BALTIMORE-WASHINGTON SCMAGLEV PROJECT

Economic Analysis: Economic Impact of Capital, Operations, Maintenance and Environmental Benefits

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FIGURES

NOTES/REVISIONS FOR VERSION CONTROL

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1. INTRODUCTION

This document presents an estimate of the economic impact of capital[1] and operation and maintenance spending for the Superconducting Maglev (SCMAGLEV) project between Washington, DC and Baltimore, MD. The analysis uses estimated economic impacts of the Superconducting Maglev (SCMAGLEV) project, along with the most recent economic data, which reflects industry and household spending patterns, imports vs domestic/regional purchasing, county, state and federal tax rates, commuting patterns and wages. This document also presents pollution reduction and other SCMAGLEV benefits. These benefits were estimated with the most up to date available current and forecasted passenger vehicle emission information. Estimates of reduced air pollution and other public benefits of SCMAGLEV were monetized based on updated damage values from recent benefit-cost guidance or other reports.

Note, construction[2] and operation estimates are based on projects and transportation systems of similar magnitude. SCMAGLEV-specific O&M expenditures will be developed as project planning advances, and will be dependent on various factors, including the selection of a preferred alternative and various operational issues that are yet to be determined.

[1] Capital cost estimates for the SCMAGLEV project do not include core system costs.
[2] Construction phase estimates are based on construction activity of the civil works.

2. ECONOMIC IMPACT

The Washington and Baltimore metropolitan areas are ranked as the 6th and 19th largest economies, respectively, among U.S. metropolitan areas. Washington's economy is dominated by the federal government sector while Baltimore's economy is more balanced among several sectors. Both economies have been adversely affected by the COVID-19 pandemic. However, COVID-19 has had comparatively less economic impact on the economies as compared with many other U.S. metropolitan areas.

Construction of the SCMAGLEV project between Washington and Baltimore will be a considerable civil works project in the region, including construction of approximately 34-miles of guideway and tunnel infrastructure, stations, trainset maintenance facility (TMF), ventilation plants, and other support facilities. U.S. companies will also be supporting the architectural and engineering design of the infrastructure. The civil infrastructure cost portion of the project alone is estimated to be in excess of $9B.

To assess the magnitude of the total national and regional economic impact of the SCMAGLEV project, a regional economic analysis was conducted using an industry-accepted input-output model. Input-output modeling is a standard technique to estimate the impact of a change in final demand in one industry on the production level of other industries and the economy as a whole within a specific region. Using input-output modeling techniques, it was estimated that construction of the SCMAGLEV infrastructure, guideway, and stations will contribute $45-billion in economic output to the nation's economy, supporting 297,040 person-years of employment during construction, which translates into an average of 42,430 jobs per year assuming a 7-year construction period. A person-year of employment refers to one job for one year. Figure 1 summarizes these national economic benefits.

	Employment (in person-years)	Labor Income (in $million)	Gross Domestic Product (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
United States	297,036	$19,464	$23,434	$44,949	$1,311	$3,804

Figure 1: National Construction Benefits, Including Multiplier Impacts (2020$)

Figure 2 summarizes the estimated regional construction impacts. The region is defined as the Baltimore-Washington metropolitan area, which is a combined statistical area consisting of the overlapping labor market region of the cities of Washington, D.C. and Baltimore, Maryland (MD). The region includes Central Maryland, Northern Virginia (VA), three counties in the Eastern Panhandle of West Virginia (WV), and one county in South Central Pennsylvania (PA). It is the most educated, highest-income, and fourth largest combined statistical area in the United States.

Officially, the Baltimore-Washington metropolitan area is designated by the U.S. government Office of Management and Budget as the Washington-Baltimore-Arlington, DC-MD-VA-WV-PA Combined Statistical Area (CSA), or the Washington-Baltimore-Arlington, CSA. It is composed primarily of two major metropolitan statistical areas (MSA), the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA and the Baltimore-Columbia-Towson, MD MSA. In addition, five other smaller urban areas not contiguous to the main urban area but having strong commuting ties with the main area are also included in the metropolitan area. These are: the Hagerstown–

Martinsburg, MD-WV MSA, the Chambersburg–Waynesboro, PA MSA, the Winchester, VA-WV MSA, the California–Lexington Park, MD MSA, and the Easton, MD micropolitan statistical area (μSA).

Across the Washington-Baltimore-Arlington, CSA, more than 243,840 person years of employment, or an average of 34,830 jobs per year for a 7-year construction period, will be supported by the SCMAGLEV construction project. SCMAGLEV construction will contribute an estimated $31 billion in output to the Washington-Baltimore-Arlington CSA economy.

Geography	Employment (in person-years)	Labor Income (in $million)	Value Added (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
Washington-Baltimore-Arlington CSA	243,837	$17,148	$16,308	$30,506	$1,184	$2,747

Figure 2: Regional Construction Benefits, Including Multiplier Impacts (2020$)

Once the service is operational, an estimated 1,740 persons will be directly employed by SCMAGLEV, including jobs in train and station operations, maintenance, inspections, marketing and management. Operating and maintenance spending will support an additional 1,970 jobs in the U.S., about 1,010 of which will be within the Washington-Baltimore-Arlington CSA (Figure 3).

Geography	Employment (in person-years)	Labor Income (in $million)	Value Added (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
United States	3,710	$240.94	$326.99	$550.69	$14.20	$26.21
Washington-Baltimore-Arlington CSA	2,751	$187.56	$225.75	$308.70	$9.85	$12.58

Figure 3: National and Regional Operation and Maintenance Benefits, including Direct plus Multiplier Impacts (2020$)

3. METHODOLOGY

3.1. METHODOLOGY FOR ECONOMIC ACTIVITY ESTIMATES

The macroeconomic method of input-output analysis was used to estimate the economic activity associated with construction of SCMAGLEV, operating and maintaining the system, increased visitation to Baltimore and station area development.

Input-output analysis is a form of macroeconomic analysis based on the interdependencies between different economic sectors or industries. Input-output economic analysis was originally developed by Wassily Leontief, who won the Nobel Prize in Economic Sciences for his work in this area. The foundation of input-output analysis involves input-output matrices. Such matrices include a series of rows and columns of data that quantify the supply chain for all sectors of an economy. Industries are listed in the headers of each row and each column. The data in each column corresponds to the level of inputs used in that industry's production function.

Input-output models estimate three types of impact: direct, indirect, and induced. These terms are another way of referring to initial, secondary, and tertiary impacts that ripple through the economy when a change is made to a given input level. This ripple effect is also called the multiplier effect. By using input-output models, economists can estimate the change in output across industries due to a change in inputs in one or more specific industries.

- The direct impact of a project is the initial spending on the project. Building the SCMAGLEV infrastructure will require spending on concrete, steel, construction equipment, labor, and other inputs.
- The indirect, or secondary, impact will result from spending by the suppliers, and by the suppliers of the suppliers, and so on, at other businesses within the region of analysis, to meet demand. For instance, suppliers of concrete will purchase cement at other companies within the region and the cement suppliers will in turn purchase materials at other regional companies
- The induced, or tertiary, impact will result from household spending by the workers of the directly or indirectly affected industries. It includes the economic activity supported by SCMAGLEV construction workers and by employees of suppliers purchasing goods and services for personal consumption.

This cycle of spending continues to work its way backward through the supply chain with each round of impacts getting smaller and smaller, until all money leaves the region of analysis by way of imports, taxes, and profits, which do not generate additional impacts locally.

In this case, the input-output analysis studies the ripple effects on various sectors of the economy caused by constructing and operating SCMAGLEV. In other words, the input-output analysis shows the benefits the SCMAGLEV project will generate by purchasing materials and hiring companies that hire workers that spend in the economy, helping it to grow.

Various governmental and other organizations have compiled economic data and developed computer models for input-output analysis. The IMPLAN input-output modeling system was used to analyze the economic impact of SCMAGLEV. IMPLAN is a widely used and accepted input-output system developed by the U.S. Forest Service and currently privately owned by IMPLAN.

IMPLAN is an input-output modeling system that uses data from public sources, including from the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, U.S. Bureau of Census,

U.S. Department of Agriculture. The system uses advanced modeling techniques to allow the user to develop customized analyses at different levels of geography and industry detail and for different time periods. IMPLAN allows the user to generate area-specific multipliers that take into account inter-industry linkages and the relationships between industries and consumers. IMPLAN is used to estimate an industry's contributions to a region, quantify the economic impact of an increase in spending, examine the effects of a new or existing business, model the impacts of expected growth or changes in an industry, or study the impact of any other event on a region.

The IMPLAN model identifies direct impacts by sector, then develops a set of indirect and induced impacts by sector. Applying these initial changes/dollars spent to the multipliers in an IMPLAN model will then display how the region will respond, economically to these purchases.

IMPLAN does not assume that all input purchases are made from local businesses; the proportion of local vs. non-local purchases varies by commodity and is built into the IMPLAN system.

IMPLAN models account for commuting patterns; thus, induced impacts will only reflect the spending of wages from residents. IMPLAN removes payroll taxes, personal taxes, and savings before allowing the remainder to be spent on goods and services. IMPLAN also accounts for imports and does not assume that all purchases of goods and services are made within the study area.

For an IMPLAN analysis, the user specifies the geographic area within which the change will occur, the industry or institution in which the change is occurring, the year of the change, and one of the following: industry sales, employment, employee compensation, or proprietor income.

With this information, and the local economic data provided by IMPLAN, the model estimates the rest of the information needed to measure the impact in terms of direct, indirect, and induced, and total economic impact.

For this study, the analysis was conducted with 2018 IMPLAN data, which was the most recent data available at the time of the analysis. The following impact areas were used in the analysis:

- United States
- Region: Washington-Baltimore-Arlington, CSA, which is composed of the following:

    Washington-Arlington-Alexandria, DC-VA-MD-WV, MSA, which is composed of:

        Principal Cities: Washington, DC; Arlington, VA; Alexandria, VA; Frederick, MD; Gaithersburg, MD; Rockville, MD; Bethesda, MD; Reston, VA

        Counties and equivalent entities: District of Columbia; Frederick County, Montgomery County; Calvert County, MD; Charles County, MD; Prince George's County, MD; Arlington County, VA; Clarke County, VA; Culpeper County, VA; Fairfax County, VA; Fauquier County, VA; Loudoun County, VA; Madison County, VA; Prince William County, VA; Rappahannock County, VA; Spotsylvania County, VA; Stafford County, VA; Warren County, VA; Alexandria city, VA; Fairfax city, VA; Falls Church city, VA; Fredericksburg city, VA; Manassas city, VA; Manassas Park city, VA; Jefferson County, WV

Baltimore-Columbia-Towson, MD, MSA, which is composed of:

        Principal Cities: Baltimore, Columbia, Towson

Counties and equivalent entities: Anne Arundel County, Baltimore city, Baltimore County, Carroll County, Harford County, Howard County, Queen Anne's County

Hagerstown-Martinsburg, MD-WV, MSA, which is composed of:

Principal Cities: Hagerstown, MD; Martinsburg, WV

Counties and equivalent entities: Washington County, MD; Berkeley County, WV; Morgan County, WV

Chambersburg-Waynesboro, PA, MSA, which is composed of:

Principal Cities: Chambersburg, Waynesboro

Counties and equivalent entities: Franklin County

Winchester, VA-WV, MSA, which is composed of:

Principal City: Winchester, VA

Counties and equivalent entities: Frederick County, VA; Hampshire County, WV

California-Lexington Park, MD, MSA, which is composed of:

Principal Cities: California, Lexington Park

Counties and equivalent entities: St. Mary's County

Easton, MD MSA, which is composed of:

Principal City: Easton

Counties and equivalent entities: Talbot County

- Local Study Area: This is the area were most of the construction will take place. It is defined as the City of Baltimore, Baltimore County, Anne Arundel County, Prince George's County and the District.
- District of Columbia
- City of Baltimore
- State of Maryland
- Commonwealth of Virginia

Applying IMPLAN to the SCMAGLEV project analysis, the economic impacts of spending on public transportation are expressed in terms of (1) employment; (2) labor income; (3) value added (also named gross regional product or gross domestic product if at regional or national scale, respectively); (4) output or sales revenue; (5) state and local tax revenues; and (6) federal tax revenues for the following types of impacts:

- Direct impacts—Direct impacts of SCMAGLEV include the construction spending, spending on ongoing operations of the SCMAGLEV system, including staff, train operations, electricity and maintenance activities, and visitor spending
- Indirect impacts—Indirect impacts refer to supporting industries who supply goods and services to enable the direct spending on SCMAGLEV—including industries supplying construction materials; equipment; and the steel, concrete, wood, and plastic materials that are needed for building guideways, and station facilities.

- Induced impacts—Induced impacts refer to industries that are supported by the re-spending of SCMAGLEV direct and indirect worker income and salaries on consumer goods and services – including food, shelter, recreation, education and personal services.

3.1.1 CONSTRUCTION

Construction impacts were estimated for the United States, the State of Maryland, the District, the Commonwealth of Virginia, the Washington-Baltimore-Arlington, CSA (referred to as the "Region") and the Local Study Area, which consists of city of Baltimore, Baltimore County, Anne Arundel County, Prince George's County and the District. The Local Study Area is the area where most of the construction will takes place.

The construction impacts were estimated based on the project's capital cost estimates[3]. The project capital cost has three components (1) the construction cost; (2) soft cost, which includes architecture and engineering, marketing, legal, management, and insurance; and (3) a contingency to reflect the uncertainty of the construction and soft cost estimates. The soft cost were estimated to be equal to 27 percent of the construction cost based on a review of other rail projects in the US. The contingency was calculated as 30 percent of the sum of the construction cost and soft cost. Based on Federal Transit Administration Project Management Oversight Procedures, a 30 percent contingency is reasonable based on the project stage. Including these three components, the project's total capital cost equals $15.3 billion (in 2020 dollars). The alignment will require the purchase of property in right-of-way costs. These right-of-way costs were not included in the analysis as these costs are in essence a transfer and do not recirculate in the economy in the same manner as other project expenditures.

The IMPLAN model only takes into account spending within the US. It was assumed that 90 percent of the construction cost and 90 percent of the soft cost will be spent within the US with the primary non-US cost being that of procuring the tunnel boring machines. Thus, including the 30 percent contingency, $13.8 billion (in 2020 dollars) of the project's $15.3 billion capital cost will be spent in the US and will generate a multiplier effect. It was assumed that 22 percent of the spending will take place in Washington and 78 percent in the rest of the Local Study Area based on the location of the guideway and the stations relative to these political boundaries.

Construction spending in the US will generate jobs in the construction and related industries during the time of the construction period. The purchase of construction materials and household spending by construction and other workers will support additional jobs during the construction period. Construction jobs are expressed in terms of person-years of employment, which corresponds to one person working one year. Based on an estimated construction duration of 7 years, the annual employment impact for the duration of the construction period was estimated by dividing the total construction employment impact by 7.

A literature review of other major transportation capital projects' economic and employment impacts was conducted to provide a basis of comparison.

3.1.2 OPERATIONS AND MAINTENANCE

As with the construction impacts, operations and maintenance impacts were estimated for the United States, the State of Maryland, the District, the Commonwealth of Virginia, the Region and the Local Study Area.

[3] Construction estimates are based on civil construction and do not include core system costs.

It was assumed that SCMAGLEV operations and maintenance jobs would be located within the Local Study Area. The distribution of jobs within the Local Area Study was assumed to be based on the location of the stations and other facilities.

The number of SCMAGLEV operations jobs, including station operations, train operations, train inspection and maintenance, facilities inspection and maintenance was based on the most recent estimates. For the purpose of the analysis, the total annual operation and maintenance spending for SCMAGLEV, including employee compensation and operation and maintenance purchases such as electricity, was assumed to be $200 million. Note that these estimates are based only on projects and transportation systems of similar magnitude. SCMAGLEV-specific O&M expenditures will be developed as project planning advances, and will be dependent on various factors, including the selection of a preferred alternative and various operational issues that are yet to be determined.

Operation and maintenance expenditures will generate permanent jobs in the rail industry and its supplying industries. Household spending by workers in the rail industry and supplier industries will generate additional jobs throughout the region.

3.1.3 ENVIRONMENTAL BENEFITS

The Federal Clean Air Act establishes national ambient air quality standards for criteria pollutants, including motor vehicle (mobile source) tailpipe emissions. Through coordinated air quality and transportation planning, states and metropolitan planning organizations assess the attainment status of the air quality standards. While greenhouse gases (GHG) are not considered a criteria pollutant, states such as Maryland as well as the District of Columbia (Washington) have established GHG emissions reduction goals from sources including the transportation sector.

To estimate the economic benefits of emission reduction due to reduced automobile travel, estimates of greenhouse gases (GHG) and main air pollutants generated per VMT were estimated with the United States Environmental Protection Agency (EPA) Motor Vehicle Emission Simulator, MOVES14b, which was the latest version available at the time of this analysis. Use of the MOVES model in the current study provides a more precise estimate of the project's effects on air pollutant emissions from motor vehicles than that provided in the previous report which used regional average values.

The EPA's MOVES is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics. The MOVES model is kept up to date by:

- Incorporating the latest data on vehicle populations, travel activity, and emission rates as well as updated fuel supply information at the county level.
- Adjusting modeling to better account for vehicle starts, long-haul truck hoteling, and off-network idling.
- Incorporating the impacts of the Heavy-Duty Greenhouse Gas Phase 2 rule and the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule.
- Improving the user interface to make the model easier to use and updating the platform for compatibility with newer software.

Emission rates were developed for 2020, 2030, 2040 and 2050 for GHG; Volatile Organic Compounds (VOC); Nitrogen Oxides (NO_x), Particulate Matter (PM), including $PM_{2.5}$

(particulates 2.5 micrometers or smaller) and PM_{10} (particulates 10 micrometers or smaller); Carbon Monoxide (CO) and Sulfur Dioxide (SO_2). To obtain a high-level estimate, the MOVES14b model was run using the national scale default inputs for Prince George's County, MD. Emissions estimated include emissions by gasoline-powered vehicles in tailpipe exhaust and from tire and brake wear emission processes for PM; vehicle start emissions were not included. Emission rates vary by vehicle type, vehicle age and condition, driving cycle, driving style and weather. Based on Maryland Department of Transportation (MDOT) 2019 traffic counts, the passenger trucks account for 12.1 percent of the passenger vehicle traffic on I-295 and I-95 between Baltimore and Washington. The emission rates used in this study reflect this vehicle type split and assume travel on urban restricted access roads.

To estimate the emission reduction benefit, the MOVES14b emission rates were applied to VMT reductions caused by SCMAGLEV as estimated with the 2018 SCMAGLEV ridership forecasting model. The analysis assumes that 2030 is the initial full opening year and that there is a two year ramp up period when ridership equals 40 percent and 80 percent of modeled ridership, respectively. The analysis assumes that 2032 is the first stabilized year of ridership.

The VMT reduction estimate is conservative as it reflects the distance between station pairs and does not reflect any potential additional decrease in VMT associated with station access and egress by transit or non-motorized modes.

The emission reduction benefits were monetized using standard damage cost per unit of pollutants (Figure 4). For VOC, NO_x, SO_2, and $PM_{2.5}$, the damage values from the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs were used. To monetize the value of the reductions in GHG, the social cost of carbon from the United States Environmental Protection Agency (EPA) was used. The social cost of carbon includes domestic and global changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. The damage values were adjusted for inflation using the Consumer Price Index for all Urban Consumers (CPI-U) for the Middle Atlantic from the Bureau of Labor Statistics. The present value of the emission benefits was estimated by discounting the stream of emission reduction benefits over the 30-year period (2030-2060) using a 3 percent discount rate.

Type of Pollutant	Damage Cost ($/metric ton) (2020$s)
VOC	$2,161
NO_x	$8,849
SO_2	$51,549
$PM_{2.5}$	$398,501
CO_2e	From $45 in 2015 to $89 in 2050 based on a 3% discount rate

Figure 4: Emissions Damage Cost

3.2. ANALYSIS

3.2.1 CREATING NEW JOBS AND INCOME

The SCMAGLEV alignment is expected to originate in the center of the District, cross the Maryland counties of Prince George's, Anne Arundel (the Baltimore-Washington International Airport (BWI) station is in Anne Arundel County), Baltimore, and terminate in Cherry Hill in the City of Baltimore. The general mileage of these segments includes:

- The District – 4.1 miles
- Prince George's County, Maryland – 12.2 miles
- Anne Arundel County, Maryland – 15.4 miles
- Baltimore County, Maryland – 1.3 miles
- City of Baltimore, Maryland – 1.5 miles

The IMPLAN input-output model was used to estimate the economic benefits of the construction and operations and maintenance spending for SCMAGLEV.

3.2.2 CONSTRUCTION

Construction of the SCMAGLEV project between Washington and Baltimore will be a considerable civil works project in the region, including construction of 34 miles of guideway and tunnel infrastructure, stations, maintenance yard, ventilation plants, and other support facilities. U.S. companies will also be supporting the architectural, engineering, and design of the infrastructure and SCMAGLEV system.

National jobs benefits associated with infrastructure construction were studied extensively. Figure 5 summarizes findings of this study in comparison with other major transportation economic impact studies and projects.

For the California High Speed Rail project, a recent statewide economic impact study based on actual spending on planning and construction between 2006 and 2019 was used. The study found that 96 percent of the spending went to California businesses and workers and found a statewide impact of 7,800 to 8,800 full-time equivalent jobs per billion invested.

A 2020 APTA study found an impact of 13,000 jobs per $1 billion of capital investment, which is significantly lower than the 2014 study. However, the 2020 study also found an impact of 20,000 per $1 billion of operations investment.

Finally, a American Association of Railroads new study reported that Class I railroads' operations and capital expenditures supported over 1.1 million jobs in the US. The new study is not included in Figure 5 as it not clear from the documentation how many of these jobs were supported by capital spending.

The Texas Central High-Speed Rail economic impact study of 2016 does not provide enough information to calculate a comparable jobs per billion investment value and was therefore also not included in Figure 5.

National-Level Impacts		
Project/Study	**Impact Estimate**	**Basis**
This study:		
SCMAGLEV	19,000 jobs per $1 billion invested	National impacts of proposed project-based analysis of preliminary capital budget, assuming 90 percent of spending takes place in the US IMPLAN economic impact model used to estimate direct, indirect, and induced impacts.
Comparable studies:		
American Public Transit Association (2020)	13,000 jobs per $1 billion invested on capital improvements	National impacts based on APTA Fact Book 2018 data. Estimated using IMPLAN. The study also showed that $1 billion investment in operations results in 20,000 jobs.
Regional/State-Level Impacts		
Project/Study	**Impact Estimate**	**Basis**
This study:		
SCMAGLEV	12,600 jobs (State of Maryland) per $1 billion invested	State-level impacts of proposed project-based analysis of current capital cost estimate, assuming 90 percent spending takes place in the US. IMPLAN economic impact model used to estimate direct, indirect, and induced impacts.
Comparable studies:		
Purple Line (2015)	11,900 jobs (Region) per $1 billion invested (2014$)	Region defined as Washington, DC, Montgomery County and Prince George's County. Analysis conducted with RIMS multipliers
Inter-County Connector	6,000 (State of Maryland) per $1 billion invested	State-level impacts of proposed project budget estimated with U.S. BEA RIMS II model.
Capital Beltway HOT Lanes	10,000 (Commonwealth of Virginia) per $1 billion invested	State-level impacts of proposed project budget estimated with U.S. BEA RIMS II model.
California High Speed Rail (2020)	7,800 to 8,800 jobs (in State of California) per $1 billion	Based on $5.7 billion of planning and construction spending between 2006 and 2019, of which 96 percent went to California firms and workers. State-level impact of spending to date with IMPLAN. Jobs are converted to full-time equivalent jobs.

Figure 5: Comparison of Capital Investment Impact Assessments

Construction of the SCMAGLEV project will contribute $45 billion in economic output to the nation's economy, supporting about 297,000 total person-years of employment during the construction period. Figure 6 summarizes these construction economic benefits for the United States. Additionally, federal, state, and local governments will benefit from these construction activities, with approximately $5.1 billion in federal, state and county tax receipts.

	Employment	Labor Income (in $million)	Gross Domestic Product (in $million)	Economic Output or Sales (in $million)	State and Local Government Receipts (in $million)	Federal Government Fiscal Receipts (in $million)
United States	*297,036*	*$19,464*	*$23,434*	*$44,949*	*$1,311*	*$3,804*

Figure 6: National Construction Benefits, Including Multiplier Impacts (2020$)

Figure 7 summarizes the regional impacts of the construction spending. Construction of SCMAGLEV will support $30.5 billion of economic output in the Region. Across the Region, there will be 243,840 person-years of employment supported by the construction project. Assuming a 7-year construction period, this will translate into an average of 34,830 jobs throughout the construction period. Most of these jobs – an estimated 222,590 person-years of employment – were estimated to be located within the Local Study Area, which consists of Washington, Baltimore city, Baltimore County, Anne Arundel County and Prince George's County, Maryland. The distribution of the impact on the economy of the Local Study Area was allocated among Washington, Baltimore City and the three Maryland counties that are part of the Local Study Area based on an estimate of where the construction activity will take place. At a State/District level, a total of about 193,330 person-years of employment will be created in Maryland, about 42,370 in Washington and about 7,600 in Virginia. Annual State tax revenues generated by the operation and maintenance of SCMAGLEV were estimated as $1.1 billion in Maryland and $71 million in Virginia.

	Employment	Labor Income (in $million)	Gross Domestic Product (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
Local Study Area:						
Washington	*42,372*	*$3,456*	*$2,524*	*$4,788*	*$0*	*$440*
Baltimore City	*22,503*	*1,747*	*1,566*	*2,912*	*56*	*279*
Baltimore County	*11,381*	*722*	*962*	*1,714*	*102*	*138*
Anne Arundel County	*91,966*	*6,501*	*5,914*	*11,138*	*543*	*1,093*
Prince George's County	*54,365*	*3,401*	*2,939*	*5,980*	*250*	*536*
Subtotal Local Study Area	*222,588*	*$15,828*	*$13,904*	*$26,532*	*$950*	*$2,486*
Rest of the Washington-Baltimore-Arlington, CSA	*21,249*	*$1,319*	*$2,404*	*$3,973*	*$234*	*$261*
Total Washington-Baltimore-Arlington, CSA (Region)	*243,837*	*$17,148*	*$16,308*	*$30,506*	*$1,184*	*$2,747*

	Employment	Labor Income (in $million)	Gross Domestic Product (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
By State:						
Maryland	*193,329*	*$13,166*	*$12,845*	*$24,168*	*$1,111*	*$2,201*
Virginia	*7,596*	*$499*	*$892*	*$1,445*	*$71*	*$100*

Figure 7: Regional Construction Benefits, Including Multiplier Impacts (2020$)

Top 20 industries that will benefit from construction of the SCMAGLEV project in the Region include:

- Construction of other new nonresidential structures
- Architectural, engineering, and related services
- Management of companies and enterprises
- Legal services
- Insurance carriers, except direct life
- Other real estate
- Hospitals
- Wholesale - Other durable goods merchant wholesalers
- Tenant-occupied housing
- Insurance agencies, brokerages, and related activities
- Offices of physicians
- Retail - Building material and garden equipment and supplies stores
- Marketing research and all other miscellaneous professional, scientific, and technical services
- Monetary authorities and depository credit intermediation
- Employment services
- Limited-service restaurants
- Commercial and industrial machinery and equipment rental and leasing
- Electric power transmission and distribution
- Full-service restaurants
- Truck transportation

3.2.3 OPERATIONS AND MAINTENANCE

SCMAGLEV service is estimated to directly employ 1,740[4] jobs annually in the United States to operate the system and maintain its infrastructure. This includes repair and maintenance, inspection, and train operator occupations.

Operation and maintenance spending will support an additional 1,970 permanent full- and part-time jobs at other businesses in the United States, resulting in a total national employment contribution of 3,710 jobs. Operation and maintenance of SCMAGLEV will generate $550 million in economic output or sales revenue and $26 million of federal tax revenues. The national operations and maintenance benefits are summarized in Figure 8.

[4] This estimate is based on an evaluation of various other railroad manpower requirements.

	Employment	Labor Income (in $million)	Gross Domestic Product (in $million)	Economic Output or Sales (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
United States	3,710	$240.94	$326.99	$550.69	$14.20	$26.21

Figure 8: National Annual Operations and Maintenance Economic Benefits (2020$)

Within the Washington-Baltimore-Arlington, CSA, operation and maintenance spending was estimated to support an additional 1,000 jobs most of which will be located within the Local Study Area. In total, operation and maintenance of SCMAGLEV will support about 2,750 permanent full- and part-time jobs in the Washington-Baltimore-Arlington, CSA, of which about 2,660 will be in the Local Study Area. At the State/District level, operations and maintenance will support 2,170 jobs in Maryland, 550 jobs in Washington and 30 jobs in Virginia. The operations and maintenance economic benefits are summarized in Figure 9.

	Employment	Labor Income (in $million)	Value Added (in $million)	Output (in $million)	State and County Government Receipts (in $million)	Federal Government Receipts (in $million)
Local Study Area:						
Washington	548	$39.83	$43.09	$53.98	$0.00	$1.70
Baltimore City, Baltimore County, Anne Arundel County, Prince George's County, MD	2,109	$141.45	$171.03	$235.28	$8.64	$9.62
Subtotal Local Study Area	2,657	$181.28	$214.12	$289.26	$8.64	$11.33
Rest of the Washington-Baltimore-Arlington, CSA	94	$6.28	$11.64	$19.44	$1.21	$1.25
Total Washington-Baltimore-Arlington, CSA (Region)	2,751	$187.56	$225.75	$308.70	$9.85	$12.58
By State:						
Maryland	2,168	$145.36	$178.46	$247.85	$8.64	$9.62
Virginia	33	$2.31	$4.09	$6.59	$0.00	$0.00

Figure 9: Regional Annual Operations and Maintenance Economic Benefits (2020$)

3.2.4 ENVIRONMENTAL BENEFITS

SCMAGLEV will reduce automobile travel in the Baltimore-Washington region. Based on the 2018 SCMAGLEV ridership forecasting model, an estimated 11.4 million SCMAGLEV passengers will divert from automobiles in 2030. Based on average vehicle occupancy, this diversion translates into a reduction of 7.9 million vehicle trips in that same year. Based on the distance between origin and destination pairs, the diverted trips will account for 300 million

vehicle miles traveled. During the 2020-2060 analysis period, the SCMAGLEV Baltimore-Washington service will lead to a reduction of more than 12.5 billion vehicle miles in the Baltimore-Washington region, of which an estimated 11.6 billion vehicle miles will be between station pairs.

3.2.5 EMISSION REDUCTIONS PER VMT

The reduction in VMT due to travelers diverting from automobile to SCMAGLEV will lead to reduction in GHG, NO_x, VOC, PM, SO_2 and CO emissions.

Greenhouse Gases (GHG) - Automobiles are a major source of greenhouse gas (GHG) emissions, a driver of climate change. GHG emissions are expressed in terms of "carbon dioxide equivalent" or "CO_2e", a measure that summarizes different greenhouse gases in a common unit.

Ozone (NO_x, VOC) – Automobile exhaust also contributes to ground level ozone pollution as it includes Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOC) that help to form ozone. Ozone affects human health and sensitive vegetation and ecosystems.

Sulfur Dioxide (SO_2) – Automobiles create this pollutant by burning sulfur-containing fuels. Sulfur dioxide poses health risks especially to young children and asthmatics.

Particulate Matter – Automobiles contribute to particulate matter (PM) pollution, which is present in tailpipe exhaust and is emitted from tire and brake wear. Both $PM_{2.5}$ and PM_{10} emissions, which are emissions of particulate matter of with a diameter of less than 2.5 micrometer and less than 10 micrometers, respectively, are reported by MOVES. Both can cause serious health problems.

Carbon Monoxide –Automobiles contribute to carbon monoxide pollution, which is present is tailpipe exhaust. The impact of outdoor CO emission is very localized and creates health problems.

The emission rates resulting from the MOVES14b analysis are presented in Figure 10. Values are provided for 2020 to serve as a reference for current pollutant emissions without SCMAGLEV.

Type of Pollutant	2020	2030	2040	2050
CO_2e	299.1018	216.9091	194.1724	192.1253
VOC	0.0191	0.0053	0.0024	0.0022
NOx	0.1174	0.0270	0.0091	0.0081
SO2	0.0020	0.0014	0.0013	0.0013
PM $_{2.5}$	0.0105	0.0076	0.0081	0.0080
PM $_{10}$	0.0386	0.0420	0.0509	0.0509

Figure 10: Emission Rates (g/VMT) 2020-2050 estimated with MOVES14b

3.2.6 EMISSION REDUCTION BENEFITS

Based on the emission rates above for 2040, the estimated emission reduction benefits associated with the reduction in VMT by SCMAGLEV in 2040 are presented in Figure 11.

Type of Pollutant	VMT reduction in 2040 (in millions of miles)	Emission Rate in 2040 (gram per VMT)	Emission Reduction in 2040 (in metric ton)
CO_2e	328.00	194.1724	63,689.12
VOC	328.00	0.0024	0.79
NOx	328.00	0.0091	3.00
SO2	328.00	0.0013	0.43
PM $_{2.5}$	328.00	0.0081	2.64
PM $_{10}$	328.00	0.0509	16.70

Figure 11:Avoided Metric Ton of Pollutant Emissions, 2040

Based on the emission rates and VMT savings, diversions from autos to SCMAGLEV will result in the following emission reductions during the 2030-2060 period: 2.2 million metric ton of GHG, 30 metric of Volatile Organic Compounds (VOC), 118 metric ton of Nitrogen Oxides (NO_x), 15 metric ton of Sulfur Dioxide (SO_2), 646 metric ton of Particulate Matter, including $PM_{2.5}$ and PM_{10}, and 5,730 metric ton of Carbon Monoxide (CO).

The present value of the reductions in GHG, VOC, NO_x, $SO_2$and PM $_{2.5}$ from the 2030 (end of 2029) opening year to 2060 was estimated as $95.9 million. The annual emission reductions were monetized using standard damage cost values per ton (see methodology section). The annual emission reduction benefits between 2030 and 2060 were discounted to present value (2020) using a 3 percent discount rate. Figure 12 presents the emission reductions by pollutant, standard damage cost per unit of pollutant emission, and the present value of the emission reduction benefit over the 2030-2060 period.

Type of Pollutant	Emission Reduction (in metric ton)	Damage Cost ($2030/metric ton)	Present Value of Emission Reduction Benefit (in $million)
CO_2e	2,199,369	$62	$78.64
VOC	30	$2,161	$0.03
NO_x	118	$8,849	$0.53
SO_2	15	$51,549	$0.44
PM $_{2.5}$	89	$398,501	$16.38
Total			$95.94

Figure 12: Present Value of Avoided Pollutants Benefit Project from2030 to2060) (3%Discount Rate) (in 2020$s)

4. CONCLUSION

Construction and operation of the Baltimore-Washington SCMAGLEV project will generate economic benefits to the region in various ways. There will be a direct economic impact through wages paid to construction and operations and maintenance workers and from materials purchased for the project's construction and operations and maintenance. There will be an indirect economic impact, in turn, from the materials suppliers hiring more workers to meet demand and the induced impact of personal spending by the suppliers' workers. In other words, as with other major capital projects, SCMAGLEV's economic impact will have a multiplier effect that will ripple through the economy not only regionally but at a national scale. The estimated economic benefits of the Baltimore-Washington SCMAGLEV are comparable to those estimated for other major capital-intensive transportation infrastructure projects in the U.S.

In addition, SCMAGLEV will generate public benefits through travel being diverted from highways to SCMAGLEV, including lower greenhouse gas and other air pollutant emissions.