LET'S MOVE NASHVILLE

Metro's Transportation Solution

Travel Time Savings Memorandum

04-05-2018

Metro Nashville PUBLIC WORKS

Nashville MTA

RTA

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Background

Metro Nashville and Davidson County (Metro) are currently in the planning and development stages for several proposed multimodal transit and transportation infrastructure improvements, as first proposed in the 25-year nMotion Strategic Transit Plan (September 2016) and the nMotion High Capacity Briefing Book (August 2017) and now more fully articulated by Let's Move Nashville's Transit Improvement Program (TIP). The TIP includes a combination of Light Rail Transit (LRT) and Rapid Bus infrastructure, as well as local bus improvements to provide a robust, countywide, multimodal transportation network for residents, businesses and visitors. This report estimates the travel time savings for LRT riders diverted from auto and bus modes that result from the proposed transit investment.

Methodology

Transportation improvements resulting from the TIP are expected to reduce the cost of travel and have the possibility to result in travel time savings benefits to users.

Benefits to existing riders are estimated as the difference between the travel time costs in the No-Build, or base case, and the travel time costs in the Build Scenario, times the number of trips. The No-Build Scenario is considered to be identical to today's transit network, in which travelers either drive or use existing local Nashville Metro Transit Authority (MTA) bus routes to travel around Nashville. The Build Scenario assumes the transit network will include a new LRT system and improvements to the existing bus system. This analysis looks at travel time savings realized by **only LRT riders**, all of whom are considered existing trip-makers diverted from either automobiles (auto) or bus.

Inputs and Calculation

Several inputs are required to calculate travel time savings. Inputs are generally provided by the client, the U.S. Department of Transportation (DOT), or are assumptions based on project information. **Table 1** provides a list of necessary inputs and their data source for this analysis.

Table 1: Travel Time Savings Inputs

Variable:	Metric:	Source:
Value of Time	$/hour	USDOT
Vehicle Occupancy Rate (VOC)	Riders/trip	USDOT
"Headway Time"	Frequency	Assumption, often based on existing bus schedule *NOTE: "Headway" time is a measure of the distance or time between vehicles in a transit system. Average wait time should be no more than half of the "headway" time – shorter "headways" typically assume less than half the "headway" time.*
Total number of riders	# of riders	Let's Move Nashville Technical Analysis
Annualization Factor	Days/year	Based on number of weekdays in a year

The following sample calculations are intended to explain how travel time savings were calculated in this model of existing users.

Existing users – in-vehicle:

$$\left(Travel\ time, hrs/trip\ (Base) - Travel\ time, hrs/trip\ (Build)\right) * Value\ of\ Time, \frac{\$}{hr} / VOC, rider/trip = Travel\ Time\ Savings, \$/rider$$

$$Travel\ Time\ Savings, \frac{\$}{rider} * Daily\ number\ of\ riders, riders * Anualization\ Factor, \frac{days}{year} = \boldsymbol{Total\ Travel\ Time\ Savings}, \$$$

Existing users – out-of-vehicle:

$$\left(Avg. Wait\ Time, \frac{hr}{trip} (Base) - Avg. Wait\ Time, \frac{hr}{trip} (Build)\right) * Value\ of\ Time, \frac{\$}{hr} / VOC, rider/trip = Travel\ Time\ Savings, \$/rider$$

$$Travel\ Time\ Savings, \frac{\$}{rider} * Daily\ number\ of\ Riders, riders * Annualization\ Factor, \frac{days}{year} = \boldsymbol{Total\ Travel\ Time\ Savings}, \$$$

Assumptions

Travel time savings is broken down into in-vehicle time and out-of-vehicle time. In-vehicle time is defined as time spent driving or riding in a vehicle, whereas out-of-vehicle time includes walk access, waiting, and transfer time.[1] For this model, it was assumed that the average travel time includes both wait and walk times for each mode. It was also assumed that peak-period bus travel time was equal to the mean travel time to work for public transportation (excluding taxicab) and the peak-period auto travel time was equal to the mean travel time to work for car, truck, or van (drove alone). Therefore, the vehicle occupancy (VOC) for autos is assumed to be equal to 1.0. The assumptions used as inputs in the travel time savings model are presented in **Table 2**.

Table 2: Travel Time Savings Model Assumptions

Variable:		Value:	Metric:	Source:
Value of Time	In-Vehicle	$14.10	$/hour	USDOT
	Out-of-Vehicle	$27.20	$/hour	USDOT (includes walk, wait and transfer time)
Ridership	Build Scenario - Bus (2040)	49,650	# of riders	HDR Calculation (based on 42% bus ridership)
	Build Scenario - LRT (2040)	67,650		HDR Calculation (based on 58% LRT ridership)
	Build Scenario -	117,300		Let's Move Nashville Technical Analysis

[1] U.S. DOT Benefit-Cost Analysis Guidance for TIGER and INFRA Applications (2017)

Variable:		**Value:**	**Metric:**	**Source:**
	Total Transit (2040)			
Ridership Diversion to LRT	Bus	37%	Percent	HDR Calculation based on ridership
	Auto	63%		HDR Calculation based on ridership
Percent peak period riders	LRT	51%	%	Let's Move Nashville Technical Analysis
Travel Time Reduction for off-peak period riders	LRT	50%	%	Assumption based on the fact that all riders would not see peak travel time savings.

In order to determine the total benefit associated with travel time savings, both in-vehicle and out-of-vehicle travel time savings were calculated for both travelers diverted from bus and auto to LRT in the Build Scenario. The 2017 and 2040 data points listed in the tables below were used to extrapolate travel times over the analysis period. To estimate travel time savings over a given time period, the difference between Auto and LRT travel times and Bus and LRT travel times were calculated for each year.

Light Rail Transit (LRT) Travel Times

LRT travel times were calculated based on station to station distances, maximum speeds of 25 mph, acceleration rates of 2.1 mph/s and deceleration rates of 2.9 mph/s and dwell times of 20 seconds per station. LRT out-of-vehicle travel times are based on initial wait time (calculated as ½ of peak headway) and 6 minutes of walking time to and from the station. The 6 minute walking time assumption is based on data from Houston METRO's Red line, which goes through areas of varying land use density. Some of the proposed Nashville LRT segments run through dense areas (with walk times less than 5 minutes) while other segments run through less dense areas (with walk times more than 10 minutes). A system average of 6 minutes was assumed for this high level analysis. Peak headway is considered between 6:00 AM and 6:00 PM.[2]

Auto Travel Times

Auto travel time data was obtained from INRIX, a company that provides historical travel time data for roadway segments based on data from commercial fleets, GPS, cell towers, mobile devices and cameras. In-vehicle travel times for autos were from peak INRIX 2017 travel time data (Tuesday, Wednesday, and Thursday travel time data for October 2017), with estimated segment travel times where data was not available. 2040 auto in-vehicle travel times were estimated by applying 28 percent increase in highway travel times between 2017 and 2040, obtained from the Nashville Area Metropolitan Planning Organization's (MPO) travel model, to 2017 INRIX data. Average auto out-of-vehicle travel times included time taken from home to reach local road network plus the time taken to walk from parking lot to final destination, which is assumed to be 9 minutes in total per trip based on data from the MPO highway network model.

[2] Let's Move Nashville Technical Analysis

Bus Travel Times

Bus in-vehicle travel times are based on MTA data for one typical weekday only and not on a 3 weekday average like the auto travel times. 2040 bus in-vehicle travel times were computed by applying the same congestion factor as auto to the 2017 bus times provided by the MTA. Bus out-of-vehicle travel times are based on initial wait time (calculated as ½ of peak headway) and 7 minutes of walking time to and from the station. One minute was added to the bus mode because we assumed access to LRT stations would be direct while bus passengers may have to cross additional traffic signals or walk an additional block due to one way routes and down town bus loops.

Travel time assumptions for AM and PM peak hour were provided for both 2017 and 2040 and are presented in **Table 3** through **Table 6**.

Table 3: 2017 AM Peak Hour - Travel Times (Minutes)

	LRT			Auto			Bus		
Corridor Name	In-vehicle time	Out-of-vehicle time	Total travel time	In-vehicles time	Out-of-vehicle time	Total travel time	In-vehicle time	Out-of-vehicle time	Total travel time
Gallatin	24.7	11	**35.7**	26.3	9	**35.3**	31	14.5	**45.5**
Charlotte	20.2	11	**31.2**	24.5	9	**33.5**	27	14.5	**41.5**
Murfreesboro	24.6	11	**35.6**	27.2	9	**36.2**	35	19	**54**
Nolensville	22.2	11	**33.2**	26.2	9	**35.2**	32	12	**44**
Average	22.9	11.0	**33.9**	26.1	9.0	**35.1**	31.3	15.0	**46.3**

Table 4: 2017 PM Peak Hour - Travel Times (Minutes)

	LRT			Auto			Bus		
Corridor Name	In-vehicle time	Out-of-vehicle time	Total travel time	In-vehicles time	Out-of-vehicle time	Total travel time	In-vehicle time	Out-of-vehicle time	Total travel time
Gallatin	24.7	11	**35.7**	28.5	9	**37.5**	38	14.5	**52.5**
Charlotte	20.2	11	**31.2**	30.6	9	**39.6**	37	14.5	**51.5**
Murfreesboro	24.6	11	**35.6**	31.9	9	**40.9**	37	19	**56**
Nolensville	22.2	11	**33.2**	32.1	9	**41.1**	43	12	**55**
Average	22.9	11.0	**33.9**	30.8	9.0	**39.8**	38.8	15.0	**53.8**

Table 5: 2040 AM Peak Hour - Travel Times (Minutes)

	LRT			Auto			Bus		
Corridor Name	In-vehicle time	Out-of-vehicle time	Total travel time	In-vehicles time	Out-of-vehicle time	Total travel time	In-vehicle time	Out-of-vehicle time	Total travel time
Gallatin	24.7	11	**35.7**	33.9	9	**42.9**	40	14.5	**54.5**
Charlotte	20.2	11	**31.2**	31.6	9	**40.6**	35	14.5	**49.5**

	LRT			Auto			Bus		
Murfreesboro	24.6	11	**35.6**	35	9	**44**	45	19	**64**
Nolensville	22.2	11	**33.2**	33.5	9	**42.5**	42	12	**54**
Average	22.9	11.0	**33.9**	33.5	9.0	**42.5**	40.5	15.0	**55.5**

Table 6: 2040 PM Peak Hour - Travel Times (Minutes)

	LRT			Auto			Bus		
Corridor Name	In-vehicle time	Out-of-vehicle time	Total travel time	In-vehicles time	Out-of-vehicle time	Total travel time	In-vehicle time	Out-of-vehicle time	Total travel time
Gallatin	24.7	11	**35.7**	36.7	9	**45.7**	49	14.5	**63.5**
Charlotte	20.2	11	**31.2**	39.5	9	**48.5**	48	14.5	**62.5**
Murfreesboro	24.6	11	**35.6**	40.8	9	**49.8**	48	19	**67**
Nolensville	22.2	11	**33.2**	41.5	9	**50.5**	55.5	12	**67.5**
Average	22.9	11.0	**33.9**	39.6	9.0	**48.6**	50.1	15.0	**65.1**

To calculate the overall benefit associated with travel time savings, we used the monetized hourly values for travel time recommended by the U.S. DOT for in-vehicle travel and out-of-vehicle travel of $14.10 and $27.20, respectively.3 The travel time unit cost of in-vehicle time as opposed to out-of-vehicle time varies based on the type of trip, travel conditions, and traveler preferences.4 The actual clock time, measured objectively, and perceived time are both taken into consideration in the travel time valuation.

The peak hour travel times were used to estimate benefits for peak period riders. Peak period riders were assumed to be commuters (or work trips) which make up 51 percent of all daily riders.[5] The peak travelers were split between AM and PM equally. It was assumed that the travel time savings for off-peak trip-makers, representing 49 percent of all riders, would be a 50 percent reduction of the estimated peak travel time savings. This reduction was based on the fact that trip-makers during peak periods would see the greatest travel time savings when diverting from auto or bus to LRT. Therefore, in order to not overstate these benefits, a reasonable assumption of 50 percent less travel time savings was used for off-peak trip-makers.

Findings

The travel time savings analysis was conducted over a 20 year period, following the end of construction in 2032 through 2052. An annualization factor of 305 days per year was used to convert weekday peak travel times to annual travel times, excluding weekends.6 Using an annualization factor of 305 will likely result in an underestimate of benefits. Based on the travel time savings in hours, the monetized value of travel time savings, and the ridership data, the total value of travel time savings for all users using the average AM and PM peak travel times is $1.26 billion in undiscounted benefits in 2017 dollars. Using a discount rate of 7 percent and 3

[3] U.S. DOT Benefit-Cost Analysis Guidance for TIGER and INFRA Applications (2017)

[4] Victoria Transport Policy Institute - "Transportation Cost and Benefit Analysis II - Travel Time Costs" (2017)

[5] Let's Move Nashville Technical Analysis

[6] Let's Move Nashville Technical Analysis

percent, per USDOT benefit-cost analysis guidance, the total value of travel time savings for all users is $225 million and $583 million, respectively.

The annual travel time saving for 2033, the first year after construction, is estimated to be $43 million in undiscounted benefits. Annual travel time savings are expected to increase over time as ridership projections increase annually.

A summary of these findings is shown in **Table 7**.

Table 7: Travel Time Savings Benefit Summary (2017 $)

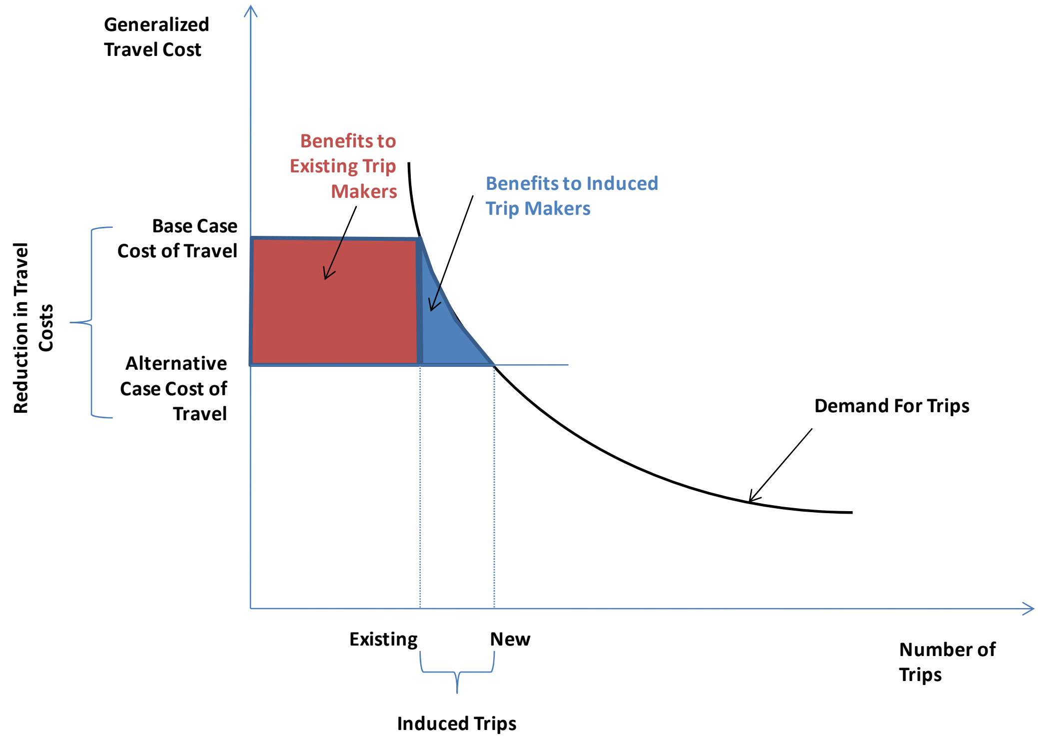
	Travel Time Savings Benefit (2032-2052)
Travel Time Savings Benefit, Undiscounted	$1,261,970,874
Travel Time Savings Benefit, Discounted at 3%	$583,396,439
Travel Time Savings Benefit, Discounted at 7%	$225,023,672

Generalized Cost Discussion

The generalized cost of travel typically combines the travel time savings and the user costs per mile, or mobility costs. The mobility costs are presented in a separate technical memorandum on mobility and accessibility and are therefore not included in this memo.

In addition, as the generalized cost of travel is reduced, additional transit trips may be expected. These induced trip-makers represent trip-makers who did not make a trip (or as many trips) in the No-Build Scenario, but are now “attracted” to the lower generalized cost allowed by the investment. However, the travel time savings costs discussed in this memorandum reflect only LRT riders, all of which are assumed to have been diverted from alternate modes following the implementation of the proposed LRT system. These benefits to existing trip-makers are represented by the red rectangle in **Figure 1**. Since all future LRT riders are accounted for as either diverted from auto or bus, there are no induced riders considered in this calculation.

Figure 1: Framework for the Estimation of User Benefits



Should there be user benefits resulting from induced trips, these would be depicted by the blue triangle in **Figure 1**. These benefits from induced trips would be estimated using the "rule-of-a-half".7 The "rule-of-a-half" multiplies the change in generalized cost by the number of induced trip-makers and divides by two, or cuts in half. **Please note that for the induced trips, the change in generalized cost from no-build to build conditions only represents both the travel time costs and the user (mobility) costs.** Social costs, including air emissions, accident occurrences, and congestion externalities are assumed not to affect trip making or modal decisions in this analysis.

Conclusion

Travel time savings, along with out-of-pocket user costs (or mobility costs), are the key components that make up the generalized cost of travel that influence a trip-maker when considering which mode of transportation to use. Having a greater variety of transit options that provide faster travel times encourages existing trip-makers to switch modes of travel.

The implementation of the TIP's LRT will result in reduced travel time for trip-makers diverting from auto and existing bus modes to LRT. As shown through this analysis, transportation mode shifts will result in an estimated annual travel time savings benefit of $43 million in 2033. Estimated annual travel time savings are expected to increase as ridership projections grow annually.

[7] Transportation Economics "Transportation Benefit-Cost Anslysis - Evaluating Benefits" - http://bca.transportationeconomics.org/benefits/induced-travel/evaluating