Technical Memorandum

Date: May 7, 2012

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Hennepin County Regional Railroad Authority

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Subject: Bottineau Transitway Draft Environmental Impact Statement
Comparison of LRT and BRT modes

Introduction

Purpose of Memorandum

This technical memorandum has been prepared as part of the ongoing Scoping analysis for the Bottineau Transitway Draft Environmental Impact Statement (Draft EIS). This memorandum compares the light rail transit (LRT) and bus rapid transit (BRT) alternatives under consideration, not with respect to alignment location, but rather for general performance related to the modes themselves. Because the BRT mode is not being considered for either of the D2 alternatives (A-C-D2 or B-C-D2), the comparison in this memorandum is generally focused on alternative B-C-D1, which would be the common alignment alternative for LRT and BRT.

This memorandum identifies the differences between modes based on the goals, objectives, and evaluation measures identified to date through the Bottineau Transitway study process, emphasizing those evaluation criteria that demonstrate the most contrast between the alternatives.

A summary evaluation against the goals and objectives is included in Appendix A.

Project Background

The Bottineau Transitway project area extends approximately 13 miles northwest from downtown Minneapolis through the neighborhoods of north Minneapolis and into the communities of Golden Valley, Robbinsdale, Crystal, Brooklyn Park, and Maple Grove in Hennepin County, Minnesota.

The Bottineau Transitway Alternatives Analysis (AA) study, which was completed by the Hennepin County Regional Railroad Authority (HCRRA) in 2010, evaluated a No-Build, an Enhanced Bus/Transportation System Management (TSM) alternative, and a wide range of commuter rail, BRT, and LRT alternatives. The study progressively narrowed the transitway Build alternatives from a wide range of options for each of the initial modes to a recommended set of 21 alternatives (9 LRT and 12 BRT) which underwent detailed evaluation.

The three most promising alternatives that came out of the AA study are:

- LRT alternative A-C-D1 (Maple Grove to Minneapolis via BNSF/Olson Memorial Highway)
- LRT alternative B-C-D1 (Brooklyn Park to Minneapolis via BNSF/Olson Memorial Highway)
- LRT alternative A-C-D2 (Maple Grove to Minneapolis via Penn Avenue/Olson Memorial Highway)

While the BRT alternatives as described in the AA were not among the most promising, a refined BRT alternative was subsequently developed to address some of the shortcomings of the initial BRT alternatives. This alternative is described as follows:

- BRT alternative B-C-D1 (Brooklyn Park to Minneapolis via BNSF/Olson Memorial Highway) with branched peak-hour service to and from Maple Grove on Route 732

As noted previously, none of the most promising alternatives identified BRT on the D2 alignment.

Memorandum Organization

The following sections identify key differentiators between the Alignment A and Alignment B alternatives, focusing on the following primary and secondary goals, which were developed as part of the Bottineau Transitway Purpose and Need:

Primary Goals

- Goal 1: Enhance Regional Access to Activity Centers
- Goal 2: Enhance the Effectiveness of Transit Service within the Corridor
- Goal 3: Provide a Cost Effective and Financially Feasible Transit System

Secondary Goals

- Goal 4: Promote Sustainable Development Patterns
- Goal 5: Support Healthy Communities and Sound Environmental Practices

Primary Goals and Objectives

Goal 1: Enhance Regional Access to Activity Centers

Total ridership: Forecast total daily ridership is 27,000 for LRT and 19,900 for BRT.

Downtown connections to regional transitway system: The LRT and BRT alternatives run in the same locations (corridors) with similar linkages to neighborhoods, activity centers, and the regional transportation system in general. However, LRT and BRT provide different linkages to the regional transitway system in downtown Minneapolis. Specifically, the LRT alternatives form an interlined (through running) system with the Blue Line (Hiawatha). LRT also connects directly to the Interchange, which offers convenient transfer connections to Northstar Commuter Rail and the Green Line (Central/Southwest LRT). In contrast, BRT does not interline with the Blue Line. Connections from BRT to Northstar Commuter Rail and the Green Line are less convenient than on LRT. While BRT does have long-term potential for interlining with the Orange Line (I-35W South BRT), it is important to acknowledge that the service plan for the Bottineau Transitway is for high frequency all day service while the service plan for I-35W BRT is likely to be less robust, limiting potential interlining benefits.

Access to employment: LRT and BRT are similar with respect to access to employment, except for access to the downtown Minneapolis employment core. LRT provides access to the downtown employment core from 5th Street, whereas BRT provides slightly greater access to downtown employment core because it circulates north-south on Marquette and 2nd Avenues. It should be noted that the BRT service route assumes BRT vehicles would run in mixed traffic on existing streets between the Interchange (current Target Field station) and Marquette and 2nd Avenue dedicated bus lanes. This operation will affect access to employment from the perspective of a downtown commuter using the transitway with a relatively slow, lower ride quality, less reliable trip (in terms of travel time) compared to LRT.

Access to special event facilities: One other notable difference is access to special events. LRT provides convenient access to Target Field, Target Center, and Mall of America Field. BRT provides reasonable access (within a quarter-mile walk) to Target Field and Target Center. However, access to Mall of America Field and the Downtown East district requires a transfer.

Capacity to handle special event traffic: In addition, the BRT alternative will not have the capacity to handle event crowds like LRT. BRT will be limited due to vehicle capacity and frequency limits (6 minute frequency and a capacity of 800 passengers in the peak hour), while LRT has a higher capacity per vehicle (7.5 minute frequency and a capacity of 2,144 passengers in the peak hour) and the ability to add a third car without increasing the frequency of the service. Accommodating special event traffic with a BRT alternative could require additional special event express service to and from major stations on the line. This would only apply during off-peak periods within a maximum possible 6 minute frequency along the transitway.

Goal 2: Enhance the Effectiveness of Transit Service within the Corridor

The effectiveness of transit service within the corridor is addressed by comparing LRT and BRT using the following measures.

Maximize new transit riders: Using the Twin Cities Metropolitan Area Regional Travel Demand Model, developed by the Metropolitan Council, new transit riders for the Bottineau Corridor were forecasted for the year 2030. New transit riders are the estimated net change in transit users between the baseline (no project) and Build (project) alternatives. These riders represent people who would change their mode of travel as a result of the project, as forecast by the travel demand model used for the project. . As shown in the table below, LRT generates approximately 1,500 net daily new transit riders more than the BRT alternative.

	LRT (B-C-D1)	BRT
Year 2030 New transit riders	7,150	5,650

Mazimize passengers per hour of revenue service: Passengers per hour of revenue service were calculated by dividing the forecast year (2030) number of annual transit riders by annual transitway (operator) revenue hours. As shown in the table below, the LRT alternative generates more than twice as many passengers per revenue hour than the BRT alternative. This is due to the increased frequency of BRT and the lower ridership forecast for BRT.

	LRT	BRT
Passengers per revenue hour	181	71

Maximize travel time savings: Comparing end-to-end travel times for the alternatives provides a means of comparing the travel time efficiency of the modes. The comparable termini used to compare modes are 97th Avenue to the Interchange (LRT) and 97th Avenue to Border Avenue (BRT). For access into the heart of downtown Minneapolis, the comparable termini are 5th Street & Nicollet Mall or 5th Street & Marquette Avenue for LRT and BRT, respectively. The table below summarizes the travel time differences for the modes and demonstrates that the LRT alternative provides a travel time advantage over the BRT alternative.

	LRT (B-C-D1)	BRT
From–to	97th Avenue–Nicollet Mall Station	97th Avenue–5th Street/Marquette Avenue

Distance	13.8 miles	14 miles
Travel Time	34 minutes 4 seconds	38 minutes 24 seconds
Average Speed	24 miles per hour	22 miles per hour

The advantage of the LRT alternative's shorter travel time is expressed in its higher user benefits. User benefits are a measure of mobility improvement and represent the aggregate perceived travel time difference for transit users between each Build alternative and the TSM alternative.[1] They are used in the estimation of the FTA cost effectiveness index (CEI). User benefits for the LRT and BRT alternatives are shown in the table below.

	LRT (B-C-D1)	BRT
Daily hours of user benefits	8,520	5,880

Goal 3: Provide a Cost Effective and Financially Feasible Transit System

Minimize capital and operating cost. A calculation of the cost effectiveness index (CEI) of LRT and BRT is provided in Appendix A. CEI is a measure of the annualized capital and operating incremental cost divided by incremental annual hours of transportation system user benefits. The increment referenced is between the transitway build and baseline conditions.

Maximize long-term investment in the regional transit system: The primary difference with respect to long-term investment is the connectivity LRT or BRT provides with the regional transit system. LRT provides relatively greater connectivity with the existing and planned transitway system due to through-running (interlining) with the Blue Line (LRT) and convenient transfer to the Green Line (LRT). BRT provides relatively less convenient connectivity with the existing and planned LRT system but has the potential to interline with future BRT lines (see discussion under Goal 1).

Maximize flexibility to efficiently expand the transit investment to accommodate transitway demand beyond 2030 weekday travel demand forecasts: The LRT alternative would have more than 2.5 times the passenger capacity of the BRT alternative during rush hours. BRT requires greater frequency (6-minute headways for BRT vs. 7.5 for LRT) to meet 2030 demand. LRT would be at 77-85 percent capacity in year 2030. In contrast, BRT would be over 100 percent capacity in 2030. LRT capacity could be expanded by 50 percent by adding a third car to the two-car trains with little adverse impacts on roadway traffic. BRT capacity expansion would require decreasing transitway headways; the addition of more frequent BRT vehicles at roadway crossings would have major adverse impacts on roadway traffic. Ridership forecast results indicate all of the capacity of the BRT alternative would be used by the year 2030, and that demand for 1,200 trips per day could not be served by the BRT alternative.

LRT has more flexibility to accommodate future demand following the initial investment.

[1] The word "perceived" represent the difference between a person's perceived travel time and the actual travel time. Perceived travel time is used to account for mode and access bias. For example, if the actual travel time is the same for a bus and an LRT trip, the perceived travel time for a typical rider will be lower for the LRT since it is considered a more enjoyable ride, among other factors. Thus, the user benefit is calculated based on perceived travel time. Actual travel time is considered in other performance measures (for example, accessibility analysis).

Secondary Goals and Objectives

Goal 4: Promote Sustainable Development Patterns

An assessment of the potential sustainable development benefits of LRT and BRT can be made by comparing the potential of each mode to generate new transit-oriented development (TOD), assuming LRT and BRT alternatives otherwise share the same alignments.

In order for BRT to be successful in attracting development and generating economic benefits comparable with LRT, certain criteria must be met. BRT must employ modern technology to provide high-quality service and brand recognition, including:

- Permanent infrastructure, such as stations, ticket machines, and roadway improvements
- Dedicated bus lanes for rapid travel unhindered by roadway congestion
- A modern bus fleet with distinct design, high capacity, and low floors for universal accessibility and rapid boarding
- Off-board payment to minimize boarding time
- Lower stop density than traditional bus service to maximize travel speeds
- High integration into regional transitway system

Together, these amenities provide two critical benefits: travel times comparable to LRT, to generate LRT-comparable economic benefits through enhanced accessibility; and demonstrated route permanence and service quality that can successfully attract private investment along the corridor.

The BRT alternative proposed for the Bottineau Transitway would meet all of the high-quality service and branding criteria above. However, the comparison of travel times to LRT alternatives presented elsewhere in this memorandum suggests that the BRT alternatives would be somewhat slower than LRT. Also, capacity limitations of BRT could put it at a disadvantage in comparison with LRT. Specifically, the more imited BRT capacity may be a limiting factor in the magnitude of economic development potential of the line compared to LRT. Finally, in the Twin Cities, where no similar dedicated transitway BRT system exists, one might expect BRT to be at a comparative disadvantage as a development incentive, at least initially, in comparison to LRT, which is more familiar and has proven ability to attract economic development. For these reasons, BRT is likely to have somewhat lesser TOD benefits than LRT.

Goal 5: Support Healthy Communities and Sound Environmental Practices

Because the basic footprint for LRT and BRT are the same for a given alignment, there are no notable differences between the two modes for most areas of the natural and built environment, including historic and cultural resources, property impacts and access, connections to pedestrian and bicycle facilities, and health, environmental and economic benefits to the transitway communities. Similarly, there are also no differences between LRT and BRT with respect to the potential for disproportionately high and adverse impacts on minority and/or low-income communities. Areas where potential differences have been identified are described below.

Noise and vibration: LRT is propelled by electricity from overhead wires; vehicles have no on-vehicle engines. As a result, the primary noise from LRT is caused by wheels on rails. LRT has noise impacts from bells at station stops, and possible curve squeal.

LRT has higher vibration impacts due to heavier vehicles on rail than BRT.

BRT assumes diesel-powered vehicles with engine noise but relatively low noise from rubber tires on pavement. BRT vehicles on a dedicated guideway would have warning devices at at-grade crossings at locations parallel to the BNSF railroad; otherwise, warning devices are not specified for BRT.

BRT has lower vibration impacts than LRT due to rubber tires on pavement surfaces.

Waters and wetlands: A difference with respect to water resources is the potential for lesser impacts from LRT due to the pervious nature of the ballasted track alignments, as opposed to the impervious roadway surface for BRT. Also, LRT does not require use of chemicals for snow/ice removal because the LRT vehicle itself clears the snow. BRT, in contrast, would require snow and ice removal from the roadway or transitway.

Traffic impacts: Given the similarities in the design of the LRT and BRT alternatives, there are no substantial differences between the two modes with respect to adverse impacts on traffic diversion, local street network, and bicycle and pedestrian facility impacts.

The BRT alternative assumes that BRT B-C-D1 and Route 732 both operate at 12-minute frequencies in the peak periods, resulting in a combined six-minute frequency on the guideway south of the Brooklyn Boulevard station. Preliminary traffic analyses indicate that six-minute frequencies are the maximum frequencies that can operate with signal prioritization without adversely disrupting general traffic at key high-volume intersections. LRT would have less much less adverse impact on traffic on the local street network than BRT. This is because LRT can operate at lower frequencies (7.5-minute) than BRT to meet ridership demand and because BRT would be street-running in downtown Minneapolis.

One issue that may be problematic is the effects on the local street network in downtown Minneapolis. The BRT alternative will travel to 2nd/Marquette Avenues in mixed traffic, and may put additonal capacity constraints on the downtown street network.

Appendix A:
LRT vs. BRT Summary Evaluation

Bottineau Transitway Summary Evaluation

Better ... Worse

			LRT (Alternative B-C-D1 only)		BRT (Guideway on B-C-D1)	
Primary Goals and Objectives that Directly Address the Primary Project Needs						
Goal 1: Enhance Regional Access to Activity Centers						
1	Maximize total transit riders	Total weekday transitway trips	27,000		19,900	
2	Improve service to people who depend on transit	People who depend on transit served by alternative	No difference		No difference	
		Service experience /ride quality for people with disabilities	No major difference in passenger restraint systems. LRT level boarding will have significant advantage over street-running BRT in downtown Minneapolis		No major difference in passenger restraint systems. Street-running portion of BRT in downtown Minneapolis would require ramp access (as opposed to level boarding elsewhere) and that right-angle turns result in significantly poorer service experience for this portion of trip.	
3	Expand reverse commute and off-peak transit service	**Reverse commute** (Ridership model output: Corridor AM peak period work trips in off-peak (northbound) direction)	3,600		3,980	
		Off-peak (Ridership model output: Corridor off-peak period trips (both directions, all trip purposes))	12,000		9,200	
4	Increase transit system linkages, access to regional destinations and multimodal transportation opportunities	Bike Connections	No difference		No difference	
		Pedestrian Connections	No difference		No difference	
		Bus Connections	No difference		No difference	
		Other Transit Connections	LRT forms interlined system with Hiawatha (Blue Line). LRT connects directly to Interchange and offers convenient transfer connection to Northstar Commuter Rail and Green Line.		No interline with Hiawatha (Blue Line). Transfer to Northstar Commuter Rail and Green Line less convenient than on LRT. Long-term potential for interlining with I-35W South BRT (Orange Line) .	
5	Maximize transit access to housing, employment, schools, community services, healthcare facilities and activity centers (measured as dedicated transitway connections to activity centers).	Retail centers Employment Population Occupied housing units Libraries and schools Parks Community centers Health centers	Similar except for access to downtown employment core. LRT provides access to downtown employment core from 5th Street.		Similar except for access to downtown employment core. BRT provides slightly greater access to downtown job core because it circulates north-south on Marquette and 2nd Avenues.	
		Special event service (transit capacity, function of station areas)	LRT provides convenient access to Target Field, Target Center, Mall of America Field. The Interchange will provide LRT passenger loading capacity at Target Field. LRT has a higher capacity per vehicle than BRT and the ability to add a third car without increasing the frequency of the service.		BRT provides reasonable access (within 1/4 mile walk) to Target Field and Target Center but less convenient than LRT. Access to Mall of America Field requires transfer. BRT will be limited due to vehicle capacity and frequency limits. Accommodating special event traffic with BRT alternative could require additional special event express service to and from major stations on the line. Station boarding areas not as accessible to LRT.	
Goal 2: Enhance the Effectiveness of Transit Service within the Corridor						
6	Maximize new transit riders	New transit riders	7,150		5,650	
7	Maximize passengers per hour of revenue service	Passengers per revenue hour	181		71	
8	Maximize travel time savings	Transportation system user benefits	Daily user benefit hours: 8,520		Daily user benefit hours: 5,880	
Goal 3: Provide a Cost-Effective and Financially Feasible Transit System						
9	Balance project costs and benefits (minimize CEI)	Cost Effectiveness Index	BCD1: 26		21	
10	Minimize project capital cost	Project capital cost ($2017)	BCD1: $1,000 million		$560 million	
	Minimize project operating cost	Project operating cost ($2011)	Annual passenger trips: 8.9 million Annual operating cost: $24.1 million Operating cost/passenger: $2.70		Annual passenger trips: 6.7 million Annual operating cost: $20.7 million Operating cost/passenger: $3.15	
	Annualized combined capital and operating cost	Reported in $2011	Annualized capital cost (BCD1): $65.0 million Annualized operating cost (BCD1): $28.9 million		Annualized capital cost: $36.1 million Annualized operating cost: $24.4 million	
11	Maximize long-term investment in the Regional Transit System	Qualitative assessment of connectivity with existing and planned transitway system (LRT and BRT)	LRT relatively greater connectivity with existing and planned transitway system due to interlining with Hiawatha (Blue Line) and convenient transfer to Central (Green Line).		BRT has less convenient connectivity with LRT system but potential to connect with other future BRT (e.g., I-35W Orange Line).	
12	Maximize flexibility to efficiently expand the transit investment to accommodate transitway demand beyond 2030 weekday travel demand forecasts	Transitway capacity and forecast demand	2030 peak hour passengers on board at maximum load point (west of Interchange) = 1,660 - 1,810 (2-car train) = 77% - 85% of 2-car train capacity used in 2030		2030 peak hour passengers on board at maximum load point (east of Interchange) = 800 (capacity constrained) = 100% of capacity used in 2030	
		Ultimate peak hour transitway line capacity	At opening, maximum LRT inbound capacity during peak hour is 1,056 seated passengers and 2,144 total passengers. (Assumes 2-car trains with LRV capacity = 66 seated passengers, 68 standees; 7.5-minute headway). In future, capacity can be increased by 50% by adding 3rd car.		As opening, maximum BRT inbound capacity during peak hour is 500 seated passengers, 800 total passengers. (Assumes BRT vehicle capacity = 50 seated passengers, 30 standees; combined 6-minute headway south of 732 branch). In future, capacity cannot be expanded by reducing headways due to resulting severe adverse impacts on roadway level of service.	

Bottineau Transitway Summary Evaluation

Better ... Worse

			LRT (Alternative B-C-D1 only)		BRT (Guideway on B-C-D1)	
Primary Goals and Objectives that Directly Address the Primary Project Needs						
Goals and Objectives that Reflect Secondary or Additional Opportunities						
Goal 4: Promote Sustainable Development Patterns						
13	Promote land development and redevelopment that supports sustainable transportation policies	Qualitative assessment	LRT likely to have somewhat greater TOD benefits based on greater ridership, perceived permanence, and familiarity to developers		BRT likely to have somewhat lesser TOD benefits based on lower ridership, perceived impermanence, and lack of familiarity to local developers. Lack of long-term capacity of BRT potentially unable to support intensified land use called for in plans	
14	Ensure compatibility with local and regional comprehensive plans	Qualitative assessment of comprehensive plans				
Goal 5: Support Healthy Communities and Sound Environmental Practices						
15	Support economic development and redevelopment efforts	Qualitative assessment	LRT likely to have somewhat greater TOD benefits based on greater ridership, perceived permanence, and familiarity to local developers		BRT likely to have somewhat lesser TOD benefits based on lower ridership, and lack of familiarity to local developers. Limited BRT capacity may be a limiting factor in the magnitude of economic development potential.	
16	Minimize impacts to the natural and built environment	Impacts on wetlands, water, and floodplains	LRT has less impact due to pervious ballasted track areas		BRT has greater impact due to impervious pavement for guideway	
		Impacts on parks	No property impact difference on parks		No property impact difference on parks	
		Impact on visual resources	LRT and BRT have station elements which would change the visual landscape. LRT has overhead catenary, whereas BRT does not.		BRT has the potential for slightly greater visual impact with 10 vehicles per hour as opposed to 8 per hour for LRT. Lesser impacts due to infrastructure (no catenary).	
		Noise and vibration impacts	LRT consists of electrified vehicles with no engines and the main noise caused by wheels on rails. LRT has noise impacts from bells at station stops, possible curve squeal. Higher vibration impacts with heavier vehicles on rail than BRT.		BRT assumes diesel-powered bus vehicles with engine noise but relatively low noise from rubber tires on pavement. BRT vehicles on dedicated transitway would have warning devices at at-grade crossings parallel to BNSF location. MUTCD only specifies warning devices for rail in street running transitways. Low vibration impacts with rubber tires on pavement surface.	
		Impacts on historic and cultural resources	No difference		No difference	
17	Minimize short- and long-term impacts to property, property access, and on-street parking	Loss of property access	No difference		No difference	
		Impacts on boulevards	No difference		No difference	
		Loss of on-street parking	No difference		No difference	
		Businesses/residences lost through full takes (parcels (acres))	No difference		No difference	
		Right-of-way acquisition through partial takes (parcels (acres))	No difference		No difference	
18	Maximize cohesion, preservation, and enhancement of Bottineau Transitway communities		No difference		No difference	
19	Maximize pedestrian and bicycle connections to the Bottineau Transitway	Bike/pedestrian crossings closed	No difference		No difference	
20	Maximize health, environmental and economic benefits to the Bottineau Transitway communities	Assessment based on ridership projections at each station, along with multimodal connection opportunities/design at stations	Greater ridership of LRT over BRT has the potential for greater transit mode share and resulting decreases in vehicle miles traveled, vehicle emissions, and increases in walking and bicycling.		Lesser ridership of BRT compared to LRT has the potential for lesser transit mode share and less decrease in vehicle miles traveled, vehicle emissions, and less increase in walking and bicycling.	
21	Minimize disproportionately high and adverse impacts on the region's minority and/or low-income communities		No difference		No difference	
22	Minimize area traffic impacts	Impacts from traffic diversion	No difference		No difference	
		Impact on local street network	LRT has less adverse impact on local street network due to less frequent headway (7.5 minues) needed to meet passenger demand. If demand increases, it can be met by addding a third LRT vehicle without increasing headway.		BRT requires more frequent headway (6-minute) to meet passenger demand than LRT. If demand increases, increasing headways is not an option due to adverse impacts on vehicle traffic. Also, BRT may degrade traffic operations on local street network where it is street-running in downtown Minneapolis.	
		Intersection closures	No difference		No difference	
		Intersections converted to right-in/right-out	No difference		No difference	