# Oasis Rail Transit

## Economic and Financial Analysis

HAM/CLE – Oasis Rail Corridor
PID No. 86436

Prepared for:
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February 9, 2016

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# **1** Executive Summary

The Eastern Corridor Transportation Program is aimed at addressing mobility and connectivity issues between the City of Cincinnati core and the eastern suburbs. It is guided by the Major Investment Study (MIS) completed by the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) in 2000, which recommended a strategy for addressing current and future mobility constraints in the region. The Eastern Corridor Program proposes roadway improvements along SR 32 and Red Bank Road and the development of a new commuter rail alignment (called the Oasis Line) from downtown Cincinnati to the eastern suburb of Milford, as well as expanded bus, bike, and other transportation system level improvements.

The current regional travel trends signal that without significant capacity enhancements along the corridor, the social costs imposed by highly congested traffic would impede economic growth in the Eastern Corridor region. Without any improvement to the transportation network in this region, it is expected that roadway congestion will increase by 15 percent between 2015 and 2045, and the travel time in an average one-way trip in the region will increase by more than six minutes.[1] The highly congested roadway conditions lead to longer travel times, reduced travel reliability, and increased traffic crashes. All of these lead to incremental social costs.

The economic analysis detailed in this report was conducted by HDR on the Oasis Line under two capital cost alternatives. Both alternatives follow a new right-of-way from the Riverfront Transit Center to the vicinity of the Boathouse, where they shift to a SORTA-owned track running to the Fairfax/Red Bank station. Alternative A utilizes existing Norfolk Southern (NS) tracks east of Fairfax/ Red Bank while Alternative B requires a parallel track along the NS right-of-way (ROW). Commuter rail operations and traffic impact remain the same under either alternative. The findings suggest that under Alternative A, the $399 million investment (capital and operation and maintenance costs in 2015 dollars) in the project is expected to generate almost $474 million in benefits over a 30-year period, with a net present value (NPV) of $75 million. [2] Under Alternative B, the $431 million project is expected to generate $475 million in benefits and a NPV of $44 million. A summary of key benefit-cost metrics is provided in Figure ES-1.

These benefits include mobility benefits to travelers as well as spillover benefits to the general public in terms of reduced environmental impacts, enhanced safety conditions, and station area development. The mobility benefits to travelers include reduced delays, lower travel costs, and increased reliability of travel, providing an enhanced connectivity within the study area. The overall regional connectivity improvement produces a more friendly business environment. The reduction in congestion and lower usage of personal vehicle also reduces vehicle operating costs and environment impacts by less vehicle emissions.

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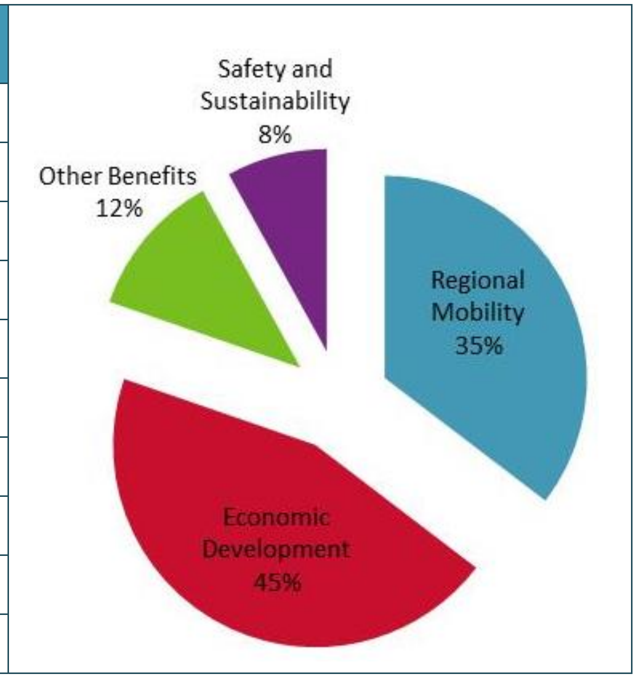
[1] HDR conducted this analysis based on results run by OKI Travel Demand Model.
[2] Net Present Value (NPV) **–** The net present value is the discounted present value of benefits minus the discounted present value of costs. The net present value is measured over the life-cycle of the project under consideration. A net present value greater than zero indicates that it is worthy investment. The discount rate applied in four percent.

**Figure ES-1: Summary Results**

| Benefits and Costs (in $ Million) | Alternative A | Alternative B |
|---|---|---|
| Total Benefits (PV) * | **$473.9** | **$475.3** |
| *Regional Mobility* | $167.7 | |
| *Economic Development* | $212.8 | |
| *Other Benefits* | $55.3 | $56.7 |
| *Safety and Sustainability* | $38.1 | |
| Total Costs (PV) | **($398.8)** | **($431.3)** |
| **Net Present Value (NPV)** | **$75.1** | **$44.0** |
| **Benefit Cost Ratio (BCR)** | **1.19** | **1.10** |
| **Payback Period** | **30 years** | **31 years** |
| **Internal Rate of Return (IRR)** | **4.7%** | **4.0%** |




Note: All benefits and costs are accumulated over 30 years and discounted at 4 percent annually. The values are in Millions of 2015 US dollar. The costs represent lifecycle costs and discounted to present value. It includes both capital and O&M costs.

Testing of sensitivity of input parameters show that key drivers of a higher NPV can be achieved through design innovations or from the latest demand inputs. The factors are:

- Construction cost savings, potentially from design innovations under alternative project delivery;
- Greater peak period share of traffic, which may be a modeling update when a detailed, local traffic analysis is performed; and
- Higher traffic growth, which may be a modeling update when a detailed, local demographic/ travel demand analysis is performed.

In addition to the social benefits due to increased mobility and accessibility, the rail investment is likely to stimulate economic activity in the region. In the short term, construction is expected to create at least 2,200 job-years over a four-year period. In the long-run, the project will likely generate over 260 jobs in the region due to the increased productivity.[3] These jobs are expected to be created across various sectors including retail, health and social service, professional service, and construction.

In sum, transportation investment within the Eastern Corridor is expected to yield significant positive economic benefits to the region. The investment in regional mobility and sustainability has the potential to improve livability and to stimulate development around the Oasis stations, as well as promote economic growth in the region.

[3] A job-year is defined as a single job held for a period of one year. In short-term construction projects, several short-term jobs are held at various points, and hence an estimate of total jobs created may be misleading.

# 2 Background

The Oasis Rail Corridor runs for approximately 17 miles between downtown Cincinnati, and eastern communities in Hamilton and Clermont counties, with an eastern terminus in the City of Milford. The Oasis line will provide a rail-based transit option to broaden the transportation network within the region. It is an important component of the Eastern Corridor Program.

The Eastern Corridor Program was initiated to address mobility and connectivity issues between the City of Cincinnati's core and the eastern suburbs. The Major Investment Study (MIS) completed in 2000 by the Ohio-Kentucky-Indiana Regional Council of Governments (OKI), identified an area covering approximately 165 square miles, extending from the Cincinnati Central Business District to the City of Milford, from the Xavier University area to a point east of the Eastgate area of Clermont County, and included the I-471 and I-275 corridors in Campbell County, Kentucky. The MIS resulted in a recommended strategy for addressing current and future deficiencies in the area.

In 2002, the Eastern Corridor Land Use Vision Plan (ECLUVP) was completed. This effort evaluated economic development, green space preservation and quality of life issues related to future land use within the Eastern Corridor. The ECLUVP was developed based on extensive input from the communities impacted and resulted in a comprehensive future land use plan complimenting the multimodal transportation vision.

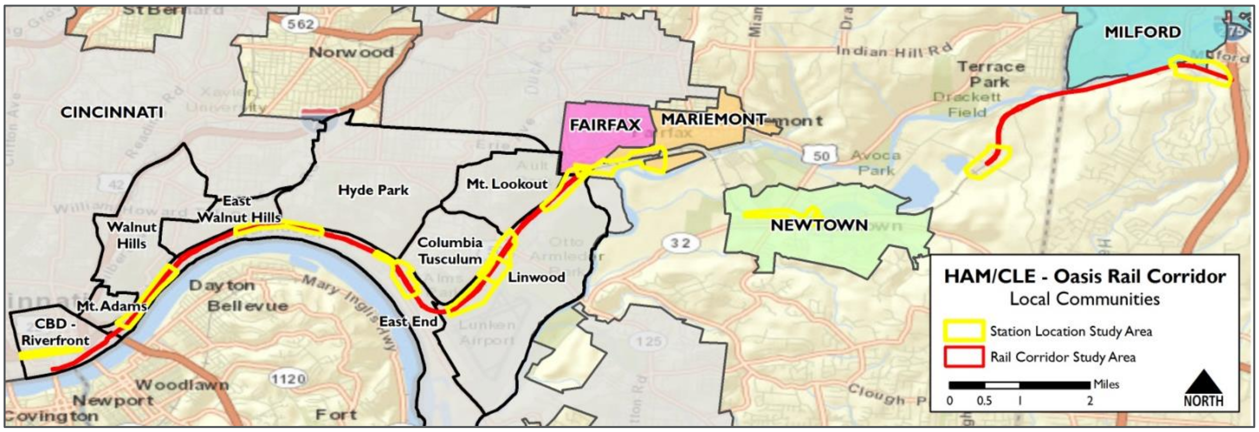
A tiered environmental assessment was undertaken to address federal requirements. The Tier 1 Final Environmental Impact Statement (FEIS) was completed and a Record of Decision (ROD) issued by the Federal Highway Administration in June 2006. In relation to the Rail Transit component of the Eastern Corridor, the ROD included the following purpose and need elements:

*Rail Transit network investments in the Eastern Corridor are needed to:*

- *Increase accessibility by reaching areas not currently being served by transit;*
- *Connect people with jobs;*
- *Provide better service to the transit-dependent (or transportation-disadvantaged);*
- *Improve overall transportation by coordinating and linking with other travel modes;*
- *Provide important future capacity and connectivity beyond reasonable limits of the highway system;*
- *Connect people with major recreational destinations and the regional attractions for non-car travel;*
- *Provide a visible, high profile link to the Cincinnati Central Business District from outlying areas;*
- *Improve regional connectivity;*
- *Link to and support the Eastern Corridor land use vision plan;*
- *Support and facilitate bus, highway and TSM improvements; and*
- *Implement regional long range transportation plans specific to rail investments.*

The study area for the Oasis Rail Corridor includes the City of Cincinnati and the communities of Fairfax, Mariemont, Newtown, and Milford, as well as unincorporated parts of Hamilton and Clermont Counties. Within the City of Cincinnati, the project area includes various neighborhoods, including (from west to east): Central Business District (CBD)-Riverfront, East End, Mt. Adams, Walnut Hills, East Walnut Hills, Hyde Park, Columbia Tusculum, Mt. Lookout, and Linwood (Figure 1). The Oasis rail service would provide an important function as the first link in the development of a regional rail/transit system. It would provide connectivity between the neighborhoods within the Study Area described here and other communities, expanding the reach of employment opportunities and economic development impacts.

**Figure 1: Oasis Rail Corridor Communities**




**A brief narrative of each city and neighborhood is provided below:**

***Fairfax:*** Fairfax is a village located just east of the City of Cincinnati, between Cincinnati and the Village of Mariemont. Fairfax has an area of 0.8 square mile and had a population of 1,697 in 2011.

***Mariemont:*** Mariemont is a village located just east of the City of Cincinnati and the Village of Fairfax along the Little Miami River. Mariemont has 0.9 square mile area and had a population of 3,402 in 2011. Mariemont is listed on the National Register of Historic Places and was designated a National Historic Landmark in 2007.

***Milford:*** Milford is an eastern suburb of Cincinnati located along the Little Miami River. Located in both Hamilton and Clermont Counties, the City of Milford is 3.8 square miles and had a population in 2011 of 6,722.

***Newtown:*** Newtown is a village located east of the City of Cincinnati, just south of the Little Miami River. Newtown has an area of 2.4 square miles and had a population of 2,671 in 2011.

***CBD-Riverfront (Downtown):*** Cincinnati's Central Business District - Riverfront neighborhood is a 0.8-square-mile area on the south end of the city, along the Ohio River. In 2010, the neighborhood had a population of 4,850. It is home to the corporate headquarters of The Kroger Company, Fifth Third Bank, and Procter & Gamble, as well as the sports arenas of Paul Brown Stadium, Great American Ballpark, and US Bank Arena. I-71 bisects the neighborhood along its southern end.

***Columbia Tusculum:*** Columbia Tusculum is roughly a 0.9-square-mile neighborhood with a population of 1,304 in 2010. Founded in 1788, it is the oldest neighborhood in Cincinnati and is also home to the Columbia Tusculum Historic District. The Columbia Tusculum neighborhood is bordered by the neighborhoods of Hyde Park, Mt. Lookout, Linwood, and East End.

***East End:*** The East End neighborhood has an area of 2.1 square miles along Cincinnati's southern border and had a population of 1,518 in 2010. The neighborhood extends about 6.5 miles along the Ohio River. At its southern-most end, it is adjacent to the Cincinnati Municipal Airport – Lunken Field.

***East Walnut Hills:*** The East Walnut Hills neighborhood has an area of 0.6 square miles and had a population of 3,794 in 2010. It borders Walnut Hills to the west and north, Evanston-East Walnut Hills to the north, Hyde Park to the east, and East End to the south. It is home to St. Ursula Academy and St. Francis DeSales Church.

***Hyde Park:*** The Hyde Park neighborhood is a 2.9-square-mile area that was established in the 1890s. In 2010, the neighborhood had a population of 13,356. It is an up-scale neighborhood that is home to the Cincinnati Country Club. Hyde Park borders the City of Norwood to the north, as well as the neighborhoods of Oakley, Mt. Lookout, Columbia Tusculum, East End, Evanston, and East Walnut Hills.

***Linwood:*** The neighborhood of Linwood is 3.0-square-miles in area and had a population of 875 in 2010. Linwood is surrounded by the neighborhoods of Mt. Lookout, Columbia Tusculum, East End, California, and Mt. Washington, as well as the Village of Fairfax to the north. Linwood is home to the Cincinnati Municipal Airport – Lunken Field.

***Mt. Adams:*** Located just south of Eden Park is the 0.2-square-mile neighborhood of Mt. Adams. The neighborhood is also bordered by I-71, I-471, and the Columbia Parkway. The surrounding neighborhoods are Walnut Hills, the East End, the CBD-Riverfront, and Pendleton. The neighborhood had a population of 1,481 in 2010.

***Mt. Lookout:*** Mt. Lookout is a 1.0 square-mile neighborhood with a population of 4,814 in 2010. The neighborhood is home to the Cincinnati Observatory, which is located in the Observatory Historic District. Mt. Lookout is surrounded by the neighborhoods of Hyde Park, Columbia Tusculum, Linwood, and Oakley, as well as the Village of Fairfax.

***Walnut Hills:*** The neighborhood of Walnut Hills has an area of 1.5 square miles and a population of 6,495 in 2010. The north and western edges of this neighborhood mostly run along I-71. To the south of the neighborhood is Eden Park. Peeble's Corner Historic District, the Harriet Beecher Stowe House, and the C.H. Burroughs House are all located in Walnut Hills. Walnut Hills is bordered by the neighborhoods of Evanston, Evanston-East Walnut Hills, East Walnut Hills, the East End, Mt. Adams, Pendleton, and Mt. Auburn.

The socioeconomic data for the study area and the larger surrounding areas comes from the 2010 Census (http://factfinder2.census.gov) and the 2010 U.S. Census Bureau's American Community Survey. The data was collected at the Census Tract level (shown in Figure 2) and includes the 18 tracts that intersect the potential station locations and rail corridor study area for this project.

**Figure 2: Census Tracts Map**

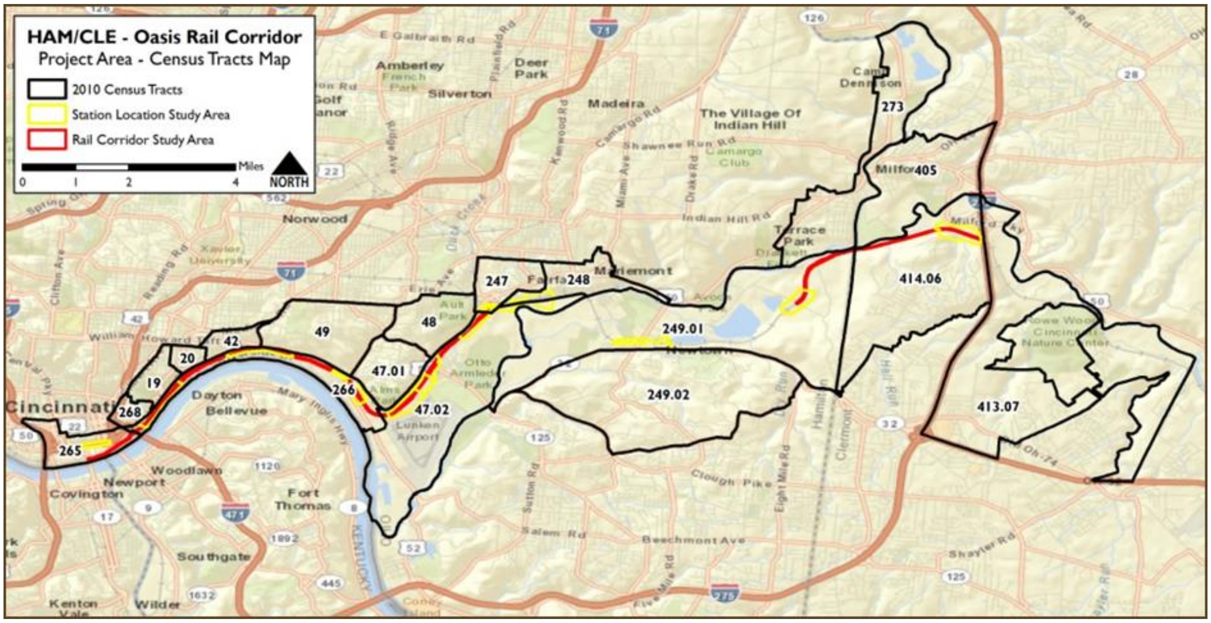



Table 1 shows 2010 population estimates for each of the 18 Census Tracts that are wholly or partially within the project study area, as well as for the City of Cincinnati, the Cincinnati-Middletown Metro Area, Clermont County, Hamilton County, and the State of Ohio.

The Census Tracts that make up the study area have a combined population of less than 55,000 persons. It is estimated that 20 percent of the population is under the age of 18, and 12 percent is age 65 and older.

The population in the study area is very similar to that in the larger, surrounding areas. The surrounding areas have a slightly higher under 18 population, but many of the individual Census Tracts in the study area have a similar youth population percentage. The over 65 population in the surrounding areas is the same as most of the study area. The male-to-female ration for the larger, surrounding areas is also the same as the average for the study area.

**Table 1: Population/Demographics**

| Census Tract/Area | 2010 Population | % Under Age 18 | % Age 65+ | % Male | % Female |
|---|---|---|---|---|---|
| 19 | 1,445 | 13% | 8% | 49% | 51% |
| 20 | 1,352 | 9% | 16% | 47% | 53% |
| 42 | 1,821 | 14% | 16% | 48% | 52% |
| 47.01 | 2,893 | 15% | 11% | 49% | 51% |
| 47.02 | 875 | 24% | 8% | 51% | 49% |
| 48 | 3,225 | 26% | 10% | 47% | 53% |
| 49 | 6,278 | 19% | 12% | 49% | 51% |
| 247 | 1,699 | 24% | 11% | 46% | 54% |
| 248 | 3,453 | 28% | 12% | 45% | 55% |
| 249.01 | 1,116 | 23% | 13% | 52% | 48% |
| 249.02 | 7,858 | 29% | 11% | 49% | 51% |
| 265 | 2,159 | 8% | 12% | 50% | 50% |
| 266 | 1,518 | 17% | 11% | 49% | 51% |
| 268 | 1,481 | 5% | 15% | 57% | 43% |
| 273 | 2,676 | 33% | 11% | 50% | 50% |
| 405 | 5,109 | 17% | 24% | 45% | 55% |
| 413.07 | 4,840 | 23% | 12% | 49% | 51% |
| 414.06 | 4,857 | 32% | 8% | 50% | 50% |
| **Totals** | **54,655** | **20%** | **12%** | **49%** | **51%** |
| City of Cincinnati | 296,943 | 22% | 11% | 48% | 52% |
| Cincinnati-Middletown, OH-KY-IN Metro Area | 2,130,151 | 25% | 12% | 49% | 51% |
| Clermont County, Ohio | 197,363 | 26% | 12% | 49% | 51% |
| Hamilton County, Ohio | 802,374 | 24% | 13% | 48% | 52% |
| State of Ohio | 11,536,504 | 24% | 14% | 49% | 51% |

Source: U.S. Census (www.census.gov), 2010 SF1 dataset.

# **3** Analytical Framework

This chapter describes the analytical framework used in the benefit-cost analysis (BCA) framework used to assess the economic worthiness of the Oasis Line. The benefits considered in the analysis represent the overall social well-being generated by the investment, and the costs represent the total investment in building and maintaining the improved facilities. The project's economic viability is determined on the basis of whether its long-term benefits exceed its costs, and whether the rate of return is adequate.

### Principles

In this analysis, HDR has employed the core principles of benefit-cost analysis laid out in the Federal Register issued by the US Department of Transportation[4]. The analysis accounts for the economic effects of the investment, both negative and positive, regardless of the source of funding. On the cost side, in addition to the project's capital outlays, the analysis accounts for the costs of capital (interest)[5], yearly operating expenses, and the costs of maintenance to keep the project's capital assets ( rail vehicles, stations, and track/signals) in good condition. These cost are compared against a comprehensive assessment of public benefits that can be broadly classified into the following categories:

- User benefits (benefits that accumulate to users of new investment);
- Non-user benefits (benefits to other travelers who may not be direct users of the facilities); and
- Wider economic benefits (other non-transportation benefits that are generated by the transportation investment).

The key analytical principles employed in developing the benefit-cost analysis are:

- Assessing benefits using appropriate metrics that are directly relevant and measurable;
- Accounting for any potential double-counting of benefits (across user and non-user benefits and wider economic benefits);
- Accounting for life-cycle costs associated with building, operating and maintaining the facilities; and
- Converting benefits to equivalent monetary values following federal guidelines.

Benefit-cost analysis for transportation projects involve a comprehensive assessment of impacts across all benefit and cost categories. The benefits are translated to equivalent monetary levels in order to compare the benefits with the project's life-cycle costs. The economic merit of a project is assessed on the basis of several economic metrics, which are described below.

[4] Federal Register, Volume 76/ No 127 revised in 2015 is the guiding document for preparing benefit cost analyses accompanying applications for TIGER grants.
[5] More precisely, Benefit-Cost Analysis accounts for the "opportunity cost" of capital. This reflects a combination of interest and the "time-preference" of the community for benefits now versus greater benefits later.

Several criteria are used by decision-makers to determine whether investment projects are economically reasonable to undertake. The most widely used of these decision criteria, and the ones presented in the results of this report, are:

- **Net Present Value (NPV) –** The net present value is the discounted present value of benefits minus the discounted present value of costs. The net present value is measured over the life-cycle of the project under consideration. A net present value greater than zero indicates that the investment returns benefits proportionally in excess of costs.
- **Benefit-Cost Ratio (BCR) –** A benefit-cost ratio is the ratio of a project's discounted stream of benefits to the project's discounted stream of costs. A benefit-cost ratio greater than 1.0 indicates that a project generates more discounted benefits over the analysis time frame than costs generated in undertaking a project. A benefit-cost ratio greater than 1.0 is considered economically worthwhile. In contrast, projects with a benefit-cost ratio less than 1.0 indicate that the project's costs exceed its benefits and may not be considered economically worthwhile.
- **Internal Rate of Return (IRR) –** The internal rate of return is the discount rate that, when applied to costs and benefits, results in a net present value of zero. Although the IRR gives the same fundamental answer as NPV, it does give added perspective. An IRR of 10 percent for example, means that the flow of benefits is sufficient to yield a return of 10 percent each year on that part of the investment, which has not been paid out. If a project's IRR is greater than the return available by investing in low-risk bonds, it can be considered economically worthwhile.
- **Payback period –** A payback period refers to the length of time that that the cumulative benefits start to exceed the original investment costs. This benchmark indicates the number of years it takes for the project to recuperate all the costs.

# 4 Impacts of Eastern Corridor Improvement

The impacts and benefit-cost results are presented for the alternative:

- Alternate A – Leveraging existing Norfolk-Southern (NS) tracks east of Fairfax/Redbank ; and
- Alternate B – Construction of parallel commuter rail track along NS ROW east of Fairfax Redbank.

The system-wide impacts and benefit-cost outcomes are assessed in comparison with a base case, which represents the no-build scenario of continued maintenance of the existing facilities without any capacity enhancement. The transportation impacts along the corridor were analyzed using the OKI Travel Demand Model and the Federal Transit Administration (FTA) Simplified Trips-on-Project Software (STOPS) ridership model. The impacts and the corresponding benefit-cost analysis outcomes are presented in subsequent sections.

## 4.1 Direct Transportation Impacts

The results from the application of the travel demand model for each of the alternatives are shown in Table 2 below. The demand model estimates that out of approximately 176,000 total daily trips in the corridor, the Oasis line is expected to attract 5,300 daily riders in the opening year of 2020, a mode share of 2.4 percent. The model expects an average annual traffic growth in the region over the next 30 years to be 0.27 percent.[6]

**Table 2: Travel Pattern in 2020 by Alternative**

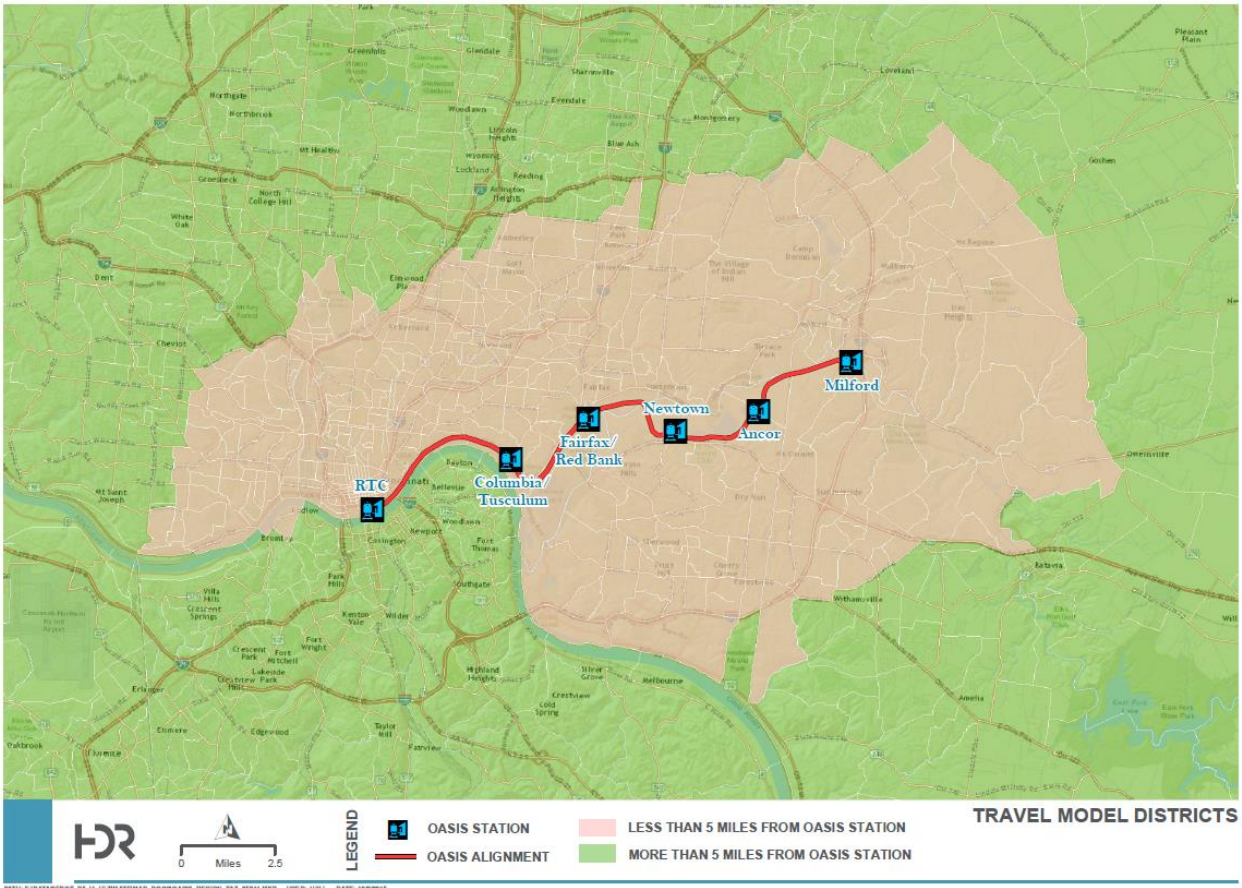
| Category | Variable | No-Build | Alternative A & B |
|---|---|---|---|
| Roadway Results | Base daily trips | 175,900 | 169,275 |
| | Avg. trip length | 11.5 mile | 11.5 mile |
| | Avg. Speed (MPH in 2015) | 32.3 | 32.3 |
| | Traffic composition – passenger car | 94.50% | 94.50% |
| | Annual Traffic Growth Rate | 0.27% | 0.27% |
| Oasis Results | Oasis daily ridership in 2020 | N/A | 5,300 |
| | Oasis daily ridership in 2040 | N/A | 6,265 |
| | Avg. Oasis rail speed (MPH) | N/A | 28.7 |
| | Avg. Fare - one way | N/A | $2.25 |

Source: OKI Travel demand model and STOPS results

Figure 3 shows the districts identified in the travel demand model and used in calculating daily trips.

[6] This estimate of growth is presented in the Tier 1 Draft Environmental Impact Statement, Eastern Corridor Multi-Modal Projects US DOT, FHA - Ohio Department of Transportation and Hamilton Co. Trans. Improvement District, PID 22970.

**Figure 3: Travel Model Districts Used in Calculating Daily Trips**




Operation of the Oasis rail service is expected to generate positive impacts on the region. The changes in travel demand patterns and congestion level estimates associated with the scenario would generate the following direct impacts on the transportation system along the corridor:

- Travel time savings for rail users due to better connectivity and lower congestion;
- Reduction in direct out-of-pocket costs for travel in terms of reduced vehicle operating costs resulting from more efficient use of fuel, oil, tires etc., and saved parking fees for rail users;
- Improved reliability of travel expressed as more predictable traffic patterns and consequently a better ability to plan trips. Reliability is particularly important for commercial travel and business travel;
- Reduced environmental impacts from more efficient traffic movements and reduced emissions caused by stop-and-go movements; and
- Enhanced transportation safety provided by better controls and more efficient traffic flow.

In addition to these direct transportation impacts, there are economic development impacts generated primarily due to the potential emergence of more dense residential and/or commercial development and the resulting increase in land values.

Table 3 shows the annualized estimates of corresponding regional impact metrics for each scenario. These impacts essentially translate to public benefits that can be accrued to the transportation system users (drivers and rail patrons), as well as the general public.

**Table 3: Total Regional Impacts by Alternative – Year 2020**

| Real Impact | Base | Alternatives A & B |
|---|---|---|
| Perceived Travel Time* (millions of hrs / year) | 13.0 | 12.9 |
| **Travel Cost - Vehicle Operation Costs (per year)** | | |
| Fuel Consumption (in millions of gallon) | 73.0 | 71.1 |
| Oil Consumption (in millions of quarts) | 1.8 | 1.7 |
| Tires Consumption (in thousands) | 260.7 | 253.6 |
| Maintenance and repair cost (millions of $) | $71.7 | $70.0 |
| Depreciation (millions of $) | $89.2 | $87.3 |
| **Improvements in Transportation Reliability (in percentage)*** | **-** | **12.5%** |
| **Reduced Environment Impact ( in tons)** | | |
| SO2 | 0.8 | 0.7 |
| PM 2.5 | 1.3 | 1.2 |
| VOC | 2.3 | 2.2 |
| NOx | 22.7 | 21.8 |
| CO2 | 60,563 | 57,241 |
| **Safety Improvements** | | |
| Fatalities avoided, Number/year | 2.8 | 2.6 |
| Injuries avoided, Number/year | 271.1 | 259.6 |
| Crashes avoided, Number/year | 753.4 | 721.4 |

* Time includes actual in-vehicle time plus "perceived" out-of-vehicle time that is adjusted for great value being placed on walk access, waiting, transfer, and standing time.

** High level of congestion leads to high uncertainty in traveling time. Highly congested roads force travelers to allocate a greater amount of time per trip than the average trip time. The values in the table indicate improvement in percentage from base to alternatives. Please refer to Appendix C for detailed computations.

## 4.2 Station Area Development Impacts

The development of a new commuter rail station results in greater value for adjacent commercial and residential areas because of the enhanced mobility and potential amenities (e.g. retail shops, restaurants, etc.) that tend to co-locate around transit, especially within walking distance. The greater value generates increased demand, which in turn can result in higher prices for properties. The benefits that arise from increased property prices are classified as "station area development" benefits. It is anticipated that the area around the seven stations along the Oasis line would experience higher development density and increases in property values over time.

To estimate the development benefits of the Oasis, a scaled benefit transfer approach is used (details provided in Appendix G: Station Area Development Benefits Related Assumptions and

Methodology). The approach relies on transferring estimated benefits from existing commuter rail studies, subject to scaling factors because of the differences in ridership catchment. In general, the studies indicate that a positive effect of commuter rails exists on residential and commercial property value. To standardize the results from the different studies, changes in property prices were weighted by each corresponding system's ridership and city population ("scaling factors" of the benefits being transferred). Estimated premiums specific to the Oasis region are presented in the table.

**Table 4: Premiums of Station Area Development Benefits**

| Property Type | Range of Property Value Change in the Station Area * | Notes |
|---|---|---|
| Residential Properties | 0.0% ~ 6.0% | A range of rates is based on studies conducted on SEPTA in Pennsylvania, Caltrain in San Francisco, Coaster Commuter rail in San Diego and MBTA in Boston |
| Commercial Properties | 3.7% ~ 20.5% | A range of rates is based on studies Coaster Commuter rail in San Diego. Properties that are within ¼ mile of San Diego downtown experienced a very high increase in property values. |

*These ranges of property value changes are adjusted to reflect the potential ridership and service area population (Cincinnati Metropolitan Statistical Area (MSA) of the Oasis region service.

Given the computed premiums, they are applied to total property value within a half-mile buffer of Oasis stations. The latest parcel data from the City of Cincinnati show that there are almost 2,000 residential properties and about 970 commercial properties within the half-mile station areas. The analysis assumes an annual increase of 3.5 percent in the number of residential and commercial parcels developed due to parcel densification and absorption of vacant land. The parcel data also indicate that the average value of a typical residential property in the area is $203,744, and that of a commercial property is $580,720. The baseline property value is then projected forward with historical data using trend analysis. Historical trends suggest a modest 2.5 to 2.6 percent annual growth in property values. The baseline property values and the premiums associated with station are developments are shown in Table 5. The station area premiums on property values, however, are expected take a period of ten years following the development of the station for full realization of benefits to reflect ramp-up. Details of the approach, data sources, and assumptions are provided in Appendix G.

**Table 5: Station Development Area Impact in 2030**

| Property Type | Average Base Property Values in 2015 | Number of Properties in 2015 | Average Base Property Values in 2030 | Average Enhanced Property Values in 2030 |
|---|---|---|---|---|
| Residential Properties | $203,744 | 1,944 | $308,650 | $308,885 |
| Commercial Properties | $580,720 | 969 | $1,083,423 | $1,261,781 |

## 4.3 Economic Impacts

Economic impacts related to a corridor level investment include estimates of the total payroll workers, economic output and value added. The methodology and the results of the economic impact assessment are given below. The business case analysis presented in this report is based on the benefits and costs associated with the investment. The economic impacts resulting primarily from these benefits are not strictly included in the analysis. But it is important to recognize the overall potential for the investment to generate new economic activity[7].

### 4.3.1 Economic Impact Analysis Methodology

Traditionally, economic impact analysis involves the estimation of three types of effect, commonly referred to as direct effect, indirect effect and induced effect:

- Direct effect: Refers to the economic activity occurring as a result of direct spending by agencies or business located in the study area (e.g., expenses related to construction activities for Oasis rail were estimated from $290 to 336 million);
- Indirect effect: Refers to the economic activity resulting from purchases by local firms who are the suppliers to the directly affected agencies or businesses (e.g., spending by suppliers of the contractors responsible for construction activities); and
- Induced effect: Represents the increase/decrease in economic activity, over and above the direct and indirect effects, associated with increased/decreased labor income that accrue to workers (of the contractor and all suppliers, in our example) and is spent on household goods and services purchased from businesses within the study area.

The indirect and induced effects are referred to as multiplier effects because they can make the total economic impact substantially larger than the direct effect alone: in theory, the larger the multiplier, the larger the overall response (total economic impact) to the initial expenditure (direct effect). The total economic impact is the sum of these direct, indirect and induced effects for the project being evaluated.

Typically, economic impacts are measured in terms of employment, industry output, and value added. The employment impact measure the number of jobs created for a full year. A job-year is defined as one person employed for one year, whether part-time or full time. Output refers to the total volume of sales. In comparison, value added refers to the value a company adds to a product or service. It is measured as the difference between the amount a company (or State government) spends to acquire it and its value at the time it is sold to other users. Thus, value added can be thought of as a measure of the contribution to the gross domestic product (GDP) made by an establishment or an industry. The total value added within a region is equivalent to the gross regional product and includes employee compensation, proprietary income, other property type income (e.g., rents) and indirect business taxes (e.g., excise taxes).

IMPLAN® system is used in this study for estimating economic impacts with the most recent data available for Hamilton and Clermont County. The event year of the economic impact is 2015 and the impacts are expressed in 2015 US dollars. The system is an input-output based regional economic assessment modeling system developed and maintained by MIG, Inc.[8] The IMPLAN® system

[7] Federal Register Vol. 76, No. 156 states that “impacts” are different from “benefits.” The total payroll of workers on a project is usually considered one of the “impacts” in an economic impact analysis. In the case of job creation, for example, every job represents both a cost to the employer (paying a wage) and a benefit to the employee (receiving a wage), so it is a transfer payment, rather than a net benefit.

[8] For more information on the IMPLAN® system, visit http://www.implan.com/.

consists of a software package[9] and data files that are updated every year. The IMPLAN data files include transaction information (intra-regional and import/export) on 440 distinct industrial sectors (corresponding to four- and five-digit North American Industry Classification System [NAICS] codes) and data on 21 economic variables, including employment, output and value added.

### 4.3.2 Analysis Results

Reported economic impacts are estimated based on short-term capital spending and long-term on-going operation and maintenance (O&M) spending as well as savings from vehicle operating costs (please refer to Section 5.2 for more details on costs). The results from the IMPLAN system were presented in this section.

**Short-term Impact**

Table 6 represents one-time employment impacts associated with project capital spending. Capital spending includes costs of construction, vehicles, stations, and systems, but excludes those of right-of-way acquisition and financing. The direct, indirect and induced employment impacts in terms of job-years are also provided by alternative.

The construction of the Oasis Rail is estimated to generate a total of 2,268 short-term direct, indirect and induced job-years in alternative A and 2,757 in alternative B throughout the construction period. Note that these are the number of jobs that are created only during the construction phase.

**Table 6: Short-term Employment, in Job-years**

| Types of Effect | Alternatives | |
|---|---|---|
| | A | B |
| Construction Expenditure (million of 2015 $) | $176.5* | $211.8* |
| Direct Jobs | 1,372 | 1,668 |
| Indirect Jobs | 329 | 400 |
| Induced Jobs | 567 | 689 |
| Total Number of Short-term Jobs | 2,268 | 2,757 |

* The cost excludes costs of right-of-way acquisition, financing, and diesel multiple unit (DMU) vehicles. DMU is excluded because they are purchased outside of Cincinnati region.
Note: Employment impacts should not be interpreted as full-time equivalent (FTE) as they reflect the mix of full and part time jobs that is typical for each sector.

Table 7 provides a summary of the economic output by construction activities under each alternative. The total output is larger than direct impact of construction activities because it combines direct, indirect, and induced impact. The combined out put for construction expenditures in Alternative A is $298.7 million and $363.1 million for Alternative B.

[9] The newly released IMPLAN Version 3.0 is used for this study.

**Table 7: Short-term Output and Value Added Economic Impact, million of 2015 US Dollar**

| Types of Effect | Alternatives | |
|---|---|---|
| | A | B |
| Construction Expenditure | $176.5* | $211.8* |
| **Total Output | $298.7 | $363.1 |

* The cost excludes costs of right-of-way acquisition, financing, and diesel multiple unit (DMU) vehicles. DMU is excluded because they are purchased outside of Cincinnati region.
** Total output is a combined effect of direct, indirect and induced.

### Long- term Impacts

Long-term economic impacts of the project consist of two categories. The first category is the O&M activities throughout the operational life of the invested transportation facility. Because of the O&M activities, annual economic outputs as well as employments would be created. The second long-term impact category arises due to savings from vehicle operation costs (refer to Table 3 in Section 4.1) for the people in the region. By reducing traffic congestion and by providing more transportation modes, the project allows people in the region to spend less on vehicle operating expenses. The cost savings can be spent in the local area to provide additional economic output to its economy.

Table 8 and Table 9 provide economic impacts from the O&M activities. O&M is the same regardless of the capital cost alternatives and therefore results do not differ by alternative. Table 8 shows that the $8.9 million spent on annual O&M costs for the Oasis Rail, is expected to annually generate 140 direct jobs and a total of 219 jobs. Table 9 presents the economic output in which $8.9 million of direct expenditure is expected to create a total annual output of $19.3 million.

**Table 8: Long-term Number of Job Estimates from O&M Activities, Annualized**

| Types of Effect | Alternative A & Alternative B* |
|---|---|
| O&M Expenditure (million of 2015 US Dollar) | $8.9 |
| Direct Jobs | 140 |
| Indirect Jobs | 35 |
| Induced Jobs | 44 |
| Total Number of Long-term Jobs | 219 |

Note: Employment impacts should not be interpreted as full-time equivalent (FTE) as they reflect the mix of full and part time jobs that is typical for each sector. * O&M is the same regardless of the capital cost alternatives and therefore results do not differ by alternative.

**Table 9: Long-term Economic Impact from O&M Activity, Annualized**

| Types of Effect | Alternative A & Alternative B** |
|---|---|
| O&M Expenditure (million of 2015 US Dollar) | $8.9 |
| *Total Output | $19.3 |

* Total Output is a combined effect of direct, indirect, and induced. ** O&M is the same regardless of alternative and therefore results do not differ by alternative.

Vehicle operating saving is the same regardless of the capital cost alternatives and therefore results do not differ by alternative. Table 10 and Table 11 present economic impact from the savings in vehicle operating costs. For example, Table 10 shows that citizens in the region are expected save approximately $5.4 million in vehicle operating cost a year due to improved transportation conditions. This savings, when spent on local economy, is expected to generate a total of 43 jobs annually. Note that the impact associated with increase/decrease in income that accrues to workers is classified as induced impact. Thus, there is no direct and indirect impact from the saving in vehicle operating costs. With the creation of 43 annual jobs, it is expected to produce $5.8 million in annual output (Table 11).

**Table 10: Long-term Number of Job Estimates from Vehicle Operation Cost Saving, Annualized**

| Types of Effect | Alternative A & Alternative B* |
|---|---|
| Average Annual Vehicle Operation Costs Savings (million of 2015 US Dollars) | $5.4 |
| Direct Jobs | 0 |
| Indirect Jobs | 0 |
| Induced Jobs | 43 |
| Total Number of Long-term Jobs | 43 |

Note: Employment impacts should not be interpreted as full-time equivalent (FTE) as they reflect the mix of full and part time jobs that is typical for each sector. * VOC is the same regardless of the capital cost alternatives and therefore results do not differ by alternative.

**Table 11: Long-term Economic Impact from Vehicle Operation Cost Saving, Annualized in million of 2015 US Dollars**

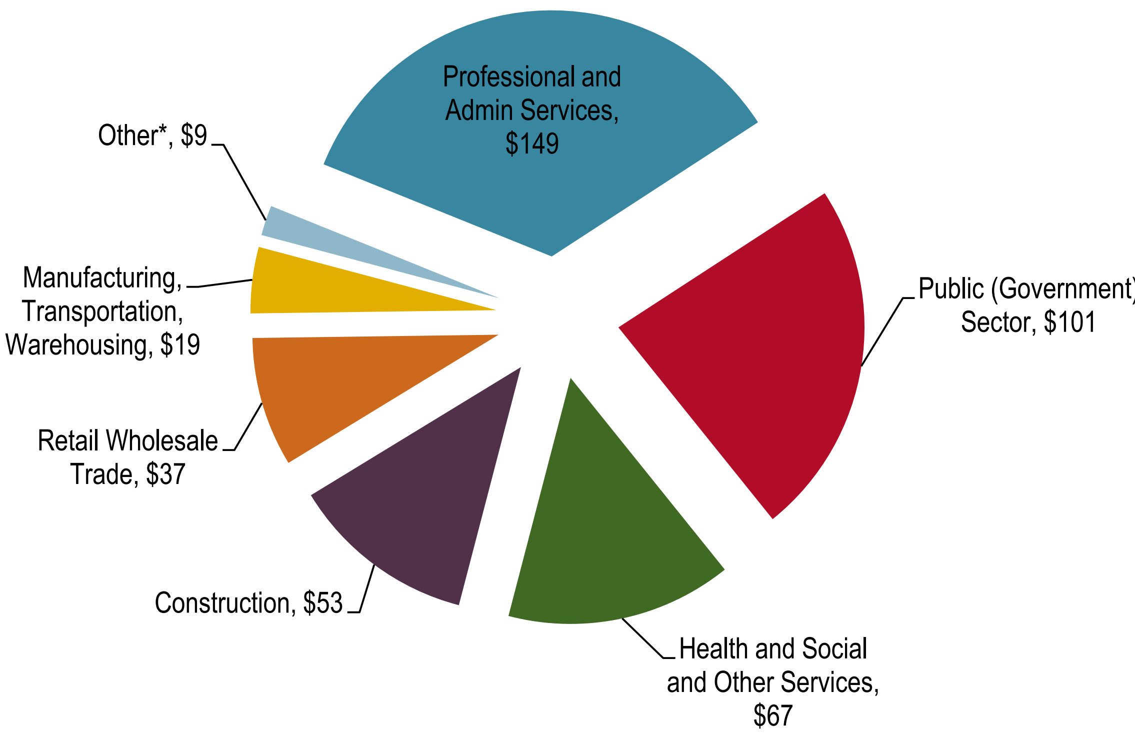
| Types of Effect | Alternative A & Alternative B** |
|---|---|
| Average Annual Vehicle Operation Costs Savings | $5.4 |
| *Total Output | $5.8 |

* Total Output is a combined effect of direct, indirect, and induced

### Economic Impacts by Sector

Figure 4 presents a breakdown of total economic output by industry in the rail alternative. With a 4 percent discount rate, the next 30 years of $25.1 million annual output (from Table 9 and Table 11) equates to a total output of $371 million in the region. Professional and Administrative Services consisted the highest portion with $149 million output, approximately 35 percent of the total. It would be followed by Public (Government) sector ($101 million), Health and social and other services ($67 million), and the Construction sector ($53 million).

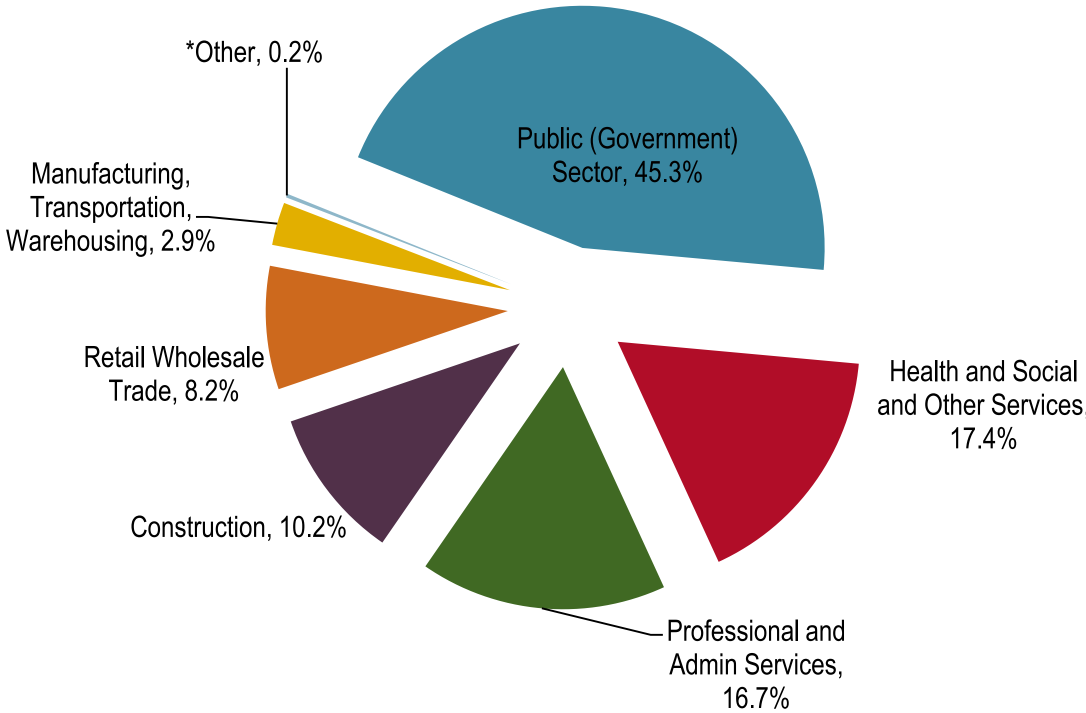
**Figure 4: Long-term Economic Output by Industry**




*Others include Agriculture, Mining and Utilities. Health and social and other services also include education, accommodation and food services. Professional and admin services include scientific technical services, management of companies and waste services.

Figure 5 provides a breakdown of long-term employment impact by industry in the Oasis rail alternative. Out of 262 annual jobs, Public sector would account for 45 percent, followed by Health and social and other services (17.4 percent), Professional and Admin services (16.5 percent), and the Construction sector (10 percent).

**Figure 5: Long-term Employment by Industry, Percentage**




*Others include Agriculture, Mining and Utilities. Health and social and other services also include education, accommodation and food services. Professional and admin services include scientific technical services, management of companies and waste services.

# 5 Benefits and Costs

The public benefits resulting from the corridor level improvements can be grouped into four categories:

1. **Regional Mobility:** Enhanced regional mobility due to more affordable travel, reduced traffic delays, and improved reliability.
2. **Sustainability and Safety:** Improved transportation safety due to reduced accidents, and higher levels of livability and sustainability due to reduced congestion and emissions.
3. **Station Area Development:** The potential for generating new development and improved land values around the new commuter rail stations.
4. **Economic Development due to Roadway Improvements:** The potential for land value changes as a result of improved access and travel times associated with the roadway component.
5. **Other Benefits:** Public earnings through fare revenue.

The **cost** items associated with the alternatives are categorized into:

1. Complete cost of procuring, constructing, and implementing the Oasis rail service.
2. Ongoing operating and maintenance costs associated with the rail service.

The following sections present the estimated benefits and costs for the alternatives.

## 5.1 Estimation of Benefits

The public benefits of the transportation system improvements within the Eastern Corridor were assessed over a 30-year period. Impacts of the transportation investment along the corridor are mainly experienced during peak periods. Impacts from special event service are calculated as well because it is expected that traffic condition during those events will be similar to that of weekday peak periods. Although weekend and evening services are envisioned, due to their marginal effect on congestion relief and overall mobility benefits, they are not included in the estimation of benefits.

Hence, regional benefits are estimated under only weekday peak periods and special event occurrences. The analytical approach used for estimating benefits, the key assumptions and parameters used, and the resulting estimates are discussed below for each category of benefits.

**Regional Mobility Benefits**

- **Travel Time Savings:** The most prominent component of traffic congestion costs is the delay associated with circuitous travel paths that add to travel length and travel time, high levels of roadway congestion, start-and-stop traffic flows, and in extreme cases, gridlock. These delays represent an opportunity cost of time – time that could be spent both at work and for leisure. Travel time includes access time, waiting time, in-vehicle time, transfer time as well as egress time. The underlying assumptions and structure for estimating travel time savings are provided in Appendix B. This analysis included only travel time savings for rail passengers. Any travel time savings accrued by auto passengers benefiting from reduced congestion levels were not included.

- **Vehicle Operation Cost Savings:** Traffic congestion leads to higher vehicle operating costs, primarily as a result of increased fuel use due to idling or start-and-stop traffic flows, both of which consume more fuel than driving at steady speeds. Parking cost is included in vehicle operation costs. The assumptions used in this analysis and the model structure for estimating vehicle operation cost savings are discussed in Appendix C.
- **Travel Reliability Improvement**: High levels of congestion lead to increased uncertainty in determining travel time. Highly congested roadways force travelers to allocate contingency time for critical trip purposes. Reduced congestion renders a more reliable traffic environment – you can generally know the estimated travel time it will take to get somewhere, leading to savings in time you might otherwise spend in traffic. The costs associated with added time for contingency are very important for commercial and commodity movements, particularly with the prominence of just-in-time logistics and delivery window guarantees as an everyday business strategy. The methodological structure for estimating travel reliability improvements is given in Appendix D.

### Sustainability and Safety Benefits

Sustainability and safety benefits are estimated on the basis of reduced environmental impacts and improved roadway safety:

- **Safety Improvements:** Crashes embody major societal costs. Vehicle crashes not only impose costs on people who are involved, but also on the rest of the traffic on that and adjoining roadways. Assumptions used and a methodology for estimating improved safety benefits are given in Appendix E.
- **Reduced Environment Impacts:** The major impact of vehicle use is exhaust emissions – an externality that imposes wide-ranging social costs on people and the environment. The negative effects of pollution depend not only on the quantity of pollution produced, but on the types of pollutants emitted and the conditions into which pollution is released. Assumptions and the methodology for estimating reduced environmental impact are in Appendix F.

### Station Area Development Benefits

Investments in fixed guideway transit systems generally result in development of clusters emerging around stops/stations with a proper Transit Oriented Development (TOD) strategy. Some part of the development benefits are captured by travel time and vehicle operation savings for those new transit riders and diverted transit riders from other modes. The remaining benefits are captured as station area development benefits, which often manifest themselves in increased property values in areas adjacent to stations. The approach for assessing station development impacts on the basis of increased density and valuation is provided in Appendix G.

### Other Benefits

Other benefits include fare revenue and residual value. Fare revenue is typically used to offset operating costs. The residual value of the rail accounts for the salvage value at the end of the analysis period.

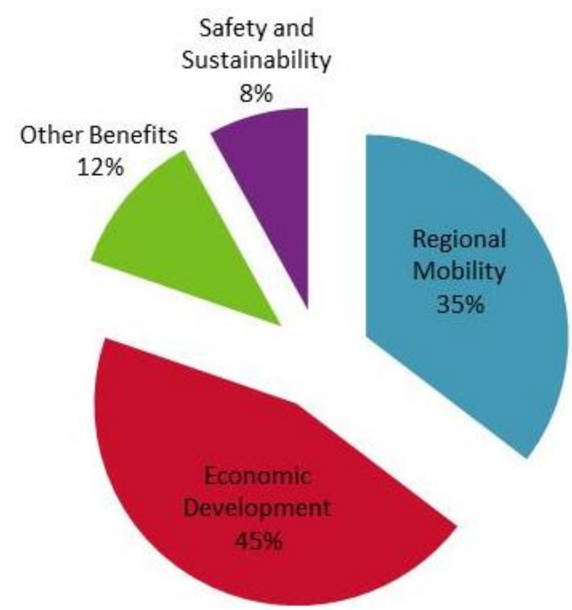
- **Fare Revenue:** Collected commuter fare revenues are invested to improve operation of the rail or offset maintenance costs. Because of their investment in improving infrastructure condition, they are counted as benefits to society.

- **Residual Value:** If the commuter rail's lifecycle is longer than the analysis period, its residual value needs to be captured. Residual value captures all the benefits that the commuter rail generates from the end of analysis period to the end of its lifecycle.

Table 12 and the chart below summarize the results of benefit computations for the Oasis rail alternatives. Alternative A and Alternative B differ in terms of capital costs and therefore in terms of residual values as well; all other operational assumptions are the same. Oasis rail accrues at least an estimated $473 million in benefits to the Eastern Corridor region. Regional mobility and station area development constitute 80% of the benefits.

**Table 12: Benefit Values and Distribution, in Millions of 2015 Dollars**

| Oasis Rail (in $ Million) | Alternative A | Alternative B |
|---|---|---|
| **Regional Mobility** | **$167.7** | |
| Travel Time Improvements | $24.7 | |
| Travel Cost Savings | $133.4 | |
| Transportation reliability imp. | $9.6 | |
| **Station Area Development** | **$212.8** | |
| **Other Benefits** | **$55.3** | **$56.7** |
| Fare Revenue[10] | $41.0 | |
| Residual Value | $14.3 | $15.7 |
| **Sustainability and Safety** | **$38.1** | |
| Safety Improvements | $34.3 | |
| Reduced Environment Impact | $3.8 | |
| **Total Benefits** | **$473.9** | **$475.3** |




Note: All benefits are accumulated over 30 years and discounted at 4 percent annually. The values are in Millions of 2015 US dollar.

[10] Fare revenue is calculated in the following way: annual trips during peak periods* $2.25 fare /one-way * 5 days * 52 weeks * 30 years over the 30-year analysis horizon.

## 5.2 Capital and Operating & Maintenance Costs

The cost category includes capital, operation, and maintenance for both roadway improvements and Oasis rail investment. Cost of construction includes the initial costs that are needed to improve roadways and/or build Oasis. Operations and maintenance costs are recurring costs borne to provide a safe and reliable rail service.

Table 13 provides Oasis capital costs by alternative. As shown in the table, the largest cost components are for procuring the diesel multiple unit vehicles, and for the 17 miles of guideway and track element improvements. The alternative (B) for not utilizing existing Norfolk Southern ROW is more expensive, due primarily to higher guideway and sitework costs.

**Table 13: Oasis Rail Construction Costs – Basic Service in 2015 Dollar, Undiscounted**

| Cost Category | Alternative A | Alternative B |
|---|---|---|
| Guideway and Track Elements | $49.8 | $71.6 |
| Stations* | $23.9 | $23.9 |
| Maintenance Facility | $20.2 | $20.2 |
| Sitework and Special Conditions | $8.9 | $15.3 |
| Systems | $20.3 | $20.3 |
| Right of Way / RR Agreements** | $34.8 | $34.8 |
| Vehicles | $77.0 | $77.0 |
| Professional Services | $36.2 | $41.0 |
| Unallocated Contingency | $17.2 | $19.5 |
| Finance Charges | $1.5 | $2.0 |
| **TOTAL** | **$289.8** | **$325.6** |

Source: Oasis Rail Conceptual Alternative Solutions HAM/CLE – Oasis Rail Corridor, by HDR Engineering (January 2015)
Notes: *The cost incorporates all seven stations. Six of them are for basic service and one for special events. The Boathouse station, which would be a special event-only station, has a capital cost of $2.0 to $2.6 million, which is included in the above figure.

The ongoing expenses associated with operating and maintaining new facilities are represented as annual costs. The annual operations and maintenance (O&M) costs for Oasis basic service are estimated to be around $8.9 million (undiscounted).

## 5.3 Benefit Cost Analysis Results

Table 14 presents the overall benefit-cost analysis (BCA) results for the improvements through the addition of Oasis rail. The values shown are the present value of benefits and costs discounted at four percent annually.[11] As shown in the table, the rail implementation is expected to generate public benefits that exceed its cost.

**Table 14: Summary of Benefits and Costs by Alternatives and Categories, in Millions of 2015 Dollar**

<table>
<tr><th colspan="2" rowspan="2">Metrics</th><th colspan="2">Alternatives</th></tr>
<tr><th>A</th><th>B</th></tr>
<tr><td colspan="2">Total Benefits ($ million)</td><td>$473.9</td><td>$475.3</td></tr>
<tr><td rowspan="3">Mobility</td><td>Travel Time Improvements</td><td colspan="2">$24.7</td></tr>
<tr><td>Travel Cost Savings</td><td colspan="2">$133.4</td></tr>
<tr><td>Transportation reliability improvements</td><td colspan="2">$9.6</td></tr>
<tr><td>Econ. Development</td><td>Station Area Development</td><td colspan="2">$212.8</td></tr>
<tr><td rowspan="2">Other</td><td>Residual Value</td><td>$14.3</td><td>$15.7</td></tr>
<tr><td>Fare Revenue</td><td colspan="2">$41.0</td></tr>
<tr><td rowspan="2">Sustainability and Safety</td><td>Safety Improvements</td><td colspan="2">$34.3</td></tr>
<tr><td>Reduced Environment Impact</td><td colspan="2">$3.8</td></tr>
<tr><td colspan="2">Total Costs ($ million)</td><td>($398.8)</td><td>($431.3)</td></tr>
<tr><td colspan="2">Capital</td><td>($263.0)</td><td>($295.5)</td></tr>
<tr><td colspan="2">Operation & Maintenance</td><td>($135.8)</td><td>($135.8)</td></tr>
<tr><td colspan="2">NPV</td><td>$75.1</td><td>$44.0</td></tr>
<tr><td colspan="2">Benefit-Cost Ratio</td><td>1.19</td><td>1.10</td></tr>
</table>

Note: All benefits and costs are accumulated over 30 years and discounted at 4 percent annually. The values are in Millions of 2015 US dollar. The costs represent lifecycle costs and discounted to present value. It includes both capital and O&M costs.

Table 14 also provides a summary of benefit-cost metrics. The benefit-cost metrics shown in the table suggest that the proposed corridor investment alternative provides sound economic benefits to the region. The BCR values are 1.19 and 1.10 for Alternative A and Alternative B respectively, which mean that for every $1 invested, the region experiences $1.19 and $1.10 in benefits, pending of whether or not Norfolk Southern track is utilized. The payback periods for the respective alternatives are 30 and 31 years with the internal rate of return of 4.0-4.7 percent.

[11] The guidelines for benefit cost analysis presented in the Federal Register indicate 4 percent and 7 percent as suggested discount rates for use in infrastructure investment analysis. For large-scale investments particularly representing significant increase in access to public transportation it is reasonable to use the lower discount rate.

# **6** Conclusion

A study of current travel patterns within the Eastern Corridor suggests that circuitous travel paths, a lack of connectivity and a reduced choice of routes and modes are contributing to roadway congestion within the study area. Left alone, roadway congestion will worsen in the coming years. This can adversely affect regional mobility and livability, which in turn can impede regional economic growth. In order to address these issues, the comprehensive Eastern Corridor's transportation options have been proposed, including construction of the Oasis rail line connecting downtown Cincinnati with Milford. The overall project will provide better travel options for all users by increasing interstate and regional connectivity along with more mode choices in ways that improve livability and which are sustainable.

The analysis of the proposed investment indicates that alleviating congestion on the roadways and providing alternative rail service can result in significant improvements to regional mobility, sustainability, and safety. The analysis also indicates that the monetary value of these anticipated benefits would exceed the necessary investment, suggesting that the Eastern Corridor Improvement Program is a worthy investment. Some of the key findings are:

- Utilizing the Norfolk Southern track (Alternative A), the rail investment will yield a greater return than the alternative of a parallel track along the NS right-of-way;
- Discounting the benefits and costs over a 30-year period at a real annual discount rate of 4 percent yields a Net Present Value (NPV) of at least $44 million, and a benefit-cost ratio of at least 1.10 (earnings of 10 cents for every dollar invested);
- The project is expected to generate over $473 million in accrued benefits over a 30-year horizon; almost 45 percent of these benefits are attributable to station area development;
- The investment will be paid back in at most 30 years and has an attractive internal rate of return of 4.0 percent at a minimum;
- In the short term, construction is expected to create at least 2,200 job-years over a four-year period. In the long-run, the project will likely generate over 260 jobs in the region; and
- The success of the project is very dependent on disciplined monitoring and management of construction costs and schedules. A study of risks identified cost overruns as the most critical risk factor.

# Appendices

Appendix A: Oasis Rail Operations

Appendix B: Travel Time Improvements Assumptions and Methodology

Appendix C: Travel Cost Improvements Assumptions and Methodology

Appendix D: Travel Reliability Improvements Related Assumptions

Appendix E: Travel Safety Improvements Related Assumptions

Appendix F: Reduced Environmental Impact Related Assumptions

Appendix G: Station Area Development Benefits Related Assumptions and Methodology

# Appendix A: Oasis Rail Operations

This chapter describes the Oasis rail transit operations.

| Basic Service | |
|---|---|
| Length of System | 17.2 miles |
| Number of Stations | 6 |
| Days of Operation | Monday-Friday |
| Headway | 30 minutes |
| One-way travel time | 35 minutes |
| Span of Service | 6:00am-6:30 pm |

A number of service operating scenarios were presented in the Conceptual Alternatives Study, including the following:

- Basic
- Evening
- Weekend; and
- Special Event

At this time, a final decision as to the level of service has not been determined.

The basic service is largely oriented to commuters working in downtown Cincinnati. In the morning, six westbound trips will be provided from Milford to downtown Cincinnati between 6:00 am and 8:00 am. Six eastbound trips will be provided in the afternoon from downtown Cincinnati to Milford between 4:30 pm and 6:30 pm. Commuter service will be provided every 30 minutes during those time periods on weekdays. During the morning and afternoon peak periods, one additional trip will be provided to enable a 15 minute frequency during the peak of the peak period. Two “reverse commute” trips will also be provided during each peak period. Operating a schedule with 30-minute headways provides an attractive travel alternative to personal vehicles, and enough time (when appropriate) to “recycle” two trains during the commute period; that is, sending the train back to Milford so that it can make a second inbound trip to the Riverfront Transit Center (RTC), reducing rail vehicle requirements and maximizing their utilization. These trains provide the reverse commute trip service for those who live in Cincinnati and work in the eastern communities or Milford. Peak Reverse commute trips would leave the RTC for Milford at 6:45 and 7:15 am and would return to Cincinnati from Milford at 5:15 and 5:45pm.

Mid-day service will also be offered in both directions at approximately 2 hour intervals to serve non-work trips. Some non-work travel may occur during the peak periods, but is anticipated at the “shoulders” of the peak when work trip levels are diminishing and vehicles and seating is likely to be available.

Optional evening, weekend and special event services would expand the range of operating hours beyond the primary work-commute purpose of the Basic Service, to provide travel options for those who have non-traditional work schedules, for recreational and shopping or personal-errand trips, as well as provide a means to allow rail passengers to reach the downtown Cincinnati Riverfront area to attend sporting or cultural events.

The basic service’s operating schedule as used for planning purposes is shown in Table A-1.

**Table A-1 Basic Service Operating Plan**

| Trainset | Westbound - Toward Cincinnati | | Trainset | Eastbound - Toward Milford | |
|---|---|---|---|---|---|
| | Depart from Milford | Arrive at Riverfront Transit Center (RTC) | | Depart from Riverfront Transit Center (RTC) | Arrive at Milford |
| **Morning Service** | | | **Morning Service** | | |
| 1 | 6:00 AM | 6:35 AM | 1 | 6:45 AM | 7:20 AM |
| 2 | 6:30 AM | 7:05 AM | 2 | 7:15 AM | 7:50 AM |
| 3 | 7:00 AM | 7:35 AM | | | |
| 4 | 7:15 AM | 7:50 AM | | | |
| 1 | 7:30 AM | 8:05 AM | | | |
| 2 | 8:00 AM | 8:35 AM | | | |
| **Midday Service** | | | **Midday Service** | | |
| 1 | 10:00 AM | 11:35 AM | 1 | 9:00: AM | 9:35 AM |
| 1 | 12:00 PM | 12:35 PM | 2 | 11:00 AM | 11:35 AM |
| 1 | 2:00 PM | 2:35 PM | 3 | 1:00 PM | 1:35 PM |
| **Afternoon/Evening Service** | | | **Afternoon/Evening Service** | | |
| 1 | 5:15 PM | 5:50 PM | 1 | 4:30 PM | 5:05 PM |
| 2 | 5:45 PM | 6:20 PM | 2 | 5:00 PM | 5:35 PM |
| | | | 3 | 5:15 PM | 5:50 PM |
| | | | 4 | 5:30 PM | 6:05 PM |
| | | | 1 | 6:00 PM | 6:35 PM |
| | | | 2 | 6:30 PM | 7:05 PM |

Source: HDR Engineering

Additional options to increase the span of Oasis service hours and to provide evening, weekend and special event coverage have also been developed, along with estimates of their associated capital and operating costs (Refer to *Oasis Rail Conceptual Alternative Solutions*, January 20, 2015).

The Oasis rail transit service is an important element of the multi-modal transportation improvements put forward as part of the Eastern Corridor Program. Other elements include roadway improvements, enhanced feeder bus services, Transportation System Management (TSM) improvements, and improvements to non-motorized transportation alternatives such as bicycling and walking.

# Appendix B: Travel Time Improvements Assumptions and Methodology

HDR used historically derived data from earlier Eastern Corridor traffic assessments and studies, as well as anecdotal evidence to compute V/C ratio for the base. Then with each alternative, the team used a standard approach in evaluating reduction in the number of daily drips due to Oasis rail to compute V/C ratio for the alternative.

**Table B-1: Roadway Volume to Capacity Ratio in 2020**

| Parameter | Base | Oasis |
|---|---|---|
| Peak time average V/C ratio | 0.85 | 0.85 |

*HDR assumption based on travel demand model results provided by HNTB.

In order to monetize travel time improvements, value of time (VOT) needs to be computed. VOT was computed based on US Department of Transportation (DOT) Guidance, which is a weighted average of personal and business VOT, taking into account the share of each type of travel as reported in BTS National Household Travel Survey. The computed VOT is applied to the estimated reduction in travel-time that results from Oasis rail.

**Table B-2: Value of Time Assumption, in 2015 US Dollars**

| Criteria | Value | Source |
|---|---|---|
| Value of Time (Local Travel – All Modes, passenger car) | $13.09 | US Census, BLS, USDOT Guidance |
| Value of Time (Local Travel – All Modes, commercial vehicle) | $26.33 | US Census, BLS, USDOT Guidance |
| Value of Time (Waiting) | $25.09 | US Census, BLS, USDOT Guidance |
| Real Growth Rate | 1.6% | US DOT Guidance |

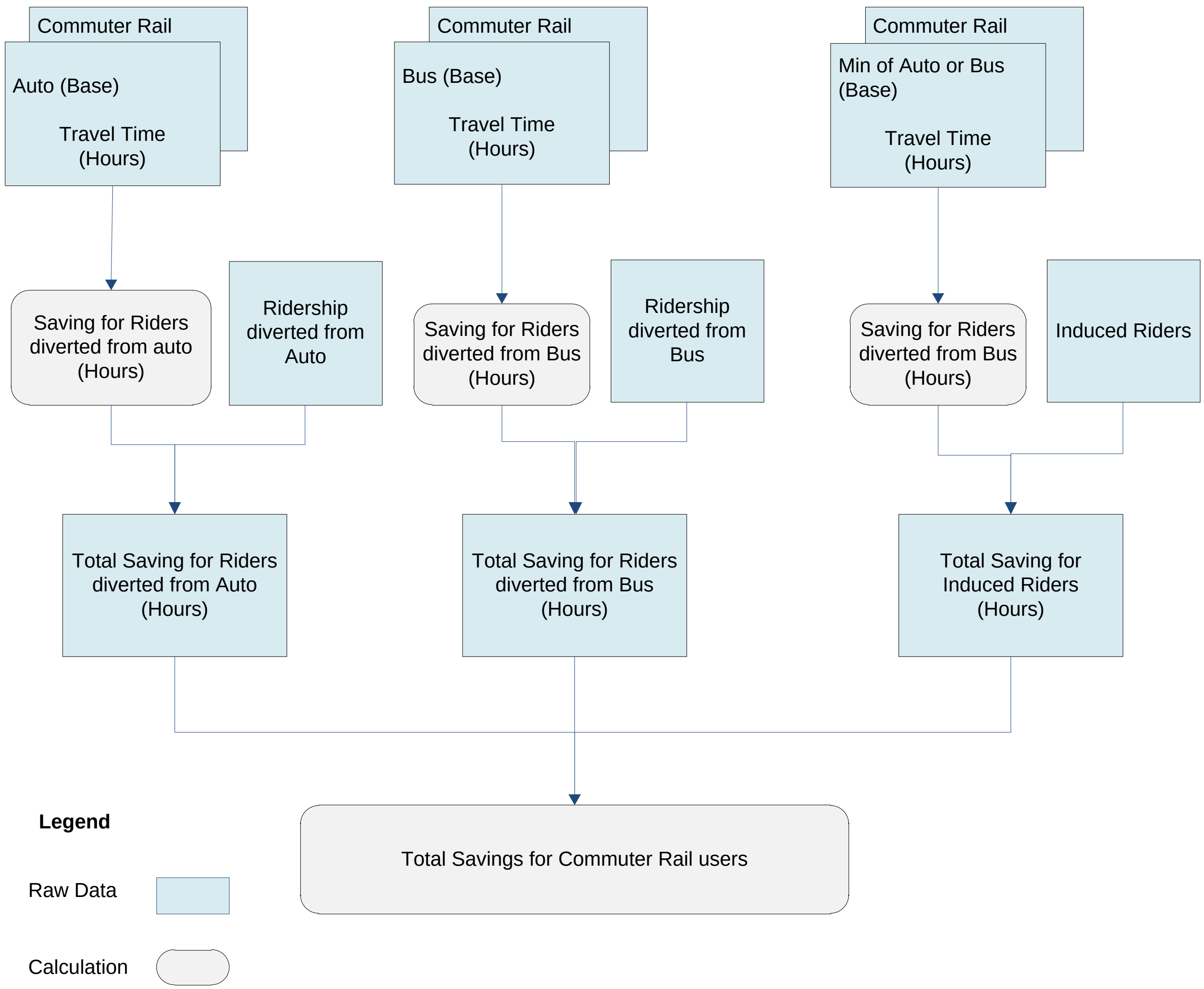
**Structure & Logic Diagram and Methodology**

Travel time savings to roadway users were not included in the BCA as improvements in roadway condition is not expected be significant.

Travel time savings to commuter rail users were assessed by computing the difference in travel time between commuter rail and automobile.[12] While this BCA does not include diversion from bus or induced trips, the general travel time savings methodology with multiple modes and induced demand is illustrated in Figure B-1. The value of travel time (in dollars per hour of travel) was broken down by vehicle class (e.g. auto vs. truck), and reflects the socio-economic characteristics of the study area (e.g. income level). In the first step, a difference in travel time cost between commuter rail riders and other modes (car and bus) is computed. Second, the number of person trips diverted from other modes (car and bus) and induced commuter riders are inputted. In the final step, the difference in travel time costs by the number of person trips diverted from other modes to calculate the total savings in travel time cost.

[12] Based on out-of-vehicle travel time parameter used in the mode choice model, multiplied by a factor of two to reflect the ratio of waiting value of time to travel value of time.

## Figure B-1: Structure and Logic Diagram for Estimating Transit Benefits



# Appendix C: Travel Cost Improvements Assumptions and Methodology

Commuters incur not only travel time costs, but also other travel costs, mainly referred to as vehicle operating costs. The following parameters were calculated based on TIGER application guidelines. Out-of-pocket costs were estimated using consumption rates for fuel, oil, tires, maintenance, and depreciation, and are a function of vehicle speed. Unit costs were then applied to these consumption rates to calculate out-of-pocket costs. Also, included in the out-of-pocket costs is a parking cost, if applicable. Table C-1 below lists these unit costs along with other out-of-pocket costs such as parking.

**Table C-1: Out-of-Pocket Cost Assumptions, in 2015 US Dollars**

| Out-of-Pocket Cost Components | Value | Source |
|---|---|---|
| Fuel ($ per gallon) * | $2.15 | AAA Fuel Gauge |
| Oil ($ per liter) | $9.96 | USDOT, FHWA HERS-ST |
| Tires ($ per 4 tires) | $361.32 | USDOT, FHWA HERS-ST |
| Maintenance ($ per 1000 mi) | $169.70 | USDOT, FHWA HERS-ST |
| Depreciation (avg. depreciable cost per vehicle) | $21,797.0 | USDOT, FHWA HERS-ST |
| Parking ($ per trip) | $2.50 | Bestparking.com/Cincinnati-parking |

Note: * The fuel cost estimate used in this BCA includes taxes but does not include any external costs, such as those considered by NHTSA units regulatory impact analysis of corporate average fuel economy standards. This cost increases based on Annual Energy Outlook published by the Energy Information Administration 2015.

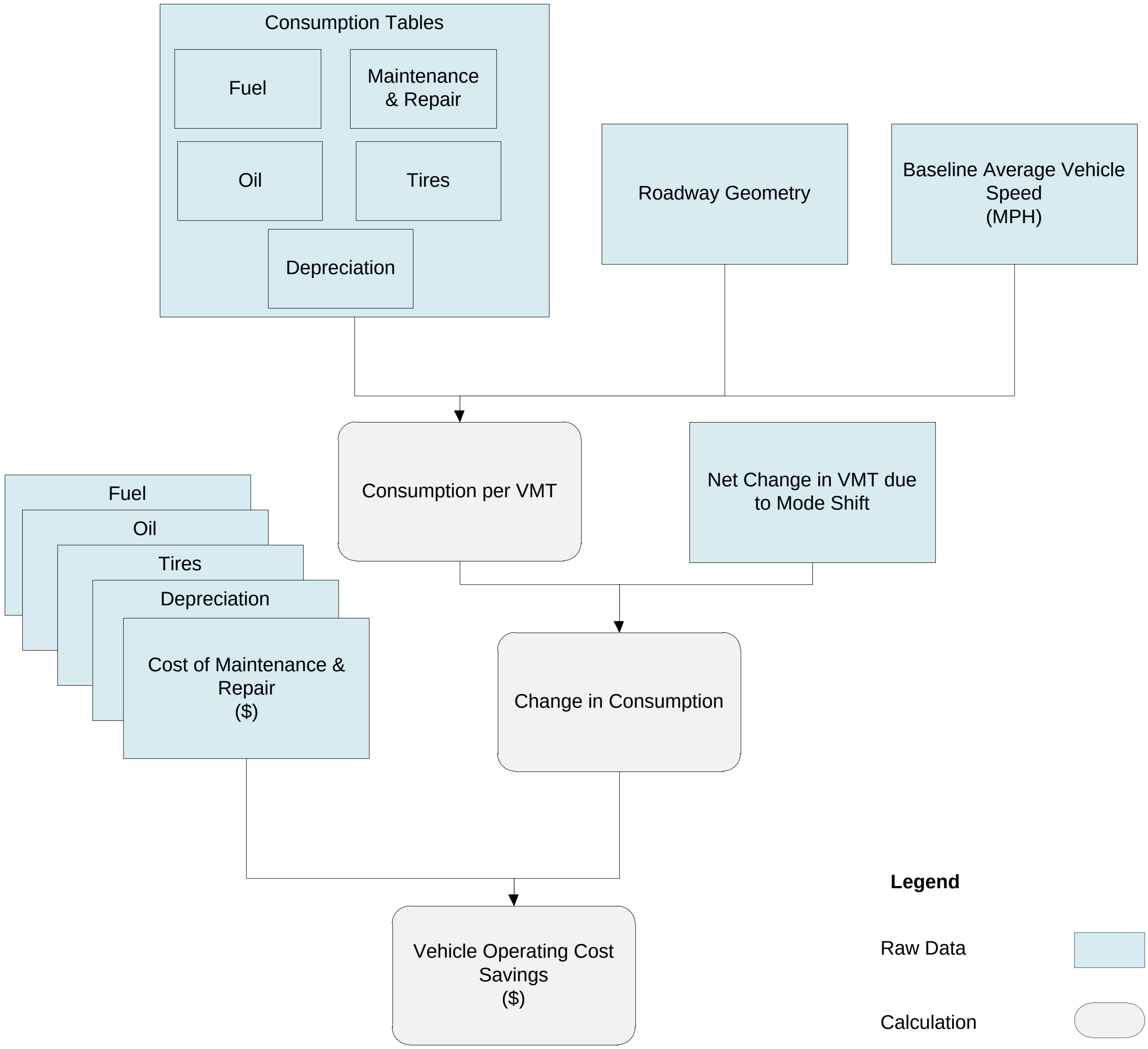
### Structure & Logic Diagram and Methodology

Vehicle operating costs are generally the most recognized of user costs, because they involve the out-of-pocket expenses associated with owning, operating, and maintaining a vehicle. The cost components associated with operating a vehicle include fuel consumption, oil consumption, maintenance and repairs, tire wear, and roadway-related vehicle depreciation. Each component is a unique function of vehicle class, vehicle speed, road grade, and surface condition.

Figure C-1 on the next page describes the structure and logic diagram for estimating vehicle operating cost savings to “remaining” roadway users. The methodology used to estimate consumption rates, as a function of speed, and the unit prices of these components are based on the Federal Highway Administration’s Highway Economic Requirement System (HERS).[13]

13 Highway Economic Requirements System Technical Report, Federal Highway Administration, August 2005.

**Figure C-1: Structure and Logic Diagram for Estimating Vehicle Operating Cost Savings**



# Appendix D: Travel Reliability Improvements Related Assumptions

Commuters put a high value on system reliability, meaning they make the decision about how to travel based on the simple question of "Can I get there when I want to be there?" Travel by automobile is typically seen as reliable. The higher the reliability of the transportation system, the more economically efficient the system can be. Transportation reliability refers to less variation around the expected travel time. Researchers have found that travelers value reliability as highly, if not higher, than general travel time savings. Researchers estimate for example that travelers value reliability at 90 to 140 percent of median travel time depending on how reliability is defined. Equation D-1 and Table D-1 present an equation and coefficients for measuring variability, which is a proxy for reliability. A decrease in volume to capacity ratio (V/C) for roadway leads to less variability. Likewise, having a consistent, reliable and understandable rail schedule provides less variability for the user.

The monetary benefits from the increase in system reliability can be calculated by multiplying value of time and reduction in variability. Equation D-1 provides a formula for calculating standard deviation of trip times by different V/C ratios. Constants in the equation (S0, S1, B and A) are derived from research work and specific values are dependent upon the types of roads. The equation indicates an inverse relation between V/C ratio and variability (standard deviation) in trip length – the higher the V/C ratio, which means more congestion, the higher variability. The reduction in variability can be multiplied by the affected traffic volumes and value of time (in $) to estimate benefits in monetary values.

**Equation D-1: Variable Equation for Standard Deviation Calculation**

$$Var = S_0 + \frac{S_1 - S_0}{1 + \exp\left(b\left(V/C - a\right)\right)}$$

**Table D-1: Coefficient used in Variable Equation**

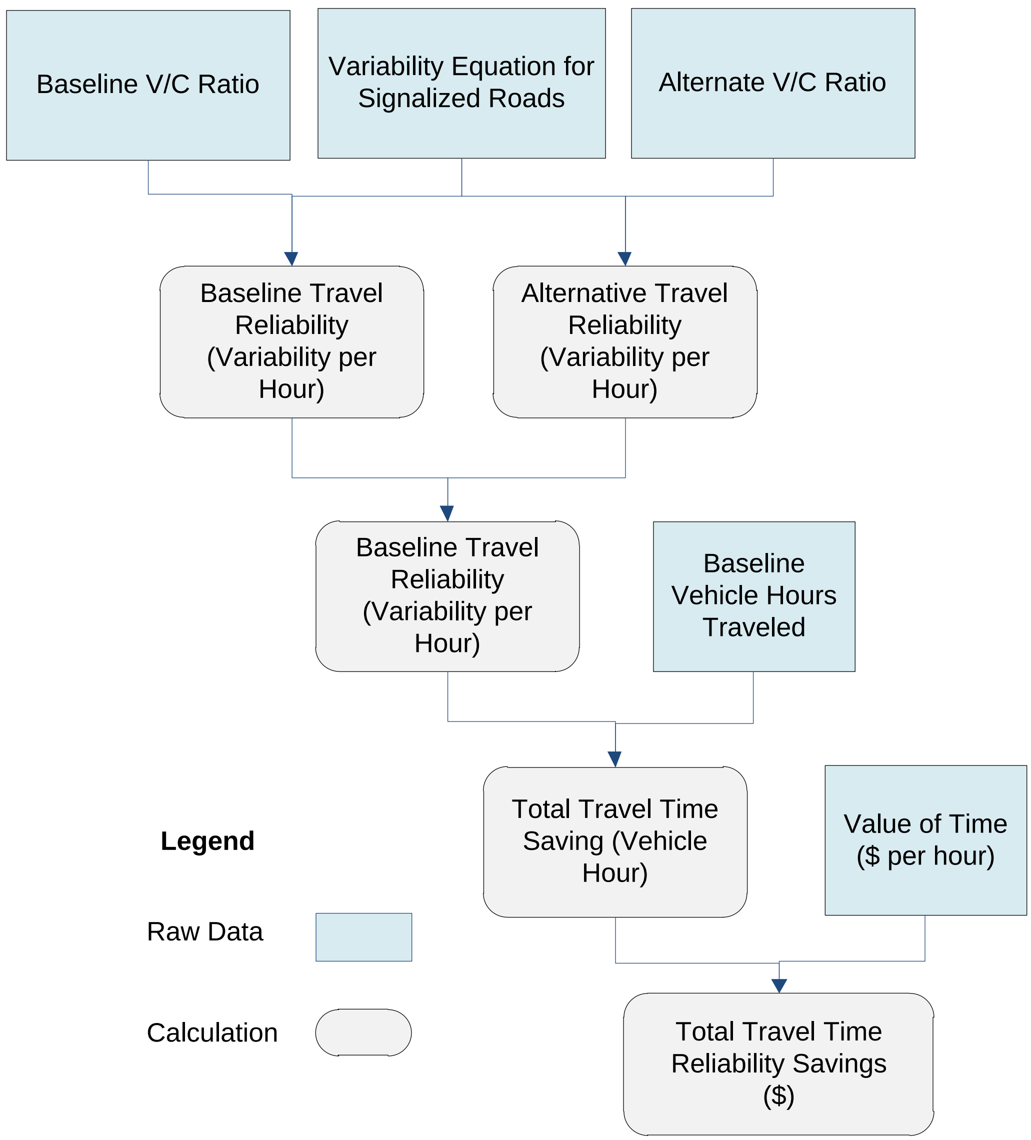
| Variable | Definition | Arterial | Signalized Roadway | Unsignalized Roadway |
|---|---|---|---|---|
| **So** | level of variability of travel time (variability at free flow speed) | 0.117 | 0.12 | 0.12 |
| **S1** | Maximum level of the variability of travel time | 0.89 | 1.25 | 1.2 |
| **B** | Constants that vary for freeways and arterials | -28 | -32 | -22 |
| **A** | Constants that vary for freeways and arterials | 1 | 1 | 1 |
| **V/C** | Volume to capacity ratio for each roadway (traffic model output) | Specific to project | | |

Source: Methodology to Assess the Benefits of Improved Trip Reliability (Ensor 2002).

**Structure & Logic Diagram and Methodology**

Reduction in travel time variability depends upon the reduction in congestion level. Reduction in congestion level decreases the variability of travel time after the project is implemented. The difference in travel time reliability was calculated between base case and the alternate case. Decreases in average travel time variability reduce costs associated with uncertainty. Figure D-1 provides the structure and logic diagram for using volume to capacity ratio to compute transportation reliability improvements.

**Figure D-1: Structure and Logic Diagram for Estimating System Reliability Benefits**



# Appendix E: Travel Safety Improvements Related Assumptions

Changes in crash costs, like other variable costs, are dependent on changes in VMT. The changes in vehicles on the road are combined estimations on per-mile crash rates for fatal, injury, property damage only (PDO) crashes. Safety benefits were calculated as the difference between the total cost of crashes under the "Build" scenario and that under the "No-Build" scenario.

Safety benefit related assumptions are listed in the following two tables. Table **E-1** lists the current fatality, injury and crash rates per 100 million vehicle mile traveled (VMT) in Hamilton and Clermont Counties. Some reduction in VMT would result in decrease in the number of crashes in the study area.

**Table E-1: 2011 Crash Rates in Hamilton and Clermont Counties, Ohio**

| Crash Type | Hamilton County | Clermont County |
|---|---|---|
| Alt Fatality rate per 100 million VMT | 0.49 | 1.33 |
| Alt Injury rate per 100 million VMT | 70 | 91 |
| Alt Crash rate per 100 million VMT | 360 | 329 |

Source: Ohio Department of Transportation.

Costs associated with each type of crash are presented in Table **E-2**, which is based on TIGER guidelines. A real income-adjusted growth rate of 0.88 percent per year is applied to the costs.

**Table E-2: Safety Benefit Assumptions, in 2015 US Dollars**

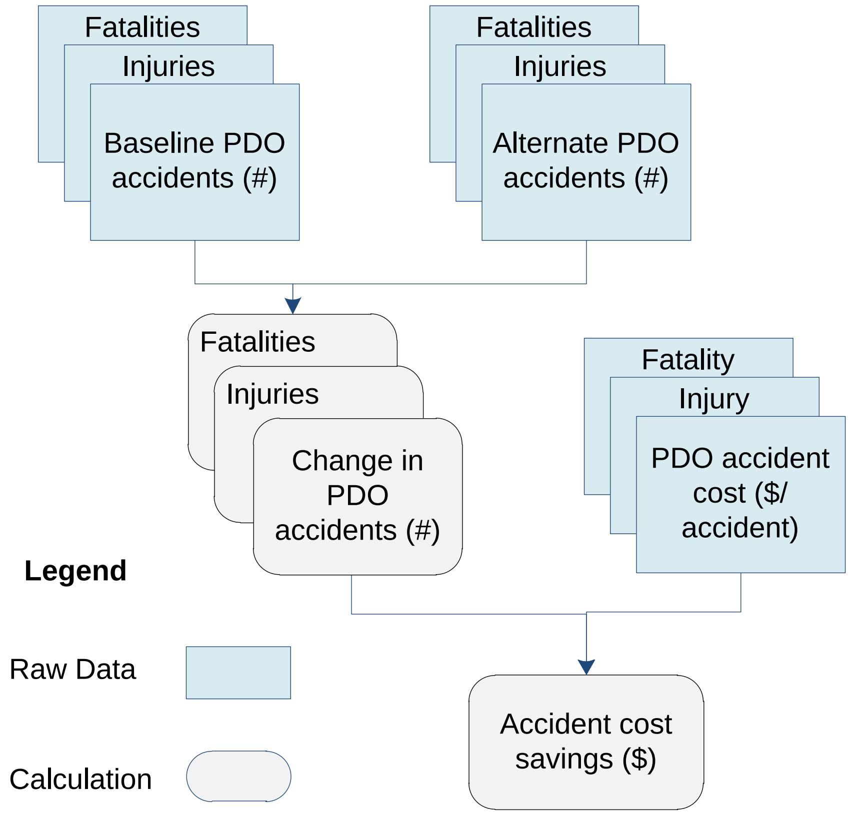
| Type of Crash | Type of Cost | 2015$ per Injury |
|---|---|---|
| Injured Persons | MAIS 1 - Minor injury | $28,665 |
| | MAIS 2 - Moderate injury | $449,087 |
| | MAIS 3 - Serious injury | $1,003,279 |
| | MAIS 4 - Severe injury | $2,541,639 |
| | MAIS 5 - Critical injury | $5,666,136 |
| Fatality | MAIS 6 - Fatal | $9,555,035 |
| Crashes** | PDO - Highway accidents | $3,992 |

Source: 2009 BTS Motor Vehicle Safety Data Table 2-17.

**Structure & Logic Diagram and Methodology**

Crash rates and crash severity on roadways are typically higher than on commuter rail systems. Therefore, modal shift from auto to a "safer" mode is likely to result in overall improvements in safety. In the Eastern Corridor, additional safety benefits are expected to accrue to roadway users and the general public because "remaining" roadway trips will be made under less congested conditions. These benefits were assessed using estimates of the marginal accident cost of roadway travel under USDOT guidance.

**Figure E-1: Structure and Logic Diagram for Estimating Crash Cost Savings**



# Appendix F: Reduced Environmental Impact Related Assumptions

Reduction in emission volumes are dependent upon the better mobility, decreases in traffic delays and reduction in vehicle-miles resulting from diversion to Oasis rail and more direct roadway connectivity. The emission rates used in this BCA were obtained from Motor Vehicle Emission Simulator (MOVES) - a tool provided by the Environmental Protection Agency (EPA). Per-unit emission costs were applied to the emission reduction volumes due to the reduction in VMT caused by modal shifts to Oasis rail. Emissions from the rail were assumed negligible.

The per unit cost of each of these emissions is shown in Table F-1. There are five types of emissions measured in this analysis: carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxide (NOx), fine particulate matter (PM 2.5), sulfur dioxide (SO2), and carbon dioxide (CO2).

**Table F-1: Emissions Cost, in 2015 US Dollars**

| Pollutant | Cost per Metric Ton* | Source |
|---|---|---|
| Carbon Monoxide (CO) | Negligible | Final Regulatory Impact Analysis Corporate Average Fuel Economy for MY 2012-MY 2016 Passenger Cars and Light Trucks, March 2011; inflated to 2015 Dollars |
| Volatile Organic Compound (VOC) | $2,030 | |
| Nitrogen Oxides (NOx) | $ 8,010 | |
| Fine Particulate Matter (PM2.5) | $366,330 | |
| Sulfur Dioxide (SO2) | $47,330 | |
| Carbon Dioxide (CO2) | $39.79 | Interagency Working Group on the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866; inflated to 2015 Dollars; average over 2015 – 2050 |

Note: * Converted from source into 2015 Dollars.

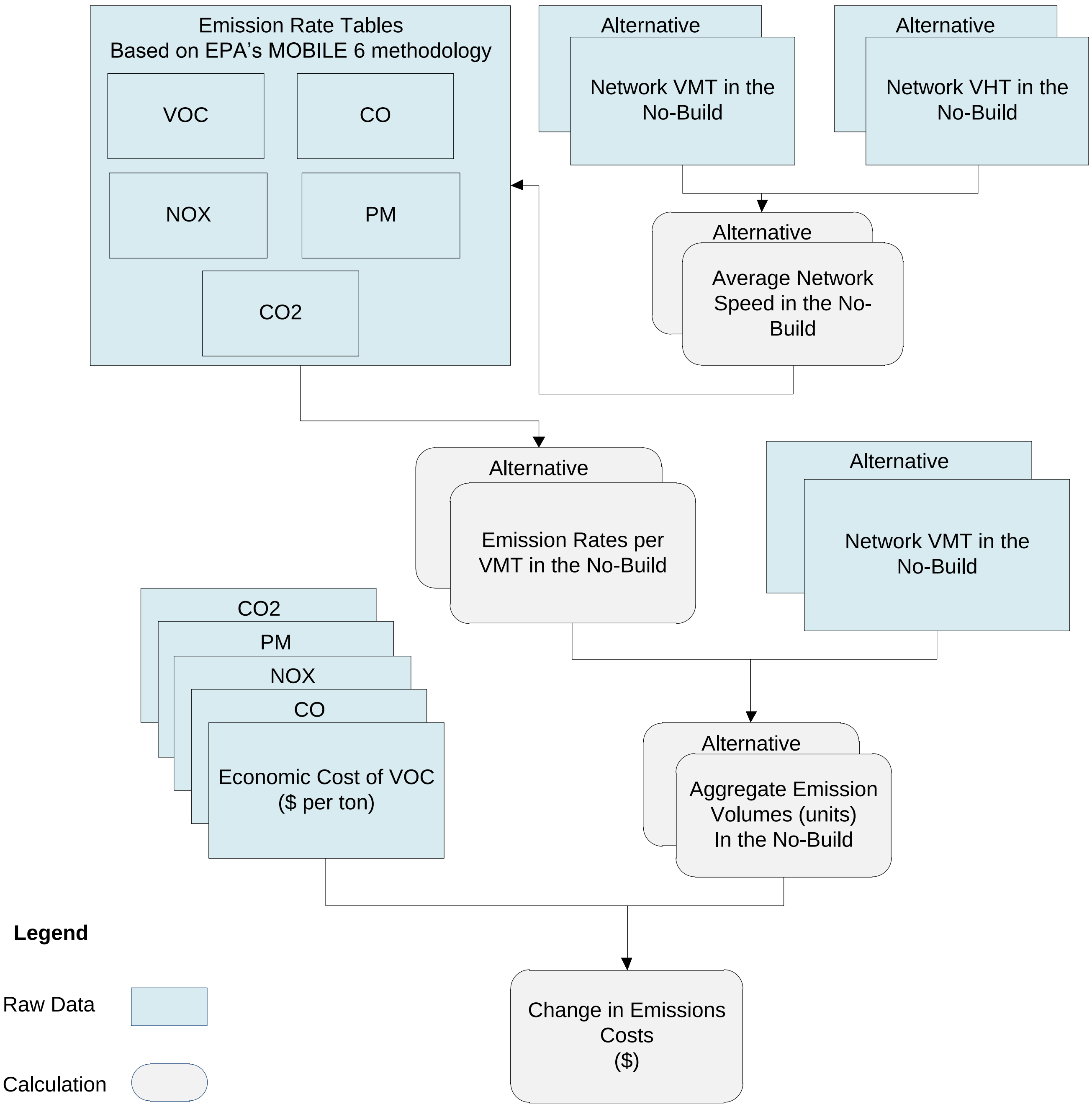
**Structure & Logic Diagram and Methodology**

Environmental benefits are gaining increasing acceptance as an important component of the economic evaluation of transportation and infrastructure projects. The main environmental impacts of vehicle use - exhaust emissions and vehicle-generated noise - can impose wide-ranging social costs on people, material, and vegetation. The negative effects of pollution depend not only on the quantity of pollution produced, but on the types of pollutants emitted and the conditions under which the pollution is released.

As with other travel costs, environmental cost savings were calculated using estimates of changes in Vehicle Miles Traveled (VMT) and speed. More precisely, emission cost savings were calculated as the difference between the total cost of emissions emitted in the build scenario (with commuter rail), and the total cost of emissions emitted in the base case (without commuter rail).

Figure F-1 describes the structure and logic of the estimation of emission cost savings. Vehicle emission rates were based on the EPA's Motor Vehicle Emission Simulator (MOVES) methodology.[14] Emission rates for carbon monoxide (CO), nitrogen oxide (NOX), volatile organic compounds (VOC), particulate matter (PM), and carbon dioxide (CO2) were estimated.

**Figure F-1: Structure and Logic Diagram for Estimating Emission Cost Savings**




[14] Environmental Protection Agency MOVES modeling system, http://www.epa.gov/otaq/models/moves/index.htm.

# Appendix G: Station Area Development Benefits Related Assumptions and Methodology

People place a value on their assessment of the quality of life in an area, which can include a sense of equity and fairness, of overall attractiveness of the physical place, and a sense of community cohesiveness. These aspects are significantly influenced by individuals' mobility and relation to the surrounding communities, as well as the accessibility of goods and services. For communities along the Eastern Corridor, Oasis commuter rail is expected to enhance livability and quality of life in the study area through community development and improved mobility especially for lower-income individuals.

Transportation Economics literature suggests that increases in real estate prices for following opening of new transit services reveal may capture benefits that transit services generate. In particular, transportation economists estimate changes in property values using a 'hedonic pricing' model (which seeks to price goods based on both internal characteristics and external factors) and a 'willingness to pay' for proximity to transit stations methodology.[15] The use of hedonic pricing assumes that if a transit project reduces automobile-travel dependence and provides households access to more amenities, it stimulates the demand for land and buildings located in the vicinity of station locations, and therefore, other things being equal, the existence of the transit raises property values in areas neighboring transit stations. Part of the increase in the value of the real estate around transit station is associated with the transportation cost savings afforded by the transit line, particularly if it generates time savings and/or the ability to reduce car ownership. In other words, by living near a transit station, the residents can, on average, travel cheaper than via car, and the value of the residence should reflect the value of these transportation cost savings.

In this study, the average incremental increases in property prices attributable to transit is referred to as transit premium. While aggregation of incremental increases in property prices is considered as total development benefits due to transit, it is adjusted to remove user cost savings that have already been captured elsewhere in this BCA to avoid double counting of benefits. The following discussion includes the estimation of transit premium for Oasis commuter rail and the methodology that follows to compute the development benefits.

**Components of Station Area Development**

There are five key components in estimating station area development benefits: 1) existing property number and 2) growth rate in construction, 3) property value and 4) growth rate, and 5) transit premium. The first four components are derived through historic, current, and forecast (or planned) land use and property data for the impact area. Property value growth is assumed to remain unchanged even with new transit service as any increase due to transit is captured in the transit premium. Also, projections on property value applied in this study are developed on a regional basis, without accounting for changes in travel demand patterns.

[15] Lancaster (1966) expresses the price of a good as a combination of hedonic (component) prices, each corresponding to the good's characteristics, so that it is equivalent to the consumers' shopping observations when comparing prices among slightly differentiated goods. "A New Approach to Consumer Theory." The Journal of Political Economy, 40, no. 4 (1966): 551-570.

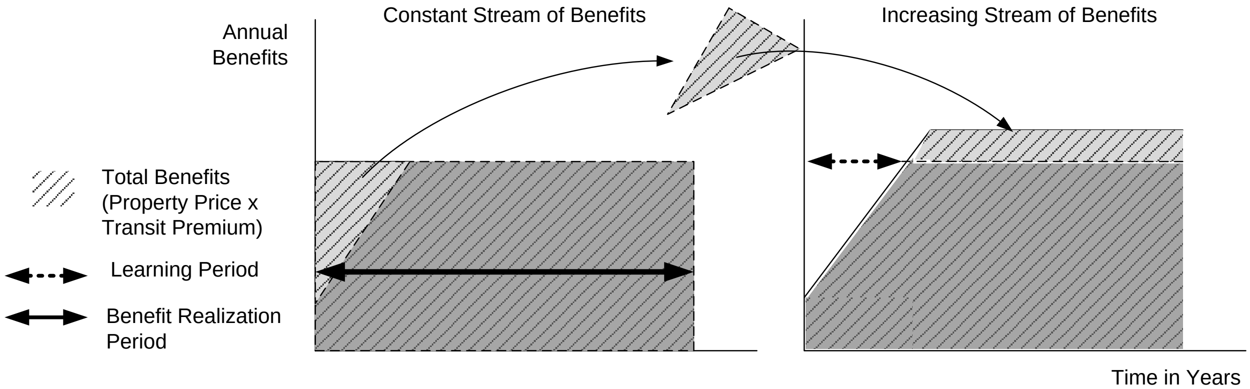
While the transit premium includes benefits from potential productivity increase due to densification of development, this BCA does not separately account for supply-side effect of land use change. The expected change in land use, with and without transit, is not estimated because land use change is often planned and is part of a larger transportation network development strategy for many planning organization. As a result, the incremental effect due to a single change in transit service cannot be distinctly measured. In this study a conservative growth estimate of property number is applied: the growth in property is assumed to be based on historic growth in construction and land use change is independent of new configurations of transportation network.

The last component of estimating station area development benefits, transit premium, or rate of increase in value due to the nearby transit, is constructed based on hedonic price estimates of existing transit impacts on property values found in recent literature. This method of transferring information from existing study sites to others is referred to as Benefit Transfer, and it is used in this study following the guidelines established by the Office of Management and Budget[16]. Among the limited number of hedonic studies conducted for estimating the impact of commuter rail, there is not one that is directly applicable to communities similar to those near Oasis because many of them are studies of systems located in large costal cities of the US. As a result ridership catchment is used when applying benefit transfer of existing estimates, where catchment is defined as the ratio of ridership over service area population. For Oasis, projected values are used to develop the catchment potential, and it is used relative to actual catchment of study area from which estimates are transferred, so that a scaled benefit transferred in performed.

The scaled transit premium is applied only to prices of new[17] properties for estimating development benefits, where new properties are estimated using the baseline property number and new construction rates. For a new property near the transit alignment, its market price or rental rate at the time of purchase or lease is assumed to capture the expected lifecycle stream of benefits generated by transit services. However, the amount of transit premium is then realized by the property owner or lessee annually at an increasing rate to reflect growing certainty over time. As a result of these two assumptions, the transit premium (as a percentage of property value) is applied only once to the price of new property, and the dollar amount of benefits is then spread over the analysis horizon of 30 years, subject to time discounting. The approach assumes that benefits are not realized instantaneously. Rather, it will take 30 years for all premiums to be realized for any given property (an assumption based on standard mortgage term for residential homes), and this duration is independent of this BCA's horizon. Instead of assuming a constant rate of realization of annual benefits, a ramp-up is used. The assumed learning of benefits is illustrated in Figure G-1.

[16] U.S. Office of Management and Budget Circular A-4: Regulatory Analysis, 2003.
[17] A new property is one that is newly impacted by transit. All existing properties are considered new in the first year of transit operation, while only those that are newly constructed in subsequent years will be considered for the remaining lifecycle of the transit alignment.

**Figure G-1: Reconfiguration of development benefits to reflect gradual realization**




The following tables show the assumptions for the estimation of station area development benefits. Baseline property data obtained from City of Cincinnati, mapped to the study area using a half-mile buffer from each Oasis station using ERSI ArcGIS is presented in Table G-1. The station buffer distance chosen is standard in hedonic pricing literature for commuter rail impacts.

**Table G-1: Property Assumptions by Type**

| In Year 2015 | Property Type | |
|---|---|---|
| | Residential Properties | Commercial |
| Property Number | 1,944 | 969 |
| Average Property Value, in 2015 Dollars | $213,890 | $580,721 |

To estimate future property value growth for residential homes, the Federal Housing Finance Agency Home Price Index and Moody's Home Price Index for the Cincinnati Metropolitan Statistical Area (MSA) from 2015 to 2030 were used, adjusted for inflation. The growth rate for commercial property values is estimated from extrapolation of historic trends using Moody's Real Commercial Price Index (excluding apartments) from 2001 to 2010, adjusted for inflation. Property number growth is developed from the Eastern Corridor Land Use Vision Plan 2002 based on expected changes in land use. These estimates are reported in Table G-2.

**Table G-2: Property Number and Value Growth Rates**

| Property Number Growth Rate | | Property Value Growth Rate | |
|---|---|---|---|
| Residential | Commercial | Residential | Commercial |
| 3.49% | 3.53% | 2.47% | 2.63% |

The transit premium rates selected from the list of studies presented earlier are of the conservative range relative to those reported in the literature. The rates that were applied reflect the station area development potential due to the commuter rail and they are presented in Table G-3.

**Table G-3: Property Change Rates**

| Property Type | Range of Property Value Change in the Station Area * | Notes |
|---|---|---|
| Residential Properties | 0.0% ~ 6.0% | A range of rates is based on studies conducted on SEPTA in Pennsylvania, Caltrain in San Francisco, Coaster Commuter rail in San Diego and MBTA in Boston |
| Commercial Properties | 3.7% ~ 20.5% | A range of rates is based on studies Coaster Commuter rail in San Diego. Properties that are within ¼ mile of San Diego downtown experienced a very high increase in property values. |

*These ranges of property value changes are adjusted to reflect the ridership catchment of the Oasis region service.

**Structure & Logic Diagram and Methodology**

In order to predict the response of the real estate market to the proposed infrastructure investment, a hybrid approach that combines local real estate data and trends, with property value impacts estimated for other systems in other cities is used. The hybrid approach, as introduced previously as a scaled benefit transfer of found development benefits, consists of the following steps:

1) Review public records documenting existing property values, historical rates of change in values, and historical rates of growth in the number of taxable lots in each evaluation area;
2) Identify potential station areas and collect data, by property type, on properties within half-mile each identified station area;
3) Estimate the average property value growth rate based on historical transaction prices;
4) Estimate the number of additional properties based on historical (or planned) land use;
5) Quantify the incremental development benefit of station area proximity, discounting capitalized benefits accounted for elsewhere, as follows:
   a. Review recent literature in hedonic pricing of commuter rail impacts;
   b. Compute ranges of premiums by property type based on the case studies selected in Step a. In this analysis, two categories of properties are used: General Residential (i.e. single-family homes, multi-family homes, apartments and condominiums) and Commercial;
   c. Compute an average premium adjustment factor by property type, using catchment factor of the ratio of system ridership to service are population, for all cities in the selected case studies. The factors are then divided by Oasis catchment potential, which is computed as ridership projections and population estimates along the Eastern Corridor;
   d. Multiply the modified adjustment factors by property type to the average transit premiums from the selected case studies: this yields the expected commuter rail premiums for the study area, by property type;
   e. Apply transit premiums to property values of each new property and then aggregate over total number of properties within the station areas; and
   f. Remove user cost savings already captured in the BCA from development benefits.

Figure G-2 illustrates the structure and logic of our approach to estimating community development benefits.

**Figure G-2: Structure and Logic Diagram for Estimating Station Area Development Benefits**