment to the center of the street. The line continues west to Rice Street and then transitions to the median through the intersection of University and Rice joining the original LPA alignment.

Operating Plan

This section describes the operations plan required for the proposed loop alignment, provides a comparison to the existing LPA alignment in St. Paul, and identifies operating requirements (i.e., annual car and train miles and hours and peak LRVs). The operations plan has been developed using the following steps:

- Confirmation of loop configuration alignment characteristics (i.e., in-street versus aerial structure, curbside versus median, signalized intersections, etc.) and proposed station locations;

- Measurement of alignment segment distances, including station to station distances, distances between alignment curves, curve lengths and anticipated curve radii (see Table 2), in-street running versus exclusive/aerial structure segment lengths, and alignment length between signalized intersections;

Table 2: Curves for LPA versus Downtown St. Paul Loop

Curve Location ¹	Radius (feet)	Speed (mph)
LPA Curves²		
University at Robert	110	10
Robert at 12th	100	10
12th at Cedar	100	10
Cedar at 4th	90	10
St. Paul Loop Curves		
University at Rice	100	10
Rice at Ravoux	200	14
Rice at John Ireland	100	10
John Ireland at Mother Teresa	150	12
Kellogg at Washington	380	20
Union Depot	100	10
Wacouta at 7th	100	10
7th at Sibley	150	12
7th at Temperance	200	14
7th at Jackson	100	10
Jackson at University	150	12

¹Reflects curves less than 25 mph in downtown St. Paul.

²LPA alignment operates in both directions through the curves.

Source: DMJM Harris, 2006.

- Development of light rail transit run time estimates utilizing alignment segment lengths, station locations, curve locations and radii, alignment characteristics (i.e., in-street versus aerial structure), maximum speed limits on roadways traveled within downtown St. Paul, establishing station dwell times and signal delay times, LRT vehicle acceleration and deceleration rates; and
- Development of operating requirements, including daily and annual train and car miles and hours and peak and fleet light rail vehicle requirements.

LRT Run Time Estimates for Downtown Loop

Table 3 presents LRT station-to-station run times for the downtown St. Paul loop. These estimates are based on alignment characteristics described above. Key assumptions that were used in the development of these run times are consistent with the original LPA.

Table 3: LRT Run Times for Downtown St. Paul Loop

Station	Max Speed (mph)	Distance		Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
		Miles	Total				
University & Rice			0.00			0:00:00	0:00:00
<i>Begin Curve</i>	10	0.02	0.02	0:00:09	0:00:00	0:00:00	0:00:09
<i>End Curve</i>	5	0.03	0.05	0:00:18	0:00:20	0:00:00	0:00:47
Capitol	20	0.15	0.20	0:00:33	0:00:00	0:00:20	0:01:40
<i>Begin Curve</i>	20	0.10	0.30	0:00:21	0:00:00	0:00:00	0:02:01
<i>End Curve</i>	20	0.04	0.34	0:00:07	0:00:00	0:00:00	0:02:08
<i>Begin Curve</i>	20	0.01	0.34	0:00:01	0:00:00	0:00:00	0:02:09
<i>End Curve</i>	5	0.02	0.36	0:00:05	0:00:20	0:00:00	0:02:34
Cathedral	20	0.22	0.57	0:00:44	0:00:20	0:00:20	0:03:58
<i>Begin Curve</i>	5	0.01	0.58	0:00:05	0:00:00	0:00:00	0:04:03
<i>End Curve</i>	20	0.08	0.66	0:00:16	0:00:00	0:00:00	0:04:19
Smith Ave.	30	0.21	0.87	0:00:31	0:00:00	0:00:20	0:05:10
<i>Begin Curve</i>	20	0.20	1.06	0:00:39	0:00:40	0:00:00	0:06:29
<i>End Curve</i>	20	0.03	1.09	0:00:05	0:00:00	0:00:00	0:06:34
Science Museum	20	0.09	1.18	0:00:19	0:00:20	0:00:20	0:07:33
<i>Begin Curve</i>	15	0.05	1.24	0:00:15	0:00:20	0:00:00	0:08:08
<i>End Curve</i>	15	0.05	1.29	0:00:12	0:00:00	0:00:00	0:08:20
Wabasha Street	20	0.16	1.45	0:00:32	0:00:40	0:00:20	0:09:52
Union Depot	30	0.46	1.91	0:01:06	0:00:20	0:00:30	0:11:48
<i>Begin Curve</i>	10	0.01	1.92	0:00:06	0:00:00	0:00:00	0:11:54
<i>End Curve</i>	5	0.02	1.94	0:00:16	0:00:00	0:00:00	0:12:10
7th Place	20	0.30	2.25	0:01:00	0:01:00	0:00:20	0:14:30
<i>Begin Curve</i>	5	0.01	2.25	0:00:04	0:00:00	0:00:00	0:14:34
<i>End Curve</i>	15	0.03	2.28	0:00:07	0:00:20	0:00:00	0:15:01
<i>Begin Curve</i>	20	0.03	2.31	0:00:06	0:00:00	0:00:00	0:15:07
<i>End Curve</i>	20	0.03	2.34	0:00:05	0:00:20	0:00:00	0:15:32
<i>Begin Curve</i>	20	0.02	2.36	0:00:03	0:00:00	0:00:00	0:15:35
<i>End Curve</i>	20	0.03	2.39	0:00:06	0:00:00	0:00:00	0:15:41
<i>Begin Curve</i>	20	0.03	2.42	0:00:05	0:00:00	0:00:00	0:15:46
<i>End Curve</i>	20	0.02	2.44	0:00:04	0:00:20	0:00:00	0:16:10
Jackson & 9th Street	20	0.04	2.48	0:00:10	0:00:00	0:00:20	0:16:40
Regions Hospital	20	0.26	2.74	0:00:54	0:01:20	0:00:20	0:19:14
<i>Begin Curve</i>	5	0.00	2.74	0:00:03	0:00:20	0:00:00	0:19:37
<i>End Curve</i>	10	0.04	2.79	0:00:15	0:00:20	0:00:00	0:20:12
University & Rice	25	0.51	3.30	0:01:20	0:01:00	0:00:20	0:22:52
TOTAL		3.30	3.30	0:11:02	0:08:20	0:03:30	0:22:52
Source: Connetics Transportation Group, 2006.						Average Speed	8.66

Following are the assumptions used to develop the operating plan for the loop alignment in downtown St. Paul:

- The maximum acceleration rate is 3.0 miles per hour per second (mphps), with a diminishing acceleration curve at higher speeds (speeds over 25 miles per hour). A constant 3.0 mphps deceleration rate is assumed;
- Twenty second dwell times were assumed at all downtown stations except Union Depot. A 30 second dwell was assumed at Union Depot;
- Maximum in-street speeds are based on posted speed limits; and
- Twenty second average delays were assumed at all signalized street crossings.

Based on these operating assumptions, the estimated one-way travel time along the loop alignment to and from the Rice Street Station is about 23 minutes. This equates to 8.66 miles per hour (mph) average line operating speed. Typically, LRVs have an average speed between 8 and 9 mph when operating in a downtown environment (based on average downtown LRV speeds in San Diego, Salt Lake City, Denver, Minneapolis, Dallas, and Sacramento). The LRT system in Sacramento has sections of shared running, similar to the assumptions for the loop alignment in downtown St. Paul.

LRT Run Time Comparison of LPA to Downtown Loop

To compare the LRT run times for the linear, bi-direction alignment of the LPA to the alternative downtown St. Paul loop, the Union Depot Station is assumed to be the end-of-the-line. The average of the existing LPA bi-directional alignment for the full route of the Central Corridor LRT project from 5th Street and 3rd Avenue in Minneapolis to Union Station is 39 minutes and 30 seconds. By comparison, the loop alignment is 41 minutes and 22 seconds, or about 1 minute and 52 seconds longer. Table 4 displays a comparison of run times between the two alignments, as well as estimated layover time at both end-of-the-line stations. Travel time west of the Rice Street Station is identical for each scenario.

Both the LPA and downtown St. Paul loop can be operated within the same train cycle time of 97 minutes and 30 seconds (e.g., round trip travel time plus layover time). However, the loop alignment requires about 3 minutes and 45 seconds more round trip travel time, thus reducing time allocated to layover time (noted in Union Depot layover time in Table 4). Although layover at the Union Depot is reduced for the loop alignment, it now occurs at a location of the rail line with passengers still on the train waiting to travel to their final destinations. Under the LPA, layover time is placed and accommodated at the end-of-the-line location where all transit riders depart the train to their final destinations.

Table 4: LRT Run Times and Layovers for LPA and Downtown St. Paul Loop

Alignment Segment	Time for LPA	Time for LRT with Loop
One-way Trip Travel Time		
Full Central Corridor LRT Line	39 minutes, 30 seconds	41 minutes, 22 seconds
Rice St. Station to Union Depot	9 minutes, 34 seconds	11 minutes, 26 seconds
Layover Time		
Layover for Minneapolis Multi-Modal Terminal ¹	6 minutes	6 minutes
Layover for St. Paul Union Depot ²	12 minutes, 30 seconds	8 minutes, 45 seconds
Round Trip Travel Time to/from Rice St. Station		
With Mid-Loop Layover at Union Depot	NA	31 minutes, 37 seconds
Without Mid-Loop Layover at Union Depot	19 minutes, 8 seconds	22 minutes, 52 seconds
Train Cycle Time		
To/From Minneapolis Multi-modal Terminal	97 minutes, 30 seconds	97 minutes, 30 seconds

¹Constrained by interlining of both Hiawatha and Central Corridor operating at 7.5 minute headways.

²Loop layover at St. Paul Union Depot is at mid-loop; LPA layover at Union Depot occurs at the end-of-the-line.

Source: Connetics Transportation Group, 2006.

Rail lines are not typically designed with loop alignments. However, those that are built in this fashion would attempt to place all layover time at the non-loop end of the alignment to eliminate passenger delays caused by mid-loop layovers. The Central Corridor would be constrained from placing all layover time at the Minneapolis end-of-the-line due to a common terminal station with Hiawatha, where the two lines would be interlined (e.g., linked together with trains traveling between the two lines). Thus, some amount of layover time was assumed on the St. Paul end. Layover time placed at any of the loop alignment stations would result in some passengers waiting through a layover before reaching their destination. Riders boarding prior to Union Depot and traveling to the 7th Place, Jackson & 9th St., and Regions Hospital stations would be required to wait at the Union Depot for an additional 8 minutes and 45 seconds of layover before proceeding to these destinations on the loop or any other location continuing west towards Minneapolis. Those same boarders heading westbound would also have to backtrack about a mile to the east before beginning their westward journey. This mid-loop layover and circuitous route pattern would not be desirable for LRT riders.

Operating Plan Requirements

LPA Operating Plan

Table 5 presents estimates of the Central Corridor LRT operating statistics with the LPA. Two-car trains have been assumed for all time periods on weekdays and one-car trains on weekends. Overall, Central Corridor LRT service with 7.5-minute peak period service frequencies and 2-car trains requires 26 cars. This car requirement is based on the peak period service frequency and the estimated round trip cycle time. The round trip cycle time includes end-of-the-line layover time. Approximately 19 percent or 18 minutes and 30 seconds of the round trip cycle time has been reserved for end-of-the-line layovers. The estimated fleet requirement is 31 cars, with a 20 percent spare ratio.

Downtown St. Paul Loop Operating Plan

Table 6 presents estimated LRT operating statistics for the proposed downtown St. Paul loop alignment. The same two-car trains have been assumed for all time periods on weekdays and one-car trains on weekends. Overall, Central Corridor LRT service with 7.5-minute peak period service frequencies and 2-car trains requires 26 cars, which is no change from the LPA. Although a lower amount of layover is assumed for the loop alignment as a result of higher run times (15 versus 19 percent), this total layover time of 14 minutes and 45 seconds still meets the minimum layover of 15 percent of the total travel time. The estimated fleet requirement is also 31 cars, with a 20 percent spare ratio.

Even though run times are slightly higher for the loop alignment, layover time is reduced to compensate for this difference, while still maintaining 15 percent preferred layover time. This negates the need for additional peak and fleet vehicles; however, one more train set may be needed if all layover is shifted to the Minneapolis end-of-the-line. Annual weekday service hours remain the same between the two alignments, where as annual car-miles increase by 5,330 due to a slightly longer alignment for the loop configuration. Weekend service however is impacted both in car-hours and car-miles. The additional run time required to complete the loop alignment decreases the layover time requirement below the 10 percent minimum on weekends, thus requiring 10 one-car trains to maintain the 10 minute design service frequencies versus the 9 one-car trains required for the LPA linear, bi-directional alignment. Weekend car-hours and car-miles increase annually by 2,180 and 1,040, respectively as a result of a slightly longer alignment for the loop configuration. Overall, the loop alignment requires 2,180 additional annual car-hours and 6,370 car-miles.

Table 5: Central Corridor LRT Operating Plan for LPA

From	To	Run Time (minutes)	Distance (miles)	Day	Headway				Consist				Vehicles		Annual		
					Peak	Base	Eve.	E/L	Peak	Base	Eve.	E/L	Peak	Total	Car-Miles	Car-Hrs	Train-Hrs
Minneapolis Multi-Modal Terminal	St. Paul Union Depot	39.50	10.67	M-F	7.5	10	10	10	2	2	2	2	26	31	1,420,390	110,080	55,040
				Sat	n/a	10	10	10	0	1	1	1			130,600	9,180	9,180
				Sun	n/a	10	10	10	0	1	1	1			148,530	10,440	10,440
ESTIMATED ANNUAL TOTALS:												26	31	1,699,520	129,700	74,660	

Source: Connetics Transportation Group, 2006.

Table 6: Central Corridor LRT Operating Plan with Downtown St. Paul Loop

From	To	Run Time (minutes)	Distance (miles)	Day	Headway				Consist				Vehicles		Annual		
					Peak	Base	Eve.	E/L	Peak	Base	Eve.	E/L	Peak	Total	Car-Miles	Car-Hrs	Train-Hrs
Minneapolis Multi-Modal Terminal	St. Paul Union Depot	41.37	10.71	M-F	7.5	10	10	10	2	2	2	2	26	31	1,425,720	110,080	55,040
				Sat	n/a	10	10	10	0	1	1	1			131,090	10,200	10,200
				Sun	n/a	10	10	10	0	1	1	1			149,080	11,600	11,600
ESTIMATED ANNUAL TOTALS:												26	31	1,705,890	131,880	76,840	

Note: One additional consist could be required if layover is shifted from Union Depot to Minneapolis end-of-the-line, thereby increasing number of vehicles, miles, and hours.

Source: Connetics Transportation Group, 2006

Results of Downtown LRT Loop Analysis

Annual Operating and Maintenance Costs and Issues

Operating requirements (i.e., annual service miles and hours) associated with the changes in services noted above have been used as inputs to estimate operating and maintenance (O&M) costs. Tables 5 and 6 compare the annual vehicle miles and hours for year 2030 between the two alignment alternatives.

Utilizing these operating statistics, annual O&M costs have been estimated for the two alignment alternatives, as shown in Table 7. O&M costs were developed using the same cost structure as the LPA. Annual total bus and LRT operating costs for each alternative is in 2006 dollars. Based on this assessment, annual O&M costs for LRT are \$901,100 higher with the downtown loop than the original LPA alignment. This is mainly due to the longer loop alignment, requiring more miles and hours to operate. Bus operating costs are assumed to be similar; however, some additional costs may result if transit riders shift to other bus service in lieu of LRT (e.g., bus route 94). O&M costs for station maintenance reflect the extra stations on the loop alignment; although, added maintenance costs could be incurred for the elevated station at Smith Avenue. In addition, if all layover is shifted to the end-of-the-line in Minneapolis, this could also increase the operating costs because of the added train set that may be required.

Table 7: Annual Corridor O&M Cost Estimates in 2030 (2006\$)

Corridor Service	Annual O&M Costs for LPA Alignment	Annual O&M Costs for Loop Alignment
Bus	\$37,362,300	\$37,362,300
LRT	\$14,906,900	\$15,808,000
Total Systemwide	\$52,269,200	\$53,170,300
Incremental Change for Loop	--	\$901,100

Source: Connetics Transportation Group, 2006.

There are a number of operational issues and challenges associated with the proposed downtown St. Paul loop alignment that could have cost and other implications, such as:

- Train layover/recovery times and location:** Service reliability is critical to the success of any transit service. Ensuring service reliability requires the need to add additional time to the scheduled trip to account for delays incurred along the trip (e.g., signal delays, traffic congestion delays, passenger volume related delays, etc.). This additional time is typically placed at the end-of-the-line locations to ensure the following trip departs on time. This is commonly called recovery or layover time and is used both to ensure service reliability and to provide the transit operator time to address personal matters (i.e., eat, restroom break, etc.). Recovery time varies by transit line and is typically determined by anticipated need and/or by a standard percentage of round trip travel time. Round trip travel time plus recovery time equal cycle time, which is divided by the proposed peak period service frequency to determine peak vehicle requirements.

Each transit property has policies regarding standard recovery time. Typical percentages range between 10 and 20 percent (some are higher).

As previously mentioned, the LPA operating plan has 19 percent recovery time, with the alternative loop alignment operating plan at 15 percent. Again, both are acceptable. The Central Corridor operating plan with the loop alignment requires approximately 15 minutes of recovery time. The LPA operating plan assumed a split of recovery time between each end-of-the-line location. In downtown Minneapolis, Central Corridor service is operated along the same alignment as Hiawatha from the Metro Dome Station to the proposed Multi-Modal Station. This plan results in two rail lines, each operating 7.5 minute peak period service frequencies operating along this common segment (3.75 minutes combined headway). At this level of service, recovery time at the Multi-Modal Station is limited to time less than the peak service frequency or less than 7.5 minutes. This would allow time for trains to arrive, de-board and board passengers, transit operators to power down the cab at one end of the train, walk to the other end of the train, power-up the forward direction cab, and depart the station platform. With variability in train arrivals and departures at end-of-the-line stations, the recovery time at this station should be limited to 6 minutes or less. The result is a need to place 8 to 9 minutes of recovery time at the St. Paul end of the Central Corridor line.

Alternative locations to place this time on the loop are at the: 1) beginning of the loop at Rice Street Station, delaying riders bound for the St. Paul CBD; 2) end of the loop again at Rice Street Station, delaying riders bound for destinations west of the St. Paul CBD along University Avenue, U of M and downtown Minneapolis; and 3) Union Depot Station, providing ample time for transfers between Central Corridor, future commuter rail and Amtrak services, but would delay trips bound for the eastern portion of the St. Paul loop (e.g., Regions Hospital, Lowertown Historic District, etc.). Bottom line, a delay would be experienced by some passengers on the loop from the establishment of recovery time in the schedule.

The recovery time could possibly be accommodated at the Minneapolis end-of-the-line using a tail track beyond the Multi-modal Terminal, which is currently being designed as part of the Northstar Commuter Rail Project. Additional crossovers and another train set may also be required. Furthermore, a “drop-back” train operator would possibly be needed to maneuver trains in and out of the terminal station. Some of the layover could also possibly be shifted to the end-of-the-line Mall of America Station on Hiawatha.

- **Maintaining on-time performance:** The need to operate strict on-time performance becomes essential since the Central Corridor LRT would run on the same tracks as Hiawatha through downtown Minneapolis. Arriving in downtown Minneapolis on-time would be critical to maintaining schedule throughout the system. Presently, there are no plans to prioritize signals for Central Corridor trains along University or in downtown St. Paul. As such, the on-time performance of Central Corridor trains is likely to be worse than Hiawatha. Without any sort of layover at the St. Paul end-of-the-line, there would be no recovery time for the Central Corridor trains if they fall

behind schedule. Therefore, on-time performance could be hindered even further, making it more difficult to maintain scheduled departures from the Multi-modal Terminal. Signal prioritization or preemption could help to maximize on-time performance and maintain schedule for Central Corridor in lieu of the layover at the Union Depot Station.

Furthermore, on-time performance is easier to maintain when a LRT line operates in a dedicated right of way such as with the LPA. Since the loop has sections that operate in shared running, the trains could get delayed by automobile traffic. Again, layover time is critical for train operations to recover from potential delays and re-establish on-time service.

- ***Train break downs/accidents and track blockage:*** Single track loop alignments present some challenges regarding train break downs, accidents (either with the train, between the train and an automobile or between two or more automobiles within the transit right of way), and other disruptions or blockage of the track or right of way. Common resolution methods include quick and effective procedures for clearing the track of impedances and additional facilities like track sidings or passing tracks located along the loop alignment to allow for the means to get a disabled train off the through track and allow revenue service to continue. Maintaining a clear rail right of way is critical when trains are operated as frequently as proposed, with 7.5 minute peak and 10 minute off-peak service.
- ***Extension of the LRT line beyond the loop alignment:*** An end-of-the-line loop alignment presents a challenge if a LRT extension is considered in the future. Several questions would arise: Where does the loop break to extend the line? Should the line service operate on one side of the loop in one direction and on the other side of the loop when returning the opposite direction? Should the loop be eliminated or only one side of the loop served by the extension of service? These questions would require further analysis to answer.

Total Capital Costs and Construction Issues

The capital cost estimates were prepared for the loop alignment extending from the intersection of University Avenue and Rice Street. The total length of the loop alternative is approximately 17,360 route feet for the single track operation or 3.3 miles. The estimate includes nine stations and other infrastructure requirements as described above and shown on the plans.

The detailed capital cost estimates for the downtown St. Paul loop are included in Appendix C. The line item costs for the loop alternative were developed in 2002 dollars. The total capital cost summaries for the LPA and loop alternatives are presented in 2002, 2006 and year of expenditure (YOE) 2014 dollars. The escalation factor used for both LRT alternatives was 2.7 percent per year for the 2006 dollars. The YOE dollars was based on the escalation rates required in the FTA's Standardized Cost Categories. Tables 8 and 9 show the capital cost estimates for the LPA and loop alternatives, respectively.

Table 8: Total Capital Costs of Central Corridor LRT for LPA

Description	2002\$	2006\$	YOE – 2014\$
Civil Construction	\$155,301,641	\$172,765,817	\$197,125,797
Utilities	\$26,785,525	\$29,797,645	\$33,606,000
Structures (tunnels, portals, bridges, etc.)	\$41,344,500	\$45,993,824	\$51,881,034
Stations	\$99,700,000	\$110,911,590	\$127,769,000
Operations Facility (yard elements included)	\$20,000,242	\$22,249,334	\$25,432,000
Traction Power System	\$15,438,231	\$17,174,310	\$20,439,169
Signal System	\$15,563,400	\$17,313,555	\$20,319,000
Communications	\$7,262,920	\$8,079,659	\$9,482,000
Fare Collection	\$2,100,000	\$2,336,152	\$2,742,000
Subtotal - Infrastructure	\$383,469,459	\$426,621,887	\$488,796,000
Right of Way	\$29,771,152	\$33,119,015	\$36,555,000
Vehicles	\$98,735,000	\$109,838,073	\$127,219,000
Engineering & Administration	\$119,985,688	\$133,478,470	\$149,725,000
Contingencies	\$103,064,462	\$114,654,397	\$129,882,000
Total	\$735,052,760	\$817,711,842	\$932,177,000

Source: DMJM Harris, 2006.

Table 9: Total Capital Costs of LRT with Downtown St. Paul Loop

Description	2002\$	2006\$	YOE – 2014\$
Civil Construction	\$150,798,226	\$167,755,979	\$191,409,572
Utilities	\$23,678,955	\$26,341,731	\$29,708,395
Structures (tunnels, portals, bridges, etc.)	\$55,724,500	\$61,990,902	\$69,925,738
Stations	\$118,000,000	\$131,269,485	\$151,221,084
Operations Facility (yard elements included)	\$20,584,734	\$22,899,555	\$26,175,232
Traction Power System	\$16,612,257	\$18,480,360	\$21,993,501
Signal System	\$16,486,300	\$18,340,238	\$21,523,904
Communications	\$7,722,535	\$8,590,959	\$10,082,043
Fare Collection	\$2,325,000	\$2,586,454	\$3,035,786
Subtotal - Infrastructure	\$411,932,507	\$458,255,662	\$525,039,951
Right of Way	\$28,008,480	\$31,158,125	\$34,390,674
Vehicles	\$98,735,000	\$109,838,073	\$127,219,000
Engineering & Administration	\$128,516,502	\$142,968,602	\$160,370,237
Contingencies	\$106,266,415	\$118,216,421	\$133,917,107
Total	\$773,458,905	\$860,436,882	\$980,882,788

Source: DMJM Harris, 2006.

The Central Corridor LRT project with the downtown St. Paul loop is estimated at \$860 million in 2006 dollars. This is approximately \$42 million more than the original LPA at \$818 million in 2006 dollars. In YOE – 2014 dollars, the LPA would cost \$932 million to construct, while LRT with the loop is \$981 million, or \$49 million greater than the LPA. Increases in costs are primarily due to the added structures as well as the increased number of stations for the loop alignment, which has four more stations than the LPA. Elevated structures were needed at Interstate 35E, Jackson Street and the Union Depot, along with an aerial station at Smith Avenue.

The unit costs were reduced for the loop stations from \$5 to \$3.5 million to account for smaller platforms and fewer amenities. Even though the loop stations only require one side platform versus two assumed for the LPA, the station costs were not cut in half because some common elements would still be needed such as electrical conduits, signaling improvements, ticket vending machines, etc. The Union Depot Station cost was also reduced from \$18 to \$12 million since a pocket track and additional platform would not be needed with the loop alignment. With that said, an overall increase in station costs occurs because of the greater number of stations with the loop, nine compared to five for the LPA. Plus, the aerial station at Smith Avenue requires greater infrastructure improvements, costing \$12 million to build.

As for utilities, the unit costs were adjusted and reduced accordingly for the loop, about two-thirds the cost per foot of guideway for the LPA. Utilities that cross streets would be impacted the same amount for single or double track because gravity flow pipes have to be lowered from manhole to manhole, not just directly under the track. The main cost of relocation is the connection; two are needed for each relocation whether single or double track.

There are numerous areas and construction issues that could impact overall costs of the downtown loop alignment. Some of these issues that would require further assessment are as follows:

- The alignment crosses 29 streets at grade, 21 of these are controlled by traffic signals. Further studies would be required to determine how LRT operations would interact with motor vehicle traffic. The result of these studies would dictate the level of modification required at each intersection including lane configuration, traffic signal modifications, and striping. Widening of intersections would require modifications to storm drain systems and could impact other utilities.
- A unit cost per foot of alignment was used to estimate utilities, based on the level of development along the line. If a major underground utility such as high voltage power or fiber optic lines were impacted by the proposed track, significant relocation costs could be incurred.
- As mentioned in the alignment descriptions there are two existing crossings of Interstate 94. Embedded track is proposed on both of these crossings to allow a minimum of two traffic lanes in each direction. Placement of embedded track on these bridges may require replacement of a portion of the existing bridge deck to accommodate the track support system. Modification of the bridge support columns and abutments may be required as well.
- On Mother Teresa Way the existing grade is rather steep. One concern is that during winter conditions the steep slope could result in loss of adhesion between LRV wheels and rails, resulting in a safety issue. If the slope is too severe the profile may need to be adjusted, requiring an extended length of aerial track.

- The existing overhead pedestrian bridge serving the Xcel Energy Center is in conflict with the aerial guideway supporting the LRT track. This bridge would require relocation, unless the City allows an at grade pedestrian crossing of Kellogg Boulevard in this area.
- On Wacouta Street north of 4th Street the LRT track would occupy a single traffic lane. During peak hours street traffic may impede LRT operations unless a coordinated pre-emption system is implemented. Light rail vehicles stopping at the 7th Place Station would impede motor vehicle traffic on Wacouta.

Ridership and Travel Time Information

This section presents an expanded range of Central Corridor LRT forecast results to examine a potential loop alignment in downtown St. Paul. It draws comparisons between the 2030 No Build, Equilibrated “New Starts” Baseline, LPA, and LRT with the downtown St. Paul loop.

The headways for the corridor routes are presented in Table 10 for each alternative. There were no headway changes to the bus routes or LRT, with the downtown loop in comparison to the LPA. The modeled running times for each route are summarized in Table 11. Times are eastbound to and westbound from the Union Depot Station. An “E” in the route description indicates eastbound service and a “W” indicates westbound service. The base year (2000) scheduled and modeled running times are presented for comparison. The running times for the bus routes also remained the same. However, adjustments were made to LRT running times with the loop as previously discussed.

Table 10: Service Plan Headways (minutes)

Bus/LRT Route	2000	2030			
		No Build	Equilibrated Baseline	LPA	LRT with Loop
16 PEAK	10	10	20	20	20
16 OFF-PEAK	10	10	30	30	30
21 PEAK	10	10	10	10	10
21 OFF-PEAK	15	15	15	15	15
50 PEAK	30	30	6	--	--
50 OFF-PEAK	60	60	10	--	--
94B PEAK	20	30	30	30	30
94B OFF-PEAK	30	--	--	--	--
94C PEAK	--	30	30	30	30
94C OFF-PEAK	30	--	--	--	--
94D PEAK	20	20	20	20	20
94D OFF-PEAK	--	30	30	30	30
LRT PEAK	--	--	--	7.5	7.5
LRT OFF-PEAK	--	--	--	10	10

Source: AECOM Consult, 2006.

Table 11: Running Times (minutes)

Bus/LRT Route	2000		2030			
	Scheduled	Modeled	No Build	Baseline	LPA	LRT with Loop
Peak						
16E ⁽¹⁾	50.0	50.1	50.9	50.9	50.9	50.9
16W ⁽²⁾	50.0	50.1	50.7	50.7	50.7	50.7
21E	64.0	56.5	56.4	56.4	56.4	56.4
21W	65.0	56.6	56.5	56.5	56.5	56.5
50E	40.0	40.1	40.3	47.6	--	--
50W	43.0	43.2	43.4	50.5	--	--
94BE	40.0	39.1	37.7	37.7	37.7	37.7
94BW	41.0	41.2	39.5	39.5	39.5	39.5
94CE	--	--	27.6	27.6	27.6	27.6
94CW	--	--	30.6	30.6	30.6	30.6
94DE	32.0	33.2	31.7	31.7	31.7	31.7
94DW	36.0	36.0	34.4	34.4	34.4	34.4
BRT	--	--	--	--	--	--
LRT	--	--	--	--	39.5	39.5
Off-Peak						
16E	61.0	61.1	61.5	61.5	61.5	61.5
16W	60.0	59.8	60.1	60.1	60.1	60.1
21E	60.0	56.5	56.4	56.4	56.4	56.4
21W	64.0	56.6	56.5	56.5	56.5	56.5
50E	41.0	40.9	41.1	42.8	--	--
50W	45.0	44.8	45.0	47.4	--	--
94BE	31.0	32.5	--	--	--	--
94BW	32.0	33.9	--	--	--	--
94CE	27.0	25.0	--	--	--	--
94CW	28.0	27.1	--	--	--	--
94DE	--	--	26.4	26.4	26.4	26.4
94DW	--	--	28.3	28.3	28.3	28.3
LRT	--	--	--	--	39.5	41.7/41.0 ⁽³⁾

⁽¹⁾E = Eastbound route

⁽²⁾W = Westbound route

⁽³⁾Times are eastbound to and westbound from the Union Depot Station

Source: AECOM Consult, 2006.

Table 12 compares station boardings for the LRT alternatives. As shown in this table, the estimated average weekday boardings for LRT with the downtown loop are 37,460 in the year 2030. Without the Union Depot layover on the loop, LRT average weekday boardings are 38,180. The best case for the loop is 5,150 riders less than the 43,330 boardings projected for the LPA.

The loss in LRT ridership between the LPA and the loop is in large part due to the one way operation in downtown St. Paul, which results in trip distances and travel times that are not comparable in each direction. For example, the Capitol Station has a short trip and travel time for someone coming *from* the Minneapolis CBD because it is the first stop on the loop. However, a passenger getting on at this station would have a very long trip and travel time *to* the Minneapolis CBD because the trains would have to circulate around downtown St. Paul on the loop first. Table 13 highlights the imbalance in travel times to and from Minneapolis for selected locations, including wait and walk time to and from origins and destinations.

A loop alignment may also require a passenger to ride the loop, get off a train and re-board another train to complete the trip around the loop, thus involving a transfer. This would occur, for example, if a passenger boarded the train at the Regions Hospital Station, wanting to go to the Science Museum Station. They would be forced to transfer at the Rice Street Station.

Furthermore, the loop configuration causes people to walk further to destinations in downtown St. Paul, especially to important employment centers situated along the original LPA alignment. These longer walking distances increase the overall commute time for passengers traveling to and from their jobs on a daily basis and discourages some people from taking transit altogether.

Most special event venues do not generate regular weekday trips like employment sites. For example, the Excel Energy Center only has approximately 140 events annually, with a seating capacity of about 18,000. Plus, people are more likely to walk longer distances to special events than to work each day. Therefore, the convenient walk access to some special event generators such as the Cathedral, Excel Energy Center, Science Museum, etc. does not produce that much additional ridership on the loop.

As a result of these issues, there are only 1,940 boardings on loop stations in downtown St. Paul, increasing to 2,770 by removing the layover. In comparison, the LPA's linear, bi-directional service would have 6,430 riders boarding stations in the heart of downtown.

With that said, the loop configuration is causing an increase in ridership at some LRT stations along the line. More riders are walking or taking a bus to and from the Rice Street Station. It is the closest LRT station that has two-way operations both outbound and inbound, and travel times to/from the west are balanced as shown in Table 13. This causes a shift in riders to the Rice Street Station, with 2,370 to 2,850 boardings for the loop versus 1,290 for the LPA. Other stations on the LRT line are comparable between the alternatives.

Table 12: Average Weekday Station Boardings, 2030

Station	LPA			LRT with Loop			Loop without Layover		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
Multimodal Terminal	620	280	900	550	270	820	560	270	830
Warehouse/Hennepin	2,360	1,250	3,610	2,020	1,110	3,130	2,060	1,130	3,190
Nicollet Mall	5,010	2,270	7,280	4,420	2,040	6,460	4,480	2,080	6,560
Government Plaza	530	270	800	520	240	760	520	250	770
Downtown East/Metro.	2,940	1,480	4,420	2,590	1,370	3,960	2,630	1,390	4,020
West Bank	1,010	340	1,350	970	330	1,300	970	330	1,300
East Bank	3,990	2,500	6,490	3,960	2,530	6,490	3,960	2,550	6,510
Stadium Village	420	240	660	370	220	590	370	230	600
29th Avenue	660	280	940	620	270	890	630	280	910
Westgate Drive	750	400	1,150	730	390	1,120	730	390	1,120
Raymond Avenue	860	430	1,290	780	420	1,200	790	420	1,210
Fairview Avenue	1,440	630	2,070	1,250	580	1,830	1,260	590	1,850
Snelling Avenue	1,350	1,510	2,860	1,100	1,410	2,510	1,110	1,410	2,520
Lexington Parkway	610	450	1,060	630	410	1,040	630	410	1,040
Dale Street	440	290	730	390	230	620	400	230	630
Rice Street	860	430	1,290	1,680	1,170	2,850	1,540	830	2,370
Capitol East	310	140	450	--	--	--	--	--	--
10th Street	310	170	480	--	--	--	--	--	--
6th Street	1,720	1,110	2,830	--	--	--	--	--	--
4th Street	1,440	580	2,020	--	--	--	--	--	--
Capitol	--	--	--	10	10	20	10	10	20
Cathedral	--	--	--	130	40	170	140	40	180
Smith Ave	--	--	--	70	20	90	100	90	190
Science Museum	--	--	--	100	50	150	150	60	210
Wabasha Street	--	--	--	10	10	20	170	10	180
Union Depot	450	200	650	120	10	130	130	10	130
7th Place	--	--	--	250	170	420	340	530	870
Jackson & 9th Street	--	--	--	160	90	250	170	90	260
Regions Hospital	--	--	--	460	230	690	490	240	730
Total	28,080	15,250	43,330	23,870	13,590	37,460	24,330	13,850	38,180

Source: AECOM Consult, 2006.

Table 13: Passenger Travel Times To and From Downtown Minneapolis¹

Origin/Destination	LPA Travel Times (minutes)		LRT Travel Times with Loop (minutes)	
	To Minneapolis	From Minneapolis	To Minneapolis ³	From Minneapolis ³
Rice Street Station	46	46	46 / 46	46 / 46
Union Depot	48	48	52 / 52	55 / 55
6th and 7th Streets ²	47	47	46 / 46	69 / 60

¹Assumes travel times to and from the Nicollet Mall Station in downtown Minneapolis and includes wait time at stations and walk time to ultimate destination as measured by center of zone containing origin/destination.

²Just east of Mears Park.

³With / without layover at Union Depot.

Source: AECOM Consult, 2006.

As shown in Table 14, the higher ridership on the 94 bus routes are the main reason the overall average weekday boardings in the corridor remain about the same with the loop (65,900) as the LPA (65,100). The 94 bus routes serve the direct Minneapolis CBD to St. Paul CBD market better than the loop. Thus, while there are not as many LRT boardings with the loop, ridership on the 94 bus routes increase. There is also slightly greater ridership on bus route 16 as some riders find that service preferable to the downtown loop.

Without the mid-loop layover at Union Depot, average weekday boardings in the corridor are 66,150. This is still fairly comparable to the LPA, as well as the loop with the layover. Again, a shift between bus and LRT riders is occurring. For purposes of this analysis, it was assumed that the 94 bus routes can accommodate the approximately 3,900 additional riders. However, it might be necessary to add bus service, which would increase the costs of the loop alignment.

Table 14: Average Weekday Boardings in Corridor, 2030

Bus/LRT Route	2000		2030				
	Observed	Modeled	No Build	Equilibrated Baseline	LPA	LRT with Loop	Loop w/o Layover
16	15,920	21,800	30,110	3,520	4,460	6,300	6,150
21	16,940	7,760	13,820	13,660	13,490	13,680	13,710
50	3,310	440	930	34,120	0	0	0
94B	4,450	3,250	620	820	470	890	890
94C	--	1,210	550	560	450	670	630
94D	--	4,940	7,760	7,210	2,960	6,900	6,620
LRT	0	0	0	0	43,270	37,460	38,150
Total	40,620	39,400	53,790	59,890	65,100	65,900	66,150

Source: AECOM Consult, 2006.

The imbalance in travel times for the loop is also reflected in the somewhat lower hours of user benefits in the corridor, as shown in Table 15. The increase in both operating and capital costs, coupled with the slight decline in user benefits results in a worsening of the FTA’s cost effectiveness indicator (CEI) as measured by the annual incremental cost per hours of user benefits. The CEI for the LPA was \$24.84, increasing to \$27.27 for LRT with the loop.

The travel time savings in the corridor are almost equivalent to the LPA once the layover on the loop is removed, with 7,746 hours of user benefits versus 7,805 for the LPA. Nonetheless, the growth in total annualized costs brings the CEI to \$26.42. Consequently, LRT without the mid-loop layover is still not as cost effective as the LPA.

These CEI numbers for LRT with the loop are sufficient to achieve entry into preliminary engineering because they meet the FTA’s required threshold of \$28.99. However, getting FTA’s approval to enter final design and ultimately receive federal funding for construction would be difficult since the CEI threshold is reduced to \$22.99 at that point in the New Starts process. If anything, the current LPA as it stands will need to consider cost saving measures in the future to advance into the next phase of project development.

Table 15: Benefits and Cost Effectiveness of Corridor, 2030

	LPA vs. Equilibrated Baseline	LRT with Loop vs. Equilibrated Baseline	Loop without Layover vs. LPA
Benefits in Corridor			
Change in Corridor Boardings	5,210	6,010	6,260
Change in Transit Linked Trips (new riders)	6,063	5,897	6,111
Travel Time Savings (hours of user benefits)	7,805	7,503	7,746
Cost Effectiveness			
Incremental Cost per Hours of User Benefits	\$24.84	\$27.27	\$26.42

Source: AECOM Consult, 2006.

Summary

This technical memorandum provides an assessment of a loop configuration for the Central Corridor LRT project in downtown St. Paul. It also compares the loop alignment with the approved Locally Preferred Alternative for the project, as summarized in Table 16. Based on this analysis, a summary of the key findings for the downtown St. Paul loop alignment are as follows:

- **Access to Activity Centers and Jobs:** Provides greater geographic coverage, with more direct walk access to some major activity centers such as the Cathedral, Xcel Energy Center, Science Museum, Regions Hospital, etc.; however, travel times and walking distances to other job concentrations in the center of downtown are much further with the loop than the LPA.
- **Parking, Traffic and On-time Performance Impacts:** Preserves curbside parking to the extent possible, except at station locations; yet, potential impacts to traffic and on-time performance of LRT trains could be incurred with sections of shared running with automobiles.
- **Operational Issues:** Encompasses a longer circuitous route pattern (+8,780 feet or +1.7 miles) and increased operating LRT run times (+2 minutes), which are not as convenient for passengers in comparison to the LPA; trip distances and travel times are also imbalanced with one-way operations, especially for riders heading west to downtown Minneapolis or those wanting to make a return trip who are forced to ride all the way around the loop; creates a mid-loop layover of almost nine minutes for passengers at the Union Depot Station, which could possibly be accommodated at the Minneapolis end-of-the-line with a tail track; and generates potential transfers at the Rice Street Station for riders trying to get from one station on the loop to another.
- **Reduction in LRT Ridership:** Reduces LRT average weekday boardings by approximately 5,000 to 6,000 due to increased travel times and operational issues with the loop; in downtown St. Paul, only 1,940 people are projected to get on at stations along the loop versus 6,430 for the LPA alignment; without the layover at Union Depot, the station boardings on the loop increase to 2,770.
- **Shift in Transit Boardings:** Shifts transit riders to 94 bus routes, which would serve the direct Minneapolis CBD to St. Paul CBD market better than the LRT loop; as a result, overall systemwide transit ridership in the corridor remains about the same between the loop (65,900), loop without the layover (66,150), and LPA (65,100).
- **Greater Infrastructure Requirements:** Requires greater infrastructure improvements than the LPA, with four more stations, elevated structures at Interstate 35E, Jackson Street and the Union Depot, and an aerial station at Smith Avenue; many unknowns still exist relative to utilities, but the single track loop operation would be expected to reduce utility relocations in downtown.

- **Increased Costs:** Increases overall costs of the Central Corridor LRT project with the loop alignment; total capital costs go from \$818 to \$860 in 2006 dollars and \$932 to \$981 in year of expenditure 2014 dollars, while the annual operating costs rise by nearly a million, from \$52.3 to \$53.3 million in 2006 dollars.
- **Decreased Cost Effectiveness:** Decreases cost effectiveness of LRT due to increased costs and reduced travel time savings; \$27.27 incremental cost per hours of user benefits is estimated with the loop and \$26.42 without the layover in comparison to \$24.84 for the LPA.
- **Difficulty in a System Extension:** If the LRT service is ever extended to the north, east, or south from Union Depot, decisions would need to be made where to break the loop to extend the line and how to operate the service.

In summary, the loop has the following advantages and disadvantages when compared to the Cedar and 4th alignment for the LPA:

Advantages

- Reduces walking distance to some major generators and special event venues throughout downtown area
- Reduces utility relocations and impacts
- Eliminates impacts on Cedar and 4th
- Only Second Street is closed to vehicular traffic
- Parking issues on streets where loop operates are less severe due to single-track operation in mixed traffic
- Provides access to track level of Union Depot.

Disadvantages

- Increases walking distance to major employers in downtown core area
- Since loop only operates in one direction, round-trip travel times are longer for all downtown passengers since they must back-track in one direction or the other
- Has higher capital (+\$49 million) and operating (+\$1 million per year) costs
- Decreases Central Corridor LRT ridership by 5,000 to 6,000 boardings per day
- Impacts more streets than LPA alternative due to longer route
- In order to maintain schedule reliability, a layover needs to be included in the loop that will delay customers
- More difficult to extend other LRT lines from Union Depot and limits commuter rail capacity of the Depot
- Not as cost effective as LPA.

Conclusion

The loop alignment raises FTA's Cost Effectiveness Index (CEI) from \$24.84 to between \$26.42 and \$27.27. The project needs to be under \$23.00 to receive a recommendation for federal construction funding. The loop alignment provides some benefits, but does not perform as well as the LPA from a ridership and cost perspective.

Table 16: Summary of LPA versus LRT with Downtown Loop

	LPA	LRT with Loop
Characteristics		
Length in Downtown St. Paul (feet)		
• One-way route	8,580	17,360
• Single track	17,160	17,360
Number of Curves Less Than 25 MPH	8	11
Number of Stations in Downtown St. Paul	5	9
Peak Weekday Headways (minutes)	7.5	7.5
Operating Run Times (minutes)		
• End-to-end for entire LRT line (one-way)	39.5	41.5
• Rice St. Station to Union Depot (one-way)	9.5	11.5
Layover Times (minutes)		
• Minneapolis Multi-modal Terminal	6	6
• St. Paul Union Depot ¹	12.5	8.75
Average Weekday Boardings (with / without layover)		
Downtown St. Paul Stations	6,430	1,940 / 2,770
Entire LRT Line	43,330	37,460 / 38,180
Systemwide Bus and LRT	65,100	65,900 / 66,150
Passenger Travel Times (with / without layover)		
Travel Time Savings (hours of user benefits)	7,805	7,503 / 7,746
Travel Times to Minneapolis from: (minutes)²		
• Rice Street Station	46	46 / 46
• Union Depot	48	52 / 52
• 6th and 7th streets (just east of Mears Park)	47	46 / 46
Travel Times from Minneapolis to: (minutes)²		
• Rice Street Station	46	46 / 46
• Union Depot	48	55 / 55
• 6th and 7th streets (just east of Mears Park)	47	69 / 60
Costs (in millions)		
Annual O&M Costs (2006 \$)	\$52.3	\$53.2
Total Capital Costs (2006 \$)	\$818	\$860
Total Capital Costs (year of expenditure 2014 \$)	\$932	\$981
Cost Effectiveness (with / without layover)		
Incremental Cost per Hours of User Benefits³	\$24.84	\$27.27 / \$26.42

¹Loop layover at St. Paul Union Depot is at mid-loop, causing a delay for passengers continuing on their trip; LPA layover at Union Depot occurs at the end-of-the-line, with all passengers deboarding.

²Includes travel time on train, as well as wait time at station and walk time to ultimate origin and destination.

³FTA's threshold to enter preliminary engineering is \$28.99 and \$22.99 for final design and construction.

Source: DMJM Harris, AECOM Consult and Connetics Transportation Group, 2006.

APPENDIX A
Plan and Profile Drawings

APPENDIX B

Typical Cross Sections

APPENDIX C
Capital Cost Estimates of Downtown St. Paul LRT Loop