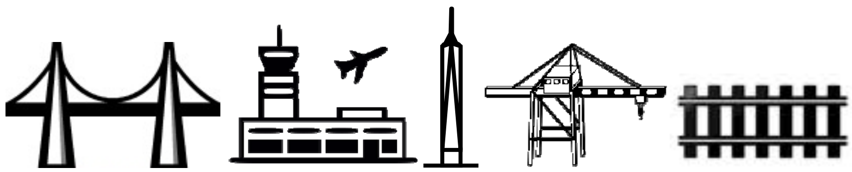
THE PORT AUTHORITY OF NY & NJ



Port Authority Cost-Benefit Analysis Framework

Planning and Regional Development Department · January 2011

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1 Introduction

Regional cost-benefit analysis is a powerful tool for guiding Port Authority investment and policy decisions. By identifying and quantifying the costs and benefits of potential projects and policies for the region's residents, visitors, and businesses as well as facility users, it can help decision-makers allocate resources to projects with the highest return for the region. This kind of analysis expands on the more narrow consideration of financial or Agency costs and benefits, and allows line departments to shape projects such that they maximize the regional return.

The Port Authority has committed to using regional cost-benefit analysis (CBA) as a key tool in evaluating discretionary projects and prioritizing capital investments. The Planning and Regional Development Department (Planning) has articulated a methodology and is working with consultants to apply it to individual projects. This manual describes that methodology.

For projects with capital costs above $250 million, Planning in partnership with the line department will engage an outside consultant to conduct a CBA at an early stage in project development. This analysis will guide decisions to advance discretionary projects and policies to final planning and design. The consultant will deliver an electronic model that can be updated during planning and design, so that CBA can be conducted on an ongoing basis to evaluate and shape the project[1]. For smaller projects, Planning will conduct an internal CBA.

This manual defines a comprehensive methodology that can be applied to the wide range of discretionary projects undertaken by the agency.[2] (CBA can, but will not necessarily be applied to state-of-good-repair and mandatory projects.) The benefits measured include transportation, safety, environmental, and wider macroeconomic benefits. The framework relies on best practices and the latest research to ensure credible analyses.

This manual assumes familiarity with the fundamentals of cost-benefit analysis. The bibliography includes a short list of works on cost-benefit analysis in general and as it relates to transportation investments in particular.

[1] The updating of the CBA depends on what information is affected by changes in the project/policy design. For instance, a change may require re-estimating traffic counts or emission reductions the consultant has provided, something we may not be able to do in house.

[2] Other benefit methodologies, such as those used by the Federal Transit Administration and the Army Corps of Engineers, explicitly restrict their scope to a few benefits that can be measured uniformly across jurisdictions.

2 General Principles

2.1 Framework

Cost-benefit analysis involves identifying all of the direct and indirect costs and benefits associated with a project, determining (where possible) their economic value, and discounting those values to determine their present value. The analysis compares the costs and benefits of all project alternatives against a common baseline; thus the definition and formation of a realistic baseline is a crucial first step in the CBA process.

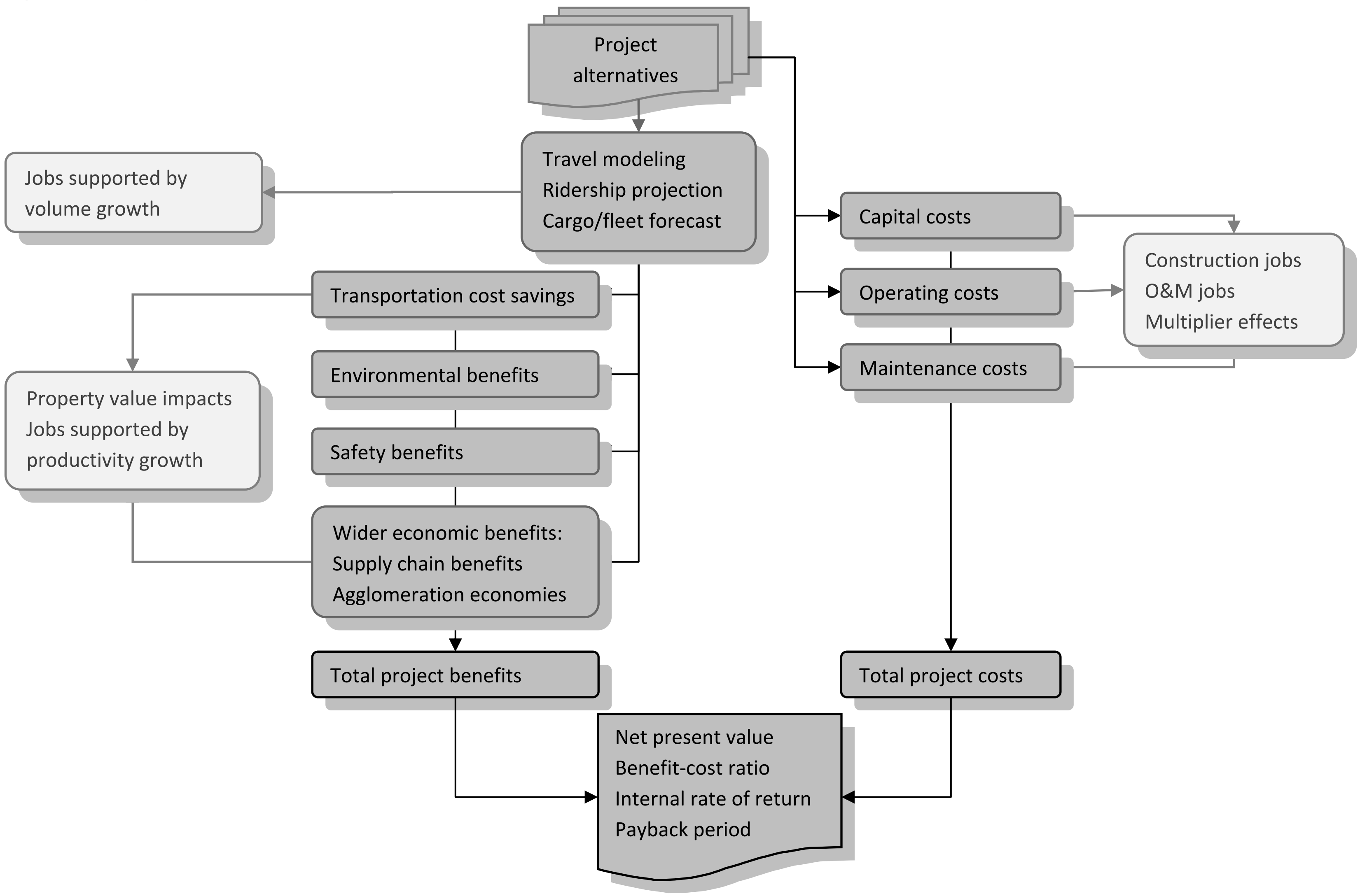
Figure 1 presents the conceptual flow of the analysis from raw data to final metrics. Once the capital and operating costs for the analysis period of the alternatives have been established, a cost-benefit analysis begins with a forecast of the behavioral changes induced by the project alternatives. This forecast establishes the raw benefits of the project. For a highway project this might be the time savings by all travelers in a year; for a freight project it might be the annual reduction in shipping costs. This forecast will typically include the effect of the project on overall volumes. For example, a project may induce a shift in traffic from one mode to another or from one region to another, or it could induce an absolute increase in travel.

The cost-benefit analysis then estimates the economic value of these benefits. Some benefits have a known monetary value. For example, reduced fuel consumption is valued at the cost of the fuel. Other benefits are measured through revealed or stated preference studies that show, for example, the amount that individuals pay or are willing to pay to take a faster route to work.

These direct benefits, along with the capital and operating costs, are primary inputs to the cost-benefit calculation. In some cases there are also secondary or indirect benefits that can be added to the calculation. If the direct cost savings are significant enough, firms may restructure their operations and further increase their productivity. The value of these productivity improvements is generally difficult to estimate but can be included in the calculation if a credible methodology is used.

Cost-benefit analysis considers the value added by a project to the economy – the increment added to consumer and producer surplus, in technical terms. Besides CBA, there are other ways to measure a project's benefits, such as the number of jobs created or the increase in property values. These effects are usually called economic impacts and sometimes warrant a separate analysis or study. During the construction phase, a project can boost construction employment. Transportation cost savings, especially for freight projects, can translate into lower prices that spur greater demand, which in turn brings higher employment throughout the economy. Travel time savings can make a region more attractive and boost local property values. These effects are not included in the cost-benefit calculation as they are simply another incarnation of the benefits already counted. For example, a transit project may boost residential property values, but these are generally thought to be a capitalization of direct benefits such as travel time savings that are already counted. These impacts are shown in a lighter color in Figure 1.

Figure 1. Analytical Framework



2.2 Point of view

Where a financial analysis considers the costs and benefits of a project from the point of view of the sponsor (e.g., the Port Authority), a regional cost-benefit analysis considers the wider point of view of the region, including the impact on residents, visitors, and businesses. For example, the only costs considered by a financial analysis would be the capital and operating costs; a CBA also considers economic, safety and environmental impacts. A financial analysis would count toll revenues as a benefit; in a CBA these are simply a transfer payment and not a real economic benefit. On the other hand, economic gains such as shorter travel times are not captured in the agency's financial analysis but count as a benefit in the CBA.

Table 1 lists the kinds of costs and benefits that are captured in the two analyses. A financial analysis only considers items in the Sponsor column, while a CBA generally captures items in both columns. Public costs and benefits will occasionally cancel a sponsor benefit or cost, as in the case of toll revenues.

A CBA also needs to avoid the double-counting of benefits. For example, travel time savings may be capitalized as higher rents for commercial property owned by the Port Authority; it would be improper to count this twice.

Table 1. Scope of Benefits Included in Regional Cost-Benefit Analysis

	Regional Cost-Benefit Analysis	
	Public	**Sponsor (Port Authority)**
Costs	• Out-of-Pocket Costs (tolls, fees, lease payments) • Environmental Impacts	• Capital Costs • Land Acquisition Costs • Operating and Maintenance Costs
Benefits	• Transportation, Environmental and Logistics Costs Savings • Congestion Management and Related Benefits • Supply Chain Reorganization • Agglomeration Economies	• Increased Revenues • Commercial Development • Productivity Improvements • Cost Reductions/ Avoidance

Adapted from HDR | Decision Economics, 2009.

Unless specified otherwise, benefits and costs will be estimated for the Port region, which consists of the following 17 counties:

New York State: Bronx, Brooklyn, New York, Queens, Staten Island, Nassau, Suffolk, Westchester, Rockland

New Jersey: Bergen, Essex, Hudson, Middlesex, Morris, Passaic, Somerset, Union

In some cases it may be difficult to judge whether benefits that occur within the region are actually captured by the region. For example, if a freight project results in lower transportation costs, who reaps the benefits and how much of those benefits stays within the region? Where the division of benefits is not clear, we require estimates of both the amount that occurs within the region and the amount that is captured within the region.

2.3 Baseline

The costs and benefits of project alternatives are measured against a baseline, the No Build alternative. This baseline scenario incorporates existing demand for transportation and all agency costs required to maintain the existing level of service. It also incorporates estimates of how all other parties would behave in the event that the agency does not advance a project alternative. For example, the baseline accounts for shifts in travel patterns and private investment that would occur if a project were not advanced.

2.4 Discount rate

Regional costs and benefits will be discounted at a real rate of 4%, which is comparable to the Port Authority's nominal cost of borrowing of up to 6% (depending on market conditions)

2.5 Appraisal period

Conventionally, costs and benefits are evaluated over a single replacement or rehabilitation lifecycle for major project components. All alternatives must be evaluated over the same period in order to avoid distortions in the analysis. Where the alternatives under consideration have different lives, the longest life should be chosen as a common appraisal period for all alternatives. Following USDOT guidance, the appraisal period should generally extend at least twenty years beyond the point at which the project is completed and benefits begin to be realized.

In case of unequal asset lives, it is also possible to create annualized figures that can be compared across the different alternatives. This method is to be preferred if using the longest life creates large discrepancies by ignoring the replacement of assets over time. Alternatively, projects can be staggered so that the timeframe of the analysis is consistent with the least common multiple of all project life spans. For instance, if an analysis is to be performed on two runway pavement options with one having an expected life of twenty years compared with ten years for the other, then it is reasonable to assume that the shorter project will be repeated once in order to cover the same timeframe of operations, twenty years, in both cases.

Due to the nature of the Agency's transportation projects, Planning advises against the use of salvage values in net present value calculations. Transportation infrastructure is not moveable and cash market values of used assets do not exist. The appraisal period and methodology needs to be selected as to avoid the incorporation of salvage values and their estimation.

2.6 Metrics

To assess the relative merits of projects or project alternatives, benefits and costs that can be monetized are discounted, summed, and analyzed in a number of ways. Benefits and costs that cannot be monetized should always be presented along with the numerical metrics.

Key metrics for weighing project benefits and costs include the following:

- **Net Present Value (NPV).** The NPV is the sum of all discounted benefits minus the sum of all discounted costs over the appraisal period. If there were no constraints on investment funds, it would be rational to carry out all projects with a positive NPV.
- **Benefit/Cost Ratio (BC).** The BC ratio is given by the ratio of the present value of project benefits divided by the present value of project costs. Higher ratios imply a higher return on all costs.
- **Internal Rate of Return (IRR).** The IRR is the discount rate at which NPV=0. The IRR can be compared with a hurdle rate (in real, not nominal terms).
- **Payback Period.** The number of years after which a project's benefits exceed its costs.

2.7 Risk analysis

Cost-benefit analysis is not a deterministic exercise. There are typically large uncertainties surrounding many of the inputs to the analysis. Risk analysis allows the final metrics to reflect these uncertainties. Among the factors creating uncertainty:

- Costs and benefits can increase or decrease due to unforeseen political, technological, economic, and environmental forces, or due to unexpected physical conditions on the site;
- The models used to forecast costs and benefits necessarily make assumptions that limit their accuracy;
- Estimates become less reliable the further out in time they project, yet CBA requires estimates of costs and benefits for decades into the future.

To account for these uncertainties, major inputs to the CBA should be subjected to a risk analysis. This produces an estimated range or distribution for each value. For example, operating costs could be projected to be normally distributed around a central value, with a specified standard deviation. When a risk analysis has been conducted for each of the inputs, Monte Carlo simulation aggregates the inputs and uncertainties to determine the weighted average net present value (or other metric) and the likelihood of exceeding specific thresholds, such as NPV=0. This weighted average is also referred to as the risk-adjusted value.[3]

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[3] For preliminary or order-of-magnitude analyses, Monte Carlo simulation may give a false sense of confidence. In such a case, the uncertainties and their implications should be clearly stated.

Figure 2 presents an example of such a simulation. In this case, the project has a 25% chance of not having a positive NPV, and a 50% chance of having an NPV of about $1 billion or more.

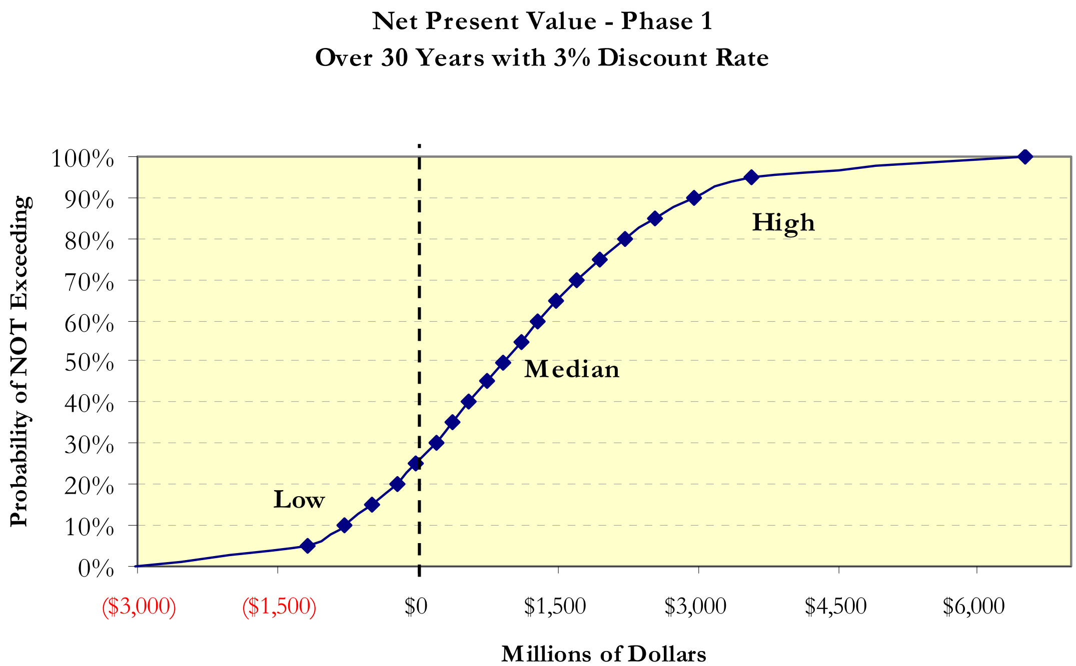

Figure 2. Distribution of Net Present Value

Source: HDR | Decision Economics, 2009.

For projects at the conceptual stage, risk analysis may be premature and can lend a false sense of certainty to the results. Sensitivity analysis is a more appropriate tool for evaluating the effects of uncertainty at this stage.

2.8 Sensitivity analysis

Sensitivity analysis tests the robustness of the results to changes in the individual assumptions used in the CBA. For example, the analysis of a transit line could test high and low ridership forecasts for ridership. Alternatively, the analysis could determine the break-even level of ridership (at which NPV = 0). Unlike risk analysis, sensitivity analysis varies one parameter while holding all others constant.

The following are examples of inputs that could be tested with sensitivity analysis:

Microeconomic assumptions	Macroeconomic assumptions	Scenarios
• Discount rate • Appraisal period • Value of time • Mode choice elasticities	• Cargo volumes • Fuel prices • Population and Employment growth	• Variations in timing • Technological changes • Related economic development • Actions by competitors • Shifts in trade patterns

3 Costs and Benefits

The central focus of any cost-benefit analysis is identifying and measuring the project's costs and benefits. For most Port Authority projects, the major costs are initial capital costs and ongoing operating and maintenance costs. All costs are included regardless of funding source. Benefits can generally be categorized as user benefits, environmental benefits, safety benefits, and wider economic benefits. If a project results in higher costs or negative environmental impacts, these are evaluated as dis-benefits, i.e.,. benefits with negative values.

The typical benefits of Port Authority projects range from more efficient transportation to increased safety and cleaner air. This section briefly describes the kinds of benefits associated with specific types of projects. Appendix B provides a more comprehensive list of the project types and benefits that should be considered in Port Authority cost-benefit analyses. Neither this discussion nor the appendix should be seen as precluding consideration of any benefit not mentioned.

3.1 Construction Period Impacts

Cost-benefit analysis generally focuses on long-term costs and benefits, but the construction phase of a project can also have important impacts. For example, a highway expansion project can temporarily increase congestion on the existing and parallel routes if fewer lanes are in service during the construction phase. During the renovation of rail or bus stations, travelers may be detoured around the construction, increasing the time to enter or leave the station; or stations or lines may be temporarily closed or diverted, forcing travelers to take longer routes. Construction projects that temporarily narrow roadways or reduce the number of station exits can also increase the likelihood of accidents during that time and make emergency evacuations more difficult. For any project, the operation of heavy construction vehicles can increase local noise and air pollution, and transportation of materials to and from the site can affect road congestion. The framework requires that construction period impacts be incorporated into the analysis if they are thought to be significant.

3.2 Road Projects

The primary aim of most roadway capacity expansion projects is to reduce travel times by reducing congestion. Projects that add general-purpose or managed-use lanes or reprogram existing lanes can reduce congestion, while those that provide alternative links or routes can directly cut travel times and reduce congestion on parallel routes. Projects that complete poorly-linked networks can also facilitate agglomeration or supply chain economies (see section 4.3). Less capital-intensive projects, such as traveler information systems and electronic tolling, can reduce congestion by encouraging the use of alternative routes or departure times, reducing incident response time, or eliminating bottlenecks.

A change in highway congestion – positive or negative – brings with it changes in several indicators that should be considered in a cost-benefit analysis:

- Travel time for individual travelers, bus transit, and truck freight;
- Vehicle operating costs, which are typically measured on a per-vehicle hour or per-vehicle mile basis, and include the cost of fuel, maintenance, and depreciation;
- Air pollution and carbon emissions;
- Fatalities, injuries, and property damage from motor vehicle crashes;
- Road maintenance expenditures, especially if there is a change in truck traffic;
- Noise levels near the affected roads;
- Reliability of travel times;
- Transaction times.

These changes can be the result not only of road projects but of any project that adds to or reduces traffic on the region’s roads.

Road projects can also be aimed at improving safety, reliability, or environmental performance. Engineering improvements, such as the construction of a center median on an undivided highway, can reduce motor vehicle crashes. Bus transit, carpool, bicycle and pedestrian facilities can improve the safety and reliability of those modes while encouraging a shift away from single-occupancy automobile travel and reducing congestion, with benefits as shown above.

3.3 Bus Terminal Projects

Bus terminal projects include a wide range of projects that can reduce costs for travelers and increase the attractiveness of bus travel. Terminal expansions, modernizations, and reconstructions can allow for more gates and faster transfers, reducing delays for buses and passengers. Pedestrian circulation and access improvements reduce in-terminal walk and transfer time for existing passengers. Electronic information systems can reduce the time that travelers spend waiting in the terminal. Systems that provide greater certainty about departure time can also have a benefit, as studies show that travelers place a value on this increased certainty.

Projects that draw new passengers from other modes of travel can have a range of effects on highway congestion and air quality. For example, capacity expansions and service improvements may draw new bus commuters away from single-occupancy vehicles, saving those commuters the cost of operating their automobiles and reducing highway congestion. Such projects might also draw travelers from commuter rail, with environmental impacts that depend on the relative emissions profile of the two forms of transit. Increased bus traffic can also accelerate wear-and-tear of the regional road network. The analysis needs to take into account both positive and negative effects.

Certain projects can improve safety for travelers and employees. Improved signage reduces the potential for accidents, and additional access and egress points can speed up emergency evacuations and reduce the impact of facility disruptions. Security upgrades can reduce the likelihood of security breaches and attacks, preventing loss of life and property damage and avoiding the costs of a facility shutdown.

Transit projects often provide greater accessibility to people who are economically, socially, or physically disadvantaged. These benefits are difficult to monetize but should be analyzed to the extent possible.

3.4 Rail Transit Projects

Transit's impact on travel behavior is the primary source of societal benefits from rail transit projects.[4] These benefits are primarily seen in shorter travel times or improved reliability. Transit projects can also induce some travelers to switch from automobile travel to transit, saving those travelers the cost of operating and parking their vehicles while reducing congestion for the remaining road users. Any change in road congestion will have other effects as indicated in section 3.2 above, such as reduced highway fatalities and injuries, reduced vehicle emissions, and reduced highway noise, and thus should be quantified and included in a transit CBA.

New or expanded rail lines, additional cars, better connectivity, upgraded tracks and signal systems, and improved operational control can provide increased frequency of service and access to and from new origins and destinations. These can cut travel times for existing riders and attract new passengers who were previously using other modes of travel.

Station renovations and upgrades can allow riders to get to or from the platform faster. Renovations can also increase customer satisfaction and comfort, although these qualities are difficult to monetize. Bicycle and auto park-and-ride facilities, bus stations, and protected bus stops can encourage a mode shift, again saving travelers the cost of operating and parking cars and reducing highway congestion.

Innovations such as information sharing systems can save time for travelers when they are planning trips. Electronic fare systems can speed the process of purchasing transit passes and boarding buses or passing through turnstiles.

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[4] ECONorthwest and Parsons Brinckerhoff Quade & Douglas, *Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners (Transit Cooperative Research Program Report 78)*, 2000.

In the cost-benefit calculation, note that fare payments are not counted as a net benefit. Instead, from the societal perspective they represent a transfer of benefits from users to the facility operator.

Rail transit is often credited with wider economic transformations, such as higher property values along rail lines and higher productivity in city centers. Changes in property values are not included in the cost-benefit calculation, since they are considered a capitalization of direct benefits such as travel time savings that are already included in the calculation. On the other hand, the Port Authority will consider credible methods for estimating the incremental productivity benefit associated with the higher effective densities that transit improvements can bring (see section 4.3).

Rail transit projects also impose costs on society beyond the direct capital, operating, and maintenance expenditures. Increased service implies greater power consumption and thus an increase in air pollution emissions at the power plant or, in the case of diesel service, alongside the rail line. A new rail line or increased service frequency can increase the noise experienced by surrounding communities. At the same time, new rail cars or infrastructure often provide energy efficiencies and are quieter than older equipment, thus reducing air pollution and noise emissions.

Transit projects often provide greater accessibility to people who are economically, socially, or physically disadvantaged. These benefits are difficult to monetize but should be analyzed to the extent possible.

3.5 Aviation Projects

As suggested by the Federal Aviation Administration's guide to benefit-cost analysis, Aviation capacity projects typically are categorized as airside, air terminal building, or landside projects. Portions of the text in this section are adapted from the FAA's guide.[5] Applicable benefits should be monetized to the extent possible.

3.5.1 Airside Projects

Airside capacity projects are intended principally to reduce airside delay, improve aircraft processing efficiency, improve predictability of landing and take-off schedules, and/or to accommodate larger, heavier, longer-range aircraft at the airport. Fewer or shorter airside delays can translate into time savings for air passengers, flight crews, and cargo; reduced aircraft operating costs; and reduced air pollution emissions. Projects that provide redundancy can reduce the costs of a facility failure. Other benefits of airside capacity projects may include noise mitigation and improved safety.

[5] Federal Aviation Administration, *FAA Airport Benefit-Cost Analysis Guidance*, 1999.

Airside safety projects affect the likelihood, frequency, or severity of crashes. The benefits are reduced fatalities and injuries and reduced property damage. Projects such as bird hazard mitigation may reduce diversions and returns of disabled aircraft.

Improved fueling and chemical supply systems can reduce local road congestion if they take supply trucks off the road. Improved de-icing systems can reduce airside delays. Fuel and chemical containment projects can reduce the frequency and severity of spills.

3.5.2 Air Terminal Building Projects

Air terminal building (ATB) capacity projects include new, reconstructed, or expanded ATBs, consisting of passenger halls, counter space, gates, baggage handling systems and areas, and passenger arrival and departure areas. Benefits of these projects chiefly take the form of reduced passenger and passenger meeter/greeter delay due to alleviation of ATB congestion, improved and/or shortened pedestrian traffic flows, and quicker unloading of passenger baggage.

Sufficient delay savings may induce some passengers to arrive at the ATB closer to actual flight times (rather than early to allow for potential delay), thus saving passenger time and reducing ATB congestion.

ATB delay benefits may extend to aircraft operations through the availability of more gates and the ability to transfer passengers more expeditiously between connecting flights. Other benefits of these projects are expedited air cargo handling, lower ATB operating and maintenance costs, and improved passenger comfort and convenience.

Capacity expansion or modernization projects have the potential to induce additional travel. The analyst must take care to net out the effects of reduced travel at other regional facilities. Furthermore, these benefits should be net of any increased congestion costs due to the higher passenger or cargo volumes.

A project that cuts airline operating costs may result in lower fares. The fare reduction should not be counted as a benefit, since the reduction is simply a transfer of a portion of the operating cost savings.

ATB security projects may be driven by regulatory requirements, but some benefits can be captured by cost-benefit analysis. Enhanced screening technologies and improved operating procedures can cut (or add to) passenger time in security checks. They can also reduce the probability of security breaches, not only preventing attacks but reducing the frequency and/or duration of facility shutdowns.

Airports with more than one ATB may undertake projects to expedite the movement of persons between the ATBs. Benefits of these projects principally include reduced delay for passengers, passenger meeter/greeters, and airport employees. Aircraft operators may also experience cost savings due to more efficient movement of crew members to gates and the ability to allow less time between connecting flights due to shorter inter-terminal passenger transit times.

3.5.3 Landside Access Projects

Efficient access to airports is vital to the perceived utility of air transportation. Access projects, including new or improved rail transit, access roads on airport property, passenger pick-up and drop-off areas, parking areas, taxi/bus marshalling areas, and acquisition of road maintenance equipment, may yield important benefits. These benefits might be reduced travel time and improved reliability for passengers, meeter/greeters, cargo shippers, and airport employees attempting to get to and from the airport by automobile, bus, taxi, or rail.

Passengers, meeter/greeters, and cargo shippers using automobile or trucks will benefit from reduced transit and vehicle hours due to less time spent in congested conditions and/or more efficient routing. These users may also be able to schedule travel time more efficiently because they can allow less buffer time in their schedules for potential airport road or parking congestion or for transit delays. To the extent that a new or improved transit option shifts some travelers out of automobiles, there can be a reduction in regional highway congestion, with benefits as described in section 3.2.

Other potential benefits include reduced automobile emissions (due to fewer automobiles and trucks tied up in congested conditions), improved safety (for persons in vehicles and airport pedestrians), and lower operating and maintenance costs (due to less employee time spent in congestion while travelling on the airport grounds).

3.6 Freight Rail Projects

The primary benefits of freight rail capacity expansion projects tend to be faster travel times, increased reliability, and – to the extent that projects shift freight from trucks onto trains – reduced truck traffic. Projects that extend rail lines to new destinations or link networks can provide more efficient freight transportation, with shorter travel times and lower costs. Infrastructure upgrades that eliminate conflicts with other modes, such as passenger rail, can improve reliability and cut operating costs. Capacity expansions and upgrades can also increase the system’s redundancy, creating reserve that can be called on in the event of a facility shutdown.

New or upgraded freight yards and transfer facilities, such as intermodal terminals, can likewise cut transportation costs and shift freight from trucks. Information systems, such as those that provide greater cargo visibility, can reduce the costs of delay.

Projects that upgrade or eliminate grade crossings can increase safety for both trains and road users and eliminate delays for motorists waiting for the train to pass.

Projects that shift freight off trucks can reduce road congestion and the negative impacts of truck traffic. At the same time, increased rail traffic can have negative air quality, noise, and visual impacts on communities alongside the rail line; where there are grade crossings, the new traffic can have congestion and safety impacts.

Generally, projects that strengthen freight networks can engender supply chain economies that go beyond the direct benefits of lower transportation costs, as discussed in section 4.3.2.

3.7 Maritime Projects

3.7.1 Maritime Capacity Expansion

Maritime capacity expansion projects are those that reduce constraints on vessel size or loading. For example, dredging allows passage for larger ships and it allows some ships to travel with heavier loads or closer to their capacity.

Water and air draft constraints may force some ships to travel at lower speeds or wait for low or high tide to pass in or out of port. Removing these constraints reduces travel time, vessel operating costs, crew costs, inventory carrying costs, and vessel emissions.

To the extent that these projects allow for larger or more heavily-laden vessels, shippers may see improved economies of scale – reduced transport and handling costs per unit cargo. There may also be a reduction in air pollution per unit cargo.

Lower unit costs at our port may induce a shift in cargo traffic from competing ports. A key benefit is that the cargo that is diverted to our port will see a reduction in transport and handling costs. If we assume a linear demand curve over the area of interest, the increase in surplus will be equal to half the reduction in unit cost multiplied by the diverted volume of cargo[6].

Not all of these cost savings accrue to the region; some may accrue to foreign ports or shippers, for example. If the goods originate in or are destined for the port's hinterland, some of the benefits of lower costs may also accrue there. The distribution of benefits may vary by commodity and direction of trade (import or export).

Any growth in cargo through the port may support additional jobs and regional income. Planning has techniques for estimating these impacts, but they are not included in the cost-benefit analysis because they do not affect the level of consumer or producer surplus. There can also be costs for the region: air pollution from the additional marine traffic, and congestion and pollution costs from new truck and rail trips to support the increase in cargo.

[6] This estimation of benefit is complicated by the fact that trade routes and volumes change over time. CBA therefore provides only a rather static view of the benefit resulting from traffic diversion.

Removal of a barrier such as a low bridge can reduce the number of allisions; dredging can reduce the chance of groundings. Potential sources for valuation of these benefits include insurance companies.

3.7.2 Terminal Capacity Improvements

Terminal capacity improvements remove growth constraints at the terminal. New equipment and operating procedures may cut handling costs. Faster loading and unloading may mean that ships can spend less time in port, cutting vessel operating costs and emissions per unit cargo. These lower costs may in turn induce a shift in cargo traffic to our port from other ports, with the positive and negative impacts suggested above.

Examples of operational improvements that could cut costs include intelligent transportation systems such as truck appointment systems, cargo visibility, and RFID systems; expanded hours of operation; development or relocation of a chassis pool; and virtual container yards.

3.7.3 Calculating Air Pollution Emissions

Air pollution emissions should be calculated with a methodology consistent with that developed in the following studies:

- Starcrest Consulting Group, *The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory*, for The Port Authority of New York and New Jersey and The Army Corps of Engineers, 2003.
- The Port Authority of New York and New Jersey, Port Commerce Department, *2006 Baseline Multi-Facility Emissions Inventory*, 2008.[7]

These documents are available on the Port Authority website.

The studies above utilize the US Environmental Protection Agency's (EPA's) MOBILE6 vehicle emission model to predict gram per mile emission factors for Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NOx), Carbon Dioxide (CO2), Particulate Matter (PM), and toxics from cars, trucks, and motorcycles under various conditions.[8]

4 Economic Values

This section discusses methodologies for monetizing benefits.

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[7] http://www.panynj.gov/about/pdf/2006-BASELINE-MULTI-FACILITY-EMISSIONS-INVENTORY.pdf
[8] Further information including MOBILE6 model download and technical documentation is available on the EPA's website (http://www.epa.gov/oms/m6.htm).[8]

4.1.1 Value of travel time savings

For many projects, and especially road and transit projects, time savings account for the largest component of project benefits. The time savings include faster travel times for existing and new users of a proposed facility and faster travel times on other routes that experience reduced congestion as a result of some users switching to the new facility.

The value of these savings varies by trip purpose. For work-related trips, the value is the cost savings experienced by the employer and includes wages and any time-varying overhead. If multiple modes are involved, the CBA should consider average compensation for workers by mode. If information is available about specific occupations (such as truck drivers) that are affected by the project, occupation-specific compensation rates should be used. For freight travel, the value of time also includes inventory cost and logistics costs.

For commutes and all other local surface transportation trips, the value of time (VOT) does not vary by mode. This approach is consistent with the methodology adopted by the US Department of Transportation. In the absence of survey data specific to a project, commute time is valued at 50% of the mean wage, and other ("leisure") trips are valued at 35% of that wage. For detailed studies, the analysis should estimate the mean wage for affected travelers. For other studies, it is acceptable to use the regional mean wage. For the New York-Northern New Jersey-Long Island metropolitan statistical area (including one county in Pennsylvania) the regional mean hourly wage in May 2009 was $26.08. The value of personal travel time is based on this hourly wage.

The value of work-related travel includes certain employer costs: supplemental pay, disability insurance, pensions, and employment taxes. Data from the Bureau of Labor Statistics indicate that in the Middle Atlantic region (NY, NJ, PA) in 2010, these benefits added 22.8% to the cost of compensation.[9] Applying this factor to the regional wage we get an hourly compensation cost of $32.08.

Intercity travel is valued more highly than local travel.[10] In a study for the Port Authority, the Louis Berger Group estimated regional values based on household incomes reported in the PANYNJ 2005 Air Passenger Survey, adjusted by the contribution of personal wages to those incomes.[11] For air passenger travel, leisure trip travel time is valued at 70% of the wage rate and business travel at 100%.

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[9] The BLS's Employer Costs for Employee Compensation show that in private industry, Middle Atlantic wages averaged $21.63 in June 2010, while time-varying benefits averaged an additional $4.94. (Source: ftp://ftp.bls.gov/pub/special.requests/ocwc/ect/ececqrtn.pdf.)

[10] See USDOT, "Departmental Guidance for the Valuation of Travel Time in Economic Analysis," 1997, p. 2.

[11] The Louis Berger Group, *Cost-Benefit Analysis Methodology for Large Projects* (submitted to the Port Authority), 2008.

When converting base year wage rates to current-year dollars, the adjustment should be based on the change in regional median incomes and not consumer prices.

4.1.1.1 Treatment of waiting, walking, transfer, and delays

Walking time to access another mode is valued at 2.0 times the in-vehicle time. Waiting for a transit connection (not including unexpected delays) is valued at 2.5 times the in-vehicle time.[12] Public transport delays are valued at 3.0 times the in-vehicle time.[13] If a project significantly affects the number of transfers between modes, the value of this transfer should be estimated based on survey data or a review of the literature.

4.1.1.2 Recommended values for travel time

Table 2 summarizes the recommended values for travel time.

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[12] This follows the methodology of the UK Department for Transport. See P.J. Mackie et al, *Value of Travel Time Savings in the UK*, January 2003.

[13] See UK Department for Transport, Transport Analysis Guidance 3.5.7 (Reliability Sub-objective), 2009, http://www.dft.gov.uk/webtag/documents/expert/unit3.5.7.php

Table 2. Value of Time, in 2009 dollars

Quantity	PANYNJ Value	USDOT Value*
Mean wage (W)	$26.08	$25.11
Mean hourly cost to employer (EC)	$32.04	$25.23
Mean air traveler wage (ATW)		
– EWR	$36.57	
– JFK	$32.00	
– LGA	$35.43	
– All PANYNJ airports	$34.28	$39.48
Mean air traveler cost to employer (ATEC)		
– EWR	$44.92	
– JFK	$39.30	
– LGA	$43.52	
– All PANYNJ airports	$42.11	$47.54
In-vehicle surface travel time (VOT):		
In-vehicle travel time, work-related trips	1.00 x EC	1.00 x EC
In-vehicle travel time, commute trips	0.50 x W	0.50 x W
In-vehicle travel time, all other trips	0.35 x W	0.50 x W
Walk access time	2.0 x VOT	1.0 x W
Wait time (for transit)	2.5 x VOT	1.0 x W
Transfer penalty	TBD	1.0 x W
Delay (for transit)	3.0 x VOT	no guidance
Air passenger travel, work-related trips	1.00*ATEC	1.00*ATEC
Air passenger travel, all other trips	0.70*ATW	0.70*ATW

* USDOT bases its estimate of hourly wages (and thus personal value of time) on household income divided by 2000. Applying the same methodology for our regional CBA would result in a much higher value of time. However, most studies appear to estimate a value of time based on wage rates. To retain consistency with those studies, we also use wage rates, from the Bureau of Labor Statistics.

4.1.2 Reliability Benefits

In scheduling trips, travelers typically consider not just average travel times but some buffer time to account for uncertainty in the actual travel time. An improvement in transportation reliability means that travelers need to budget less additional time to arrive on time at their destination. There are a number of ways to measure this improvement, such as the change in standard deviation of travel time, or the change in the average delay. Table 3 shows several such performance measures for highway travel. At the same time, researchers have estimated the monetary value of these improvements. Table 4 suggests techniques for valuing changes in travel time reliability on several modes.

Table 3. Reliability Performance Measures

Reliability Performance Metric	Definition	Units
Buffer Index	Difference between 95^{th} percentile travel time and mean travel time, normalized by mean travel time	Percent
Planning Time	95^{th} percentile travel time	Minutes
Planning Time Index	95^{th} percentile travel time index divided by free-flow travel time index	None
Percent Variation (coefficient of variation)	Standard deviation of travel time divided by mean travel time	Percent
Travel Time Variance	Common statistical definition of variance	None
Failure Measure	Percent of trips with travel times > (1.3 *mean travel time)	Percent

Adapted from Cambridge Systematics, *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies* (SHRP 2 Project L03), 2010.

Table 4. Valuation of Changes in Travel Time Reliability

Mode	Typical Impacts	Measurement Unit	Valuation
Roadway (Passenger Vehicles)	Increase in trip time reliability / decrease in unanticipated delays	Difference between 90th and 50th percentile travel time	1.0x to 1.3x in-vehicle VOT estimate
Transit (Buses and Trains)	Increase in on-time arrival / decrease in unanticipated delays	Difference in average minutes lateness	2.0x to 3.0x in-vehicle VOT estimate
Freight (Truck and Rail)	Increase in on-time delivery reliability / decrease in unanticipated delays	Difference between actual arrival and scheduled delivery	1.0x to 1.3x in-vehicle VOT estimate or average shipping cost/minute
Air Travel	Increase in on-time arrival / decrease in unanticipated delays	Difference in average minutes lateness	1.5x in-flight VOT estimate

Adapted from The Louis Berger Group, Supplement to *Cost-Benefit Analysis Methodology for Large Projects* (submitted to the Port Authority), 2009.

For road travel, if the change in the standard deviation is available instead of the change in the 50^{th}-90^{th} percentile times, it should be valued at 0.8 times the value of in-vehicle VOT. As an expedient when reliability measures are not possible for road travel times, the value of time during highly congested periods should be multiplied by 2.5, as per Small et al (1999).[14]

For transit, there is little consensus on the value that passengers place on transit reliability, probably due to the heterogeneity of transit modes.[15] First, different metrics are suitable for different modes. For infrequent service such as intercity buses and trains, minutes of lateness relative to scheduled arrival time might be an appropriate metric. For frequent service such as peak hour subway service, standard deviation is probably an appropriate basis. Second, trip types vary significantly across modes, so using the same monetary value for all modes is inappropriate. The guidelines above should be used for order-of-magnitude evaluation. Where projects are likely to have a significant impact on transit reliability, or there is likely to be a significant switch to or from transit, we recommend conducting a stated preference survey to establish a value of time for delays.

4.1.3 Value of vehicle operating costs changes

Vehicle operating costs include vehicle depreciation, fuel and oil consumption, tire replacement, and maintenance. For commercial vehicles, the costs include inventory depreciation and logistics costs.

Appendix B provides vehicle operating costs for two classes of automobiles and five classes of trucks, from the Federal Highway Administration's HERS documentation.

4.1.4 Value of change in accidents

Where projects have an impact on human health, the Port Authority recommends using a value of life of $6.1 million in 2009 dollars.[16]

The USDOT ranks injuries on a scale of 1 to 6 and estimates the cost of each injury as a fraction of the value of a statistical life, as shown in Table 5. If the distribution of injury types is known, the cost of an average incident can be estimated.

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[14] Ken Small et al, Valuation of Travel Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation (National Cooperative Highway Research Program Report 431), 1999.

[15] RAND Europe, *The Value of Reliability in Transport* (Dutch Ministry of Transport, 2005), pp. 27-32.

[16] Based on USDOT, "Treatment of the Economic Value of a Statistical Life in Departmental Analyses – 2009 Annual Revision" and adjusted by the change in the Wages and Salaries component of the Employment Cost Index published by the Bureau of Labor Statistics.

Table 5. Abbreviated Injury Scale

AIS Code	Description of Injury	Fraction of VSL
AIS 1	Minor	0.2%
AIS 2	Moderate	1.6%
AIS 3	Serious	5.8%
AIS 4	Severe	18.8%
AIS 5	Critical	76.3%
AIS 6	Fatal	100.0%

Source: US Department of Transportation, 2009.

The Louis Berger Group estimated the average cost of injury accidents (including fatal accidents), based on historical distributions of injuries and fatalities across several years for the entire United States.[17] Table 6 presents these costs, based on a value of life of $6.1 million. Heavy truck accidents have a higher cost than other motor vehicle accidents, because they are more likely to be fatal, and aviation crashes are still more costly as they are much more likely to be fatal. If local data are available on the distribution of injuries for a particular project, they should be used to estimate the cost of accidents based on the value of statistical life and the injury scale given above.

Table 6. Injury Valuation

Incident Type	Economic Cost (2009 dollars)
Value of Statistical Life	$6,100,000
Heavy truck injury accidents	$1,506,000
All other motor vehicle injury accidents	$1,400,000
Aviation injury accidents	$5,354,000

4.1.5 Pavement damage

The Federal Highway Administration has estimated the average damage to federal highways per vehicle mile for several classes of vehicles. Its 1997 *Highway Cost Allocation Study* provides estimated costs for pavement damage (tables V-4 through V-6) and bridge repair (table V-15). The Port Authority may be able to provide data on the damage cost of overweight trucks, based on differential damage rates for the decks of the George Washington Bridge.

[17] The Louis Berger Group, Memo on Value of Life and Damages, for the Port Authority of NY&NJ, 2009.

4.2 Environmental benefits

4.2.1 Air pollution emissions

Muller and Mendelsohn (2007) have estimated the value of air pollution reductions at the county level. We have adjusted those estimates to reflect a uniform value of statistical life, as prescribed by USDOT. Appendix C presents the value of a ton of reductions of each of five pollutants in 2009 dollars for the 17 counties in the Port Authority region.

Cost-benefit analyses should estimate a project's impact on carbon emissions, as it contributes to the agency's carbon emissions reduction goal. However, since the impact of these emissions is global and not regional, a monetary value for these emissions need not be calculated[18]. Similarly, reductions in air pollution that occur outside the region and do not accrue locally, such as from the deployment of more efficient ships or improvements in air traffic patterns, should not be included in this regional analysis.

4.2.2 Environmental costs

Some projects may have an effect on wetlands, open space, or other natural systems. State laws may require the agency to provide compensation by restoring other wetlands or purchasing other land for public use as open space. The analyst should assess the net impact of the project to regional ecological systems, taking into account any compensation in kind.

4.3 Wider economic benefits

Beyond the direct benefits described in the previous sections, transportation investments can provide indirect benefits to the wider regional economy. There is greater uncertainty surrounding estimates of indirect benefits, so it may be appropriate to present cost-benefit results with and without these benefits.

One approach to estimating these benefits is through the use of REMI TranSight, from Regional Economic Models, Inc. While REMI is relatively easy to use, it is difficult to validate the econometric coefficients used in its calculations. Any comprehensive cost-benefit results from REMI should be presented alongside (but separate from) the conventional cost-benefit metrics.

4.3.1 Agglomeration

In certain sectors of the economy, there is some evidence that productivity increases as the travel time between businesses shrinks. The UK Department for Transport has developed models to estimate the relationship between travel time savings and productivity improvements. However, these models do not isolate effects caused by changes in travel time over time. The Transportation Research Board is sponsoring research (Transit Cooperative Research Program H-39) that may develop a more robust model that could be applied to the Port Authority region.

[18] This might change when/if a price of carbon is established by Federal or State legislation.

4.3.2 Supply Chain Logistics Effects

For some businesses, shorter and more reliable travel times may provide an incentive to reorganize supply chains. Such reorganization can provide cost savings that are additional to the direct value of the time savings. For example, businesses may consolidate or relocate warehousing or distribution operations, providing welfare gains beyond those captured by a traditional travel demand model.

Research sponsored by the Federal Highway Administration (FHWA) provides order-of-magnitude estimates of the benefits of supply chain logistics reorganization that are additional to direct travel time and cost savings.[19] The FHWA study estimates these additional benefits of highway-freight improvements to be 15 percent of conventional user benefits. The US Department of Transportation provides similar calculations of the estimated supply chain benefits as a result of highway improvements.[20] Estimated supply chain benefits as a result of a 10 percent transportation improvement as shown in Table 7 were generated based on a sample of real-world industry examples and vary by the type of business. Appendix A of USDOT's Guide suggests a methodology for use on individual projects.

Table 7. Rough Estimate of the Supply Chain Benefit from a 10 Percent Transportation Improvement

Infrastructure Benefit	Supply Chain Impact	Supply Chain Benefit Expressed as % of Operating Costs	Supply Chain Benefit Expressed as % of Transport Costs
10% Transport Cost Reduction	Lower material cost by substituting farther cheaper sources	0.1%	1.5%
	Consolidate plants due to extended reach	0.2%	4.1%
	Switch modes and reduce shipment size, decreasing inventory	0.1%	1.2%
10% Capacity Increase	Less safety stock	0.1%	1.1%
	Rationalization of fleet and warehouse assets	0.01%	0.3%
Secondary Effects	Increasing service levels	Not quantified	Not quantified
	Converting cost savings into price reductions	Not quantified	Not quantified
	On-Demand supply chains	Not quantified	Not quantified
Total		0.5%	8.2%

Source: Boston Logistics Group, Inc., in USDOT (2006).

[19] *FHWA Freight BCA Study: Summary of Phase II Results*, January 2004, http://ops.fhwa.dot.gov/freight_analysis/bca_study_phase2/index.htm

[20] *Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects*, for US Department of Transportation, August 2006, http://www.dot.gov/freight/guide061018/index.htm

4.4 Distributional effects

Beyond the calculation of net regional benefits, cost-benefit analysis should consider the distribution of costs and benefits. In particular, the analysis should identify groups among which costs and benefits will be particularly concentrated. For example, a freight village project could reduce region-wide air pollution emissions but increase truck traffic and associated impacts in a particular neighborhood.

Appendix A – Bibliography

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Appendix B – Tables of Benefits

The benefits listed on the following pages are divided into tables corresponding to the type of infrastructure: general, road, bus terminal, rail transit, aviation, rail freight, and marine. The leftmost column lists types of projects, and the next column lists typical benefits of such projects. The third column suggests the units in which these benefits can be measured, and the fourth identifies the method for valuing these benefits. Section 4 above and the accompanying spreadsheets provide monetary values for benefits marked "Internal" in the last column. The valuation of other benefits will be developed by the CBA project team (the consultant in the case of a consultant CBA).

In some cases, a project will generate benefits or costs that are listed in more than one table. For example, most of the benefits for a marine terminal project are listed in the Maritime table; but to the extent the project affects road congestion, the Roadway table should also be consulted.

For benefits marked "Internal" in the Source of Value Data, we are providing monetary values. For benefits marked "External," the consultant will propose methods for valuing the cost or benefit.
For Impacts marked "Not core," the Agency does not require a quantitative measure of cost or benefit. Consultants should instead provide a qualitative assessment.

Project Type: Aviation

Aviation: Airside	Typical Impacts	Measurement Unit	Valuation	Source of Value Data
Capacity				
New, Expanded / Exteneded, Rehabilited runway, taxiway, taxilane (airside pavement)	Reduced Air Passenger Travel Time	Travel Time	Air Passenger Value of Time	Business Travel:100% of wage rate; Personal Travel: 70%
	Reduced Aircraft Delay Hours	Opportunity cost of delays. Cost of resources allocated to cover potential delays	Hourly aircraft operating cost by Aircraft type and type of activity (in flight, gate time; taxing).	Aviation
Redundiancy, power supply cross connection	Reduced Air Cargo Travel Time	Cargo Travel Time	Air Cargo Value of Time	External*
	Labor cost reduction (pilots, flight crew, other aviation related labor costs)	Labor cost savings	Hourly labor costs by aviation related occupation	Internal**
Airside support equipment (snow removal, etc.)	Reduced facility maintenance costs	Maintenance cost savings	Facility maintenance cost	External*
	Reduction of Aircraft Emissions: Emissions and Dispersion Modeling System (EDMS)	Aircraft emissions reduction - per ton of pollutant	Per ton polluntant cost (airport/aircraft pollutants different from vehicle?)	Airport/Aircraft emissions Cost Table
Accommodation of larger planes; more efficient aircrafts	Reduction of Aircraft Noise	The Integrated Noise Model (INM) as required by FAA. Regions unacceptably impacted - number of residences that are must be purcahsed or modified	Cost of avoided purchase or modification (control cost). Ideally would use willingness to pay (WTP) - damage cost. Noise Depreciation Index for housing.	External*
	Safety Improvements	Reduced fatalities, injuries, damage per approach	Accident Cost (air relted fatalities)	Value of Life range
Noise reduction for infrastructure (insulation, structure removal)	Avoided costs (loss of benefits) associated with facility failure/shutdown	Reduced delay time and missed flights/connections	External*	
Next generation navigational aids and commuinication systems				

Project Type: Aviation

Aviation: Airside	Typical Impacts	Measurement Unit	Valuation	Source of Value Data
Safety/Security/Design				
Improved signage and lighting on runway	Reduction in replacement/restoration costs of destroyed/damaged aircrafts and their parts	Aircraft restoration costs	Average Aircraft replacement/restoration cost	External*
Runway safety area expansion	Safety Improvements	Reduced fatalities, injuries, damage per approach	Accident and Value of Life costs	Value of Life range.
Bird hazard mitigation	Aviod and reduce bird strikes	Reduction in bird strikes	Cost of plane aircraft diversions and returns resulting from bird strikes	Aviation

Aviation: Airside	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Environmental				
Fuel and chemical containment	Reduced mitigation/remediation costs	Mitigation/Remediation cost savings	External*	
Hydrant fueling systems Radiant deicing facility	**Reduce freight traffic and resulting congestion on roadways:**			
	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Damage per VMT of truck or bus	TBD
	- Noise	Not core: does not require quantitative evaluation		

Project Type: Aviation

Aviation: ATB	Typical Impacts	Measurement Unit	Valuation	Source of Value Data
Capacity				
ATB expansion, modernization, reconstruction	More gates and faster transfers reduces aircraft, passenger and cargo delays	Travel Time Savings	Air Passenger/Cargo Value of Time	Internal**: Passenger VOT External*: Cargo VOT
	Improved passenger schedule predictability	Delay/Wait Time	Value of Delay/Wait Time	Value of Time while waiting (100% of wage rate - might be more for aviation)
	Lower operating and maintenance costs	Operating cost savings	Operating costs (building, building systems, and equipment)	Aviation
	Improved customer comfort and satisfaction	Satisfaction Rate and rankings of amenities as reported in PANYNJ passenger surveys	Not core***: does not require quantitative evaluation	

Aviation: ATB	Typical Impacts	Measurement Unit	Valuation	Source of Value Data
Security				
Enhanced security systems for baggage, cargo, and passengers	Faster, more efficient screening	Travel Time Savings	Air Passenger Value of Time	Business Travel:100% of wage rate; Personal Travel: 70%
Security fencing, bollards, gates, and walls	Improved security: lower probabilities of security breaches and attacks	Prevention of lives lost and injury.	Value of life and injury. OEMT threat assessment and ranking	Value of Life range
Advanced security screening technologies	Avoided costs (loss of benefits) associated with facility shutdown	External*		

Project Type: Aviation

Aviation: ATB	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Interterminal Transportation				
Investment in rail or bus inter-terminal transportation.	Reduced Air Passenger Travel Time	Travel Time	Air Passenger Value of Time	Business Travel:100% of wage rate; Personal Travel: 70%
	Reduced Air Cargo Travel Time	Cargo Travel Time	Air Cargo Value of Time	External*
	Lower maintenance and operating costs	Operating cost savings	Inter-terminal transportation operating costs	External*
	Improved passenger comfort and satisfaction	Satisfaction Rate	Not core***: does not require quantitative evaluation	

Project Type: Aviation

Aviation: Landside	Typical Impacts	Measurement Unit	Valuation	Source of Value Data
Access to Airport				
	Encourage mode switch - increase transit ridership			
Improved airport access roads and transit options	**Reduce/increase congestion on roadways; Change incident response time; Change number of incidents; Change mode share; Change vehicle occupancy rate;**			
	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Business Travel:100% of wage rate; Personal Travel: 70%
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
Improvements in passenger drop-off/pick-up and transit areas	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range.
	- Roadway wear and tear	Heavy vehicle VMT	Damage per VMT of truck or bus	TBD
	- Noise		Not core***: does not require quantitative evaluation	
	Improved schedule predictability and travel time to airport	Delay/Wait Time	Value of Delay/Wait Time	Value of Time while waiting (100% of wage rate - might be more for aviation)
	Lower operating and maintenance costs	Operating cost savings	Road/Transit operating and maintenance costs	External*

Project Type: Rail Transit

Transit: Capacity	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Infrastructure:				
	Increased frequency of service and destination choices:			
New or Expanded Passenger Rail Tunnels	Passenger Travel Time	Passenger Travel Time	Value of Time	Transit Value of Time
	Reliability	Delay/Wait Time	Value of Delay/Wait Time	Transit Value of Time while waiting (100% of wage rate) - range
New or Expanded Station	Encourage mode switch - increase transit ridership	Ridership forecasts	Not core: does not require quantitative evaluation	
	Less wait/walk for connections to destination	Wait/Walk Time	Value of Wait/Walk Time	Transit Value of Time while waiting/walking (100% of wage rate) - range
Enhanced and/ or additional Railcars	Added desirabilty of nearby locations	Incremental change in Rental Rates and Real Estate values - (???)	Square foot price of apartment/office rental?	External PA Development
	Reduce Congestion on Roadways:			
Additional Service	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
Providing connections with other services and routes	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range.
Signaling and Track upgrades: increased capacity by reducing headway	- Noise	Not core: does not require quantitative evaluation		
	Parking Cost savings	Reduced automobiles that park	Average Parking Costs	Looking into this impact as an added benefit
	Equity - Environmental Justice	Providing mobility to people who are economically, socially, and physically disadvantaged	External	
	Railway emissions: mobile and stationary	Emissions per passenger mile	External	
	Loss of open space	Value of property surrounding open spaces (urban parks, greenbelts, water bodies, etc.)	Not core: does not require quantitative evaluation	
	Removal of Wetlands	Property value of wetlands or enhancement value	Per acre property value	External
	Noise reduction	Railroad noise levels	External	
	Reduced facility disruptions and/or duration and extent of disruption	Number, duration; and extent of disruption in service or facility shut down	External	

Project Type: Rail Transit

Transit: Reconstruction, Rehabilitation and Restoration	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
System Enhancement				
Fuel effiecient train cars	Reduce emissions	Fuel Reduction effect on emissions	Control cost per ton of polluntant.	Internal: PATH
	Power use efficiency and reduction	Reduction of BTUs	Cost of Electricity	Internal: PATH
Regeneration of power/electricity	Decrease stopage and service delays.	Delay Time; Time out of commission	Facility disruption costs	External
	Streamlined and more reliable transfers may induce increased use of service	External		
Transit Center Network and Timed Transfer: synchronization of service				

Transit: Facility Improvements	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Bike Stations	**Encourage mode switch - increase transit ridership**			
Park-and-Ride	**Reduce Congestion on Roadways:**			
Bus Stations/Stops	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
Waiting shelter	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range.
	- Noise		Not core: does not require quantitative evaluation	
	Reliability	Delay/Wait Time	Value of Delay/Wait Time	Transit Value of Time while waiting (100% of wage rate) - range
	Customer satisfaction and value	Satisfaction Rate	Not core: does not require quantitative evaluation	

Transit: Electronic Innovations	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Information Sharing Systems	Better decision of mode and destination choice	Time spent waiting	Delay Time	Transit Value of Time while waiting
Electronic Fare Cards	Less time spent at turnstyle and station and more convenience for frequent riders	Time spent adding money to cards at stati	Delay Time	Transit Value of Time while waiting

Project Type: Freight-Rail

Freight Rail: Capacity	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
New/Extended Freight Rail Lines	**Reduce freight traffic and resulting congestion on roadways:**			
	- Travel Time saving	Vehicle Hours Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
New/Upgraded Rail Bridge/Tunnel	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
Reopen/Refurbish Preexisting Rail Lines	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Damage per VMT of truck or bus	TBD
	- Noise	Not core: does not require quantitative evaluation		
Upgrade Tracks (speed/weight)	Reduce unpredictability from Congestion on Railways (Transit and Freight)	Delay Time	VOT for freight/passenger: - crew wages - operating cost mph	External
	Rail Safety	Accidents	Cost of Delay, Cost of repair	External
Upgrade/Eliminate grade crossing	Reliability	Standard deviation in delay time	Delay Time variation	External
	Rail Travel Time	Speed	VOT for freight/passenger: - crew wages - operating cost mph	External
	Reduced Transportation Cost from switch to rail	Transportation Costs	Differential of explicit operating cost per unit (exclude implicity VOT/VOC savings)	External
	Warehouse Utilization and Brownfield Development	Not core: does not require quantitative evaluation		
	Competitive access to new markets from increased logistical efficiencies and opportunity to streamline operations	Wider Economic Benefit - External		
	Loss of open space	Value of property surrounding open spaces (urban parks, greenbelts, water bodies, etc.)	Not core: does not require quantitative evaluation	
	Removal of Wetlands	Property value of wetlands or Enhancement value	Per acre property value	External
	Noise and Vibration from train and train operations	External		

Project Type: Freight-Rail

Freight Rail: Connectivity/Supply Chain	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Freight Yards	**Reduce freight traffic and resulting congestion on roadways:**			
	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
Intermodal/Inland/Satelite Port terminal/facility or Intermodal Rail	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Control cost per ton of polluntant - convert to per VMT	Emissions Cost Table
Infromation Systems - scheduling/cargo visibilty	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Noise	Not core: does not require quantitative evaluation		
Track alignments	Reduced Transportation Cost from switch to rail	Transportation Costs	Differential of explicit operating cost per unit (exclude implicity VOT/VOC savings)	External
	Reliability	Standard deviation in delay time	Delay Time variation	External
Signalization/Electronic Control	Rail Travel Time	Speed	Travel Time	External
	Reduce unpredictability from Congestion on Railways (Transit and Freight)	Delay Time	VOT for freight/passenger: - crew wages - operating cost mph	External
Supply Chain benefits: lower cost to supply resources, consolidation of faclities (greater market reach), reduction in inventory through smaller order quantities.	Increased throughput and delivery speed by reducing congestion at the Port	Delay Time at port (cargo dwell time)	Cost per unit per hour	External
	Warehouse Utilization and Brownfield Development	Not core: does not require quantitative evaluation		

Notes: Consider long haul and short haul rail and how the impacts will differ
Additional volume from new rail will increase market share but not necessarily take away from truck market share
Trucks are more competitive with short haul than long haul rail

Project Type: **Maritime**

Maritime Projects: Waterway	Typical Benefits and Costs	Measurement Unit	Valuation	Source of Value Data
Navigable waterway improvement Channel deepening Air draft improvement	Increased maneuverability and reduced travel time Can operate at low tide Can operate at higher speeds	Hours of travel time	Account for vessel operating cost and value of cargo	External
		Reduction in vessel emissions; Coast Guard may have data on ships idling at anchorage outside harbor	Damage cost per ton of pollutant	Internal
	Increased loads for existing vessels Accommodation of larger vessels	Reduction in transport and handling cost per unit cargo volume		External
		Reduced emissions per unit cargo volume	Damage cost per ton of pollutant	Internal
	Diversion of traffic from less efficient routes			
	Reduced costs for diverted cargo	(Half of) reduction in transport and handling cost per unit cargo volume		External
	External costs of new marine, road, and rail traffic	Pollution emissions from new vessel traffic	Damage cost per ton of pollutant	Internal
		For road traffic, see road sheet		
		For rail traffic, see rail sheet		
	Wider economic benefits, such as unlocking brownfields for warehouse development	E.g., industrial rents		External
	Supply chain benefits: wholesale cost savings induce a change in production inputs	Cost savings from substitution of inputs		External
	Damaged or enhanced wetlands or wildlife habitat	Acres of wetlands	Per acre value	External
	Fewer groundings or allisions	Reduction in rate of groundings or allisions	Insurance rate differential	External. E.g., estimate Bayonne Bridge effect by consulting insurers on differential in premium between Bklyn/Port Jersey and Port Newark/Elizabeth

Project Type: Maritime

Maritime Projects - Terminal	Typical Benefits and Costs	Measurement Unit	Valuation	Source of Value Data
New terminal Increased lift capacity Increased terminal storage capacity Increased gate capacity Increased yard productivity ***Operational improvements*** ITS, scheduling, cargo visibility, e.g. RFID Hours of operation Correct design deficiencies Improve operational design, e.g. chassis pool, virtual container yard	Increased throughput and delivery speed	Reduction in transport and handling cost per unit cargo volume		External
		Reduced costs of holding cargo at terminal (dwell time)		External
	Reduced dwell time for ship in port	Reduction in transport cost per unit cargo volume		External
		Reduced emissions per unit cargo volume	Damage cost per ton of pollutant	Internal
	Diversion of traffic from less efficient routes			
	Reduced costs for diverted cargo	(Half of) reduction in transport and handling cost per unit cargo volume		External
	External costs of new marine, road, and rail traffic	Pollution emissions from new vessel traffic	Damage cost per ton of pollutant	Internal
		For road traffic, see road sheet		
		For rail traffic, see rail sheet		
	Wider economic benefits, such as unlocking brownfields for warehouse development	E.g., industrial rents		External
	Supply chain benefits: wholesale cost savings induce a change in production inputs	Cost savings from substitution of inputs		External
	Faster truck operations Reduced VMT Increased reliability Reduced congestion and pollution	For road traffic, see road sheet		
		For rail traffic, see rail sheet		
	Damaged or enhanced wetlands or wildlife habitat	Acres of wetlands	Per acre value	External

Project Type: Maritime

Maritime Projects - Connectivity	Typical Benefits and Costs	Measurement Unit	Valuation	Source of Value Data
Improved intermodal connectors On-dock/near-dock rail Local freight distribution centers	Reduced congestion	For road traffic, see road sheet		
		For rail traffic, see rail sheet		
	Increased reliability	Reduced logistics costs		Internal
	Reduced truck VMT	Reduction in vehicle operating costs and emissions, net of any increase in rail operating costs and emissions		Internal

Project Type: Road

Roadway: Capacity	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Infrastructure:				
New or Expanded Roadway/Bridge Safety Improvements Enhanced Design Standards Bike Lanes Pedestrian Access Construction of HOV/HOT/transit lanes: change in mode share and vehicle occupany Reprogramming existing capacity, e.g., convert multipurpose lanes to managed use; change use of shoulders; accelerator ramps; pedestrian access	**Reduce/increase congestion on roadways; Change incident response time;**			
	- Travel Time saving	Vehicle Hours Traveled	Passenger/Truck Value of Time	Auto Passenger/Bus Passenger/Truck Driver and Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
	- Accident reduction savings (primary and secondary)	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Damage per VMT of truck or bus	TBD
	- Noise		Not core: does not require quantitative evaluation	
	Bike Rider Safety	Bike accidents involving vehicles on roadway	Not core: does not require quantitative evaluation	
	Reduce Crash Rates and resulting vehicular delays	Crash rate per VMT (external valuation). Reduction in nonrecurrent delays from accidents.	Accident Costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	Environmental impacts of changed land use, e.g. ecological impacts,	Enhancement value - value of property surrounding open	Not core: does not require quantitative evaluation	

Project Type: Road

Roadway: Reconstruction, Rehabilitation and Restoration

System Enhancement	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Reengineering of Traffic Flow Reconfigure alignment to reduce trip length Reversible/Removable Lanes	**Reduce/increase congestion on roadways;** **Change incident response time;**			
	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Maintenance cost per VMT	TBD
	- Noise		Not core: does not require quantitative evaluation	

Roadway: Electronic Innovations	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Advanced Traveler Management Systems	**Reduce/increase congestion on roadways;**			
Itinerary Planning and Route Selection Diversion: change in mode share	- Travel Time saving	Vehicle Hours Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
Electronic Tolling	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Maintenance cost per VMT	TBD
	- Noise		Not core: does not require quantitative evaluation	
	Reliability	Reduction in buffer time added to travel	Wait Time	Value of Wait Time
	Reduced Transaction Time			External

Project Type: Bus Terminal

Bus Terminal: Capacity and Facility Improvements	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Infrastructure:				
Terminal expansion, modernization, reconstruction	**Reduce/increase congestion on roadways; Reduce auto ownership and use for other trips:**			
	- Travel Time saving	Vehicle Hours Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
Added Gate Capacity	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings (net of increased bus emissions)	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
Pedestrian Circulation Improvements	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Parking cost savings			
Access Improvements	- Noise		Not core: does not require quantitative evaluation	
	More gates and faster transfers reduces bus and passenger delays	Passenger Hours Traveled	Value of Time for Travel or Waiting	Internal**: Passenger VOT External*: Bus VOT
New/Expanded Bus Parking	Reduce travel time for existing riders	Passenger Hours Traveled	Value of Time for Travel or Waiting	Passenger Value of Time
	Reduce walk time in terminal	Passenger Hours Traveled	Value of Time for Walk to Transit	Passenger VOT
Improved Signage	Improved passenger schedule predictability	Delay/Wait Time	Value of Delay/Wait Time	Value of Time while waiting (100% of wage rate - might be more for aviation)
	Lower operating and maintenance costs	Operating cost savings	Operating costs (building, building systems, and equipment)	TB&T
ADA compliance	Improved customer comfort and satisfaction	Satisfaction Rate and rankings of amenities as reported in PANYNJ passenger surveys	Not core***: does not require quantitative evaluation	
	Increase roadway wear & tear from buses	Heavy vehicle VMT	Damage per bus VMT	TBD
Build redundancy	Improve speed of evacuation	Risk of major loss of life	Risk assessment; Value of Life	
	Increase desirabilty of nearby locations (must avoid double counting)	Incremental change in Rental Rates and Real Estate values - (???)	Square foot price of apartment/office rental?	External PA Development
	Greater equity - environmental justice	Providing mobility to people who are economically, socially, and physically disadvantaged	External	
	Improve security: reduce probability of security breaches and attacks	Prevention of lives lost and injury.	Risk assessment; Value of Life	Value of Life range
	Reduce facility disruptions and/or duration and extent of disruption	Number, duration; and extent of disruption in service or facility shut down	External	External
			Avoided costs (loss of benefits) associated with facility shutdown	External

Project Type: Bus Terminal

Bus Terminal: Electronic Innovations	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Information sharing systems	Increase mode share, with benefits as above	See above		
	Reduce passenger wait time	Hours of waiting time	Value of Time for Waiting	
	Reduce cost of waiting	Hours of waiting time	Willingness to pay for greater certainty of travel time	TBD
	Reduce traveler confusion	Qualitative	Not core: does not require quantitative evaluation	

Project Type: **General**

Construction Impacts	Typical Benefit Types	Measurement Unit	Valuation	Source of Value Data
Divert or delay traffic during construction	**Increase congestion on roadways:**			
	- Travel Time saving	Vehicle Miles Traveled	Passenger/Truck Value of Time	Passenger/Freight Value of Time Table
	- Vehicle Operating Cost savings	Vehicle Hours Traveled	VOC per mile	VOC Table
	- Environmental Cost savings	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
	- Accident reduction savings	Vehicle Miles Traveled	Accident and Value of Life costs	Value of Life range. Consider freight specific costs in regards to property damage costs.
	- Roadway wear and tear	Heavy vehicle VMT	Damage per VMT of truck or bus	TBD
	- Noise		Not core: does not require quantitative evaluation	
Use construction machinery	Emissions from construction machinery	Emissions	Damage cost per ton of pollutant	Emissions Cost Table
	Noise from construction machinery		Not core: does not require quantitative evaluation	

Appendix C – Monetary Values

The tables on the following pages provide monetary values for time savings, vehicle operating costs, air pollution reductions, and fatalities, all adjusted for inflation.

Port Authority Regional Cost Benefit Analysis Framework
Benefit Valuations

Regional Value of Time

Item	Base value	Base year	Inflator	2009 value	Source
Mean wage	$ 26.08	2009	RW	$ 26.08	BLS, Occupational Employment Statistics, May 2009
Mean cost to employer	$ 32.04	2009	RW	$ 32.04	Includes benefits, from BLS Employer Cost of Comp
Air Travel					
Mean air traveler wage, EWR	$ 32.00	2005	RW	$ 36.57	Berger CBA framework, based on PA air traveler sur
Mean air traveler wage, JFK	$ 28.00	2005	RW	$ 32.00	Berger CBA framework, based on PA air traveler sur
Mean air traveler wage, LGA	$ 31.00	2005	RW	$ 35.43	Berger CBA framework, based on PA air traveler sur
Mean air traveler wage, overall	$ 30.00	2005	RW	$ 34.28	Berger CBA framework, based on PA air traveler sur
Mean air traveler cost to employer, EWR	$ 39.31	2005	RW	$ 44.92	Includes benefits, from BLS Employer Cost of Comp
Mean air traveler cost to employer, JFK	$ 34.39	2005	RW	$ 39.30	Includes benefits, from BLS Employer Cost of Comp
Mean air traveler cost to employer, LGA	$ 38.08	2005	RW	$ 43.52	Includes benefits, from BLS Employer Cost of Comp
Mean air traveler cost to employer, overall	$ 36.85	2005	RW	$ 42.11	Includes benefits, from BLS Employer Cost of Comp
Mean air traveler wage, personal travel (national)	$ 33.30	2000	NW	$ 39.48	USDOT, 2003, Value of Time
Mean cost to employer, business travel (national)	$ 40.10	2000	NW	$ 47.54	USDOT, 2003, Value of Time

Port Authority Regional Cost Benefit Analysis Framework
Benefit Valuations

Vehicle Operating Costs
Source: HERS-ST Documentation (2002), via HDR

In Source Year Dollars

Data:	Fuel Cost	Tire Cost	Repair and Maint Cost	Vehicle Depreciable Value	Oil Cost
Units:	$ per gallon	$ per tire	average cost per vehicle per 1000 miles	average depreciable cost per vehicle	$ per quart (includes the labor charge for changing the oil)
4-Tire Truck	*Recommend pulling curent fuel prices for gasoline and diesel from AAA fuel gauge.*	$ 78.80	$ 129.80	$ 23,028.00	$ 3.57
6-Tire Truck		$ 190.10	$ 242.90	$ 34,410.00	$ 1.43
3-4 Axle Truck		$ 470.70	$ 343.50	$ 75,702.00	$ 1.43
4-Axle Comb.		$ 470.70	$ 355.80	$ 87,690.00	$ 1.43
5-Axle Comb.		$ 470.70	$ 355.80	$ 95,349.00	$ 1.43
Small Automobile		$ 45.20	$ 84.10	$ 18,117.00	$ 3.57
Med/Lg Automobile		$ 71.50	$ 102.10	$ 21,369.00	$ 3.57
Source:	http://www.fuelgaugereport.com/	HERS Technical Report, 2002	HERS Technical Report, 2002	HERS Technical Report, 2002	HERS Technical Report, 2002
Dollar Year	n/a	1997	1997	1997	1997
Relevant CPI	n/a	BLS Series CUUR0000SETC01	BLS Series CUUR0000SETD	BLS Series CUUR0000SS45021	BLS Series CUUR0000SS47021

Inflated to 2009 Dollars

Data:	Fuel Cost	Tire Cost	Repair and Maint Cost	Vehicle Depreciable Value	Oil Cost
Units:	$ per gallon	$ per tire	average cost per vehicle per 1000 miles	average depreciable cost per vehicle	$ per quart (includes the labor charge for changing the oil)
4-Tire Truck	*Recommend pulling curent fuel prices for gasoline and diesel from AAA fuel gauge.*	$ 95.08	$ 194.13	$ 21,117.62	$ 7.98
6-Tire Truck		$ 229.36	$ 363.29	$ 31,555.38	$ 3.19
3-4 Axle Truck		$ 567.92	$ 513.74	$ 69,421.83	$ 3.19
4-Axle Comb.		$ 567.92	$ 532.14	$ 80,415.32	$ 3.19
5-Axle Comb.		$ 567.92	$ 532.14	$ 87,438.94	$ 3.19
Small Automobile		$ 54.54	$ 125.78	$ 16,614.03	$ 7.98
Med/Lg Automobile		$ 86.27	$ 152.70	$ 19,596.25	$ 7.98
Source:	http://www.fuelgaugereport.com/	HERS 2002 Tech Manual	HERS 2002 Tech Manual	HERS 2002 Tech Manual	HERS 2002 Tech Manual
Dollar Year	n/a	inflated to 2009	inflated to 2009	inflated to 2009	inflated to 2009
Relevant CPI	n/a	BLS Series CUUR0000SETC01	BLS Series CUUR0000SETD	BLS Series CUUR0000SS45021	BLS Series CUUR0000SS47021

Port Authority Regional Cost Benefit Analysis Framework
Benefit Valuations

Value of Air Pollution Reduction

Source: Nicholas Z. Muller and Robert Mendelsohn, Measuring the Damages of Air Pollution in the U

Values are adjusted as follows:
M&M's county-level estimates are based on a uniform value of statistical life (VSL) of $2.0 million (in 2000 dollars). We use a uniform VSL of $5.8 million (in 2007 dollars). M&M also estimated national gross annual damage reduction for each pollutant from the Clean Air Act for both their baseline valuation of $2.0 million and for USEPA's valuation of $6.2 million. We assume linear growth between the two valuations to determine damages for USDOT's intermediate VSL, and apply this growth factor to the county-level estimates. Finally, we adjust for inflation.

Adjustment for statistical value of life ($millions)

M&M baseline VSL	$2.0	2000	NCPI	$2.5
USEPA VSL	$6.2	2000	NCPI	$7.7
USDOT VSL	$5.8	2007	NCPI	$6.0
Percent that USDOT-M&M baseline is of USEPA-M&M baseline				67%

National Gross Annual Damages (billions of 2000 $)

	Particulate Matter (PM25)	**Particulate Matter (PM10)**	**Nitrogen Oxides (NOx)**	**Ammonia (NH3)**	**Sulfur Dioxide (SO2)**	**Volatile Organic Compounds (VOC)**
M&M baseline	$28.3	$9.1	$5.8	$16.4	$32.0	$19.3
EPA method	$71.4	$11.9	$26.3	$41.3	$80.5	$45.2
EPA method with USDOT VSL	$57.2	$11.0	$19.5	$33.1	$64.5	$36.7
Adjustment factor	2.02	1.21	3.37	2.02	2.02	1.90

M&M Reported Marginal Benefits Per Ton, using $2.0 million VSL, in 2000 $

County	FIPS	PM25	PM10	NOX	NH3	SO2	VOC
Bronx County	36005	55,740	5,875	2,603	24,557	12,505	5,730
Kings County	36047	119,999	14,206	3,656	15,003	25,988	12,402
Nassau County	36059	87,629	8,820	3,237	57,467	19,795	8,958
New York County	36061	69,486	7,380	3,047	17,081	15,898	7,112
Queens County	36081	162,056	18,557	3,933	23,301	34,020	16,674
Richmond County	36085	36,740	4,180	2,025	11,238	9,140	3,828
Rockland County	36087	25,937	2,844	2,188	13,224	8,502	2,702
Suffolk County	36103	10,722	1,012	590	20,060	3,353	1,126
Westchester County	36119	33,472	3,574	1,206	29,472	9,054	3,469
Bergen County	34003	113,923	12,413	6,113	13,928	26,252	11,766
Essex County	34013	75,398	8,599	4,154	11,377	17,117	7,849
Hudson County	34017	85,328	9,593	4,823	13,278	18,707	8,788
Middlesex County	34023	40,248	4,536	2,420	19,460	10,790	4,227
Morris County	34027	38,009	4,035	2,356	19,908	11,391	3,956
Passaic County	34031	49,881	5,175	3,272	11,668	12,329	5,177
Somerset County	34035	31,701	3,476	2,269	10,820	9,902	3,323
Union County	34039	57,807	6,320	3,159	10,985	14,138	5,993

Marginal Benefits adjusted for USDOT's $6.2 million VSL, 2000 $

County	FIPS						
Bronx County	36005	112,676	7,088	8,774	49,563	25,217	10,887
Kings County	36047	242,575	17,138	12,324	30,281	52,405	23,565
Nassau County	36059	177,139	10,640	10,909	115,988	39,916	17,020
New York County	36061	140,464	8,903	10,270	34,474	32,059	13,514
Queens County	36081	327,591	22,387	13,257	47,029	68,602	31,682
Richmond County	36085	74,269	5,043	6,826	22,683	18,430	7,274
Rockland County	36087	52,431	3,431	7,375	26,691	17,144	5,134
Suffolk County	36103	21,674	1,221	1,990	40,487	6,762	2,140
Westchester County	36119	67,662	4,311	4,065	59,484	18,258	6,591
Bergen County	34003	230,291	14,975	20,604	28,110	52,939	22,356
Essex County	34013	152,414	10,373	14,000	22,962	34,516	14,913
Hudson County	34017	172,487	11,572	16,257	26,800	37,723	16,697
Middlesex County	34023	81,360	5,472	8,156	39,276	21,758	8,031
Morris County	34027	76,833	4,867	7,941	40,181	22,970	7,516
Passaic County	34031	100,832	6,243	11,027	23,550	24,861	9,837
Somerset County	34035	64,083	4,193	7,648	21,838	19,969	6,314
Union County	34039	116,855	7,624	10,646	22,172	28,511	11,386

Marginal Benefits adjusted to 2009 $

County	FIPS						
Bronx County	36005	146,201	9,196	11,385	64,310	32,720	14,127
Kings County	36047	314,749	22,237	15,991	39,291	67,997	30,576
Nassau County	36059	229,844	13,806	14,155	150,498	51,793	22,084
New York County	36061	182,257	11,552	13,325	44,732	41,598	17,535
Queens County	36081	425,061	29,047	17,201	61,022	89,014	41,109
Richmond County	36085	96,366	6,543	8,857	29,432	23,914	9,439
Rockland County	36087	68,031	4,452	9,569	34,632	22,245	6,662
Suffolk County	36103	28,122	1,585	2,582	52,534	8,774	2,776
Westchester County	36119	87,794	5,594	5,275	77,182	23,690	8,552
Bergen County	34003	298,810	19,430	26,735	36,474	68,690	29,008
Essex County	34013	197,762	13,460	18,166	29,794	44,786	19,350
Hudson County	34017	223,808	15,015	21,094	34,774	48,947	21,665
Middlesex County	34023	105,567	7,100	10,582	50,962	28,232	10,420
Morris County	34027	99,694	6,316	10,303	52,136	29,804	9,753
Passaic County	34031	130,833	8,100	14,308	30,557	32,258	12,764
Somerset County	34035	83,149	5,441	9,924	28,335	25,910	8,193
Union County	34039	151,623	9,893	13,814	28,769	36,994	14,774

Port Authority Regional Cost Benefit Analysis Framework
Benefit Valuations

Safety

Item	Value	Year	Inflator	2009 Value
Value of Statistical Life ($millions)	$5,800,000	2007	NWS	$6,081,754
Heavy truck injury accidents	$1,436,203	2007	NWS	$1,505,971
All other motor vehicle injury accidents	$1,335,489	2007	NWS	$1,400,365
Aviation injury accidents	$5,106,171	2007	NWS	$5,354,220

Note that USDOT issued guidance in 2008, but base year value appears to be in 2007 dollars.