Economic Analysis of Completing the Appalachian Development Highway System: Technical Report

Prepared for:
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WSP/Parsons Brinckerhoff

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Table of Contents

List of Tables

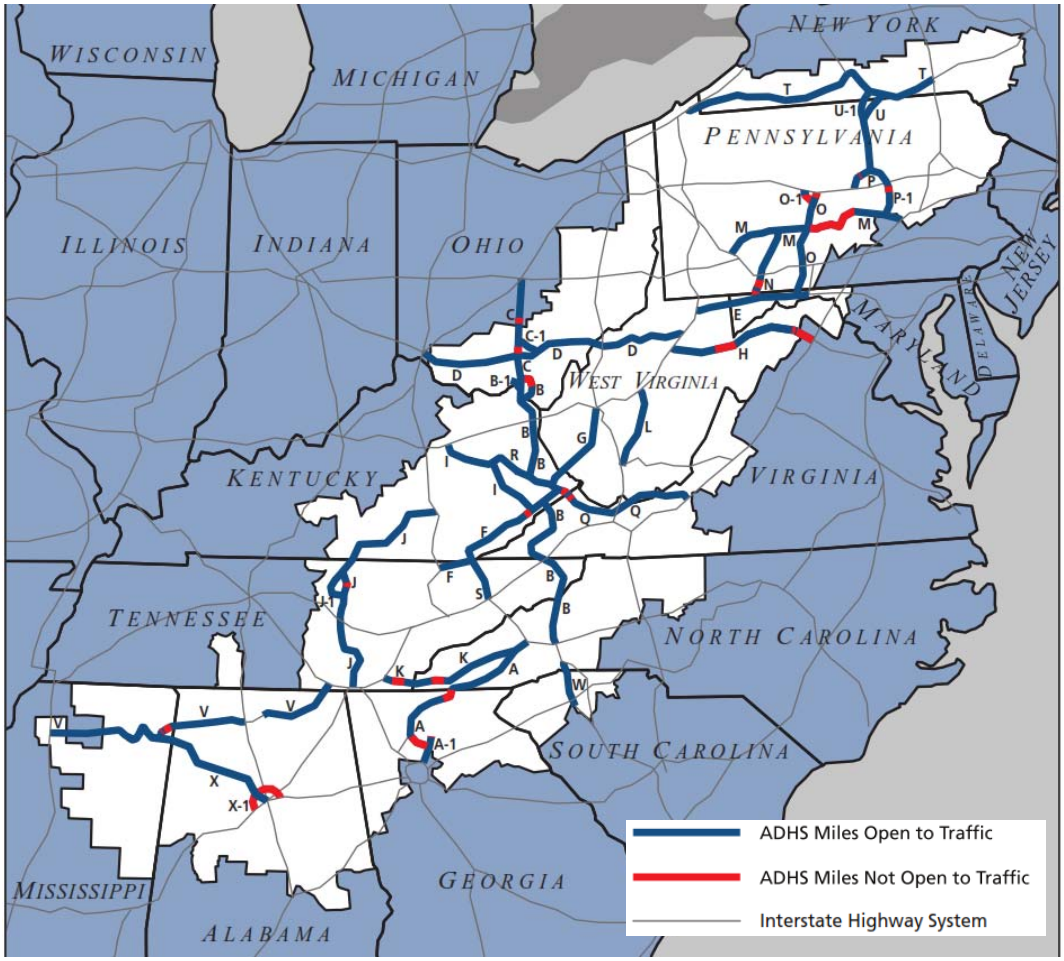
List of Figures

Overview and Findings

Background

This economic study was sponsored by the Appalachian Regional Commission (ARC) to estimate the economic impacts, benefits, and costs of completing the Appalachian Development Highway System (ADHS). The ADHS was authorized by Congress with the purpose of stimulating economic development by reducing isolation and improving access for an economically depressed region that had been largely left unserved by the interstate highway system. A 3,662-mile system, the ADHS is composed of 32 corridors located in 13 Appalachian states with 3,090 eligible miles (see Figure 1). At the end of FY 2016, a total of 2794.7 miles, or 90.4 percent of the authorized network, were either complete or open to traffic, or under construction. ADHS completion will link the whole system into an integrated transportation network connecting Appalachia to both domestic and global markets. The analysis in this report is based on economic data and forecasts from 2015, the most recent complete year for which data were available as the report was being developed.

Figure 1: Appalachian Development Highway System, as of September 30, 2016.



Source: Appalachian Regional Commission, 2016.

The purposes of this study are to:

(1) Describe the effects that historical completion of the ADHS to date has had (and continues to have) on connecting Appalachian people and businesses to economic markets, and consequently the impacts it has had on improving the Region's economy.

(2) Assess the additional future improvements in travel performance, trade, and economic development that can be expected from completion of the remaining elements of the ADHS.

(3) Calculate the relative benefits and costs of completing the ADHS system, evaluate how those benefits are likely to be experienced on particular corridors, and estimate how accelerating ADHS completion would generate larger transportation benefits and economic impacts much sooner.

This study both extends and improves upon prior studies of the economic benefits and impacts of ADHS completion. Before this study, the most recent extensive economic analysis of the ADHS was a June 2008 report, which estimated the future economic and travel efficiency returns to ADHS investments. Key enhancements in the current study include:

(1) Integration of national data sources, such as Freight Analysis Framework (FAF) and Highway Performance Monitoring System (HPMS), with statewide transportation performance modeling and data systems for each Appalachian state;

(2) New quantitative analysis of the transportation and economic impacts of ADHS completion to date (1965 to 2015);

(3) Estimates of how accelerating ADHS completion to 2035 (compared to 2045) would change the economic impacts and benefits for Appalachia; and

(4) Return on investment (ROI) analysis of five major ADHS corridors that have sections remaining to be built.

Results of this study include a full range of transportation performance and economic development indicators. These are defined and organized as follows:

- Transportation System Performance Benefits: Including travel-time savings, route diversion and resulting reduced mileages, and increased ranges of workforce and business accessibility;
- Valuation of Economic Benefits: Including the dollar value of travel time, reliability, operating costs, logistical costs, environmental and safety costs, as well as enhanced productivity;
- Total Economic Impacts: Including full economic development impacts on the economy of the Appalachian Region in terms of employment by industry, gross regional product, and personal income; and
- Benefit-Cost Analysis: Benefit-cost ratios to measure expected return on investment.

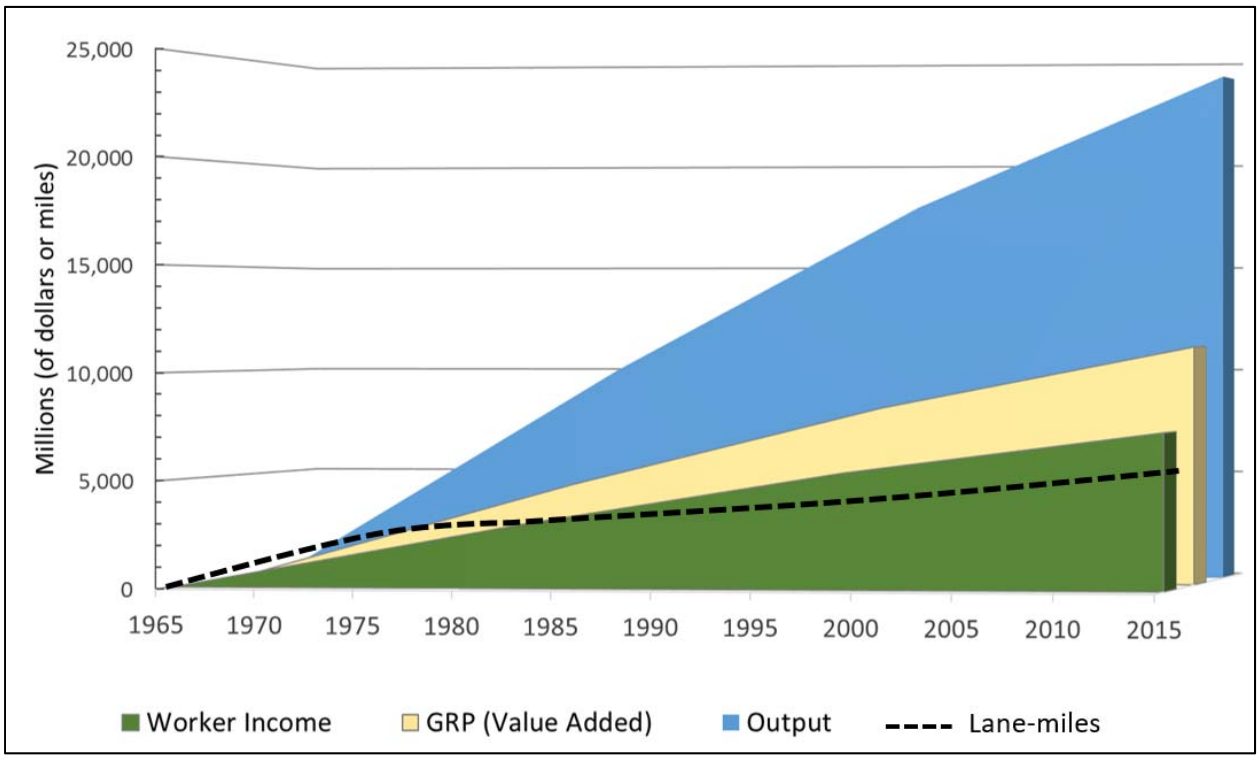
Key findings pertain to the historic impact of ADHS completion to date, anticipated benefits of system completion, wider economic impacts of system completion, benefit-cost analysis of system completion, and the potential near-term benefits and impacts of accelerated completion.

Key Findings: Impact to Date

A historical analysis of the economic impact of the ADHS from 1965 to 2015 finds that:

- Over a period of 50 years, over 90 percent of the ADHS has been completed, including 5,119 lane-miles of highway construction leading to the opening of 2,794.7 miles of completed highways on the ADHS network. This includes construction of new highway segments and expansion of existing highway segments. A majority of the highway improvements completed to date have been in economically distressed, rural counties.
- As a result of the ADHS investment to date, areas served by the ADHS now experience transportation system benefits in terms of faster and more reliable travel times, savings in vehicle operating and logistics costs, better safety, and substantially better access to labor and business delivery markets. For instance, travelers today experience 360 million hours per year of travel time savings compared to what would have been the case without these highway system improvements. Counties with ADHS investments also have nearly twice the improvement in workforce access than other parts of the Appalachian states.
- In 2015 the ADHS enabled approximately $10.7 billion in annual transportation cost savings and productivity gains. These gains extend beyond the Appalachian states, benefiting the entire US Economy. Twenty percent of car vehicle hours saved and 31 percent of freight truck vehicle hours saved accrue to trips with at least one end located outside of the 13 Appalachian states. This indicates that the ADHS plays a particularly important role serving longer-distance goods movement and trade, connecting the Region to destinations throughout the U.S.
- The transportation changes have affected almost all sectors of the economy, leading to increased business productivity and competitiveness. Those counties with the greatest transportation cost savings and access benefits have also shown solid employment growth. For example, the Appalachian counties most directly served by ADHS investments have grown 20 percent more than the Appalachian states as a whole from 1965 to 2015.
- The accessibility and transportation cost savings enabled by ADHS system completion to date can be directly linked to the creation of over 168,000 added jobs and over $11 billion per year in GRP in the Appalachian states as of 2015 (see Figure 2). The cumulative effect of added GRP growth continuing year after year for over 50 years (from 1965 to 2015) adds up to $388 billion in constant (2015) dollars.
- The impact of ADHS completion on regional GRP and employment has continued to grow in every period of ADHS development (see Figure 2). While the largest share of economic impact is attributable to a large block of highway system improvements made between 1965 and 1983, there is still significant ongoing growth in benefits and economic impacts from ADHS system investment, which can be expected to grow as the system is completed in the first part of the 21st century.

Figure 2: Impact of ADHS Completion to Date on the Economy of Appalachian States



Note: All economic values are in millions of constant 2015 dollars

Sources: ARC (for lane-miles), travel and economic model analyses by EDR Group and WSP Parsons Brinckerhoff as reported in chapter 3 of the full report (for economic impact measures).

Key Findings: Future System Completion

Transportation Benefits of ADHS Completion

The analysis of economic impacts associated with future ADHS completion finds that:

- As of FY 2015, 295.3 miles of the authorized ADHS network remains to be completed, though many of these remaining road segments have not yet been completed because they have difficult topography (which makes them more expensive to complete) and/or significant environmental challenges (which makes design and approval more difficult to achieve). Altogether, the work to be completed to realize the ADHS vision will occur on 17 corridors throughout Appalachia.
- Nevertheless, the benefits of completing the ADHS network are substantial, summing to over $2.2 billion in annual transportation cost savings and productivity gains by 2045. These benefits from completion of a network connecting Appalachian with broader labor markets, truck delivery markets, inland distribution and export gateways. These market access and intermodal connectivity benefits are measurable. For instance, completion of the ADHS is calculated to bring a 30 percent increase in population market access for businesses located along the affected corridors.

- Completion of the ADHS network will also bring significant travel efficiencies for car and truck movements to, from and within the Region. Most notably, network characteristics consistent with models used by Departments of Transportation in the Appalachian States demonstrate how completion of the system by 2045 will bring faster travel times and reduced delays due to better road geometrics (including curves and passing lanes), enabling a total of 114 million vehicle-hours of time saved per year.
- The benefits of ADHS completion include not only benefits to businesses dependent on the system for transportation, but also significant benefits to the quality of life for those living, working and visiting the Region. These include savings in personal travel time by residents, and improvements in safety and the environment.

Economic Impacts of System Completion

- The benefits described above will have the wider impact of enabling significant improvements in the economic competitiveness of the Region, through savings in business costs associated with business vehicle operations, worker time and logistics, as well as enhanced productivity due to larger market access. The competitiveness improvements due to ADHS completion will support more inward investment to the Region, more exports and ultimately more business growth. These economic impacts will occur most dominantly within Appalachian counties, with further growth occurring in other parts of the 13 Appalachian states.
- Application of an economic simulation and forecasting model shows the consequence of greater economic competitiveness on regional economic growth. The results are summarized in Table 2. The estimated economic impact on the 13 Appalachian states is expected to be in the magnitude of over $4.2 billion of additional GRP each year, supporting roughly 46,000 additional jobs. Around 77 percent of these impacts will occur within Appalachian counties. Table 1 demonstrates how the business sales, value added, and wage income impacts develop from 2015 to 2045.

Table 1: Annual Economic Impacts of ADHS Completion in 2045

Annual Economic Impact of Future ADHS Completion	
Business Output ($M Sales)	$8,703
Value Added ($M GRP)	$4,236
Wage Income ($M Earned)	$2,673
Employment (Jobs)	46,849

Source: Economic Analysis of Completing the Appalachian Development Highway System, 2017–chapter 4.
**Note: All values are in constant 2015 dollars*

Benefit-Cost Analysis

Table 2 shows the benefits and costs of ADHS completion by 2045. Costs and benefits are discounted at 7 percent and include all costs and benefits accruing in the United States. The table demonstrates that ADHS completion is expected to generate societal benefits more than three and a half times its cost. Depending on the discount rate – the benefit/cost ratio could be even greater. Furthermore, the benefits shown in Table 2 include all benefits to the United States economy. If benefits are understood from a strictly

regional perspective (counting only benefits accruing to Appalachian states) the benefits would still be over 2.7 times greater than the costs.

More than half of the benefits are attributable to travel time and reliability savings, with other significant benefits accruing based on supply chain benefits to truck traffic (enabling trucks to be more responsive to the needs of shippers up and down supply chains), savings in mileage and associated fuel and vehicle operating costs, and to a lesser degree safety and environmental costs as well as productivity gains from enhanced market access.

Table 2: Benefit-Cost Analysis for ADHS Completion (present value of future cost and benefit streams)

Elements of Benefit and Cost	Present value ($ millions) with 7% discount rate
Vehicle Operating Cost Savings	$1,659
Travel Time Saved	$8,622
Reliability Time Saved	$2,526
Safety Benefit	$950
Environmental and Emissions Benefit	$358
Logistics and Supply Chain Savings	$1,786
Market Access (Productivity Gain)	$419
Present Value of Total Benefits	**$16,320**
Present Value of Total Costs	**$4,471**
Benefit-Cost Ratio	**3.65**

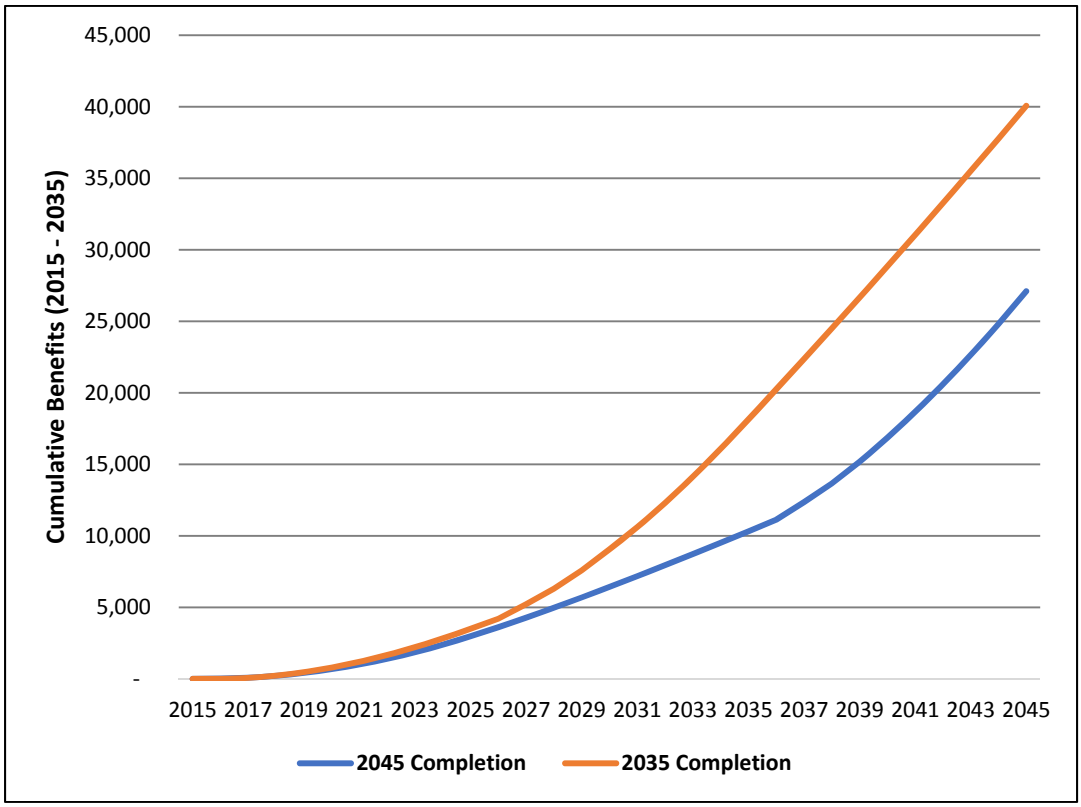
Source: Economic Analysis of Completing the Appalachian Development Highway System, 2017–chapter 4
**Note: All values are net present values of cost or benefit streams covering the period of 2016–2075, using the specified 3 percent or 7 percent discount rate, and presented in terms of their 2015 value (millions of dollars)*

The Case for Accelerated Completion of ADHS

There are significant challenges and uncertainties regarding both the availability of funds for ADHS completion and as well as time required to complete the stakeholder discussion and approval processes that are needed to achieve desirable plans and designs. Of course, delays in ADHS completion also lead to delays in achieving regional benefits. To understand the consequences of delaying vs. accelerating system completion, the study team conducted a comparison of benefits and costs associated with a 2045 completion date versus an accelerated 2035 completion date.

Figure 3 illustrates the comparative rate at which benefits will accrue with 2035 completion compared to 2045 completion. This analysis demonstrates that if the completion of ADHS can be accelerated to occur by 2035, the Region can experience nearly $8 Billion in additional cumulative undiscounted transportation benefits by that year in comparison to a 2045 completion scenario. It is expected that by 2035 the Region could gain over 11,000 more jobs as a result of accelerating completion of ADHS, as well as over $1 billion more in GRP and more than $2 billion in additional annual business sales (output).

Figure 3: Transportation Benefits of Accelerated 2035 Completion versus 2045 Completion



Source: See chapter 4.
Note: All benefits reported in millions of constant 2015 dollars.

Conclusions

The ADHS investments to date have provided 5,117 additional lane-miles of highway, achieving $10.7 billion in annual benefits—in terms of transportation system performance, access improvement (isolation reduction), and resulting economic growth on the order of 168,000 jobs and $11.1 billion in annual GRP. Completion of the system will also have substantial benefits, in terms of achieving network connectivity to economic markets and intermodal facilities, and enabling trade and regional economic growth to the effect of over 46,000 additional jobs and over $4 billion in additional GRP growth. Based on current cost estimates, the achievement of ADHS system completion will bring a strong ROI (return on investment) for Appalachia as well as the broader set of Appalachian states and the nation realizing $3.65 of benefit for every dollar spent on the system. These broader impacts are enabled by two factors: the role of ADHS links in facilitating long distance trips and trade, and by the economic (supplier-buyer) links tying Appalachia to outside areas. An examination of five individual corridors that are not yet completed also indicates a positive ROI for each of them. While costs and timing are significant uncertainties, the analysis shows that efforts to accelerate ADHS completion can work to enhance the net benefits.

1. Introduction

1.1 Study Objectives

The Appalachian Development Highway System (ADHS) is a federally designated 3,090-mile network of modern highways, comprising 32 highway corridors spread across 13 states. It is designed to link isolated and economically distressed areas of Appalachia to the Interstate Highway System and major economic markets. Development of this network was originally authorized by a broad bipartisan majority of Congress through the Appalachian Regional Development Act of 1965. Over the subsequent 50 years (1965-2015), approximately 90 percent of the designated system mileage has been constructed with a combination of federal and state funding. Today, about ten percent remains to be completed by the states.

This report examines the impacts of the ADHS on economic growth and transportation connectivity in Appalachia—including both how ADHS development to date has affected jobs and income in Appalachia, and the expected future benefits, costs, and economic growth impacts of completing remaining portions of the ADHS. Its purpose is to provide an updated assessment of the effects of completing the ADHS, including implications for the Appalachian Region, the broader 13 Appalachian states, and the United States overall.

The study, which draws on state-of-the-art economic and transportation analysis models as well as local business interviews, addresses the following questions:

- To what extent have the completed portions of the ADHS contributed to economic gains (increases in jobs and income) in Appalachia?
- What are the expected economic growth impacts, and transportation system benefits of completing the remaining sections of the ADHS?
- What are the costs and benefits of completing the entire ADHS as well as a set of major ADHS corridors, and what kind of economic gains would be realized if the system were completed more quickly?

1.2 ADHS Completion Challenges

An early goal of the ADHS was to create better transportation access to, from, and within Appalachia, to help the Region's economy attract investment, diversify its industry mix beyond the extractive, resource-based economy, and alleviate its persistent concentration of poverty. This required the development of new access routes that could: (a) reduce costs of travel and business operations in the Region, (b) expand job and labor market opportunities, (c) expand access to broader health, education, and business delivery markets, and (d) expand freight connectivity to airports, ports, and intermodal terminals.

While much of the ADHS system has been completed, there are clear challenges for completion of the remaining links in the network. The breadth of the Region and its rugged, mountainous terrain has meant that highway development in Appalachia is difficult, costly, and accompanied by design and

environmental challenges. At the same time, the extent of long-term poverty in this region and the implications of improved accessibility enabled by ADHS corridors are also substantial. Consequently, both the potential costs and benefits for completion of the ADHS system are meaningful for the Appalachian Region and for the U.S. as a whole.

The evolution of the ADHS is now at a critical juncture, as the system is nearing completion yet some key corridor elements remain to be finished. While construction of ADHS corridors can be funded with 100 percent Federal funds (no state match required), there no longer is a dedicated stream of funding allocated to states for the ADHS.[1] There is now an increasing need to demonstrate where and how there is benefit to be gained from funding and constructing the remaining segments. This calls for a new type of analysis that can more directly show the economic importance of completing the ADHS in terms of impacts of individual corridors, as well as the broader regional and national economic stakes and their distribution among locations and among elements of the economy.

1.3 Study Scope and Approach

The Appalachian Regional Commission (ARC) has sponsored several past research studies to assess the economic impacts of the ADHS program, and outside parties have conducted additional studies of this topic. These studies are summarized in a synthesis report on past research completed in 2016.[2] This current study was commissioned by ARC's Planning and Research Division to accomplish three further goals:

(1) Quantify the cumulative transportation and economic effects of ADHS investments over the 1965-2015 period;

(2) Provide an updated analysis of the benefits, costs, and economic impacts associated with future completion of all remaining segments of the ADHS; and

(3) Examine the transportation benefits, economic opportunities, and the return on investment associated with completion of five of the largest remaining ADHS corridors.

To address these three goals, the research team completed a two-step process.

- First, impacts on travel conditions were analyzed using detailed travel and highway network models to represent traffic flows, speeds, congestion, reliability, and connectivity conditions. The models were configured to represent the highway system performance and conditions in three ways:
    - Today (2015),
    - As they existed in earlier years without ADHS highway segments, and
    - As they would exist in the future if remaining ADHS segments were completed.

[1] For example, this means that ADHS projects now compete with the full-set of state transportation priorities such as congestion relief in large urban areas, or rebuilding structurally deficient bridges.

[2] Appalachian Development Highway System Economic Analysis Study: Synthesis of Findings to Date, Appalachian Regional Council, 2016. See https://www.arc.gov/research/researchreportdetails.asp?REPORT_ID=128.

- Second, multi-regional economic forecasting and simulation models were applied to assess how the transportation system conditions under those three situations affected the economy. Information about changes in travel efficiency fed both a benefit-cost analysis of the efficiency of investment, and an economic impact study that examined broader effects on competitiveness, as well as job and income generation among industries and locations. The economic analysis was supplemented by interviews with corridor-specific business and economic development representatives to document their expectations for their region.

The analysis of past impacts is referred to as "backcasting," while the analysis of expected future impacts is referred to as "forecasting." Forecasting studies normally start with a baseline forecast and then assess what would be the future effects of a hypothetical scenario in which proposed new projects are added. Backcasting studies, in contrast, start with a history in which (ADHS) investments have already occurred, and assess what have been the past effects in comparison to a hypothetical scenario if those projects had not occurred. This study employs the same modeling and analysis approach to provide full consistency in assessing both historical and expected future effects.

1.4 ADHS Completion–Plans and Possible Alternative Highway Improvements

The ADHS was designated in the 1960s but has been altered in various ways over time to adjust exact highway routing, modify the highway classification, or sometimes even add new corridors. In this study, the research team used the best available information to define the completion of ADHS corridors and the full system, largely relying on the September 2013 ADHS Completion Plan Report and the 2015 ADHS Status Report.[3] These reports outline the timing (by year) that Appalachian states expect to finish each corridor and the estimated cost for the completion work. There is wide variation in the timing of completion by corridor and by state. In fact, many of the corridors not yet completed are under-construction today with new investment and segment completion expected each year. For example, Kentucky has two corridors that it is working to finish (Q and F) with completion dates anticipated in 2019 and 2024.

Other highway corridor projects have completion dates further out, extending beyond 2040. For example, Corridor H in West Virginia is estimated to finish in 2042 even as the state makes steady progress on a continuous basis to finish its highway work. Other large corridor projects are more difficult to forecast with certainty given: a) the removal of dedicated funding for ADHS in the last Federal transportation bill; b) environmental challenges and difficult terrain to complete certain segments; and c) limited state DOT funding and competition for and prioritization with other projects.

In reality, some projects may vary from the analysis conducted in this study in terms of timing, highway routing, highway classification or other characteristics. From working with state DOTs, ARC is aware that some state DOTs are already considering modifications to ADHS corridor completion. Lacking more formal decisions about these roadways, and given the possibility of increased levels of infrastructure investment

[3] See: https://www.arc.gov/images/programs/transp/ADHSCompletionPlanReport-9-2013.pdf ; https://www.arc.gov/images/programs/transp/ADHSFY2015StatusReport.pdf.

in the future, this research deliberately analyzed ADHS corridor completion as originally envisioned and stated in the most recent completion plan and status report. This research thus represents the best estimates and projections available of the economic impacts, benefits, and costs of ADHS corridor and system completion as of February 2017.

In effect, the results of this study demonstrate in economic terms what is at stake in decisions regarding both the implementation and timing of ADHS completion.

2 Analysis Process: Methods and Models

This section describes the overall analysis approach used in the study. It describes how a set of state-of-the-art transportation and economic analysis models were combined and validated to assess the impacts and benefits of completing the ADHS in a way that is consistent with local, state and federal highway statistics measuring the ADHS travel market and its performance. Overall, the modeling is comprised of three major elements:

- The first is the travel demand and transportation system performance element, demonstrating how the transportation system is expected to perform as a result of ADHS completion (or how it performs now as a result of completion to date).
- The second element applies valuation factors to generate monetary benefits and utilizes economic impact modeling to demonstrate how the transportation performance improvements enable firms to produce more output, create more jobs and improve the overall economic performance of the Region.
- The final element compares the costs and benefits of ADHS completion. In order to enhance the understanding of the findings and context of the analytical modeling, the research team conducted interviews with corridor-level stakeholders about the effects anticipated with ADHS completion.

2.1 Modeling Travel Demand and Transportation System Performance Impacts

As a system comprised of new facilities serving highly dispersed traffic markets which are both regional and national in nature, the ADHS is fundamentally unlike other projects for which departments of transportation (DOTs) or metropolitan planning organizations (MPOs) typically forecast traffic. The market for the yet-to-be-completed ADHS cannot be observed in typical traffic flow maps of the existing facilities because:

(1) There are no existing facilities in place with comparable characteristics,

(2) A widely disbursed complex of local, municipal and lower classified state facilities are currently carrying traffic that may comprise a future market for ADHS,

(3) The ADHS may re-route national traffic not currently traveling into, out of or through Appalachian counties, and

(4) By attracting new business to Appalachia, ADHS may save travel hours and mileage by shortening trips that currently do not even have ends in Appalachia.

For all of these reasons, the Appalachian travel market is not expected to be identified through a simple process of looking at existing flow maps, or applying typical state models validated for higher volume state

facilities, or looking only at diversion of national truck traffic. Instead, the research team applied an all-sources approach of combining all known state and federal data sources to characterize the potential future travel market for ADHS, and the potential sources of savings from economic patterns resulting from system completion.

The "all sources" approach means that no single data source or model is seen as definitive with regard to the ADHS travel market and its performance; instead multiple sources of measuring ADHS traffic and performance are considered and validated against each other and the most consistent and defensible findings were used for economic analysis.

Key sources of information used in developing the transportation performance estimates included:

(1) Validated Statewide Travel Demand Models from each of 13 Appalachian states, including data on passenger and truck trips, and origin-destination (O-D) patterns.

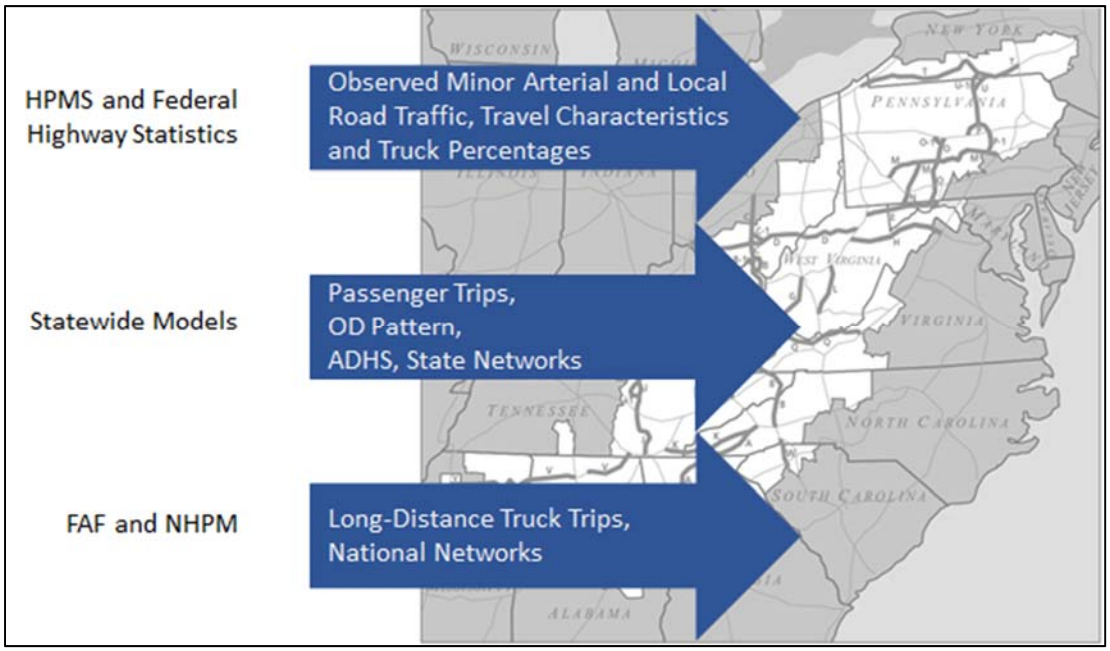
(2) FHWA's Highway Performance Monitoring System (HPMS) data files from the 13 Appalachian states, and their associated reporting of vehicle miles of travel by cars and trucks, by functional highway system.

(3) Federal Highway Statistics published by the Federal Highway Administration (FHWA) documenting lane miles constructed and vehicle miles of travel by cars and trucks in all fifty states from 1965 to 2015.

(4) FHWA highway network data including the National Highway Planning Network (NHPN) and Freight Analysis Framework (FAF) networks.

The following is a high-level description of how these sources are used in assessing the size of the ADHS travel market. Figure 4 illustrates how the all-sources approach combines the best available state and federal data sources to estimate and validate the size and performance of the travel markets served by the ADHS.

Figure 4: Models and Data Used to Demonstrate Effects of ADHS



Source: EDR Group.

Statewide Travel Demand Models

A primary source of information on ADHS travel demand and transportation system performance is the travel demand models developed by the thirteen states with ADHS facilities. Each of the states in the Region has (to some degree) calibrated and used four-step travel demand models for its internal planning. These models have different degrees of accuracy relative to known traffic counts, and varying degrees of detail in representing different classifications of roadways. However, the state models serve as an important resource because they include:

(1) Detailed sub-county Traffic Analysis Zone (TAZ) level estimates of passenger car and truck traffic produced and attracted to different areas in states served by the ADHS.

(2) A validated distribution of origin-destination (OD) patterns for trips exchanged between these zones.

(3) A validated and "assignable" highway network that can be used for determining the likely routing of traffic between different origins and destinations served by the ADHS in ways that explicitly account for factors expected to be influenced by ADHS completion such as:

   a. Design Speed,

   b. Terrain,

   c. Mileage of linear roadway (including straight or crooked/ 'winding' nature of routes),

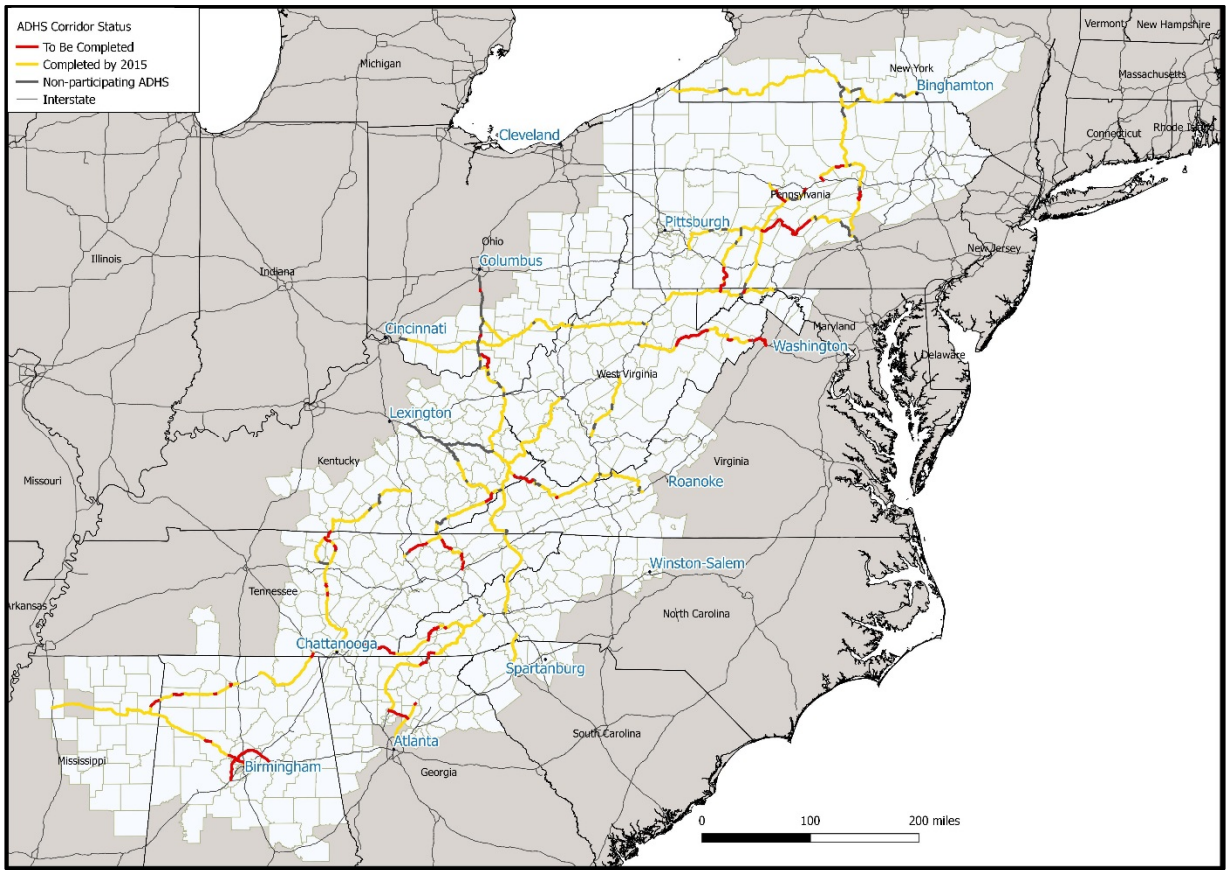
   d. Design Capacity, and

   e. Ability to carry commercial trucks.

The Origin-Destination Matrices from these 13 models are combined into an overall regional OD matrix for the combined 13-state Region to provide an initial accounting of trips originating or terminating within the thirteen states served by the ADHS. Furthermore, the networks of these 13 state models are also combined into an overall assignable network to demonstrate likely routing for any travel into, out of, and through these states.

The statewide models alone, however, do not account for some significant other travel patterns and traffic sources served by the ADHS, including: (a) assignment of traffic on minor arterials, collectors, and local facilities; and (b) national long-distance truck and passenger traffic. For these elements of ADHS demand, state models are supplemented with other available data sources from the Federal Highway Administration including the NHPN (National Highway Planning Network) and FAF (Freight Analysis Framework), as well as data from state DOT sources. These supplementary sources make it possible to more completely estimate and more fully validate the size and performance of the travel markets served by the ADHS. Figure 5 shows the Traffic Analysis Zones (TAZs) resulting from this process, allowing loading of state and national traffic to the ADHS. There are 460 TAZs representing the 420 Appalachian counties. In other words, most of the TAZs are counties, though some counties have been split into two TAZs.

Figure 5: Traffic Analysis Zones relative to Appalachian Development Highway System



Source: EDR Group.

Highway Performance Monitoring System (HPMS) and Federal Highway Statistics

Because statewide models are typically validated to forecast traffic on major state facilities (at the principal arterial level and above), minor arterials, collectors and municipal or rural county facilities are not consistently represented in these models. For example, many of the statewide models load traffic onto state highways from "centroids" that represent areas as large as a quarter or a third of an entire county, without capturing the true distances or volumes of the local facilities that carry traffic to higher level roadways. While the state models demonstrate a level of trips generated in rural areas served by minor arterials and local roads, and give an indication of demand in these areas, they do not accurately reflect the true mileage and travel speeds on these lower classified systems. This is problematic for understanding the role of the ADHS because one of the key rationales for ADHS completion is its ability to replace slow and circuitous local routes with more direct and faster principal arterials or above.

For example, assume that a trip on a rural county roadway entails driving 50 miles at an average speed of 40 miles per hour to connect an origin and a destination 40 miles apart (as a straight line distance), effectively involving an hour and 15 minutes of travel time. Replacing this route with an ADHS corridor may enable the same trip to occur by driving 45 miles at a speed of 60 miles per hour, effectively involving only 45 minutes of travel time (reducing the vehicle hours of travel by 40 percent). Hence, it is important to account for (1) the likely overall vehicle miles of travel (VMT) currently carried on minor arterials and below, (2) typical speeds on these facilities, and (3) how these compare to the speed and design standards of proposed ADHS facilities when considering ADHS effects on these trips.

These speed and travel time effects are addressed by applying data on VMT, speeds, and car/truck percentages (observed in HPMS and Federal Highway Statistics) to trips generated in counties served by the ADHS. This brings the analysis to reasonable base-case estimates of historic and no-build future travel times and costs for traffic using minor arterials, collectors, and municipal or county facilities to reach areas that would be served by ADHS in the build alternative. Overall, applying HPMS characteristics to statewide model trips generated in rural areas yields traffic shares consistent with Federal Highway Statistics. Federal data show this traffic accounts for approximately 45 percent of VMT (and 52 percent of travel in rural areas) on highways in the affected states in 2014. When the differential in distance per-trip and average speed between ADHS standards and minor arterial, collector or local road standards are considered, these facilities account for a significant share of Vehicle Hours Traveled (VHT) savings associated with ADHS, details that often do not appear in the more aggregate statewide models.

NHPN and FAF Network and Estimates

Because the statewide networks described above have varying levels of detail, and each statewide model treats external (long distance national travel) differently, long-distance truck travel is estimated by utilizing additional Federal data sources to represent the routing of long-distance truck traffic into and out of the Appalachian states. The networks used for integrating long-distance truck traffic are national freight highway networks assembled by Oak Ridge National Laboratory in support of the FAF and the recently produced routable FHWA NHPN.

The FAF network comprises the base network for estimating the exchange of long-distance truck traffic between the highway networks in Appalachian states (including all ADHS corridors) and the rest of the

United States. This network has a comprehensive collection of national highway system and other roads throughout the nation.

The FAF network contains information on functional class but not on speed or capacity. Therefore, for link attributes that affect capacity but that are not in the FAF network (such as the number of lanes, speeds, and terrain), the methodology references national street data layers from TransCAD and/or the relevant statewide model networks to properly attribute the network. It is important to consider these attributes in the capacity calculations because ADHS corridor projects typically add lanes and other similar improvements to new or more direct highway routes. In some cases, the roadway characteristic of the FAF network have been checked against (or augmented by) data from the 2016 NHPN.

As with passenger travel, there are two types of truck freight flows: short and long-distance. Short distance freight flows are assembled from the statewide model trip tables, just as with the passenger trip tables described previously (for both base and forecast years). Long distance freight flows are disaggregated from the FAF commodity flow forecasts to county-to-county truck flows based on industry-level employment and then further into the ADHS TAZ structure (derived from statewide models as described above). Tests were conducted during the research process.

Use of VMT, VHT, and Trips at the Corridor Level

Given the all-sources approach to developing a large-scale regional travel model to analyze the ADHS, it is important to note that the VMT, VHT, and trip estimates for each ADHS corridor do not reflect simply an improved performance for traffic counts that may be shown on existing flow maps of affected areas. Instead, because the methodology accounts for the re-assignment of national truck traffic, statewide traffic, and traffic from collectors and local facilities, the VMT and VHT benefits shown at the corridor level are national in nature, reflecting re-routing of traffic to and from destinations not currently served, and patterns extending beyond any given immediate corridor area. Specifically, corridor level estimates must be understood to account for:

(1) Re-assignment of traffic from multiple collectors and local facilities onto the new faster and more direct ADHS routes.

(2) Transportation savings outside of the corridor area occurring due to relief of multiple bottlenecks and disbursed traffic on competing lower-capacity routes currently being utilized.

(3) Transportation savings occurring due to business migration into corridor areas, making jobs, goods, and services not locally available today accessible with much shorter travel times in the future.

(4) Transportation savings occurring on future trips due to background economic growth not accounted for in today's counts.

These four considerations, resulting from the all-sources methodology, are vital to properly measuring the transportation benefits and impacts of corridor-specific investments shown in chapter 5.

Transportation Efficiency Impacts

The transportation performance and efficiency effects of the ADHS are primarily estimated based on the travel methodology described above and monetized into transportation benefits (see below). Sources of improved efficiency result from: (1) shorter travel distances (measured in terms of VMT) due to more direct routing between origins and destinations served, and (2) shorter and more reliable travel times (measured as VHT) due to higher highway design speeds and additional capacity on ADHS corridors.

Mileage Associated Impacts include factors such as the reduction in vehicle operating costs (from reduced fuel consumption as well as wear and tear on vehicles), reduced crash costs (from crash rate reductions associated with higher ADHS design standards as well as from reduced mileage traveled), reduced emissions costs (from reduced mileage traveled), and logistics/supply chain savings (associated with more efficient use of the time goods spend in transit, reduced likelihood of spoilage and other savings associated with streamlined freight operations).

Time Associated Impacts include factors such as reduced time spent in transit for goods, reduced travel time for individuals and less "reliability time" spent waiting for goods with uncertain arrival periods. Because the networks currently (or historically) used in the absence of the ADHS are exceptionally low capacity, lack opportunities to pass slower vehicles, and are particularly subject to weather events, flooding or seasonal variation, the gain in reliability leads to "reliability time" savings, which account for a significant share of travel time savings reported in subsequent chapters.

Market Access Impacts

In addition to more efficient routing and travel conditions for existing traffic, the ADHS is expected to expand the mix of workers, visitors, products, and business relationships available to areas served by the system. This aspect of performance is regarded in the report as "Market Access," measured in terms of three key concepts:

Workforce Access represents the magnitude of the workforce that a business can draw upon to get workers. A larger workforce typically enables businesses to get more specialized workers that better match to their needs. For purposes of this study, the population accessible within a 60-minute commute was used as a proxy measure to represent comparative differences (and changes) in workforce access among locations. Workforce access is typically enhanced in cases where ADHS corridors improve speeds or reduce the mileage needed for potential workers to get to or from an Appalachian county to a potential place of work. Improvements in labor market access enable existing businesses to be more productive by increasing the size and competitiveness of the available workforce in any given occupation. New businesses can also be attracted to Appalachia as a result of these improved labor market conditions.

Supplier and Delivery Market Access is defined in terms of the same-day truck delivery market that can be reached from any given business location. This is the area to which a truck can travel and return in the same day–allowing for three hours travel each way and one hour for loading and unloading at each end of the trop. For purposes of this study, the employment accessible within a 240-minute drive time was used as a proxy measure to represent comparative differences (and changes) in business delivery access among locations. As with labor market access, delivery market access is also enhanced

in cases where the ADHS corridors improve speeds or reduce the mileage needed for goods to be supplied to factories in Appalachian counties or for the purchasing of goods made and sold from Appalachian counties. Improvements in delivery market access enable existing businesses to be more productive by enabling scale economies, thus enabling producers to enjoy lower prices for the inputs of production, as well as a wider range of possible supplies that can be used to make and sell goods and services. In addition to enhancing productivity for existing businesses, such improved market conditions are also anticipated to attract new business to Appalachia.

International Gateway and Inter-Modal Center Access is defined as average drive time from an Appalachian county to an inter-modal facility (airport, marine port, or rail terminal). These facilities provide for transfers of people or freight from roads to other modes of travel, and hence open up access to broader markets.

2.2 Factors for Valuation of Transportation Benefits

Both transportation system efficiency benefits (e.g., travel times, reliability, and safety) and market access benefits (e.g., labor and same day delivery markets) can be valued in dollar terms. The transportation system efficiency benefits are valued on the basis of both actual measurable dollar impacts (e.g., operating costs of vehicles and worker hourly costs) and the valuation that people ascribe to social benefits (e.g., personal time saved, as well as safety and environment improvements) that are based on surveys. Table 3 shows the per-hour and per-mile values used to derive specific transportation system efficiency benefits.

The productivity value of market access benefits was calculated by the TREDIS (Transportation Economic Development Impact System) economic model[4], using valuation factors consistent with elasticities of agglomeration benefits described in NCHRP Report 786 (*Assessing Productivity Impacts of Transportation Investments*, Transportation Research Board, 2014), with additional detail of differences by industry. The economic modeling analysis process is discussed further in Section 2.4.

For the benefit-cost analysis, all benefits and costs are discounted at both seven percent and three percent (consistent with USDOT TIGER guidance) to demonstrate the potential magnitude of benefits in relation to costs, as well as to demonstrate what is at stake when considering scenarios to accelerate completion of the system.

[4] http://tredis.com/.

Table 3: Monetary Values for Transportation Performance Benefits

Benefit Type	Value Per Unit
Vehicle Operation Cost *(per hour)*–Car	$0.14
Vehicle Operation Cost *(per hour)*–Truck	$0.45
Vehicle Operation Cost *(per mile)*–Car	$5.03
Vehicle Operation Cost *(per mile)*–Truck	$22.56
Passenger Time Cost *(per hour)*–Car	$18.45
Crew Time Cost *(per hour)*–Truck	$32.43
Reliability Time Cost *(per hour)*–Car and Light Truck	$18.45
Reliability Time Cost *(per hour)*–Freight Truck	$72.57
Safety Cost *(per incident)*–property damage only	$4,198
Safety Cost *(per incident)*–personal injury	$174,030
Safety Cost *(per incident)*–Fatality	$9,600,000
Emission Values *(per U.S. ton)*–NOx	$7,266
Emission Values *(per U.S. ton)*–SOx	$42,947
Emission Values *(per U.S. ton)*–VOC	$1,844
Emission Values *(per U.S. ton)*–PM	$332,405
Emission Values *(per U.S. ton)*–CO_2	$43
Freight Logistics Time Factor (per ton hour)–Freight Truck	$1.67

Source: Value of time, safety and emissions are from the Federal Highway Administration, TIGER Grant Benefit-Cost Guidance. Value of reliability is from NCHRP Report 786, Assessing Productivity Impacts of Transportation Investments, Transportation Research Board, 2014.All values adjusted to 2015 dollars. See also TREDIS® Data Sources and Default Values, TREDIS® Version 5.0, 2017.

2.3 Use of Interviews and Local Information Sources

To aid in interpreting and appropriately describing anticipated economic and performance benefits of ADHS, a set of interviews were conducted, focused on five corridors that have significant mileage and high costs for remaining segments to be built. They were corridors H, K, N, Q, and X1. The purpose of the "local" interviews were to obtain insight regarding: (a) what the expectation is for improved economic opportunities as a result of better highway performance and access, and (b) how the need for the project may have evolved since its initial proposal. Unsurprisingly, the remaining unfinished segments are those that pose a combination of challenging terrains and engineering constraints which affects the cost to construct. Some also pose higher environmental concerns.

The interviewees are noted in the Acknowledgements page at the front of the report. They included economic developers, regional/state transportation planners/engineers, county administrators, business trade organization representatives, academics, and non-profit organizational staff. The interviews focused on obtaining information regarding: (a) context in terms of perceived project benefits and beneficiaries, (b) expected impact of the project from the perspectives of transportation, the economy, and the environment, (c) changes in importance of the project due to changes in local or regional transportation conditions or economic conditions, and (d) project importance, remaining obstacles, and problems. Results were used to ensure that the overall system analysis findings (in chapter 4) and the specific corridor analysis findings (in chapter 5) are generally consistent with local observations.

2.4 Modeling Regional Economic Development Impacts

The transportation performance indicators and benefits described in section 2.1 and 2.2 represent factors that provide the basis and inputs to estimate the wider impacts on the regional economy of Appalachia and the 13 Appalachian states. These economic development impacts were estimated using the TREDIS (Transportation Economic Development Impact System) model. TREDIS is a computational framework for estimating regional economic impacts following a change in transportation facilities and operating conditions. The overall modeling framework consists of four elements that interact to produce results. Figure 6 shows the relationship between four key economic modeling components:

- The analysis of transport cost savings and associated travel efficiencies;
- The analysis of market access improvements and associated economic growth;
- The allocation of the above two effects among various sectors in the economy; and
- The application of a regional economic simulation and forecasting model that estimates impacts on supply, demand, and prices (for labor and capital), the flow of investment (to and from regions), and total regional economic impacts (on income and jobs) over time.

Figure 6: Components of Economic Impact Process

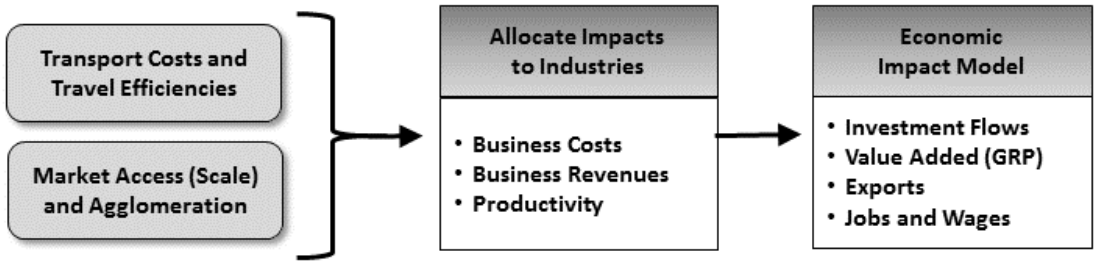


Figure 7 outlines four steps in the economic impact analysis process:

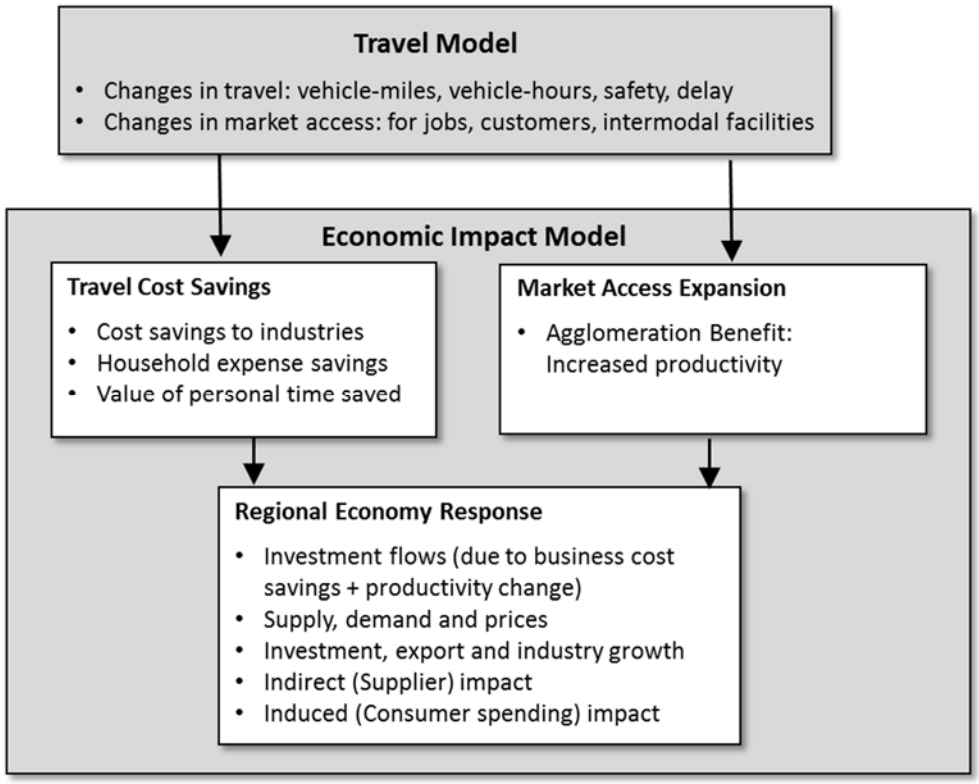
(1) Travel Model: The transportation analysis and performance indicators described in Section 2.1 provide the basis for changes in VMT (reflecting travel distance improvement) and VHT (reflecting speed improvement), as well as impacts on market access and connectivity improvements;

(2) Travel Cost Savings: A travel-cost analysis is applied to calculate the net value of the time and cost savings for businesses and households (Section 2.2), based on forecasts of expected future trips;

(3) Market Access Expansion: A market access analysis is applied to calculate how changes in access to population centers, delivery areas and access to intermodal terminals affect regional competitiveness and economic growth opportunities; and

(4) Regional Economic Response: A dynamic regional economic model is applied to estimate the long-range economic impacts and adjustments expected to result from the regional business cost and regional access changes.

Figure 7: Economic Impact Modeling Approach



Travel-Cost Response Element

The Travel-Cost Response element translates travel demand characteristics for future scenarios into direct cost savings that accrue to households and businesses. The travel demand characteristics are derived from the transportation performance characteristics described in section 2.1, and they include VMT, VHT, Trips, congestion levels, vehicle occupancy, and freight loads. These interact with values of time and operation costs of travel to determine direct dollar savings to households and firms. In addition, the travel cost methodology estimates the cost savings value of improved travel-time reliability for business. Industry benefits are further segmented among industrial sectors based on the Region's commodity mix and each industry's utilization of different travel modes.

Market Access Response Element

The second element of the economic impact methodology estimates impacts of improved access and connectivity, in terms of their effects on the scale of business markets and implications for productivity increases and revenue growth. These impacts are distinct from those estimated by the Travel Cost element in that they represent improvements in business operations and markets rather than cost savings for existing trips. Because firms have better access to labor, inputs, and consumers, and because consumers have better access to goods, the Region as a whole becomes more attractive place for business location (as described in section 2.1).

Economic Adjustment Element

The third element is the core economic impact model, which uses information on the direct travel cost savings and market access impacts described above, to estimate broader effects on productivity, net inflows of investment, business growth, labor costs, and migration of households. It also calculates additional "indirect" impacts on growth of business related to business suppliers, and "induced" impacts related to consumer re-spending of added worker income. Indirect effects reflect economic activity generated through regional business-to-business linkages in the supply chain. For example, if the pharmaceuticals manufacturing sector is forecast to grow in Appalachia, then businesses that supply materials and products to that sector will also benefit (as well as their suppliers, etc.). To the extent that these "upstream" suppliers are located within the Region, Appalachia will gain additional economic activity.

Induced impacts stem from increases in local consumer spending following a gain in personal income in the Region. To follow the previous example, the pharmaceuticals manufacturing sector also may increase total wage outlay. To the extent that the increase in wages is spent locally on goods and services, Appalachia gains additional economic activity as a result. The outcome of the economic impact model is a series of projections of changes in employment, business output, GRP or value added, and wage impacts by industry – for the Region and the thirteen Appalachian states.

2.5 Benefit-Cost Analysis

As a final step, the benefit-cost analysis element summarizes the time streams of future benefits and costs of transportation investment in the Appalachian Region. This analysis utilizes information from each of the elements described in section 2.4 and organizes them in terms of economic benefit measures. It then compares them with capital and operating and maintenance (O&M) cost estimates to develop net present values and benefit-cost ratios.

First, all benefits are estimated for the year 2045 (the forecast years for transportation performance estimation) and itemized by type: A) industry savings; B) out-of-pocket household savings; C) household time savings; and D) market access impacts. All benefit types are calculated separately for the Appalachian Region and for the entire U.S. For the first three benefits (A through C), which comprise direct travel efficiency savings, the portion of benefits accruing to the Appalachian Region was determined based on the number of local versus nonlocal trip ends. Market access benefits, element D, reflect additional sources of regional economic growth, and for those impacts, it is assumed that productivity gains and increases in international exports are a national benefit. But, that all of the benefits to the Appalachian Region related to the attraction of business activity will cancel out at the national level.

Second, each type of benefit is estimated over time between forecast years and extending out to the year 2075 to facilitate analysis of the present value of future benefit and cost streams. Benefit streams for each dollar of ADHS investment are assumed to support a useful asset life of 30 years from the year of construction. This is because of the length of this analysis period, and because ARC's current cost estimates include initial construction outlays only, excluding assumptions about the annual operation and maintenance cost, or preservation cost at the end of a project's useful life (30 years). These extended values were estimated on the basis of: 1) estimated growth rate in the underlying traffic volumes; 2) the planned program completion schedule (including both the anticipated 2045 completion schedule as well

as an accelerated schedule to complete by 2035); and 3) empirical research on the timing of market access impacts (see below). The application of these phase-in schedules yields dollar estimates for each impact type for all years in the forecast horizon.

In the final step, a discount rate is applied to determine the present value of the benefit and cost streams. The discounting is performed for costs and each of type of benefit (A through D) for two alternative real discount rates – 3 percent and 7 percent. The result of this step is a matrix of present values of benefits and costs. Finally, benefits, and costs are compared to determine net present values (present value of benefits minus costs) and benefit-cost ratios using alternative discount rates and regional/national perspectives.

3 Backcasting—Effects of ADHS to Date (1965–2015)

The purpose of this chapter is to provide information on the extent to which historic development of the Appalachian Development Highway System (ADHS) has supported the development of the Appalachian regional economy from the program's inception in 1965 through the start of 2016. The ADHS is planned to comprise 3,090 miles, and as of the end of FY 2015 (the period examined in this chapter), 87.7 percent of those miles were open to traffic and 83.4 percent were complete. (The percent open to traffic increased to 90.4 percent by the end of FY 2016.) This retrospective analysis is designed to provide insight into how the incremental development of the ADHS has led to a significantly more productive and competitive Appalachian economy, with more jobs, people and income than would be the case without it.

The analysis process represents a significant enhancement beyond prior studies in estimating the impacts to date of ADHS. It was developed using rigorous economic modeling that controlled for variation in both transportation patterns and the economy of Appalachian counties and the broader 13 Appalachian states over a span of 50 years. It also used a modeling framework (in terms of both highway network models and economic models) that was fully consistent with the forward-looking forecast analysis of ADHS completion that are addressed later in this report.

The retrospective analysis process used in this report is known as "backcasting," as opposed to the usual "forecasting" process that is normally used in transportation economic analysis. Forecasting studies normally start with a baseline forecast and then assess what would be the future effects of a hypothetical scenario in which a proposed new project is added. Backcasting studies, in contrast, start with a history in which planned (ADHS) investments have already been made, and assess what would have been the past effects of a hypothetical scenario if those investments were not made. The results of this backcasting exercise are then discussed in the broader context of how the ADHS system has complemented and reinforced other ARC economic development programs to enhance the Region's overall productivity and attractiveness for business investment.

3.1 ADHS System Construction to Date

Completion over Time

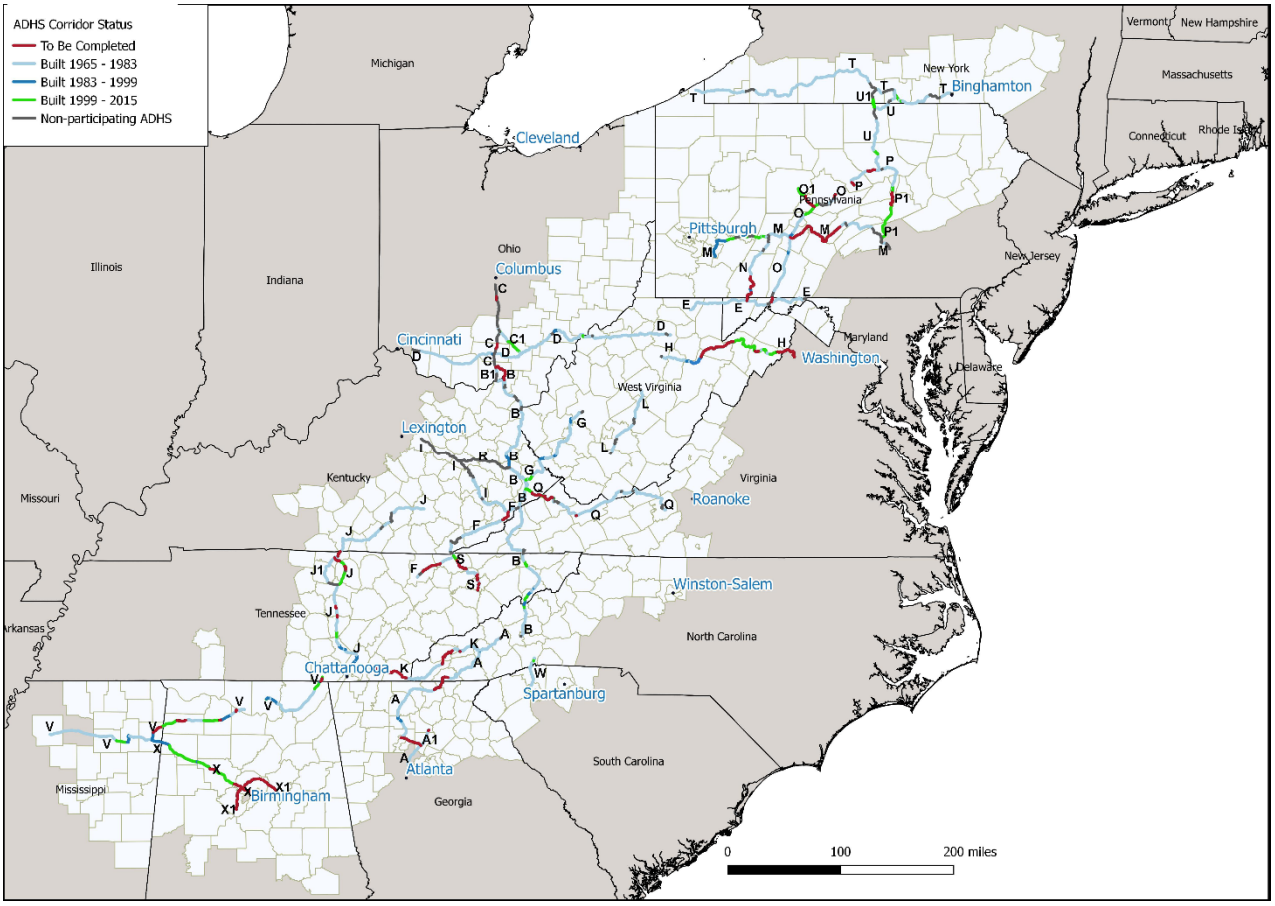
Over the 1965 to 2015 period, significant progress has been made in the development of the ADHS. Investment in this period has totaled $11.2 billion resulting in the completion of 5,119 lane-miles of highway added to the transportation system in the 13 states of the Appalachian Region. Table 4 shows the overall investment and infrastructure additions made over time, and Figure 8 shows the geographic location of corridors associated with each of three time periods defined for this study.

Table 4: ADHS Investment and Miles Added Over Historic Development Periods

	1965–1983	1983–1999	1999–2015	All Periods
ADHS Investment ($M)	$3,255	$1,661	$6,287	$11,203
ADHS Lane Miles Added	4,356	267	496	5,119

Source: ARC. Note that all investment numbers reflect actual dollars spent in various years within the specified time periods; they are not modified or adjusted to any constant dollar concept (and thus would be significantly larger if inflated to today's dollars).

Figure 8: ADHS Corridor Segments and Completion Status by Time Period



Sources: Appalachian Regional Commission

A large share of ADHS construction occurred in the first 18 years of the program, as the Region built high priority corridors and completed those highway segments that had fewer technical or environmental concerns. Additional progress on the more challenging and difficult segments has continued in subsequent periods through 2015, and is proposed to continue until completion of the system by 2045. While ARC records enable this general illustration of where and when progress on the ADHS has been most concentrated, it is important to note that the specific limits and characteristics of each individual highway improvement are beyond the available data and scope of the current report.

ADHS Improvements Complement a Larger Highway System

When considering the historic economic impact of the ADHS, it is important to understand the ADHS as one of several major highway expansion programs affecting the 13 Appalachian states in the period from 1965 to 2015. The ADHS segments completed over this time period total 5,119 lane-miles and serve 5.6 billion vehicle miles of travel annually. The ADHS has also made communities, regions, and businesses accessible to both the NHS and the interstate highway system—broader effects that would not have otherwise occurred.

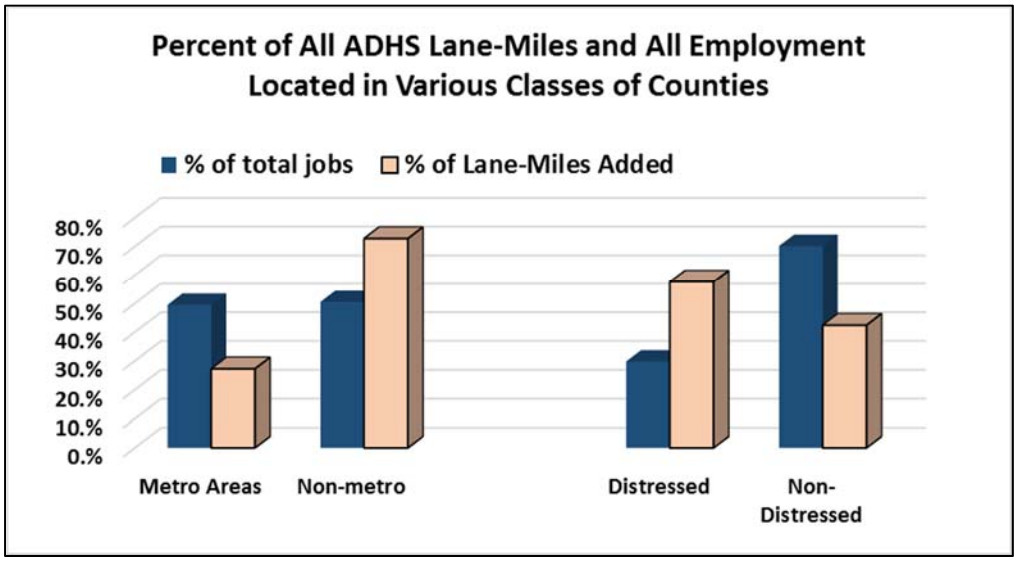
The ADHS investments are a small portion of the total highway miles in the 13 Appalachian states (See Table 5). However, they are intentionally concentrated in distressed and non-metro counties. Figure 9 shows that while the non-metro counties accounted for just half of total Appalachian Region employment, they received 73 percent of the ADHS lane miles. Similarly, distressed counties account for just 30 percent of regional employment but 58 percent of the ADHS lane miles added.

Table 5: ADHS Cumulative Lane Miles Added vs. Overall Highway Lane Miles Added

ADHS Investments	Periods		
	By 1983	By 1999	By 2015
Total ADHS Lane Miles Added	4,356	4,623	5,119
Total Lane Miles of All Highways in 13 Appalachian states	1,203,721	1,323,681	1,496,283

Source: Appalachian Regional Commission and Federal Highway Statistics Series 1965-2015.

Figure 9: Emphasis of ADHS Segments in Non-Metro and Distressed Areas

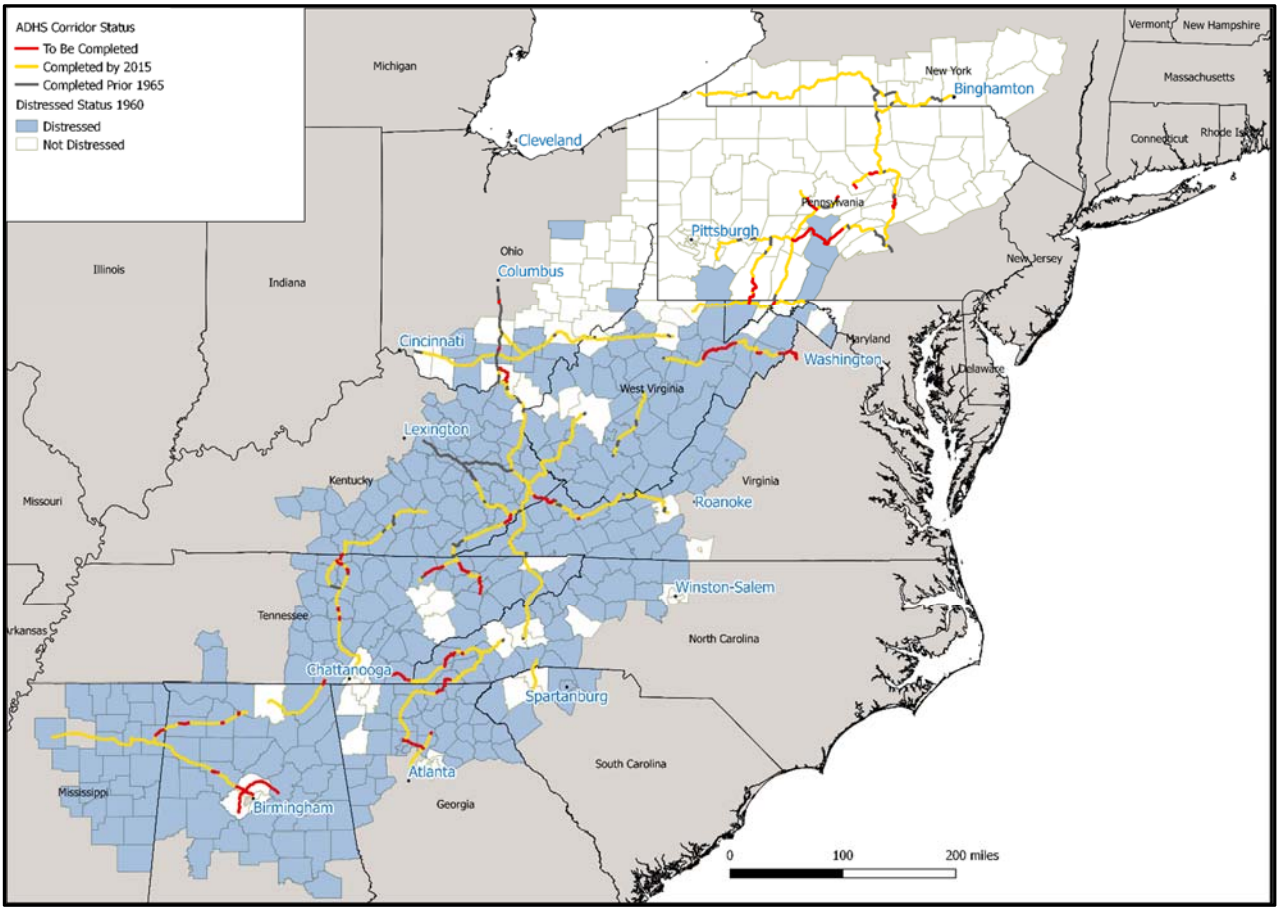


Source: EDR Group and ARC

Figure 10 illustrates the location of ADHS segments, and the counties considered to be economically distressed as of 1965 when the ADHS program was started. It illustrates how most of the ADHS corridors

were designed to serve as links from non-metro, largely distressed areas to non-distressed areas that included major metro areas at the periphery (and often outside the boundaries) of Appalachia.

Figure 10: ADHS Investments 1965-2015: Connecting Distressed Counties with Metro Areas



Source: Map generated by EDR Group based on data from ARC

The share of ADHS lane miles built in counties considered to be economically distressed as of 1965 is shown in Table 6. As poverty has been reduced (and definitions of economic distress have been revised), the share of lane miles now considered to be in economically distressed areas has fallen.

Table 6: ADHS Investment in Distressed Counties

ADHS Investments	Period of Highway Completion		
	1965–1983	1983–1999	1999–2015
Lane Miles built in Distressed Counties			
1965 Distress Definition	2,548	183	258
Total Lane Miles Built	4,356	267	496
Percent of Lane-Miles in Distressed Counties (1960 Classification)	58%	69%	52%

Source: Appalachian Regional Commission

3.2 Transportation System Performance

The ADHS enables both transportation system efficiencies and productivity gains from expanded market access. These benefits repeat every year and grow over time. They represent the value of:

a) reduced average travel times and travel distance changes (enabled by less circuitous and faster speed trips into, out of and through Appalachia);

b) enhanced reliability and reduced uncertainty (a reduction in the "reliability" or "schedule time" that households and businesses build into their schedules to allow for arrival time uncertainties on rural and local roads that are highly susceptible to inclement weather, crash delay, slow moving vehicles, or impassible conditions); and

c) enhanced business productivity (due to broader access to workers, customers, and trade partners).

Travel System Efficiency Benefits

Travel Time and Reliability Savings. The transportation network efficiency benefits of the ADHS are primarily in the form of travel time and reliability benefits. Table 7 below shows the daily vehicle hours of travel (VHT) time, and hours of reliability time saved in 2015 due to ADHS improvements as of four points in time. The numbers shown for each year reflect the cumulative effect of corridor projects completed prior to and within that year.

Table 7: Travel Time and Reliability Savings in 2015, from Completed Projects

Millions of hours saved, annually for all projects completed →	As of 1983	As of 1999	As of 2015
Total VHT Time Savings (millions of hours)	208.1	218.3	231.0
Car & Light Trucks	179.8	188.6	199.5
Freight Trucks	28.3	29.7	31.5
Total Reliability Time Savings (millions of hours)	116.3	122.0	129.1
Car & Light Trucks	100.5	105.4	111.5
Freight Trucks	15.8	16.6	17.6
Total Hours Saved (Reliability and VHT)	**324.4**	**340.3**	**360.1**

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

The analysis reveals that the ADHS now saves 231 million hours per year of travel time each year, representing 632,000 hours per day, compared to what would have been the case without the ADHS. This travel benefit is a product of faster speeds and growing traffic volumes over time (meaning more travelers benefit from highway completion). In addition to the hours of time saved by increased travel speeds and shorter routes on the ADHS, it is estimated that 129 million hours of "reliability time" are saved annually, representing another 360,000 hours saved daily due to greater reliability (reduced travel time uncertainty). This is slack time that businesses and people build into their schedules to allow for uncertainty in arrival times which they could more productively use if they can gain greater certainty about their arrival time. The total transportation system efficiency savings is equal to 360 million vehicle hours saved annually.

While the overall travel time savings are widely distributed geographically, the reliability time gains are located primarily within Appalachia as they result from the addition of passing lanes (which are most important on steep grades where some trucks cannot maintain full speed) and from the improved routing that reduces reliance on local roads, collectors, and minor arterials (that were formerly necessary to get from the heart of Appalachia to the larger national highway system). Combined, these two kinds of of travel time savings equate to over 986,000 hours each day, representing 360 million hours each year, that are saved because of the completed ADHS segments.

Spatial Distribution of Time Savings Benefit. Information is also available on the distribution of the time savings benefits by trip origin and destination. In this regard, it is important to note that there are two different geographies of interest: (a) the extent to which affected trips are serving locations in Appalachian counties, and (b) the extent to which affected trips are serving locations within the broader set of the 13 Appalachian states. While locations within Appalachia are of interest to assess effects on the target area, the 13 state departments of transportation (DOTs) that construct and fund the ADHS may be particularly interested in the wider statewide benefits for their constituencies. This report considers both study areas.

The benefits of ADHS investments accrue to all highway travelers, but are particularly important for long distance freight movements. Freight-carrying trucks account for just 4.3 percent of all traffic on the road systems of the 13 Appalachian states, but represent approximately 14 percent of all vehicle-hours of travel time savings attributable to these ADHS routes. A further breakdown of car and freight truck benefits is shown in Table 8, categorized by the mode and trip origin/destination. It shows that while nearly 68 percent of the car trips have an origin and/or destination within Appalachian counties, the ratio drops to 60 percent for freight truck trips. The importance of long-distance travel is also shown by the fact that 20 percent of car VHT savings and 31 percent of freight truck VHT savings accrue to trip ends located outside of the 13 Appalachian states. This indicates that the ADHS plays a particularly important role serving longer-distance goods movement and trade, connecting the Region to destinations throughout the U.S.

Table 8: Travel Time and Reliability Savings from Completed Projects, by Trip Origin/Destination Location

Savings as of 2015 *(millions of hours saved annually)*	Appalachian Counties	Appalachian States	Rest of U.S. States	Total
Total (millions of hours saved)	240.3	282.8	77.3	360.1
Car & Light Trucks	211.0	248.8	62.1	311.0
Freight Trucks	29.3	34.0	15.1	49.1
Percent of Total: Cars & Light Trucks only	67.8%	79.9%	20.1%	100%
Percent of Total: Freight Trucks only	59.6%	69.2%	30.8%	100%

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

Travel efficiency benefits of the ADHS are spatially distributed broadly throughout the entire region, as shown in Table 9 and Figure 11, and generally track with the location of completed ADHS segments. The table classifies Appalachian counties based on the extent of travel efficiency benefits (time and reliability savings) occurring there due to ADHS improvements done over 1965-2015. The “most affected counties” (shown in dark blue in the Figure 11) are those that account for around 20 percent of total travel benefits, while the “moderate affected counties” representing the next 50 percent of travel benefits from the ADHS. It shows that while the highest concentrations of today’s travel efficiency benefits accrue in the

areas targeted for direct investment since 1965, these benefits extend far beyond the core areas where direct investment was made, and are now benefitting other parts of the Region, including cities that are hundreds of miles away from where the initial investments were made.

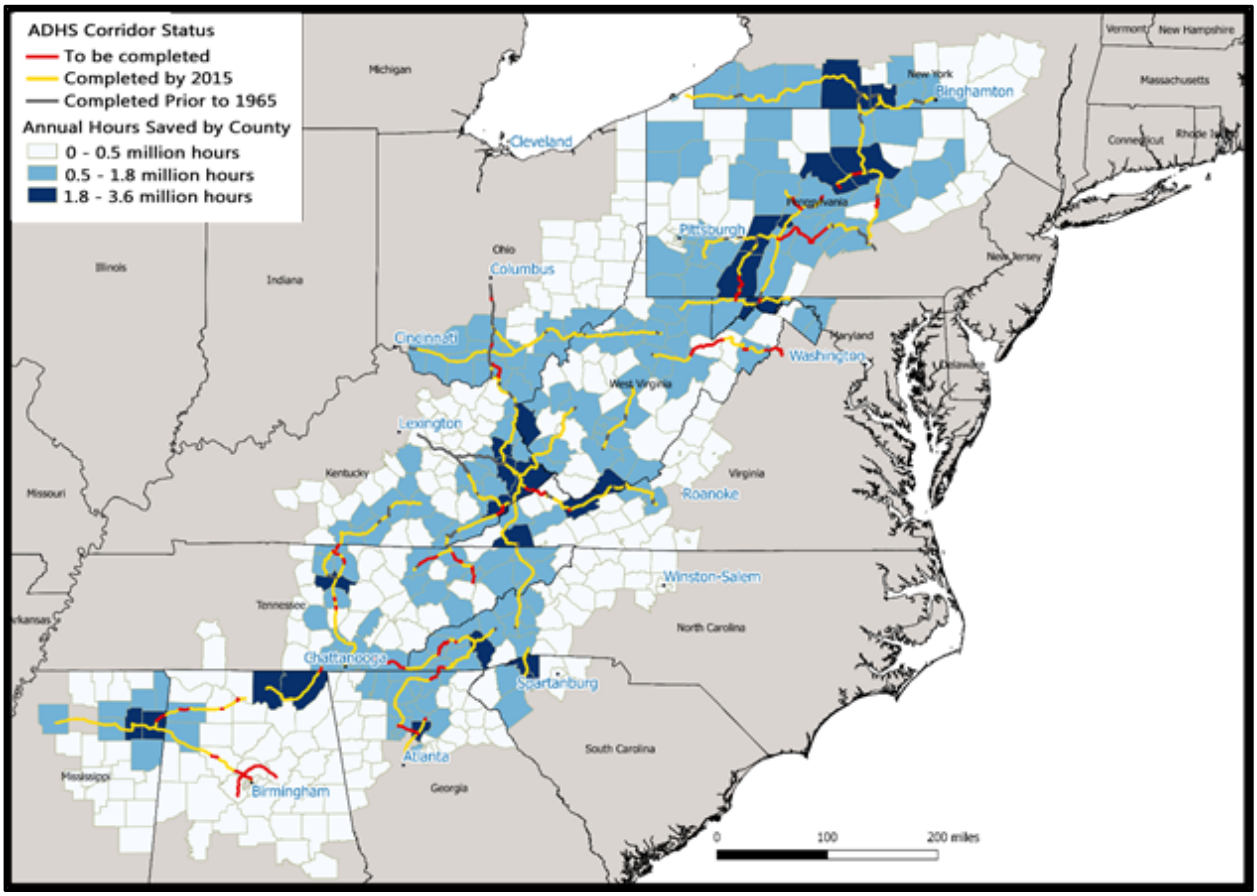
Table 9: Distribution of Travel Efficiency Benefits by County, as of 2015

Groupings of Counties by Benefit Levels	Percent of all Hours Saved	Number of Zones*
Most Affected Counties	21%	25
Moderate Affected Counties	45%	172
Other Affected Counties	34%	183
Total	100%	420

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

**Note: The 420 counties in Appalachia are represented by 460 zones in the travel model; the counties represented by multiple zones have large populations which were in the least affected category*

Figure 11: Annual Travel Efficiency Benefits in 2015 from Past ADHS Improvements



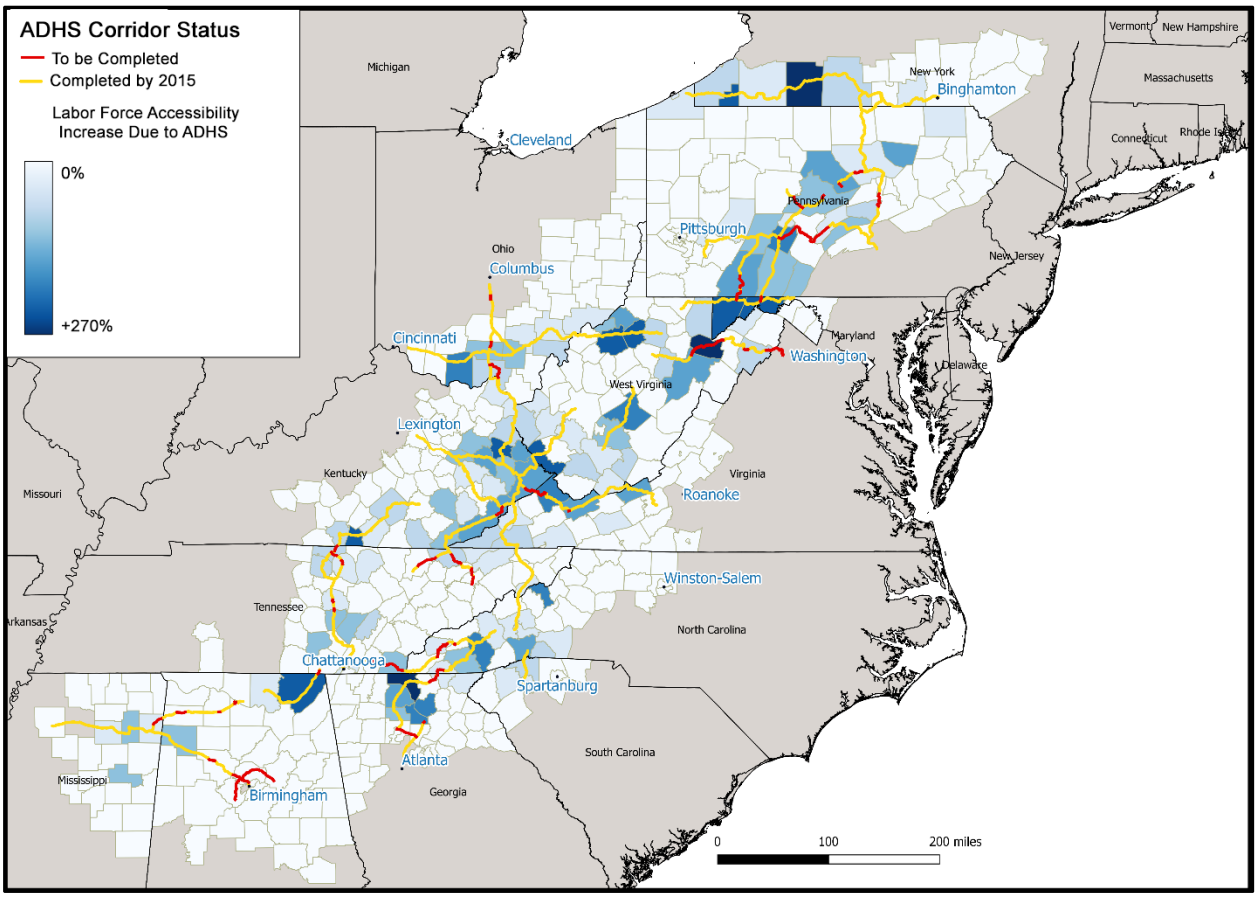
Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

Market Access Benefits

Besides providing travel efficiency (cost savings) due to travel time and reliability improvements, the ADHS has had substantial impacts on the accessibility of Appalachian communities to (1) labor markets, (2) truck delivery markets, and (3) intermodal terminals–both within and outside the periphery of Appalachia.

Labor Market Access. The ADHS investments enable firms located in counties served by ADHS corridors to gain access to more workers. That allows them to draw from a wider pool of highly qualified workers and access workers with specialized skills that match the products and services that they produce. This effect can be viewed in terms of the increases in number of workers that can reach an Appalachian business within a one-hour commute. Alternatively, it can be viewed in terms of increases in the number of job opportunities that can be reached within one hour by an Appalachian resident. In addition, the ADHS also affected access to broader product delivery markets. Figure 12 and Table 10 illustrate the extent of greater workforce access available to each county in the ADHS (as of 2015), that can be attributed to ADHS investment to date. For these measures, the improvement in access to population is used as a proxy to measure workforce access.

Figure 12: Increases in Accessible Workforce in 2015 from Past ADHS Improvements



Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

In this map for 2015, the shades of blue represent the ratio of people accessible to each Appalachian county within a 60-minute drive time in comparison to the number that would be available if ADHS were not in place. The darkest shade of blue correlates to counties where there are from 1.9 to 2.7 times as many people within a 60-minute drive of the indicated county in 2015 than would be the case without ADHS. It is notable (and expected) that the largest workforce access improvements occur near the location of now completed ADHS segments, and that they are mostly in remote areas away from the major population centers. Most of the workforce access gains are to distressed counties.

The map indicates that workforce accessibility gains tend to be greatest in those counties where ADHS links were constructed (or adjacent counties to them), but it also shows that some surrounding counties also benefit from this access. As shown in Table 10, much of the workforce accessibility gain is attributable to the initial boom in ADHS construction completed between 1965 and 1983, largely because during this period the ADHS made vital connections to the interstate and NHS systems also underdevelopment in that period, opening up the largest segments of workforce in Appalachia. However, further improvements in workforce accessibility continue to accrue in subsequent periods. This table also shows that those counties that were "most affected" in terms of travel efficiency benefits also had the largest gains in workforce market access.

Table 10: Average Workforce Access Gains Attributable to ADHS Improvements

ADHS Investments	Period of ADHS Link Completion		
	1965–1983	1965–1999	1965–2015
Most Affected Counties	19.3%	19.6%	21.7%
Moderate Affected Counties	8.2%	8.3%	8.7%
Other Affected Counties	0.9%	1.0%	1.1%

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

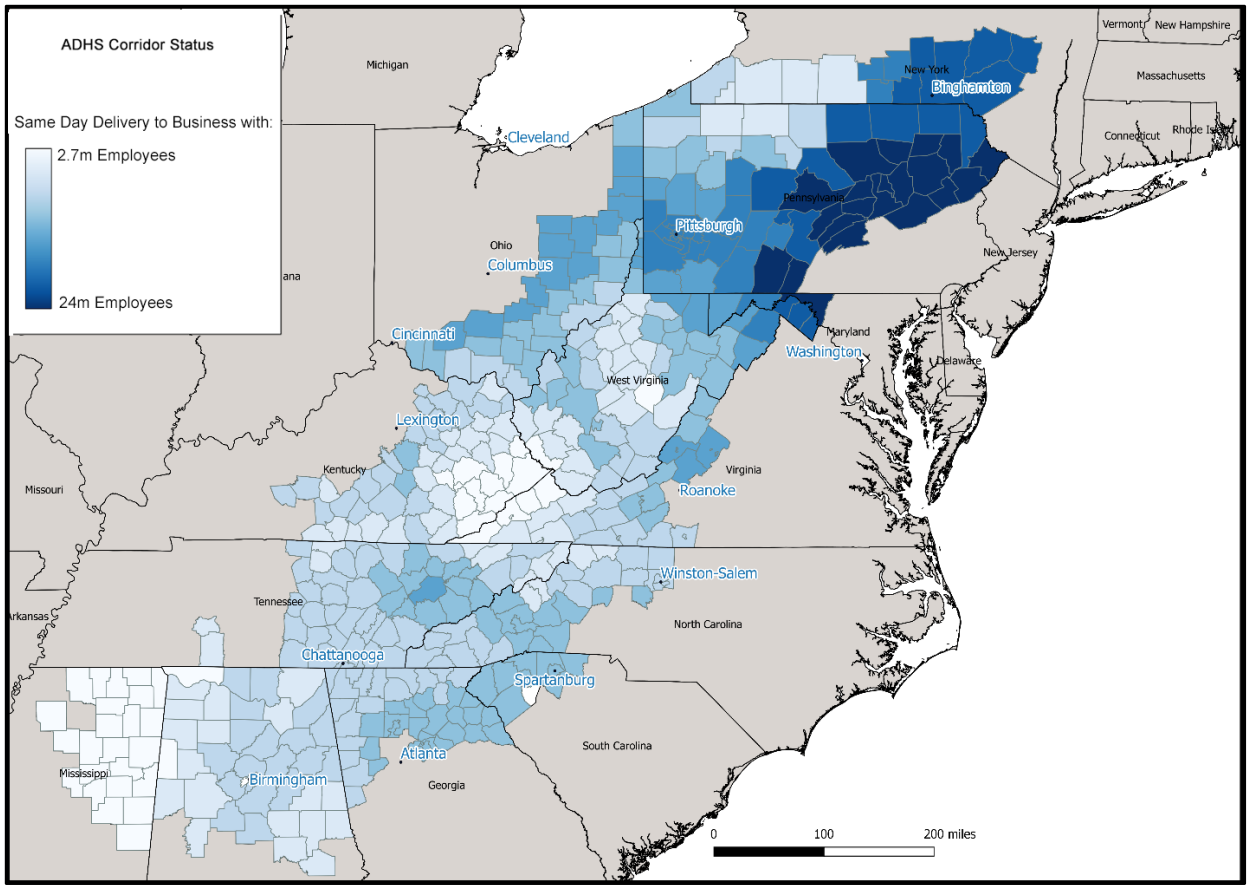
Same-Day Visit and Delivery Market Access. The ADHS system, by connecting with other Interstate highways and U.S. highways, also broadens the range of same-day markets for tourism travel and truck deliveries. By connecting the core of the Appalachian Region with outlying population markets, residents of outside areas have greater opportunities to visit recreation and tourism destinations in Appalachia. At the same time, Appalachian business locations can serve broader customer markets (both business-to-business markets and consumer markets) via same-day truck deliveries. For this study, the same-day market was measured in terms of the area that can be reached within a four-hour one-way trip. Figure 13 illustrates the size of same-day markets reachable from Appalachian counties as of 1965, *before* the ADHS program started.

Truck delivery markets are measured on the basis of the number of business employees (a proxy for business activity and potential trading partners) reachable from any given county within four hours of one-way travel (representing a same-day round trip). The darker shaded counties represent larger size markets accessible via same-day truck delivery. Not surprisingly, counties that could already serve major metropolitan area markets at the periphery of Appalachia are shaded. The white space (lack of delivery market) in the central region is very striking.

Figure 14 shows the counties that in 2015 have enhanced access to same-day markets as a result of ADHS improvements over the 1965-2015 period. The filling in of access for the central areas (which were white

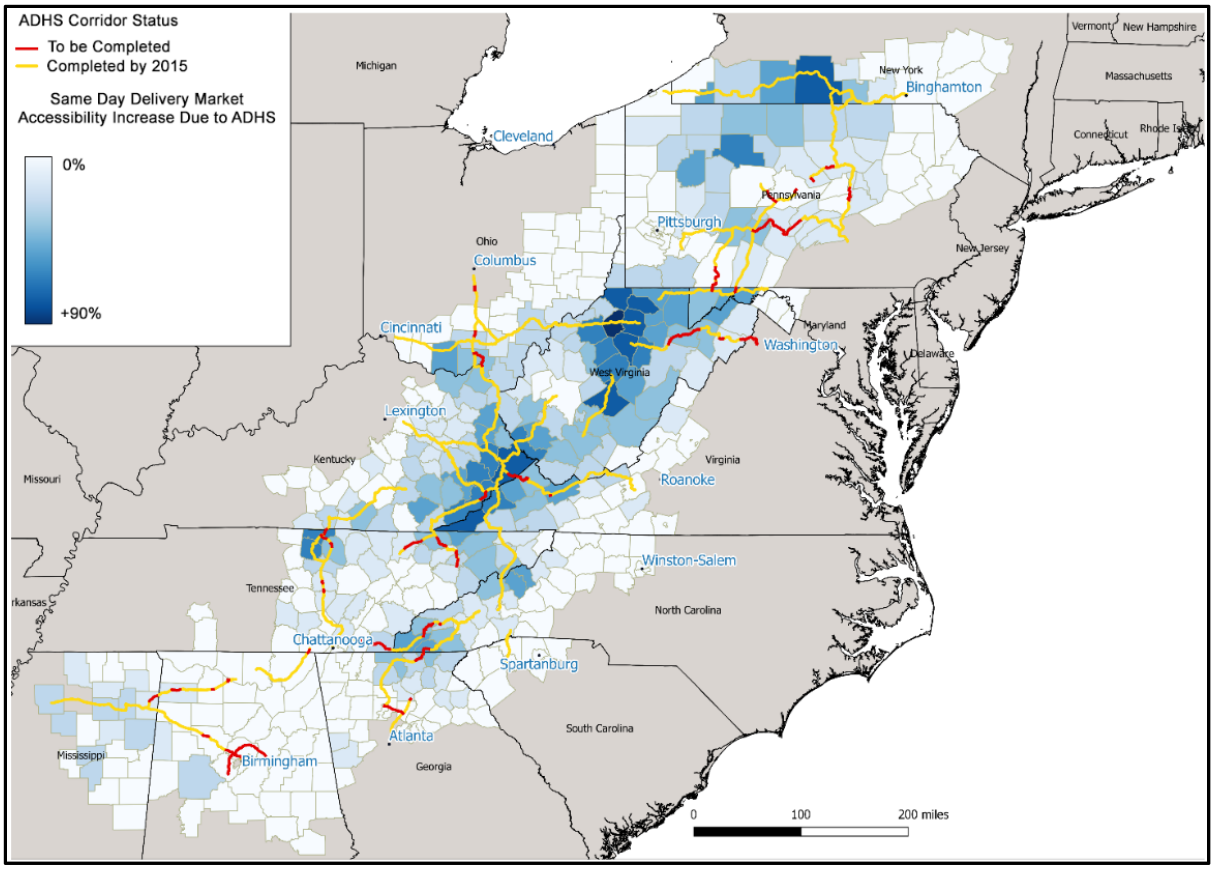
in Figure 13) is quite striking. The shades of blue in this graphic indicate variations in the ratio of workers within a four-hour drive time in 2015 with ADHS in place relative to the number that would be accessible without ADHS. As shown in the legend, the darkest shade of blue corresponds to counties that have experienced an increase of 63.8 to 89.3 percent in the economic activity (number of jobs) accessible within four hours with ADHS (compared to without ADHS) in 2015.

Figure 13: Relative Size of Same-Day Market Accessible from Appalachian Counties as of 1965



Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

Figure 14: Increase in Same-Day Delivery Market in 2015 from Past ADHS Improvements



Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

Table 11 shows the *percentage gains* in same-day truck delivery markets due to ADHS investments. There are two key findings. First, those counties that were "most affected" in terms of travel efficiency benefits also tended to have the largest gain in same day truck market access. Second, while the truck delivery access improvements appear more modest in percentage terms than the gains in workforce access, that is largely because of the larger scale of delivery markets and the complementary role of the ADHS with national highway networks for longer distance trips. From 1965 to 2015, the ADHS has evolved to also serve a role of reducing the travel time within a same-day delivery radius that is ultimately enabled by the National Highway System (NHS) and the Interstate highway systems. For example, ADHS may reduce a delivery time from four hours to two hours in 2015, resulting in significant impacts as shown in the previous chapter. However, with both NHS and the interstate systems in place, there are relatively few areas not within a same-day delivery radius of even the most remote ADHS core counties. The increases in available customer markets shown in Table 11 are more than sufficient to support economic impact as will be further described, and represent improved access to several key industry sectors.

Table 11: Increases Same-Day Market Access Due to ADHS Investments

Appalachian Counties	Periods		
	1965–1983	1965–1999	1965–2015
Most Affected Counties	7.10%	7.50%	8.30%
Moderate Affected Counties	6.10%	6.30%	7.00%
Other Affected Counties	1.80%	2.00%	2.30%

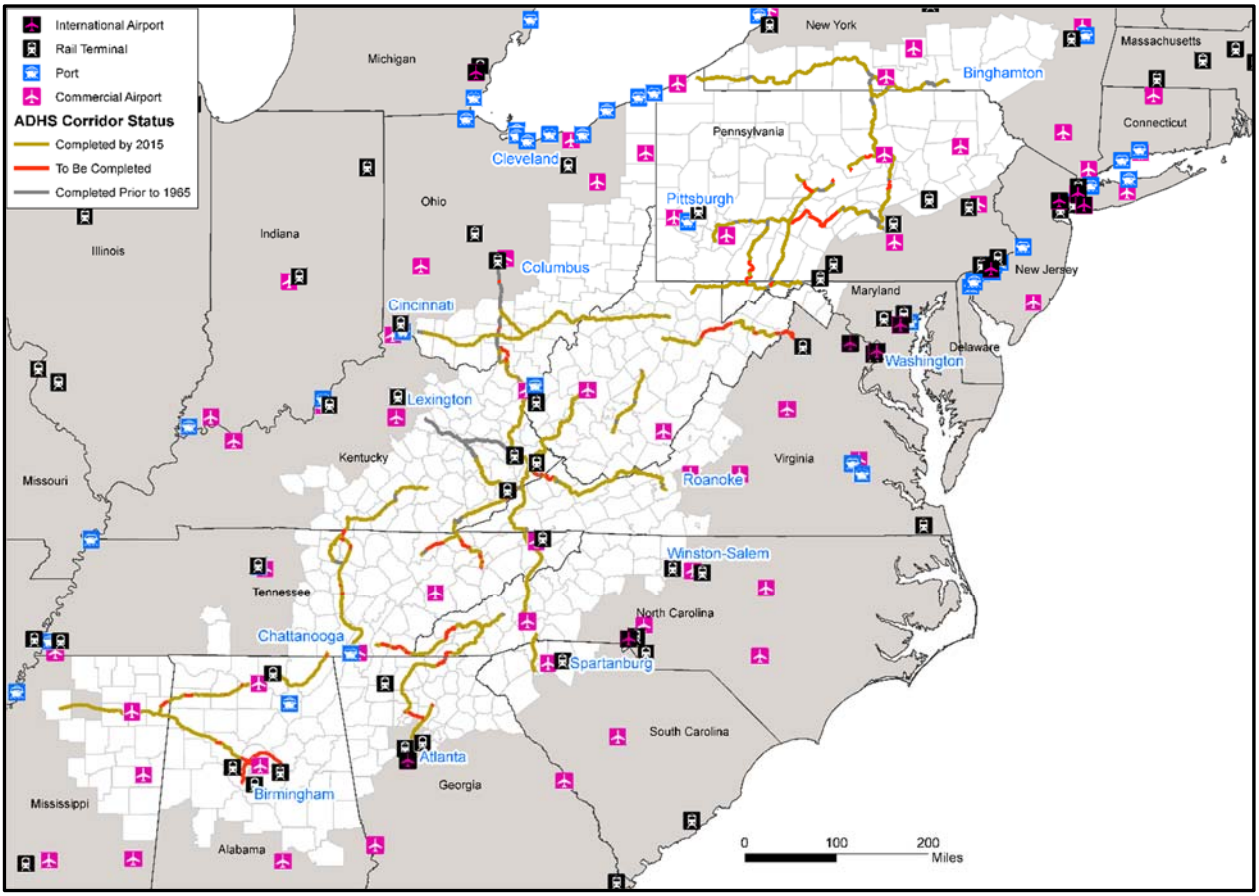
Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

Intermodal Terminal Access. An important aspect of the ADHS is that its highways provide connectivity to broader interstate routes (e.g., east-west links across the mountains) and thus enable access from the core of Appalachia to intermodal terminals—major airports, marine ports, and intermodal rail facilities. The locations of these intermodal facilities, relative to the ADHS, is shown in Figure 15.

The importance of access to these terminals is that they enhance Appalachian visitor and truck delivery markets beyond the same day markets noted in the preceding discussion. And they facilitate the logistics for domestic and global trade opportunities (see Section 3.5 for case study examples). A detailed analysis of enhancing rail, air and marine intermodal connectivity was conducted by measuring how the package of ADHS links completed between 1965 and 2015 has affected average travel times from a sample of locations within Appalachia to the nearest major national airport, marine port, and intermodal rail terminal. While there were many different values for the travel time improvement between various Appalachian locations and various intermodal terminals, the bottom line is that this analysis process indicated that intermodal access provides a 17.6 percent increase in market access productivity, over the impact of just same day highway access improvements. These effects are represented as business productivity and revenue enhancement, which are discussed in the economic analysis section below.

Figure 15: Locations of Intermodal Terminals Affected by ADHS Access

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and



Federal Highway Statistics.

3.3 Valuation of Transportation Benefits

The travel efficiency benefits are valued in dollars, stemming from the travel efficiency impacts. The travel savings (hours and miles) translate into reduced vehicle operating costs, business labor costs and shipper logistics costs. The savings in personal travel time does not affect the flow of money in the economy, but has a very real value to the people involved, and is included in the benefit-cost analysis. Table 12 shows the annual transportation cost savings occurring in 2015 as a result of ADHS completion to date.

Table 12: Value of Travel Efficiency Savings from Completed Projects as of 2015 ($ millions/yr.)

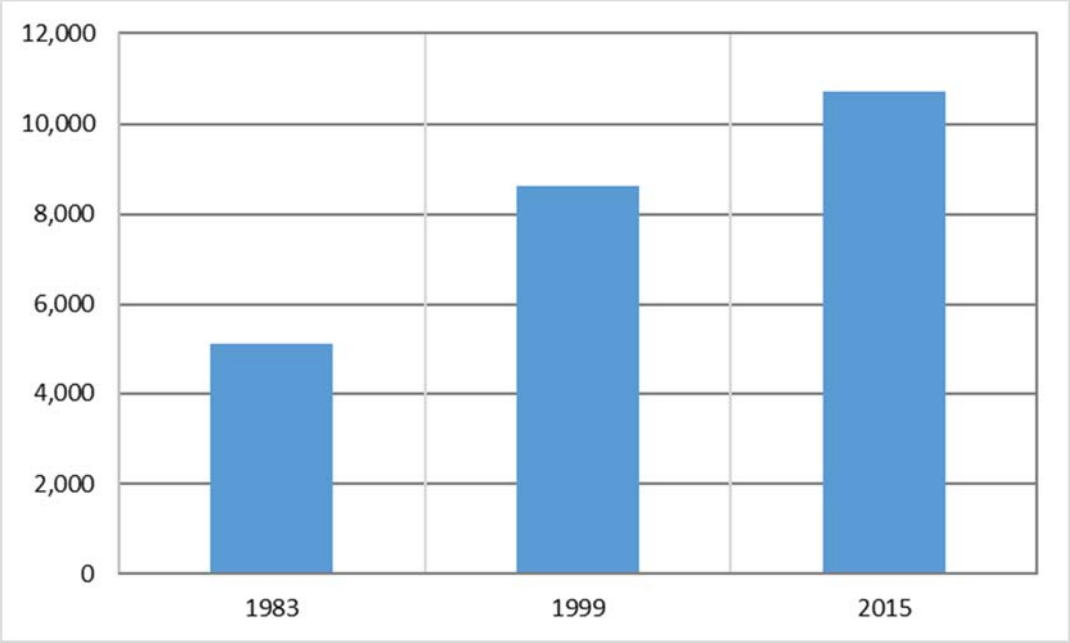
Category of Value	Freight Truck	Car and Light Truck	Total
Vehicle Operating Cost Savings	$930	$2,473	$3,403
Business Travel Time Cost Savings	$1,431	$2,261	$3,692
Shipper/ Logistics Cost Savings	$555	$0	$555
Personal Travel Time Savings	$0	$3,059	$3,059
Total	**$2,916**	**$7,793**	**$10,709**

Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics. Valuation factors are defined in chapter 2.
Note: All dollar values are in 2015 constant dollars.

The value of access benefits shows up primarily as an increase in economic productivity insofar as it enables firms to gain "economies of scale" from serving wider customer markets (including same day delivery and intermodal connectivity effects) and "economies of specialization" from accessing wider labor markets with more diversified worker skills. These effects are estimated as impacts on economic growth and competitiveness, which are addressed later.

Benefits Over Time. The travel efficiency benefits from earlier period ADHS projects are continuing to grow over time, and represent a product of on-going investment that is supporting and facilitating further traffic growth over time. It is important to look retrospectively at improvements made in different periods to understand that ongoing investments continue to add to the annual economic benefit of the system, and to see how today's transportation and productivity benefits of ADHS would be greatly diminished if the program had not continued to develop towards initial vision.

Figure 16: Annual Travel Efficiency Benefits from ADHS, Over Time (millions of 2015 dollars)



Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.
Note: Value of savings applies to all highway travelers.

3.4 Economic Development Impacts

Analysis Overview. The travel efficiency and access benefits discussed in the prior section affect business operating costs, household spending and economic productivity within the Appalachian Region, the broader 13 Appalachian states (including areas not in Appalachia), as well as in other adjacent states. Approximately 31 percent of the truck-related efficiency benefits and 20 percent of the car-related efficiency benefits occurring on ADHS segments actually accrue to outside parties who use the ADHS as part of longer distance trips going to/from the Region or passing through the 13-state region. The additional access and associated economic development benefits for outside areas have not been calculated as the economic development impacts are focused on the 13 Appalachian states. For the majority of trips that do originate or end within these states, the cost savings and productivity benefits lead to the creation of additional jobs, worker earnings and broader gross regional product (GRP) within Appalachia.

This study estimated those impacts using a multi-regional economic impact model that has been specially calibrated to show effects of transportation cost, access, and connectivity improvements. This modeling process has two internal steps. First, the various transportation impacts (including travel time and cost savings, reliability improvements, labor market and truck delivery market enhancements and intermodal connectivity) are applied to each of twenty specific industries in each of the 13 Appalachian states to assess the relative impact on its productivity and competitiveness. This step reflects the fact that some industries in some areas are more sensitive than others to changes in relative transportation costs, or changes in relative reliability changes, or changes in relative market size. The second step is to apply statistically validated cost-impact relationships and inter-industry trade relationships to calculate the expected impact on economic growth in each industry in the 13-state region.

Economic Impacts Over Time

Annual Effect. Overall, ADHS investment made over the 1965-2015 period enable the 13-state region to attract business investment and grow the economy. The result is that it is estimated to produce over $24 billion per year of added business sales, representing over $11 billion per year of added gross regional product (GRP) as of 2015, compared to what would be the case without the ADHS. This increased economic activity has helped create or support over 168,000 jobs with nearly $7.3 billion/year of added worker income as of 2015. Table 13 summarizes these economic impacts and Figure 17 shows how they have grown over time. It is important to note that while the economic growth effect grew most rapidly in the earlier 1965-1983 period, when the largest initial investment in ADHS construction was made, the economic growth effects recur year after year, and these sustained effects accumulate over time (and will continue to grow larger into the future) as economic gains from highway investment take time to be fully realized.

The vast majority of the economic growth impact is concentrated in the counties that comprise Appalachia. This is to be expected, since all of the ADHS highway miles are within Appalachia, and they predominantly serve trips with origins and/or destinations within the area. The broader impact on the rest of the 13-state region includes direct benefits for some additional industries, as well as wider indirect ("multiplier") effects on outside suppliers to Appalachian businesses. Even as the ADHS has enabled more Appalachian residents to commute to jobs in larger cities outside of the Appalachian counties, those workers have brought back the wages to be spent in their home communities.

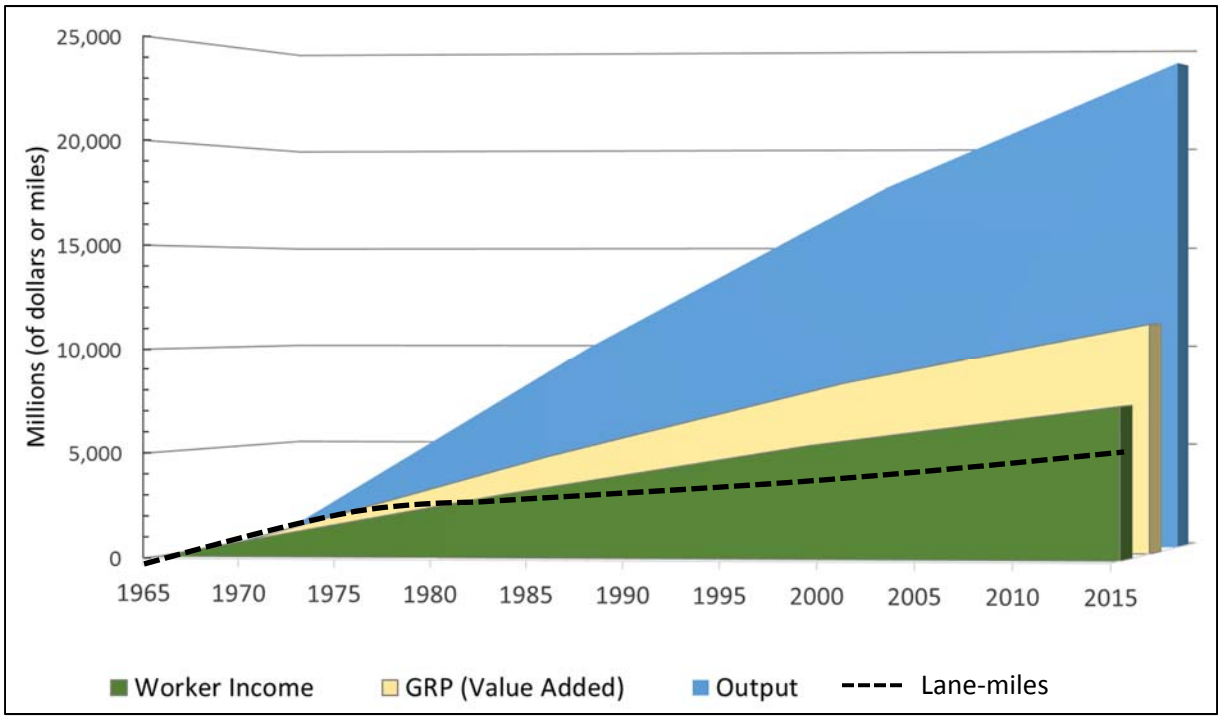
Table 13: Impact of ADHS Projects on the Economy of Appalachia and Appalachian States

Increase compared to "no build" case	As of 1983	As of 1999	As of 2015
13-State Appalachian Region			
Business Output (Revenue) in $M/year	$9,959	$15,207	$24,183
GRP (Value Added) in $M/year	$4,611	$7,037	$11,173
Worker Income in $M/year	$3,006	$4,587	$7,282
Employment level (single year)	69,385	105,897	168,336
Lane-Miles Built to date	4,356	4,623	5,119
Appalachia			
Business Output (Revenue) in $M/year	$8,063	$12,312	$19,578
GRP (Value Added) in $M/year	$3,733	$5,697	$9,046
Worker Income in $M/year	$2,434	$3,714	$5,895
Employment level (single year)	56,174	85,734	136,284
Lane-Miles Built to date	3,527	3,743	4,144

Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in 2015 constant dollars.

The growth of these impacts over time is illustrated in Figure 17. It is notable that the growth of lane-miles was most pronounced in the early years, though economic growth was more pronounced in later years. Since all impacts are in constant 2015 dollars, the interpretation is that economic development impacts are not immediate, but rather take years to accumulate. The program continues to create additional economic activity from investment well into the 21st century. This suggests that there may be additional potential for greater economic growth from continued investment to complete the system.

Figure 17: Impact of ADHS Completion to Date on the Economy of Appalachian States



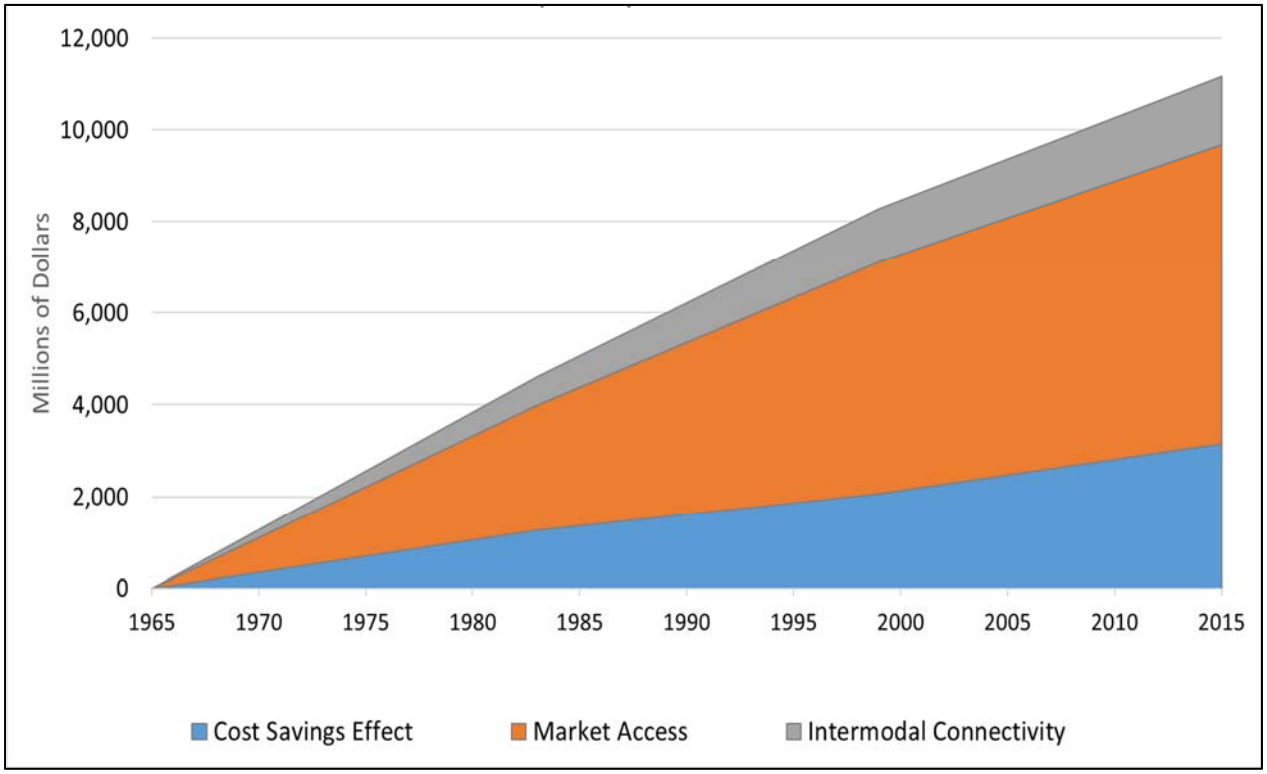
Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in 2015 constant dollars.

Cumulative Effect. Adding up the impact for every year from 1965 to 2015 (in constant 2015 dollars) yields a cumulative impact of approximately $388 billion more GRP generated in the 13-state region over 50 years, compared to what would otherwise be expected to occur over that time period. This result also reflects a total of 5.8 million additional job-years of employment generated over that same period. Note that this is a total effect and does not reflect any discount rate adjustment to represent a net present value.

Economic Impacts by Industry

The economic growth impacts of ADHS investment are concentrated in industries that: (a) are present in Appalachian counties, (b) are sources of national economic growth and (b) gain competitiveness from cost savings, enhanced market access and intermodal connectivity. The relative roles of these factors (cost savings, market access, and intermodal connectivity) in driving economic growth are shown in Figure 18 with market access benefits playing the largest role in generating economic development impacts.

Figure 18: Causal Factors Driving Economic Growth (GRP) Impacts of ADHS Completion to Date



Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in 2015 constant dollars.

The estimated industry mix of job and GRP impacts are shown in Table 14. This industry distribution of economic impact is notably different from the pattern of underlying industries concentrated in the Region, since the most affected industries (in terms of jobs and GRP) are those industries with the highest growth rate *and* greatest sensitivity to relative costs and market access improvements. The table below shows that growth industries such as professional and business services and tourism were the economic sectors that actually grew the most in the 13-state region due to economic competitiveness benefits from the ADHS.

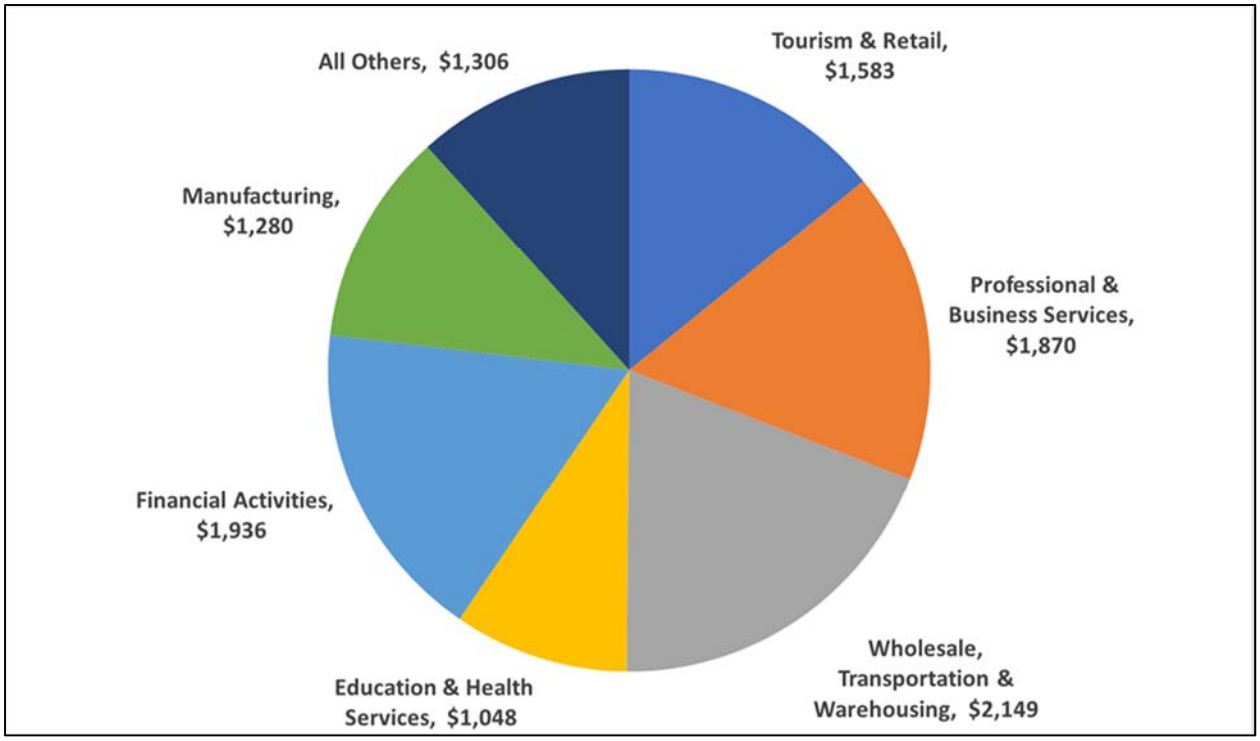
Table 14: Employment and GRP Impacts of ADHS by Industry as of 2015

Industry	Added Jobs (Compared to No ADHS)	Added GRP (in $ millions/year)
Professional and Business Services	34,657	$1,870
Leisure and Hospitality (Tourism)	25,995	$804
Education and Health Services	19,751	$1,048
Retail Trade	17,165	$779
Financial Activities	18,044	$1,936
Manufacturing	12,313	$1,280
Warehousing	11,124	$607
Wholesale Trade	8,153	$1,083
Transportation	7,101	$460
Agriculture and Extraction	6,273	$357
Media and Information	3,049	$414
Construction	3,188	$181
Utilities	1,015	$316
Government	509	$37
Total in Year 2015	**168,335**	**$11,173**

Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in 2015 constant dollars.

This finding supports a conclusion that the ADHS has helped enable the Region to shift from a resource-based economy to a knowledge-intensive and service-based economy, following a trend also occurring outside the Region. The second largest share of employment gain is in leisure and recreational services, indicating that the access enabled by ADHS has supported growth of the Appalachian tourism economy. Among other top impacted industries are education and health services, financial activities, and manufacturing, all of which are integral to attracting and retaining the firms and workforce needed to sustain overall economic growth. It is also notable that in terms of GRP growth, financial services and manufacturing produce disproportionately more GRP income for the Region than their job impacts, a sign of their economic importance. Finally, there are significant GRP gains for wholesale and warehousing industries, which reflect the benefit of better transportation for supply chains. These major elements of economic impact are summarized by the grouping of industries shown in Figure 19.

Figure 19: Top Economic Sectors in Terms of GRP Income Growth Due to ADHS



Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in millions of 2015 constant dollars.

Economic Impacts in Appalachian Counties

While the economic impact modeling focused on region-wide impacts, it is also notable that those Appalachian counties that most directly benefitted from ADHS investments (in terms of time savings and access gains) also had higher employment growth than other Appalachian counties over the 1965–2015 period. This result can be seen in Table 15, which shows how changes in county employment growth over time relate to county differences in ADHS benefit (defined from Table 9).

Table 15: Employment Growth in Appalachian Counties from 1978 to 2015, by Strata of ADHS Benefit

Impact of ADHS Investments (from Table 9 in section 3.2)	Periods			
	1978–1983	1983–1995	1995–2015	1978–2015
Most Affected Counties	0.10%	43.50%	7.80%	54.90%
Moderate Affected Counties	-2.10%	36.70%	4.70%	40.00%
Other Affected Counties	-2.30%	31.80%	-1.30%	27.10%
Appalachian Region Total	-2.00%	35.00%	2.20%	35.20%

Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All dollar values are in 2015 constant dollars.

3.5 Case Studies: ADHS Connectivity to Inland Logistics Facilities and Global Trade

There is a growing recognition of the importance of inland intermodal logistics facilities which are the meeting point for highways with rail, waterways, and airports. In Appalachia, a number of these facilities have now been developed providing vital connections between modes, offering up cost and time savings for shippers, and connecting Appalachia to seaports and global markets. To highlight how the ADHS plays an important role in trade and economic development, the ARC team visited two Appalachian logistics facilities to better understand how they operate, link to the ADHS and generate economic opportunities for the Region.

Port of Huntsville (Alabama)–International Intermodal Center

The Port of Huntsville is in northern Alabama and includes multiple freight and passenger travel functions and economic development activities within a single 7,000 acre facility:

- Huntsville International Airport – providing passenger air transportation to numerous domestic and international destinations;
- International Intermodal Center – a multimodal freight logistics facility with both intermodal rail (truck-rail) activity and warehousing, as well as dedicated air cargo operations and facilities; and
- Jetplex Industrial Park – a 4,000 acre business park hosting 70 companies and providing 6,100 jobs for Huntsville area workers.

Figure 20: Port of Huntsville International Intermodal Center

A key enabler of this facility was the construction of Corridor V, running east-west from northern Mississippi through Alabama and into Tennessee. Corridor V provides direct access to the Port of Huntsville and is a full interstate (I-565) in this segment of the corridor, with easy linkages to the I-65 corridor with Nashville to the north and Birmingham to the south.

The international intermodal center (IIC) opened in 1986, assisted by an earlier industrial rail extension grant that was funded by a combination of local, ARC and Economic Development Administration (EDA) resources. The rail facility serves a Norfolk Southern east-west mainline route that provides inbound freight rail service directly from the ports of Charleston and Savannah, along with outbound rail to the northeast and connections to west coast markets. The heaviest freight rail volumes to the facility represent international goods from the ports that are then warehoused and distributed via truck to the Appalachian Region. But the facility has also allowed local companies to locate near the facility to receive and ship goods throughout the country.

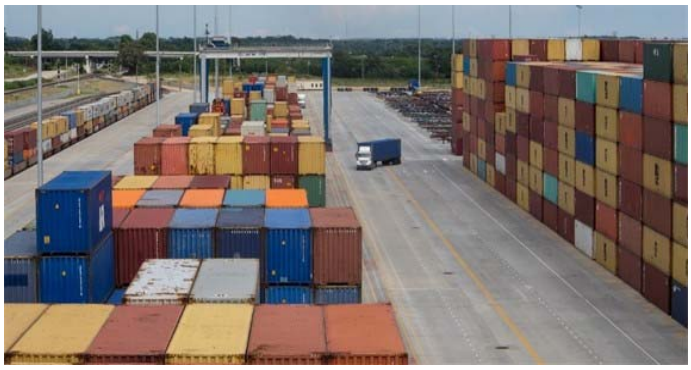
The air cargo facility sits directly next to the rail facility, and handles ten 747 dedicated air cargo planes per week helping Huntsville become the 17th largest airport for international air cargo in the U.S. The facility has included a foreign trade zone (FTZ) designation since 1983, establishing it as a permanent port

of entry. The port would like to see more ADHS corridors upgraded to full interstate status with limited access and no traffic lights, as Corridor V is predominantly U.S. highway 72 which limits the effectiveness of the corridor for long-distance freight trucking.

Greer Inland Port (South Carolina)

A more recently developed facility, the Greer Inland Port in South Carolina opened in 2013 to serve a very specific logistics opportunity in the Spartanburg/Greenville area. The BMW auto assembly plant located here in 1995 kick-started industrial development in the Region and was the original impetus to develop an inland port to facilitate imports and exports by container. Owned and operated by the South Carolina Ports Authority, Greer lies 212 miles inland from the Charleston deep water seaport. Similar to the Virginia Inland Port in Front Royal, VA, Greer has a dedicated Norfolk Southern "shuttle train" between the seaport and inland port that sends 200 containers ("boxes") each way every day. The inland port provides a reliable, cost competitive service to handle a 50/50 mix of: 1) exports (goods from the Region trucked to Greer that go by rail to the Charleston seaport bound for global markets); and 2) imports (goods arriving at Charleston, travel by rail to Greer for inland distribution).

Figure 21: Greer Inland Port



Constructed at a cost of $47 million and employing about 55 employees on-site, the Greer Inland Port handles 100,000 container lifts per year, ahead of forecast and already at 80 percent of current capacity. The facility is served by multiple highway connections which expands the customer base that is served by the inland port. For example, two of the largest shippers using the Greer Inland Port – the Eastman chemical company and John Deere (both in Tennessee) – use ADHS Corridor W (U.S. 25) to truck commodities to Greer for export. Greer has 50 acres of paved facility, including container storage space, and another 100 acres for later expansion.

The relatively abundant land for industrial development and strong highway system (combined with the Greer Inland Port) have helped the area attract major distribution centers such as Rite-Aid and Dollar Tree, with Michelin and Adidas two other major area shippers benefiting from Greer. BMW provided an initial anchor tenant and is the largest single customer generating about 65 percent of total volume at Greer. The success at Greer is leading South Carolina to develop a second inland port in Dillon.

Common Features of the Two Case Studies. As demonstrated by the two case studies, ADHS corridors play a direct role in helping Appalachia and its businesses connect to global and domestic trade, and world-class logistics facilities. An integrated multi-modal transportation system is necessary to successfully link Appalachian businesses to export opportunities and distribution to inland markets. The ADHS continues to play an important role in enabling inland logistics facilities, with trade and economic development benefits for the Region.

4 Forecasting—Effects of ADHS System Completion (2016–2045)

While the preceding chapter showed how past ADHS investments have provided transportation system benefits and economic growth impacts, further progress to complete the system will provide additional transportation benefits and economic growth opportunities. Specifically, completion of the full system will enable the originally envisioned set of point-to-point connections without missing links or impeded routing. While some "network" effects have been achieved to-date, system completion is expected to extend these to their full potential. For this reason, the effects of final completion of the ADHS include not only the incremental performance effects of improved accessibility, speed, and routing on the improved segments, but also some additional transportation cost savings and productivity gains associated with the existence of a seamless system connecting all envisioned origins and destinations served by ADHS.

4.1 ADHS Corridors Remaining to be Completed

The ADHS is part of a federal-state partnership, which (a) enables federal surface transportation funds (apportioned to the individual states) to be used to fund completion of ADHS corridors, but (b) places decision-making for project planning, funds allocation and implementation in hands of the states. The individual states provide completion time and cost estimates to ARC, which are then summarized in annual reports issued by ARC. While these plans vary from state to state, the frequent use of 2045 as full completion year (assumed in this report) comes from state plans.

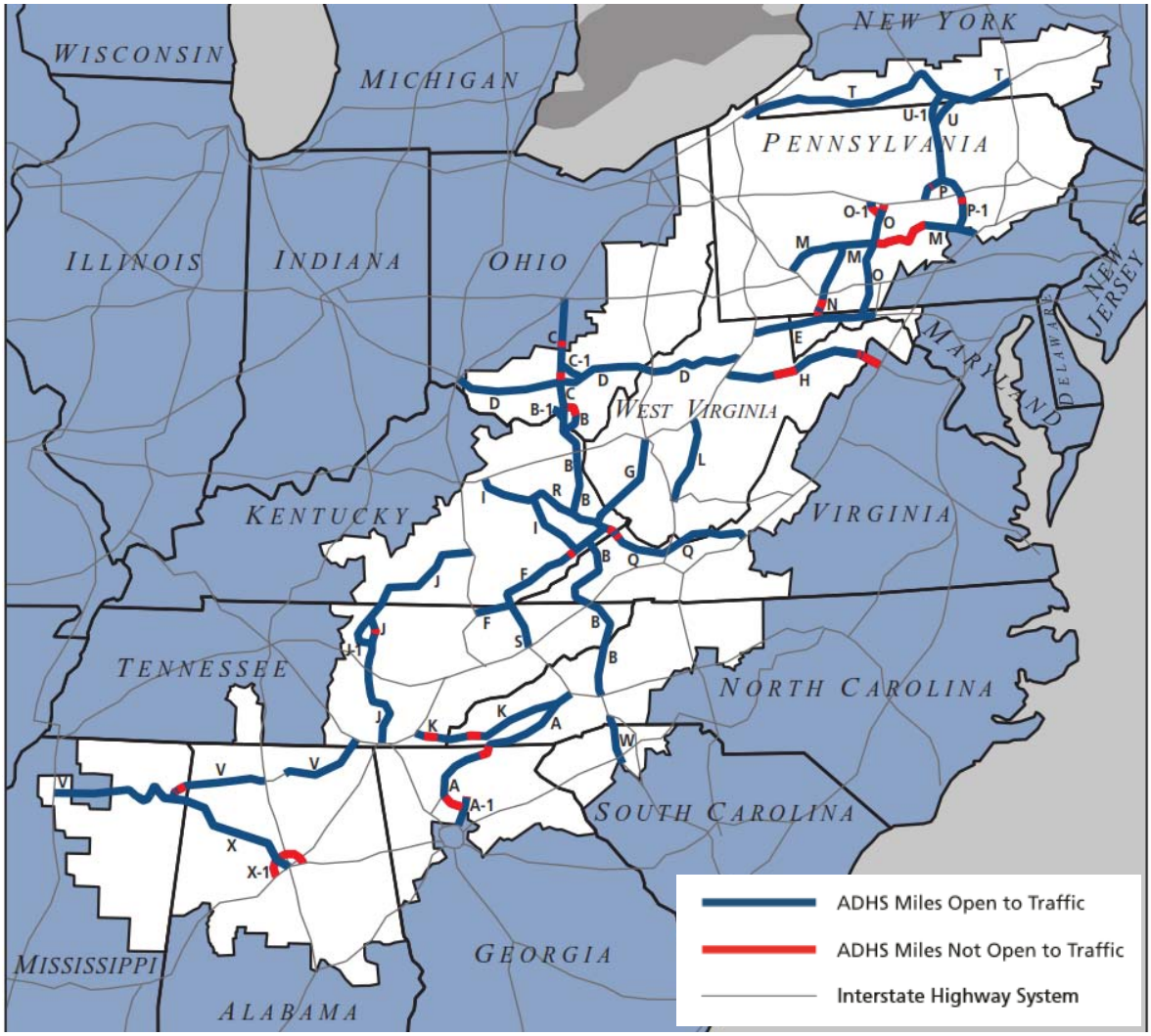
Currently, just 295 miles of the authorized ADHS network remains to be completed, though many of these remaining road segments have not yet been completed because they have difficult topography (which makes them more expensive to complete) and/or significant environmental challenges (which makes design and approval more difficult to achieve). See Table 16 and Figure 22.

Table 16: Future Completion of the ADHS by Investment and Miles Over Time

	2016–2025	2026–2035	2036–2045	Total
ADHS Cost to Complete ($M)	$3,374.0	$2,192.4	$5,348.4	$10,914.8
Highway Miles to be Completed	120.6	57.3	117.4	295.3

Source: Estimates based on Appalachian Development Highway System Cost-to-Complete Report, 2012; and Status of the Appalachian Development Highway System, September 2016
Note: Costs are in millions of constant 2015 dollars.

Figure 22: Segments of the ADHS Remaining to be Completed (as of September 30, 2016)



4.2 Transportation System Performance

ADHS completion will generate changes in travel mileage as well as travel time and reliability. Travel mileage changes include the offsetting effects of (a) providing more direct routes for some travelers, and (b) providing faster speeds that attract some travelers to go out of their way to shift from existing slow routes to the newer faster routes. The first effect generates reductions in total vehicle-miles of travel, while the second effect generates additions to vehicle-miles of travel, although they are offset by the value of time savings. Ultimately, travel models indicate that net changes in total vehicle mileage will be small, but travel time and reliability improvements will significant, as shown in Table 19. Therefore, this section focuses on benefits of improved travel time and reliability.

Travel Time and Reliability Savings. Table 17 shows the daily hours of vehicle travel time and hours of "reliability time" expected to be saved by 2045 as a result of ADHS completion by that year. The table presents savings for three points in time leading up to 2045, demonstrating the gains from incremental completion of projects after 2016.

Table 17: Forecast Travel Time & Reliability Savings from Phased Completion of ADHS by 2045

Millions of Vehicle-Hours Saved/Year as of →	2025	2035	2045
Total VHT Time Savings	19.9	24.5	78.1
Car & Light Trucks	17.8	21.8	68.9
Freight Trucks	2.1	2.7	9.1
Total Reliability Savings	11.0	13.5	43.0
Car & Light Trucks	10.5	12.8	40.7
Freight Trucks	0.5	0.7	2.3
Total Hours Saved (Reliability and VHT)	**31.0**	**38.0**	**121.0**

Source: EDR Group Analysis Using Consolidated Travel Models compiled by Parsons Brinckerhoff with further data on travel characteristics from HPMS, and Federal Highway Statistics.

The table demonstrates that when completed in 2045, the ADHS is expected to save over 78 million vehicle hours per year of travel time, representing nearly 214,000 vehicle hours per day, compared to what would be the case without ADHS completion. This effect is a product of faster speeds and growing traffic volumes over time. In addition, it is estimated that over 43 million vehicle hours will be saved annually due to greater reliability (reduced travel time uncertainty). This is slack time that businesses and people build into their schedules to allow for uncertainty in arrival times. It is time that could be used more productively if travelers gain certainty about travel times due to increased reliability of the highway network. The total transportation system efficiency savings is equal to over 121 million vehicle hours saved annually.

Spatial Distribution of Time Savings and Reliability Benefit. Information is also available on the distribution of the time and reliability savings benefits by trip origin and destination. In this regard, as with historical benefits described in chapter 3, it is important to note that there are two different geographies of interest: (a) the extent to which affected trips are serving locations in Appalachian counties and (b) the extent to which affected trips are serving locations within the broader set of the 13 Appalachian states. While locations within Appalachia are of interest to assess effects on the target area, the 13 state DOTs that are responsible for construction of the ADHS are particularly interested in wider statewide benefits for their constituencies. This report considers both study areas.

The benefits of ADHS investments accrue to all travelers, but are particularly important for long distance freight movements. Freight-carrying trucks account for just 4.3 percent of all traffic on the road systems of the 13 Appalachian states, but nearly ten percent of all vehicle hours of travel time savings attributable to completing the ADHS by 2045. A further breakdown of car and freight truck benefits is shown in

Table 18, categorized by the mode and trip origin and destination. It shows that 56 percent of the hours saved for car travel is for trips that have origins and/or destinations within Appalachian counties. The corresponding figure for freight truck trips is 44 percent, meaning that 56 percent of all freight truck trips affected by ADHS completion have an origin or destination beyond Appalachia. This highlights the national trade benefits of the ADHS. The national importance of ADHS travel time savings for long-distance travel is further shown by the fact that 16 percent of the car VHT savings and 20 percent of the freight truck VHT savings accrue to trip ends located fully outside of the 13 Appalachian states.

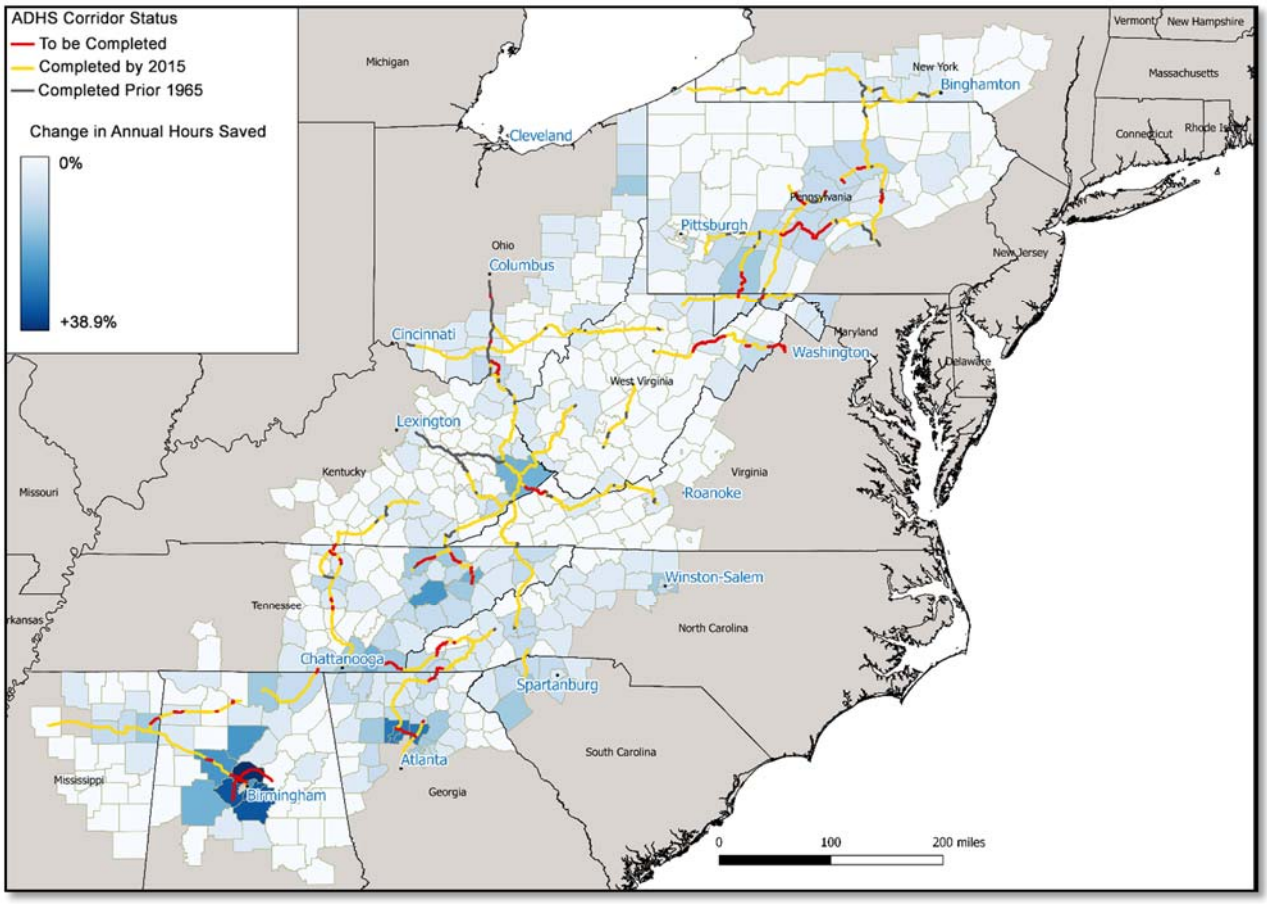
Table 18: Forecast Travel Time & Reliability Savings from ADHS Completion, by Location of Trip Ends

Millions of Vehicle-Hours Saved/Year as of 2045	Appalachian		Rest of U.S. States	Total
	Counties	States		
Total (millions of vehicle hours saved)	66.9	101.2	19.8	**121.0**
Car & Light Trucks	61.9	92.1	17.5	**109.6**
Freight Trucks	5.0	9.1	2.3	**11.4**
Percent of Total: Cars & Light Trucks only	56%	84%	16%	**100%**
Percent of Total: Freight Trucks only	44%	80%	20%	**100%**

Source: EDR Group Analysis Utilizing consolidated travel models compiled by Parsons Brinckerhoff, along with HPMS and Federal Highway Statistics.

While the travel time and reliability savings accrue throughout the United States, Figure 23 demonstrates that travel time savings and reliability gains from completion of the ADHS are expected to be most concentrated within the counties most directly served by the system. Of particular interest is Corridor X1, which offers robust cost savings due to its large market in the area surrounding Birmingham, AL.

Figure 23: ***Distribution of Travel Efficiency Benefits for Completing ADHS (2045)***



Source: EDR Group Analysis utilizing consolidated travel models compiled by Parsons Brinckerhoff, along with HPMS and Federal Highway Statistics.

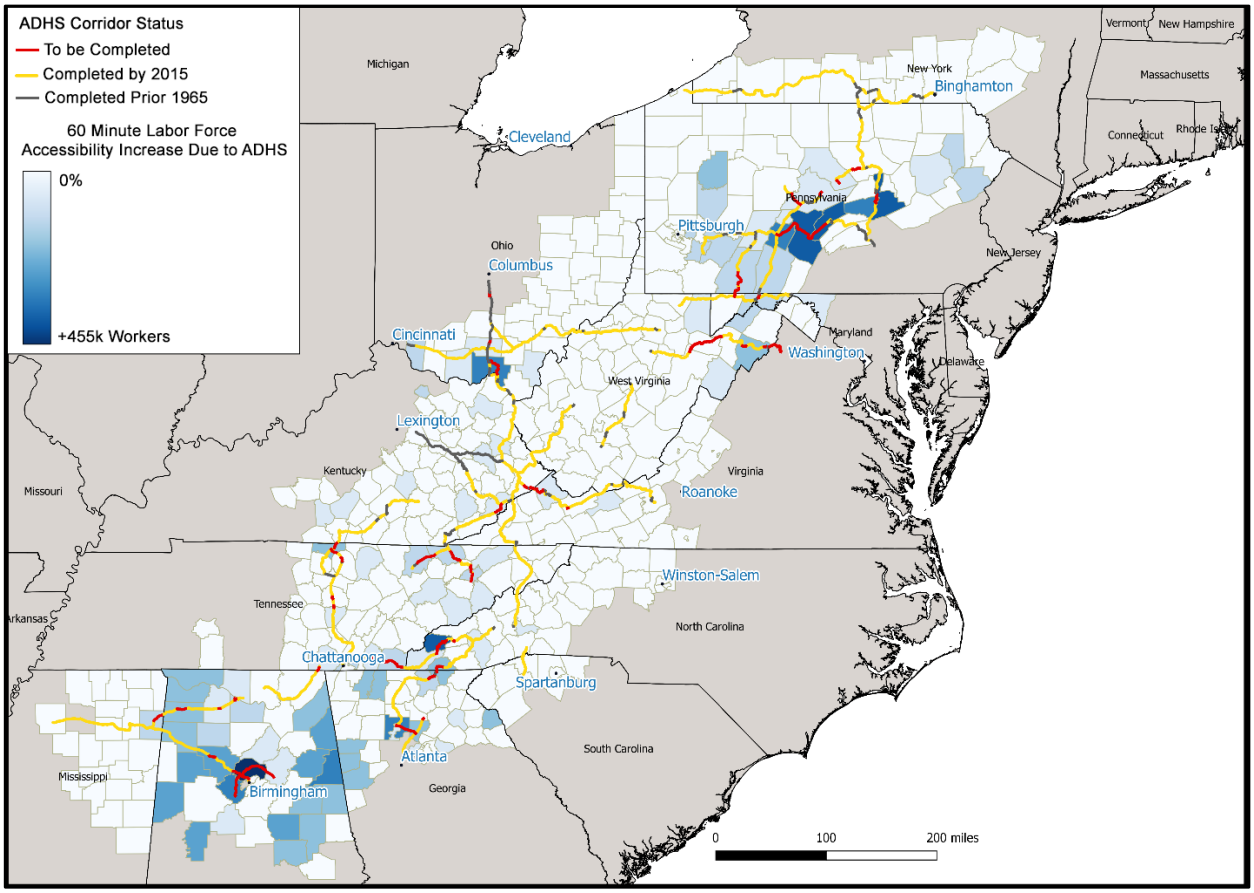
It is also worth noting that while the overall travel time savings are widely distributed, the reliability time gains are primarily within Appalachia. This stems from the fact that reliability improvements result from the addition of passing lanes (which are important on steep grades where some trucks cannot maintain full speed) and from improved routing that reduces reliance on local roads, collectors, and minor arterials.

Access Benefits

In addition to travel efficiency (cost savings) due to travel time and reliability improvements, the completion of the ADHS is expected to have substantial impacts on the accessibility of Appalachian communities to (1) labor markets, (2) truck delivery markets and (3) intermodal terminals—both within and beyond the Appalachian states. Each category of access benefit is described in the following pages.

Labor Market Access. Completion of the ADHS will enable firms in counties served by the ADHS corridors to gain access to 27 percent more workers within a one-hour commute. They will be able to draw from a wider pool of highly-qualified workers and obtain workers with specialized skills necessary for the products and services they produce. These effects are measured in terms of increases in the number of people who are reachable within a one-hour commute from each Appalachian county. Figure 24 demonstrates the extent and location of greater workforce access for each county in Appalachia as a result of ADHS completion in 2045.

Figure 24: Increases in Accessible Workforce in 2045 Attributable to ADHS Completion



Source: EDR Group Analysis utilizing consolidated travel models compiled by Parsons Brinckerhoff, along with HPMS and Federal Highway Statistics.

For this measure of labor market access, the improvement in access to population is used as a proxy for what is more technically the level of business access to working age individuals. For instance, it is especially notable that due to the reach of Corridor X1 and the size of the Birmingham metropolitan area, that highway improvement is expected to boost workforce accessibility for areas throughout Alabama.

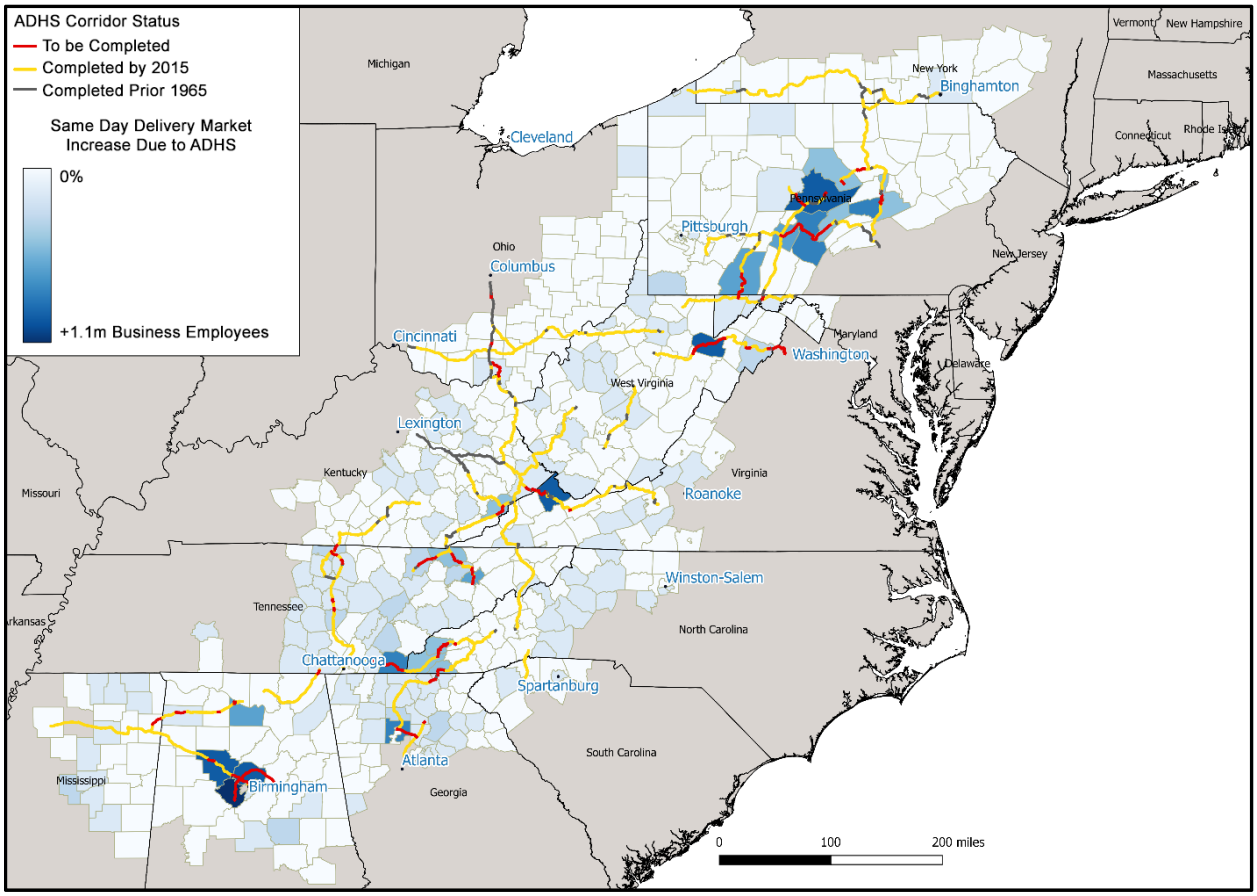
In this map, the shades of blue represent the ratio of people in 2045 expected to be accessible to the respective Appalachian county within a 60-minute drive-time in comparison to the number that would be accessible if ADHS was not in place. The darkest shade of blue correlates to counties where there is the largest increase in labor market access enabled by ADHS completion. Consistent with the pattern of historic investment shown in chapter 3, completion of the ADHS is expected to achieve the largest workforce access improvements in those areas most directly served by ADHS, i.e., areas that are remote from major population centers.

Same-Day Visit and Delivery Market Access. By connecting with other interstate highways and other principal arterials, ADHS broadens the range of same-day markets for tourism-related travel and truck deliveries. Because of the ADHS, residents of outlying population markets will have greater opportunities to visit recreation and tourism destinations in Appalachia. At the same time, Appalachian business locations can serve broader customer markets (both business-to-business markets and consumer markets) via same-day truck deliveries. For this study, the same-day market is measured in terms of the area that can be reached within a four-hour one-way trip.

Figure 25 illustrates the increase in the size of the same-day markets accessible by counties affected by the ADHS, relative to the expected level of access if the ADHS is not completed. Truck delivery market gains are calculated here on the basis of the number of business employees (a proxy for business activity and potential trading partners) reachable from any given county within a four-hour one-way travel radius. Altogether, firms located in counties served by the ADHS corridors are projected to gain access to 3 percent more same-day customers. While this figure may seem small, it represents a substantial potential impact on business profits. The darker shaded counties represent business locations with the highest percentage gain in accessible trading partners in 2045.

That figure also shows how completion of ADHS corridors will provide currently missing “links” between key markets served by ADHS and vital inter-modal facilities. Examples include Corridor X1 enhancing access to the intermodal rail facility in Birmingham, Alabama and Corridor H improving connections from West Virginia to the Virginia Inland Port in Front Royal.

Figure 25: Increase in Same-Day Market Access Attributable to ADHS Completion in 2045



Source: EDR Group Analysis Utilizing Consolidated Travel Models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics.

4.3 Valuation of Transportation Benefits

The travel efficiency benefits, such as hours of travel time saved, are valued in monetary (dollar) terms. For freight and business-related trips, the value of time represents business and labor costs and shipper logistics cots. Savings in personal travel time do not affect the flow of money in the economy, but have a very real value to the people involved (and are included in the benefit-cost analysis). In addition to travel time savings, vehicle mileage savings result in savings due to reduced exposure to crashes, reduced emissions, and reduced fuel consumption and other vehicle operating costs. Table 17 demonstrates the value of travel efficiency savings expected by 2045 (in terms of annual savings per year) from VMT and VHT reductions.

The value of access benefits is the increase in economic productivity occurring as firms gain "economies of scale" from serving wider customer markets (including same day delivery and intermodal connectivity effects) and "economies of specialization" from accessing wider labor and supplier markets (with more diversified and specialized worker skills and materials). The larger workforce, supplier and customer pools resulting from enhanced access make the Appalachian Region more productive and attractive for inward investment.

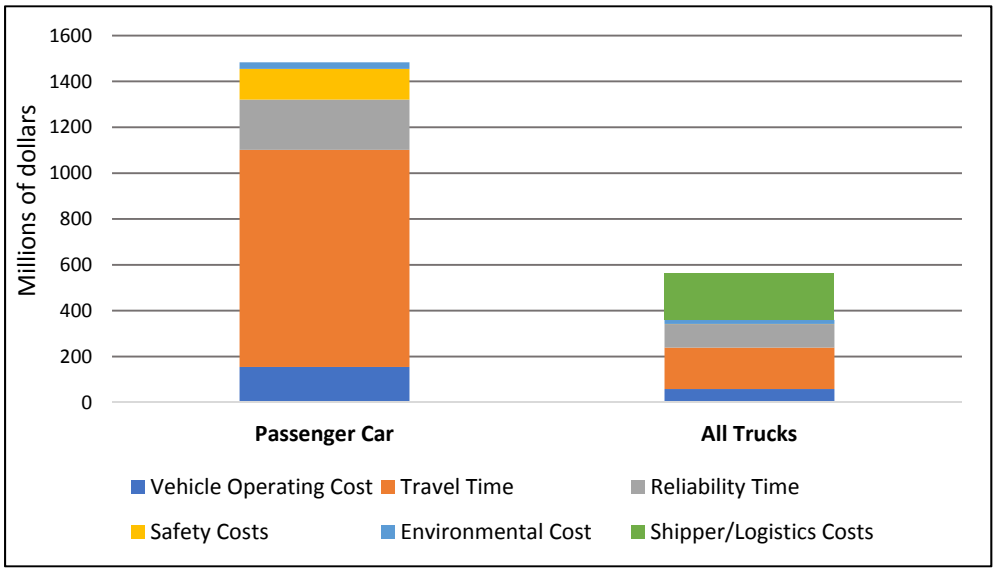
Only the "productivity effect" of market access is counted for the purposes of valuing net national benefits. However, the subsequent section on wider economic impacts will further address the role of market access with regard to regional competitiveness, business attraction and economic performance. Table 19 and Figure 26 show the value of travel efficiency savings and market access productivity gains expected in 2025, 2035 and 2045 (in terms of annual savings per year) from VMT and VHT reductions. Increasing levels of system completion combined with overall growth in the market for ADHS travel brings the annual undiscounted value of travel efficiency gains from just over $587 million by 2025 to over $2.2 billion in 2045, with the largest gains represented by travel time and reliability savings. It is notable that the largest source of benefit for car travel is time savings, while logistics cost savings are as important as time savings for truck travel.

Table 19*: *Travel Efficiency Benefits from Future ADHS Completion (in millions of 2015 dollars)

Category of Value	As of 2025	As of 2035	As of 2045
Vehicle Operating Cost	$48.2	$59.7	$212.5
Travel Time	$259.1	$319.0	$1,128.1
Reliability Time	$72.4	$89.8	$321.0
Safety Costs	$29.8	$36.4	$127.9
Environmental Cost	$6.9	$10.4	$45.7
Shipper/Logistics Costs	$42.6	$54.7	$201.4
Market Access (productivity gain only)	$128.1	$230.0	$248.9
Total	**$587.1**	**$799.9**	**$2,285.6**

Source: EDR Group Analysis Using Consolidated Travel Models compiled by Parsons Brinckerhoff, Federal Highway Statistics, and HPMS; valuation factors are defined in chapter 2. All numbers in millions of constant 2015 dollars.

Figure 26: Sources of Benefit Associated with ADHS Completion (as of 2045)



Source: Source: EDR Group Analysis utilizing consolidated travel models compiled by Parsons Brinckerhoff, along with factors from HPMS and Federal Highway Statistics. Valuation factors are defined in chapter 2. All values are annual benefits as of 2045, expressed in millions of 2015 dollars.

4.4 Economic Development Impacts

Analysis Overview. The transportation benefits discussed in the prior section affect business operating costs, household spending and economic productivity within Appalachia. These changes in money flows enable greater economic growth and development within the Appalachian Region, as well as broader economic impacts on the 13 Appalachian states as well as other nearby states.

This study estimates the wider economic impacts of ADHS completion using a multi-regional economic impact model that has been calibrated to show effects of transportation cost, access, and connectivity improvements. First, transportation impacts (including travel time, cost savings, reliability improvements, labor market and truck delivery market enhancements, and intermodal connectivity) are applied to specific industries in each of the 13 Appalachian states to assess the relative impact on the productivity and competitiveness of that industry within the Region. This reflects the fact that some industries in some areas are more sensitive than others to changes in relative costs, reliability, or market size. The second step is to apply statistically validated cost-impact relationships and inter-industry trade relationships to calculate the expected impact on economic growth in each industry in the Region.

The analysis focuses on impacts for the Appalachian Region and the broader 13 Appalachian states. However, it should be noted that approximately 20 percent of the truck-related efficiency benefits and 16 percent of the car related efficiency benefits actually accrue to parties located outside of the Appalachian states, who use the ADHS as part of longer distance trips going to/from the Region or passing through the 13-state region. The additional market access and economic development benefits for outside areas have not been calculated as the economic development impacts are focused on the 13 states.

Economic Impacts Over Time

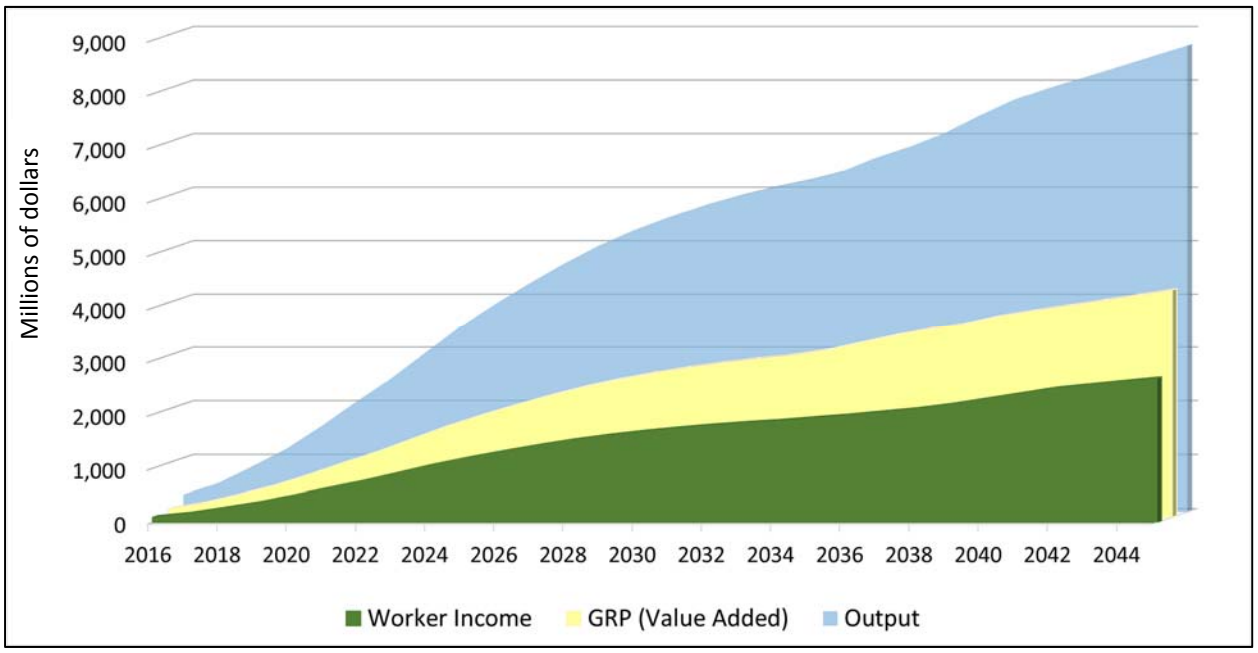
Completion of the ADHS is expected to generate significant economic impacts. For example, the combined economy of the 13 Appalachian states is estimated to be able to produce and sell $8.7 billion more in goods and services per year (output), over $4.2 billion more in gross regional product, paying workers nearly $2.7 billion more in wages, and adding nearly 47,000 more jobs than if the ADHS is not completed. Table 20 and Figure 27 show how business output (sales), value added, wage income and employment impacts are projected to develop from 2015 to 2045. It is notable that economic growth is particularly pronounced in later years, reflecting the phased completion of ADHS segments and the fact that economic development impacts accumulate over time.

Table 20: Annual Economic Impacts of ADHS Completion (in $ millions of 2015 Dollars)

Annual Economic Impact of Completing ADHS *	Appalachia			Appalachian States		
	As of 2025	As of 2035	As of 2045	As of 2025	As of 2035	As of 2045
Business Output ($M Sales)	$2,982	$4,855	$6,717	$3,875	$6,299	$8,704
Value Added ($M GRP)	$1,450	$2,356	$3,269	$1,883	$3,056	$4,236
Wage Income ($M Earned)	$909	$1,474	$2,063	$1,181	$1,913	$2,673
Employment (Jobs)	19,821	29,674	36,156	25,751	38,502	46,849

Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
**Note: All values are in constant 2015 dollars.*

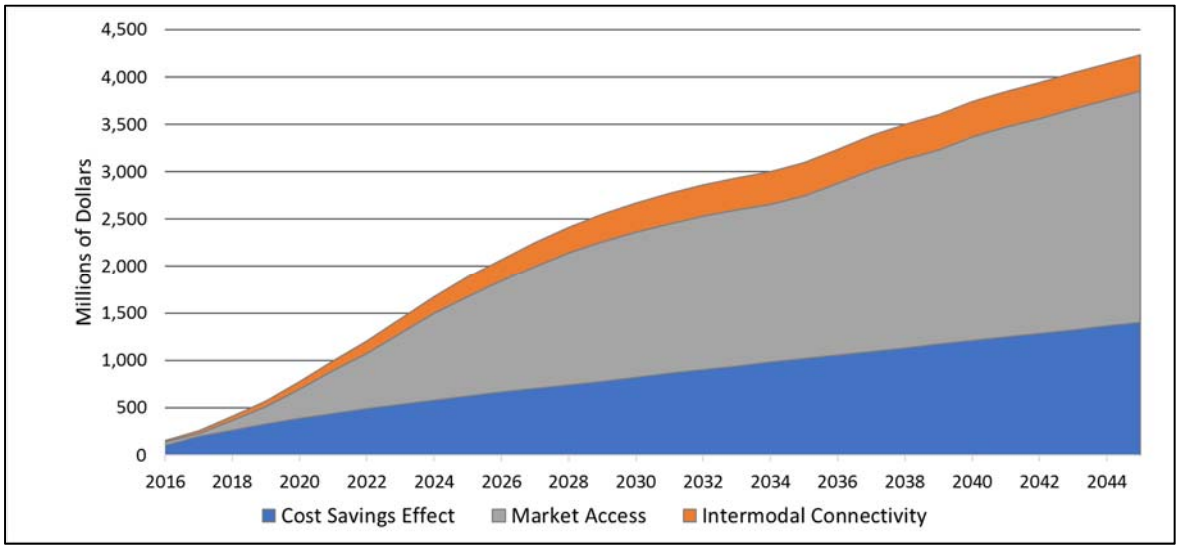
Figure 27: Future Impacts of ADHS Completion on the Economy of the 13 Appalachian States



Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All values are in constant 2015 dollars.

In addition, the relative role of transportation efficiency, market access, and intermodal connectivity in the growth of gross regional product (GRP) is illustrated in Figure 28. The GRP impact of cost savings reflects an assumption of linear, gradual completion of ADHS segments over the period from 2016 to 2045. The GRP impact of market access enhancement reflects both time lags and cumulative growth effects of improving market access over time.

Figure 28: Causal Factors Driving Economic Growth (GRP) Impacts of ADHS Completion



Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
Note: All values are in constant 2015 dollars.

Economic Impacts by Industry

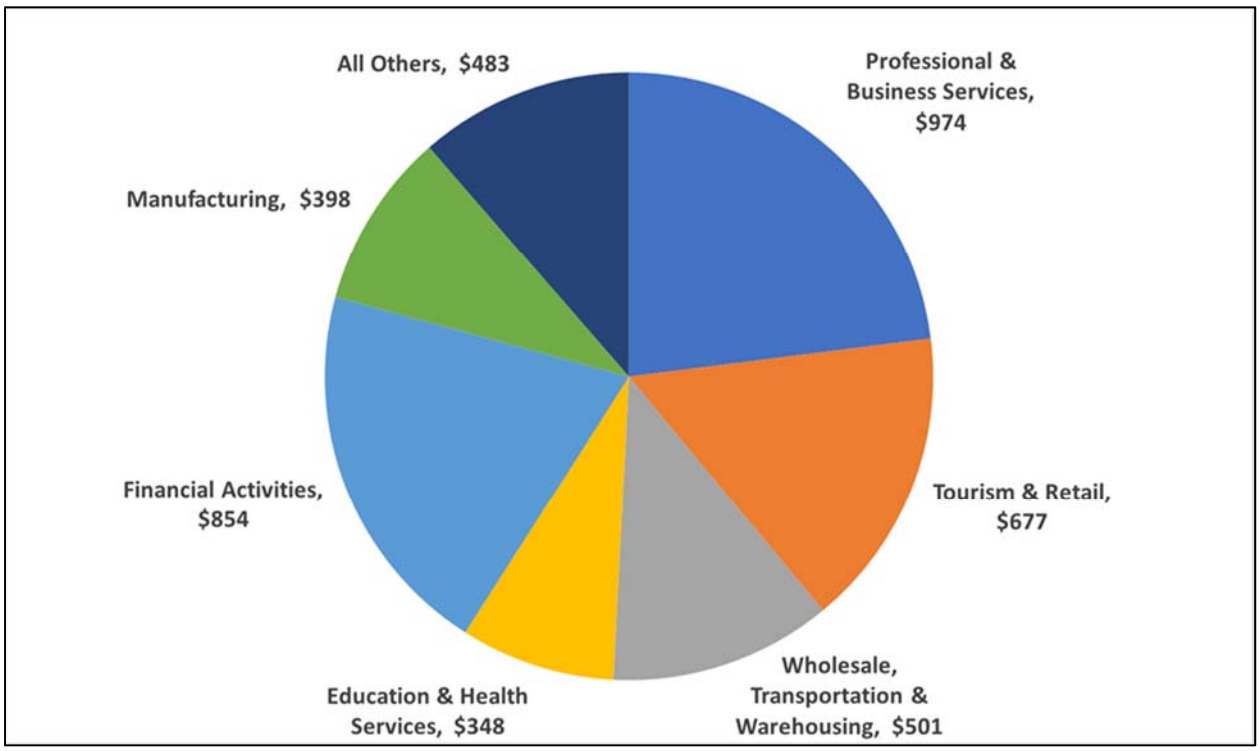
The estimated industry mix of jobs and GRP impacts for ADHS system completion is shown in Table 21 and Figure 29. In general, the most affected industries (in terms of jobs and GRP) are those with the highest underlying growth rates and the greatest sensitivity to the relative costs of transportation or access to the enhanced labor and supply markets enabled by ADHS. The table shows a continuation of the historical effect of ADHS introduced in chapter 3, whereby the ADHS facilitates the most significant growth in Appalachia's service and knowledge economy, with professional and business services, education and healthcare, and financial services among the sectors most stimulated by the system.

Table 21: Projected 2045 Employment and GRP Impact due to ADHS Completion, by Industry

Industry	Added Jobs (Compared to No ADHS)	Added GRP * (in $ millions/year)
Professional and Business Services	14,619	$974.4
Leisure and Hospitality (Tourism)	6,249	$385.5
Education and Health Services	5,405	$348.4
Financial Activities	4,264	$853.7
Retail Trade	3,520	$291.7
Manufacturing	3,041	$398.1
Warehousing	2,735	$165.0
Transportation	2,358	$171.5
Construction	1,453	$86.9
Wholesale Trade	1,038	$164.7
Media and Information	836	$147.5
Agriculture and Extraction	622	$138.2
Utilities	489	$97.0
Government	219	$13.2
Total in Year 2045	**46,849**	**$4,236**

Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.
**Note: All values are in constant 2015 dollars.*

Figure 29: Top Economic Sectors Impacted Due to ADHS Completion (in Millions of Dollars of GRP)



Source: Analysis by EDR Group using the TREDIS economic impact model for the 13 Appalachian states.

4.5 Benefit-Cost Analysis

This section presents the results of a return-on-investment analysis that compares the benefits of system completion, with remaining investment costs. Following the standards of traditional benefit-cost analysis, the benefits are measured in terms of their "social valuation"—representing financial gains (for actual cost savings), productivity gains (for business activity) and "willingness to pay" valuation for non-money benefits including personal time, safety, and the environment. Further impacts on attracting greater economic investment and growth into the economy are not included (except when viewed as a separate regional perspective analysis). These benefits are compared to construction and operating costs over time, and expressed in terms of their discounted net present values. Overall, the analysis shows that completing the ADHS can provide benefits equivalent to approximately four times the cost when benefits are carried out to 2075 (allowing for a 30-year life after 2045 completion) and discounted at seven percent.

Cost Estimates and Assumptions

Table 22 shows the estimated completion dates and cost to complete the remaining ADHS corridor projects. While the baseline scenario of the benefit-cost analysis presumes a 2045 completion date, an alternative scenario is also considered with an accelerated 2035 completion date (discussed further in section 4.6).

Table ***23*** respectively show the construction outlays by year for each of these scenarios.

Table 22: Estimated Corridor Completion Under Accelerated and Non-Accelerated Schedules

Corridor Name	State	Estimated Completion Year (2045 or sooner)	Accelerated Schedule Completion Year (2035 or sooner)	Estimated Cost (Undiscounted) $M
Corridor H	West Virginia	2042	2035	$810.0
	Virginia	2026	2026	$138.3
Corridor K	Tennessee	2025	2025	$535.5
	North Carolina	2028	2028	$760.5
Corridor M	Pennsylvania	2045*	2035	$1,477.1
Corridor N	Pennsylvania	2045*	2035	$510.1
	Maryland	2022	2022	$183.9
Corridor Q	Virginia	2021	2021	$474.1
	Kentucky	2019	2019	$371.2
Corridor X1	Alabama	2045	2035	$2,966.4
Other Corridors	Multiple States	varies	varies	$2,687.7
All Corridors	**Multiple States**	**varies**	**Varies**	**$10,914.8**

**Pennsylvania DOT currently has no plans to complete this corridor, so the year 2045 was assumed for analysis purposes only.*

Source: Appalachian Development Highway System Cost-to-Complete Report (2012) and Completion Plan Report (2013).

Table 23: ADHS Corridor Construction Project Outlays by Year Under 2045 and Accelerated Scenarios

Year	Completion by 2045 Capital Cost (Undiscounted $M)	Accelerated Completion by 2035 Capital Cost (Undiscounted $M)
2015	$0.0	$0.0
2016	$399.0	$399.0
2017	$432.0	$432.0
2018	$520.7	$520.7
2019	$538.4	$538.4
2020	$343.7	$529.1
2021	$310.7	$496.1
2022	$231.7	$417.1
2023	$220.3	$519.3
2024	$220.3	$519.3
2025	$157.3	$576.3
2026	$142.8	$561.8
2027	$108.2	$527.2
2028	$108.2	$527.2
2029	$39.1	$562.3
2030	$185.4	$523.3
2031	$185.4	$523.3
2032	$259.0	$685.6
2033	$372.7	$685.6
2034	$372.7	$685.6
2035	$419.0	$685.6
2036	$475.2	$0.0
2037	$475.2	$0.0
2038	$475.2	$0.0
2039	$539.0	$0.0
2040	$539.0	$0.0
2041	$539.0	$0.0
2042	$685.6	$0.0
2043	$540.1	$0.0
2044	$540.1	$0.0
2045	$540.1	$0.0

Benefit-Cost Analysis Results

Benefit-cost analysis results are presented from both a regional and a national perspective.

- *Regional Perspective:* This includes only the share of transportation efficiency gains that accrue within the Appalachian Region, and also include the economic development gains to the Region associated with both local productivity and inward investment.
- *National Perspective:* This includes all transportation efficiency gains accruing in the United States, but only includes market access gains that result in national productivity gains (about 22 percent of market access effects). Market access gains attributable to inward investment and business in-migration to Appalachia (about 78 percent of market access effects) are shown in the regional perspective only.

Table 24 shows that from the national perspective, ADHS completion is expected to generate societal benefits 3.7 times its cost (when discounted at 7 percent) and even higher when a smaller discount rate is assumed. From the regional perspective, benefits are approximately 2.7 times the costs when discounted at 7 percent.

Table 24: Benefit-Cost Analysis of ADHS Completion by 2045 (Present Value)*

Benefit and Cost Elements	Regional Perspective		National Perspective	
	with 3% discount rate	with 7% discount rate	with 3% discount rate	with 7% discount rate
Vehicle Operating Cost Savings	$3,195	$1,053	$5,042	$1,659
Travel Time Saved	$16,919	$5,602	$26,069	$8,622
Reliability Time Saved	$4,830	$1,589	$7,692	$2,526
Safety Benefit	$1,914	$637	$2,853	$950
Environmental & Emissions Benefit	$804	$223	$1,292	$358
Logistics and Supply Chain Savings	$3,073	$986	$5,566	$1,786
Market Access (Productivity Gain)	$4,993	$1,994	$1,049	$419
Total Cumulative Benefits	**$35,727**	**$12,083**	**$49,563**	**$16,320**
Total Cumulative Costs	**$7,005**	**$4,471**	**$7,005**	**$4,471**
Benefit-Cost Ratio	**5.1**	**2.7**	**7.1**	**3.7**

**Note: All values are net present values of cost or benefit streams covering the period of 2016-2075, using the specified 3 percent or 7 percent discount rate, and presented in terms of their 2015 value (millions of dollars)*

The effect of changing the discount rate assumption (consistent with U.S. DOT guidance) is considerable, due to the disproportionate share of benefits associated with Corridor X1 in particular (which is not anticipated for completion until 2045). With X1 accounting for over 36 percent of total investment costs, a significant reduction in the discounting of these long-term benefits (accruing between 2045 and 2075) causes the lower discount rate to greatly magnify benefits in present-value terms. Consequently, the 7 percent discount rate may be more useful in reflecting effects of completing the overall system, accounting for the value of the likely time it will take before the benefits of X1 are expected to occur. The Appendix shows the benefit and cost streams by year supporting Table 24 which accounts for specific sources of benefit, phasing of project costs, traffic growth rates, and other temporal aspects of the benefit-cost ratio.

4.6 Accelerating ADHS Completion

This section explores the effect of accelerating ADHS completion. It presents effects of a hypothetical analysis in which it is assumed that all ADHS corridors are completed by 2035 rather than 2045. The purpose is to assess potential gains associated with competing the ADHS sooner (as could be accomplished if more funding was made available sooner). Alternatively, it can be viewed as showing the lost economic opportunities associated with delay and longer time required to complete the system.

It is important to note that some of the corridors are expected to be completed by 2035 anyway, so the hypothetical acceleration scenario only accelerates projects that would otherwise take longer to complete. The specific completion years that were assumed for each major unfinished corridor are shown in preceding Table 22.

The analysis findings are that accelerating the completion of ADHS from 2045 to 2035 can enable benefits to accrue more quickly than would be the case if implementation were to occur on the 2045 schedule presumed throughout this report. By completing the ADHS sooner, the Region can experience significantly more benefits in the near term. Table 25 demonstrates how acceleration would allow the Region to experience nearly $8 billion in additional undiscounted cumulative benefits by 2035 in comparison to a scenario that would not complete the ADHS until 2045. Figure 30 shows how acceleration speeds the development of societal benefits to the year 2045. Further information on benefit and cost streams, as well as year by year phasing assumptions, are shown in the Appendix.

Table 25: Comparative Benefits of 2035 Completion vs. 2045 Completion (Undiscounted $M)

Benefit and Cost Elements	Cumulative Value (2015-2035) 2045 Completion	Cumulative Value (2015-2035) 2035 Completion
Vehicle Operating Cost Savings	$820	$1,537
Travel Time Saved	$4,396	$8,231
Reliability Time Saved	$1,231	$2,315
Safety Benefit	$505	$944
Environmental and Emissions Benefit	$125	$243
Logistics and Supply Chain Savings	$732	$1,382
Market Access (Productivity Gain)	$2,511	$3,497
Total Cumulative Benefits	**$10,320**	**$18,149**

Figure 30: Development of Benefits 2035 Completion vs. 2045 Completion

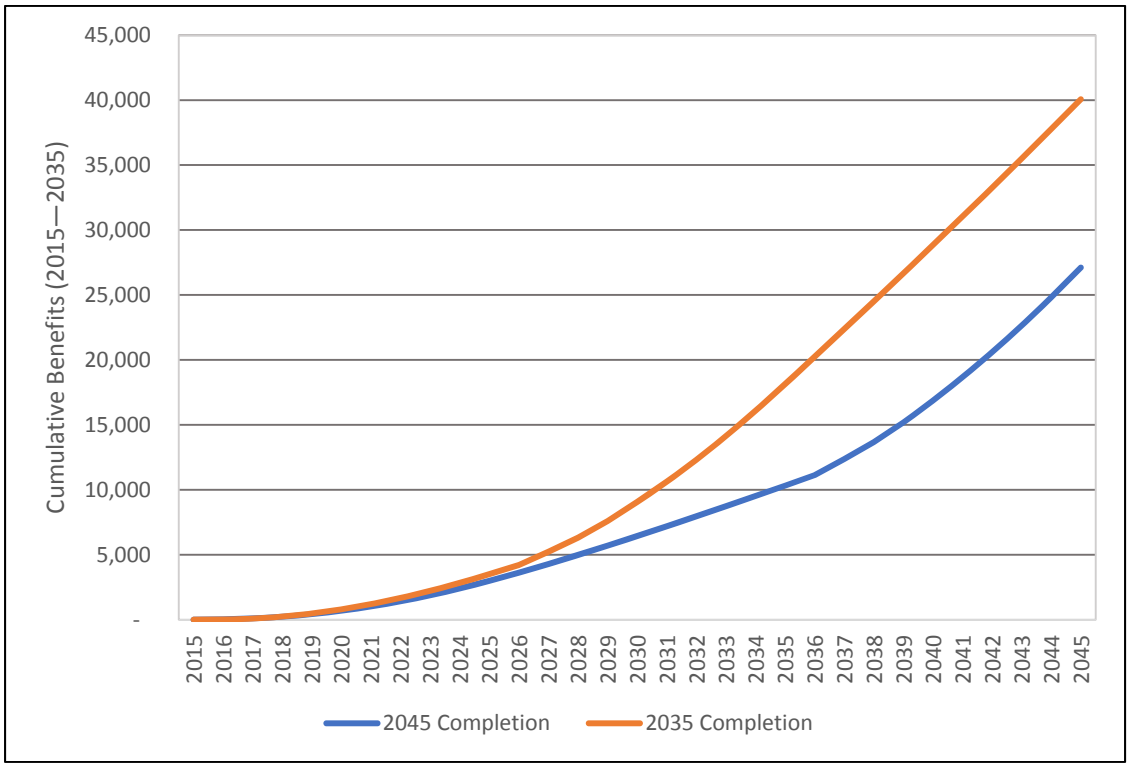


Table 26 shows the annual economic impact for the 2045 ADHS completion and the accelerated completion to 2035. The table shows that by 2035 the Region is estimated to gain over 11,000 more jobs as a result of accelerating completion of ADHS, as well as over $1 billion more in GRP and more than $2 billion in additional annual business sales (output).

Table 26: Economic Impacts of Completing ADHS

Economic Impacts of Completing ADHS	Annual Impact in 2035 (2045 Completion)	Annual Impact in 2035 (Accelerated)
Employment Impact of ADHS	38,502	49,700
Business Output Impact of ADHS	$6,299	$8,439
Value Added (GRP) Impact of ADHS	$3,056	$4,111
Wage Income Impact of ADHS	$1,913	$2,592

5 Corridor Level Analyses

5.1 Overview and Methodology

Overview. While chapter 4 examined the system-wide transportation and economic effects of ADHS completion, this chapter examines the local and regional effects of individual corridor improvements. This focus on individual corridors has two important uses. First, it provides a more complete insight into the local and regional context for ADHS completion, by identifying the range of opportunities, benefits and challenges facing individual corridor projects. Second, it provides new estimates of the economic impacts, benefits and costs of completing the largest remaining corridor projects.

This chapter focuses on five ADHS corridors that remain unfinished and account for 75 percent of the total estimated cost for the ADHS system's completion. They are corridors H, K, N, Q and X1. (Refer to corridor map in chapter 4 to see their locations within the ADHS). For each of the five corridors, the text covers the following:

- A description of the corridor and its state of completion—drawn from ARC records;
- A discussion of expected local and regional effects of corridor completion based on interviews with regional stakeholders;
- Findings on expected transportation system performance benefits and costs associated with ADHS corridor completion–based on regional transportation modeling; and
- Findings on expected economic impacts of corridor completion–based on regional economic impact modeling.

This form of presentation is necessarily repetitive, since the same four parts are repeated for each of the five corridors. Readers who are interested in specific corridors may therefore wish to read just the section covering that corridor. Readers who are interested in overall system-wide analysis may skip this chapter entirely and move on to the study conclusions in chapter 6.

Methodology. The *descriptive statistics* about corridors – including project cost, completion status and completion plans – are drawn from: (a) Appalachian Development Highway System Cost-to-Complete Report, 2012, (b) ADHS Completion Plan Report, 2013, (c) ADHS Status Report, 2015, and (d) ADHS web site (www.eadhs.org), which includes the ADHS Information Management System.

The *discussion of expected local and regional effects* draws from interviews with ARC staff and representatives of local organizations that included economic developers, transportation planners, engineers, county administrators, business organizations, academics, and non-profit institutions. The interviews were not designed to be comprehensive in coverage, but rather to provide insight to validate the reasonableness of transportation and economic model results, and aid in their interpretation. Accordingly, the interviews focused on perceptions of project need, importance, and expectations regarding potential economic opportunities and impacts associated with the project. The interviewees are noted in the Acknowledgements page at the front of the report.

The *transportation benefit results* are framed in terms of aggregate travel time, cost, reliability, and safety benefits across the Region's road networks. This is important, because the ADHS serves to connect the Region with much broader networks of county, state, and Interstate highways. Thus, the total transportation benefits of completing any individual ADHS corridor will include both: (a) benefits of faster, more reliable and safer travel for those already using the existing highway, and (b) benefits for travelers who would otherwise be on other roads—including other county roads and minor arterial roadways—as routes to access major market centers and outside destinations. This transportation benefit analysis draws from the same travel network modeling process that was used to assess system-wide impacts in chapter 4, and the results represent transportation benefits across the 13 Appalachian states.

The *economic impact results* are framed in terms of aggregate jobs, wages, GRP (value added) and business output impacts for all industries on a region-wide scale. This is also important, since the ADHS network connections serve to reduce costs and enhance productivity across the Region. Thus, the total economic growth impacts of completing any individual ADHS corridor will include consequences of both: (a) improved competitiveness for businesses located in counties directly served by the highway corridor, and (b) improved competitiveness for businesses that are located further away but also stand to benefit because their supplier and customer shipments can be more efficient and cost effective with the improved highway in place. The average wage rate for new jobs, measured in terms of personal income generated per new job, is also shown to indicate cases where the highway completion will generate particularly high paying jobs.

This economic impact analysis draws from the same regional economic model modeling process that was used to assess region-wide impacts in chapter 4, and the results represent economic impacts across the 13 Appalachian states. All economic impact values are presented for a single year, which is ten years following highway completion. All values are shown in constant 2015 dollars.

Interpretation. It is important to note that all of the projected transportation benefits and economic development impacts of ADHS corridor completion are based on assumptions that over the next 30 years, there will be: (a) continued efforts to address job training and local infrastructure development needs within the Region, and (b) continued statewide and national economic growth that will provide a basis for regional business attraction and development over this period. The local interviews consistently raised the point that the ADHS projects can complement and build upon those other economic development efforts, and the economic impact model projections implicitly incorporate that assumption.

5.2 Corridor H—West Virginia and Virginia

Characteristics of Corridor H and Its State of Completion

Routes: U.S. 33, U.S. 48, State Route 55
Total length: 146.1 miles
Unbuilt segments: 55.4 miles
Completion year: 2026 (Virginia), 2042 (West Virginia)
Estimated Cost: $ 948.3 million

Corridor H runs from I-81 at Strasburg (VA) to the state line near Wardensville and further to I-79 at Weston (WV), as shown in Figure 31.

The unbuilt segments include:

(1) U.S. 48/55 in Strasburg at the intersection of I-81/I-66 in Shenandoah County (VA) and from Strasburg to Wardensville in Hardy County (WV).
(2) U.S. 33/55 between Harrisonburg (WV) and the National Forest border close to Elkins (WV) in Tucker County.

Projects underway to further complete this corridor include:

In Virginia:

- Location Study Phase for 14.4 miles

In West Virginia:

- Supplemental Final Environmental Impact Statement (SFEIS) under way from CR 31 north of Parsons to SR 32 east of Davis.
- Location approved by ARC and FHWA from SR 55 west of Wardensville to the Virginia State line.
- Final design and ROW acquisition from CR 7 northeast of Elkins to CR 31 north of Parsons.
- Construction on a section from SR 32 of Davis in Tucker County to West of WV 93 near Grant/Tucker County Line.

Currently, over 70 percent of the authorized Corridor H mileage is open to traffic (either completed or in the final stage of completion) (as shown in Figure 32).

Figure 31: Map of Corridor H Area

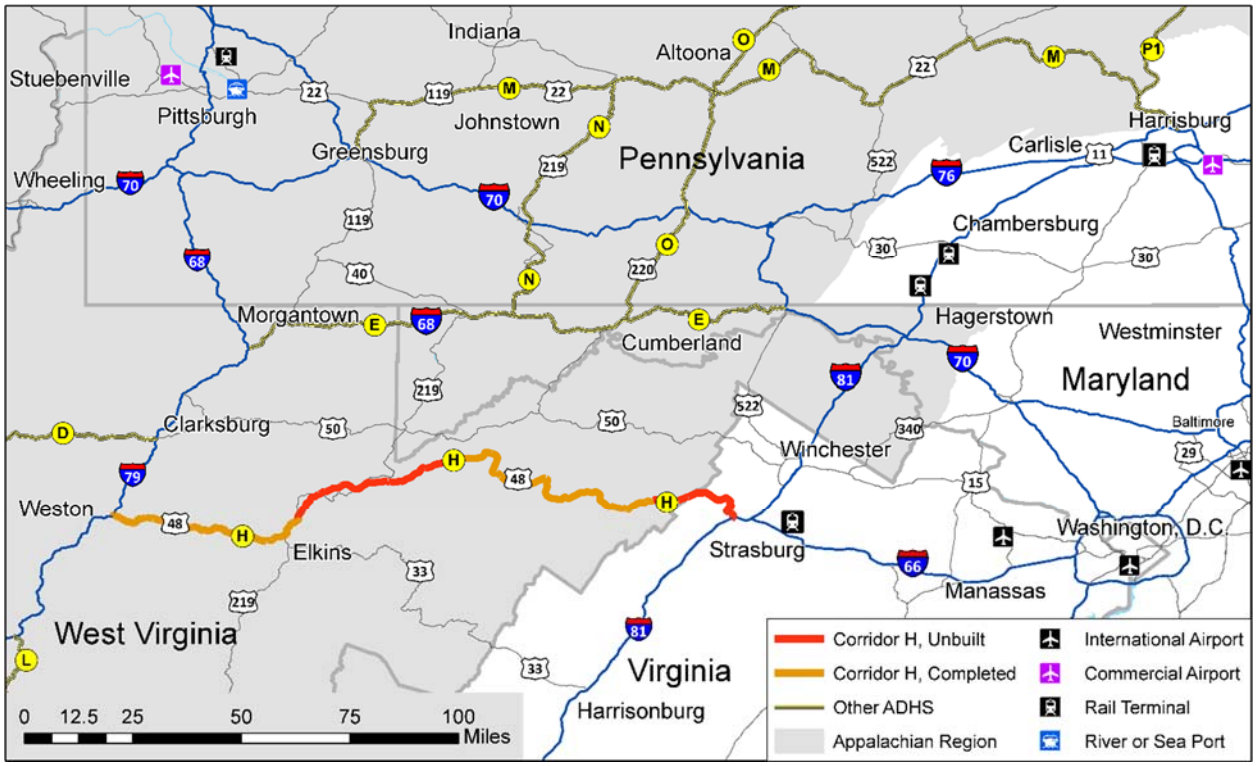
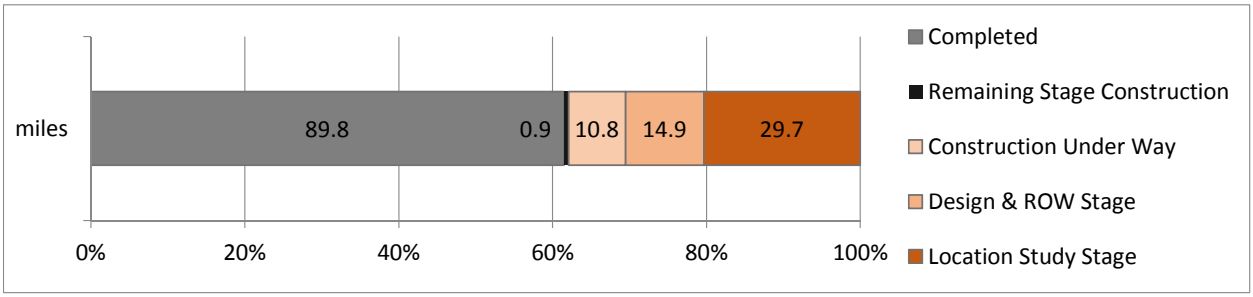


Figure 32: Length of Corridor H by Status (Authorized)



Source: ADHS Status Report, September 2015

Expected Local and Regional Effects of Corridor H Completion

Completion of Corridor H is expected to increase road capacity, travel speeds, reliability, and safety, while reducing travel times. Trip distance will remain approximately the same for those using the same corridor but is also expected to recapture truck trips (in particular) that currently use more circuitous routes. Based on observations of prior segment completion and how various businesses have benefitted, completing access from West Virginia to Virginia (and vice versa) is also expected to support local business expansion. The current two-lane road configuration raises safety concerns and creates bottlenecks where the four-lane corridor abuts with the two-lane segment. The current configuration also results in slower speeds

and higher travel times on the corridor. There is an awareness among interviewees that a balance needs to be achieved between commerce and the natural/scenic assets of the area.

Local interviews indicate that the highway corridor completion is expected to improve business and job markets in many ways. Local businesses expect to gain access to a broader labor market, and working-age residents living along the corridor expect gain more job access opportunities. Area manufacturers see gains from the enhanced connectivity to I-81 and I-66 east and the Virginia Inland Port at Front Royal (VA). The economic gains come from reduced transportation costs as well as enlargement of customer delivery markets and further export market opportunities. Quality of life for residents is expected to increase with improved regional access to specialized medical services and regional retail destinations in western Virginia. It is also expected to enable weekend trip tourism from the DC-Baltimore region to ski resorts and other visitor attractions, as well as additional pass-through tourism trips to destinations further west. Completing Corridor H is considered an important project for economic development in West Virginia.

Transportation Benefits and Costs of Corridor H Completion

The travel modeling estimates that completion of Corridor H will produce savings in both travel distances (reflected in reduced VMT, or vehicle-miles of travel) and travel times (reflected in reduced VHT, or vehicle-hours of travel), as shown in Table 27. A savings of over 205,000 vehicle-miles per day is expected. Apart from a small reduction of the alignment length of the new segment, slightly shorter trip lengths are expected because the new segment allows a higher speed and will therefore attract traffic that today uses longer (but currently faster) routes. The higher speed on Corridor H leads to travel time savings of VHT of just over 20,000 hours per day. Gains in travel time reliability enable additional savings of more than 14,000 hours of "buffer time"—the schedule padding done by time-sensitive travelers to allow for arrival time uncertainty.

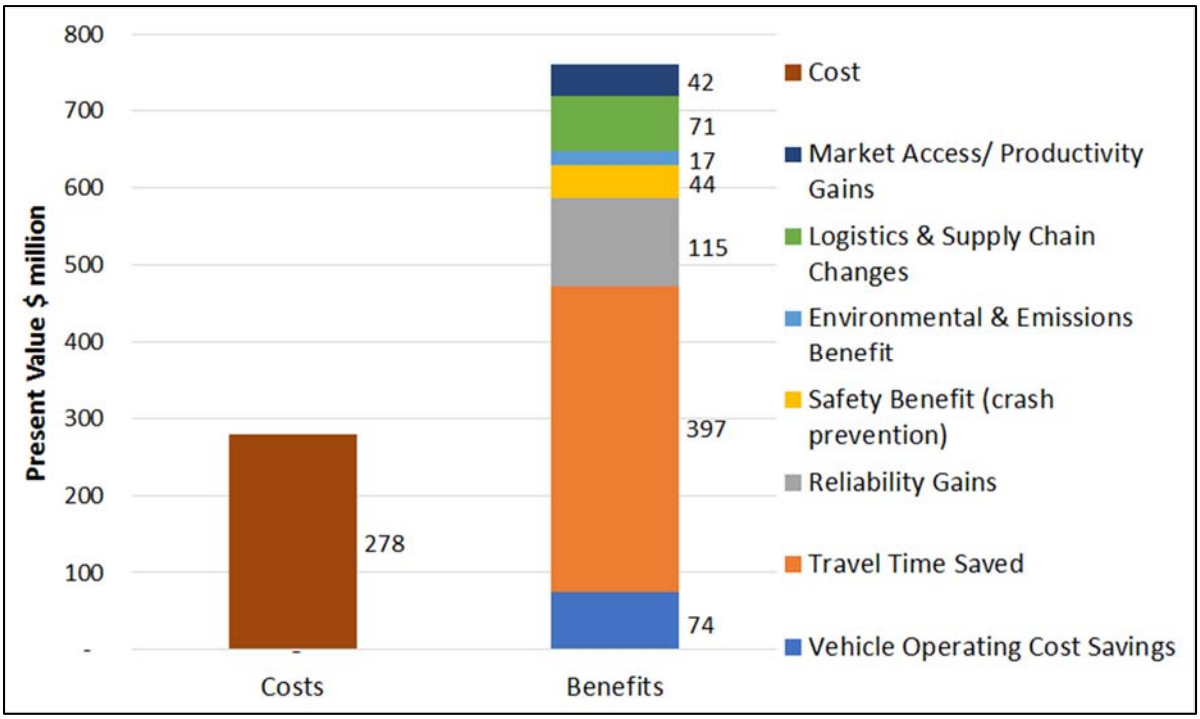
Table 27: Corridor H Completion: Savings in Miles Traveled, Travel Time, and Travel Reliability

Savings	VMT (miles per day)			VHT (hours per day)			Reliability (hours per day)		
Year	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**
2040	182,029	23,483	205,512	18,352	2,368	20,720	13,515	1,271	14,705

Source: EDR Group analysis using consolidated travel models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics

Besides the travel time and travel cost savings, additional safety benefits are expected as a consequence of a less winding route, with passing lanes and shoulders. There will also be business logistics and market access productivity gains for non-travelers. Figure 33 compares the discounted present value of future cost and benefit streams associated with corridor H completion. The discounted present value of all benefits sums to a total of $761 million, compared to a cost of $278 million (based on a discount rate of 7 percent). The result of the benefit-cost analysis is a favorable benefit/cost ratio of 2.7 (meaning that benefits are estimated to be 2.7 times larger than costs) and a net present value benefit of $483 million for Corridor H. With a lower discount rate of 3 percent, the benefit-cost ratio rises to 4.8.

Figure 33: Costs and Benefits of Corridor H Completion (7 percent discount rate)



Economic Impacts of Corridor H Completion

The economic impact projections of Corridor H completion are shown in Table 28. Completion of corridor H is forecast to generate annual economic growth representing about 1,850 added jobs and $166 million per year of additional GRP. The industry composition of the additional jobs is shown in Figure 34. Roughly one quarter of the new jobs are expected to be in professional and business services, and another quarter of the jobs are expected to be in tourism and associated retail sectors. Other notable sectors that are also expected to gain include technical services and specialty manufacturing (including wood products).

Table 28: Corridor H Economic Impacts (annual, ten yrs. following completion)

	($M)		($)
Output (sales)	$352		
Value Added (GRP)	$166	Value Added per job	$89,508
Income	$104	Income per Job	$56,026
	Jobs		
Employment	1,852		

Figure 34: Corridor H: Employment Impact by Industry Sector (annual, ten yrs. following completion)

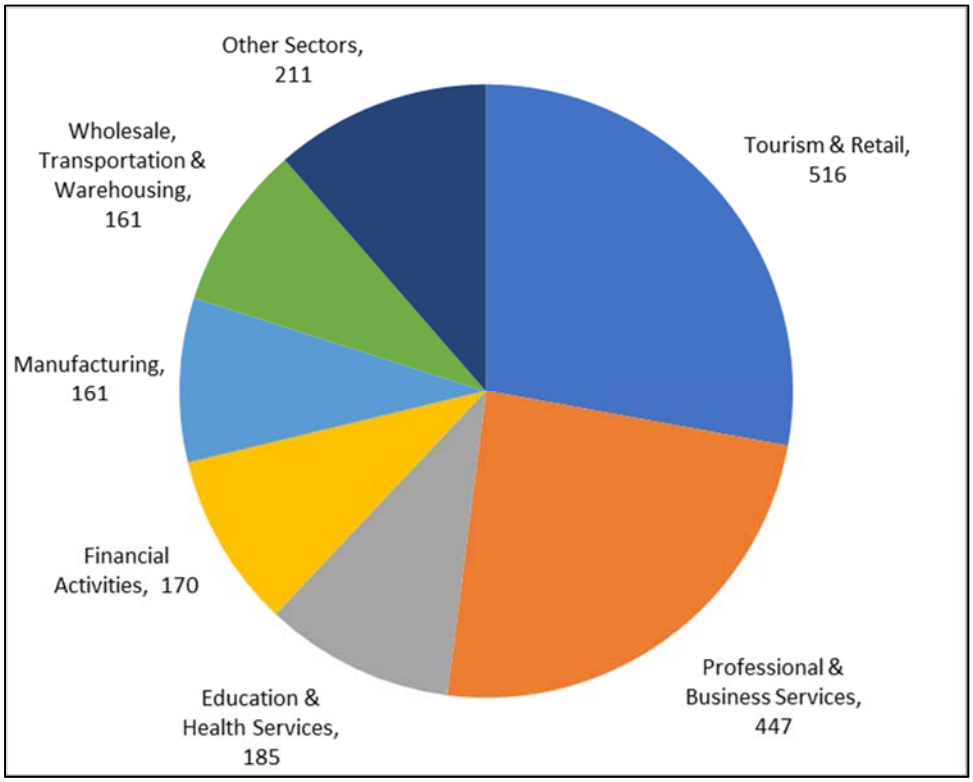
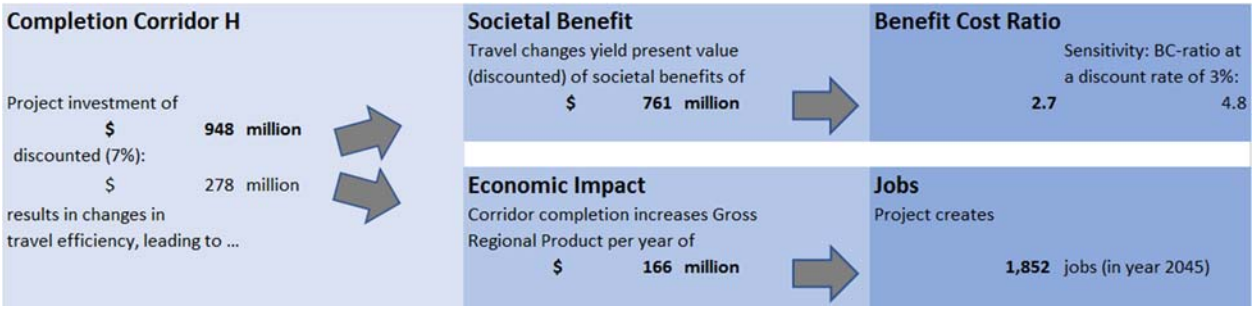


Figure 35: Summary of Corridor H Completion Impacts



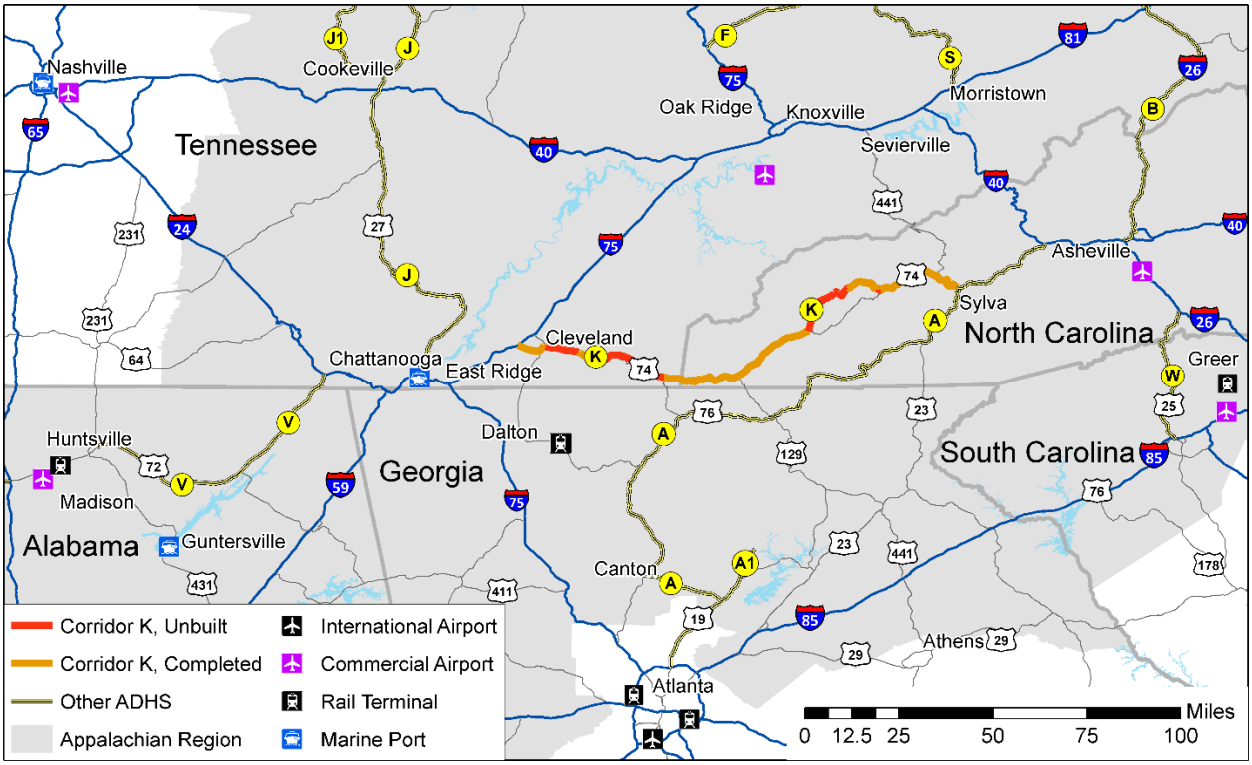
5.3 Corridor K—Tennessee and North Carolina

Characteristics of Corridor K and Its State of Completion

Routes: U.S. 19, State Route 40, U.S. 64, U.S. 74, State Route 311
Total length: 127.7 miles
Unbuilt segment: 46.2 miles
Completion year: 2025 (Tennessee), 2028 (North Carolina)
Estimated Cost: $1,296.0 million

Corridor K runs from Corridor A at Sylva (NC) to Wolf Creek at the State line and further to I-75 in Cleveland (TN) as shown in Figure 36.

Figure 36: Map of Corridor K Area



The unbuilt segments include:

(1) U.S. Highway 64 through the Ocoee Gorge in Polk County (TN).
(2) an 11-mile segment between Robbinsville and Stecoah with an eventual improvement between Andrews and Robbinsville in Graham County (NC).

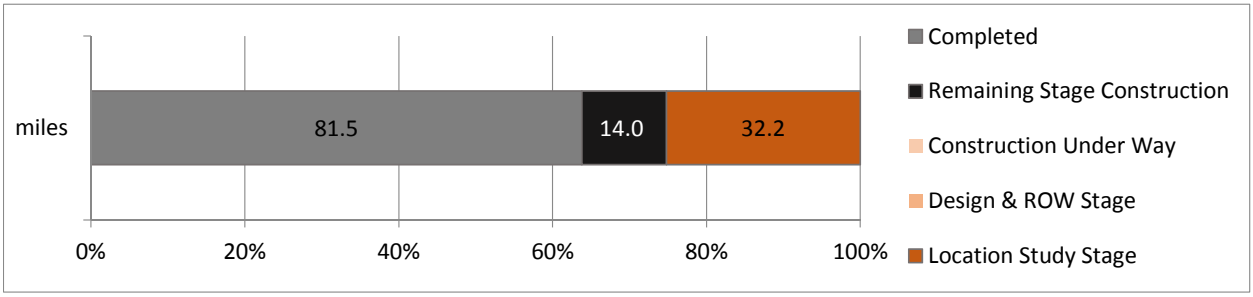
Projects underway to further complete this corridor include:

- In Tennessee: Location/Environmental study to establish an alternate route for a 14.1-mile section of the corridor along U.S. 64/74 (SR-40) near the Ocoee River and Ocoee Lake to Ducktown.

- In North Carolina: Location study and preliminary engineering is underway for the section from Robbinsville to Stecoah.

Currently, three-quarters of the authorized Corridor K mileage is open to traffic, while one quarter is still unbuilt or unfinished (as shown in Figure 37).

Figure 37: Length of Corridor K in North Carolina and Tennessee by Status (Authorized)



Source: ADHS Status Report, September 2015

Expected Local and Regional Effects of Corridor K Completion

Completion of Corridor K is expected to have significant impacts on road capacity, travel speeds, reliability, and safety. The current two-lane road is mountainous, narrow and curving which raises the risk of crashes and susceptibility to rock slides. The current two-lane road configuration also raises concerns regarding both safety and bottleneck delays that occur where four-lane section turns to two lanes.

Segment completion is expected to enhance truck logistics and delivery access westward to Chattanooga, TN and eastward to Asheville NC, as well as to the ports of Charleston (SC) and Norfolk (VA). Local Truck manufacturers will be able to reach existing markets more quickly and reap travel cost savings. They are further expected to gain an increase in domestic exports from the improved port access.

Improved access to specialized medical services and regional retail destinations in western Virginia is expected to benefit area residents. Local business expects to have a broader labor market and working-age households will expect to have increased job access opportunities, particularly in the direction of Chattanooga.

Access to and through this area is currently a challenge for residents, tourists, and local employers. Topographical barriers constrain access to other parts of the two states and to surrounding states. This limits tourism growth as well as other types of commercial opportunities for the area. A local concern is that, without improvement to Corridor K, future tourism traffic may decline as commercial vehicle traffic continues to grow. For parts of the area, there is no road redundancy in any direction and there has been a history of road closures in one or all directions due to landslides and fallen trees. The lack of connections is currently affecting businesses making site selection decisions throughout the Region including in Chattanooga and Asheville.

There is significant local concern about the environmental impact of various proposed locations for Corridor K. The currently unimproved section of Corridor K goes through the Cherokee National Forest, an environmentally sensitive area that constrains highway development options. There is an awareness

among interviewees that a balance needs to be achieved between commerce and the natural/scenic assets of the area. For this reason, local stakeholders have been discussing safety, economic and environmental tradeoffs involved in adopting various options for highway alignment and design.

Transportation Benefits and Costs of Corridor K Completion

The travel modeling estimates that completion of Corridor K will lead to savings in travel times and reliability, with a measurable change in travel distances. Most notably, a savings of nearly 226,000 vehicle-miles per day is expected from completion of the corridor (Table 29). Beyond a small reduction of the alignment length of the new segment, shorter trip lengths are expected because the new segment allows a higher speed and therefore attracts traffic that today uses longer, but currently faster, routes. The higher speed of the new segment will lead to VMT savings of more than 226,000 hours per day. Gains in reliability will enable more than 16,000 additional hours saved by reducing the need for buffering schedules to allow for arrival time uncertainty.

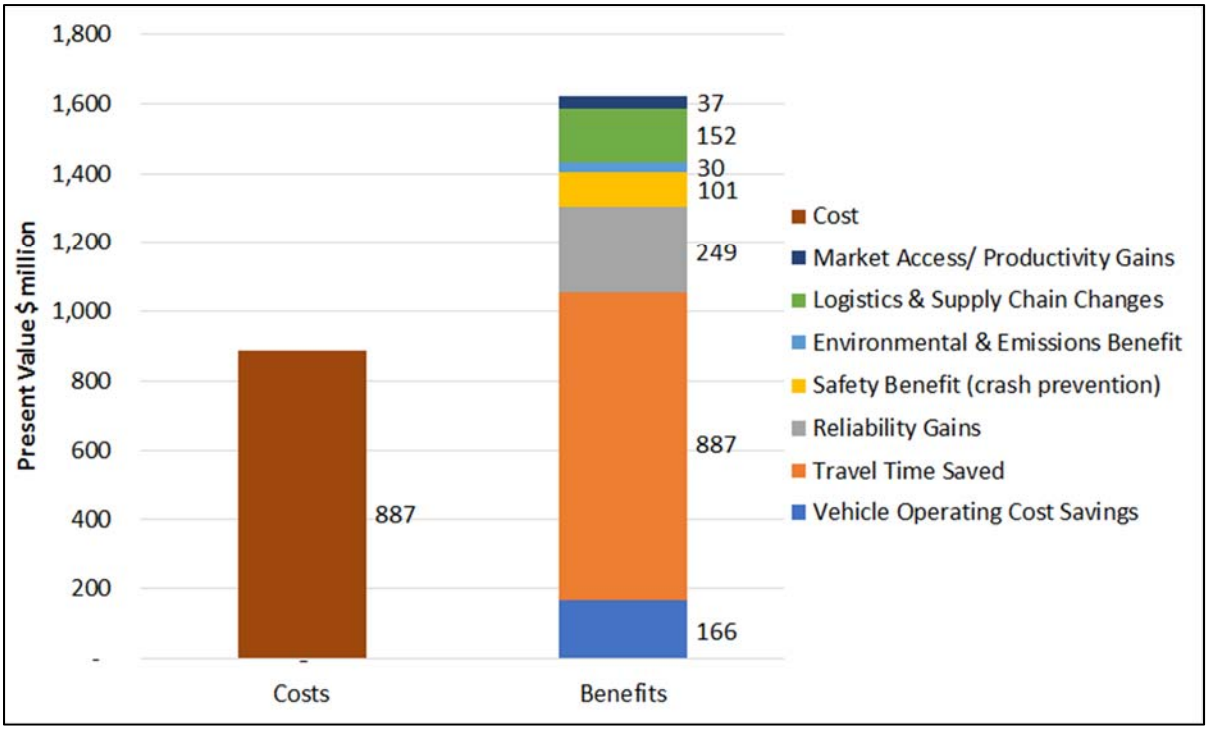
Table 29: Corridor K Completion: Savings in Miles Traveled, Travel Time, and Travel Reliability

Savings	VMT (miles per day)			VHT (hours per day)			Reliability (hours per day)		
Year	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**
2040	200,152	25,815	225,967	20,177	2,603	22,780	14,904	1,307	16,211

Source: EDR Group Analysis using consolidated travel models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics

Besides the travel time savings, there are also substantial benefits from (a) logistics and supply chain savings, and (b) productivity gains from improved market access (agglomeration effect). Further safety benefits will be enabled by less winding routes and the addition of passing lanes and shoulders. Figure 38 compares the discounted present value of future cost and benefit streams associated with Corridor K completion. The discounted present value of all benefits sums to a total of $1.623 billion, compared to a cost of $887 million (based on a discount rate of 7 percent). The result of the benefit-cost analysis is a favorable benefit-cost ratio of 1.8 and a positive net present value of $736 million for Corridor K. With a lower discount rate of 3 percent, the benefit-cost ratio rises to 3.3.

Figure 38: Costs and Benefits of Corridor K Completion (7 percent discount rate)



Economic Impacts of Corridor K Completion

The economic impact projections of Corridor K completion are shown in Table 30. Altogether, the expected annual economic impacts are $453 million/year in annual business output and 2,368 jobs. Figure 39 shows the industry mix of the new jobs. Nearly one-third of the jobs will be in tourism, hospitality, and related retail sectors. Nearly one-fifth will be in professional and business services. A smaller number of jobs are projected to be in other economic sectors, including warehousing and freight transportation, as well as manufacturing (largely focused on technology products).

Table 30: Corridor K Economic Impacts (annual, ten yrs. following completion)

	($M)		($)
Output (sales)	$453		
Value Added (GRP)	$205	Value Added per job	$86,776
Income	$135	Income per Job	$56,940
Output (sales)	Jobs		
Employment (GRP)	2,368		

Figure 39: Corridor K: Employment Impact by Industry Sector (annual, ten yrs. following completion)

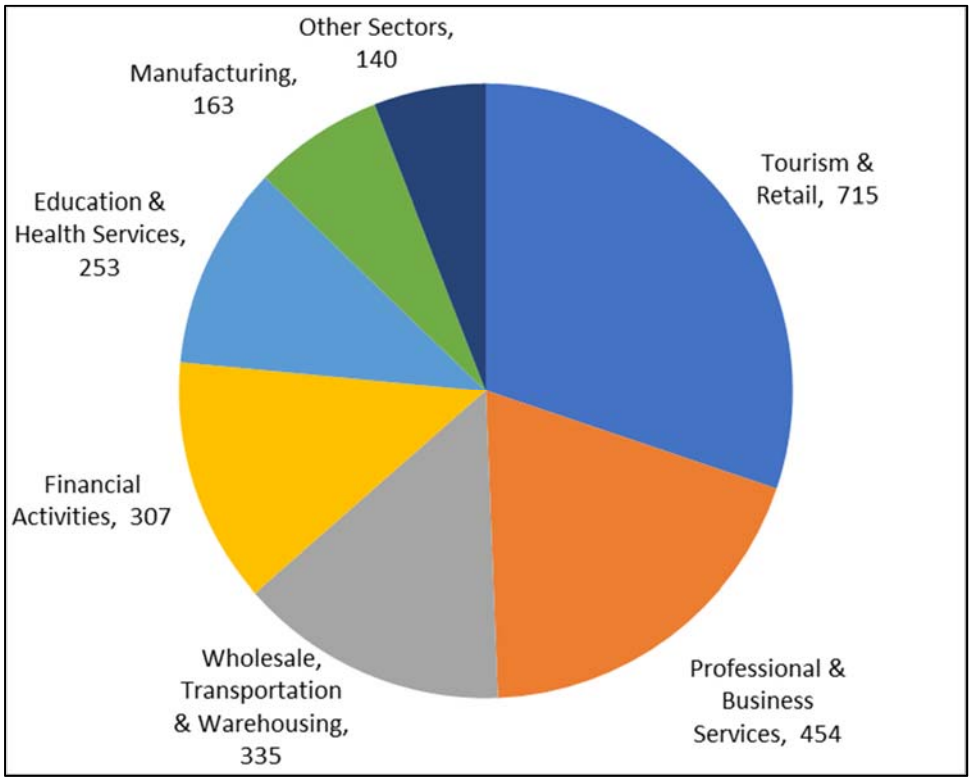


Figure 40: Overview of Corridor K Completion Impacts

5.4 Corridor N—Pennsylvania and Maryland

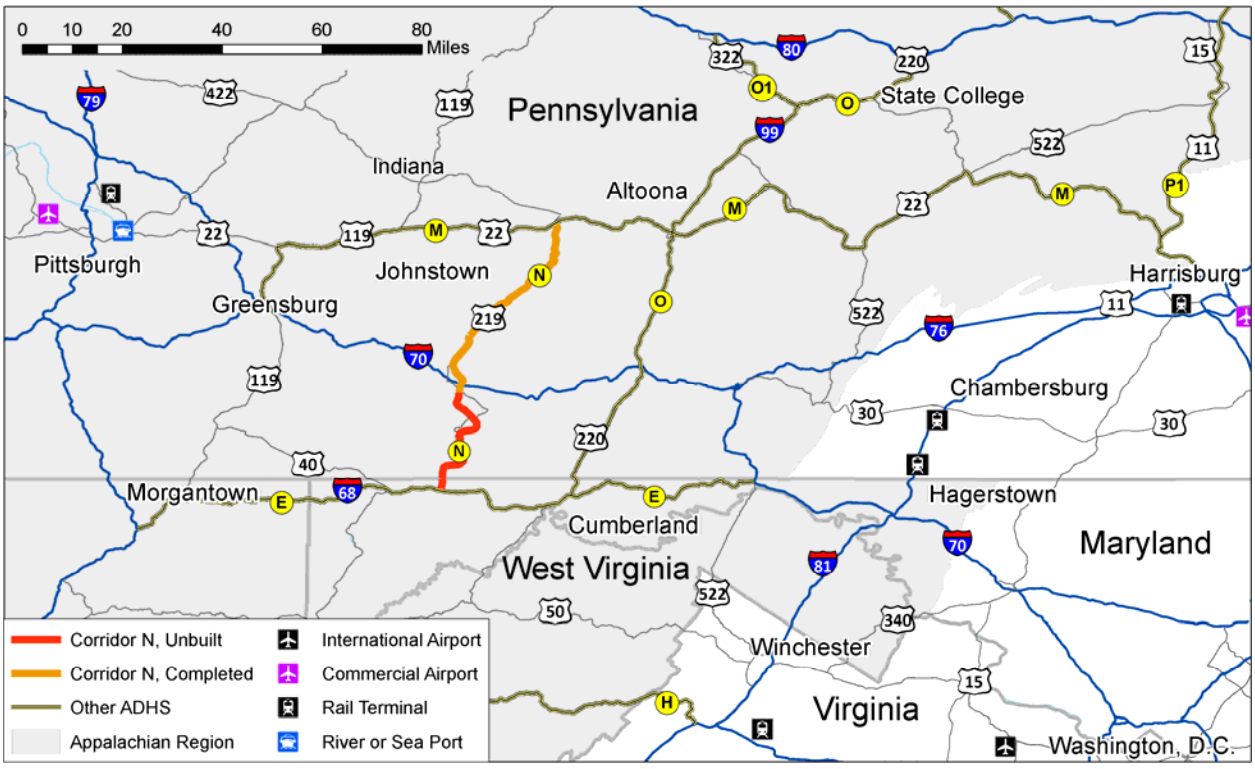
Characteristics of Corridor N and Its State of Completion

Route:	U.S. 219
Length:	54.4 miles
Unbuilt segment:	20.9 miles
Completion year:	2022 (Maryland), To be determined (Pennsylvania)
Estimated Cost:	$ 694 million

Corridor N runs from the junction with Corridor M (U.S. 22) near Ebensburg (PA) to the state line near Salisbury (PA) and further to the junction with Corridor E at Grantsville (MD) as shown in Figure 41.

The unbuilt segment is U.S. 219 between Meyersdale (PA) and the junction with Corridor E at Grantsville (MD). It would provide the affected parts of Somerset County (PA) and Garrett County (MD) with improved travel north to the PA Turnpike (toward Pittsburgh or Harrisburg), as well as to Corridor(s) M (toward Altoona) and O (toward State College), and south to I-68 E/W (Corridor E) and I-70 E.

Figure 41: Map of Corridor N Area

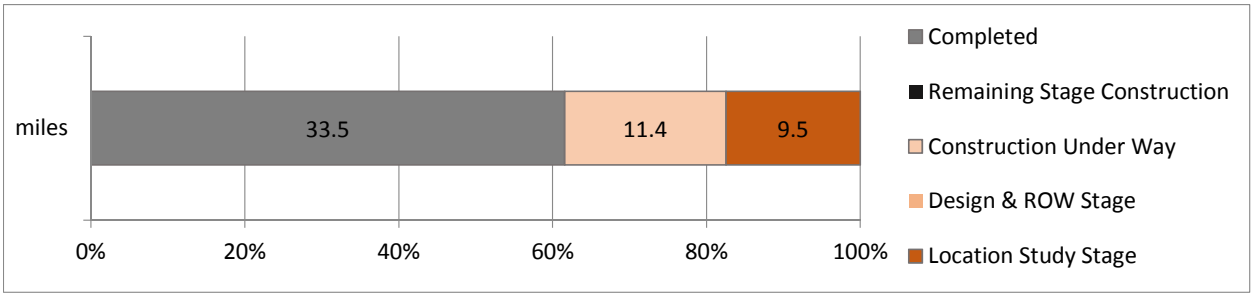


Maryland DOT and Pennsylvania DOT have initiated joint project planning activities for the full length of U.S. 219, from I-68 in Maryland to just south of Meyersdale, Pennsylvania. Projects underway to further complete this corridor include:

- In Maryland: Planning and Environmental Linkage (PEL) Study on a 7.0-mile section from I-68 in Maryland to Meyersdale.
- In Pennsylvania: Construction (earthwork and structures) underway on section from Meyersdale north to just south of the Pennsylvania Turnpike.

Currently, more than 60 percent of the authorized Corridor N mileage is open to traffic, while 40 percent is still unbuilt or unfinished (as shown in Figure 37).

Figure 42: Length of Corridor N by Status (Authorized)



Source: ADHS Status Report, Sep 2015

Expected Local and Regional Effects of Corridor N Completion

Completion of Corridor N is expected to improve travel speed, reliability, and safety. The current two-lane road configuration raises concerns regarding safety as well as bottleneck delays occurring in places where four-lane segments of the corridor meet the two-lane segments. The current roads weren't designed to handle the heavy-duty trucks that now travel the four-lane segment (that enters from Cambria and stops just south of the PA Turnpike). Commercial vehicles instead use I-68 E/W as a diversion to U.S. 219 to connect to the Pennsylvania Turnpike. This added mileage increases transportation costs. The upgrade will eliminate these road performance problems, thus benefitting residents, local businesses, and tourists. Some environmental concerns exist but options are on the table to minimize adverse effects.

Local interviews indicate that both households and businesses stand to gain, which is important in the face of coal mining job losses in the area. Resident workers can gain broader job access to the north. Manufacturers may be able to expand their delivery markets. Fracking activity may also find a logistics benefit with improved travel. Traffic from the Port of Baltimore headed to Pittsburgh or Erie Pennsylvania, or to Ohio can also gain a faster, non-toll travel option once Corridor N is completed. There is also a potential for growth in tourism given the size of the Baltimore-DC market that is two hours to the east.

Transportation Benefits and Costs of Corridor N Completion

The travel estimates that completion of Corridor N will reduce travel mileage and save travel time (Table 31). VMT is projected to be reduced by roughly 87,000 miles per day. Beyond a small reduction of the alignment length of the new segment, shorter trip lengths are expected because the new segment allows a higher speed and therefore attracts traffic that today uses longer, but still currently faster routes. The higher speed of the new segment will lead to travel time savings (VHT) of 8,700 hours per day. Gains in reliability of the network will also enable savings of more than 6,000 hours of "buffer time" savings, associated with padding schedules to allow for arrival time uncertainty.

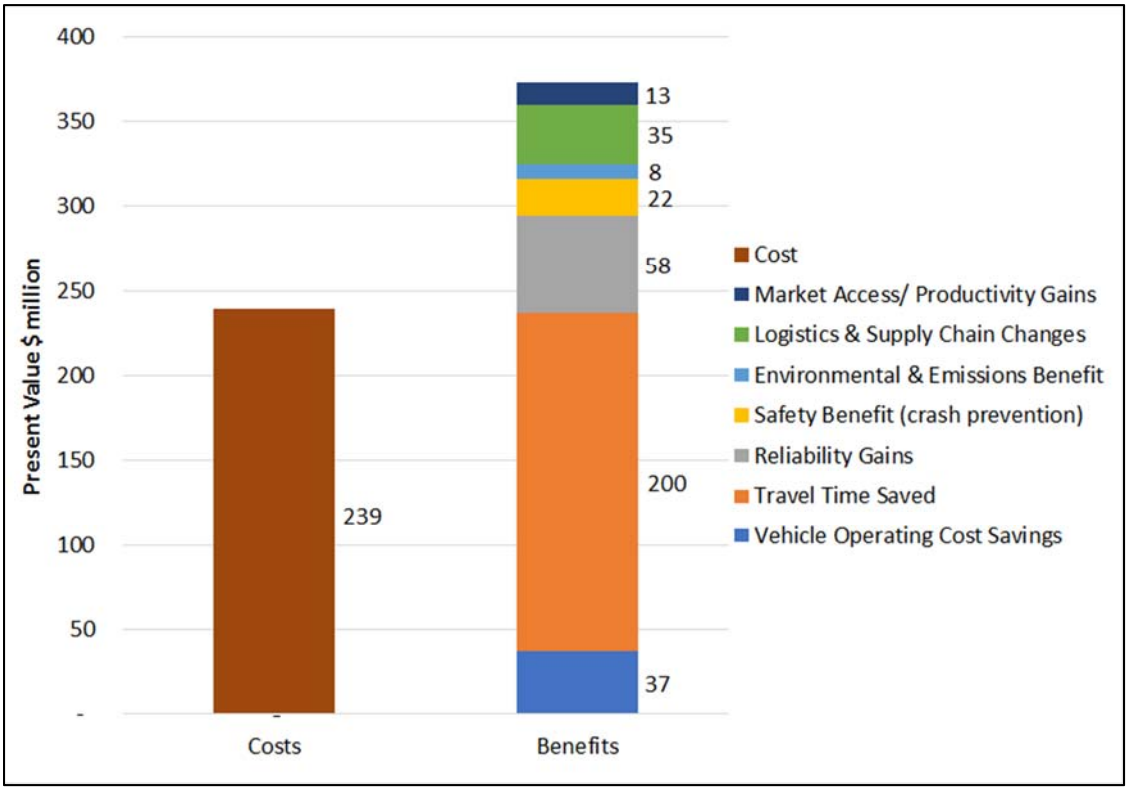
Table 31: Corridor N Completion: Savings in Miles Traveled, Travel Time, and Travel Reliability

Savings	VMT (miles per day)			VHT (hours per day)			Reliability (hours per day)		
Year	Car	Truck	Total	Car	Truck	Total	Car	Truck	Total
2040	76,975	9,925	86,899	7,760	1,001	8,761	5,698	506	6,204

Source: EDR Group Analysis using consolidated travel models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics

The benefits of Corridor N completion consist of travel time and cost savings, safety and environment benefits, and wider economic benefits (logistics and market access productivity gains). Figure 43 compares the present value of future cost and benefit streams associated with Corridor N completion. The discounted present value of benefits sum to a total of $373 million compared to a cost of $239 million (discount rate of 7 percent). Because improvements of Corridor N are scheduled to finish by 2021, the present value of costs is not much lower than the undiscounted total expected cost. The result of the benefit-cost analysis is a favorable benefit-cost ratio of 1.6 and a net benefit of $134 million for Corridor N. With a lower discount rate of 3 percent, the benefit-cost ratio rises to 2.9.

Figure 43: Costs and Benefits of Corridor N Completion (7 percent discount rate)



Economic Impacts of Corridor N Completion

The economic impact projections of Corridor N (by the tenth year following project completion) are shown in Table 32. Altogether, the expected annual economic impacts total $125 million/year in output and 700 jobs. Figure 44 shows the industry mix of the new jobs. Notably, over one-third of the jobs will be in tourism, hospitality, and retail. Another one-quarter of the jobs will be in the high growth sector of

professional and business services. A smaller number of jobs are expected to gain in the specialty manufacturing sector (e.g., metal and wood related products).

Table 32: Corridor N Economic Impacts (annual, ten yrs. following completion)

	($M)		($)
Output (sales)	$125		
Value Added (GRP)	$61	Value Added per job	$87,141
Income	$39	Income per Job	$55,661
	Jobs		
Employment	700		

Figure 44: Corridor N: Employment Impact by Industry Sector (annual, ten yrs. following completion)

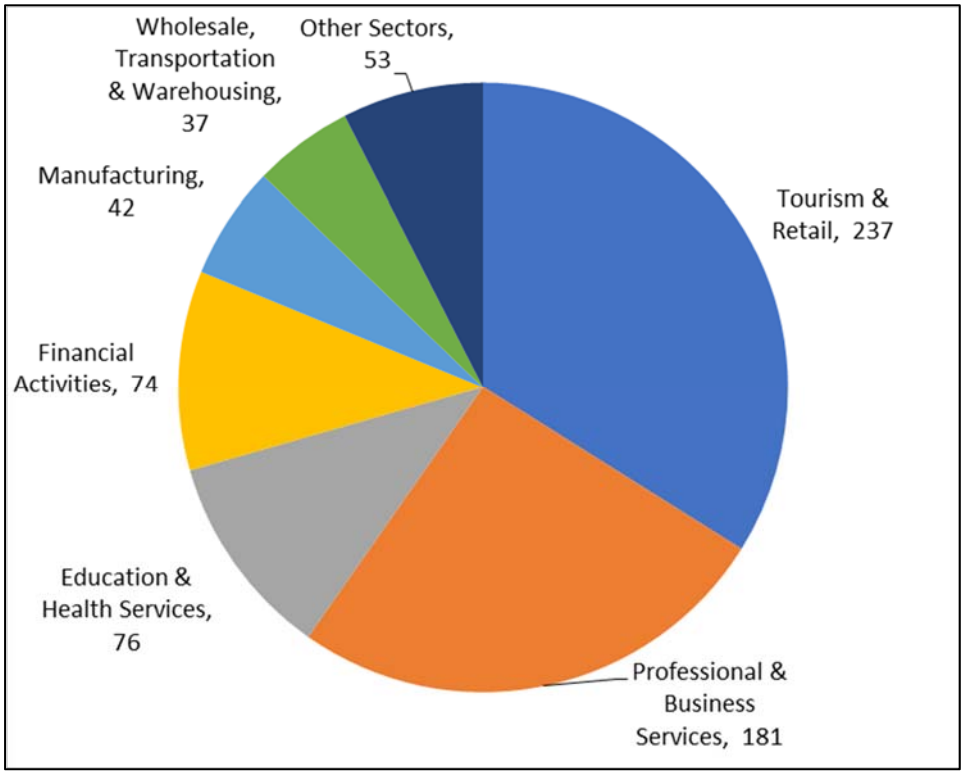


Figure 45: Summary of Corridor N Completion Impacts

5.5 Corridor Q—Virginia and Kentucky

Characteristics of Corridor Q and Its State of Completion

Routes: U.S. 460 / State Route 80
Total length: 163.6 miles
Unbuilt segment: 23.9 miles
Completion year: 2019 (Kentucky), 2021 (Virginia)
Estimated Cost: $ 845.3 million

Corridor Q runs from I-81 at Christiansburg to Breaks Interstate Park (VA) / Elkhorn City (KY) at the state line and further to Corridor B (U.S. 23) at Shelbiana, KY (near Pikeville) as shown in Figure 46.

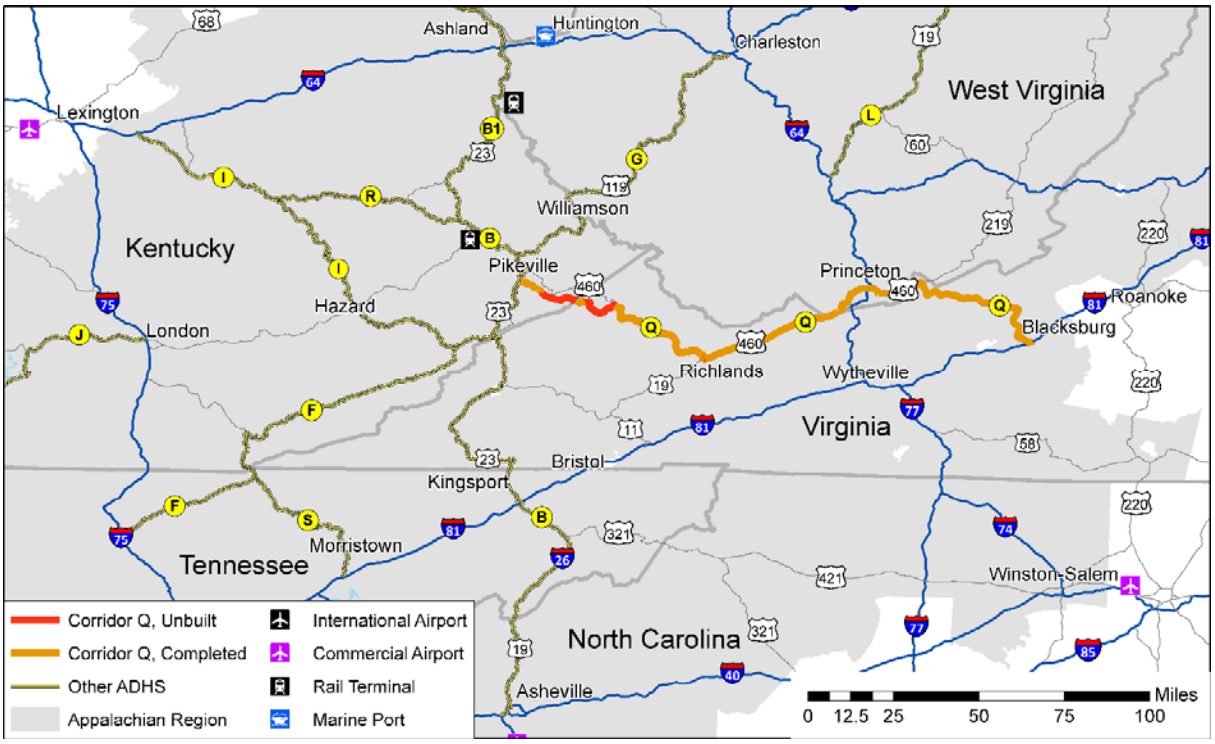
The unbuilt segments include:

(1) Pike County, KY, connecting near Pikesville to Corridors B (U.S. 23), G and F (U.S. 119).
(2) Buchanan County (VA), segment just east of the Kentucky line.

Projects underway to further complete this corridor include:

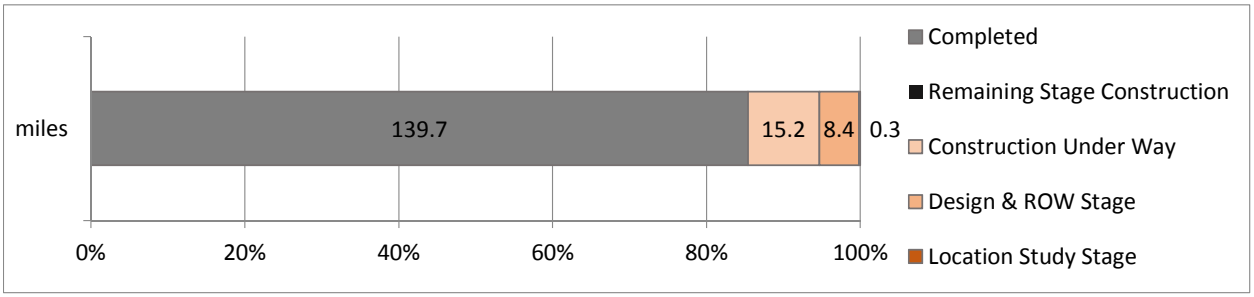
- In Kentucky, (a) final construction is complete on five sections (with the exception of surfacing) and has begun on two other sections, and (b) the design phase for three sections is complete, and is near completion for the following: Section 7A-2, Ramp at Beaver Creek near Elkhorn City; and surfacing for four sections.
- In Virginia, construction of an approximately 6.5-mile section near the Kentucky State Line.

Figure 46: Map of Corridor Q Area



Currently, 85 percent of the authorized Corridor Q mileage is open to traffic, while 15 percent is still unbuilt or unfinished (as shown in Figure 47) but most of the project is under construction with near-term completion dates (2019 in Kentucky, 2021 in Virginia).

Figure 47: Length of Corridor Q by Status (Authorized)



Source: ADHS Status Report, Sep 2015

Expected Local and Regional Effects of Corridor Q Completion

Completion of Corridor Q is expected to improve road capacity, speeds, reliability, and safety, while reducing travel times. Trip distances are likely to remain relatively unchanged, though. The current 60-minute trip between Pikeville, KY and Grundy, VA is expected to become about 40 minutes, and the Elkhorn City trip to Pikeville would be reduced from 40 minutes to 25 minutes after improvements. The current two-lane road is mountainous, slow and without passing capability, curving and unsafe, so Corridor Q is also expected to improve safety.

The 2016 Cumberland Plateau Planning District Commission's Comprehensive Economic Development Strategy points to several barriers to economic growth that could be overcome with corridor completion. With the project, resident working-age households would have broader job access. Breaks Interstate Park straddles the state border and tourist visits are expected to increase as a consequence of improved travel conditions. The proposed project has become more important over the years due to the dramatic contraction in coal mining and the loss of jobs this area has experienced. A completed Corridor Q can help to achieve a new industry mix. In addition to completing Corridor Q, interviewees also stressed that the Coalfields Expressway (CFX) which links the 4-county region to I-77 and U.S. 23 (Corridor B) needs to be completed as well. Together, these investments are expected to reduce travel times, thus facilitating goods movement within and through the Region, opening the area to additional tourism, and helping to reverse the Region's current population and employment decline. CFX and Corridor Q will also provide important links to a broader network of highways that promotes trade and job growth within the multi-state Appalachian Region and the nation.

Transportation Benefits and Costs of Corridor Q Completion

The completion of Corridor Q would provide transportation benefits such as reduced mileage and travel time savings (Table 33). VMT is estimated to be reduced by 157,000 Miles per day. Apart from a small reduction of the alignment length of the new segment, shorter trip lengths are assumed because the new segment allows a higher speed and therefore attracts traffic that today uses longer, but at present faster, routes. The higher speed of the new segment leads to travel time savings (VHT) of almost 16,000 hours

per day. Gains in reliability of the network enable additional savings of more than 11,000 hours of "buffer time" savings by reducing the need for padding schedules to allow for arrival time uncertainty.

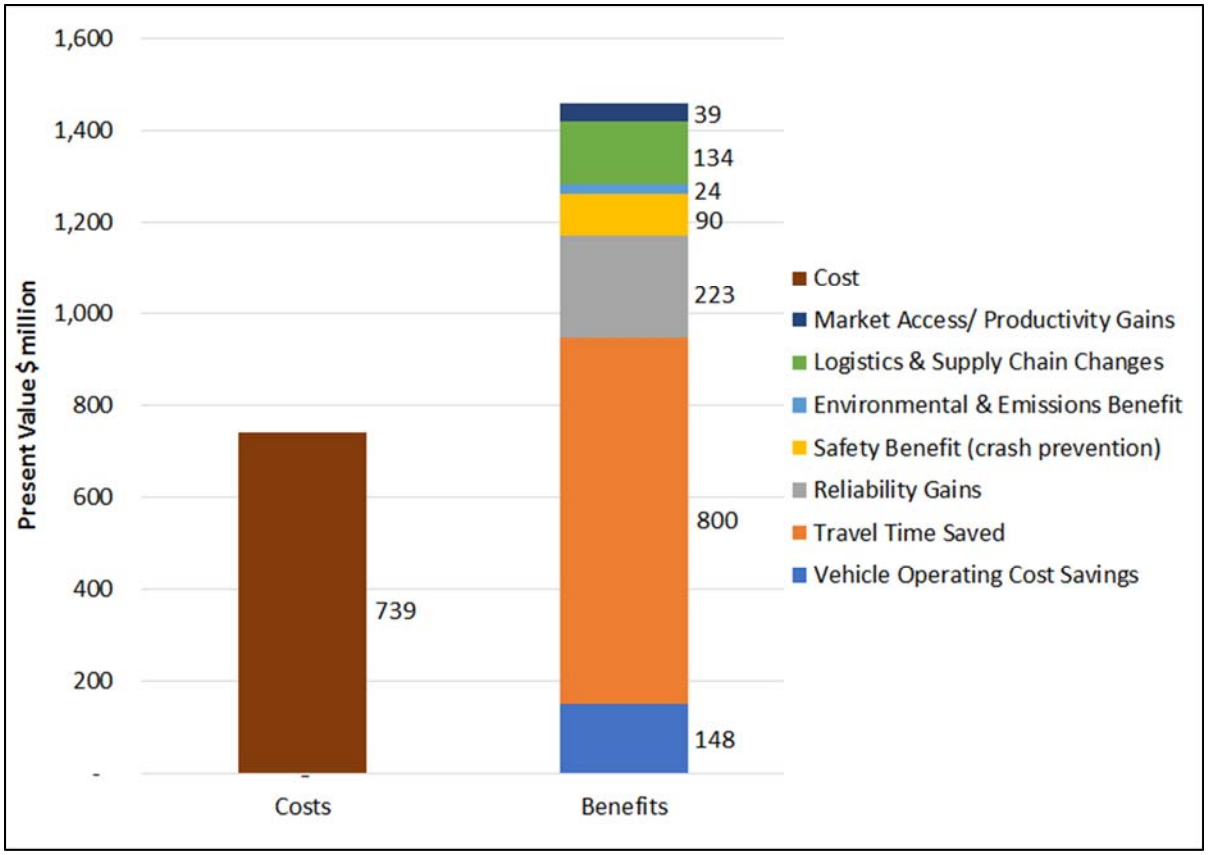
Table 33: Corridor Q Completion: Savings in Miles Traveled, Travel Time, and Travel Reliability

Savings	VMT (miles per day)			VHT (hours per day)			Reliability (hours per day)		
Year	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**
2040	139,595	18,010	157,605	14,071	1,815	15,886	1,035	911	11,285

Source: EDR Group Analysis using consolidated travel models compiled by Parsons Brinckerhoff, HPMS, and Federal Highway Statistics

The benefits of Corridor Q completion consist of travel time and cost savings, as discussed above, along with safety benefits (from less winding roads with directional lanes and shoulders) and wider economic benefits (logistics and market access productivity gains). Figure 48 compares the discounted present value of these benefits to the cost of Corridor Q completion (capital investment, operation, and maintenance cost), all discounted at a rate of 7 percent and shows the resulting benefit/cost ratio. The benefits sum to a total of $1.458 billion compared to a discounted cost of $739 million. The result of the benefit-cost analysis is a benefit-cost ratio of 2.0 and a net benefit of $719 million for Corridor Q. With a lower discount rate of 3 percent, the benefit-cost ratio rises to 3.4.

Figure 48: Costs and Benefits of Corridor Q Completion (7 percent discount rate)



Economic Impacts of Corridor Q Completion

The economic impact projections of Corridor Q completion are shown in Table 34. Altogether, the expected annual economic impacts total $201 million/year in output and 987 jobs. Figure 49 shows the industry mix of the new jobs. Notably, nearly half of the projected new jobs will be in either tourism-related activities, or in professional and business services. The next largest category is "other"—which include energy resource and telecommunications related activities.

Table 34: Corridor Q Economic Impacts (annual, ten yrs. following completion)

	($M)		($)
Output (sales)	$201		
Value Added (GRP)	$97	Value Added per job	$98,607
Income	$61	Income per Job	$61,604
	Jobs		
Employment	987		

Figure 49: Corridor Q: Employment Impact by Industry Sector (annual, ten yrs. following completion)

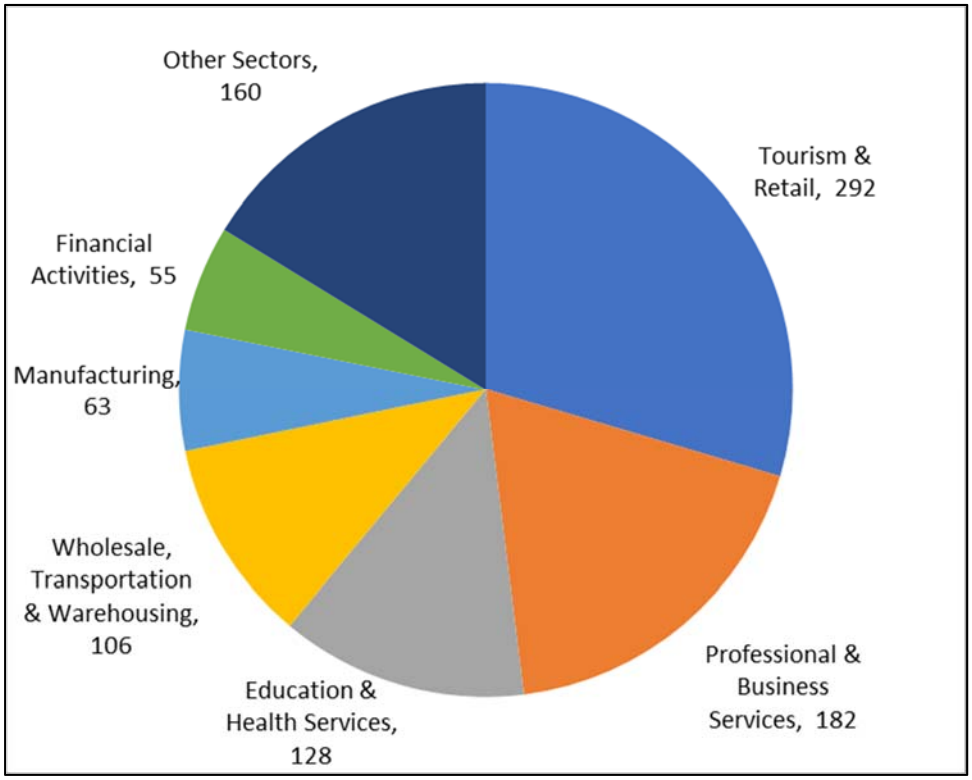


Figure 50: Summary of Corridor Q Impacts Completion

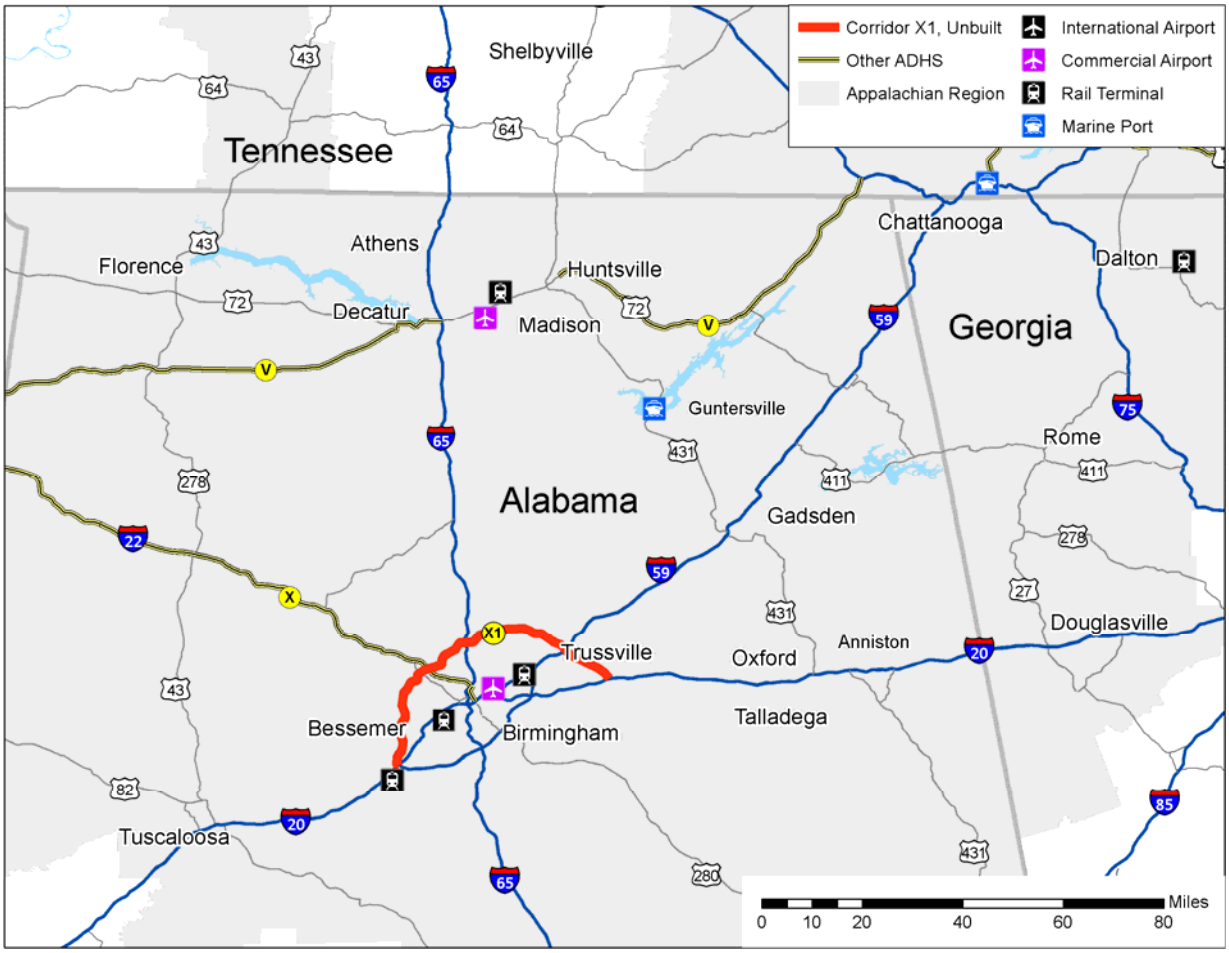
5.6 Corridor X1—Alabama

Characteristics of Corridor X1 and Its State of Completion

Route: Birmingham Northern Beltline
Total length: 65 miles
Unbuilt segment: 65 miles
Completion year: 2045
Estimated Cost: $ 2,966.4 million

Corridor X1 in Alabama was added to ADHS by Section 123 of the FY 2004 Consolidated Appropriations Act. Also referred to as the Birmingham Northern Beltline, this corridor extends approximately 65 miles starting near I-20/59, in the vicinity of I-459 southwest of Birmingham. It extends northward crossing SR 269 and Corridor X (I-22), continuing eastward across I-65, U.S. 31, SR 79, SR75, I-59, U.S. 11, U.S. 411, and finally connecting to I-20 to the east of Birmingham as shown in Figure 51.

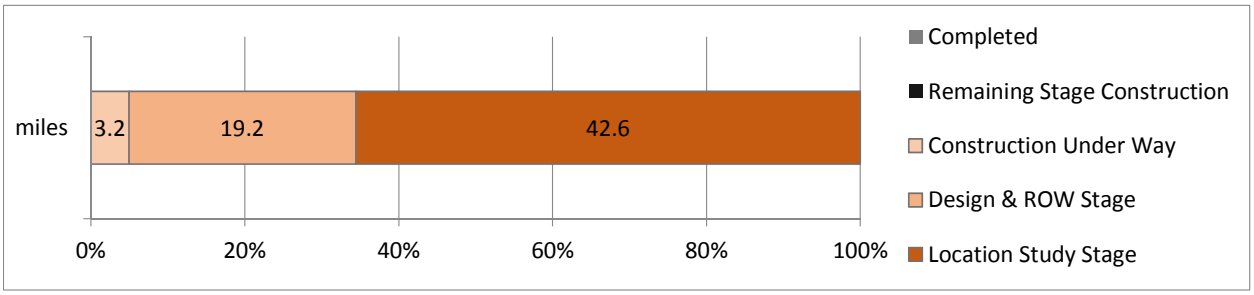
Figure 51: Map of Corridor X1 Area



The unbuilt segment represents the entire Birmingham Northern Beltline. This 65-mile alignment is the remaining northern half of what will become a complete beltway around the city of Birmingham. The southern by-pass (33 miles in length) opened in 1984 and runs from Trussville at I-59 (east of the city) to McCalla at I-20 (southwest of the city).

Currently, none of the authorized Corridor X1 mileage has been built (as shown in Figure 52). However, work has begun on construction of a 3.2-mile section from west of SR 79 to east of SR 75. The rest of the mileage is in the Location Study stage or the Design stage.

Figure 52: Length of Corridor X1 by Status (Authorized)



Source: ADHS Status Report, September 2015.

Expected Local and Regional Effects of Corridor X1 Completion

Completion of Corridor X1 is expected to provide a circumferential route that can help to reduce isolation for parts of Northern Jefferson County, as well as reduce regional road congestion and enable economic growth to the north of Birmingham, AL. Currently, congestion has grown worse around Birmingham with Interstates 65, 59, and 20 converging in the downtown area. Northern Jefferson County has pockets of inaccessibility, particularly for many disadvantaged communities. The Birmingham Northern Beltline is expected to increase capacity, speeds, and reliability and to decrease travel time. Residents, commuters, and area businesses, especially in the northern communities of Jefferson County, stand to benefit from reduced delay. Corridor X1 will also provide better access to the Huntsville area and the Port of Huntsville to the north, and various Gulf ports to the south. The proposed bypass will also provide greatly improved highway access to a recently opened rail intermodal facility located in McCalla. Interviewees additionally expect that the Port of Birmingham, an inland port on the Black Warrior River on the western edge of the county, may attract new business since the truck route (269) that serves the facility would likely interchange with Corridor X1.

Transportation Benefits and Costs of Corridor X1 Completion

The improvement in Corridor X1 will provide significant transportation efficiencies in the form of reduced highway miles traveled and travel time savings (Table 35). VMT will be reduced by roughly 683,000 Miles per day as travelers have new options for connectivity for local, regional and long-distance trips (that no longer need to travel into the heart of Birmingham). The higher speed of the new segment will lead to travel time savings (VHT) of almost 69,000 hours per day. Gains in reliability of the network will enable additional savings of almost 49,000 hours of "buffer time" savings by reducing the need for padding schedules to allow for arrival time uncertainty.

Table 35: Corridor X1 Completion: Savings in Miles Traveled, Travel Time, and Travel Reliability

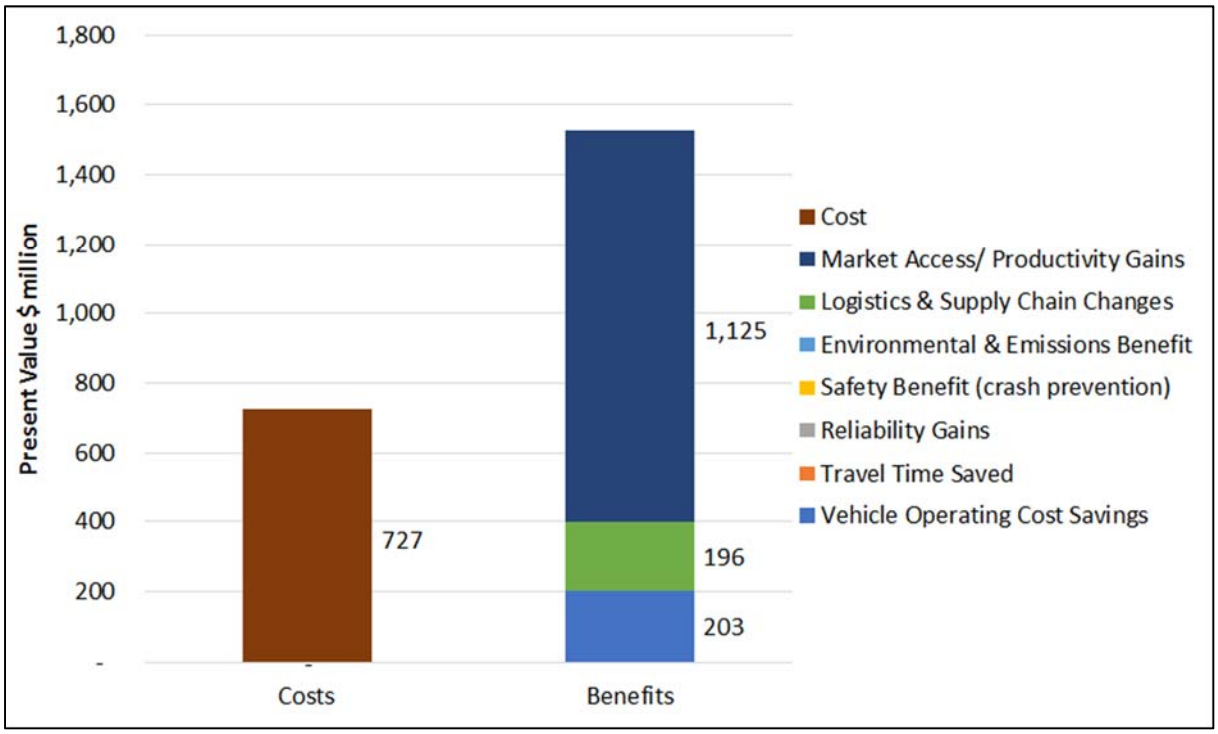
Savings	VMT (miles per day)			VHT (hours per day)			Reliability (hours per day)		
Year	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**	**Car**	**Truck**	**Total**
2040	605,389	78,107	683,497	61,025	7,874	68,900	45,003	3,964	48,966

Source: EDR Group Analysis Using consolidated travel models compiled by Parsons Brinckerhoff, HPMS, and federal highway Statistics

The benefits of Corridor X1 completion consist of travel time and cost savings, as discussed above, plus safety benefits and wider economic benefits (logistics and market access productivity gains). Figure 53 compares the discounted present value of these benefits and costs of Corridor X1 completion (capital investment, operation, and maintenance cost). The market access enhancement effect is particularly large for Corridor X1 as it will provide critical highway connectivity for a large metropolitan area of 1.2 million residents that is also a major regional economic center and job generator.

Altogether, the discounted present value of benefits sums to $3.078 billion, compared to a cost of $727 million (based on a discount rate of 7 percent). With corridor construction not scheduled until the more distant future, discounting leads to a considerably lower present value of future costs and benefits. The result of the analysis is a benefit-cost ratio of 4.2 and a net present value benefit of $2.351 billion for Corridor X1. With a lower discount rate of 3 percent, the benefit-cost ratio rises to over 6.

Figure 53: Costs and Benefits of Corridor X1 Completion (7 percent discount rate)



Economic Impacts of Corridor X1 Completion

The regional economic impact projections for Corridor X1 (by the tenth year following project completion) are shown in Table 36. Altogether, the expected annual economic impacts total $2.671 billion/year in business output and 13,937 jobs. Figure 54 shows the industry mix of the new jobs. The two largest categories, financial activities and professional and business services, each account for one-fifth of the jobs. The particularly high shares for these two industry categories can be explained by the more urban location of Corridor X1. It also explains why projected income impacts are particularly high relative to jobs. The projected average income per new job enabled by Corridor X1 is $61,691 (in 2015 dollars), considerably higher than the Alabama statewide average ($49,524 for 2015).

Table 36: Corridor X1 Economic Impacts (annual, ten yrs. following completion)

	($M)		($)
Output (sales)	$2,671		
Value Added (GRP)	$1,395	Value Added per job	$100,102
Income	$860	Income per Job	$61,691
	Jobs		
Employment	13,937		

Figure 54: Corridor X1: Employment Impact by Industry Sector (annual, ten yrs. following completion)

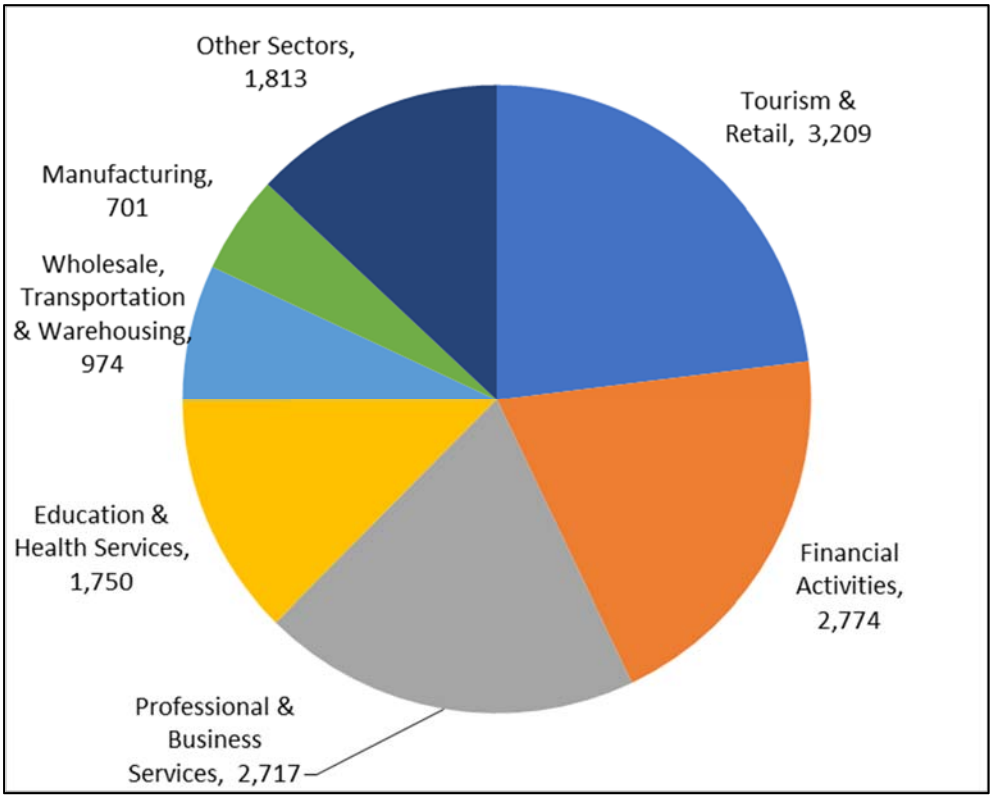


Figure 55: Summary of Corridor X1 Completion Impacts

5.7 Corridor Analysis Findings

The corridor analyses presented in this chapter represent a wide range of different regions, in terms of their scope, scale, location, topography, urban/rural status, and economic context. As a consequence, there are differences among corridors in terms of the project costs, benefits, and economic impacts of project completion. Despite these differences, a primary finding of the corridor analyses is that each corridor is estimated to have benefits exceeding costs, meaning that there is a positive return on investment (ROI) for these remaining corridor projects.

The benefit and economic impact estimates that are generated for each corridor are based on a series of assumptions noted at the beginning of this chapter, which include continued national growth over the next 30 years and continued efforts at supporting non-transportation (as well as transportation) factors affecting economic development in Appalachia over this same period. While future events may lead to some variation in the actual impacts, the underlying conclusion is that there is significant merit to completion of individual ADHS corridors as part of regional transportation system.

6 Conclusions

6.1 Effectiveness of ADHS Investment to Date

From this retrospective analysis of the economic impacts of the ADHS to date, it is clear that the system has had, and continues to have, a profound impact on the Region's economic performance. Most notably, a historical view of the economic impact of the ADHS from 1965 to 2015 finds:

- Areas served by the ADHS have enjoyed significant travel time savings and significantly enhanced workforce access and same-day truck delivery access. As of 2015, annual VHT and travel reliability savings due to ADHS corridor investments are estimated to be 360 million hours per year. These travel efficiency gains affect almost all sectors of the economy, leading to increased business productivity and competitiveness. The benefitting areas are largely rural and economically distressed counties. As of 2015, the value of transportation cost savings and productivity gains amounts to $10.7 billion/year.
- As of 2015, the value of transportation cost savings and productivity gains amounts to $10.7 billion per year. These gains extend beyond the Appalachian Region, benefiting the entire US Economy. Twenty percent of car vehicle hours saved and 31 percent of freight truck vehicle hours saved accrue to trips with at least one end located outside of the 13 Appalachian states. This indicates that the ADHS plays a particularly important role serving longer-distance goods movement and trade, connecting the Region to destinations throughout the U.S.
- Those counties with the greatest travel efficiency and access benefits have also shown the highest rates of employment growth over time.
- The accessibility and transportation cost savings enabled by ADHS system completion to date can be directly linked to the creation of over 168,000 added jobs and over $11.1 billion in additional annual GRP, as of 2015. The cumulative effect of GRP growth continuing year after year, for over fifty years (from 1965 to 2015), adds up to $388 billion.
- The impact of ADHS corridor completion on regional GRP and employment has continued to grow in every period of ADHS development. While the largest share of economic impact is attributable to a large block of highway system improvements made between 1965 and 1983, there is still significant ongoing growth in benefits and economic impacts from ADHS system investment, which can be expected to grow as the system is completed in the first part of the 21st century.

6.2 System-wide Completion Effects

A separate analysis of ADHS completion impacts demonstrates a compelling case for additional investment to complete the ADHS network, and if possible accelerating completion of this system. Notable findings include:

- Completion of remaining ADHS corridor projects will bring savings in vehicle operating costs, traveler time and reliability. For example, by 2045 ADHS completion is expected to

result in 121 million additional hours of travel time and reliability gains for the U.S., leading to over $1.8 billion in annual transportation efficiency, safety and environmental cost savings. However, there are also substantial connectivity benefits from completing the entire ADHS network, which will further enhance freight logistics, the scale of labor and business markets, and overall business productivity.

- ADHS system completion will generate a strong ROI (return on investment) for both the Region and U.S. The present value of benefits – including travel time, travel cost, safety, logistics, market access and environmental benefits – is estimated to exceed $16.3 billion. That is 3.7 times greater than the present value of costs associated with system completion with benefits larger than costs in all scenarios tested in this study. National gains will also include effects on facilitating long-distance trips and intermodal connectivity.
- The impact of fully completing the ADHS system will be in the form of increased economic competitiveness, which will support more inward investment into the Region as well as more exports from the Region to the rest of the world. The overall impact is estimated to be nearly 47,000 additional jobs and $4.2 billion per year in additional GRP realized within ten years after system completion. Around 77 percent of those impacts will occur within the Appalachian counties; the rest will be disbursed elsewhere in the 13 Appalachian states.
- Accelerated completion by 2035 rather than 2045 would help the Region realize economic growth and development impacts more quickly. For instance, it would lead to over 11,000 more jobs and over $1 billion of additional GRP per year within the same study period.
- More than 50 percent of the jobs created by ADHS completion will be in the high-value knowledge or service sectors of the economy such as professional services, health-care, and financial services.

6.3 Bottom Line: Economic Impacts, Benefits and Costs of ADHS

The ADHS investments to date have provided 5,119 additional lane-miles of highway, achieving $10.7 billion in annual benefits—in terms of transportation system performance, access improvement (isolation reduction), and resulting economic growth on the order of 168,000 jobs and $11.2 billion in annual GRP. Completion of the system will also have substantial benefits, in terms of achieving network connectivity to economic markets and intermodal facilities, and in terms of enabling trade and regional economic growth to the effect of nearly 47,000 additional jobs and over $4.2 billion in additional GRP growth. Based on available cost estimates, the achievement of ADHS system completion will bring a strong ROI (return on investment) for Appalachia as well as the broader set of Appalachian states and the nation, realizing $3.65 of benefit for every dollar spent on the system. An examination of five major ADHS corridors that are not yet completed also indicates a positive ROI for each, helping support the benefits of completing each element of the ADHS. While future costs and timing remain uncertain, the analysis shows that efforts to accelerate ADHS completion can help the Region enjoy significantly higher benefits much sooner.

Appendix: Time Series Information

Table 37: Cost and Benefit Streams for ADHS Completion by 2045 at Comparative Discount Rates

	Total Cost			Benefits					
				Regional Perspective			National Perspective		
Year	Not discounted	3% discount rate	7% discount rate	Not discounted	3% discount rate	7% discount rate	Not discounted	3% discount rate	7% discount rate
2015	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2016	$399.0	$399.0	$399.0	$24.0	$24.0	$24.0	$31.9	$31.9	$31.9
2017	$432.0	$419.4	$403.7	$63.6	$61.7	$59.4	$87.8	$85.2	$82.0
2018	$520.7	$490.8	$454.8	$138.0	$130.1	$120.6	$194.6	$183.4	$169.9
2019	$538.4	$492.7	$439.5	$187.3	$171.4	$152.9	$257.7	$235.8	$210.4
2020	$343.7	$305.4	$262.2	$271.2	$241.0	$206.9	$371.3	$329.9	$283.3
2021	$310.7	$268.0	$221.5	$336.6	$290.4	$240.0	$452.4	$390.3	$322.6
2022	$231.7	$194.0	$154.4	$376.8	$315.6	$251.1	$491.8	$411.8	$327.7
2023	$220.3	$179.1	$137.2	$467.4	$380.0	$291.1	$609.1	$495.2	$379.3
2024	$220.3	$173.9	$128.2	$538.6	$425.2	$313.5	$696.0	$549.4	$405.1
2025	$157.3	$120.5	$85.5	$587.1	$450.0	$319.3	$748.0	$573.3	$406.9
2026	$142.8	$106.2	$72.6	$626.5	$466.2	$318.5	$787.4	$585.9	$400.3
2027	$108.2	$78.2	$51.4	$663.4	$479.3	$315.2	$824.7	$595.8	$391.8
2028	$108.2	$75.9	$48.0	$699.2	$490.4	$310.4	$862.3	$604.8	$382.9
2029	$39.1	$26.6	$16.2	$720.3	$490.5	$298.9	$879.2	$598.7	$364.8
2030	$185.4	$122.6	$71.9	$736.5	$486.9	$285.6	$890.6	$588.8	$345.4
2031	$185.4	$119.0	$67.2	$751.4	$482.3	$272.4	$901.8	$578.8	$326.9
2032	$259.0	$161.4	$87.7	$765.1	$476.8	$259.2	$912.9	$568.9	$309.2
2033	$372.7	$225.5	$118.0	$777.6	$470.5	$246.2	$923.9	$559.0	$292.5
2034	$372.7	$218.9	$110.3	$789.2	$463.6	$233.5	$934.7	$549.0	$276.5
2035	$419.0	$239.0	$115.9	$799.9	$456.2	$221.2	$945.5	$539.2	$261.4
2036	$475.2	$263.1	$122.8	$810.0	$448.5	$209.3	$956.3	$529.5	$247.1
2037	$475.2	$255.5	$114.8	$1,231.5	$662.0	$297.4	$1,615.8	$868.6	$390.2
2038	$475.2	$248.0	$107.3	$1,301.0	$679.0	$293.7	$1,721.9	$898.7	$388.7
2039	$539.0	$273.1	$113.7	$1,515.4	$767.8	$319.7	$2,057.1	$1,042.3	$433.9
2040	$539.0	$265.1	$106.3	$1,687.6	$830.2	$332.7	$2,326.3	$1,144.4	$458.6
2041	$539.0	$257.4	$99.3	$1,809.2	$864.1	$333.3	$2,516.3	$1,201.8	$463.6
2042	$685.6	$317.9	$118.1	$1,930.8	$895.3	$332.5	$2,706.7	$1,255.1	$466.1
2043	$540.1	$243.1	$86.9	$2,046.9	$921.5	$329.4	$2,888.9	$1,300.5	$464.9
2044	$540.1	$236.1	$81.2	$2,165.1	$946.3	$325.6	$3,074.7	$1,343.9	$462.4
2045	$540.1	$229.2	$75.9	$2,285.6	$969.9	$321.3	$3,264.5	$1,385.3	$458.9
2046	$17.0	$6.8	$2.1	$2,308.7	$951.1	$303.3	$3,300.7	$1,359.8	$433.6
2047	$17.0	$6.6	$2.0	$2,332.0	$932.8	$286.3	$3,337.5	$1,334.9	$409.8
2048	$17.0	$6.4	$1.8	$2,355.4	$914.7	$270.3	$3,374.6	$1,310.5	$387.2
2049	$17.0	$6.2	$1.7	$2,379.0	$897.0	$255.1	$3,412.2	$1,286.5	$365.9
2050	$17.0	$6.0	$1.6	$2,403.0	$879.6	$240.8	$3,450.3	$1,263.0	$345.8
2051	$17.0	$5.9	$1.5	$2,427.2	$862.6	$227.3	$3,489.0	$1,239.9	$326.8
2052	$17.0	$5.7	$1.4	$2,352.9	$811.8	$206.0	$3,371.9	$1,163.4	$295.2
2053	$17.0	$5.5	$1.3	$2,435.9	$816.0	$199.3	$3,503.5	$1,173.6	$286.6
2054	$17.0	$5.4	$1.2	$2,439.9	$793.5	$186.5	$3,510.4	$1,141.7	$268.4
2055	$17.0	$5.2	$1.1	$2,443.9	$771.7	$174.6	$3,517.3	$1,110.6	$251.3
2056	$17.0	$5.1	$1.1	$2,458.9	$753.8	$164.2	$3,541.7	$1,085.7	$236.5
2057	$17.0	$4.9	$1.0	$2,474.2	$736.4	$154.4	$3,566.4	$1,061.5	$222.6
2058	$17.0	$4.8	$0.9	$2,499.3	$722.2	$145.8	$3,606.9	$1,042.2	$210.4
2059	$17.0	$4.6	$0.9	$2,371.2	$665.2	$129.3	$3,404.8	$955.2	$185.6
2060	$17.0	$4.5	$0.8	$2,395.4	$652.4	$122.0	$3,443.7	$938.0	$175.4
2061	$17.0	$4.4	$0.8	$2,419.8	$639.9	$115.2	$3,483.0	$921.0	$165.8
2062	$17.0	$4.2	$0.7	$2,444.6	$627.6	$108.8	$3,522.9	$904.5	$156.8
2063	$17.0	$4.1	$0.7	$2,469.7	$615.6	$102.7	$3,563.3	$888.2	$148.2
2064	$17.0	$4.0	$0.6	$2,495.1	$603.8	$97.0	$3,604.3	$872.2	$140.1
2065	$17.0	$3.9	$0.6	$2,521.0	$592.3	$91.6	$3,645.9	$856.6	$132.4
2066	$17.0	$3.8	$0.5	$2,547.1	$581.0	$86.5	$3,688.0	$841.3	$125.2
2067	$17.0	$3.7	$0.5	$2,573.7	$570.0	$81.7	$3,730.9	$826.3	$118.4
2068	$17.0	$3.5	$0.5	$2,600.7	$559.2	$77.1	$3,774.5	$811.6	$111.9
2069	$17.0	$3.4	$0.4	$2,628.0	$548.6	$72.8	$3,818.4	$797.1	$105.8
2070	$17.0	$3.3	$0.4	$2,655.7	$538.2	$68.8	$3,863.2	$783.0	$100.1
2071	$17.0	$3.2	$0.4	$2,683.8	$528.1	$65.0	$3,908.5	$769.1	$94.6
2072	$17.0	$3.2	$0.4	$2,712.3	$518.2	$61.4	$3,954.5	$755.5	$89.5
2073	$17.0	$3.1	$0.3	$2,577.1	$478.0	$54.5	$3,740.8	$693.8	$79.1
2074	$17.0	$3.0	$0.3	$2,604.5	$469.0	$51.5	$3,785.2	$681.6	$74.8
2075	$17.0	$2.9	$0.3	$2,632.4	$460.2	$48.6	$3,830.2	$669.6	$70.7

Table 38: Cost & Benefit Streams for 2035 Acceleration and 2045 Completion Scenarios

	2045 Completion				2035 Completion			
Year	Cost (Undiscounted $M)	Cost (7% Discount Rate $M)	Regional Benefits (Undiscounted $M)	Regional Benefits (7% Discount Rate $M)	Cost (Undiscounted $M)	Cost (7% Discount Rate $M)	Regional Benefits (Undiscounted $M)	Regional Benefits (7% Discount Rate $M)
2015	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2016	$399.0	$399.0	$24.0	$24.0	$399.0	$399.0	$10.1	$10.1
2017	$432.0	$403.7	$63.6	$59.4	$432.0	$403.7	$73.8	$68.9
2018	$520.7	$454.8	$138.0	$120.6	$520.7	$454.8	$161.1	$140.7
2019	$538.4	$439.5	$187.3	$152.9	$538.4	$439.5	$226.9	$185.2
2020	$343.7	$262.2	$271.2	$206.9	$529.1	$403.7	$327.6	$249.9
2021	$310.7	$221.5	$336.6	$240.0	$496.1	$353.7	$407.0	$290.2
2022	$231.7	$154.4	$376.8	$251.1	$417.1	$277.9	$456.7	$304.3
2023	$220.3	$137.2	$467.4	$291.1	$519.3	$323.4	$562.7	$350.4
2024	$220.3	$128.2	$538.6	$313.5	$519.3	$302.2	$616.6	$358.8
2025	$157.3	$85.5	$587.1	$319.3	$576.3	$313.5	$662.9	$360.6
2026	$142.8	$72.6	$626.5	$318.5	$561.8	$285.6	$702.3	$357.0
2027	$108.2	$51.4	$663.4	$315.2	$527.2	$250.5	$1,021.3	$485.2
2028	$108.2	$48.0	$699.2	$310.4	$527.2	$234.1	$1,087.3	$482.8
2029	$39.1	$16.2	$720.3	$298.9	$562.3	$233.3	$1,274.0	$528.7
2030	$185.4	$71.9	$736.5	$285.6	$523.3	$202.9	$1,469.5	$569.9
2031	$185.4	$67.2	$751.4	$272.4	$523.3	$189.7	$1,563.2	$566.6
2032	$259.0	$87.7	$765.1	$259.2	$685.6	$232.2	$1,688.4	$571.9
2033	$372.7	$118.0	$777.6	$246.2	$685.6	$217.0	$1,815.6	$574.8
2034	$372.7	$110.3	$789.2	$233.5	$685.6	$202.8	$1,945.0	$575.5
2035	$419.0	$115.9	$799.9	$221.2	$685.6	$189.6	$2,076.7	$574.2
2036	$475.2	$122.8	$810.0	$209.3	$0.0	$0.0	$2,097.1	$541.9
2037	$475.2	$114.8	$1,231.5	$297.4	$0.0	$0.0	$2,117.5	$511.4
2038	$475.2	$107.3	$1,301.0	$293.7	$0.0	$0.0	$2,138.3	$482.6
2039	$539.0	$113.7	$1,515.4	$319.7	$0.0	$0.0	$2,159.1	$455.5
2040	$539.0	$106.3	$1,687.6	$332.7	$0.0	$0.0	$2,180.0	$429.8
2041	$539.0	$99.3	$1,809.2	$333.3	$0.0	$0.0	$2,201.4	$405.6
2042	$685.6	$118.1	$1,930.8	$332.5	$0.0	$0.0	$2,222.9	$382.8
2043	$540.1	$86.9	$2,046.9	$329.4	$0.0	$0.0	$2,244.5	$361.2
2044	$540.1	$81.2	$2,165.1	$325.6	$0.0	$0.0	$2,266.5	$340.9
2045	$540.1	$75.9	$2,285.6	$321.3	$0.0	$0.0	$2,288.8	$321.7