Appendix A: Full Benefit-Cost Report

PROJECT AND BASE CASE OVERVIEW

The Louisville-Southern Indiana Ohio River Bridges Project in the Louisville Metropolitan Area (LMA) is requesting a $135 million TIGER II Discretionary Grants to support the Project. As the proposed TIGER II Discretionary Grant would provide a critical element in enabling the overall $3.1 billion (present value) project to be constructed, the benefit-cost analysis has been undertaken on two levels:

1. First, the overall benefit/cost relationship of the entire Project, which potential TIGER II funds may enable to be financed; as well as
2. An estimation of the proportional "share" of the benefit commensurate with the share of Project costs covered by the proposed $135 million in TIGER II Discretionary Grants assistance (approximately 4.35% of the estimated present value cost of the overall project or $3.1 billion and referred to as the TIGER II Portion).

The benefit-cost analysis is presented for both the entire Project and the 4.35% share because although the benefit/cost ratio is assumed to be the same (the share of benefits from the project attributable to TIGER II assistance is assumed to be no more than TIGER II assistance's share of costs).The analysis of the overall Project illustrates:

1. The significant net present value of the Project, as well as the significant employment, earnings and output effects which may be enabled by the TIGER II assistance, and should be taken into consideration, though not directly divisible by the proposed $135 million TIGER II funds to be applied to the Project,
2. The $135 million in TIGER II assistance will be leveraged to achieve a much larger societal benefit and is supported by the magnitude of the significant societal benefits of the entire Project. The overall societal benefit cannot be directly divisible by the proposed $135 million TIGER II assistance since this overall benefit is not fully supported by the TIGER II assistance.
3. Although only the 4.35% of the overall benefits of the project are associated directly with the TIGER II assistance, the benefit-cost ratio, Net Present Value and other findings presented show the Project to be very competitive with other projects of similar size and cost.

For the abovementioned reasons, this benefit-cost analysis offers the cost and benefit relationships for a $135 million project, as a proportional share within the context of the entire Project as proposed in this TIGER II application. To illustrate the magnitude of the larger project, results are presented for entire Project as well as the TIGER II Portion.

The Benefit-Cost analysis has been conducted over a period of 46 years (2011 – 2056). Unless otherwise stated, all analysis relates to the costs and benefits over this period and where relevant, in 2010 dollars.

Figure BC-I shows the assumptions of the Base and Project case used in the benefit-cost analysis for the Project.

Base Case	**Project Case**
Ohio River Bridges Project is unable to proceed at any level. The $3.1 billion in associated other project costs do not accrue. The benefits in travel efficiency, safety and environmental quality do not accrue.	Ohio River Bridges Project proceeds as anticipated, leveraging the $135 million in TIGER II assistance. The $3.1 billion in associated overall project costs accrue (with the TIGER II assistance supporting a 4.35% share of the overall project) The benefits of the overall project accrue (with the TIGER II assistance assumed to be responsible for benefits associated with its proportionate 4.35% share of the overall project). While some additional benefits from the leveraging of the funds may accrue, available modeling and methods do not quantify these benefits, therefore only 4.35% of benefits are "claimed" in the benefit-cost analysis.

The following is a summary of key elements of the costs and economic benefits expected to accrue from the Project (both the overall Project and the TIGER II Portion).The information summarized in this section is supported by relevant appendices. The following appendices are referenced throughout the benefit-cost analysis narrative:

Appendix I includes a complete set of tables showing the detailed results of the benefit-cost analysis at the 7% discount rate.

The following elements are covered in **Appendix I**:

Appendix I-A: **(I-A FULL for the overall project)**	Direct Travel Impacts of the Project (Includes all relevant travel related impacts)
Appendix I-B: **(I-B – FULL for the overall project)**	Direct Economic Impacts of the Project by Year (Includes impacts on earnings, output and employment)
Appendix I-C: **(I-C – FULL for the overall project)**	Detailed Benefit Cost Report by Mode (Included modal breakdown of all cost and benefit elements)
Appendix I-D: **(I-D – FULL for the overall project)`**	Detailed Benefit Cost Report by Year

Appendix II includes a description of the TREDIS benefit-cost methodology and underlying assumptions of the model not otherwise covered in the benefit-cost analysis. **Appendix III** includes a summary of assumptions regarding changes in travel demand. **Appendix IV** includes all data sources and default values used in deriving economic benefits.

The **Appendices** are offered to provide a reference for any particular components of costs or benefits over time. The following is an analysis of key elements of benefit-cost appropriate for this TIGER II Application.

PROJECT COSTS

Overview of Costs

The overall costs of the Project include startup costs (which include the costs of constructing the project), as well as annual operations and maintenance costs, which accrue throughout the useful life of the project (assumed to be approximately 50 years).The analysis includes some residual value at the end of the analysis period because the benefit-cost modeling software used only estimates the benefits as far as 2056, and because the Project's useful life extends beyond this date (reported in **Appendix I-D**). Based on the life cycle cost analysis, project schedule and construction costs given in the Project Description, **Table BC-I** shows a summary of the assumed costs (startup and annual operating) associated with the TIGER II Portion as a 4.35% share of the overall Project. For context, **Table BC-II** shows the costs of the entire project (which includes the TIGER II Portion).

Table BC-I: Costs Assumed in BCA for the TIGER II Portion ($2010)

Startup Construction Costs ($m)					
Cost Category	Road	Rail	Air	Water	Total
Property Acquisition	6.51	0	0	0	6.51
Engineering & Design	7.16	0	0	0	7.16
Right-of-Way (paving, rails)	121.33	0	0	0	121.33
Transport Structures (bridges)	0	0	0	0	0
Terminal Bldgs & Equipment	0	0	0	0	0
Vehicles	0	0	0	0	0
Total Startup Costs	**135**	**0**	**0**	**0**	**135**
Annual Operations & Maintenance Costs ($m/yr)					
Cost Category	Road	Rail	Air	Water	Total
Ongoing Operations	0.42	0	0	0	0.42
Maintenance & Rehabilitation	0.61	0	0	0	0.61
Total Annual Costs	**1.03**	**0**	**0**	**0**	**1.03**

Table BC-II: Costs Assumed in BCA for the Overall $3.1 Billion Project ($2010)

Startup Construction Costs ($m)					
Cost Category	**Road**	**Rail**	**Air**	**Water**	**Total**
Property Acquisition	150	0	0	0	150
Engineering & Design	165	0	0	0	165
Right-of-Way (paving, rails)	2,796.00	0	0	0	2,796.00
Transport Structures (bridges)	0	0	0	0	0
Terminal Bldgs & Equipment	0	0	0	0	0
Vehicles	0	0	0	0	0
Total Startup Costs	**3,111.00**	**0**	**0**	**0**	**3,111.00**
Annual Operations & Maintenance Costs ($m/yr)					
Cost Category	Road	Rail	Air	Water	Total
Ongoing Operations	9.68	0	0	0	9.68
Maintenance & Rehabilitation	14.09	0	0	0	14.09
Total Annual Costs	**23.77**	**0**	**0**	**0**	**23.77**

PROJECT BENEFITS BY TYPE

The Project is expected to have all applicable benefits relating to the criteria for the TIGER II program. Below, we summarize the quantifiable economic benefits pertinent to each aspect of the TIGER II BCA criteria and explain how the benefits were derived. The relevant types of benefits for each of the TIGER II BCA criteria are reported in 2010 constant dollars, while cumulative totals are discounted at 7%, and undiscounted totals are given for the overall benefit-cost ratio and net present value analysis in **Section IV**. The estimation of project benefits refers to 2025 as the year of the most current available forecast (based on the 2003 Final Environmental Impact Statement (FEIS) for the Ohio River Bridges Project), and 2056 as the horizon year of the benefit-cost analysis (as the furthest out-year available through the selected benefit-cost estimation software).Since the Project has an extended construction period and a 50 year estimated life, the project will still have residual value in 2056, as shown in the final table of **Appendix I-D**.

(a) Livability

The Ohio River Bridges Project is expected to enhance livability throughout the Louisville Metropolitan Area (LMA) by providing more efficient routes to Louisville's economic centers as well as connections to employment opportunities and cultural resources throughout the region. By enhancing traffic routing, the overall Project will reduce the amount of truck and passenger car traffic on the overall transportation network, thereby increasing overall accessibility throughout the area.

Similarly, the TIGER II Portion is expected to generate substantial regional travel time and travel cost savings. By 2025, the TIGER II Portion is expected to reduce annual (non-cumulative) vehicle miles traveled (VMT) within the LMA by over 2.13 million, including nearly 1.94 million passenger miles and 0.19 million truck ton-miles. The TIGER II Portion is expected to reduce vehicle hours traveled (VHT) in 2025 by over 575 thousand person-hours, including 523 thousand passenger person-hours and over 52 thousand truck person-hours. These values are presented in **Appendix I-D**: Benefits and Costs by Year, Impact on Travel Characteristics table (2025 is Project Year 15).

To place these estimates within the context of the overall Project, by the year 2025 the $3.1 billion project is expected to reduce annual (non-cumulative) VMT within the LMA by 49.14 million miles, including 44.69 million passenger miles and approximately 4.45 million truck ton-miles. The overall Project is expected to reduce VHT in 2025 by over 13.26 million hours, including 12.06 million passenger person-hours and 1.20 million truck person-hours. These values are presented in **Appendix I-D-FULL**: Benefits and Costs by Year, Impact on Travel Characteristics table (2025 is Project Year 15).

Appendix III provides greater detail about the modeling and assumptions for deriving VHT and VMT savings.

(b) Economic Competitiveness

The Ohio River Bridges Project significantly enhances the economic competitiveness of the United States by substantially reducing the cost of connecting to Louisville's manufacturing base, labor pool and consumer markets, as well as the area's intermodal transportation facilities. Given that the Project's scope encompasses critical national routes such as Interstates 64, 65, and 71, there is a direct correlation of completing the project to improving the nation's economic competitiveness. It is estimated that the present value of the TIGER II Portion's vehicle operating cost savings alone will be approximately $1.35 Million, with the overall Project enabled by the TIGER II assistance to yield vehicle operating cost savings of approximately $31.17 Million.

By providing more efficient connections across the Ohio River for both national traffic as well as the region's workers and other travelers, the Project significantly reduces the mileage and hours required to support industrial activity related to the regional and national economy. The VMT and VHT savings of the project are translated into cost savings by applying the travel time and operating costs per hour or per mile, respectively (cost assumptions given in the *Economic Value Factors* and *Commodity Value Factors* reported in the tables on pp. 6-8 of **Appendix IV**). When these savings are translated into productivity gains (as described in p. 13 of **Appendix II**), the TIGER II Portion is expected to yield $11.64 Million in shipper/logistics cost savings (**Appendix I-C**: Present Value of Benefit Stream table).The overall Project is expected to provide $268.28 Million in shipper/logistics cost savings (**Appendix I-C- FULL**: Present Value of Benefit Stream table).

Additionally, the TIGER II Portion of the project is also expected to yield $104.19 million in time and reliability cost savings, of which $40.95 million is expected to be in business savings and $63.24 million is expected to be in personal household savings (**Appendix I-C**: Present Value of Benefit Stream table).As with vehicle operating costs, the time and reliability savings are estimated based on the *Economic Value Factors* and *Commodity Value Factors* reported in the tables on pp. 6-8 of **Appendix IV**. For the TIGER II Portion of the project, these savings are expected to yield 44 new jobs in 2056 (the out-horizon year of the analysis), and nearly $352.93 Million in additional output and $109.53 Million in additional cumulative wage earnings accruing in the region from 2012 to 2056 (due to construction impact and operational efficiency only).The previous totals do not include induced, indirect or business attraction effects. The development of these direct effects by year is shown in **Appendix I-B**. **Appendixes I-C and I-D** which show the breakdown of different types of benefits by mode and by year.

The overall Project is expected to yield $2.40 billion in time and reliability cost savings, of which $943.62 Million is expected to be in business savings and $1.46 billion is expected to be in personal household savings (**Appendix I-C - FULL**: Present Value of Benefit Stream table).As with vehicle operating costs, the time and reliability savings are estimated based on the *Economic Value Factors* and *Commodity Value Factors* reported in the tables on pp. 6-8 of **Appendix IV**. For the overall Project, these savings are expected to yield 1,016 new jobs in 2056 (the out-horizon year of the analysis), and nearly $8.13 Billion in additional output and $2.52 Billion in additional cumulative earnings accruing in the region from 2012 to 2056 (due to construction impact and operational efficiency only).The previous totals do not include induced, indirect or business attraction effects. The development of these direct effects by year is shown in **Appendix I-B - FULL**. **Appendixes I-C - FULL and I-D - FULL** which show the breakdown of different types of benefits by mode and by year.

(c) Safety

The Ohio River Bridges Project is expected to yield significant safety benefits on the basis that by enabling shorter and more direct routing of traffic and reducing vehicle miles of travel for cars and trucks, it reduces the exposure of cars and trucks to the risks of the transportation system.

On this basis, the TIGER II Portion of the project is expected to save $3.04 million (the overall project is expected to save $70.04 million) in safety cost (in 2010 constant dollars) (**Appendix I-C (and Appendix I-C – FULL)**: Present Value of Benefit Stream table).The safety cost is estimated as a function of the VMT savings, applying the per-vehicle mile crash and severity rates and cost value of crashes at different levels of severity given in the table on page 8 of **Appendix IV**. These rates are applied to the VMT (for truck and passenger car trips) to derive the safety impact for each year of analysis.

(d) State of Good Repair

The justification of the project for improving the overall state of good repair is previously covered in the TIGER II application. The benefit-cost analysis does not claim a separate, quantifiable benefit for the improved state of repair, but rather assumes that the efficiency gains associated with the development enabled by the Project are generally attributable to its improved state of repair for the overall stock of bridge structures crossing the Ohio River.

(e) Sustainability

The environmental benefit of the Project is expected to accrue from the reductions in vehicle miles travelled for passenger cars and trucks. The benefit is calculated by taking the environmental cost given on page 9 of **Appendix IV** and applying it to the vehicle miles of travel in the year accrued. Based on this approach , the environmental benefit of the TIGER II Portion of the project in constant 2010 dollars is estimated to be $0.58 million, and for the overall $3.1 billion project is $13.42 million --(**Appendix I-C and Appendix I-C - FULL**: Present Value of Benefit Stream table).

BENEFIT COST AND NET PRESENT VALUE ANALYSIS

At a discount rate of 7% to the year 2056, the TIGER II Portion of the project is estimated to have a full societal benefit stream with a present value of $131.51 million, a cost stream of $93.94 million, yielding a net present value of $37.57 million and a benefit-cost ratio of 1.4 (**Appendix I-C**: Efficiency Measures table).The overall Project is estimated to have a full societal benefit stream with a present value of $3.03 billion, a cost stream of $2.17 billion yielding a net present value of $865.56 million and a benefit-cost ratio of 1.4 as shown in (**Appendix I-C - FULL**: Efficiency Measures table)

Table BC-III provides a summary of cost and benefit steams associated with the TIGER II Portion of the project and Table **BC-IV** provides a summary of cost and benefit streams of the overall Project. **Appendices I-C** and **I-D** give the different elements of economic benefits used in the benefit-cost analysis. Some totals in **Table BC-2** may be slightly different from **Appendices I-C** and **I-D** due to rounding (**Appendices I-C** and **I-D** will have slightly more accurate totals because they are computed within the computerized model, allowing for greater decimal precision in calculations).

Sensitivity Analysis

The benefits presented in the benefit cost analysis strive to be realistic and prudent, erring on the side of understating, and not overstating the project benefits. Sensitivity testing reveals that the potential benefit of the project is likely to substantially exceed what is quantified in current models. Specifically, the travel demand model used in the 2003 environmental document models only the average annual weekday traffic, which is expanded directly to total annual weekday traffic used in the benefit-cost analysis. However, while congestion does not occur on weekends, the more direct routing and accessibility provided by the bridges is expected to benefit weekend travelers as well, although none of the available modeling explicitly analyzes average annual daily traffic. For this reason, the benefit-cost analysis conservatively only accounts for benefits that were modeled in the average annual weekday model. However, sensitivity analysis shows that if the VMT and VHT levels of the weekday model are adjusted upwards by 15% to 20% to account for weekend travel, the benefit-cost ratio would increase to 1.61 or 1.68 for a 15% and 20% assumption, respectively.

Furthermore the 7% discount rate heavily discounts the robust benefit stream occurring in the later years of the project. For this reason, different net present value and benefit-cost ratios are compared with different assumptions regarding the discount rate. The assumed 7% discount rate is used for the benefit-cost analysis in the TIGER II application. However, sensitivity testing shows that the benefit-cost ratio, as well as the present value of both the overall $3.1 billion project as well as the $135 million TIGER II Portion of the project are highly sensitive to the difference between the 7% and 3% discount rate. The table below compares key outcomes of the project at the 3% versus 7% discount rate. While 7% is used in the benefit cost analysis, the 3% analysis with the benefit/cost ratio of 2.24 gives greater weight to the later occurring, long-term and substantial benefits of the project to the United States. If "off-model" weekend traffic is taken into account, the BCR ratio at the 3% level could be as high as 2.96.

The sensitivity analysis in the table below shows that the benefit cost ratio and net present value shown in the benefit cost analysis is very prudent, and greater levels of economic benefit may well occur and would likely be found by more rigorous modeling or in the event of a lower than 7% discount rate.

Sensitivity Test	**7% Discount Rate**	**3% Discount Rate**
Average Total Weekday Traffic *(Expanded directly from Average Annual Weekday in 2003 Environmental Document)* Used in Benefit-Cost Analysis	$37.6 million (TIGER II Portion) $865.6 million (entire Project) Benefit-Cost Ratio= 1.40	$181.4 million (TIGER II Portion) $4.18 billion (Entire project) Benefit-Cost Ratio= 2.24
Average Total Weekday Traffic *+ 15% Weekend Traffic*	$57.3 million (TIGER II Portion) $1.3 billion (Entire Project) BCR = 1.61	$227.2 million (TIGER II Portion) $5.2 billion (entire Project) BCR = 2.84
Average Total Weekday Traffic *+ 20% Weekend Traffic*	$63.9 million (TIGER II Portion) $1.5 billion (Entire Project) Benefit-Cost Ratio = 1.68	$242.4 million (TIGER II Portion) $5.6 billion (entire Project) Benefit-Cost Ratio= 2.96

Table BC-III: Year by Year Development of Cost and Benefit Streams (TIGER II Portion)

Calendar Year	Project Year	Affected Users (trips) -- Include Passenger Cars and Trucks	Travel Time Savings (VHT)	Travel Distance Savings (VMT)	Total Value of Time Saved (Including logistics savings)($Million 2010)	Total Value of Operating Cost Savings(Including Safety and Environmental Cost) ($Million 2010)	Initial Costs ($2010)	Operations & Maintenance Costs	Undiscounted net benefits	Discounted at 7%
2011	1	0	0	0	0	0	0	0	0	0
2012	2	0	0	0	0	0	3 4	0	-3 4	-2 97
2013	3	0	0	0	0	0	4 14	0	-4 14	-3 38
2014	4	0	0	0	0	0	13 77	0	-13 77	-10 51
2015	5	0	0	0	0	0	21 71	0	-21 71	-15 48
2016	6	-74359	-260495	-965366	5 88	0 79	23 19	1 03	-17 55	-11 69
2017	7	-87715	-307284	-1138762	6 94	0 93	24 5	1 03	-17 66	-11
2018	8	-101358	-355080	-1315888	8 01	1 08	11 7	1 03	-3 63	-2 11
2019	9	-115293	-403899	-1496806	9 12	1 24	8 82	1 03	0 5	0 27
2020	10	-129526	-453759	-1681578	10 24	1 39	9 62	1 03	0 98	0 5
2021	11	-144060	-504675	-1870268	11 39	1 55	6 63	1 03	5 27	2 5
2022	12	-158901	-556666	-2062940	12 56	1 7	5 61	1 03	7 62	3 38
2023	13	-160664	-562845	-2085838	12 7	1 71	0	1 03	13 39	5 56
2024	14	-162448	-569092	-2108991	12 84	1 74	0	1 03	13 55	5 26
2025	15	-164251	-575409	-2132401	12 99	1 76	0	1 03	13 71	4 97
2026	16	-166074	-581796	-2156071	13 13	1 78	0	1 03	13 88	4 7
2027	17	-167918	-588254	-2180003	13 27	1 8	0	1 03	14 04	4 45
2028	18	-169781	-594784	-2204201	13 42	1 82	0	1 03	14 21	4 2
2029	19	-171666	-601386	-2228668	13 57	1 84	0	1 03	14 38	3 98
2030	20	-173572	-608061	-2253406	13 72	1 86	0	1 03	14 55	3 76
2031	21	-175498	-614811	-2278419	13 86	1 88	0	1 03	14 72	3 56
2032	22	-177446	-621635	-2303709	14 03	1 9	0	1 03	14 9	3 36
2033	23	-179416	-628535	-2329280	14 18	1 92	0	1 03	15 07	3 18
2034	24	-181407	-635512	-2355135	14 34	1 94	0	1 03	15 25	3 01
2035	25	-183421	-642566	-2381277	14 51	1 96	0	1 03	15 43	2 84
2036	26	-185457	-649699	-2407710	14 65	1 98	0	1 03	15 62	2 69
2037	27	-187516	-656910	-2434435	14 82	2	0	1 03	15 8	2 54
2038	28	-189597	-664202	-2461457	14 99	2 03	0	1 03	15 99	2 4
2039	29	-191702	-671574	-2488780	15 15	2 06	0	1 03	16 18	2 27
2040	30	-193829	-679029	-2516405	15 33	2 08	0	1 03	16 37	2 15
2041	31	-195981	-686566	-2544337	15 5	2 1	0	1 03	16 56	2 03
2042	32	-198156	-694187	-2572579	15 66	2 12	0	1 03	16 76	1 92
2043	33	-200356	-701893	-2601135	15 84	2 15	0	1 03	16 95	1 82
2044	34	-202580	-709684	-2630007	16 01	2 17	0	1 03	17 15	1 72
2045	35	-204828	-717561	-2659201	16 19	2 19	0	1 03	17 36	1 63
2046	36	-207102	-725526	-2688718	16 38	2 22	0	1 03	17 56	1 54
2047	37	-209401	-733579	-2718562	16 55	2 23	0	1 03	17 77	1 45
2048	38	-211725	-741722	-2748738	16 74	2 26	0	1 03	17 97	1 37
2049	39	-214075	-749955	-2779249	16 92	2 29	0	1 03	18 19	1 3
2050	40	-216452	-758280	-2810099	17 11	2 32	0	1 03	18 4	1 23
2051	41	-218854	-766697	-2841291	17 31	2 34	0	1 03	18 61	1 16
2052	42	-221283	-775207	-2872830	17 49	2 37	0	1 03	18 83	1 1
2053	43	-223740	-783812	-2904718	17 69	2 39	0	1 03	19 05	1 04
2054	44	-226223	-792512	-2936960	17 88	2 42	0	1 03	19 28	0 98
2055	45	-228734	-801309	-2969561	18 08	2 44	0	1 03	19 5	0 93
2056	46	-231273	-810203	-3002523	18 28	2 47	0	1 03	43 99	1 96

*** Project is calculated to have a residual value with a present value of at the end of the analysis period, reflected in $24.27 million deducted from cost stream.*

Table BC-IV Year by Year Development of Cost and Benefit Streams ($3.1 billion Project)

Calendar Year	Project Year	Affected Users (trips) - - Include Passenger Cars and Trucks	Travel Time Savings (VHT)	Travel Distance Savings (VMT)	Total Value of Time Saved (Including logistics savings)($Million 2010)	Total Value of Operating Cost Savings(Including Safety and Environmental Cost) ($Million 2010)	Initial Costs ($2010)	Operations & Maintenance Costs	Undiscounted net benefits	Discounted at 7%
2011	1	0	0	0	0	0	0	0	0	0
2012	2	0	0	0	0	0	78 38	0	-78 38	-68 46
2013	3	0	0	0	0	0	95 46	0	-95 46	-77 92
2014	4	0	0	0	0	0	317 36	0	-317 36	-242 11
2015	5	0	0	0	0	0	500 31	0	-500 31	-356 72
2016	6	-2405555	-8427253	-31230410	190 16	25 76	534 4	23 77	-342 25	-228 06
2017	7	-2837632	-9940929	-36839912	224 32	30 39	564 58	23 77	-333 65	-207 78
2018	8	-3279006	-11487169	-42570097	259 21	35 1	269 63	23 77	0 92	0 54
2019	9	-3729828	-13066511	-48422954	294 86	39 94	203 15	23 77	107 87	58 67
2020	10	-4190255	-14679499	-54400498	331 24	44 87	221 64	23 77	130 7	66 44
2021	11	-4660443	-16326686	-60504778	368 41	49 9	152 76	23 77	241 79	114 87
2022	12	-5140553	-18008631	-66737870	406 36	55 03	129 35	23 77	308 29	136 89
2023	13	-5197614	-18208527	-67478661	410 88	55 65	0	23 77	442 76	183 73
2024	14	-5255307	-18410642	-68227674	415 44	56 27	0	23 77	447 94	173 72
2025	15	-5313641	-18615000	-68985001	420 05	56 89	0	23 77	453 18	164 25
2026	16	-5372622	-18821627	-69750735	424 72	57 52	0	23 77	458 47	155 3
2027	17	-5432259	-19030547	-70524968	429 42	58 17	0	23 77	463 82	146 83
2028	18	-5492557	-19241786	-71307795	434 19	58 8	0	23 77	469 23	138 83
2029	19	-5553524	-19455369	-72099311	439 02	59 46	0	23 77	474 71	131 26
2030	20	-5615168	-19671324	-72899614	443 9	60 12	0	23 77	480 24	124 1
2031	21	-5677496	-19889676	-73708799	448 82	60 79	0	23 77	485 83	117 34
2032	22	-5740517	-20110451	-74526967	453 8	61 46	0	23 77	491 49	110 94
2033	23	-5804236	-20333677	-75354216	458 84	62 15	0	23 77	497 21	104 89
2034	24	-5868663	-20559381	-76190648	463 93	62 83	0	23 77	502 99	99 16
2035	25	-5933806	-20787590	-77036364	469 08	63 54	0	23 77	508 84	93 75
2036	26	-5999671	-21018332	-77891468	474 28	64 25	0	23 77	514 75	88 64
2037	27	-6066267	-21251636	-78756063	479 55	64 95	0	23 77	520 73	83 8
2038	28	-6133603	-21487529	-79630256	484 87	65 67	0	23 77	526 77	79 23
2039	29	-6201686	-21726041	-80514151	490 26	66 4	0	23 77	532 89	74 9
2040	30	-6270524	-21967200	-81407859	495 69	67 14	0	23 77	539 06	70 82
2041	31	-6340127	-22211036	-82311486	501 2	67 88	0	23 77	545 31	66 95
2042	32	-6410503	-22457578	-83225143	506 75	68 64	0	23 77	551 63	63 29
2043	33	-6481659	-22706857	-84148942	512 38	69 41	0	23 77	558 02	59 84
2044	34	-6553606	-22958903	-85082996	518 07	70 17	0	23 77	564 47	56 57
2045	35	-6626351	-23213747	-86027417	523 83	70 95	0	23 77	571	53 48
2046	36	-6699903	-23471420	-86982321	529 63	71 73	0	23 77	577 6	50 56
2047	37	-6774272	-23731952	-87947825	535 52	72 53	0	23 77	584 28	47 8
2048	38	-6849467	-23995377	-88924046	541 46	73 34	0	23 77	591 03	45 19
2049	39	-6925496	-24261726	-89911103	547 48	74 15	0	23 77	597 85	42 72
2050	40	-7002369	-24531031	-90909116	553 55	74 98	0	23 77	604 75	40 39
2051	41	-7080095	-24803325	-91918207	559 69	75 82	0	23 77	611 73	38 18
2052	42	-7158684	-25078642	-92938499	565 9	76 65	0	23 77	618 78	36 09
2053	43	-7238145	-25357015	-93970117	572 18	77 5	0	23 77	625 92	34 12
2054	44	-7318489	-25638478	-95013185	578 54	78 36	0	23 77	633 13	32 26
2055	45	-7399724	-25923065	-96067831	584 96	79 23	0	23 77	640 42	30 49
2056	46	-7481861	-26210811	-97134184	591 45	80 1	0	23 77	1206 99	53 71

*** Project is calculated to have a residual value with a present value of at the end of the analysis period, reflected in $559.20 million deducted from cost stream.*

Appendix IA (Entire Project Enabled by TIGER) - Direct Travel Impacts of the Project

Reduction/Savings in:	Passenger Car On-the-Clock	Passenger Car Commute	Passenger Car Personal/Reek	Truck Freight Freight	Total
Gross Vehicle Trips	248,047	961,919	2,232,426	342,666	3,785,058
Gross VMT	3,220,306	12,488,235	28,982,749	4,448,710	49,140,000
Gross VHT	868,971	3,369,841	7,820,742	1,200,446	13,260,000
Gross Buffer Time (hrs)	21,724	84,246	195,519	30,011	331,500
Passenger Trips	270,371	1,048,492	3,270,804	-	4,589,667
...diverted from in-model source	270,371	1,048,492	3,270,804	-	4,589,667
...diverted from other source	-	-	-	-	-
...induced from latent demand	-	-	-	-	-
Passenger Miles	3,510,134	13,612,176	42,463,623	-	59,585,933
Freight Ton Trips	-	-	-	5,996,655	5,996,655
...diverted from in-model source	-	-	-	5,996,655	5,996,655
...diverted from other source	-	-	-	-	-
...induced from latent demand	-	-	-	-	-
Freight Ton Miles	-	-	-	77,852,425	77,852,425
Fatalities	0	0	0	0	1
Personal Injuries	3	11	26	1	41
Property Damage	7	26	60	9	101
Local Portion of Trip Ends	1	1	1	0	
Total Value of Travel Impacts:					
Passenger Cost - Net Total	26,047,406	77,870,286	121,459,445	-	225,377,137
Crew Cost - Net Total	-	-	-	37,543,949	37,543,949
Freight Cost - Net Total	-	-	-	30,074,244	30,074,244
Reliability Cost - Net Total	597,418	1,786,016	2,072,497	1,763,755	6,219,685
Vet Opera Cost - Net Total	1,867,777	7,243,176	16,809,994	5,249,478	31,170,426
Toll Cost - Net Total	78,644	304,980	707,800	108,644	1,200,068
Safety Cost - Net Total	552,854	2,143,950	4,975,689	179,190	7,851,684
Environmental Cost - Net Total	90,169	349,671	811,517	253,576	1,504,933
Induced Benefit - Total	-	-	-	-	-
Total Value of Travel Impacts:	29,234,268	89,698,079	146,836,942	75,172,836	340,942,125
Local Value of Travel Impacts:					
Passenger Cost - Net Local	24,159,967	68,529,136	112,658,290	-	205,347,393
Crew Cost - Net Local	-	-	-	16,894,777	16,894,777
Freight Cost - Net Local	-	-	-	13,533,410	13,533,410
Reliability Cost - Net Local	554,128	1,571,769	1,922,320	793,690	4,841,907
Vet Opera Cost - Net Local	1,732,435	6,374,301	15,591,914	2,362,265	26,060,915
Toll Cost - Net Local	72,946	268,396	656,512	48,890	1,046,743
Safety Cost - Net Local	512,794	1,886,767	4,615,142	80,636	7,095,338
Environmental Cost - Net Local	83,635	307,725	752,713	114,109	1,258,182
Induced Benefit - Local	-	-	-	-	-
Local Value of Travel Impacts:	27,115,904	78,938,093	136,196,891	33,827,776	276,078,664

Appendix IB (Entire Project Enabled by TIGER) - Direct Economic Effects of the Project

Project Year	Calendar Year	Business Output ($ mil.)	Value Added ($ mil.)	Jobs	Wage Income ($ mil.)
1	2011	-	-	-	-
2	2012	74.600	36.535	485	23.151
3	2013	90.853	44.495	591	28.195
4	2014	302.057	147.932	1,964	93.740
5	2015	476.188	233.213	3,096	147.780
6	2016	574.998	281.604	3,739	178.444
7	2017	611.368	299.417	3,975	189.732
8	2018	338.456	165.759	2,201	105.036
9	2019	283.161	138.678	1,841	87.876
10	2020	308.917	151.292	2,009	95.869
11	2021	251.681	123.260	1,637	78.106
12	2022	237.897	116.510	1,547	73.829
13	2023	115.797	56.712	753	35.936
14	2024	116.819	57.212	760	36.253
15	2025	117.851	57.718	766	36.574
16	2026	118.896	58.229	773	36.898
17	2027	119.952	58.746	780	37.226
18	2028	121.019	59.269	787	37.557
19	2029	122.099	59.798	794	37.892
20	2030	123.190	60.332	801	38.231
21	2031	124.294	60.873	808	38.573
22	2032	125.410	61.419	815	38.920
23	2033	126.538	61.972	823	39.270
24	2034	127.679	62.530	830	39.624
25	2035	128.832	63.095	838	39.982
26	2036	129.998	63.666	845	40.343
27	2037	131.177	64.244	853	40.709
28	2038	132.369	64.828	861	41.079
29	2039	133.575	65.418	869	41.454
30	2040	134.794	66.015	877	41.832
31	2041	136.026	66.619	885	42.214
32	2042	137.272	67.229	893	42.601
33	2043	138.532	67.846	901	42.992
34	2044	139.806	68.470	909	43.387
35	2045	141.094	69.101	917	43.787
36	2046	142.396	69.738	926	44.191
37	2047	143.713	70.383	935	44.600
38	2048	145.044	71.035	943	45.013
39	2049	146.390	71.695	952	45.431
40	2050	147.752	72.361	961	45.853
41	2051	149.128	73.035	970	46.280
42	2052	150.519	73.717	979	46.712
43	2053	151.926	74.406	988	47.149
44	2054	153.349	75.102	997	47.590
45	2055	154.787	75.807	1,007	48.036
46	2056	156.241	76.519	1,016	48.488
	Sum of Impact for all Years	**8,134.440**	**3,983.832**		**2,524.435**

Appendix IC (Entire Project Enabled by TIGER)- Benefits and Costs By Mode

Present Value of Benefit Stream ($m 2010 Const dollars)

Mode	(A) Traveler Benefits ($) Vehicle Operating Costs	Time & Reliability Costs	(B) Traveler Benefits (non-$) Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus	(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)
Pass Car - OTC	16.66	237.69	-	4.93	-	-	--	--
Pass Car - Commute	64.61	355.29	355.29	19.13	-	-	--	--
Pass Car - Pressure	149.95	-	1,101.97	44.39	-	-	--	--
Truck - Freight	46.83	350.65	-	1.60	-	268.28	--	--
Project Totals	**278.06**	**943.62**	**1,457.26**	**70.04**	**-**	**268.28**	**-**	**13.42**

Present Value of Cost Stream ($m 2010 Const dollars)

Facility Type	Startup Costs	Annual O&M Costs	Residual Value	Net Total Costs
Road	1,963.00	227.00	24.88	2,165.11
Rail	-	-	-	-
Air	-	-	-	-
Marine	-	-	-	-
Total for All Facilities	**1,963.00**	**227.00**	**24.88**	**2,165.11**

Efficiency Measures

Benefit Measure	Benefit Definition	Present Value of Benefit Stream	Present Value of Cost Stream	Net Present Value (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	**A+B**	2,749	2,165	584	1.27
Full User Benefit	**A+B+C**	3,017	2,165	852	1.39
Total Societal Benefit	**A+B+C+D+E**	3,030.68	2,165.11	865.56	1.40

Wider Measures

Impact Measure	Impact Definition	Present Value of Impact Stream	Present Value of Cost Stream	Net Present Value (Impacts - Costs)	Impact/Cost Ratio
Ad's Gross Regional Product	**GRP**	411	2,165	(1,754)	0.19
GRP plus Traveler non-$ Benefit	**GRP+B**	1,938	2,165	(227)	0.90
GRP plus Total non-$ Benefit	**GRP+B+E**	1,951.75	2,165.11	-213.36	0.90

Appendix ID- Benefits and Costs By Year

Project's Impact on Travel Characteristics

Project Year	Calendar Year	Vehicles			Passengers			Freight Tons		
		Vehicle Trips	Vehicle Miles (VMT)	Vehicle Hours (VHT)	Passenger Trips	Passenger Miles	Passenger Hours	Freight Ton Trips	Freight Ton Miles	Freight Ton Hours
1	2011	-	-	-	-	-	-	-	-	-
2	2012	-	-	-	-	-	-	-	-	-
3	2013	-	-	-	-	-	-	-	-	-
4	2014	-	-	-	-	-	-	-	-	-
5	2015	-	-	-	-	-	-	-	-	-
6	2016	(1,713,545)	(22,246,319)	(6,002,975)	(2,077,802)	(26,975,329)	(7,279,057)	(2,714,764)	(35,244,809)	(9,510,507)
7	2017	(2,021,326)	(26,242,129)	(7,081,209)	(2,451,010)	(31,820,548)	(8,586,497)	(3,202,381)	(41,575,364)	(11,218,753)
8	2018	(2,335,729)	(30,323,905)	(8,182,641)	(2,832,247)	(36,770,007)	(9,922,065)	(3,700,488)	(48,042,114)	(12,963,750)
9	2019	(2,656,863)	(34,493,062)	(9,307,652)	(3,221,646)	(41,825,423)	(11,286,225)	(4,209,259)	(54,647,305)	(14,746,104)
10	2020	(2,984,838)	(38,751,039)	(10,456,630)	(3,619,340)	(46,988,539)	(12,679,447)	(4,728,869)	(61,393,211)	(16,566,428)
11	2021	(3,319,766)	(43,099,293)	(11,629,968)	(4,025,466)	(52,261,123)	(14,102,207)	(5,259,495)	(68,282,143)	(18,425,347)
12	2022	(3,661,763)	(47,539,304)	(12,828,066)	(4,440,162)	(57,644,969)	(15,554,991)	(5,801,319)	(75,316,445)	(20,323,493)
13	2023	(3,702,408)	(48,066,990)	(12,970,458)	(4,489,448)	(58,284,828)	(15,727,652)	(5,865,713)	(76,152,458)	(20,549,083)
14	2024	(3,743,505)	(48,600,534)	(13,114,430)	(4,539,281)	(58,931,790)	(15,902,229)	(5,930,823)	(76,997,750)	(20,777,178)
15	2025	(3,785,058)	(49,140,000)	(13,260,000)	(4,589,667)	(59,585,933)	(16,078,743)	(5,996,655)	(77,852,425)	(21,007,805)
16	2026	(3,827,072)	(49,685,454)	(13,407,186)	(4,640,612)	(60,247,336)	(16,257,217)	(6,063,218)	(78,716,587)	(21,240,992)
17	2027	(3,869,553)	(50,236,963)	(13,556,006)	(4,692,123)	(60,916,082)	(16,437,672)	(6,130,520)	(79,590,341)	(21,476,767)
18	2028	(3,912,505)	(50,794,593)	(13,706,477)	(4,744,206)	(61,592,250)	(16,620,131)	(6,198,568)	(80,473,794)	(21,715,159)
19	2029	(3,955,933)	(51,358,413)	(13,858,619)	(4,796,866)	(62,275,924)	(16,804,614)	(6,267,372)	(81,367,053)	(21,956,197)
20	2030	(3,999,844)	(51,928,491)	(14,012,450)	(4,850,112)	(62,967,187)	(16,991,145)	(6,336,940)	(82,270,227)	(22,199,911)
21	2031	(4,044,243)	(52,504,897)	(14,167,988)	(4,903,948)	(63,666,123)	(17,179,747)	(6,407,280)	(83,183,427)	(22,446,330)
22	2032	(4,089,134)	(53,087,702)	(14,325,253)	(4,958,382)	(64,372,817)	(17,370,442)	(6,478,401)	(84,106,763)	(22,695,484)
23	2033	(4,134,523)	(53,676,975)	(14,484,263)	(5,013,420)	(65,087,355)	(17,563,254)	(6,550,311)	(85,040,348)	(22,947,404)
24	2034	(4,180,416)	(54,272,790)	(14,645,038)	(5,069,069)	(65,809,825)	(17,758,206)	(6,623,020)	(85,984,296)	(23,202,120)
25	2035	(4,226,819)	(54,875,218)	(14,807,598)	(5,125,335)	(66,540,314)	(17,955,322)	(6,696,535)	(86,938,721)	(23,459,664)
26	2036	(4,273,737)	(55,484,333)	(14,971,963)	(5,182,227)	(67,278,911)	(18,154,626)	(6,770,867)	(87,903,741)	(23,720,066)
27	2037	(4,321,175)	(56,100,209)	(15,138,152)	(5,239,749)	(68,025,707)	(18,356,143)	(6,846,024)	(88,879,473)	(23,983,359)
28	2038	(4,369,140)	(56,722,921)	(15,306,185)	(5,297,911)	(68,780,793)	(18,559,896)	(6,922,014)	(89,866,035)	(24,249,574)
29	2039	(4,417,638)	(57,352,545)	(15,476,084)	(5,356,717)	(69,544,259)	(18,765,911)	(6,998,849)	(90,863,548)	(24,518,744)
30	2040	(4,466,673)	(57,989,159)	(15,647,868)	(5,416,177)	(70,316,201)	(18,974,212)	(7,076,536)	(91,872,133)	(24,790,902)
31	2041	(4,516,253)	(58,632,838)	(15,821,560)	(5,476,296)	(71,096,710)	(19,184,826)	(7,155,086)	(92,891,914)	(25,066,081)
32	2042	(4,566,384)	(59,283,663)	(15,997,179)	(5,537,083)	(71,885,884)	(19,397,778)	(7,234,507)	(93,923,014)	(25,344,315)
33	2043	(4,617,071)	(59,941,712)	(16,174,748)	(5,598,545)	(72,683,817)	(19,613,093)	(7,314,810)	(94,965,560)	(25,625,637)
34	2044	(4,668,320)	(60,607,065)	(16,354,287)	(5,660,689)	(73,490,608)	(19,830,798)	(7,396,004)	(96,019,677)	(25,910,081)
35	2045	(4,720,139)	(61,279,803)	(16,535,820)	(5,723,522)	(74,306,353)	(20,050,920)	(7,478,100)	(97,085,496)	(26,197,683)
36	2046	(4,772,532)	(61,960,009)	(16,719,367)	(5,787,054)	(75,131,154)	(20,273,485)	(7,561,107)	(98,163,145)	(26,488,477)
37	2047	(4,825,507)	(62,647,765)	(16,904,952)	(5,851,290)	(75,965,110)	(20,498,521)	(7,645,035)	(99,252,756)	(26,782,500)
38	2048	(4,879,070)	(63,343,155)	(17,092,597)	(5,916,239)	(76,808,322)	(20,726,055)	(7,729,895)	(100,354,461)	(27,079,785)
39	2049	(4,933,228)	(64,046,264)	(17,282,325)	(5,981,909)	(77,660,895)	(20,956,114)	(7,815,697)	(101,468,396)	(27,380,371)
40	2050	(4,987,987)	(64,757,178)	(17,474,159)	(6,048,309)	(78,522,931)	(21,188,727)	(7,902,451)	(102,594,695)	(27,684,293)
41	2051	(5,043,353)	(65,475,982)	(17,668,122)	(6,115,445)	(79,394,535)	(21,423,922)	(7,990,168)	(103,733,496)	(27,991,589)
42	2052	(5,099,335)	(66,202,766)	(17,864,238)	(6,183,326)	(80,275,815)	(21,661,727)	(8,078,859)	(104,884,938)	(28,302,295)
43	2053	(5,155,937)	(66,937,616)	(18,062,531)	(6,251,961)	(81,166,876)	(21,902,172)	(8,168,535)	(106,049,161)	(28,616,451)
44	2054	(5,213,168)	(67,680,624)	(18,263,025)	(6,321,358)	(82,067,828)	(22,145,286)	(8,259,205)	(107,226,306)	(28,934,093)
45	2055	(5,271,034)	(68,431,879)	(18,465,745)	(6,391,525)	(82,978,781)	(22,391,099)	(8,350,883)	(108,416,518)	(29,255,262)
46	2056	(5,329,543)	(69,191,473)	(18,670,715)	(6,462,471)	(83,899,846)	(22,639,640)	(8,443,577)	(109,619,942)	(29,579,995)

Present Value of Benefit Stream ($m 2010 Const dollars)

Project Year	Calendar Year	(A) Traveler Benefits ($) Vehicle Operating Costs	(A) Traveler Benefits ($) Time & Reliability Costs	(B) Traveler Benefits (non-$) Value of Personal Time & Reliability	(B) Traveler Benefits (non-$) Safety Cost	(B) Traveler Benefits (non-$) Additional Consumer Surplus	(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits (Undiscounted)	Total Benefits(7% Discount)
1	2011	-	-	-	-	-	-	-	-	-	-
2	2012	-	-	-	-	-	-	-	-	-	-
3	2013	-	-	-	-	-	-	-	-	-	-
4	2014	-	-	-	-	-	-	-	-	-	-
5	2015	-	-	-	-	-	-	-	-	-	-
6	2016	14.11	47.89	73.96	3.55	-	13.62	-	0.68	153.81	102.49
7	2017	16.65	56.49	87.24	4.19	-	16 06	-	0.80	181.43	112.99
8	2018	19.24	65.28	100.81	4.85	-	18 56	-	0.93	209.65	122.02
9	2019	21.88	74.25	114.67	5.51	-	21.11	-	1.06	238.48	129.72
10	2020	24.58	83.42	128.82	6.19	-	23.72	-	1.19	267.92	136.19
11	2021	27.34	92.78	143.28	6.89	-	26 38	-	1.32	297.98	141.57
12	2022	30.16	102 33	158.04	7.60	-	29 09	-	1.46	328.68	145.94
13	2023	30.49	103.47	159.79	7.68	-	29.42	-	1.47	332.32	137.90
14	2024	30.83	104.62	161.57	7.77	-	29.74	-	1.49	336.01	130.31
15	2025	31.17	105.78	163.36	7.85	-	30 07	-	1.50	339.74	123.14
16	2026	31.52	106 95	165.17	7.94	-	30.41	-	1.52	343.51	116.36
17	2027	31.87	108.14	167.01	8.03	-	30.75	-	1.54	347.33	109.95
18	2028	32.22	109 34	168.86	8.12	-	31 09	-	1.56	351.18	103.90
19	2029	32.58	110 56	170.73	8.21	-	31.43	-	1.57	355.08	98.18
20	2030	32.94	111.78	172.63	8.30	-	31.78	-	1.59	359.02	92.78
21	2031	33.30	113 02	174.55	8.39	-	32.13	-	1.61	363.01	87.67
22	2032	33.67	114 28	176.48	8.48	-	32.49	-	1.63	367.04	82.84
23	2033	34.05	115 55	178.44	8.58	-	32 85	-	1.64	371.11	78.28
24	2034	34.43	116 83	180.42	8.67	-	33 22	-	1.66	375.23	73.98
25	2035	34.81	118.13	182.43	8.77	-	33 58	-	1.68	379.39	69.90
26	2036	35.19	119.44	184.45	8.87	-	33 96	-	1.70	383.61	66.06
27	2037	35.59	120.76	186.50	8.96	-	34 33	-	1.72	387.86	62.42
28	2038	35.98	122.10	188.57	9.06	-	34.72	-	1.74	392.17	58.98
29	2039	36.38	123.46	190.66	9.16	-	35.10	-	1.76	396.52	55.74
30	2040	36.78	124 83	192.78	9.27	-	35.49	-	1.78	400.92	52.67
31	2041	37.19	126 22	194.92	9.37	-	35 88	-	1.80	405.37	49.77
32	2042	37.60	127.62	197.08	9.47	-	36 28	-	1.82	409.87	47.03
33	2043	38.02	129 03	199.27	9.58	-	36.69	-	1.84	414.42	44.44
34	2044	38.44	130.47	201.48	9.68	-	37 09	-	1.86	419.02	41.99
35	2045	38.87	131 91	203.72	9.79	-	37 50	-	1.88	423.67	39.68
36	2046	39.30	133 38	205.98	9.90	-	37 92	-	1.90	428.38	37.50
37	2047	39.74	134 86	208.27	10.01	-	38 34	-	1.92	433.13	35.43
38	2048	40.18	136 35	210.58	10.12	-	38.77	-	1.94	437.94	33.48
39	2049	40.63	137 87	212.91	10.23	-	39 20	-	1.96	442.80	31.64
40	2050	41.08	139.40	215.28	10.35	-	39.63	-	1.98	447.72	29.90
41	2051	41.53	140 95	217.67	10.46	-	40 07	-	2.01	452.69	28.25
42	2052	41.99	142 51	220.08	10.58	-	40 52	-	2.03	457.71	26.70
43	2053	42.46	144 09	222.53	10.70	-	40 97	-	2.05	462.79	25.23
44	2054	42.93	145.69	225.00	10.81	-	41.42	-	2.07	467.93	23.84
45	2055	43.41	147 31	227.49	10.93	-	41 88	-	2.10	473.12	22.53
46	2056	43.89	148 94	230.02	11.06	-	42 35	-	2.12	478.37	21.29
Project Totals		**1,405.01**	**4,768.08**	**7,363.48**	**353.92**	**-**	**1,355.60**	**-**	**67.84**	**15,313.93**	**3,030.68**

Project's Net Benefits ($m 2010 Const dollars)

		Project Costs					Project Benefits (from above)		Project Net Benefits	
Project Year	Calendar Year	Startup Costs	O&M Costs	Residual Value	Total Costs (Undiscounted)	Total Costs(7% Discount)	Total Benefits (Undiscounted)	Total Benefits (7% Discount)	Net Total Benefits (Undiscounted)	Net Total Benefits (7% Discount)
1	2011	-	-	-	-	-	-	-	-	-
2	2012	78.38	-	-	78.38	68.46	-	-	(78.38)	(68.46)
3	2013	95.46	-	-	95.46	77.92	-	-	(95.46)	(77.92)
4	2014	317.36	-	-	317.36	242.11	-	-	(317.36)	(242.11)
5	2015	500.31	-	-	500.31	356.72	-	-	(500.31)	(356.72)
6	2016	534.40	23.77	-	558.17	371.93	153.81	102.49	(404.37)	(269.45)
7	2017	564.58	23.77	-	588.35	366.39	181.43	112.99	(406.92)	(253.41)
8	2018	269.63	23.77	-	293.40	170.76	209.65	122.02	(83.75)	(48.74)
9	2019	203.15	23.77	-	226.92	123.43	238.48	129.72	11.56	6.29
10	2020	221.64	23.77	-	245.41	124.76	267.92	136.19	22.50	11.44
11	2021	152.76	23.77	-	176.53	83.87	297.98	141.57	121.45	57.70
12	2022	129.35	23.77	-	153.12	67.99	328.68	145.94	175.56	77 95
13	2023	-	23.77	-	23.77	9.86	332.32	137.90	308.55	128.04
14	2024	-	23.77	-	23.77	9.22	336.01	130.31	312.24	121.09
15	2025	-	23.77	-	23.77	8.62	339.74	123.14	315.97	114.52
16	2026	-	23.77	-	23.77	8.05	343.51	116.36	319.74	108.31
17	2027	-	23.77	-	23.77	7.52	347.33	109.95	323.56	102.43
18	2028	-	23.77	-	23.77	7.03	351.18	103.90	327.41	96 87
19	2029	-	23.77	-	23.77	6.57	355.08	98.18	331.31	91.61
20	2030	-	23.77	-	23.77	6.14	359.02	92.78	335.25	86.64
21	2031	-	23.77	-	23.77	5.74	363.01	87.67	339.24	81.93
22	2032	-	23.77	-	23.77	5.37	367.04	82.84	343.27	77.48
23	2033	-	23.77	-	23.77	5.01	371.11	78.28	347.34	73.27
24	2034	-	23.77	-	23.77	4.69	375.23	73.98	351.46	69 29
25	2035	-	23.77	-	23.77	4.38	379.39	69.90	355.62	65.52
26	2036	-	23.77	-	23.77	4.09	383.61	66.06	359.84	61 96
27	2037	-	23.77	-	23.77	3.83	387.86	62.42	364.09	58.59
28	2038	-	23.77	-	23.77	3.58	392.17	58.98	368.40	55.41
29	2039	-	23.77	-	23.77	3.34	396.52	55.74	372.75	52.40
30	2040	-	23.77	-	23.77	3.12	400.92	52.67	377.15	49 55
31	2041	-	23.77	-	23.77	2.92	405.37	49.77	381.60	46.85
32	2042	-	23.77	-	23.77	2.73	409.87	47.03	386.10	44 30
33	2043	-	23.77	-	23.77	2.55	414.42	44.44	390.65	41.89
34	2044	-	23.77	-	23.77	2.38	419.02	41.99	395.25	39.61
35	2045	-	23.77	-	23.77	2.23	423.67	39.68	399.90	37.46
36	2046	-	23.77	-	23.77	2.08	428.38	37.50	404.61	35.42
37	2047	-	23.77	-	23.77	1.94	433.13	35.43	409.36	33.49
38	2048	-	23.77	-	23.77	1.82	437.94	33.48	414.17	31.67
39	2049	-	23.77	-	23.77	1.70	442.80	31.64	419.03	29.94
40	2050	-	23.77	-	23.77	1.59	447.72	29.90	423.95	28 31
41	2051	-	23.77	-	23.77	1.48	452.69	28.25	428.92	26.77
42	2052	-	23.77	-	23.77	1.39	457.71	26.70	433.94	25 31
43	2053	-	23.77	-	23.77	1.30	462.79	25.23	439.02	23.93
44	2054	-	23.77	-	23.77	1.21	467.93	23.84	444.16	22.63
45	2055	-	23.77	-	23.77	1.13	473.12	22.53	449.35	21.40
46	2056	-	23.77	(559.20)	(535.43)	(23.83)	478.37	21.29	1,013.80	45.11
Project Totals		**3,067.01**	**974.57**	**(559.20)**	**3,482.38**	**2,165.11**	**15,313.93**	**3,030.68**	**11,831.54**	**865.56**

Startup Construction Costs ($m)

Cost Category	Road	Rail	Air	Water	Total
Property Acquisition	150	-	-	-	**150**
Engineering & Design	165	-	-	-	**165**
Right-of-Way (paving, rails)	2,796	-	-	-	**2,796**
Transport Structures (bridges)	-	-	-	-	**-**
Terminal Blogs & Equipment	-	-	-	-	**-**
Vehicles	-	-	-	-	**-**
Total Startup Costs	**3,111**	**-**	**-**	**-**	**3,111**

Annual Operations & Maintenance Costs ($m/yr)

Cost Category	Road	Rail	Air	Water	Total
Ongoing Operations	9.68	-	-	-	**9.68**
Maintenance & Rehabilitation	14.09	-	-	-	**14.09**
Total Annual Costs	**23.77**	**-**	**-**	**-**	**23.77**

Appendix IA (Partial - $135 Million TIGER Only)- Direct Travel Impacts of the Project

Reduction/Savings in:	Passenger Car On-the-Clock	Passenger Car Commute	Passenger Car Personal/Reek	Truck Freight Freight	Total
Gross Vehicle Trips	10,764	41,742	96,875	14,870	164,251
Gross VMT	139,743	541,919	1,257,690	193,049	2,132,401
Gross VHT	37,709	146,232	339,376	52,092	575,409
Gross Buffer Time (hrs)	943	3,656	8,484	1,302	14,385
Passenger Trips	11,733	45,499	141,935	-	199,166
...diverted from in-model source	11,733	45,499	141,935	-	199,166
...diverted from other source	-	-	-	-	-
...induced from latent demand	-	-	-	-	-
Passenger Miles	152,320	590,692	1,842,685	-	2,585,696
Freight Ton Trips	-	-	-	260,225	260,225
...diverted from in-model source	-	-	-	260,225	260,225
...diverted from other source	-	-	-	-	-
...induced from latent demand	-	-	-	-	-
Freight Ton Miles	-	-	-	3,378,358	3,378,358
Fatalities	-	0.01	0.02	-	0.03
Personal Injuries	0.13	0.49	1.13	0.02	1.77
Property Damage	0.29	1.12	2.59	0.38	4.38
Local Portion of Trip Ends	0.93	0.88	0.93	0.45	
Total Value of Travel Impacts:					
Passenger Cost - Net Total	1,130,327	3,379,129	5,270,653	-	9,780,110
Crew Cost - Net Total	-	-	-	1,629,177	1,629,177
Freight Cost - Net Total	-	-	-	1,305,038	1,305,038
Reliability Cost - Net Total	25,925	77,503	89,935	76,536	269,899
Vet Opera Cost - Net Total	81,051	314,313	729,460	227,798	1,352,622
Toll Cost - Net Total	3,413	13,234	30,715	4,715	52,076
Safety Cost - Net Total	23,991	93,035	215,917	7,776	340,719
Environmental Cost - Net Total	3,913	15,174	35,215	11,004	65,306
Induced Benefit - Total	-	-	-	-	-
Total Value of Travel Impacts:	1,268,619	3,892,389	6,371,895	3,262,043	14,794,947
Local Value of Travel Impacts:					
Passenger Cost - Net Local	1,048,422	2,973,776	4,888,733	-	8,910,931
Crew Cost - Net Local	-	-	-	733,130	733,130
Freight Cost - Net Local	-	-	-	587,267	587,267
Reliability Cost - Net Local	24,046	68,206	83,418	34,441	210,111
Vet Opera Cost - Net Local	75,178	276,609	676,602	102,509	1,130,898
Toll Cost - Net Local	3,165	11,647	28,489	2,122	45,423
Safety Cost - Net Local	22,252	81,875	200,271	3,499	307,898
Environmental Cost - Net Local	3,629	13,354	32,664	4,952	54,598
Induced Benefit - Local	-	-	-	-	-
Local Value of Travel Impacts:	1,176,693	3,425,466	5,910,177	1,467,920	11,980,256

Appendix IB(Partial - $135 Million TIGER Only)- Direct Economic Effects of the Project

Project Year	Calendar Year	Business Output	Value Added	Jobs	Wage Income
1	2011	-	-	-	-
2	2012	3.24	1.59	21	1.01
3	2013	3.94	1.93	26	1.22
4	2014	13.11	6.42	85	4.07
5	2015	20.66	10.12	134	6.41
6	2016	24.95	12.22	162	7.74
7	2017	26.53	12.99	173	8.23
8	2018	14.69	7.19	95	4.56
9	2019	12.29	6.02	80	3.81
10	2020	13.40	6.56	87	4.16
11	2021	10.92	5.35	71	3.39
12	2022	10.32	5.06	67	3.20
13	2023	5.02	2.46	33	1.56
14	2024	5.07	2.48	33	1.57
15	2025	5.11	2.50	33	1.59
16	2026	5.16	2.53	34	1.60
17	2027	5.20	2.55	34	1.62
18	2028	5.25	2.57	34	1.63
19	2029	5.30	2.59	34	1.64
20	2030	5.34	2.62	35	1.66
21	2031	5.39	2.64	35	1.67
22	2032	5.44	2.67	35	1.69
23	2033	5.49	2.69	36	1.70
24	2034	5.54	2.71	36	1.72
25	2035	5.59	2.74	36	1.74
26	2036	5.64	2.76	37	1.75
27	2037	5.69	2.79	37	1.77
28	2038	5.74	2.81	37	1.78
29	2039	5.80	2.84	38	1.80
30	2040	5.85	2.86	38	1.82
31	2041	5.90	2.89	38	1.83
32	2042	5.96	2.92	39	1.85
33	2043	6.01	2.94	39	1.87
34	2044	6.07	2.97	39	1.88
35	2045	6.12	3.00	40	1.90
36	2046	6.18	3.03	40	1.92
37	2047	6.24	3.05	41	1.94
38	2048	6.29	3.08	41	1.95
39	2049	6.35	3.11	41	1.97
40	2050	6.41	3.14	42	1.99
41	2051	6.47	3.17	42	2.01
42	2052	6.53	3.20	42	2.03
43	2053	6.59	3.23	43	2.05
44	2054	6.65	3.26	43	2.07
45	2055	6.72	3.29	44	2.08
46	2056	6.78	3.32	44	2.10
	Sum of Impact for all Years	**352.93**	**172.85**		**109.53**

Appendix IC (Partial - $135 Million TIGER Only)- Benefits and Costs By Mode

Present Value of Benefit Stream ($m 2010 Const dollars)

Mode	(A) Traveler Benefits ($) Vehicle Operating Costs	(A) Traveler Benefits ($) Time & Reliability Costs	(B) Traveler Benefits (non-$) Value of Personal Time & Reliability	(B) Traveler Benefits (non-$) Safety Cost	(B) Traveler Benefits (non-$) Additional Consumer Surplus	(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)
Pass Car - OTC	0.72	10.31	-	0.21	-	-	-	-
Pass Car - Commute	2.80	15.42	15.42	0.83	-	-	-	-
Pass Car - Pressure	6.51	-	47.82	1.93	-	-	-	-
Truck - Freight	2.03	15.22	-	0.07	-	11.64	-	-
Project Totals	**12.07**	**40.95**	**63.24**	**3.04**	**-**	**11.64**	**-**	**0.58**

Present Value of Cost Stream ($m 2010 Const dollars)

Facility Type	Startup Costs	Annual O&M Costs	Residual Value	Net Total Costs
Road	85.18	9.84	1.08	93.94
Rail	-	-	-	-
Air	-	-	-	-
Marine	-	-	-	-
Total for All Facilities	**85.18**	**9.84**	**1.08**	**93.94**

Efficiency Measures

Benefit Measure	Benefit Definition	Present Value of Benefit Stream	Present Value of Cost Stream	Net Present Value (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	**A+B**	119.29	93.94	25.35	1.27
Full User Benefit	**A+B+C**	130.93	93.94	36.99	1.39
Total Societal Benefit	**A+B+C+D+E**	**131.51**	**93.94**	**37.57**	**1.40**

Wider Measures

Impact Measure	Impact Definition	Present Value of Impact Stream	Present Value of Cost Stream	Net Present Value (Impacts - Costs)	Impact/Cost Ratio
Ad's Gross Regional Product	**GRP**	17.84	93.94	(76.10)	0.19
GRP plus Traveler non-$ Benefit	**GRP+B**	84.11	93.94	(9.83)	0.90
GRP plus Total non-$ Benefit	**GRP+B+E**	**84.69**	**93.94**	**(9.24)**	**0.90**

Appendix ID (Partial - $135 Million TIGER Only)- Benefits and Costs By Year

Project's Impact on Travel Characteristics

		Vehicles			Passengers			Freight Tons		
Project Year	Calendar Year	Vehicle Trips	Vehicle Miles (VMT)	Vehicle Hours (VHT)	Passenger Trips	Passenger Miles	Passenger Hours	Freight Ton Trips	Freight Ton Miles	Freight Ton Hours
1	2011	-	-	-	-	-	-	-	-	-
2	2012	-	-	-	-	-	-	-	-	-
3	2013	-	-	-	-	-	-	-	-	-
4	2014	-	-	-	-	-	-	-	-	-
5	2015	-	-	-	-	-	-	-	-	-
6	2016	(74,359)	(965,366)	(260,495)	(90,165)	(1,170,579)	(315,870)	(117,807)	(1,529,427)	(412,698)
7	2017	(87,715)	(1,138,762)	(307,284)	(106,360)	(1,380,834)	(372,606)	(138,967)	(1,804,137)	(486,825)
8	2018	(101,358)	(1,315,888)	(355,080)	(122,904)	(1,595,613)	(430,562)	(160,583)	(2,084,758)	(562,547)
9	2019	(115,293)	(1,496,806)	(403,899)	(139,802)	(1,814,990)	(489,759)	(182,661)	(2,371,386)	(639,891)
10	2020	(129,526)	(1,681,578)	(453,759)	(157,060)	(2,039,040)	(550,217)	(205,209)	(2,664,120)	(718,881)
11	2021	(144,060)	(1,870,268)	(504,675)	(174,683)	(2,267,841)	(611,957)	(228,236)	(2,963,061)	(799,547)
12	2022	(158,901)	(2,062,940)	(556,666)	(192,679)	(2,501,470)	(674,999)	(251,748)	(3,268,310)	(881,915)
13	2023	(160,664)	(2,085,838)	(562,845)	(194,817)	(2,529,236)	(682,492)	(254,543)	(3,304,588)	(891,704)
14	2024	(162,448)	(2,108,991)	(569,092)	(196,980)	(2,557,310)	(690,067)	(257,368)	(3,341,269)	(901,602)
15	2025	(164,251)	(2,132,401)	(575,409)	(199,166)	(2,585,696)	(697,727)	(260,225)	(3,378,358)	(911,610)
16	2026	(166,074)	(2,156,071)	(581,796)	(201,377)	(2,614,398)	(705,472)	(263,113)	(3,415,857)	(921,729)
17	2027	(167,918)	(2,180,003)	(588,254)	(203,612)	(2,643,418)	(713,303)	(266,034)	(3,453,773)	(931,960)
18	2028	(169,781)	(2,204,201)	(594,784)	(205,873)	(2,672,759)	(721,220)	(268,987)	(3,492,110)	(942,305)
19	2029	(171,666)	(2,228,668)	(601,386)	(208,158)	(2,702,427)	(729,226)	(271,973)	(3,530,873)	(952,764)
20	2030	(173,572)	(2,253,406)	(608,061)	(210,468)	(2,732,424)	(737,320)	(274,992)	(3,570,065)	(963,340)
21	2031	(175,498)	(2,278,419)	(614,811)	(212,805)	(2,762,754)	(745,505)	(278,044)	(3,609,693)	(974,033)
22	2032	(177,446)	(2,303,709)	(621,635)	(215,167)	(2,793,421)	(753,780)	(281,130)	(3,649,761)	(984,845)
23	2033	(179,416)	(2,329,280)	(628,535)	(217,555)	(2,824,427)	(762,147)	(284,251)	(3,690,273)	(995,777)
24	2034	(181,407)	(2,355,135)	(635,512)	(219,970)	(2,855,779)	(770,606)	(287,406)	(3,731,235)	(1,006,830)
25	2035	(183,421)	(2,381,277)	(642,566)	(222,412)	(2,887,478)	(779,160)	(290,596)	(3,772,652)	(1,018,006)
26	2036	(185,457)	(2,407,710)	(649,699)	(224,880)	(2,919,529)	(787,809)	(293,822)	(3,814,528)	(1,029,306)
27	2037	(187,516)	(2,434,435)	(656,910)	(227,376)	(2,951,936)	(796,553)	(297,083)	(3,856,869)	(1,040,731)
28	2038	(189,597)	(2,461,457)	(664,202)	(229,900)	(2,984,702)	(805,395)	(300,381)	(3,899,681)	(1,052,283)
29	2039	(191,702)	(2,488,780)	(671,574)	(232,452)	(3,017,832)	(814,335)	(303,715)	(3,942,967)	(1,063,963)
30	2040	(193,829)	(2,516,405)	(679,029)	(235,032)	(3,051,330)	(823,374)	(307,086)	(3,986,734)	(1,075,773)
31	2041	(195,981)	(2,544,337)	(686,566)	(237,641)	(3,085,200)	(832,514)	(310,495)	(4,030,987)	(1,087,714)
32	2042	(198,156)	(2,572,579)	(694,187)	(240,279)	(3,119,446)	(841,755)	(313,942)	(4,075,731)	(1,099,788)
33	2043	(200,356)	(2,601,135)	(701,893)	(242,946)	(3,154,071)	(851,098)	(317,426)	(4,120,971)	(1,111,996)
34	2044	(202,580)	(2,630,007)	(709,684)	(245,643)	(3,189,082)	(860,545)	(320,950)	(4,166,714)	(1,124,339)
35	2045	(204,828)	(2,659,201)	(717,561)	(248,370)	(3,224,480)	(870,097)	(324,512)	(4,212,965)	(1,136,819)
36	2046	(207,102)	(2,688,718)	(725,526)	(251,126)	(3,260,272)	(879,755)	(328,114)	(4,259,729)	(1,149,438)
37	2047	(209,401)	(2,718,562)	(733,579)	(253,914)	(3,296,461)	(889,521)	(331,757)	(4,307,012)	(1,162,196)
38	2048	(211,725)	(2,748,738)	(741,722)	(256,732)	(3,333,052)	(899,394)	(335,439)	(4,354,819)	(1,175,097)
39	2049	(214,075)	(2,779,249)	(749,955)	(259,582)	(3,370,049)	(909,378)	(339,162)	(4,403,158)	(1,188,140)
40	2050	(216,452)	(2,810,099)	(758,280)	(262,463)	(3,407,456)	(919,472)	(342,927)	(4,452,033)	(1,201,329)
41	2051	(218,854)	(2,841,291)	(766,697)	(265,377)	(3,445,279)	(929,678)	(346,734)	(4,501,450)	(1,214,663)
42	2052	(221,283)	(2,872,830)	(775,207)	(268,323)	(3,483,522)	(939,997)	(350,582)	(4,551,417)	(1,228,146)
43	2053	(223,740)	(2,904,718)	(783,812)	(271,301)	(3,522,189)	(950,431)	(354,474)	(4,601,937)	(1,241,779)
44	2054	(226,223)	(2,936,960)	(792,512)	(274,312)	(3,561,285)	(960,981)	(358,408)	(4,653,019)	(1,255,562)
45	2055	(228,734)	(2,969,561)	(801,309)	(277,357)	(3,600,815)	(971,648)	(362,387)	(4,704,667)	(1,269,499)
46	2056	(231,273)	(3,002,523)	(810,203)	(280,436)	(3,640,784)	(982,433)	(366,409)	(4,756,889)	(1,283,591)

Present Value of Benefit Stream ($m 2010 Const dollars)

		(A) Traveler Benefits ($)		(B) Traveler Benefits (non-$)			(C) Shipper/ Logistics Cost	(D) Business Productivity	(E) Social/ Environ.		
Project Year	Calendar Year	Vehicle Operating Costs	Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus	($)	($)	(non-$)	Total Benefits (Undiscounted)	Total Benefits(7% Discount)
1	2011	-	-	-	-	-	-	-	-	-	-
2	2012	-	-	-	-	-	-	-	-	-	-
3	2013	-	-	-	-	-	-	-	-	-	-
4	2014	-	-	-	-	-	-	-	-	-	-
5	2015	-	-	-	-	-	-	-	-	-	-
6	2016	0.61	2.08	3.21	0.15	-	0.59	-	0.03	6.67	4.45
7	2017	0.72	2.45	3.79	0.18	-	0.70	-	0.03	7.87	4.90
8	2018	0.83	2.83	4.37	0.21	-	0.81	-	0.04	9.10	5.29
9	2019	0.95	3.22	4.98	0.24	-	0.92	-	0.05	10.35	5.63
10	2020	1.07	3.62	5.59	0.27	-	1.03	-	0.05	11.63	5.91
11	2021	1.19	4.03	6.22	0.30	-	1.14	-	0.06	12.93	6.14
12	2022	1.31	4.44	6.86	0.33	-	1.26	-	0.06	14.26	6.33
13	2023	1.32	4.49	6.93	0.33	-	1.28	-	0.06	14.42	5.98
14	2024	1.34	4.54	7.01	0.34	-	1.29	-	0.06	14.58	5.65
15	2025	1.35	4.59	7.09	0.34	-	1.31	-	0.07	14.74	5.34
16	2026	1.37	4.64	7.17	0.34	-	1.32	-	0.07	14.91	5.05
17	2027	1.38	4.69	7.25	0.35	-	1.33	-	0.07	15.07	4.77
18	2028	1.40	4.74	7.33	0.35	-	1.35	-	0.07	15.24	4.51
19	2029	1.41	4.80	7.41	0.36	-	1.36	-	0.07	15.41	4.26
20	2030	1.43	4.85	7.49	0.36	-	1.38	-	0.07	15.58	4.03
21	2031	1.45	4.90	7.57	0.36	-	1.39	-	0.07	15.75	3.80
22	2032	1.46	4.96	7.66	0.37	-	1.41	-	0.07	15.93	3.59
23	2033	1.48	5.01	7.74	0.37	-	1.43	-	0.07	16.10	3.40
24	2034	1.49	5.07	7.83	0.38	-	1.44	-	0.07	16.28	3.21
25	2035	1.51	5.13	7.92	0.38	-	1.46	-	0.07	16.46	3.03
26	2036	1.53	5.18	8.00	0.38	-	1.47	-	0.07	16.65	2.87
27	2037	1.54	5.24	8.09	0.39	-	1.49	-	0.07	16.83	2.71
28	2038	1.56	5.30	8.18	0.39	-	1.51	-	0.08	17.02	2.56
29	2039	1.58	5.36	8.27	0.40	-	1.52	-	0.08	17.21	2.42
30	2040	1.60	5.42	8.37	0.40	-	1.54	-	0.08	17.40	2.29
31	2041	1.61	5.48	8.46	0.41	-	1.56	-	0.08	17.59	2.16
32	2042	1.63	5.54	8.55	0.41	-	1.57	-	0.08	17.79	2.04
33	2043	1.65	5.60	8.65	0.42	-	1.59	-	0.08	17.98	1.93
34	2044	1.67	5.66	8.74	0.42	-	1.61	-	0.08	18.18	1.82
35	2045	1.69	5.72	8.84	0.42	-	1.63	-	0.08	18.39	1.72
36	2046	1.71	5.79	8.94	0.43	-	1.65	-	0.08	18.59	1.63
37	2047	1.72	5.85	9.04	0.43	-	1.66	-	0.08	18.80	1.54
38	2048	1.74	5.92	9.14	0.44	-	1.68	-	0.08	19.00	1.45
39	2049	1.76	5.98	9.24	0.44	-	1.70	-	0.09	19.22	1.37
40	2050	1.78	6.05	9.34	0.45	-	1.72	-	0.09	19.43	1.30
41	2051	1.80	6.12	9.45	0.45	-	1.74	-	0.09	19.64	1.23
42	2052	1.82	6.18	9.55	0.46	-	1.76	-	0.09	19.86	1.16
43	2053	1.84	6.25	9.66	0.46	-	1.78	-	0.09	20.08	1.09
44	2054	1.86	6.32	9.76	0.47	-	1.80	-	0.09	20.31	1.03
45	2055	1.88	6.39	9.87	0.47	-	1.82	-	0.09	20.53	0.98
46	2056	1.90	6.46	9.98	0.48	-	1.84	-	0.09	20.76	0.92
Project Totals		**60.97**	**206.91**	**319.53**	**15.36**	**-**	**58.82**	**-**	**2.94**	**664.54**	**131.51**

Project's Net Benefits ($m 2010 Const dollars)

		Project Costs					Project Benefits (from above)		Project Net Benefits	
Project Year	Calendar Year	Startup Costs	O&M Costs	Residual Value	Total Costs (Undiscounted)	Total Costs(7% Discount)	Total Benefits (Undiscounted)	Total Benefits (7% Discount)	Net Total Benefits (Undiscounted)	Net Total Benefits (7% Discount)
1	2011	-	-	-	-	-	-	-	-	-
2	2012	3.40	-	-	3.40	2.97	-	-	(3.40)	(2.97)
3	2013	4.14	-	-	4.14	3.38	-	-	(4.14)	(3.38)
4	2014	13.77	-	-	13.77	10.51	-	-	(13.77)	(10.51)
5	2015	21.71	-	-	21.71	15.48	-	-	(21.71)	(15.48)
6	2016	23.19	1.03	-	24.22	16.14	6.67	4.45	(17.55)	(11.69)
7	2017	24 50	1.03	-	25.53	15.90	7.87	4.90	(17.66)	(11.00)
8	2018	11.70	1.03	-	12.73	7.41	9.10	5.29	(3.63)	(2.11)
9	2019	8.82	1.03	-	9.85	5.36	10.35	5.63	0.50	0.27
10	2020	9.62	1.03	-	10.65	5.41	11.63	5.91	0.98	0.50
11	2021	6.63	1.03	-	7.66	3.64	12.93	6.14	5.27	2.50
12	2022	5.61	1.03	-	6.64	2.95	14.26	6 33	7.62	3.38
13	2023	-	1.03	-	1.03	0.43	14.42	5.98	13.39	5.56
14	2024	-	1.03	-	1.03	0.40	14.58	5.65	13.55	5.26
15	2025	-	1.03	-	1.03	0.37	14.74	5.34	13.71	4.97
16	2026	-	1.03	-	1.03	0.35	14.91	5.05	13.88	4.70
17	2027	-	1.03	-	1.03	0.33	15.07	4.77	14.04	4.45
18	2028	-	1.03	-	1.03	0.30	15.24	4.51	14.21	4.20
19	2029	-	1.03	-	1.03	0.28	15.41	4.26	14.38	3.98
20	2030	-	1.03	-	1.03	0.27	15.58	4.03	14.55	3.76
21	2031	-	1.03	-	1.03	0.25	15.75	3.80	14.72	3.56
22	2032	-	1.03	-	1.03	0.23	15.93	3.59	14.90	3.36
23	2033	-	1.03	-	1.03	0.22	16.10	3.40	15.07	3.18
24	2034	-	1.03	-	1.03	0.20	16.28	3.21	15.25	3.01
25	2035	-	1.03	-	1.03	0.19	16.46	3.03	15.43	2.84
26	2036	-	1.03	-	1.03	0.18	16.65	2.87	15.62	2.69
27	2037	-	1.03	-	1.03	0.17	16.83	2.71	15.80	2.54
28	2038	-	1.03	-	1.03	0.15	17.02	2.56	15.99	2.40
29	2039	-	1.03	-	1.03	0.14	17.21	2.42	16.18	2.27
30	2040	-	1.03	-	1.03	0.14	17.40	2.29	16.37	2.15
31	2041	-	1.03	-	1.03	0.13	17.59	2.16	16.56	2.03
32	2042	-	1.03	-	1.03	0.12	17.79	2.04	16.76	1.92
33	2043	-	1.03	-	1.03	0.11	17.98	1.93	16.95	1.82
34	2044	-	1.03	-	1.03	0.10	18.18	1.82	17.15	1.72
35	2045	-	1.03	-	1.03	0.10	18.39	1.72	17.36	1.63
36	2046	-	1.03	-	1.03	0.09	18.59	1.63	17.56	1.54
37	2047	-	1.03	-	1.03	0.08	18.80	1.54	17.77	1.45
38	2048	-	1.03	-	1.03	0.08	19.00	1.45	17.97	1.37
39	2049	-	1.03	-	1.03	0.07	19.22	1.37	18.19	1.30
40	2050	-	1.03	-	1.03	0.07	19.43	1.30	18.40	1.23
41	2051	-	1.03	-	1.03	0.06	19.64	1.23	18.61	1.16
42	2052	-	1.03	-	1.03	0.06	19.86	1.16	18.83	1.10
43	2053	-	1.03	-	1.03	0.06	20.08	1.09	19.05	1.04
44	2054	-	1.03	-	1.03	0.05	20.31	1.03	19.28	0.98
45	2055	-	1.03	-	1.03	0.05	20.53	0.98	19.50	0.93
46	2056	-	1.03	(24.27)	(23.24)	(1.03)	20.76	0.92	43.99	1.96
Project Totals		**133.09**	**42.23**	**(24.27)**	**151.05**	**93.94**	**664.54**	**131.51**	**513.48**	**37.57**

Startup Construction Costs ($m)

Cost Category	Road	Rail	Air	Water	Total
Property Acquisition	7	-	-	-	**7**
Engineering & Design	7	-	-	-	**7**
Right-of-Way (paving, rails)	121	-	-	-	**121**
Transport Structures (bridges)	-	-	-	-	**-**
Terminal Blogs & Equipment	-	-	-	-	**-**
Vehicles	-	-	-	-	**-**
Total Startup Costs	**135**	**-**	**-**	**-**	**135**

Annual Operations & Maintenance Costs ($m/yr)

Cost Category	Road	Rail	Air	Water	Total
Ongoing Operations	0.42	-	-	-	**0.42**
Maintenance & Rehabilitation	0.61	-	-	-	**0.61**
Total Annual Costs	**1.03**	**-**	**-**	**-**	**1.03**

TREDIS® Transportation Economic Development Impact System

TREDIS® Technical Document: Benefit-Cost Module

Version 3.6.3

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1 Introduction

1.1 A Comprehensive Suite of Documents

This technical document is part of a suite that describes and supports TREDIS v3.6.3. The current document provides a technical explanation of the Benefits Cost module, including underlying economic theory and sample calculations. The entire suite of documents is as follows:

- *TREDIS v363 User's Manual* – the user manual provides technical assistance with the model's online interface, including how to create a project, add, modify, and delete scenario data, and navigate through the results;
- *Data Sources and Default Values for Multimodal Transportation Studies* – this indicates where TREDIS draws on default data and provides source and reference information;
- *TREDIS v363 Overview* – the model's overall purpose and architecture is described here, including the different ways TREDIS can be used as well as how the primary modules interrelate to produce results;
- *TREDIS Case Studies* – these documents assist the user in modeling particular types of situations, addressing which input values to use for different impact type, potential data sources for their inputs, and how to interpret results in the context of the projects' overall goals. The current case studies describe
  - *Reducing Highway Congestion*
  - *Adding Transit Capacity, and*
  - *Improving Freight Infrastructure*
- *TREDIS Technical Documentation* – this group of documents provides technical detail as to how inputs and background data are processed into final results, including a discussion of some of the underlying economic theory. The suite includes:
  - *Travel Cost Module*
  - *Market Access Module*
  - *Economic Adjustment Module*
  - *Benefit-Cost Module*
  - *Finance Module*

1.2 The TREDIS Modular Structure

TREDIS is the *Transportation Economic Development Impact System*. It is an integrated framework for transportation planning and project assessment – designed to cover a wide range of applications, from looking at the benefit/cost impacts of a single transportation investment, to analyzing the macroeconomic impacts of alternative long-range plans. It models passenger and freight travel across all modes, and it assesses costs, benefits, and impacts across a range of economic responses and societal perspectives. To integrate this range of features, TREDIS operates as four separate but interconnected modules:

- *Travel Cost,*
- *Market Access,*

- *Economic Adjustment, and*
- *Benefit/Cost.*

A fifth optional module has been added in TREDIS v3.6.3. The Finance module is available to subscribing users and predicts the tax revenue impacts of projects. It also shows the effect of imposing or changing fuel taxes, roadway tolls, passenger transit fares, freight handling fees, infrastructure fees, or other factors affecting costs for various modes or types of movement in the project area.

As shown in Figure 1-1, the Travel Cost module looks at how changes in the amount, type, and quality of travel translate into user and nonuser benefits, as well as direct travel impacts. The Market Access module, in contrast, considers the network effects of travel – how changes in access to markets translate into improved conditions for business attraction and productivity. Together, these two modules constitute the direct effects of a transportation project or policy. These direct impacts are then used by the Economic Adjustment module to estimate secondary economic effects, and also by the Benefit-Cost module, to itemize costs, benefits, and impacts for the project.

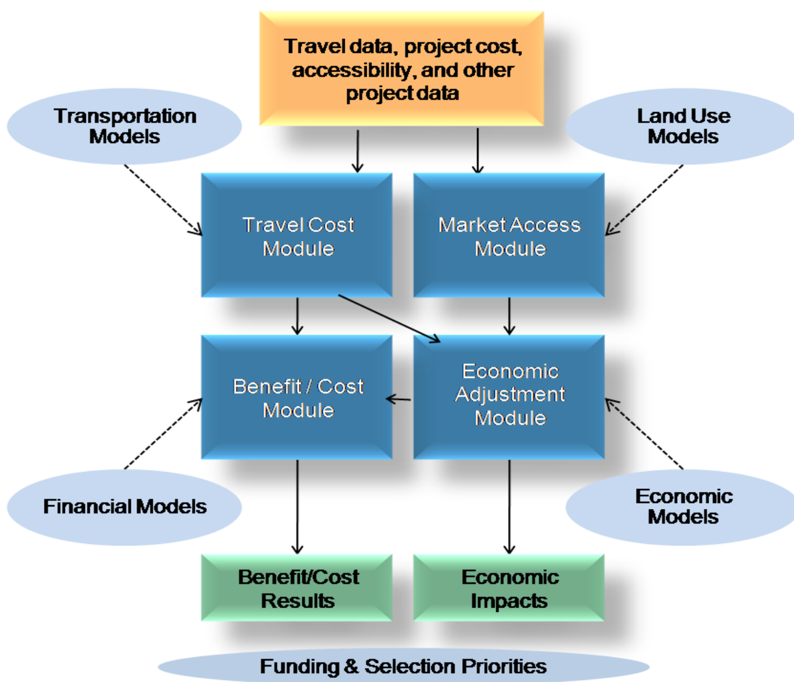

Figure 1-1: TREDIS Modular Structure

TREDIS is designed so that the four modules shown in Figure 1-1**Error! Reference source not found.** can be used as a seamless tool to analyze the effects of transportation projects "from scratch." However, TREDIS can also be separated so that each of the four modules may be used individually, in any combination with one another, or in conjunction with a user's in-house substitute. For example, a user may already have estimated the direct travel impacts of a transportation policy (for example, using HERS-ST) and is only interested in the market access effects and regional economic impacts. In this case, TREDIS' Travel Cost and Benefit-Cost modules may be circumvented. More generally, if a user has an in-house tool that performs similar functions to those of any of the TREDIS modules, then these tools may be used without disrupting the overall flow of the model. *Contact TREDIS support staff for more information on how to incorporate your in-house modeling into the TREDIS framework.*

2 TREDIS Benefit Cost Module

2.1 Distinguishing Benefit/Cost and Impact Analysis[1]

In the transportation research literature, it has long been clear that *economic impacts* of transportation projects are not the same as the *economic value of project benefits*. In general:

- Economic *impacts* are defined as impacts on the flow of money in the economy, and are typically measured in terms of increased Jobs or Income.
- *Benefits*, as used in benefit-cost analysis, are defined as the dollar value of net welfare gain to transportation system users (user benefits) and non-users (external benefits).

Example of economic impact. It is possible that a transportation project will reduce business operating costs, which can increase profits (a component of value added). That may also improve competitiveness for locating a business in the affected area, resulting in further business sales and income growth there. Such impacts directly affect the flow of corporate income and lead directly to increases in worker income. As such, they represent an *economic impact* on the affected area.

Example of economic value of benefit. It is possible that a transportation project may serve reduce driver frustration about expected or unexpected delays, reduce air pollution levels and enhance or otherwise affect the visual beauty of an area. All of these impacts are seen as having a value to society, which shows up in either willingness to pay studies (representing stated preferences) or in observed property value changes (reflecting revealed preferences). Such "societal" (or social) benefits can be counted in a benefit-cost analysis. However, not all types of benefit change the flow of income in the economy.

Both concepts have their use. The economic value of benefits is used in benefit/cost analysis to establish the economic efficiency of particular transportation investments. However, the measurement of economic impacts can also be useful, as it can show the extent to which transportation improvements lead to tangible benefits for local constituents, and it can also show movement towards addressing social equity goals such as the redistribution of future business growth to areas of current economic distress.

TREDIS carefully accounts for the difference between economic impacts and benefits, and separately reports both effects. In practice, economic impact analysis and benefit/cost

[1] This discussion draws from a working paper by Glen Weisbrod, which subsequently developed into the published article: "Models to predict the economic development impact of transportation projects: historical experience and new applications," *Annals of Regional Science*, 2008.

analysis are quite different from each other, and are performed for different reasons. For instance, an economic impact analysis might be conducted as part of an Environmental Impact Study (EIS) to identify expected social and economic development consequences of a project. In such cases, it is important to determine the "full" impact in terms of population, employment, personal income, or business output, because these may lead to subsequent environmental and/or land use impacts. Benefit/cost studies, on the other hand, are used to justify a particular investment strategy, select among a list of project alternatives, or prioritize the scheduling of reconstruction projects. These two analytic approaches are outlined in Figure 2-1, and their differences are further discussed in the text that follows.

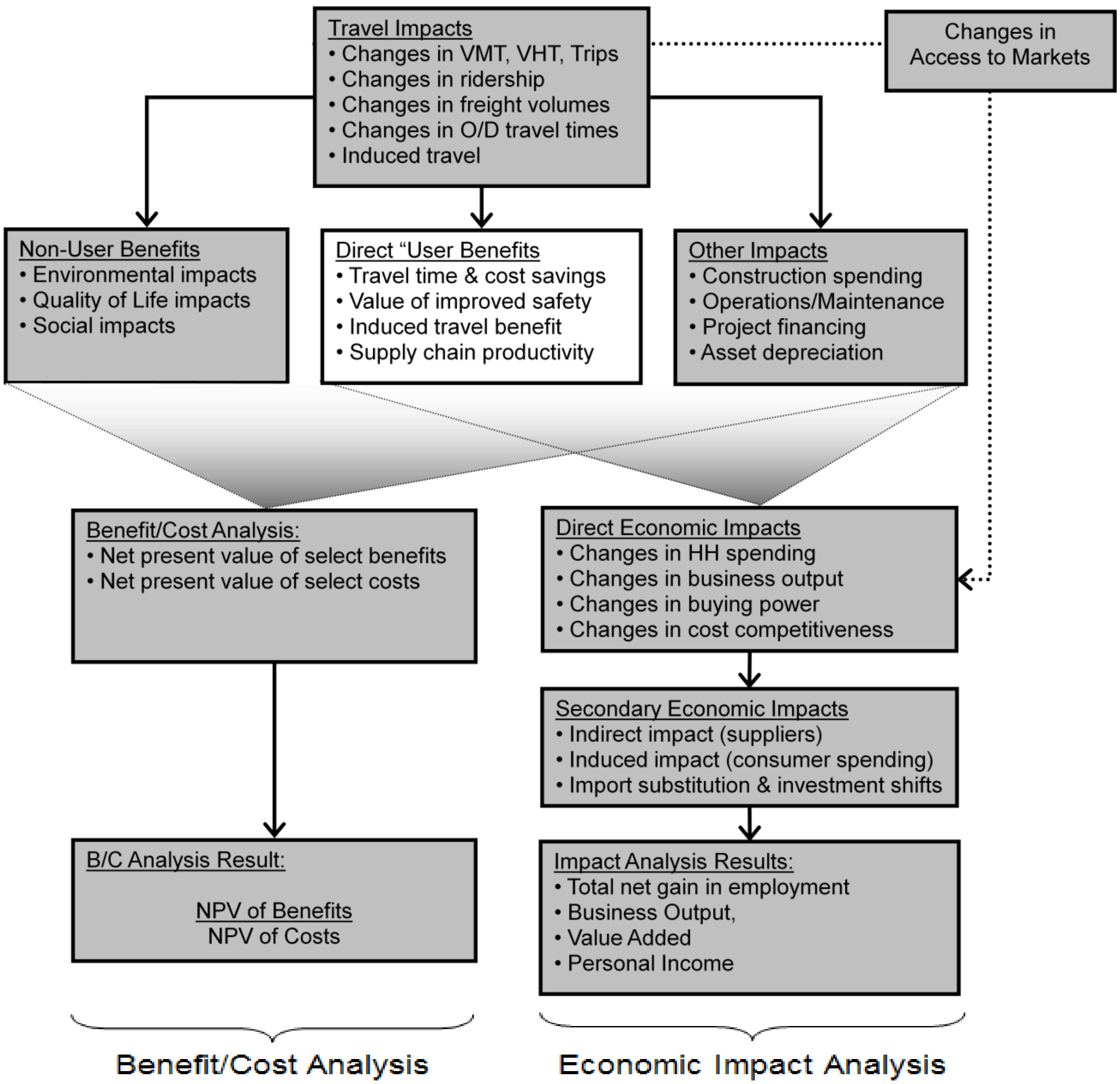

Figure 2-1: Overview of Benefit-Cost Analysis and Economic Impact Analysis

The need for separate valuation of traveler, economic and other social impacts is stressed in the NCHRP *Guidebook for Assessing Social and Economic Impacts of Transportation Projects* (David Forkenbrock and Glen Weisbrod, 2001). Yet it can be argued that one of the most dangerous elements of applied economic impact modeling has been the blurring of these differences in the use of economic impact studies. As shown above, this blurring can occur in the translation of direct *travel* impacts to either benefits or direct *economic* impacts.

Key similarities and differences between benefit/cost and economic impact analysis are as follows:

- *Similarities* – Business-related travel time savings and travel-related money savings (including operating costs) affect the economy through changes in expenditures by households and businesses, and through productivity enhancement for businesses. However, these are elements are also measurable components of overall project *benefit*. The similarities between some measures of economic benefit and direct travel impact is underscored in Figure 2-1, where there is considerable overlap in the inputs to either type of analysis, particular in the calculation of direct travel impacts.
- *Factors Where Economic Development Measures are Broader* – Impacts on a regional economy can <u>include</u> some factors that may not be counted in the net value of project benefits. For example, a project that reduces household spending on road tolls may generate economic impacts through increased disposable income. However, a toll reduction is typically not included as a project benefit because tolls reflect a transfer of income between parties rather than a net growth of income. As another example, economic growth impacts on a region or country can include short-term effects of construction spending, as well as longer-term effects of attracting business investment from another region or country. However, in benefit-cost accounting, construction spending by itself does not necessarily bring any net income benefit over the alternative of spending the same money on other investments (that is the opportunity cost.) In addition, while business relocation decisions are typically motivated by the opportunity to increase profitability and return on investment, the net productivity benefit for the broader nation or world is usually less than the impact on a local area's economic growth, because local business activity growth can be displaced from outside the region.
- *Factors Where Economic Development Measures are Narrower* – Impacts on the economy can <u>exclude</u> some factors that may be counted in the net value of project benefits. For instance, the dollar value of personal travel time improvements (an element of traveler impact) and the dollar valuation of air quality improvements (an element of social impact) are both real project benefits that can be assigned an economic value. However, that value does not automatically turn into an equivalent change in the flow of money and income in the economy. In addition, improvements in transportation safety are a clear social benefit, but they do not necessarily create any more net jobs and income in a local economy; in fact, they could lead to a loss of jobs and income in medical and car repair occupations. As a final example, consumer surplus theory requires that both the costs *and benefits* of induced household travel be measured. In contrast, only the costs of induced household travel lead to a gain or loss of regional economic activity.

These similarities and differences lead to a series of alternative ways to view the economic impacts and benefits of transportation projects.

2.2 Alternative Views of Economic Benefits

In the TREDIS Benefit Cost module, transportation benefits are categorized in terms of four distinct levels of breadth:

- *Traveler Benefit* are the traditionally-used measure of user benefits, and are defined to include benefits accruing to drivers, passengers and vehicle costs as a result of improvements in travel times, travel expenses and travel safety. Additional benefits, associated with switching modes of travel, origin-destination patterns and "induced" generation of additional travel are also counted (through the concept of "consumer surplus").
- *Broader "User" Benefit* measures are now becoming more common. They include all traveler benefits (above) but also add logistics benefits. These are the time and shipping cost savings to industries producing or consuming the commodities on board freight modes. This class of benefits is included as "user" because industries are the ultimate "users" of freight transportation system. Benefits arise because as shipping costs go down, businesses can increase productivity through inventory management, production scheduling, or distributional efficiencies.
- *Wider "Societal" Benefit* (or "social" benefit) measures include all of the broader user benefits, but also add benefits to parties not directly using the transportation system (or facility being upgraded). These are commonly called "externalities" because they accrue to parties external to market in question. These are frequently include a valuation of environmental and quality of life impacts such as air quality, water quality and noise impacts[2], where the valuation may be based on "willingness to pay" concepts, observed tradeoffs made by consumers or actual markets (such as emission credits). Wider social benefits can also include "agglomeration" benefits, when a transport project facilitates greater accessibility and connectivity of productive factors in an economy. These "market access" effects are the result of knowledge spillovers, better matching of worker skills (and other inputs) to business needs, and sharing of commonly-needed inputs to production. It is important to note that reducing transportation cost and improving market access can improve the competitive environment of a study area, attracting business from outside areas. While this "attraction" can be included as economic development impacts (next bullet), they should not be included as a wider social benefit. Only productivity gains (typically measured as output per worker) may be included as social benefits.
- *Economic Development Impact* measures reflect income generated in the economy of a given area, including indirect and induced activity. As noted in earlier discussion, they can be triggered both by user and non-user benefits, insofar as those benefits lead to changes in the flow of income in the economy. It is important to note, though, that not all elements of societal benefit are directly reflected in the flow of dollars in the economy (personal time savings and environmental impact are commonly cited as

[2] The valuation of these environmental and economic development benefits, which can be captured in TREDIS, are reviewed in *Monetary Valuation per Dollar of Investment in Different Performance Measures* by Glen Weisbrod, Teresa Lynch and Michael Meyer, prepared by Economic Development Research Group for the National Cooperative Highway Research Program, NCHRP 8-36-61, 2007.

examples of this situation[3]). Economic development impacts may also include business attraction from increased regional competitiveness, noting that this attracted business may come at the expense of region's outside the area of interest.

In TREDIS, these four levels of benefit or impact are carefully defined and distinguished. To avoid double counting, they should never be added together. A comparison of the coverage of these alternative measures is shown in Table 2-1.

Table 2-1: Difference Between Economic Benefits and Regional Economic Impacts

	Traveler Benefit	Full User Benefit	Societal Benefit	Economic Development Impact
$ Passenger Time Savings for personal travel	Yes	Yes	Yes	--
$ Passenger Time Savings for business travel	Yes	Yes	Yes	Yes
$ Travel Vehicle Operating Expense Savings	Yes	Yes	Yes	Yes
$ Shipper/Receiver Productivity Gain	--	Yes	Yes	Yes
$ Market Access Productivity Gain	--	--	Yes	Yes
$ Value of Quality of Life/Environmental Benefits	--	--	Yes	--
$ Local Income Growth from Economic Impacts	--	--	--	Yes

2.3 Role of Study Area Definition in Measuring Benefits

All of the various measures of benefit and impact discussed above are sensitive to the areas for which information is collected.

Issues for Measuring User Benefits. In theory, user benefits should be measured at a global scale. However, in practice, state/provincial, regional and local transportation agencies tend to collect information and maintain transportation models or databases covering a limited area -- typically their area of jurisdiction plus surrounding areas. This allows them to capture benefits of local transportation improvements for incoming, outgoing, internal and pass-through trips. Sometimes planning agencies are interested in calculating the extent to which total user benefits accrue to users with home or business locations within the region. TREDIS allows for both local and total benefit calculations.

Another concern, though, is that travel models may miss the impact of projects affecting inter-city or inter-regional movements outside of their area of coverage. This could lead to under-estimation of benefits, as the analysis process may not capture impacts on the generation and routing of external trips that have a choice of using or avoiding the study area. For most projects, however, this is not a major concern. TREDIS also provides a means for estimating benefits associated with "induced demand," which encompasses new travel (which could include trips that previously were not captured in the analysis process due to study area limitations) See Section 3.2 for a complete discussion of how induced demand is handled in TREDIS.

[3] In theory, improvements in personal time savings and environmental improvement could generate additional income in the economy of an area through indirect processes such as attraction of more in-migration. In reality, the extent of any such effect is not established in the research literature. This does not really matter, since it would be foolhardy to equate economic growth effects with all societal benefits.

Issues for Measuring Societal Benefits. In theory, societal benefits should be measured at a national or global scale. However, in practice, state/provincial, regional and local agencies tend to apply environmental impact models (such as air quality impact models) to the results of travel models. As a result, whatever spatial limitations apply for the travel model coverage will usually also apply for the environmental impact coverage.

Issues for Measuring User Impacts. Impacts on the economy are different from user and societal benefits in that they are intrinsically tied to the definition of the study area. That makes it important to track both gross and net impacts on the economy, which TREDIS handles by giving options to see economic impacts at either the study area level or a national level.

To understand net/gross differences, consider a transportation project that leads to changes in the location of business activity, creating areas where business activity and income grow and other areas where they decline. All of those changes (*gross effects* on the economy of local areas) are considered to be economic impacts. They may be viewed as positive effects for one region and negative for others. Many of the gains and losses covered as impacts will tend to cancel each other out, creating a *net result* for a larger consolidated set of regions that may be zero or a value much smaller than those localized impacts.

As a result, the nature of economic development impacts depends on the definition of the impact region. In particular, local business growth may be considered a beneficial outcome for the affected region receiving that growth, but its inclusion of business relocations from outside regions means that it is counting some impacts that would not necessarily be a benefit from a larger national view.

On the other hand, business relocations due to transportation access improvement would normally occur only if there were also some resulting business profit or productivity gain (exceeding the transaction costs of relocation), and that would be counted as a productivity benefit. Business relocation or shifts in economic growth patterns may also reflect desirable distributional impacts (e.g., better use of underutilized human capital and infrastructure capital, especially in economically distressed areas) that can also be counted as a national benefit.

TREDIS accounts for these complex issues by distinguishing business attraction from business productivity in the Market Access module (see separate technical documentation). This module is designed in such a way that business attraction and productivity are estimated jointly, without double-counting. Business attraction undergoes a net-adjustment process where competing sub-areas in broader study region may draw some of the growth from one another. Only the net effects are included as economic development impacts in the Benefit Cost module.

3 How the Benefit-Cost Module Works

The benefit/cost module in TREDIS gathers relevant user-defined data and output from preceding modules to estimate net present values of benefits and costs (see Figure 3-1).

Depending on how the project has been set up by the user, these may include:

- direct user and non-user travel impacts, calculated by the Travel Cost module (including benefits to commodity shippers and receivers),
- productivity benefits, calculated from the market Access Module
- secondary (indirect and induced) economic impacts, calculated in the TREDIS Economic Adjustment module[4], triggered by any of the above direct impacts (but not triggered by construction spending).

The entire process is motivated by the need to identify where a particular impact falls on the benefit mapping shown earlier in Table 2-1. Data from the travel cost module is therefore filtered and categorized based on whether it is a user benefit or non-user benefit, and user benefits are further categorized as travel efficiency or the broader measure of "full" user benefit, which included freight shippers. Market access impacts are distilled to include only productivity gains, and regional income growth is included as an economic development impact (as will be discussed, regional income growth is displayed separately from efficiency measures – in its own section labeled "Wider Impacts").

This process is completed in several steps. First, direct user and non-user impacts are aggregated from the Travel Cost module. The next step is to estimate induced travel benefits based on reported travel characteristics and mode-switching patterns. The third step is to reconcile various impact measures to avoid double-counting. Finally, net present values of all cost and benefit streams are reported by mode or year in the final reports.

[4] The TREDIS framework allow users to substitute in-house modules.

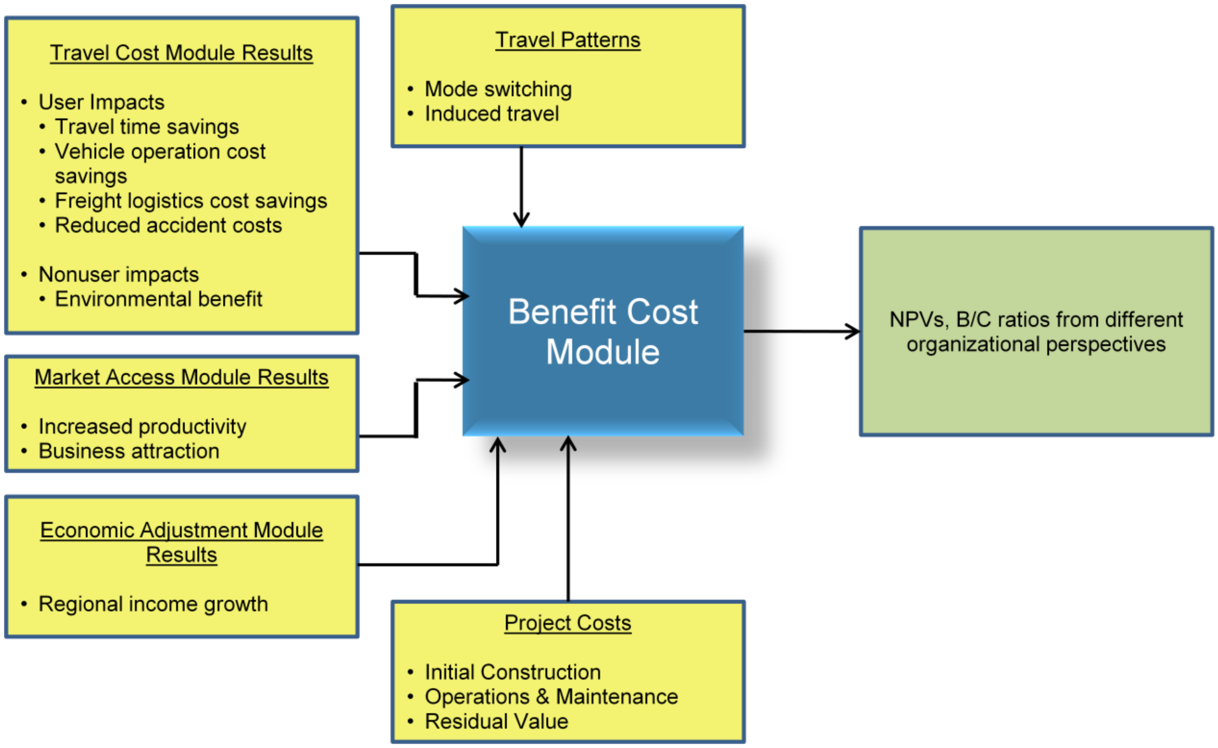

Figure 3-1: Overview of Benefit-Cost Module

3.1 Calculation of User and Non-User Benefits

The first step to estimating benefits from a transport investment is to assemble direct user and non-user impacts. In the TREDIS framework, these calculations are typically made by the Travel Cost module, but a customized process can be substituted, if desired. The ultimate result of the travel cost module is an array of direct user and nonuser costs for each scenario[5].

User benefits may include savings in costs associated with:

- travel time costs for vehicle drivers/crew, occupants (passengers), and cargo,
- costs of travel time variability,
- vehicle operation costs (which vary with congestion levels),
- tolls or fares,
- accident costs.

Each benefit category is monetized based on changes in travel characteristics (Trips, VMT, VHT, vehicle occupancy and loadings, etc), levels of service (travel times, reliability, and congestion), and value factors suggested by regulatory guidance and a literature review. For a full discussion of monetization rates, see separate document: *Data Sources and Default Values for Multimodal Transportation Studies*. As discussed above, user benefits also include time cost savings accruing to shippers and receivers of the commodities on-board freight

[5] See separate technical documentation of the Travel Cost module

modes[6]. Note that TREDIS provides an option to estimate benefits from greater travel time and system reliability.

Non-user benefits may include:

- benefits from reduced emissions

As with user benefits, emissions benefits are monetized based on changes in travel characteristics (Trips, VMT, VHT, vehicle occupancy and loadings, etc), as well as guidance from regulatory agencies and a review of relevant literatures. It should be noted that the default monetization rates (discussed in *Data Sources and Default Values for Multimodal Transportation Studies)* include health effects from pollutants as well as green house gasses.

3.2 Accounting for Induced Travel[7]

All costs correspond to levels for a scenario. Benefits are estimated by differencing two scenarios (for example, *build* vs. *no-build*). As such, negative values reflect a detriment or adverse situation. For projects with no induced travel, the change in direct travel impacts between two scenarios can simply be calculated as the difference between two scenarios. However, for projects with induced travel, this "simple" difference must be adjusted to account for travelers' and shippers' economic response to travel cost changes.

A new piece of infrastructure or policy may reduce travel costs through any of the user cost types discussed above. Over time, firms and households recognize this lower price as an opportunity to decrease production costs or satisfy new trips. In both cases, the total number of trips (or miles traveled) may increase in the long-term. If direct impacts are calculated as the "simple" user cost difference between scenarios, then overall benefit might be underestimated because the new (induced) trips are tallied as having costs but no benefits. In reality, induced trips are made *precisely because they have value*, which outweighs the cost of making the trip. Figure 3-2 demonstrates graphically the standard economic interpretation of induced travel.

[6] For a further discussion, see FHWA's website on incorporating freight in benefit/cost analysis, which has some excellent technical and non-technical reviews: http://ops fhwa.dot.gov/freight/freight_analysis/cba/index.htm.
[7] For more information, see Brian Alstadt and Glen Weisbrod, "A generalized approach for assessing the direct user impacts of transport projects", Transportation *Research Record No. 2079,* National Academies Press, Washington D.C.

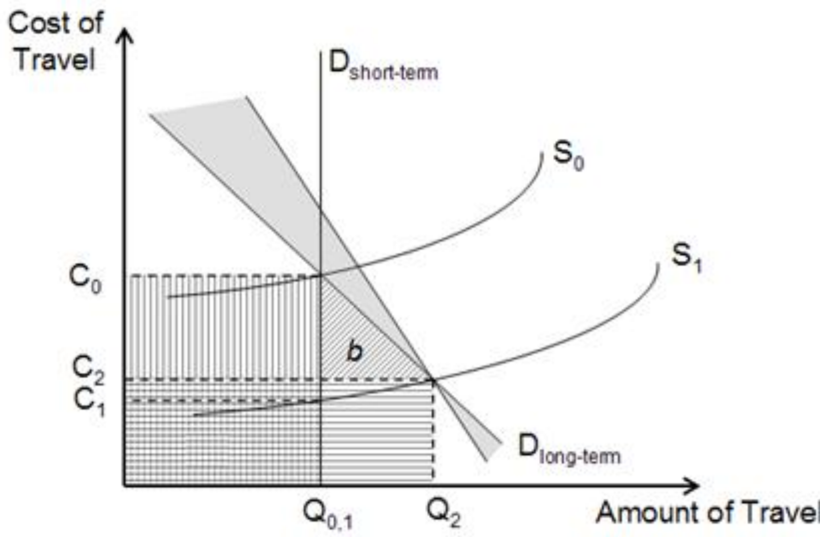

Figure 3-2: A Graphical Representation of Induced Travel

Over the short-term, travel demand has limited sensitivity to cost changes. (This differs by trip purpose.) The relative insensitivity is reflected by a nearly vertical (inelastic) short-term demand curve. Thus, following an investment that increases supply, travelers initially consume the same amount of travel ($Q_0 = Q_1$) and simply enjoy the lower costs. Over time, however, households and firms decide to purchase or pay for more travel, which may again increase the unit cost of travel (from C_1 to C_2) due to congestion. This is reflected in a long-term demand curve that has pivoted or shifted (or both, as indicated by the grey shaded line), such that it crosses the new supply curve at a lower cost (C_2) but higher travel volume (Q_2). The short-term benefit is shown as area *a*, and the induced benefit as area *b*; together, they comprise the net increase in consumer and/or producer surplus from the change in supply.

The TREDIS Benefit Cost module accounts for induced travel based on the theory shown in Figure 3-2. If S_0 and S_1 reflect the respective supply curves for *no-build* and *build* scenarios, then area *b* is the induced benefit – the increase in consumer surplus accruing to induced travelers. Note that the benefit to the existing pool of travelers (to the left of $Q_{0,1}$) are already accounted for in TREDIS.

To estimate the induced benefit, total travel volume is calculated and reconciled across all modes. This step is important because increases in demand for one mode may simply reflect a switch from another. If this occurs (and if both modes are included in the model), then including mode-shift as induced would be double-counting, because the benefits of mode-switching are already captured by the net changes in user costs across both modes (however, if only one of the modes is included, then the induced benefit may be used to proxy the consumer surplus gain in the mode switch). TREDIS measures the quantity of travel consumed (*Q*) as either *passenger*trips* or *ton*trips*, depending on whether the mode is passenger-focused or freight-focused. Note that these measures normalize demand among all competing modes, and the benefits of more trips and increased ridership are captured. In the following equations, indexes are *s* = scenario, *t* = travel period, *m* = travel mode, *p* = trip purpose.

$$PassVol_{mp}^{st} = \left(VehicleTrips_{mp}^{st}\right)\left(PassPerVeh_{mp}^{st}\right) \quad (1a)$$

$$FreightVol_{mp}^{st} = \left(VehicleTrips_{mp}^{st}\right)\left(TonsPerVeh_{mp}^{st}\right) \quad (1b)$$

These measures of travel volume are calculated for each of the two scenarios and differences are generated for each mode/trip purpose combination. For any instances where total volume increases, the modeler then determines the fraction of increased volume that resulted from mode switching, and enters that value in the appropriate input table. Any remaining increase (not captured by mode shifting) is assumed to be induced, as shown in the following equation, where *Q* may be either of the measures (1a) or (1b):

$$InducedQ_{mp}^{t} = \left(Q_{mp}^{build,t} - Q_{mp}^{no-build,t}\right)\left(1 - ModeShift_{mp}^{t}\right). \quad (2)$$

In practice, equation (1a) is used for all passenger-focused modes, and equation (1b) is used for freight-focused modes. Unit travel costs for each scenario are calculated as

$$C_{mp}^{st} = \frac{UserCost_{mp}^{st}}{Q_{mp}^{st}}, \quad (3)$$

The induced benefit (area *b*) is therefore calculated as

$$InducedBenefit_{mp}^{t} = \tfrac{1}{2}\, InducedQ_{mp}^{t}\left(C_{mp}^{base,t} - C_{mp}^{alternative,t}\right). \quad (4)$$

3.3 Productivity from Market Access Improvements

Thus far, direct user impacts (including shipper/receiver logistics benefits), direct non-user impacts, and induced benefits have all been accounted for. The next step is to incorporate the results of the Market Access module, which estimates the economic consequences of improved access to consumer, producer, and labor markets.

The Market Access module uses cross-sectional regression analysis to estimate how a range of accessibility factors (covering a variety of modes and markets) affects a study area's industry production (after controlling for other factors). In particular, it estimates three types of impacts:

- Increased *production* from business migration. Accessibility is one factor in spatial competition, so that all else equal, greater accessibility will attract more business. This impact is not incorporated into benefit/cost analysis, because the transferred activity does not yield any net welfare gain at the national level.
- Increased worker *productivity*. Accessibility feeds agglomeration economies by means of input sharing, input matching, and knowledge spillovers. These mechanisms can create value in a region that is additional to user benefits. As such, productivity benefits are included in benefit/cost analysis.
- Increased international *exports*. Improved access to international gateways can stimulate export activity. Increased exports are not included in benefit/cost analysis.

The theoretical foundations of agglomeration and productivity have expanded greatly over the past few decades.[8] This body of academic work has continued to formalize the intuitive notion that proximity is a self-reinforcing element of economic growth (otherwise why have cities in the first place?). More recent work has built upon these theoretical foundations to incorporate agglomeration into transportation analysis and decision-making[9]. Our model relating accessibility and productivity draws from this empirical body of work[10].

3.4 Regional Income Growth

The Benefit-Cost module derives economic development impacts (the far right column in Table 2-1) from the Economic Adjustment module (see separate technical documentation. That module links to a regional economic module to translate direct economic impacts into total regional economic impacts, including indirect and induced growth. This is important for the benefit/cost module because economic development impacts are known to exclude several benefit measures also included in Table 2-1. In practice, the process of translating direct travel impacts (as calculated by the Travel Cost module) into total economic impacts is performed completely within the TREDIS Economic Adjustment module. This is for several reasons. First, direct travel cost savings must first be translated into direct *economic* impacts before total regional growth can be estimated. *In other words, direct economic impacts are <u>not</u> equivalent to direct travel cost savings*. Second, if the analysis includes economic development impacts from both market access improvements and indirect and induced growth from improved travel operations, then the two economic growth measures must be reconciled to avoid double-counting.

Due to these complexities, the regional income growth value passed from the Economic Adjustment module to the Benefit Cost module reflects the present value of *total* regional income growth, and therefore already includes select user benefits and productivity gains as shown earlier in Table 2-1. *However, economic impacts from construction and operations & maintenance spending are explicitly excluded from the economic development impacts used in the Benefit Cost module.*

The measure of regional income growth is "value added." This is defined as the value of business output minus the cost of materials used. That value represents the sum of worker wages and retained business income (which may be reinvested in the business or taken as investment income by business owners).

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[8] Rosenthal, S. and W. Strange (2003), provide an excellent nontechnical discussion of the nature and sources of agglomeration economies. Online at http://www.core.ucl.ac.be/staff/thisseHandbook/rosenthal%3Astrange.pdf

[9] A good example is the United Kingdom's Department for Transport project "Wider Economic Benefits of Transport Improvements – Links Between City Size and Productivity" (Online at http://www.dft.gov.uk/rmd/project.asp?intProjectID=11775).

[10] Our model's implied elasticities are generally in line with previous work, although direct comparisons are generally difficult for reasons discussed by Melo, P., Graham, D., and Noland, R. (2007) "A Meta-Analysis of Estimates of Urban Agglomeration Economies", *Regional Science and Urban Economics*, Vol. 39 (3), pp. 332-342.

3.5 Phase-In of Project Costs

The final step to estimating benefit/cost results is to discount costs and benefits over time. This is done in several steps. First, project costs and phase-in information are gathered from appropriate user input tables. These are used to estimate the present value of costs, after estimating any residual value of constructed facilities. Next, benefits are phased in over time, and the present value of the benefit stream is estimated. Finally, present values of benefits and costs are compared.

Startup Costs. TREDIS project startup costs relate to the initialization, design, and construction of transportation facilities. These are itemized by mode (road, rail, air, marine) and cost type:

- *Property Acquisition* – for example, right-of-way purchases or easements
- *Engineering and Design* – these are the soft costs of construction, including planning, analysis, legal, architectural, engineering, and design work.
- *Right-of-Way (paving, rails)* – these costs involve earthmoving, grading, drainage, and paving. For railroads, this includes all expenditures on the laying of rails; for airports, this includes runway construction.
- *Transport Structures (bridges)* – this category includes road bridges and flyovers, railroad bridges, and marine docks
- *Terminal Buildings and Equipment* – for example, operations offices, maintenance facilities, airport terminals, or storage buildings
- *Vehicles* – for example, rail cars and engines, ferries, airplanes, barges, or maintenance or service vehicles

Note that while not all of these cost types generate economic impacts, they are all included in project costs for benefit/cost analysis. Furthermore, startup costs are entered on a scenario-by-scenario basis, and project costs are based on differences (build vs. no-build). Therefore, if any costs are included in the no-build scenario (possibly some sunk costs), only differences are included in the benefit cost analysis.

Startup costs are phased in based on the phase-in detail table on the project page (see separate *TREDIS User's Manual* for more information). This may be customized on a year-by-year basis, but the default allocation is constant spending for the entire construction period. Therefore, if the construction start year is set to 2010 and the construction end year is set to 2013, the default TREDIS assumption is to assign 25% of net startup construction costs to each construction year (including the start and end years).

Ongoing Life Cycle Costs. A second type of cost relates to the operations and maintenance (O&M) of transportation facilities over its useful life. These are also itemized by mode and cost type:

- *Ongoing Operations* – for example, transit service operation, highway toll collection, systems operation, or incident management
- *Maintenance & Rehabilitation* – for example, crack repair, repaving, or vegetation control; also includes vehicle servicing.

O&M costs are entered as annual expenditures, and these are assumed to begin in the year of project completion (operation period start year) and continue through the time period of analysis (to the operation period end year).

Residual Value. For each of the startup construction categories available in TREDIS, the Useful Life Inputs table (under the Fixed Factors menu on the Project page – see separate *User's Manual*) is used to indicate its service life. This indicates how long the facility is expected to be in service before needing to be rebuilt, and are used by the Benefit Cost module to establish a residual value if the analysis period is shorter than the facility's expected life. For example, for the project described above, any facility with a useful life longer than 20 years will generate a residual value on the benefit/cost analysis report page.

Residual value is calculated based on the remaining dollar value after the transportation facility is depreciated over the operations period (using a straight-line depreciation method). As an example, assume the project described above constructs a $70 million terminal building. The default useful life for facilities of this type is 40 years. Therefore, after the 20 year operations period, using straight-line depreciation, the building has a residual value of 50%, or $35 million. For each project, this calculation is made across all facility types and modes to determine a single net residual value. This is included as a negative (dis-) cost in the operation period end year when calculating the present value of costs.

Cost Phase-in Example. To bring the three concepts of startup costs, O&M costs, and residual value together, consider a project with the following variables:

- Net startup construction costs = $100m (entire construction period)
- Net O&M costs = $1m per year
- Construction Period Start Year = 2010
- Construction Period End Year = 2013
- Operation Period Start Year = 2013
- Operation Period End Year = 2030

Using the default phase-in and residual value assumptions, the TREDIS Benefit Cost Module will generate the following *undiscounted* cost schedule (all dollars in $millions)

Table 3-1: Example of TREDIS Cost Phase-In

Year	Startup Costs ($m)	O&M Costs ($m)	Residual Value ($m)	Total Costs ($m)
2010	25	0	0	25
2011	25	0	0	25
2012	25	0	0	25
2013	25	1	0	26
2014	0	1	0	1
2015	0	1	0	1
2016	0	1	0	1

2017	0	1	0	1
2018	0	1	0	1
2019	0	1	0	1
2020	0	1	0	1
2021	0	1	0	1
2022	0	1	0	1
2023	0	1	0	1
2024	0	1	0	1
2025	0	1	0	1
2026	0	1	0	1
2027	0	1	0	1
2028	0	1	0	1
2029	0	1	0	1
2030	0	1	-35	-34

3.6 Phase-In of Project Benefits

Chapter Two of this Technical Document identified a number of categories of benefits that can result from a transportation investment. From the standpoint of how these phase in, these may be reduced to just three:

- *Operational Benefits* – including time and vehicle operation cost savings, shipper/receiver logistical benefits, accident reduction, environmental benefits, and increased consumer surplus from induced travel.
- *Productivity Benefits* – from increased access to markets, measured as increased output per worker (labor productivity).
- *Economic Development Impacts* – including income generation from direct, indirect, and induced impacts of operational benefits and business attraction (but not construction spending). Measured as net increase in value added (GRP).

Each of these types of impact streams is phased in differently. Operational benefits are phased in according to the Phase-In Detail input table on the project page (see separate *User's Manual* for information on how default values are estimated). Market access productivity impacts are phased in based on time-series research on how these benefits unfold for different types of economies (see separate documentation of the Market Access module[11] for more information). Economic development impacts are phased in based on the phase in of the underlying direct impacts, incorporating any lag effects (see separate technical documentation on the Economic Adjustment module for more information).

A hypothetical example of undiscounted benefits streams is shown below:

[11] Or see "Economic Impact Study of Completing the Appalachian Development Highway System", Report by Cambridge Systematics, Economic Development Research Group, and HDR Decision Economics, June 2008 (http://www.arc.gov/research/researchreportdetails.asp?REPORT_ID=69)

Table 3-2: Example of TREDIS Benefit and Impact Phase-In

Year	Travel-Related Benefits ($m)	Productivity Benefits ($m)	Economic Development Impacts ($m)
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	17.01	0.04	17.88
2014	17.24	0.08	18.18
2015	17.49	0.18	18.53
2016	17.73	0.38	19.00
2017	17.98	0.77	19.67
2018	18.23	1.43	20.62
2019	18.49	2.30	21.81
2020	18.74	3.17	23.00
2021	19.01	3.83	23.96
2022	19.27	4.22	24.64
2023	19.54	4.42	25.14
2024	19.82	4.52	25.53
2025	20.09	4.56	25.87
2026	20.37	4.58	26.18
2027	20.66	4.59	26.49
2028	20.95	4.60	26.80
2029	21.24	4.60	27.11
2030	21.54	4.60	27.42

3.7 Discounting Cost and Benefit Streams

The final step before reporting benefit/cost results is calculating the present value of all cost and benefit streams. This is done by applying a *discount rate* that represents today's value of the streams of costs and benefits that extend into the future. This effectively diminishes the value of more distant future benefits and costs. The discount rate is a user-provided value.

The value most frequently selected discount rate value is the "*opportunity cost of capital*" – i.e., the private sector cost of borrowing money over and above the rate of inflation. (The private sector borrowing cost is used because public sector borrowing competes against and hence displaces money available for private borrowing.) An alternative measure is the "*social discount rate*" -- a typically higher rate that accounts for society's value of investing for the long-term future. Most US states use a discount rate in the range of 5%, although the US government recommends using a social discount rate of 7%. FHWA's Economic Analysis Primer[12] provides the following advice about selecting a discount rate:

> As a rule of best practice, economic analysis should be done in real terms, i.e., using dollars and discount rates that do not include the effects of inflation. A real discount rate can be estimated by removing the rate of inflation (as measured by a general price index such as the CPI) from a market (or nominal) interest rate for government borrowing. The selected market rate for government borrowing should be based on government bonds with maturities comparable in length to the analysis period used for the economic analysis. Real discount rates calculated in this manner have historically ranged from 3 percent to 5 percent - the rates most often used by States for discounting highway investments. [...] Due to the importance of the discount rate, care should be taken to select one that reflects a State's actual time value of resources." [p. 13]

Calculating the Discount Factor. For each future year, a discount factor is applied to costs and benefits accruing in that year. The discount factor is specific to a future year *y* and the chosen discount rate *r*. In this equation, 2010 reflects the current year.

$$Discount\ Factor_y = 1/(1+r)^{(y-2010)}$$

Sample Calculation. Using the examples from the two preceding sections, the following table provides a sample calculation of applying a discount factor to cost and benefit streams. The discounted sums represent the present value of the cost and benefit streams.

Table 3-3: Sample Application of Discount Factor

	Undiscounted			Discounted	
Year	Total Costs	Travel Benefits	Discount Factor (r=5%)	Total Costs	Travel Benefits
2010	25	0	1.000	25.00	0
2011	25	0	0.952	23.81	0
2012	25	0	0.907	22.68	0
2013	26	17.01	0.864	22.46	14.69
2014	1	17.24	0.823	0.82	14.19
2015	1	17.49	0.784	0.78	13.70

[12] "Economic Analysis Primer", *Report by the Office of Asset Management*. FHWA (http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer.cfm)

2016	1	17.73	0.746	0.75	13.23
2017	1	17.98	0.711	0.71	12.78
2018	1	18.23	0.677	0.68	12.34
2019	1	18.49	0.645	0.64	11.92
2020	1	18.74	0.614	0.61	11.51
2021	1	19.01	0.585	0.58	11.11
2022	1	19.27	0.557	0.56	10.73
2023	1	19.54	0.530	0.53	10.36
2024	1	19.82	0.505	0.51	10.01
2025	1	20.09	0.481	0.48	9.66
2026	1	20.37	0.458	0.46	9.33
2027	1	20.66	0.436	0.44	9.01
2028	1	20.95	0.416	0.42	8.70
2029	1	21.24	0.396	0.40	8.41
2030	-34	21.54	0.377	-12.81	8.12
Totals	**83**	**345.39**		**90.49**	**199.80**

Benefit Cost Metrics. Finally, the present value of cost and benefit streams can be used to calculate final metrics. TREDIS presents two:

- *Net Present Value (NPV)* – for the benefit or impact concept in question, the net present value reflects the present value of benefits (or impacts) minus costs. For example, in Table 3-3, the net present value of travel benefits is 109.31.
- *Benefit Cost Ratio (BCR)* – for the benefit or impact concept in question, the benefit cost ratio reflects the ratio of present value of benefits vs. costs. Following the example in Table 3-3, the BCR of travel benefits is 2.21.

4 Benefit Cost Module Results

The results of the TREDIS Benefit Cost module are presented as an array of tables based on the framework outlined in this document. Where relevant, benefits and costs are shown separately by mode or trip purpose.

Table 4-1 shows the present value of project benefits. Note that benefit measures generally increase in breadth and inclusiveness from left to right. For benefit categories (A) through (C), benefits are itemized by mode and trip purpose. Benefit categories (D) and (E) are shown as totals only.

Table 4-1: "Present Value of Benefits" Results Table

Present Value of Benefit Stream ($m 2008 Const dollars)								
	(A) Traveler Benefits ($)		(B) Traveler Benefits (non-$)			(C) Shipper/ Logistics Benefit ($)	(D) Market Access Productivity ($)	(E) Social/ Environ. (non-$)
Mode	Vehicle Operating Costs	Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus			
Pass Car - OTC	10.8	217.7	0	0.9	0.1	0	--	--
Pass Car - Commute	46.2	445.4	445.4	1.6	0.6	0	--	--
Pass Car - Pers/Rec	23.1	0	399.4	0.4	0.4	0	--	--
Truck - Freight	36	265.4	0	2.7	0	195.3	--	--
Project Totals	**116.1**	**928.5**	**844.9**	**5.6**	**1.1**	**195.3**	**75.9**	**5.7**

Table 4-2 shows the project's present value of costs by cost category. Recall that startup and O&M costs are calculated as differences between build vs. no-build scenarios.

Table 4-2: "Present Value of Costs" Results Table

Present Value of Cost Stream ($m 2008 Const dollars)				
Facility Type	Startup Costs	Annual O&M Costs	Residual Value	Net Total Costs
Road	679.5	1.2	54.5	626.1
Rail	0	0	0	0
Air	0	0	0	0
Marine	0	0	0	0
Total for All Facilities	**679.5**	**1.2**	**54.5**	**626.1**

Table 4-3 provides "standard" benefit cost metrics for three different categorizations of benefits. "Traveler Benefit" is the narrowest, including traveler benefits, but excluding shipper/receiver logistical benefits and market externalities. "Full User Benefit" adds freight shippers and receivers as a broader definition of transport "user". Finally, "Total Societal Benefit" is the broadest measure of travel-related benefits, including all traveler benefits, plus "external" benefits to the broader society.

Table 4-3: "Travel Efficiency" Benefit Cost Results Table

Efficiency Measures ($m 2008 Const dollars)					
Benefit Measure	Benefit Definition	Present Value of Benefit Stream	Present Value of Cost Stream	Net Present Value (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	**A+B**	1,896	626	1,270	3.03
Full User Benefit	**A+B+C**	2,092	626	1,466	3.34
Total Societal Benefit	**A+B+C+D+E**	2,173	626	1,547	3.47

Finally, Table 4-4 displays how broader impacts compare to project costs. In the top row, the narrowest measure compares the increase in gross regional product (GRP) to project costs. The next row adds category (B) from Table 4-1, the value of personal travel time (that does not generate any regional income). Lastly, environmental benefits are added in the bottom row to show the broadest possible measure of regional impact compared to project costs.

Table 4-4: "Wider" Impacts vs. Costs Results Table

Wider Measures ($m 2008 Const dollars)					
Impact Measure	Impact Definition	Present Value of Impact Stream	Present Value of Cost Stream	Net Present Value (Impacts - Costs)	Impact/Cost Ratio
Add'l Gross Regional Product	**GRP**	1,628	626	1002	2.60
GRP plus Traveler non-$ Benefit	**GRP+B**	2,480	626	1,854	3.96
GRP plus Total non-$ Benefit	**GRP+B+E**	2,485	626	1,859	3.97

.

Appendix A: Glossary

Acronym or Expression	Stands for:	Definition
Case	*TREDIS term*	A comparison of two selected Scenarios
FAF	Freight analysis framework	
FF	Free-flow	
GRP	Gross Regional Product	
LEAP	Local Economic Assessment Package	Software package used to model market access impacts and comparative growth
Linked Area	*TREDIS term*	external region(s) that are directly connected to, but are not within the study regions
NAICS	North American Industry Classification System	
NPV	Net present value	
Period	*TREDIS term*	A time period specified at the Project level, defined solely by its travel demand characteristics; multiple periods may be used to model differences in peak vs. off-peak, or seasonal differences resulting from road closures
Project	*TREDIS term*	[Always capitalized] the major unit of a TREDIS analysis defined by certain parameters being held constant. It has the following features: (1) the geography (Region) is constant over the entire analysis, (2) all Scenarios within the Project have the same time horizon (that is, the same Construction Period and Operation Period, as well as the same Analysis Year), and (3) certain parameters, such as the discount rate, are "fixed" across Scenarios when they are being compared.
Region	*TREDIS term*	Region being studied, defined by selecting the county or counties where the Build Scenario would take place
Report	*TREDIS term*	Results of a TREDIS analysis presented in a table or series of tables
Scenario	*TREDIS term*	Within a TREDIS Project, alternatives such as Base (no-build) and Project (build) Scenarios that may be compared
SCTG	Standard Classification of Transported Goods	
STCC	Standard Transportation Commodity Code	
TREDIS	Transportation Economic Development System	
VA	Value added	
VHT	Vehicle hours traveled	
VMT	Vehicle miles traveled	

TREDIS

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Ohio River Bridges, TIGER II Application
Benefit Cost Analysis: Appendix III – Travel Demand Assumptions

I. INTRODUCTION

This **Appendix** is offered in support of the TIGER II grant application for funding in support of the Ohio River Bridges in Louisville, KY. The benefit-cost analysis of the project assumes that $135 Million of TIGER funding will be leveraged to support a larger $3.1 Billion bridges project. For the purposes of the TIGER II application, the "TIGER share" of the larger project's economic benefit is claimed to be commensurate with the $135 Million share of the larger $3.1 Billion investment (or 4.34%). The travel demand assumptions for the application are based on the 2003 environmental documentation (Section 5) provided for the larger $3.1 Billion project, then assuming that only 4.34% of the VMT and VHT savings (and associated transportation efficiencies) can be directly divisible by the $135 Million requested in TIGER funding.

For this reason, the VMT and VHT inputs to the benefit cost analysis are derived first from the VMT and VHT savings found in the 2003 environmental document, with the "TIGER Share" reported as a percentage of this calculation. The 2025 environmental document represents the most current available forecast of VMT and VHT changes expected to occur due to the project, therefore for the benefit cost analysis, the 2025 VMT and VHT levels are interpolated to 2016 (the first year of operation of the project) and extrapolated to 2056 (the last year of the benefit-cost analysis model) using the annual traffic growth rate of 1.1% (based on VMT annualized growth in the Louisville are MPO model). This **Appendix** explains how the magnitude of this travel time and cost savings is estimated for the benefit-cost analysis based on available modeling and data.

II. OBJECTIVE AND SCOPE

The scope of this **Appendix** includes a clear explanation of how regional vehicle miles travelled (VMT) and vehicle hours travelled (VHT) savings are derived in a comparison of model results and traffic analysis of year 2025 travel demand and transportation system performance with and without the transportation improvements covered in the TIGER II application for the Ohio River Bridges.

The specific objectives of the report are:

(1) Describe the different model and traffic analysis results conducted in support of the benefit cost analysis for the project

(2) Describe how these results were synthesized and adjusted into a conservative estimate of VMT and VHT savings associated with the project in a manner that could be replicated starting with the same assumptions, and scaled to the share of the overall project cost covered by $135 Million in TIGER funding. (**While the general result is expected to be replicable from the starting inputs and assumptions in this appendix, it is understood that the benefit-cost modeling software calculates levels of decimal precision not reported here, hence some results may differ somewhat due to rounding and may not match precisely calculations done by hand**).

III. METHODOLOGY

A. OVERVIEW OF METHODOLOGY

The estimation of VMT and VHT savings associated with implementation of the project in this TIGER II application involves the synthesis of three key elements. These elements are:

(1) Findings from 2003 environmental documentation (Section 5, Table 5.2.4) showing the overall anticipated VMT and VHT savings associated with the preferred alternative bridge project (described in the environmental document as "Two Bridges/Highway, Far East C-1/C-3".

(2) Assumptions from the 2030 KIPDA MPO regional model with regard to overall shares of trip purposes, and the internal, external and external to internal or internal to external shares of trips, and assumptions from federal highway statistics pertaining to the percent trucks by functional classification.

B. 2003 VMT AND VHT ASSUMPTIONS FROM THE ENVIRONMENTAL DOCUMENT

Section 5 of the 2003 environmental document for the Ohio River Bridges, in Table 5.2.4 shows the VMT and VHT savings associated with implementation of the overall $3.1 Billion Ohio River Bridges project. The document reports that without the project, the regional average annual daily VMT and VHT are likely to be:

31,731,000 VMT
923,000 VHT

And if the project is completed the results are likely to be:

31,542,000 VMT
872,000 VHT

Showing the project to yield an average annual daily VMT and VHT savings of:

189,000 VMT
51,000 VHT

When expanded to a total annual VMT and VHT (average annual weekday *260), the following total annual VMT and VHT savings in 2025 are expected:

49,140,000 VMT
13,260,000 VHT

These savings form the basis for travel demand assumptions in the benefit-cost analysis.

C. TRIP PURPOSES

For the purposes of benefit-cost analysis, the VMT and VHT savings reported above are allocated to trip purposes to support application of per-vehicle, per-hour and per-mile cost factors as given in **Appendix IV.**

Percent Trucks

Of the overall VMT and VHT, the percent trucks are estimated based on the VMT and VHT occurring on different national functional classifications from the 2030 forecast resulting from the latest validation of the KIPDA model. A truck percentage of VMT for each functional classification is used (based on 2008 Federal Highway Statistics) to arrive at an approximation of the truck-share of VMT for each functional classification. The percent trucks used in the B/C analysis represents the overall model-wide percent trucks suggested by the federal percentages applied to the VMT by functional class suggested in the validation of the KIPDA model. According to the 2030 forecast from the KIPDA MPO, the following breakdown of VMT by functional classifications is expected on the overall KIPDA network (per the latest validation of the KIPDA model):

TABLE BC III-I: DERIVATION OF PERCENT TRUCKS FRO KIPDA VMT BY FUNCTIONAL CLASSIFCIATION AND FEDERAL HIGHWAY STATISTICS

HPMS Functional Classes	Model Validation VMT	Model Validation VHT	Truck % of VMT (Federal Statistics)	Estimated Truck VMT Assumption
FC 1 Rural Interstate	4,716,995	105,989	19.5%	921,756
FC 2 Rural Principal Arterial	208,334	5,321	10.4%	21,749
FC 6 Rural Minor Arterial	1,570,888	45,415	10.4%	163,989
FC 7 Rural Major Collector	2,308,715	59,768	7.9%	181,416
FC 8 Rural Minor Collector	796,895	23,944	7.9%	62,619
FC 9 Rural Local Access	122,898	4,436	7.9%	9,657
FC 11 Urban Interstate	12,179,493	309,302	8.5%	1,032,243
FC 12 Urban OFE	744,048	15,330	8.5%	63,060
FC 14 Urban Other Principal Arterial	5,693,601	183,969	8.5%	482,547
FC 16 Urban Minor Arterial	5,653,654	177,051	4.7%	267,101
FC 17 Urban Collector	2,513,995	78,246	4.7%	118,771
FC 19 Urban Local	701,670	22,470	4.7%	33,150
Rural Ramps	183,177	5,456	19.5%	35,795
Urban Ramps	1,469,087	40,685	8.5%	124,509
Model-Wide	**37,211,185**	**1,031,239**	**9.1%**	**3,518,360**

The above analysis yields a 9.1% trucks as a share of overall traffic savings assumed in the benefit cost analysis.
When this share is applied to the VMT and VHT totals reported in the previous section, the VMT and VHT savings of the project are estimated to be:

4,448,710 VMT for trucks and 44,691,290VMT for passenger cars and
1,200,446 VHT for trucks and 12,059,554 VHT for passenger cars

The VMT and VHT savings estimates reported in this table are found in the row corresponding with the forecast year (2025) in **Table BC-IV of the benefit-cost write up**, as well as in 2025 **Appendixes I-A - FULL** and **I-D - FULL** of the Benefit-Cost Analysis.

With the TIGER share of the project assumed to be only 4.34% of this overall savings, the amounts for 2025 in **Table BC-III** of the benefit-cost write up, as well as in 2025 in **Appendixes I-A** and **I-D** are:

193,049 VMT for trucks and 1,939,352 VMT for passenger cars and
52,093 VHT for trucks and 523,317 for passenger cars

To further control for any possible over-statement of regional benefits, **Appendix I-A** (and **Appendix I-A FULL**) show that no benefits accrue until 2014 (when the first phase of the project is expected to be operational).

Purposes for Passenger Car Trips

For the purposes of benefit cost analysis, the passenger car VMT and VHT are allocated into the purposes of:

- ON the Clock (travel that is paid by business)
- Commuting (travel to and from work) and
- Personal/Recreational (all other travel)

Based on the trip purposes and average trip lengths (in miles, by purpose) in the KIPDA model, the following assumptions are made regarding the share of passenger car trips by purpose:

- 7.2% On the Clock (assumed to be 10% of non-work trips in the KIPDA model)
- 27.9% Commuting (reported as work trips in the KIPDA model)
- 64.9% Personal/Recreational (assumed to be all other trip in the KIPDA model)

The truck percentage and the above break-down of passenger car trip purpose percentages as shown above account for how VMT and VHT and their associated savings are allocated to trip purposes in the benefit cost analysis.

Occupancy and Load Factors

For the purposes of benefit cost analysis, each of the trip purposes is assumed to have its own vehicle occupancy rate, and trucks are assumed to have an average number of tons per truck.

To derive vehicle occupancy factors, average occupancy factors in the MPO model for work trips (1.09) is assumed to apply to the commuting and "on the clock" purposes, and a weighted average occupancy factor for other purposes (weighted by the number of trips by purpose) is assumed for the overall personal/recreational purpose, yielding a personal/recreational occupancy rate of 1.47 persons per vehicle.

A truck loading factor of 17.5 tons per truck is based on the USDOT comprehensive size and weight study.

Further documentation of how various cost factors are applied to the VMT and VHT derived in this appendix are described in **Appendix IV**.

TREDIS® Transportation Economic Development Impact System

TREDIS® Data Sources and Default Values

Version 3.6.3

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Data Sources and Default Values for Multimodal Transportation Studies

TREDIS comes pre-loaded with an extensive database of information on current characteristics of your study area(s) and modes. This includes:

Economy - baseline measures

- mix of employment, wages, value added (GDP), and income, by industry
- domestic and international import, export and internal shipments, by commodity
- indicators of relative cost of doing business - labor, electricity, land/building values
- forecast (year-to-year change in employment and income by industry (option from Moody's Economy.com)

Market Access and Connectivity - baseline measures

- scale of labor and retail markets (population within 40 minute travel time)
- scale of same day truck delivery market (employment within 3-hour travel time)
- average road access time to commercial airports with scheduled domestic air service
- average road access time to commercial marine ports with scheduled freight service
- average road access time to public intermodal rail terminal
- average road access time to major international gateway airport

Unit Values - may be split by mode and/or trip purpose

- Unit value of passenger time savings (per traveler by mode)
- Unit value of vehicle operating cost savings (avg. per vehicle-mile or vehicle-hr)
- Unit value of cargo time savings (per ton, by mode and commodity class)
- Unit value of crash reduction (by type: mortality, injury, property damage)
- Unit value of emissions reduction (user supplied or average per vehicle-mile)
- Reliability Factors (congestion rating factor, logistics cost factor)
- Business Productivity (effective density/agglomeration scale factors)

USER INPUTS - All that is needed to run TREDIS is a scenario that represents some ***change*** in travel characteristics, defined in terms of at least one of the following items

Available Modes - sub-modes may be defined as desired (examples in parentheses)

- Cars (may split by trip purpose: work, commute or personal):
- Trucks (may split delivery vans, light trucks, heavy trucks, multiple trailer, etc.)

- Transit (may split by trip purpose or sub-mode: van, regular bus, BRT, light rail, etc.)
- Rail (may split freight, commuter rail, inter-city passenger, high speed rail, etc.)
- Marine (may split passenger ferry, car ferry, barge, freighter, cruise ship, etc.)
- Air (may split general aviation, air taxi/charter, freight, prop, regional jets, full size commercial airliners, jumbo jets, etc.),

Modal Characteristics - (change) for each available mode:

- Avg. Vehicle occupancy (passengers)
- Avg. Driver/crew size (commercial services)
- Avg. Cargo carried (tons)
- Avg. fare, toll, road user fee or freight fee
- Cargo mix (default or user-selected commodity mix)
- Operating costs/mile (or per km)
- Fuel economy (miles/gallon or per liter)
- Emission rates (various pollutants and CO, per mile or per km)

Traffic Characteristics - (change) may be split by mode, vehicle class, trip purpose, time period:

- Volume, speed or average trip distance
- Baseline traffic growth rate (annual rate)
- VMT vehicle miles traveled (or VKT vehicle kilometers traveled)
- VHT vehicle hours traveled
- Congestion levels (volume/capacity ratio, or percent of major routes congested)
- Reliability (time variability or buffer time)
- Safety (accident rates: mortality, injury, property damage)
- Induced travel

Origin/Destination Patterns - may be split by mode, vehicle class, trip purpose, time period:

- Fraction of trips internal to study area (local origin and destination)
- Fraction of trips with coming into the study area (outside origin, local destination)
- Fraction of trips leaving the study area (local origin, outside destination)
- Fraction of trips passing through the study area (outside origin and destination)

Access Characteristics (change) - for each county in the study area:

- Size of labor and shopper markets (population within 40 minute travel time)
- Size of same day truck delivery market (employment within 3-hour travel time)
- Average road access time to commercial airports (and activity scale of the airport)
- Average road access time to marine port
- Average road access time to an intermodal rail terminal
- Average road access time to international gateway airport

Policy, Program or Project Attributes (change) - may be split by mode, vehicle class, time period:

- Regulation or Restrictions on Use of Facility or Equipment (e.g., truck lanes, carpool lanes, bridge weight limits, airport runway limits, port vessel size limits)
- Charges for Use of Facility or Equipment: Tolls, Taxes, Fees (per vehicle, per trip, per mile, or per fuel unit; for specific facilities or areas)
- Cost of Constructing or Reconstructing Facility & Purchasing Equipment (total, over time, by type)
- Cost of Operating Facility & Equipment (total, allocation over time, budget elements)
- Public/private partnership roles (finance, operation, revenue collection)
- Contingent development (dependent on transport access investment)

Why Default Values? TREDIS, as the first fully multi-modal analysis system, is designed to allow users maximum flexibility in defining characteristics of transport modes, their operating performance and valuation of operating cost and time delay factors. However, with that flexibility comes a responsibility to ensure that reasonable values are adopted to generate believable results. We also recognize that there is wide variation in the technical background and knowledge of analysts. Accordingly, we provide default values for fixed factors which represent generally accepted averages or typical values in the US, while also providing users with a full capability to override or replace any or all of those default values.

There are default values, and allowable ranges for analyst entry, for the following factors:

- Crew Time Cost ($/crewmember-hour)
- Passenger Time Cost ($/passenger-hour)
- Freight Time Cost ($/ton-hour)
- Buffer Time Cost ($/hr per vehicle trip)
- Average Crew Size
- Average Passenger Occupancy
- Average Freight Cargo (tons)
- Vehicle Mileage-based Operating ($/mile)
- Vehicle Time-based Operating Cost ($/hr.)
- Cost per Collision ($/occurrence)
- Cost per Personal Injury ($/occurrence)
- Cost per Fatality ($/occurrence)
- Accident Rates (occurrence/VMT)
- Environmental/Emissions Cost ($/mi)

When to Use or Override Default Values. Analysts may rely on the default values for fixed factors unless they have reason to override them. However, they should understand that it is fully appropriate to override the defaults when:

a) the study involves types of vehicles (and associated operating cost and capacity factors) that are different from the default average (e.g., transit system using mini-buses instead of standard buses; airport with general aviation rather than commercial aircraft); or

b) the study area has vehicle passenger occupancy rates and/or freight loads that are significantly different from the assumed defaults; or

c) the study is being done in Canada, using Canadian rather than US dollars; or

d) the study is being done in a state or province that has wage and income levels significantly different from the assumed national average, and the applicable government agency prefers to use values of time that reflect local wage rates; or

e) the sponsoring agency dictates that different assumptions to be used.

However, even when these situations apply, the new factors should remain within a reasonable range. Upper and lower bounds have been set to define the reasonable range based on: (a) the range of commonly available vehicle sizes and types, and (b) the range of operating cost and time valuation factors observed in published literature. Analysts are warned to be careful about using values outside of these ranges.

Interpreting Default Values for Economic Concepts. TREDIS, as the first system to show both benefit/cost analysis and economic impact analysis, has to carefully distinguish social benefits from business impacts for all modes. This affects the way that default values are expressed in the table that follows. This includes the following effects:

a) Values may appear higher than those used in some previous studies due to updating. While the system typically calculates benefits and impacts over a long time horizon (e.g., 25-30 years), all analysis is done in constant dollars. Currently, default values and ranges are expressed in constant 2007 or 2008 dollars, and findings on default values from earlier studies have been adjusted upward to reflect those constant year values. However, analysis in future years may be in 2009 or later dollars, requiring all defaults and ranges to be adjusted again.

b) Values are sometimes different for traveler benefit valuation and total economic impact. Different trip purposes are assigned to different benefit and impact classes. Time savings for personal travel is classified as a social benefit value that affects benefit/cost ratios but does not have any impact on the flow of income in the economy. Time savings for business travel is classified as a business operating cost change affecting both benefit/cost ratios and economic impacts. Time savings for commuting has elements of both of these classifications (a social benefit for affected households, but also an element of wage rate impact for businesses), as explained in the footnotes.

c) Some but not all values are increased by the role of fringe benefits in long-term impacts. Fringe benefits come into play in different ways for different trip classes. For economic impact studies, the valuation of business travel time is measured as the long-term business cost. While delay in the short-term may cause workers to put in more hours to complete deliveries, continued delays over a long-term period will require affected businesses to hire more workers to complete a given set of deliveries. Hence the need to add fringe benefit costs in the long-term business travel time value. Other classes of travel also have time valuations pegged to wage rates, but they do not lead to additional worker hiring so their values do not incorporate fringe benefits.

The table which follows shows default values for each factor, along with the normally acceptable range. These ranges were set on the basis of actual variation observed in vehicle sizes (affecting occupancy and operating costs) and the observed range of time valuation factors used in studies over the past decade. The table also denotes whether the various factors are normally used in (1) traditional benefit/cost studies focusing on traveler benefits and/or (2) economic impact analysis.

Economic Impact Modeling Factor	Default Value		Acceptable Range	Factor in traveler benefits	Factor in economic impacts
Crew Time Cost ($/hr per crew member) – the business cost of labor for professional drivers and paid crew (including cost of wages plus fringe benefits). <See note A>	Car: Truck: Bus: Rail-transit: Rail-freight: Aircraft: Ship:	$21.60 $25.02 $22.31 $30.84 $33.42 $77.84 $42.33	18 – 25 18 – 40 15 – 30 20 – 45 20 – 45 50 – 99 25 – 50	X X X X X X X	X X X X X X X
Average Crew Size (number) – including professional driver/ pilot and supporting paid crew. (This should be customized for the applicable location and type of vehicles.) <See note B>	Car: Truck: Bus: Rail-transit: Rail-freight: Aircraft: Ship:	0.0 1.2 1.0 2.0 2.0 4.7 (no default)	0 – 1 1 – 2 1 – 2 1 – 4 1 – 4 1 – 12 1 – 1,000	N.A.	N.A.
Passenger Time Cost ($/hr per occupant) – the business opportunity cost, or user valuation, of the average passenger's time. This is in addition to the passenger vehicle operating cost per hour. The same values apply for in-vehicle and out-of-vehicle time (except for transit OVTT = out-of-vehicle). <See note C>	<u>Ground Transport:</u> *(car-truck-bus-rail)* On-the-Clock: Commute *=user benefit* *+wage premium* Personal: *(transit OVTT* <u>Air Transport:</u> Business Commute Personal	 $27.50 $21.20 *$10.60* *$10.60* $10.60 *$21.20)* $40.10 $33.30 $33.30	 *( ) = public transit* 20 (10) – 40 16 (8) – 35 10 (5) – 16 *(10 – 16)* 25 – 50 20 – 40 20 – 40	 X X - X X X X X	 X X X -- -- X X --

Economic Impact Modeling Factor	Default Value	Acceptable Range	Factor in traveler benefits	Factor in economic impacts
Buffer Time Cost ($/hr) – the business opportunity cost, or user valuation, of lost scheduling time due to unreliable travel conditions (i.e., effect of "schedule padding"). <See note D>	<u>Passenger Modes:</u> *Same as above* <u>Truck Freight:</u> non-mfg goods $0.75 Non-dur. mfg: $2.25 Durable mfg.: $5.00	 0 - 2 0 - 5 0 - 15	 X X X	 X X X
Average Passenger Occupancy (number) – the total number of occupants excluding professional driver and supporting paid crew. (Note: in most cases, the car driver is counted as an occupant and not a crew member.) <See note E>	Car: 1.5 Truck: 0 Bus: 10.5 Rail-pass: 120 Rail-freight: 0 Aircraft: 105 Ship: (no default)	0 – 5 0 – 4 1 – 60 1 – 600 0 – 4 0 – 400 0 – 1,000	N.A.	N.A.
Freight Logistics Time Cost ($/hr. per ton) – business opportunity cost of freight delay, including shipper inventory, dock handling & consignee schedule disruption. <See note F>	<u>Truck & Air only</u> non-mfg goods: $0.75 Non-dur. mfg: $1.50 Durable mfg.: $2.50	 0 - 2 0 - 4 0 - 8	 -- -- --	 X X X
Average Freight Cargo (tons) – the total number of tons of freight per vehicle <See note G>	Truck: non-mfg: 1.0 Truck: mfg goods: 17.5 Rail-freight: 3,024 Aircraft: 4.6 Ship: 14,000	0 – 10 8 – 25 25 – 5,000 0 – 6 0 – 30,000	N.A.	N.A.
Vehicle Mileage-based Operating Cost: Free Flow ($/mile) – the average per-mile cost of vehicles' fuel, tires, maintenance, and depreciation for travel in free-flow conditions. <See note H>	Car: $ 0.58 Truck: $ 1.18 Bus: $ 1.45 Train: $ 8.21 Air: $16.45 Ship: $25.00	0.30 – 0.90 0.9 – 1.5 1 – 2 5 – 12 5 – 25 1 – 100	X X X X X X	X X X X X X

Economic Impact Modeling Factor	Default Value		Acceptable Range	Factor in traveler benefits	Factor in economic impacts
Vehicle Mileage-based Operating Cost: Congested ($/mile) – the per-mile costs of roadway vehicles operating under congested roadway conditions. <See note I>	Car: Truck: Bus:	$0.64 $1.46 $1.55	0.35 – 1.2 1.15 – 1.75 1 – 2	X X X	X X X
Vehicle Time-based Operating Cost: ($/hour) – the average per-hour cost of vehicles' fuel, tires, maintenance, and depreciation for travel. <See note J>	Air: Ship:	$3,650.00 $260.00	3,000 – 4,000 200 – 1,000	X X	X X
$ per Accident <See note K>	Cars and Trucks: Prop Damage Pers. Injury Fatality - *Econ cost* - *Social adder*	 $ 3,160 $ 83,520 $ 6,000,000 *$1,221,500* *$4,778,500*	 1,000 – 5,000 80,000 – 250,000 $ 2.6m – 8.5m	 X X X X	 X X X --
Accident Rates**:** All rates shown are per 100m Vehicle Miles Traveled <See note L>	Passenger Car /Truck: Prop Damage Pers. Injury Fatality Public Transit: Pers. Injury Fatality Air Travel: Pers. Injury Fatality	 206 /198 90 /12 1.5 /0.4 585 7.6 0.184 0.012	 100 – 300 50 – 150 0 – 5 400 – 800 0 – 20 0 – 1 0 – 1	 N.A.	 N.A.

Economic Impact Modeling Factor	Default Value	Acceptable Range	Factor in traveler benefits	Factor in economic impacts
Environmental Cost: Mileage-Based ($/vmt) — cost of air pollution and greenhouse gases per vehicle-mile of travel <See note M>	Car: $0.028 Truck: $0.05	0 – 1 0 – 1	X X	-- --

Notes:

A. **Crew wages** are drawn from the BLS National Compensation Survey (issued June 2007) for applicable transport occupations, with 40% added for fringe benefits (national average in those occupations). Values for truck drivers, bus drivers and train engineers are published BLS values for those occupations, plus fringe benefits. Values for aviation are based on weighted average of $34.11/hr. for flight attendants and $94.47/hr. for pilots, plus fringe. Values for marine (ferry or freighter) are based on weighted average of $13.11 for sailors and $30.04 for ship engineers, plus fringe. Source: http://www.bls.gov/ncs/ocs/sp/ncbl0910.pdf

B. **Default crew size** for all modes are drawn from typical values for New York City, San Francisco and Chicago, as reported in Chester, Mikhail, Institute of Transportation Studies, UC Berkeley, 2008.

C. **Values of time** shown here are generally consistent with methods for valuing *user travel time benefits* as followed by HERS and BCA.Net software, as well as CUTR and USDOT guidance. However, values have also been updated to reflect 2007 wage rates (average of all occupations, not just transport occupations), based on BLS wage data. Also, additional long-term business costs (beyond the user value of travel time) have been added in the form of fringe benefit costs for "on-the-clock travel" and wage premiums paid by employers for commuting in higher-cost congested areas. As a result, car/light truck "on-the-clock" travel time is calculated as a business cost valued at 100% of the national average wage rate plus 30% fringe. Both commuting and personal travel time are treated as a non-money user benefit with a value set at 50% of the wage rate (no fringe added). For economic impact analysis only, there is an additional allowance for the effect of higher commuting cost on employer cost in the form of a wage rate premium valued at another 50% of the wage rate per hour without fringe (per research by Zax et al.). For public transit, the wider range reflects possible variation in riding conditions, as noted by CUTR: "*Transit travel time should be valued at 25 ‑ 35 percent of prevailing wage under comfortable conditions (when sitting), but can be significantly higher for crowded transit vehicles (100% of wage rate) or for waiting under unpleasant conditions (up to175% of wage rate).*" For out-of-vehicle transit time, TREDIS uses 100% of the wage rate, but allows for a wider range of values.

D. **The costs of travel time variability** (non-recurring delay) is calculated using the concept of "buffer time", which is defined as the additional schedule time needed to ensure an on-time arrival 95% of the time (19 out of every 20 trips) versus the average travel time. For example, If a weekday commute normally (i.e., on average) takes 30 minutes to complete, but unplanned congestion causes 5% of trips (about 1 per month) to take 45 minutes, then the commuter must schedule 45 minutes for the trip on the average day to ensure an on-time arrival (even though it is likely to only to take 30 minutes). This trip therefore requires 15 minutes of "buffer time". For passenger travel, buffer time has been shown to be valued similarly to travel time unless a schedule constraint exists (see CUTR). For Freight Trucks, the value of buffer time can vary widely for carrier types and commodity, but is generally higher than passenger travel (relative to travel time). USDOT reports that the value of reliability can vary from 20% to 250% of "standard" delay (http://ops.fhwa.dot.gov/freight/documents/improve_econ.pdf).

E. **Typical passenger loadings** for all modes are drawn from typical values for New York City, San Francisco and Chicago, as reported in Chester, Mikhail, Institute of Transportation Studies, UC Berkeley, 2008.

F. **Freight logistics cost** is estimated on the basis of values assigned for recurring travel time delay from HEAT documentation, based on literature review and additional research by Cambridge Systematics and EDR Group. These logistics cost values, added to crew cost and vehicle operating cost, yield total freight costs per hour in line with TTI congestion studies.

G. **Typical Cargo loadings** for trucks come from the USDOT Comprehensive Truck Size and Weight Study; data for rail is from the Association of American Railroads www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf ; data for water transport is based on 1000 TEUs per ship at 14 tons per TEU from InfoMare and NY/NJ port; data for air transport from Bureau of Transportation Statistics.

H. **Vehicle operating cost per mile: for free flow conditions is defined for cars as an average** of small, medium and large cars and SUV; source AAA. Truck cost is based on FHWA Truck Size and Weight Study, with cost/mile ranging from $1.03 - $1.38 depending on speed.

I. **Vehicle operating cost per mile: for congested road conditions** is based on auto fuel consumption estimates from US EPA and truck fuel consumption estimates from Berwick and Farooq (2003), using an assumptions of stop-and-go travel conditions (as defined by US EPA at www.fueleconomy.gov and with a long-term (30-year) fuel cost of $4.00 per gallon.

J. **Per hour operating cost** is to be used for modes where vehicle operating cost is most easily measurable on a time-basis (air and marine). The operating cost/hour for water freight cost/mile ranges from $242/hour for 11,000 ton vessel to $491/hour for 265,000 ton vessel; default represents a 90,000 ton vessel. 2008. Airline costs are from www.airlines.org/economics/cost+of+delays/

K. **Accident costs** are derived from the following sources: total fatality cost including both money costs and social value of lost life (lifetime earnings) is from "Treatment of the Economic Value of a Statistical Life in Departmental Analysis – 2009 Annual Revision," USDOT, Memorandum to Modal Administrators, March 18, 2009. http://ostpxweb.dot.gov/policy/reports/VSL%20Guidance%20031809%20a.pdf Detailed values for injury and property damage are drawn from Blincoe, L. et al. (2002). *The Economic Cost of Motor Vehicle Crashes, 2000* (Table 2) and then updated from 2000 dollars to 2008 dollars by the CPI change (25%).

http://thedesignstate.com/wp-content/uploads/2009/04/economicimpact2000.pdf The difference between total fatality valuation and fatality cost is attributed to social valuation of lost life.

L. **Accident rates** are from Bureau of Transportation Statistics: http://www.bts.gov/publications/national_transportation_statistics/#chapter_2

M. **Environmental costs** per VMT can include a wide variety of air pollution, water pollution, noise pollution and land quality/use impacts. However, the default values shown here include only costs associated with air pollutants defined by the Clean Air Act (NOx - nitrogen oxides, SO_2 - sulfur dioxide, PM - particulate matter and VOC - volatile organic compounds) plus greenhouse gases.

N. For the Clean Air Act pollutants, the total cost per VMT is estimated to be 1.1c for cars and 3.9c for large trucks (source: FHWA: *1997 Federal Highway Cost Allocation Study Final Report Addendum*, Federal Highway Administration, USDOT, 2000, Table 12. For greenhouse gases, the total cost per VMT is estimated to be 1.7c for cars and 2.4c for trucks based on Littman (Todd Littman: "Climate Change Emission Valuation for Transportation Economic Analysis," VTPI, 2009 and drawing from *Transportation Energy Data Book*, Oak Ridge National Laboratory, 2008). Also shown in Table 5.10.7-2 of Littman: Transportation Cost and Benefit Analysis II – Air Pollution Costs, Victoria Transport Policy Institute, updated 2009. Note that there are also some studies that have derived values based on changing market values for emission credits; these sources have been used to derive estimates as high as 5c per VMT for cars and 26c/vmt for trucks.

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