

**User Benefits resulting from the introduction of high speed passenger rail service  
between Oklahoma City and Tulsa**

Prepared by

Richard S. Marshment, Ph.D.  
Mathew Mantell

Mary Court, Ph.D.  
Dimitrios Karapanagiotis

University of Oklahoma  
Norman, Oklahoma  
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Rail Programs Division  
Oklahoma Department of Transportation  
Joe Kyle, Rail Programs Division Manager

This report describes the methodology used to estimate the dollar value of the benefits to users of a proposed high speed passenger rail service operating between Tulsa and Oklahoma City. We first introduce a theoretical framework illustrating graphically how to calculate benefits to different groups of users. We then present the year 2010 travel forecasts whose derivations are documented elsewhere.<sup>1</sup> The next section covers the unit costs employed in converting non-pecuniary impacts into monetary benefits. The final section computes user benefits. Non-user benefits such as energy conservation, environmental improvements, and employment and income generation are discussed in companion reports.<sup>2</sup>

## USER BENEFITS IN A TWO MODE ENVIRONMENT

User benefits refer to the welfare gained by travelers in the Tulsa to Oklahoma City corridor as a result of introducing high speed passenger rail service. Transportation improvements generate user benefits in the form of travel time savings, lower vehicle operating costs, and increased safety. Economists measure these benefits according to the *willingness to pay* principle which is the monetary value of the welfare travelers would be willing to purchase but for which they do not have to pay. For example, the fare a traveler would have to pay for a trip between Tulsa from Oklahoma City might be substantially lower than the fare the traveler would be willing to pay if, for example, that person could not otherwise travel or safety was a particularly high priority. Since some benefits for which people are willing to pay are not separately priced, e.g. enhanced mobility and safety, investment studies employ a variety of techniques to indirectly measure the value travelers assign to different kinds of benefits. These values lead to a measure called *generalized cost* which summarizes all the costs, monetary and otherwise, paid by a traveler to make a trip including out-of-pocket expenditures, time, risk, convenience and comfort. Generalized cost is necessary to calculate *consumer surplus*, which is the difference between total user benefits and total user payments.<sup>3</sup>

Figure 1, adapted from Wohl and Hendrickson<sup>4</sup>, illustrates how the generalized cost and consumer surplus concepts can be used to quantify the benefits of high speed passenger rail service in the Oklahoma City to Tulsa corridor. Figure 1 depicts the Turner Turnpike and Oklahoma City to Tulsa passenger rail markets. Initially there is no passenger rail service in the corridor. The generalized cost of making the trip via the Turner Turnpike is  $0c_1$ . The demand function for passenger travel on the Turnpike is labeled  $d_1$ . Generalized cost  $0c_1$  yields passenger volume  $0v_1$ . Travel conditions in the corridor improve with the introduction of high speed rail service causing a downward shift in the demand for Turner Turnpike use to  $d_2$ . Initially travelers must choose between paying  $0p_2$  to use the rail line, a user cost less than  $0c_1$ , or continuing to pay  $0c_1$  to use the Turner Turnpike. Lower price  $0p_2$  attracts  $0v_1 - 0v_2 = 0r_1$  travelers from the Turner Turnpike

There are three groups of users who would benefit from the high speed rail service. First, there are the  $0v_1 - 0v_2 = 0r_1$  travelers who shift from the Turner Turnpike to the rail system. These travelers must benefit or else they would not switch. Second, there are those (both turnpike and rail) users who did not travel prior to the introduction of rail service. Since the rail line increases capacity in the corridor producing lower prices for all travelers, the overall improvement induces some persons to make trips which were not worthwhile prior to the rail service. And third, there are turnpike users who remain turnpike users after the rail service is introduced. Figure 1 shows how to account for the benefits of these three groups.

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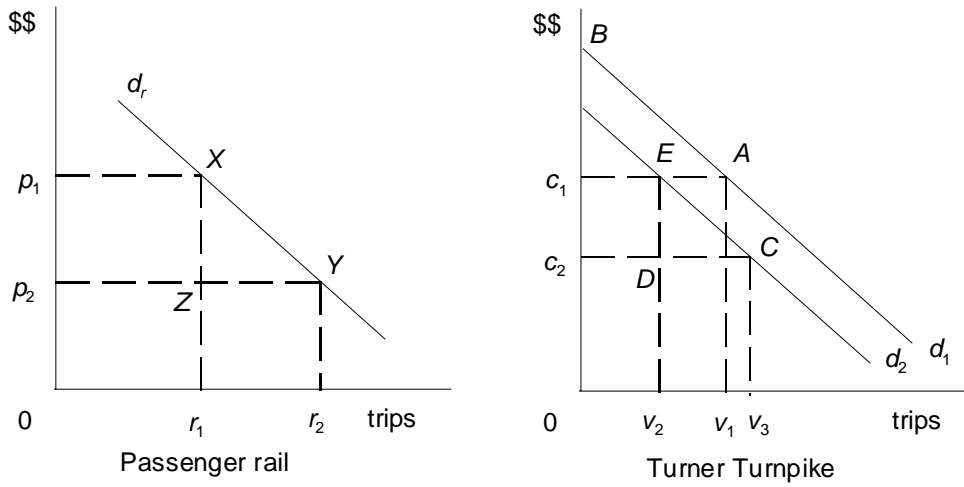
<sup>1</sup>Marshment, R., Court, M., Mantell, M., and Karapanagiotis, D., *Patronage forecast for the proposed high speed passenger rail service between Tulsa and Oklahoma City*, Oklahoma Transportation Center, July 2003.

<sup>2</sup>Court, M., R. Marshment, D. Karapanagiotis, and M. Mantell, *Output, earnings, and job impact analysis for construction of a high speed rail corridor between Tulsa and Oklahoma City using RIMS-II Multipliers*, Oklahoma Transportation Center, March 2003.

<sup>3</sup> For a general introduction to this material, see Banister, D., and J. Berechman, *Transport Investment and Economic Development*, University College London, 2000, pp. 161-209, 278-285.

<sup>4</sup> Wohl, Martin, and Chris Hendrickson, *Transportation Investment and Pricing Principles*, John Wiley & Sons, 1984, pp. 95-97.

**FIGURE 1 Consumer surplus model for rail and auto travel in the Oklahoma City to Tulsa corridor**



Prior to introducing rail service, there were  $0v_1$  travelers in the corridor paying  $0c_1$  per trip. Total user payments therefore equals  $(0c_1)(0v_1)$ , equivalent to the area  $Ac_10v_1$  in Figure 1. But most users are willing to pay more than  $0c_1$  to travel in the corridor. The total amount they are willing to pay in excess of what they have to pay is called *consumer surplus* and equals the triangular area  $ABC_1$  in Figure 1.

Rail service enters the market with a lower generalized cost than passenger car travel. In Figure 1, the introduction of high speed passenger rail service at a generalized cost of  $0p_2$  will divert  $0r_1$  Turner Turnpike users to the rail line, where  $0r_1 = 0v_1 - 0v_2$ . This is the first group of beneficiaries. Following Button, their benefit net of the costs they pay equals "... half of the difference in benefit between the cost reductions ...."<sup>5</sup> Eq. (1), using the nomenclature in Figure 1, shows net user benefit (*NUB*) for those who shift as one-half the difference between the cost reductions on the Turnpike and the rail line times the number of travelers who switch.

$$NUB_s = 0.5 * 0r_1 * [(0p_1 - 0p_2) + (0c_1 - 0c_2)], \quad 0p_1 = 0c_1 \quad (1)$$

The diversion of  $0r_1$  travelers from the Turner Turnpike to the rail line results in less congestion on the Turnpike. The effect is to reduce the cost of traveling the Turnpike from  $0c_1$  to  $0c_2$ . The price reduction induces  $0v_3 - 0v_2$  new Turnpike travelers, that is, persons who did not travel at all prior to the introduction of the rail line. The rail line also attracts induced travelers. Setting  $0p_1$  equal to  $0c_1$ , the rail line induces  $0r_2 - 0r_1$  new rail travelers. Induced travel on the Turnpike and the rail line constitutes the second group of beneficiaries. Their benefits equal the sum of the two triangular areas  $CDE$  [Eq. (2)] and  $XYZ$  [Eq. (3)].

$$NUB_{induced\ Turnpike} = 0.5 * (0c_1 - 0c_2) * (0v_3 - 0v_2) \quad (2)$$

$$NUB_{induced\ rail} = 0.5 * (0p_1 - 0p_2) * (0r_2 - 0r_1) \quad (3)$$

The third group of beneficiaries are those who remain on the Turnpike after passenger rail service commences. There were  $0v_2$  travelers willing to travel the turnpike when the cost was  $0c_1$  but who, after introduction of the rail line, only have to pay  $0c_2$ . Each Turnpike traveler increases their consumer surplus

<sup>5</sup> Button, Kenneth J., *Transport Economics*, 2<sup>nd</sup> ed., Edward Elgar Publishing, 1993, pp. 182-184.

by the amount of the price reduction,  $0c_1 - 0c_2$ . The total benefit to this group equals the area  $0p_1CD0p_2$  in Figure 1 and is calculated according to Eq. (4).

$$NUB_{NS} = (0c_1 - 0c_2)(0v_2) \tag{4}$$

## PATRONAGE FORECASTS

Forecasted year 2010 HSR ridership on the Tulsa to Oklahoma City line is in the range of 133,955 to 491,655. Table 1 categorizes forecasted HSR patronage by trip purpose and whether the trip is diverted from the Turner Turnpike or induced. The percentages reflect the output of the mode split model borrowed from the Tampa to Orlando corridor.<sup>6</sup> Multiplying the percentages in Table 1 by the highest year 2010 annual patronage forecast yields Table 2. Since the value of time and other factors are different for different trip purposes, the patronage forecast must remain disaggregated in this manner so that benefits can be calculated separately for each group. Benefits calculated for this volume can be considered an upper limit.

**TABLE 1 Percentage of HSR trips between Tulsa and Oklahoma City by purpose and source**

Trip purpose	Diverted trips	Induced trips	Total trips
Commute	12.2	0	12.2
Resident business	40.7	0.5	41.2
Resident non-business	19.3	0.2	19.5
Non-resident business	3.0	0.0	3.0
Non-resident non-business	23.7	0.4	24.1

**TABLE 2 Patronage forecast for the proposed high speed passenger rail service between Tulsa and Oklahoma City in passengers per year**

Trip purpose	Diverted trips	Induced trips	Total trips
Commute	59,982		59,982
Resident business	200,104	2,458	202,562
Resident non-business	94,889	983	95,872
Non-resident business	14,750		14,750
Non-resident non-business	116,522	1,967	118,489

## GENERALIZED COSTS

Generalized cost includes all relevant influences affecting traveler decisions regarding mode of travel. Out-of-pocket expenses for fuel, maintenance, and tolls, are one portion of the cost of making a trip. Travel time cost is the other major component. Travelers repeatedly demonstrate a willingness to pay out-of-pocket to reduce time spent traveling. An analysis of intercity travel patterns in the Orlando to Tampa, Florida, corridor indicated peoples' willingness to pay for reductions in travel time varied with trip purpose. Table 3 reports these results. Note the high value business travelers assign to conserving travel time.

Table 4 provides the travel distances and costs for the proposed high speed passenger rail line and automobile travel between Oklahoma City and Tulsa. Note the column in Table 4 describing auto travel in the corridor before and after introduction of rail service. The rail line is not forecast to divert enough travelers from the Turner Turnpike to significantly affect travel time. This treatment simplifies calculation of user benefits

<sup>6</sup> *Patronage forecast for the proposed high speed passenger rail service between Tulsa and Oklahoma City*, Oklahoma Transportation Center, 22 July 2003.

**TABLE 3 Intercity/commute value of time analysis results for the Tampa to Orlando high speed passenger rail corridor**

Trip purpose	Willingness to pay to conserve one hour of travel time
Commute	\$ 7.00
Business	19.25
Non-business (alone)	9.00
Non-business (group)	7.25

SOURCE: Exhibit C-2, AECOM Consult & Wilbur Smith Associates, *Investment Grade Ridership Study, Supplemental Details*, p. C-5.

**TABLE 4 In-vehicle and out-of-vehicle travel time and travel cost between Oklahoma City and Tulsa for high speed passenger rail service and private automobile**

	Private automobile		High speed passenger rail	
	before rail	after rail	before rail	after rail
In-vehicle travel time	100.75 min. <sup>a</sup>	100.75 min. <sup>a</sup>	NA	59.4 min. <sup>b</sup>
Out-of-vehicle travel time	10 min.	10 min.	NA	60 min.
Business travel cost	\$42.50 <sup>a,c</sup>	\$42.50 <sup>a,c</sup>	NA	\$28.00 <sup>d</sup>
Non-business travel cost	\$16.50 <sup>e</sup>	\$16.50 <sup>e</sup>	NA	\$28.00 <sup>d</sup>
Travel distance	108.25 mi. <sup>a</sup>	108.25 mi. <sup>a</sup>	NA	101.68 mi. <sup>b</sup>

NOTES: NA = not available. <sup>a</sup>Result of travel survey. See Marshment, R., M. Court, M. Mantell, and D. Karapanagiotis, *Patronage forecast for the proposed high speed passenger rail service between Tulsa and Oklahoma City*, July, 2003, Appendix C. <sup>b</sup>Carter-Burgess Associates, ..... <sup>c</sup>Based on \$0.36 per mile vehicle operating cost plus \$3.50 Turnpike Toll. Cost data from AECOM Consulting and Wilbur Smith Associates, *Investment grade ridership study: Supplemental Details*, 20 NOV 2003, p. D-8. <sup>d</sup>Marshment, R., M. Court, M. Mantell, and D. Karapanagiotis, Table 6, p. 12. <sup>e</sup>Based on \$0.12 per mile vehicle operating cost plus \$3.50 toll. See footnote c.

Eq. (5) uses of the data in Tables 3 and 4 to construct the generalized cost of making a trip between Tulsa and Oklahoma City. Note in Eq. (5) that out-of-vehicle travel time is weighted at twice the value of in-vehicle travel time. Travelers demonstrate a willingness to spend more to save travel time spent out of the vehicle than time spent in the vehicle. The Orlando to Tampa high speed passenger rail study constrained the value of out-of-vehicle time to twice in-vehicle time;<sup>7</sup> urban studies weight out-of-vehicle time up to six times in-vehicle time.<sup>8</sup>

$$\$GC_{mode,t} = (\$m_{mode})(TD_{mode}) + (\$VOT_t)(IVTT_{mode}) + 2 * (\$VOT_t)(OVTT_{mode}) \quad (5)$$

where

- GC = generalized cost
- m = cost to traveler per unit of distance; Orlando to Tampa high speed rail corridor study reported \$0.36 per mile for business travel in company auto, \$0.06 per mile for rental cars, \$0.12 per mile for non-business travel<sup>9</sup>
- TD = travel distance
- VOT = value of time in dollars per hour
- IVTT = in-vehicle travel time in hours
- OVTT = out-of-vehicle travel time in hours
- mode = values will vary by mode of travel, i.e. high speed passenger train or private auto on the Turner Turnpike
- t = trip purpose, i.e. business, commute, non-business

<sup>7</sup> *op. cit.*, pp. C-5, C-6.

<sup>8</sup> Meyer, Michael, and Eric Miller, *Urban Transportation Planning*, 2<sup>nd</sup> ed., McGraw Hill, 2001, p. 299.

<sup>9</sup> AECOM Consulting and Wilbur Smith Associates, *Investment Grade Ridership Study: Supplemental Details*, 20 NOV 2002, p. D-3.

Table 5 shows the generalized cost for the Oklahoma City to Tulsa corridor.

**TABLE 5 Generalized cost for travel in the Oklahoma City to Tulsa corridor by mode**

Trip purpose	Turnpike before	Turnpike after	Rail before	Rail after
Commuter	\$27.25	\$27.25	NA	\$20.93
Resident Business	78.21	78.21	NA	57.56
Non-resident Business	78.21	78.21	NA	57.56
Resident non-business	31.31	31.31	NA	26.91
Non-resident non-business	31.31	31.31	NA	26.91

NOTE: NA = not applicable

To illustrate how these figures were derived, consider the Turnpike trip before the introduction of rail. CBD to CBD distance is 108.75 miles. For business trips, the cost per mile is \$0.36 per mile<sup>10</sup> yielding fuel and maintenance costs of (108.75 X \$0.36 = ) \$39.15. In-vehicle travel time is 101.75 minutes and out-of-vehicle time is 10 minutes. From Table 3 business travel time is worth \$19.25 per hour. The value of IVTT is therefore 101.75 X (\$19.25/60) = \$32.64 and the value of OVTT is 2 X [10 X (\$19.25/60)] = \$6.42. The total generalized cost of an auto trip via the Turner Turnpike between the Oklahoma City and Tulsa downtowns is the sum of the three figures: \$39.15 + 32.64 + 6.42 = \$78.21. The calculation is summarized in Eq. (6).

$$\begin{aligned} \$GC_{Turnpike, 2003} &= (\$0.36 / \text{mile}) (108.75 \text{ mi.}) + (\$19.25 \text{ per hour} / 60) (101.75 \text{ min.}) \\ &+ 2 (\$19.25 \text{ per hour} / 60) (10 \text{ min.}) = \$78.21 \end{aligned} \quad (6)$$

Vehicle operating costs of \$0.12 and \$0.36 per mile exclude all fuel taxes as these represent transfer payments to the operator and not real savings to travelers. For the same reason tolls and fares paid by travelers are not included in the calculation of user savings.<sup>11</sup>

### USER BENEFIT CALCULATIONS

As there are no savings to travelers who do not switch from the Turnpike to the train, all user benefits derive from application of Eq.s (1) and (3). To illustrate the calculations, benefits to commuters who switch to the rail service from the turnpike equal \$189,543 as derived in Eq. (7) according to Eq. (1):

$$\begin{aligned} NUB_{s,c} &= 0.5 * 0r_1 * [(0p_1 - 0p_2) + (0c_1 - 0c_2)] = \\ &= 0.5 * 59,982 * [(\$27.25 - \$27.25) + (\$27.25 - \$20.93)] = \$189,543 \end{aligned} \quad (7)$$

where all variables are as previously defined and the subscript *c* indicates commuters. Benefits to induced non-resident non-business travelers is shown in Eq. (8) calculated according to Eq. (3):

$$NUB_{induced rail} = 0.5 * (0p_1 - 0p_2) * (0r_2 - 0r_1) = 0.5 * (\$34.81 - \$26.91) (1,967) = \$7,770 \quad (8)$$

Benefits to the respective groups of travelers calculated in the same manner as Eq.s (7) and (8) are summarized in Table 6. These are annual benefits which commence in the year 2010. Note the biggest beneficiaries of this project are resident business travelers.

<sup>10</sup>AECOM Consulting and Wilbur Smith Associates, *Investment Grade Ridership Study: Supplemental Details*, 20 NOV 2002, p. D-3.

<sup>11</sup> Wohl, Martin and Chris Hendrickson, *Transportation Investment and Pricing Principles*, John Wiley & Sons, 1984, p. 56.

**TABLE 6 User benefits by type of user for the proposed high speed passenger rail service between Tulsa and Oklahoma City in dollars for the year 2010**

Trip purpose	Diverted trips	Induced trips	Total trips
Commuter	\$ 189,543		\$ 189,543
Resident business	2,066,074	\$ 25,379	2,091,453
Resident non-business	979,729	10,149	989,878
Non-resident business	32,450		32,450
Non-resident non-business	256,348	17,094	273,442
<b>TOTAL</b>	<b>\$3,524,144</b>	<b>\$ 52,622</b>	<b>\$3,576,766</b>