Appendix B

I-73 Economic Modeling White Paper

1 Purpose, Methodology, and Assumptions

Interstate 73 (I-73) is a proposed limited-access interstate project that will transverse the Pee Dee Region of South Carolina, and is defined and analyzed as two separate segments:

1. I-73 North from future-developed I-74 in North Carolina, southeast to I-95; and,
2. I-73 South from I-95/I-73 North, southeast toward Myrtle Beach.

CDM Smith is tasked with reevaluating the potential economic impacts stemming from the proposed I-73 development via a travel efficiency-related perspective, using currently-available travel demand modeling and economic impact analysis data and techniques. An economic analysis is conducted herein similarly, albeit not identically, to the previous EIS analysis in 2005, with differences delineated in Section 2.4, below.

In general, the process of determining economic impacts via a travel efficiency-related perspective from a roadway development entails three overarching steps: 1) travel demand modeling; 2) monetizing travel efficiency benefits from the travel demand data; and, 3) translating monetized benefits (as applicable) into standard economic impact metrics.

1.1 Travel Demand Modeling

As the proposed I-73 improvements would affect the border regions between South and North Carolina, a bi-state travel demand model (TDM) was developed specifically for this project. A geographically-appropriate TDM was developed by stitching together the South Carolina Statewide Model and the North Carolina Statewide Model via TransCAD.

The bi-state TDM was separately run for each of the South and North segments, for years 2010 and 2040, and for both the I-73 build and existing-plus-committed/no-build scenarios. Data from the TDM for those segment-scenario-year combinations entails bi-state, network-level, average daily vehicle-miles travelled (VMT), vehicle-hours travelled (VHT), and speeds (in miles-per-hour, MPH) for five trip categories – three pertaining to passenger vehicles (PV), two to commercial vehicles (CV):

- passenger vehicles
  - home-based work (HBW, or commuting)
  - home-based other (HBO, or personal)
  - non-home based (NHB, or business-related)
- commercial vehicles
  - local truck (Truck 1, or light trucking and delivery)
  - long-distance truck (Truck 2, or tractor trailer trucking)

For each independent segment-scenario and trip purpose, VMT and VHT are interpolated between the two anchor years 2010 and 2040 via respective average annual growth rates. Such interpolated annual data for the segment-specific build scenarios are differenced from the no-build scenarios to identify the incremental changes in VMT and VHT across the analysis years.

1.2 Benefits Monetization

Differences in VMT and VHT between the respective build and no-build scenarios are the basis for travel efficiencies that can be monetized into societal benefits (or dis-benefits). Monetizing the travel efficiencies from changes in VMT and VHT adheres to standard industry practices, such as the latest FHWA guidelines for conducting benefit-cost analyses for TIGER and FASTLANE grant applications, and includes the four typical (dis)benefit categories:

- travel times (dis)savings, from ΔVHT
- vehicle-operating cost (dis)savings, from ΔVMT and speeds
- accident cost (dis)savings, from ΔVMT
- emissions cost (dis)savings, from ΔVMT and speeds

As the data from the TDM are in average daily metrics, the incremental changes in VMT and VHT are annualized via assumptions regarding operating days per year for each trip purpose. Such annualized changes in TDM characteristics are then applied monetization assumptions regarding the per-mile or per-hour costs of travel for the four (dis)benefit categories.

Most of the monetization assumptions are sourced from the existing FHWA FASTLANE guidelines, a REMI TranSight® model for South Carolina obtained for the recently-conducted South Carolina Multimodal Transportation Plan (SC MTP, 2014), and the Energy Information Administration (EIA) for average annual gasoline and diesel fuel prices (for the Lower Atlantic PADD 1C region in 2015[1]).

All dollar-value metrics applied are in constant 2016 dollars[2]. Note that for the fuel- and emissions costs-per mile are also a function of average travel speeds, and the respective dollars/gallon and dollars/gram monetized assumptions were applied to speed-determined fuel consumption and emissions rates per mile for each passenger and commercial vehicles from the REMI model. Figure 1 lists the assumptions used in the benefits monetization.

[1] https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r1z_a.htm

[2] some of the assumptions from the FASTLANE, REMI, and EIA were in earlier dollar terms originally (e.g., 2014 or 2015); such assumptions were inflated to constant 2016 dollars using the Bureau of Labor Statistics (BLS) national Consumer Price Inflation (CPI) index

Figure 1: Monetization Assumptions

Assumptions	Factor	Source
Annualization (days/year)		
PV, Commuting (HBW)	260	CDM Smith
PV, Business (NHB)	300	CDM Smith
PV, Personal (HBO)	365	CDM Smith
CV, Light Trucking and Delivery	300	CDM Smith
CV, Tractor Trailer Trucking	300	CDM Smith
Value of Time (dollars/person-hour)		
PV, Commuting (HBW)	$13.61	FASTLANE guidelines
PV, Business (NHB)	$25.20	FASTLANE guidelines
PV, Personal (HBO)	$13.06	FASTLANE guidelines
CV, Light Trucking and Delivery	$27.01	FASTLANE guidelines
CV, Tractor Trailer Trucking	$27.01	FASTLANE guidelines
Vehicle Occupancy (persons/vehicle)		
PV, Commuting (HBW)	1.10	SCDOT TDM
PV, Business (NHB)	1.66	SCDOT TDM
PV, Personal (HBO)	1.72	SCDOT TDM
CV, Light Trucking and Delivery	1.20	CDM Smith
CV, Tractor Trailer Trucking	1.05	CDM Smith
Vehicle Operating Costs (dollars/mile)		
PV, Non-Fuel	$0.044	REMI TranSight South Carolina v3.5.6
CV, Non-Fuel	$0.104	REMI TranSight South Carolina v3.5.6
Fuel Costs (dollars/gallon)		
PV, Fuel	$2.447	Energy Information Administration
CV, Fuel	$2.697	Energy Information Administration
Accident Rate (accidents/million VMT)		
Fatalities	0.010	REMI TranSight South Carolina v3.5.6
Injuries	0.798	REMI TranSight South Carolina v3.5.6
PDO	2.523	REMI TranSight South Carolina v3.5.6
Accident Costs (dollars/accident)		
Fatalities	$9,705,472	FASTLANE guidelines
Injuries	$242,637	FASTLANE guidelines
PDO	$4,244	FASTLANE guidelines
Emissions Costs (dollars/gram)		
VOC	$0.002	FASTLANE guidelines
NOX	$0.008	FASTLANE guidelines
SOX	$0.048	FASTLANE guidelines
PM	$0.370	FASTLANE guidelines

1.3 Economic Impact Estimation

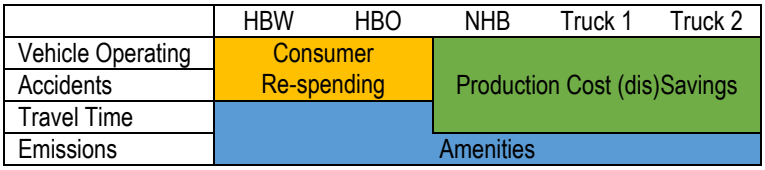
Typically, economic impacts from travel efficiency-related societal benefits are estimated via a dynamic economic model with a temporal dimension and the ability to reflect changes in industry structures, i.e., a REMI economic model (PI+ or TranSight®)[3]. A temporal dimension is requisite given the (dis)benefits are expected to occur across multiple future years; and, a

[3] as opposed to static economic models with fixed industry structures and lacking temporal or feedback dynamism, such as IMPLAN or RIMS input/output models

dynamic model with alterable industry structures is requisite given that transportation improvements can affect the operating cost structures of industries.

In estimating transportation-related impacts, the societal (dis)benefits are not input variables into standard, available economic models as travel time, vehicle-operating, accident, and emissions cost (dis)savings. Rather, they are translated into categories for modeling purposes and are designated as "policy variables" in the REMI models; translation of the trip-purpose-specific benefits categories into such policy variables is summarized below.

Figure 2: Travel Efficiency Benefits by Trip Purpose into Economic Policy Variables



Travel time, vehicle-operating, and accident cost (dis)savings for non-home based (NHB, or business) and truck trips are direct *Production Cost (dis)Savings* for industries, reflecting tangible changes to business operations. Vehicle operating and accident cost (dis)savings for commuting (HBW) and personal (HBO) trips reflect changes in *Consumer Spending* patterns, shifting between transportation-related consumption (e.g., gas/tires/oil, insurance, repairs, etc.) to other discretionary consumption activities (e.g., entertainment, restaurant services, etc.). Travel time (dis)savings for commuting and personal trips, and all emissions (dis)savings do not reflect actual monetary transactions within an economy, but are implicitly recognized as *Amenities* to a region, or rather a factor contributing to relative attractiveness of the area.

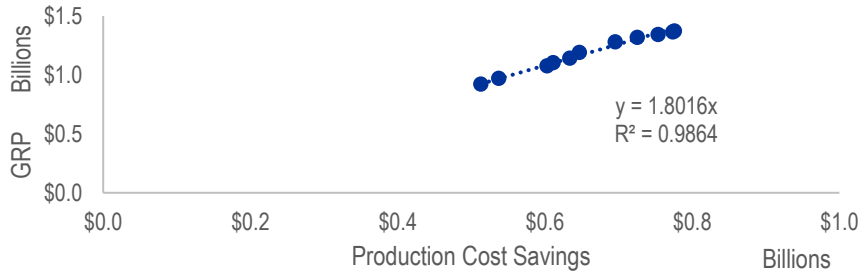
Such policy variables are typically input into a REMI model across time (with details by industry, commodity, etc.) to derive standard economic impact metrics, which include:

- *Gross Regional Product (GRP)* – net dollar-value economic activity (i.e., total output less gross intermediate inputs), synonymous with value-added; includes income, profits, taxes, etc., required to produce final goods and services
- *Jobs/Employment* – full-time-equivalent (FTE) annual jobs
- *Income* – wage/salary earnings paid to the associated jobs

Unfortunately, a REMI model or an appropriate substitute was not readily available for this reevaluation. Fortunately, CDM Smith recently conducted the 2014 SC MTP and calculated various travel-efficiency-related impacts to the State with a dozen runs. Using available information from that study, relative relationships between the economic results metrics and the applied travel efficiency benefit inputs were derived via a multivariate regression exercise. GRP was regression-tested against the policy variables (i.e., production cost savings, consumer re-spending, and amenities), and was determined to be sufficiently explained, statistically, by

production cost savings[4]. Such a crude relative relationship between GRP and production cost savings, differentiated by year, was then applied to the respective benefits for I-73 to derive GRP. Furthermore, relationships from the SC MTP regarding average GRP/employee and income/employee were thus applied for the other two results metrics.

Figure 3: SC MTP, Crude Relativity of GRP/Production Cost Savings (example for 2040)



2 Economic Impacts

Economic impacts are estimated and presented for the independently-evaluated South and North alignments, as well as a tested South and North combination to ascertain network-wide effects. Aggregate, bi-state TDM data for changes in VMT and VHT are presented, as well as the monetized benefit categories, the equivalent REMI policy variables, and the resultant economic impact metrics. As the impacts are derived from a bi-state network, the impact estimates are thus for the Carolinas, combined; however, a significant majority of the estimated impacts would be concentrated within the counties along the alignment and the major metropolitan areas abutting those counties.

Results are presented at an aggregated level without the trip purpose detail for the sake of simplifying the data summarization; however, there are nuances in the TDM and monetization of benefits between the five trip purposes within the analyses calculations. 2010 data is presented for TDM metrics only because it serves as an anchor year for interpolation between 2040; no benefits or impacts are expected to be realized until 2025, when it is assumed the full build scenarios would be complete. As such, the benefits and impact results are presented for 2025, the first year of expected full realization, and 2040 as the last analysis year available from the travel demand model. Impacts between 2025 and 2040 are a simple interpolation.

2.1 South Alignment

Per the bi-state TDM, constructing the I-73 South segment would result in an average daily, networkwide increase in vehicle-miles travelled (VMT) by 174,600 and 204,900 for the anchor years 2010 and 2040, respectively. Such VMT increases at higher average network speeds

[4] while the order-of-magnitude of the SC MTP vs. I-73 is drastically different, the relativity between the benefits-related policy variables (i.e., production cost versus consumer re-spending versus amenities) and between the input and output variables (e.g., production cost versus GRP) across the two analyses is assumed to be alike enough to apply

correspond with a reduction in vehicle-hours travelled (VHT) by 2,700 and 13,800 for the anchor years 2010 and 2040, respectively, see Figure 4. TDM characteristics for 2025 are interpolated from the anchor years, and projected as a 189,400 increase in daily VMT and a 7,200 decrease in VHT.

Figure 4: South Alignment TDM to Benefits to Impacts

	2010	2025	2040
TDM (Daily)			
no build VMT	299,308,819	341,695,058	390,083,770
build VMT	299,483,398	341,884,435	390,288,637
Δ VMT	174,579	189,377	204,866
no build VHT	7,196,023	8,837,011	10,852,213
build VHT	7,193,358	8,829,774	10,838,459
Δ VHT	-2,665	-7,237	-13,755
Monetized Annual Benefits			
Travel Time	#N/A	$54.4	$106.1
Vehicle Operating	#N/A	-$10.5	-$11.5
Accidents	#N/A	-$17.5	-$18.8
Emissions	#N/A	-$16.2	-$17.3
Total	#N/A	$10.2	$58.5
REMI Policy Variables			
Production Cost Savings	#N/A	$7.5	$24.3
Consumer Re-spending	#N/A	-$13.5	-$14.4
Amenities	#N/A	$16.2	$48.7
Total	#N/A	$10.2	$58.5
Economic Impacts			
GRP	#N/A	$10.8	$43.6
Employment	#N/A	106	365
Income	#N/A	$7.4	$32.5

* all monetized data are in millions of 2016$

After annualizing the incremental changes in daily TDM characteristics and applying respective monetization factors (see Figure 1), the monetized (dis)benefits from I-73 South amount to $10.2 million in 2025, escalating to $58.5 million in 2040. Travel time savings are the dominant category, stemming from VHT reductions, which are partially offset by dis-savings in vehicle-operating, accident, and emissions cost increases stemming from VMT increases.

Monetized annual travel-efficiency-related benefits are categorized by policy variables (normally input into a REMI model) for deriving economic impact measures via applying simply-derived ratios of annual GRP/production cost savings from work done for the SC MTP. Such policy variables, specifically the production cost savings, translate via the ratio application into gross regional product (GRP) impacts from $10.8 million in 2025 to $43.6 million in 2040. Given SC MTP effective ratios of average GRP-and income-per-employee, the GRP impacts translate into 106 jobs earning $7.4 million in 2025, to 365 jobs earning $32.5 million in 2040.

2.2 North Alignment

Per the bi-state TDM, constructing the I-73 North segment would result in an average daily, networkwide increase in vehicle-miles travelled (VMT) from 121,800 to 111,500 for the anchor years 2010 and 2040, respectively. Such VMT increases at higher average network speeds

correspond with a reduction in vehicle-hours travelled (VHT) by 5,200 and 10,400 for the anchor years 2010 and 2040, respectively, see Figure 5. TDM characteristics for 2025 are interpolated from the anchor years, and forecasted as a 118,300 increase in daily VMT and a 7,400 decrease in VHT.

Figure 5: North Alignment TDM to Benefits to Impacts

	2010	2025	2040
TDM (Daily)			
no build VMT	299,308,819	341,695,058	390,083,770
build VMT	299,430,593	341,813,395	390,195,256
Δ VMT	121,775	118,337	111,485
no build VHT	7,196,023	8,837,011	10,852,213
build VHT	7,190,805	8,829,566	10,841,795
Δ VHT	-5,218	-7,446	-10,418
Monetized Annual Benefits			
Travel Time	#N/A	$59.4	$78.7
Vehicle Operating	#N/A	-$5.5	-$5.7
Accidents	#N/A	-$11.0	-$10.0
Emissions	#N/A	-$12.5	-$9.8
Total	#N/A	$30.5	$53.2
REMI Policy Variables			
Production Cost Savings	#N/A	$25.5	$28.7
Consumer Re-spending	#N/A	-$10.1	-$7.4
Amenities	#N/A	$15.1	$31.9
Total	#N/A	$30.5	$53.2
Economic Impacts			
GRP	#N/A	$36.5	$51.5
Employment	#N/A	358	432
Income	#N/A	$25.0	$38.4

* all monetized data are in millions of 2016$

After annualizing the incremental changes in daily TDM characteristics and applying respective monetization factors (see Figure 1), the monetized (dis) benefits from I-73 North amount to $30.5 million in 2025, escalating to $53.2 million in 2040. Travel time savings are the dominant category, stemming from VHT reductions, which are partially offset by dis-savings in vehicle-operating, accident, and emissions cost increases stemming from VMT increases.

Monetized annual travel-efficiency-related benefits are categorized by policy for the purposes of deriving economic impact measures via applying ratios of annual GRP/production cost savings from work done for the SC MTP. Such policy variables, specifically the production cost savings, translate via the ratio application into gross regional product impacts from $36.5 million in 2025 to $51.5 million in 2040. Given SC MTP effective ratios of average GRP-and income-per-employee, the GRP impacts translate into 358 jobs earning $25.0 million in 2025, to 432 jobs earning $38.4 million in 2040.

2.3 Combined North and South Alignment

Given that the North and South segments of I-73 would combine as a singular route, they should not be characterized as exhibiting independent utility. As such, a combined analysis, assuming the entire route from Charlotte to Myrtle Beach, is also conducted to determine how the entire corridor would affect the Carolinas, rather than just each segment independently as in the previously-presented sections. In effect, the stand-alone South and North analyses reflect the relatively constrained effects on narrower geographic catchment areas pertaining to the respective segments demarcated by I-95, rather than the true bi-state network-wide effects resulting from both North and South combined. Combining the proposed I-73 as one singular route to correspond with the planning intentions exemplifies how the network effect from constructing both segments is much larger than the simple summation of the effects from either segment independently.

A test TDM run was conducted for a combined I-73 North and South in year 2040 to determine that larger, network-wide effect[5], yielding changes in VHT and VMT that are greater than simply totaling the independently forecasted results for the two respective segments. Per the bi-state TDM, the combined I-73 corridor would result in an average daily, networkwide increase in vehicle-miles travelled (VMT) of 331,800 in 2040 and a reduction in vehicle-hours travelled (VHT) of 33,700, see Figure 6. In comparison with the individually-analyzed North and South segments, that VMT increase is 4.9% higher than the simple segment summation (204,900+111,500); however, the VHT savings are 39.4% higher than simple summation of the respective segments (13,800+10,400) – yielding much larger net benefits (and thus impacts) from combining the segments simultaneously.

After annualizing the incremental changes in daily TDM characteristics and applying respective monetization factors (see Figure 1), the monetized (dis)benefits from I-73 North and South amount to $185 million in 2040, about 65% greater than just summing the individual North and South segments ($59 + $53 million). Travel time savings are, by far, the dominant category, stemming from much larger VHT reductions, which are partially offset by dis-savings in vehicle-operating, accident, and emissions cost increases stemming from VMT increases.

Monetized annual travel-efficiency-related benefits are categorized by policy variables for the purposes of deriving impact measures via applying ratios of annual GRP/production cost savings from work done for the SC MTP. Such policy variables, specifically the production cost savings, translate via the ratio application into gross regional product impacts from $206 million in 2040. Given SC MTP effective ratios of average GRP-and income-per-employee, the GRP impacts translate into 1,730 jobs earning $154 million in 2040. Such impacts are more than twice the simple aggregation of the individual North and South segments' impacts derived in the previous sections, reflecting the interdependency of the North and South segments serving as one continuous route.

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[5] only 2040 was run as a test outside the contracted SOW to gauge the relativity of the network effects; 2010 was not included due to level of efforts in coding the combined network; however, a 2010 anchor run could be conducted later to be used for intervening year interpolations

Figure 6: North and South Alignments Combined TDM to Benefits to Impacts

	2010	2025	2040
TDM (Daily)			
no build VMT	#N/A	#N/A	390,083,770
build VMT	#N/A	#N/A	390,415,565
Δ VMT	#N/A	#N/A	331,795
no build VHT	#N/A	#N/A	10,852,213
build VHT	#N/A	#N/A	10,818,523
Δ VHT	#N/A	#N/A	-33,690
Monetized Annual Benefits			
Travel Time	#N/A	#N/A	$266.8
Vehicle Operating	#N/A	#N/A	-$17.1
Accidents	#N/A	#N/A	-$31.5
Emissions	#N/A	#N/A	-$33.3
Total	#N/A	#N/A	$184.9
REMI Policy Variables			
Production Cost Savings	#N/A	#N/A	$114.8
Consumer Re-spending	#N/A	#N/A	-$28.9
Amenities	#N/A	#N/A	$99.0
Total	#N/A	#N/A	$184.9
Economic Impacts			
GRP	#N/A	#N/A	$206.2
Employment	#N/A	#N/A	1,729
Income	#N/A	#N/A	$153.8

* all monetized data are in millions of 2016$; only 2040 was run for testing; no related 2010 results are available for interpolation

2.4 Processes Comparison with 2005 EIS

Estimated economic impacts in this reevaluation are different than those previously estimated over a decade ago. Various factors account for the differences, which include, but are not limited to: travel demand modeling, benefits monetization, and economic modeling, assumptions, and analyses procedures.

Travel Demand Modeling – Bridging two statewide models, the currently-developed and applied bi-state network is a different scale and resolution than previously, with:

- a more refined roadway network and zone system, including:
  - network with minor arterials and collector facilities
  - zoning system conforming to the 2010 Census
- more detailed trip purposes, including:
  - passenger vehicles (HBW, HBO, and NHB)
  - commercial vehicles (local/light and long-distance tractor-trailer)
- more accurate congestion estimates; detailed volume delay curve by roadway type
- more recent validation

In addition to a decade-plus of improved and refined industry analyses standards, such model improvements facilitate a more robust, accurate, and realistic estimation of travel characteristics at the network level. Also, the historically-conducted TDM regionalization may not have properly

reflected the network effect of the proposed I-73 construction within just the geographies analyzed, exaggerating any differences associated with only the modeling improvements.

Benefits Monetization – Generally, the benefits monetization process is conducted similarly to previously, translating TDM changes in VHT and VMT into the standard benefit categories of travel time, vehicle operating, accident, and emissions cost (dis)savings. However, various intermediate calculations and the various applied factors for monetization have been refined to correspond with improved industry standards and processes, especially FHWA-recommended standardized assumptions, per TIGER/FASTLANE guidance:

- travel time
  - effectively same process as previously, translating ΔVHT
  - updated values of time, per FHWA guidance
- vehicle operating costs
  - similar process as previously, translating ΔVMT per speeds
  - more-accurate/realistic calculations for fuel versus non-fuel components
- accidents
  - similar process as previously, translating ΔVMT
  - additional resolution by fatalities, injuries, and property-damage only (PDO)
- emissions
  - similar process as previously, translating ΔVMT per speeds
  - improved industry standards for calculations and rate assumptions

Economic Impacts – Without accessibility to a currently-available REMI model, the calculation process for estimating economic impacts from travel-efficiency benefits is drastically different than previously. In the original EIS, the benefits were input directly into REMI (an extremely complex dynamic-equilibrium econometric model), and accordingly reflect the advantages of properly corresponding modeling inputs with outputs. Currently, without such accessibility, the estimation process relies on ratio proxies from a conceptually- and geographically-similar analysis, but with an order-of-magnitude difference. Such a shortcut obviously diminishes the accuracy of any estimates; however, in the absence of accessibility to industry-standard tools, such a proportionally-based estimate is the best available option. Additionally, the geographic extent of the impacts analysis was previously confined to a narrower regional scale.

Aside from the procedure limitations imposed by inaccessibility to an economic model, the differences between previous and current impact estimates result from fundamental differences in the economy. Since the previous EIS analysis, the economy experienced the “Great Recession” followed by tempered growth and fundamental structural changes. Consequently, even the basic relativity between economic relationships (including modeling inputs/outputs) has altered towards the more conservative compared with history.

Combined Differences – In all, the modeling processes, data, and assumptions have improved with a decade-plus worth of industry analyses advancement, and as such, the comparability of current results to previous is invariably not apples-to-apples. Despite the difficulty in direct comparability, the top-level estimates currently are more conservative than previously, but reflect more realistic and accurate conditions under the existing circumstances.