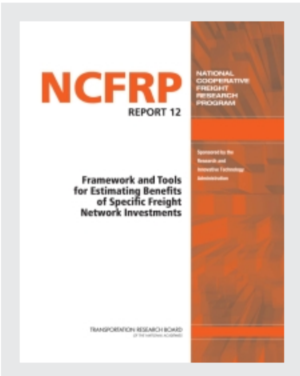

Framework and Tools for Estimating Benefits of Specific Freight Network Investments

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Transportation Research Board

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 12

Framework and Tools for Estimating Benefits of Specific Freight Network Investments

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Research and Innovative Technology Administration (RITA) under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between RITA and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

Program guidance is provided by an Oversight Committee comprised of a representative cross section of freight stakeholders appointed by the National Research Council of The National Academies. The NCFRP Oversight Committee meets annually to formulate the research program by identifying the highest priority projects and defining funding levels and expected products. Research problem statements recommending research needs for consideration by the Oversight Committee are solicited annually, but may be submitted to TRB at any time. Each selected project is assigned to a panel, appointed by TRB, which provides technical guidance and counsel throughout the life of the project. Heavy emphasis is placed on including members representing the intended users of the research products.

The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.

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The project that is the subject of this report was a part of the National Cooperative Freight Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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FOREWORD

By William C. Rogers
Staff Officer
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NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments provides a comprehensive analytical framework and related tools that private-sector freight transportation modes and public-sector transportation interests can use to estimate private and public benefits to evaluate potential freight infrastructure investments. Using interviews with transportation planners and an extensive review of prior research and a review of current methods used to assess freight benefits or prioritize improvement projects, the research developed a freight evaluation framework with three main functions: (1) to enhance public planning and decision-making processes regarding freight; (2) to supplement benefit/cost assessment with distributional impact measures; and (3) to advance public-private cooperation. The framework is capable of handling projects that span all of the different modes and able to assess benefits from a variety of project types, including those that improve freight operations, as well as generate more capacity through infrastructure expansion. The research, by developing a practical set of formats for information collection, will support public-private agency discussions by helping all parties understand the wide range of perspectives and interests in potential freight investments.

The existing transportation network is straining under the volume of freight moving through it, and those volumes are predicted to keep growing. In addition, capital investments, whether for timely maintenance or new constructions, have not kept pace with freight demand. Investment decisions affecting the future of efficient freight movement have been hindered by the absence of analytical frameworks, tools, and data of sufficient quality and detail to be credibly used to estimate benefits and impacts, and to assess attendant risks. In addition, significant capital investment is needed to improve the efficiency and productivity of freight movement. However, investment funds are scarce, and for many freight infrastructure investments, costs are borne and benefits are enjoyed locally and nationally by both the public and private sector. Because of this complex interrelationship, a new, consistent, and usable analytic framework is necessary to guide and focus these multi-dimensional investment decisions.

Under NCFRP Project 5, Cambridge Systematics was asked to fill a critical gap in the resources available to freight planning and investment decisionmakers, both public and private, by providing an integrated analytical approach for supporting and evaluating complex freight investment decisions. The framework that was developed allows stakeholders to evaluate potential benefits of highway, rail, seaport, and intermodal connector projects on a common basis using existing data and analytical tools in a manner that is consistent with existing decision-making processes of different stakeholders.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

Framework and Tools for Estimating Benefits of Specific Freight Network Investments

Introduction and Background

Over the last several years, freight planning and investment activities have evolved considerably. The previous 10 to 15 years saw states and metropolitan planning organizations (MPOs) undertaking efforts to learn about freight movements, freight stakeholders, and freight impacts and to more explicitly incorporate freight-related issues within existing transportation planning and programming activities. As a result, these public-sector agencies are now more aware of how freight movements impact the condition and performance of their systems and how improving freight efficiency can impact business attraction and retention efforts, regional and state economies, and quality of life.

Now, many states and MPOs have moved beyond the planning stage and are interested in how to address freight-specific needs and implement improvement projects. These agencies are considering where and how it makes sense to invest public dollars in freight improvement projects, who should be involved, and how risks and rewards should be allocated. Attitudes and activities among private-sector freight investment decisionmakers have evolved, as well. Railroads, for instance, have shown a willingness to partner with public-sector entities to make system investments that have demonstrable public and private benefits. In addition, there is increasing interest by private infrastructure developers and concessionaires in making freight transportation investments that promise favorable returns to shareholders.

These and other freight stakeholders have begun to realize that freight system investments must involve partnerships between the public sector and the private sector, among a variety of different private-sector entities, and across public-sector jurisdictions and agencies. Developing and sustaining these partnerships require analytical tools that can provide insights into the nature and allocation of freight benefits and costs, as well as how they accrue across modal, jurisdictional, and interest (public/private) boundaries.

The NCFRP research project described in this report, *NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments,* developed such a tool. Through the identification of best practices, interviews with public and private freight stakeholders, and an assessment of the data and methods used to evaluate freight investments, this project has developed a Freight Evaluation Framework that represents an integrated analytical approach to supporting and evaluating complex freight investment decisions. This Framework defines a wide range of public and private benefits and impacts of freight infrastructure investments and identifies the tools and supporting data necessary to evaluate these benefits and impacts. The Framework is capable of handling projects that span all of the different freight modes and is able to assess benefits from a variety of project types and scales. It distinguishes how benefits and impacts are evaluated at the local, regional, state, and national level; and in so doing, it recognizes the role that different public-sector entities play in making funding decisions for freight investments.

The Framework was developed, and is designed to be applied, with the following three main functions in mind:

1. **To enhance public planning and decision-making processes regarding freight.** State departments of transportation (DOTs) and MPOs are increasingly facing freight planning issues—which by their very nature involve a combination of public interests, private operator interests, and shipper/industry interests. As a result, freight planners face a growing need to consider the roles and perspectives of these other parties in their public agency decision-making processes, but often are not equipped to do so. The Freight Evaluation Framework provides a common method to help planners understand the wide range of perspectives and interests in potential freight investments, and to more effectively integrate those interests within a decision-making process.
2. **To supplement benefit/cost assessment with distributional impact measures.** The traditional form of benefit/cost analysis, which compares total benefits and total costs of alternatives, may work for projects that are publicly financed, built, owned, and operated. However, that form of analysis is not always sufficient for freight projects that often require public-sector negotiation with private infrastructure owners and freight service providers. In such situations, there is a real need to consider the distribution of cost burdens and benefits among parties, particularly those that have a role in project funding and implementation.
3. **To advance public-private cooperation.** Often, freight projects can only be implemented if there is cooperation between public agencies and private parties in terms of responsibility for infrastructure facility financing, development, operation, and maintenance. That requires some degree of trust that neither party is taking advantage of the other. So, to craft appropriate financial and operating agreements, public agencies and private companies need a framework and process that *both* parties can accept to provide transparency and enable understanding of the concerns of the other.

The remainder of this chapter describes the key issues and challenges in evaluating freight investments, and how these challenges were addressed during the development of the Freight Evaluation Framework. An overview of the Framework, along with supporting data and tools that can be used in its application, also are presented. The full *NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments* provides a detailed description of the development, testing, and use of the Framework in assessing freight investments; it also presents case studies illustrating how the Framework can be applied and used for various project types.

Key Issues and Challenges in Evaluating Freight Projects

Both public- and private-sector freight stakeholders face a number of different challenges when evaluating potential freight investments. The Freight Evaluation Framework was developed to explicitly address these challenges, which are described in this section, within an integrated analytical approach.

Addressing the Motivations of Different Types of Stakeholders

Many previous research efforts have discussed "stakeholder types" that are involved in the identification, planning, financing, and implementation of freight improvement projects. Typically, these efforts have categorized freight stakeholders as public or quasi-public (DOTs, MPOs, port authorities) and private (shippers and carriers). This structure, however, does not fully account for the broad range of stakeholders who stand to gain or lose from freight transportation investments, which provides the foundation for determining appropriate benefits and impacts. In addition, it does not fully recognize emerging public/private partnerships and interactions, which are an important (and growing) aspect of freight projects and have blurred the distinctions between public- and private-sector roles.

This research resulted in a more nuanced understanding of the types of freight stakeholders involved in freight investment decisions, as well as their concerns and interests. This definition was critical in understanding the types of benefits about which these stakeholders are most concerned, the methods used to measure them, and how those issues could be addressed within an integrated evaluation framework. In general, freight projects can affect four types of stakeholders that are grouped as follows:

1. **Asset providers** who develop, lease, maintain, or finance freight investments (both fixed and mobile);
2. **Service providers** who provide transportation or logistics services for freight shipments;
3. **End users** who include both shippers/consignees, as well as end customers for finished goods; and
4. **Other impacted parties** who include neighborhood/community interests, environmental/land use interests, business interests, and others.

Table S.1 describes the typical public- and private-sector roles of these stakeholder types.

It is important to note that some freight stakeholders play dual roles. Railroads, for instance, are both asset providers and service providers; commercial real estate developers provide infrastructure and can be impacted by the freight investment decisions made (or not made) by service providers or end users; and government agencies may be both asset providers and impacted parties representing their citizens. Understanding these and other interrelationships is important when assessing the types of benefits different stakeholders are concerned with at different points in the investment decision-making process.

Table S.1. Freight investment stakeholder types.

Stakeholder Type	Stakeholder Examples
Asset Provider	State DOT Concessionaire Railroad Financier Commercial Real Estate Developer Port
Service Provider	Railroad Trucking Company Logistics Provider
End User	Freight shipper/consignee End customer
Other Impacted Party	Neighborhood/Community Residents and Property Owners Environmental Resource Agency Chamber of Commerce/Economic Development Agency Commercial Real Estate Developer

Stakeholder Perspectives

It is also critically important to describe the interest points and perspectives of different stakeholder types—essentially, what "stake" these stakeholders have in the success of a freight improvement project. Understanding the perspectives of different stakeholders—and how they can change depending on the type of project and/or role the stakeholder is playing in the project development—is important in developing an understanding of the types of benefits with which they are most concerned and the adequacy of the tools, techniques, and processes to measure them.

This research identified the following four types of stakeholder interest/perspectives:

1. Parties with a **direct financial stake** in the development and performance of a freight investment. These are primarily asset providers (both development and ongoing maintenance/operation) that have a vested financial interest in a freight improvement project. These stakeholders are providing capital (public funding, in the case of a state DOT; private capital in the case of a concessionaire or developer) in the hope of attaining particular goals, missions, or mandates. Without this group's concurrence on how a proposed improvement meets criteria for moving forward, there is no project.
2. Parties that have an **indirect financial stake** in the result of a freight investment. These stakeholders typically consist of service providers that operate transportation services on freight infrastructure, as well as shippers who are the true "users" of freight infrastructure capacity and services. In practice, these two groups are connected because service carriers pass on a significant share of their net costs to shippers. Together, these parties have a financial interest in the project outcome, but no direct investment stake in the project itself. However, the interests of these parties are an important consideration in making investment decisions, because impacts and benefits to these stakeholders can influence the net benefit/cost calculation made by those with direct financial stakes.
3. Parties that have a **major nonfinancial stake** in the result of a freight investment. These typically include nearby landowners and occupants affected by access, noise, safety, or livability impacts or community organizations or resource agencies concerned about broader environmental impacts related to the construction or operation of facilities. There is a clear path in which the project may affect these parties, and those concerns need to be considered as factors in project design and decision making. These impacts can be quantified in monetary terms, although it is sometimes desirable to consider them in the context of nonfinancial tradeoffs.
4. Parties that have a **tangential stake** in the result of a freight infrastructure project, either financial or nonfinancial. These stakeholders may include private companies (or a consortium of companies) affected by indirect and induced economic growth impacts; or local or regional taxpayers affected by project financing strategies. Many of their interests are likely to be in the form of concerns (that can potentially be addressed) and more general policy interests, rather than measurable direct effects of an individual project. These stakeholders should be kept informed and given the opportunity to air their views and provide input to the decision process.

Table S.2 describes the interest/perspectives of different stakeholder types.

Evaluating Different Investment Types

Previous research has focused on classifying freight projects into the following three types:

Table S.2. Interest/perspective of stakeholder types.

Stakeholder Type	Interest/Perspective			
	Category 1 (Direct Financial)	Category 2 (Indirect Financial)	Category 3 (Major Nonfinancial)	Category 4 (Tangential)
Asset Provider	●			
Service Provider	●	●		
End User		●	*	●
Other Impacted Party			●	●

* End users that are shippers or consignees generally translate all impacts into revenue or cost (Category 2) changes. However, infrastructure improvements also may affect passenger travel, in which case, there may be personal time or convenience impacts that fall into Category 3.

1. Infrastructure enhancements,
2. Capacity upgrades, or
3. Operational improvements.

However, this structure does not fully account for the sophistication of freight decision-making processes, the relationships among different project types, and the sheer number of stakeholder types that they can include.

Despite the growing sophistication of freight investment decisions and partnerships, the justification for any investment is still fairly simple, and can usually be explained in terms of enhanced capacity. In fact, although different types of freight stakeholders may explain it using different terms—for example, carriers may discuss improved reliability, while shippers may talk of a decreased need to hold inventory and a DOT may refer to system efficiency—these stakeholders are all, in essence, concerned with enhancing the capacity of the freight system within the following four typical project types:

1. **Physical infrastructure projects** enhance the capacity, design speed, or volume of freight infrastructure.
2. **Productivity projects** increase the size, weight, or volume of freight vehicles.
3. **Reliability and density projects** affect the utilization or safety of freight vehicles.
4. **Integration and consolidation projects** allow for more efficient communication or transfer of materials between freight vehicles, infrastructure, and facilities.

Dividing projects into these four types allows viewing the many types of freight investments in a simpler context that focuses on effective core functionality, rather than long lists of project types. Sample projects that may be included for different modes for each of these four project types are summarized in Table S.3.

Evaluating Projects of Differing Scales

The size, scope, and timeline of freight investment projects can vary considerably. In the past, freight projects have been completed by stakeholders working independently and on an as-needed basis—for example, railroads have traditionally prioritized investments and fully funded their most pressing capital projects and rolling stock purchases as their revenue streams

Table S.3. Capacity enhancement project types.

Project Type	Sample Project Types across Different Transportation Modes
Physical Infrastructure	• Expanding marine terminals • Increasing highway lane width/adding highway capacity • Redesigning interchanges or addressing localized bottlenecks • Lengthening railway sidings • Developing parallel lanes, tracks, or terminal slots • Increasing the number or length of runways
Productivity	• Operating longer combination vehicles or larger vessels • Lengthening trains
Reliability and Density	• Enhancing turn-outs and emergency pull-outs • Implementing controls for vehicle separation, design, and channelization • Using information services to reduce vehicle interactions, plan routing, and avoid congestion and incidents • Improving incident management techniques
Integration and Consolidation	• Improving/streamlining logistics services • Improving efficiency of cross-modal transfers • Ensuring interoperability of technology applications • Developing shared-use corridors

allowed. However, the increased prevalence of new institutional arrangements and strategies, such as multistate coalitions and public-private partnerships, has created new opportunities to engage multiple stakeholders on projects of varying scope, timeline, and cost. Projects such as the Alameda Corridor, although a rail infrastructure project, are able to bring other public and private partners into coordination with the railroads to plan and finance a large infrastructure project with benefits to numerous stakeholders.

The project team has categorized freight investments according to three different scales, described as follows and in Table S.4.

1. **Site and local—**Projects that involve a single site/facility or infrastructure element, or otherwise benefit freight mobility on a local scale;
2. **Statewide and regional—**Projects that involve statewide or regional operations or infrastructure, or benefit freight mobility on a statewide or multicounty scale; and
3. **Multistate or national—**Projects that involve infrastructure or operations that span several states or the nation, or that benefit regional or national freight mobility.

Accounting for Different Costs, Benefits, and Impacts

The types of benefits received by different stakeholder groups also have been discussed in previous studies and research efforts. However, many of these previous efforts tended to focus only on a handful of stakeholder and project types, typically public-sector transportation planning agencies (DOTs, MPOs) or a single carrier mode (such as benefits from Class I and shortline freight railroads). It is important to identify benefits that are of concern to the broader set of freight stakeholders, including infrastructure developers, investment bankers, industrial site selection analysts, supply chain professionals, and others. In general, the types of benefits that are meaningful to these freight stakeholders can be summarized in two categories: cost factors, and benefit and other impact factors.

Table S.4. Project scales and sample project types.

Project Scale	Sample Projects Typical for Stakeholder Type
Site and Local	• Roadway enhancement projects • Enhanced signals or use of Intelligent Transportation System (ITS) • Site access enhancements or operational improvements • Warehouse/development center site development • Terminal expansion at nonstrategic land, air, or marine ports • Class I classification yard improvements
Statewide and Regional	• Statewide or regional ITS projects • Bottleneck alleviation projects • Bridge safety or capacity enhancement projects
Multistate or National	• Trade corridor improvement projects • Projects to enhance capacity or throughput at strategic land, air, or marine ports that serve as key national entry points • Class I railroad double-tracking projects

1. **Cost factors** include:
   - **Facility capital costs,** which tend to be dictated by site location and design, as well as the partners involved in the planning process;
   - **Facility maintenance costs,** or the ongoing costs of maintaining a facility to ensure safe operations and upkeep; and
   - **Operating costs,** such as labor costs, fuel costs, equipment costs, and the time lost to congestion or to the breakdown of efficient supply chains.
2. **Benefit and other impact factors** include:
   - **Capacity,** which includes alleviating the impact of highway and rail system bottlenecks, as well as the throughput attainable on any transportation infrastructure or facility access point;
   - **Productivity,** or the ability to operate a supply chain from start to finish with maximum efficiency;
   - **Loss and damage,** or maximizing the safety and security of freight operations and movements to minimize loss to the shipper, carrier, or community;
   - **Scheduling/reliability,** or the ability to have predictable and timely delivery of goods, allows for streamlined inventories, less disruption in the manufacturing or supply process, and a more efficient supply chain;
   - **Tax revenue,** such as that received by new industrial land development, distribution center, or other freight-intensive land uses;
   - **Wider economic development,** such as increased jobs that result from a distribution center, transload, or intermodal facility, as well as multiplier effects to regional economies;
   - **Safety,** or minimizing of impacts of freight land uses on neighboring communities, and the safe operation of freight vehicles and facilities; and
   - **Environmental quality,** such as mitigation of air or water quality impacts, reduction of truck vehicle miles traveled (VMT), and noise or vibration reduction.

Although some benefits, such as safety, are likely to be considered by all freight stakeholders, it is certainly the case that each stakeholder group will be interested primarily in just a few benefits or impacts. The scale of the benefits or impacts received by a particular freight investment strategy will likely be the determining factors as to whether a freight stakeholder chooses to participate in a freight investment strategy or not. As shown in Table S.5, the primary considerations for most freight stakeholder types can be summarized by about two to four benefits. For example, although it is likely that a service provider considers a wide range of variables when determining participation in a freight investment project, the ultimate decision generally is determined by the underlying impact on operating costs and system capacity.

Understanding the primary benefits felt by each stakeholder group has several practical applications. First, by understanding who benefits from a freight improvement project, it is easier to assign responsibility for a project at a level that is proportionate to the benefit received. This is very useful when entering into a project where several different stakeholder types, including carriers, public agencies, and communities, are involved in project planning, approval, and financing. In addition, understanding the benefits received by user groups can help to highlight those situations where there may be a compelling public interest in supporting freight network improvements.

Understanding Both Public and Private Decision-Making Processes

Differences in the types of benefits considered by different stakeholders necessarily lead to different types of freight investment decision processes. The decision-making process employed by public-sector stakeholders is much more "transparent," and focuses on building consensus on a wide range of issues. In many situations, the number of stakeholders with a vote at the table is quite large, the multiple objectives (and impacts) of a proposed freight investment often may be muddled, the funding sources and mechanisms are numerous and complex, and the final decision to move forward or not with any given proposal rarely rests

Table S.5. Stakeholder types and benefits.

	Type of Beneficiary			
Benefit Category	**Asset Provider**	**Service Provider**	**End User**	**Other Impacted Party**
Cost Factors				
Facility Capital Costs	●	○	○	○
Facility Maintenance Costs	●	○	○	○
Operating Costs	●	●	○	○
Benefit and Other Impact Factors				
Capacity (Includes Bottleneck Congestion)	●	●	○	◐
Loss and Damage	○	◐	●	○
Scheduling and Reliability	○	●	●	○
Business Productivity	○	○	●	○
Tax Revenue	○	○	○	●
Wider Economic Developments	○	○	◐	●
Safety	◐	◐	◐	●
Environmental Quality, Sustainability, or Energy Use	◐	◐	◐	●

Key: Less Important ○ → ◐ → ● More Important with a single agency or decisionmaker. This complex process has many positive aspects; for example, it has given more people a voice in what happens in their communities, and it is more "fail safe" than the early days of publicly funded transportation investments. At the same time, this highly participatory process often drags out the timeframe for planning and implementation of any significant improvements, and may ultimately kill a project or program through "death by a thousand cuts."

By comparison, the private-sector process is much more narrowly focused on projects that relate directly to business goals and objectives. The process is much less inclusive, and stakeholders and decisionmakers are brought into the process only to address specific issues (e.g., permits, approvals) or to provide specific areas of support (e.g., funding, incentives). As opposed to the public process, the final decision to move forward or not with any given proposal often rests with a single decisionmaker or a collection of senior executives.

In addition, different stakeholders assess benefits at different points in the process. The public-sector process typically consists of the following five key steps:

1. **Needs identification—**When system needs and deficiencies are identified and potential approaches are identified;
2. **Plan development—**When transportation vision, goals, and strategies are documented;
3. **Project programming—**When the process of actually implementing transportation improvement projects begins;
4. **Project development—**When more detailed design and a more formal assessment of the necessary permitting and approval activities occurs; and
5. **Project implementation—**When final approval is obtained, detailed construction plans are developed, and right-of-way (if necessary) and construction permits are acquired.

Within this process, public-sector stakeholders (e.g., infrastructure providers [state DOTs] and impacted parties) typically begin developing a detailed understanding of potential investment benefits only within the project programming and project development stages. However, with the exception of a handful of states, this benefit assessment occurs *after* a proposed project has entered the pipeline and is generally used to decide among competing investments (both freight-related and nonfreight-related) to build support for an investment or suite of investments among impacted parties, and/or to allocate costs and benefits across different stakeholder types.

Among private-sector freight stakeholders (e.g., railroads, shippers, and industrial site developers), potential investment benefits are assessed as a *first* step in the process. Railroads, for example, immediately assess a project's potential impact on operations and revenue, and calculate net present value (NPV) of potential investments very early in the process. Similarly, one of the only factors a financial investor or concessionaire will consider within the decision-making process is financial returns, typically via due diligence studies that involve third-party confirmation of market demand and revenue assumptions.

This mismatch on when benefits are assessed within the decision-making process can make it difficult for all types of investment stakeholders to focus attention on freight investments that might have benefits for all parties.

Assessing Risk

Risk assessment has long been a critical component of private-sector investment decision making. Monitoring safety, regulatory compliance, and emissions is important because the costs associated with risk experience can be very high, and sizable loss can be devastating to smaller firms. Risk management metrics also have a role in customer satisfaction, potential market development, and market access. All of the functions in this category can have a direct cost (insurance, employee safety and retention, financial penalties and downtime, etc.). On the public-sector side, risk management techniques are typically included in asset management strategies for pavements, bridges, and other investments. Rarely are risk management techniques employed as part of the investment decision-making activities of these agencies, including freight investments.

However, risk assessment has taken on increasing importance among public-sector agencies given recent interest in utilizing public-private partnerships or shared asset activities. The emphasis placed on financial evaluation is typical for private-sector projects, but the degree of analysis devoted to risk assessment stands out, and (according to players in this market) exceeds that to which the public sector is accustomed. Public-private partnerships provide a route to funding and operating a project by accessing private-sector funds and support. It is a partnership that is marked with differences, however, because the public sector is responsible for promoting projects for the good of its constituents and the private sector functions and operates based on its bottom line. Financially, they have evolved separately and rely on different sources of funds. For the private sector to participate, the public-sector agency should have established policies, processes, and frameworks that facilitate a partnership.

A Framework for Addressing These Challenges

The Freight Evaluation Framework, shown in Figure S.1, addresses the challenges described above by providing a common approach to evaluating freight investments. The Framework allows stakeholders to evaluate the potential benefits of highway, rail, seaport, and intermodal connector projects on an "apples-to-apples" basis using existing data and analytical tools and in a manner that is consistent with the existing decision-making processes of different stakeholders.

The Framework consists of four key elements, described as follows:

1. **Identify Benefit Categories and Metrics.** As described earlier, different stakeholders value different potential benefits. Although there are a few measures, such as transportation cost savings, crash reductions, emission reductions, and pavement/track conditions, that are important across a wide array of stakeholders, others (such as maintenance savings and asset velocity) will be relevant to a smaller set. It is these unique benefits, however, that are likely to drive that stakeholder's decision on whether to participate in the investment. The Framework recognizes this and reflects the impact or benefit categories that are likely to be most important to different freight stakeholders in determining whether the project is beneficial from that group's perspective.
2. **Calculate Project Costs.** The costs of a constructed facility or implemented technology to the owner include both the initial capital cost and the subsequent operation and maintenance costs. Each of these major cost categories consists of a number of cost components. The magnitude of each of these cost components depends on the nature, size, and location of the project, as well as the owning organization (i.e., public or private).
3. **Calculate Benefits and Impacts.** The Framework addresses benefits and impacts proceeds in two parallel tracks: benefit/cost analysis (BCA) and economic impact analysis (EIA). Benefit/cost analysis identifies the benefits of investing (as compared with not investing), and compares these to the project costs. Economic impact analysis, in contrast, compares the overall economic growth (for example, employment, income, and output) in the specified study region with or without investing. For the purpose of both BCA and EIA, all costs

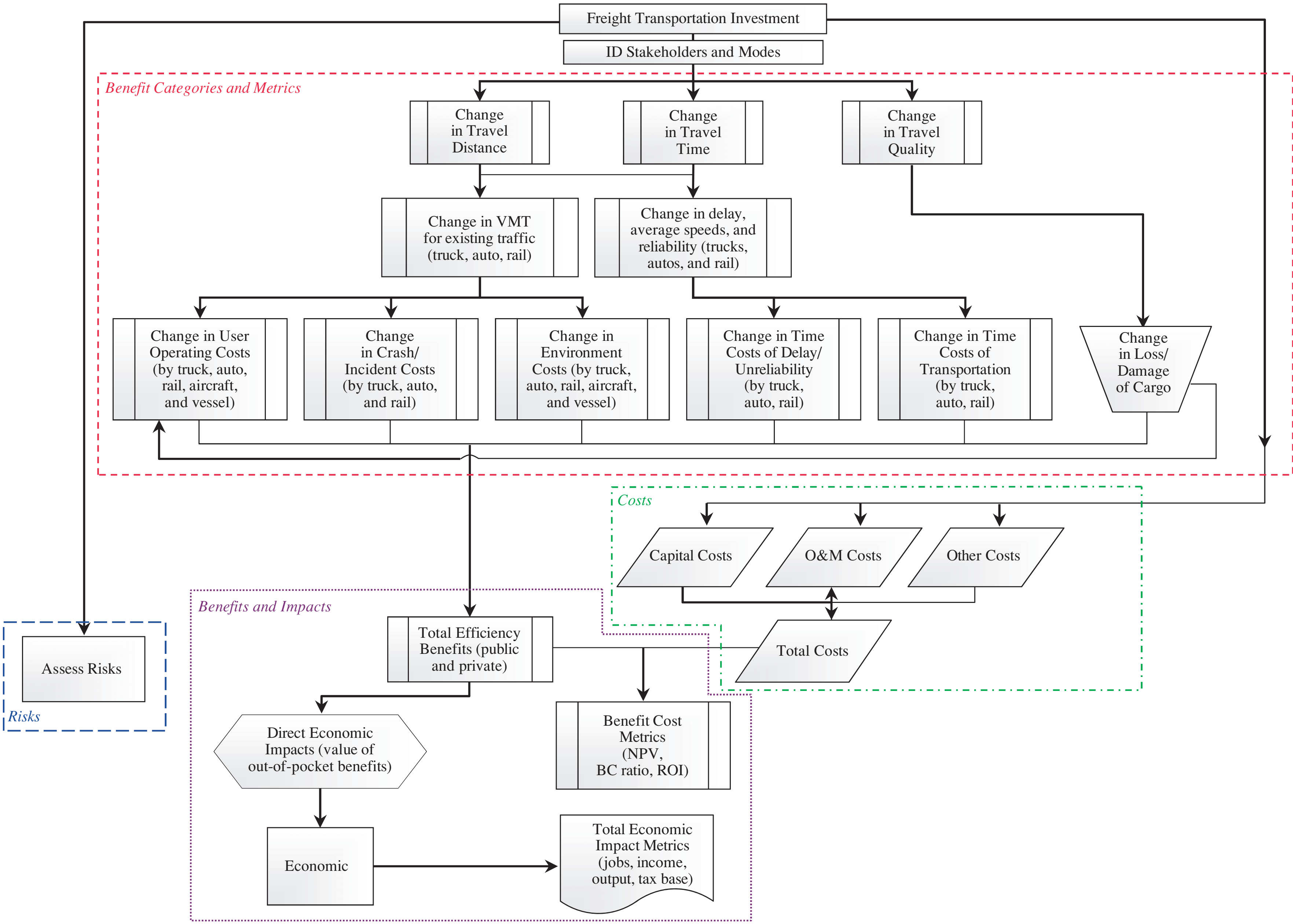


Figure S.1. Freight Evaluation Framework.

and benefits are measured over the project lifecycle to capture the timing of costs and benefits. Then the NPV of the costs and benefits is calculated using the appropriate discount rate.

4. **Assess Risks.** The incorporation of risk into the Framework represents a significant enhancement to the freight investment analysis tools, methods, and processes that have been developed as a part of previous research efforts. Risk in the context of a freight investment refers to downside outcomes due to uncertainty. From a financial perspective, investors or bondholders may experience weaker-than-anticipated returns on their investment. Weak returns can be the result of weaker-than-expected demand for a facility's services, or higher-than-expected capital or operating costs, or a combination of the two. From the public's perspective, the project may not yield its anticipated benefits in the form of congestion mitigation or job creation.

NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments details the specific structure and use of the Framework in each of these key areas.

Existing Data and Analytical Tools

The Freight Evaluation Framework was developed to utilize the wide array of analysis tools currently employed by different freight stakeholders. These tools provide different functions at different points in time, as shown in Figure S.2 and described as follows (a detailed description of these analysis tools is provided in this report):

- **Strategic planning tools** include tools used to assess long-term needs and deficiencies impacting the transportation system and the lifecycle costs of operating and maintaining transportation infrastructure (for asset providers), and longer-term market analyses, production, and site selection alternatives (for service providers and end users).
- **Carrier cost and performance analysis tools** are operational analysis tools that estimate the operational performance and cost of freight carrier operations under alternative scenarios to represent the impact of transportation projects, programs, or policies, and primarily are used by freight infrastructure providers and carriers.
- **Shipper cost and performance models** estimate the cost and time characteristics of alternative freight mode and service options, and are intended to represent the total logistics time, cost, and safety/reliability tradeoffs available for a shipment so that optimal shipping decisions can be made. These tools primarily are used by end users (i.e., the businesses that

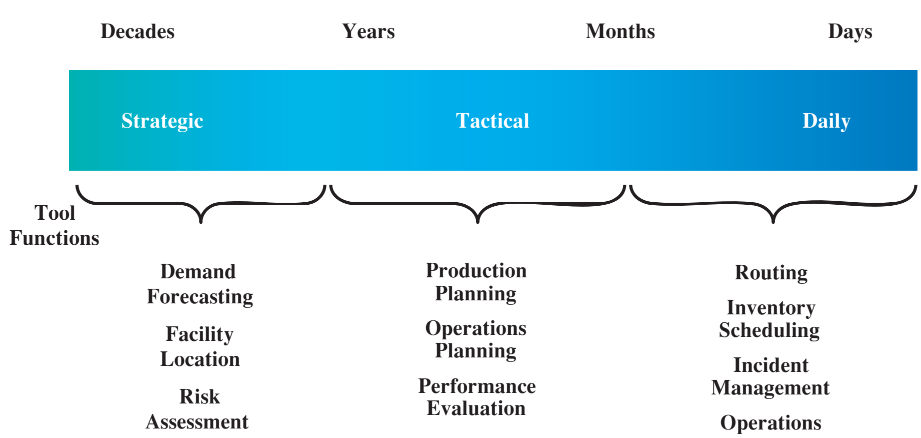


Figure S.2. Benefit assessment spectrum.

generate outgoing freight or the consignees who receive the freight and ultimately pay the shipper cost).

- **Transportation system efficiency models,** often defined as benefit/cost analysis systems, are intended to evaluate the benefit and cost streams over a specified period of analysis to determine whether a proposed investment will yield benefits in excess of its cost.
- **Economic development impact models** estimate impacts of transportation projects on income and jobs in the economy, and are primarily used by public-sector (local, regional, or state) transportation agencies to explicitly consider business productivity and economic development impacts that are not represented by transportation system efficiency tools.
- **Financial impact accounting tools,** typically used by those who have a direct stake in the cost of a project, provide estimates on how the proposal will affect outgoing cost streams, incoming revenue streams, cash flow, borrowing or bond requirements, net profit or loss over time, upside/downside risk, and rate of return.
- **Risk assessment tools** assist private-sector asset providers and end users in understanding and quantifying critical areas of uncertainty related to making investment decisions.

These tools have varying degrees of importance to different stakeholders, as shown in Table S.6.

These existing tools make it possible to estimate costs and benefits for a wide range of freight improvement projects within the Freight Evaluation Framework, often well enough to facilitate further discussion between public and private parties. But one of the primary advantages of using the Framework is its ability to allocate those costs and benefits to affected stakeholder groups in a way that can enable further discussion. Figure S.3 shows an example of how benefits from a freight investment are allocated among different stakeholders (this report provides detailed case studies on how the Freight Evaluation Framework is applied to actual freight investments).

Conclusions

The Freight Evaluation Framework has proven to provide a method and process for identifying and evaluating the costs, benefits, and impacts of a wide variety of freight investments. The following sections provide an overview of the most critical conclusions and

Table S.6. Importance of analysis tools to freight investment stakeholders.

	Tool Types						
Stakeholder Types	**Strategic Planning**	**Carrier Cost and Performance**	**Shipper Cost and Performance**	**Transportation System Efficiency**	**Economic Development Impact**	**Financial Impact**	**Risk Assessment**
Asset Provider	●	●	○	●	●	●	●
Service Provider	●	●	◐	●	○	◐	●
End User	◐	◐	●	◐	○	◐	◐
Other Impacted Party	○	○	○	◐	◐	○	○

Key: Less Important ○ → ◐ → ● More Important

Benefit metric	Infrastructure Provider	User	Service Provider	Public
Reduced Shipping Cost	--	--	$738,630	--
Reduced Inventory Carrying Cost	--	$468,439	--	--
Travel Time Savings	--	$1,191,735	--	--
Reduced Vehicle Operating Costs	$16,631	--	--	--
Safety Benefits	--	--	--	$209
Emissions Savings	--	--	--	$1,996

Figure S.3. Typical example of a stakeholder benefit and cost allocation.

lessons learned from the research process. This report also details lessons learned and potential next steps.

There are numerous available tools that can be used to assess benefits, costs, and risks of freight investments. What is needed are clear procedures that help analysts and decisionmakers integrate these tools and guide the analysis to ensure consistency from project to project.

This research uncovered a wide variety of investment decision-making techniques and tools that currently are used to assess user benefits, conduct return on investment assessments, and conduct benefit/cost analysis, economic impact analysis, and risk analysis. However, there is general agreement among both public- and private-sector freight stakeholders that the Freight Evaluation Framework is a very useful way to frame an investment decision analysis. Many analysts find it difficult to wade through the variety of tools and data and determine which are the most appropriate for their particular situation. Many also feel that having a structure that guides the analyst through steps of an analysis would be very useful. Some specific features of the Framework that are particularly useful include the following:

- Identification of stakeholders and relationships between benefit categories and stakeholders. This helps in allocation of costs among beneficiaries.
- Categorization of benefits and relationships among benefits, project types, and modes. This essentially provides a checklist for the analyst to make sure he/she has considered all appropriate benefit types for a particular project type.
- Ability to conduct multimodal comparisons, as well as to consider cross-modal impacts of projects.
- Incorporation of risk analysis. As described earlier, risk analysis is a critical element of private-sector decision making, but it often is not explicitly accounted for in public-sector analyses. Incorporating risk analysis also can help compensate for uncertainty introduced as a result of data or methodology weaknesses.

Allocation of benefits and costs among stakeholders is a critical feature of the Freight Evaluation Framework, but could be enhanced.

Initial tests of the Framework uncovered a number of issues related to how freight stakeholders are engaged throughout the application of the evaluation framework, including the following:

- **Disaggregating benefits by stakeholder type.** As described earlier, the Freight Evaluation Framework identifies and classifies stakeholders into different groups and then adds a table to assign or allocate the various elements of benefit and cost to specific stakeholder groups. However, in carrying out the analysis, it can become a challenge to effectively assign various classes of benefits to specific stakeholders when there are dynamic interactions among them. Tracking the string of payments among facility developers, owners, and operators can be challenging, and estimating their final allocations may require the type of risk analysis that is included in the Framework.

- **Consistency among stakeholders and benefits.** Maintaining consistency with how stakeholders are identified and how they might benefit from particular projects will add value to the Framework. For instance, the results and findings from a study can look very different depending on the level of detail in which stakeholders are defined and the degree of depth to which their interactions are traced. Both detail and consistency are required to generate useful results.
- **Accounting for sensitivity differences.** Finally, there are potentially large differences in the sensitivity to cost, benefits, and risk among different stakeholder types that are not all captured within the existing Framework. This becomes important if the Framework is used to help rank projects from the perspectives of various stakeholder groups. In some cases, there may be "lexicographic preferences" (i.e., issues of such importance to a particular stakeholder group that outweigh any and all other possible costs and benefits to that particular agent). In such cases, group preferences may include factors missing in the current framework. It may be possible for the framework to be expanded to account for, and incorporate, these types of preferences. Alternatively, it may be necessary to just note cases where the Framework does not (or cannot) encompass other major considerations.

Solutions to existing problems are easier to measure and assess than "new opportunities." The Freight Evaluation Framework works well when there is a clearly defined problem to be solved. In these cases, there are clearly defined goals for the project, benefits that are expected, and "success" elements or performance measures. For instance, the Framework is very easy to apply to capacity enhancement projects that are designed to solve a particular problem or issue (e.g., limited double-stack clearance, truck access through local neighborhoods). In these cases, it is straightforward to identify the specific baseline conditions and current costs or disbenefits to be resolved.

Application of the Framework becomes more challenging for projects that are designed to take advantage of new opportunities (e.g., "greenfield" projects). In many cases, the primary benefit of these types of new (not expanded) capacity investments where there are no existing users is the ability to accommodate additional traffic. Analytical models used to support the original market justification for such projects were often based on unconstrained forecasts and just assumed that operating conditions would worsen without the capital investment. In the real world, that is often not a realistic assumption. For instance, as congestion rises under a no-build scenario, a variety of different outcomes may occur, and hence may be represented by an alternative scenario as follows:

- Cases where, without the new investment, businesses will merely stay in place and endure continuing growth of congestion delays and costs;
- Cases where, without the new investment, business activity shifts to other shipping modes, routes, or facilities that can offer a second best solution for remaining in place; or
- Cases where, without the new investment, some businesses will simply relocate to another location where costs are not as high as would be incurred if they stayed in place.

It is both necessary and possible to define both project scenarios and alternative scenarios to represent the expected changes in freight demand patterns and business responses to them. In addition, the risk analysis method used in these cases shows how alternative assumptions about key factors such as freight demand growth can be explored and represented in a report on benefit/cost findings.

The Framework could benefit from a more consistent approach to identifying the sources of risk and uncertainty that should be incorporated in the analysis.

As described earlier, risk analysis often is focused on the market and cost risks that create the greatest uncertainties, and that could lead to different project outcomes. The market risks may be a result of normal fluctuations (such as business cycles), which may be reasonably predictable, or other random events that are important to consider, but difficult to predict. Guidance could be developed to help identify the most typical sources of each type of risk and uncertainty for different types of projects. In addition, guidance could be provided for how to account for methodological uncertainty in the analysis. Given that there are a number of key performance attributes of freight investments that are difficult to predict with currently available tools and data, having a way to assess the level of uncertainty this introduces into investment decisions would be helpful.

CHAPTER 1

Introduction

Over the last several years, freight planning and investment activities have evolved considerably. During the past 15 years, transportation planners across North America have become aware of the changing nature of freight movements, as increasingly global economic markets and longer supply chains have caused freight traffic to grow at a faster rate than passenger traffic—a trend that has held for road, rail, air, and marine modes. During this same period, state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) have undertaken efforts to more explicitly incorporate freight-related issues within existing transportation planning and programming activities, by learning about freight movements, identifying and engaging freight stakeholders, pinpointing locations of freight bottlenecks, and assessing the impacts of freight movements on statewide and regional economies. As a result, these public-sector agencies are now more aware of how freight movements impact the condition and performance of their systems, and how improving freight efficiency can impact business attraction and retention efforts, regional and state economies, and quality of life.

Now, many states and MPOs have moved beyond the planning stage and are interested in how to address freight-specific needs and implement improvement projects. These agencies are focusing their attention on where and how it makes sense to invest public dollars in freight improvement projects, who should be involved, and how risks and rewards should be allocated. Attitudes and activities among private-sector freight investment decisionmakers have evolved as well. Railroads, for instance, have shown a willingness to partner with public-sector entities to make system investments that have demonstrable public and private benefits. Also, there is increasing interest by private infrastructure developers and concessionaires in making freight transportation investments that promise favorable returns to shareholders.

These and other freight stakeholders have begun to realize that freight system investments must involve partnerships between the public sector and the private sector, among a variety of different private sector entities, and across public sector jurisdictions and agencies. Developing and sustaining these partnerships requires analytical tools that can provide insights into the nature and allocation of freight benefits and costs, and how they accrue across modal, jurisdictional, and interest (public-private) boundaries.

Many previous efforts of the NCHRP, NCFRP, FHWA, and other research sponsors have helped advance the resources and techniques available to state DOTs, MPOs, multistate coalitions, and other stakeholders to identify and quantify the economic impacts of freight investments. Yet, those efforts have not fully distinguished among the various public and private stakeholders involved in investment decisions, the types of benefits and results that drive their decision processes, or how various benefits should be considered in freight investment decisions. In addition, they do not address risk analysis nor do they address the different types of perspectives and tools needed to deal with decisions at different stages of freight planning, project selection, and project implementation.

The results of this research begin to fill a critical gap in the resources available to freight planning and investment decisionmakers across these boundaries by providing an integrated analytical approach to supporting and evaluating complex freight investment decisions. The Freight Evaluation Framework developed as part of this effort defines a consistent approach to evaluating freight projects by defining a wide range of public and private benefits and impacts of freight infrastructure investments and identifying the tools and supporting data necessary to evaluate these benefits and impacts. This Framework is capable of handling projects that span all of the different freight modes and able to assess benefits from a variety of project types, including those that improve freight operations, as well as generate more capacity (both terminal and mainline) through infrastructure expansion. The Framework distinguishes how benefits and impacts are evaluated at the local, regional, state, and national level and, in so doing, recognizes the role that different public-sector entities play in making funding decisions for freight investments. Finally, in addressing the private-sector component of the benefits analysis, it recognizes the variety of private-sector entities involved in freight investments, including recognition of the different performance requirements and perspectives of different types of modal carriers and logistics service providers (LSPs), carriers versus shippers, and different types of shippers.

The Framework was developed, and is designed to be applied, with the following three main functions in mind:

- **To Enhance Public Planning and Decision-Making Processes Regarding Freight—**State DOTs and MPOs are increasingly facing freight planning issues, which by their very nature involve a combination of public interests, private-operator interests, and shipper/industry interests. As a result, freight planners face a growing need to consider the roles and perspectives of these other parties in their public agency decision-making processes, but often are not equipped to do so. The Freight Evaluation Framework provides a common method to help planners understand the wide range of perspectives and interests in potential freight investments, and to more effectively integrate those interests within a decision-making process.
- **To Supplement Benefit/Cost Assessment with Distributional Impact Measures—**The traditional form of benefit/cost analysis, which compares total benefits and total costs of alternatives, may work for projects that are publicly financed, built, owned, and operated. However, that form of analysis is not sufficient for freight project plans that require public-sector negotiation with private infrastructure owners and freight service providers. In those situations, there is a real need to consider the distribution of cost burdens and benefits among parties, particularly those that have a role in project funding and implementation.
- **To Advance Public-Private Cooperation—**Often, freight projects can only be implemented if there is cooperation between public agencies and private parties in terms of responsibility for infrastructure facility financing, development, operation, and maintenance. That requires some degree of trust that neither party is taking advantage of the other. So, to craft appropriate financial and operating agreements, public agencies and private companies need a framework and process that *both* can accept to provide transparency and enable understanding of the concerns of the other.

1.1 Summary of the Technical Approach and Product

This project report describes the development and application of a process and framework for evaluating alternative designs and proposals for freight transportation projects, in a format that portrays the magnitude and incidence of benefits, costs, and impacts. This Freight Evaluation Framework was developed specifically to address the three objectives described above. It is based on a recognition that freight transportation projects tend to be multilayered, in the sense that they have both public and private stakeholders responsible for different aspects of project planning, financing, and operation. The Framework itself is comprised of a practical set of formats for information collection and reporting of analysis findings, with guidance on their use. It is designed to support public-private agency discussions, to be applicable across different types of projects and different modes of transportation, and to build upon already available tools and data sources.

The Freight Evaluation Framework was developed using a series of research efforts that are described in subsequent sections of this report. The complete research plan is provided in Appendix A. First, the research team reviewed prior studies, including research reports and guidebooks, that have documented freight planning and programming processes used by states and MPOs around North America. This was followed by a review of methods currently used to assess freight benefits or prioritize improvement projects, including state-specific planning processes and nationally available evaluation and planning guidelines for general transportation planning.

Second, the research team assessed the differences among various public- and private-sector views of project benefits and costs. This effort focused on identifying the fundamental differences between local-scale freight projects, national network capacity projects, and international port or gateway projects, in terms of the parties involved and classes of benefits and costs. It also examined the complexities involved in assessing benefits and costs of systemwide improvements to highway networks, rail networks, port distribution systems, and multimodal projects that have effects on different types of stakeholders at different spatial scales.

Third, the research team assessed available project evaluation and impact analysis tools that are available for specific modes, including both public- and private-sector benefit assessment tools. These various tools covered freight project impacts on freight carriers and transportation service providers, shippers and end users, and on broader income and economic growth.

Fourth, the research team conducted a series of interviews with transportation planners representing a range of different agencies, to identify key issues of concern to them and to identify available examples of multimodal freight projects around the United States in which project benefits and costs have been examined.

Based on those four lines of research, the research team developed the Freight Evaluation Framework for assessing benefits and costs of different types of freight projects, which was designed to cover a wide range of modal combinations, project improvement types, project scales, and a mix of public and private parties involved in (and affected by) project planning and implementation activities. We presented this Framework to the NCFRP-05 Panel, made the necessary revisions, and presented it to a national workshop of transportation planning practitioners and experts for further review and discussion. Based on the outcome of that workshop, the Framework was further refined and is presented in this report.

1.2 Organization of the Report

The remaining sections of this report identify the key issues and challenges in evaluating freight investments, current practices (both public and private) in evaluating freight investments, and the data and tools available to support these decisions. Subsequent sections include the following:

- A description of **key issues in freight planning and freight project evaluation—**Chapter 2 lays out a systematic structure for classifying project investments, stakeholders, outcome metrics, and benefit/cost factors.
- A summary of **current practices in freight investment decision making—**Chapter 3 describes elements of the decision-making process, stakeholders involved, the strategic and tactical factors they consider in project assessment, and available assessment tools.
- An overview of the **Freight Evaluation Framework—**Chapter 4 describes the guiding principles and key structural elements for presenting project costs, benefits, and uncertainties within the Framework itself.
- A description of the process for **testing the Framework—**Chapter 5 presents six detailed case studies that illustrate how the Freight Evaluation Framework can be applied to different types of freight projects. Findings from a workshop of national freight transportation planning, financing, and implementation experts also are presented.
- Detailed **guidance for using the Framework—**Building on previous findings, Chapter 6 lays out key steps required to apply the Framework to evaluate potential freight investments.
- A discussion of **lessons learned and suggested topics for future research—**Chapter 7 identifies pitfalls to avoid and topics where there is need for research to further improve the use of the Framework.
- Appendix E (to the contractors' final report), **Workshop Participants and Presentations,** is available on the project webpage.

CHAPTER 2

Key Issues to Address in Evaluating Freight Projects

Both public- and private-sector freight stakeholders face a number of different challenges when evaluating potential freight investments. It was critically important to understand these key issues in order to develop an evaluation framework to address them. As described earlier, freight projects are particularly challenging for planning, evaluation, and decision making for the simple reason that they frequently involve some element of access, connection, or use of rail, marine, or aviation facilities that are owned and operated by private companies. That tends to make many freight projects both multimodal and multilayered in terms of the roles of various public and private stakeholders.

Balancing public, private operator, and shipper/industry interests and benefits can help engage all potential stakeholders in planning and development of freight investments and foster meaningful discussions about how costs, benefits, and risks should be shared. The following sections describe the types of challenges affecting the evaluation of freight investments and how they could be addressed within an evaluation framework.

2.1 Addressing the Motivations of Different Types of Stakeholders

Many previous research efforts have discussed stakeholder types that are involved in the identification, planning, financing, and implementation of freight improvement projects. Typically, these efforts have categorized freight stakeholders as public or quasi-public (i.e., DOTs, MPOs, port authorities) and private (i.e., shippers and carriers). This structure, however, does not fully account for the broad range of stakeholders who stand to gain or lose from freight transportation investments, which provides the foundation for determining appropriate benefits and impacts. In addition, it does not fully recognize emerging public-private partnerships and interactions, which are an important (and growing) aspect of freight projects.

It is important to develop a more nuanced understanding of the types of freight stakeholders involved in freight investment decisions, as well as their concerns and interests. This definition is useful in understanding the types of benefits these stakeholders are most concerned about, and the methods used to measure them. In general, freight projects can affect four types of stakeholders, which the study team grouped as:

- **Asset providers** who develop, lease, maintain, or finance freight investments (both fixed and mobile);
- **Service providers** who provide transportation or logistics services for freight shipments;
- **End users** who include both shippers/consignees, as well as end customers for finished goods; and
- **Other impacted parties** who include neighborhood/community interests, environmental/land use interests, business interests, and others.

Table 2.1 describes the typical public- and private-sector roles of these stakeholder types.

It is important to note that some freight stakeholders play dual roles. Railroads, for instance, are both asset providers and service providers; commercial real estate developers provide infrastructure and can be impacted by the freight investment decisions made (or not made) by service providers or end users; and government agencies may be both asset providers and impacted parties representing their citizens. Understanding these and other interrelationships is important when assessing the types of benefits different stakeholders are concerned with at different points in the investment decision-making process.

Stakeholder Perspectives

It also is critically important to describe the interest points and perspectives of different stakeholder types—essentially,

Table 2.1. Freight investment stakeholder types.

Stakeholder Type	Stakeholder Examples
Asset Provider	State DOT Concessionaire Railroad Financier Commercial Real Estate Developer Port
Service Provider	Railroad Trucking Company Logistics Provider
End User	Freight Shipper/Consignee End Customer
Other Impacted Party	Neighborhood/Community Residents and Property Owners Environmental Resource Agency Chamber of Commerce/Economic Development Agency Commercial Real Estate Developer

what "stake" these stakeholders have in the success of a freight improvement project. Understanding the perspectives of different stakeholders—and how they can change depending on the type of project and/or role the stakeholder is playing in project development—is important in developing an understanding of the types of benefits with which they are most concerned and the adequacy of the tools, techniques, and processes to measure them.

The research team has identified the following four types of stakeholder interest/perspectives:

- Parties with a **direct financial stake** in the development and performance of a freight investment. These are primarily asset providers (both development and ongoing maintenance/operation) that have a vested financial interest in a freight improvement project. These stakeholders are providing capital (public funding, in the case of a state DOT; private capital in the case of a concessionaire or developer) in the hope of attaining particular goals, missions, or mandates. Without this group's concurrence on how a proposed improvement meets criteria for moving forward, there is no project.
- Parties that have an **indirect financial stake** in the result of a freight investment. These stakeholders typically consist of service providers that operate transportation services on freight infrastructure, as well as shippers who are the true "users" of freight infrastructure capacity and services. In practice, these two groups are connected because service carriers pass on a significant share of their net costs to shippers. Together, these parties have a financial interest in the project outcome but no direct investment stake in the project itself. However, the interests of these parties are an important consideration in making investment decisions, because impacts and benefits to these stakeholders can influence the net benefit-cost calculation made by those with direct financial stakes.
- Parties that have a **major nonfinancial stake** in the result of a freight investment. These typically include nearby land owners and occupants affected by access, noise, safety, or livability impacts; or community organizations or resource agencies concerned about broader environmental impacts related to the construction or operation of facilities. There is a clear path in which the project may affect these parties, and those concerns need to be considered as factors in project design and decision making. These impacts can be quantified in monetary terms, although it is sometimes desirable to consider them in the context of nonfinancial tradeoffs.
- Parties that have a **tangential stake** in the result of a freight infrastructure project, either financial or nonfinancial. These stakeholders may include private companies (or a consortium of companies) affected by indirect and induced economic growth impacts, or local or regional taxpayers affected by project financing strategies. Many of their interests are likely to be in the form of concerns (that potentially can be addressed) and more general policy interests, rather than measurable direct effects of an individual project. These stakeholders should be kept informed and given the opportunity to air their views and provide input to the decision process.

Table 2.2. Interest/perspectives of stakeholder types.

	Interest/Perspective			
Stakeholder Type	Category 1 (Direct Financial)	Category 2 (Indirect Financial)	Category 3 (Major Nonfinancial)	Category 4 (Tangential)
Asset Provider	●			
Service Provider	●	●		
End User		●	*	●
Other Impacted Party			●	●

* End users that are shippers or consignees generally translate all impacts into revenue or cost (Category 2) changes. However, infrastructure improvements also may affect passenger travel, in which case, there may be personal time or convenience impacts that fall into Category 3.

Table 2.2 describes the interest/perspectives of different stakeholder types.

2.2 Evaluating Different Investment Types

Previous research has focused on classifying freight projects into three types: infrastructure enhancements, capacity upgrades, or operational improvements. However, this structure does not fully account for the sophistication of freight decision-making processes, the relationships among different project types, and the sheer number of stakeholder types that they can include.

Despite the growing sophistication of freight investment decisions and partnerships, the justification for any investment is still fairly simple and usually can be explained in terms of enhanced capacity. In fact, although different types of freight stakeholders may explain it using different terms (e.g., carriers may discuss improved reliability, while shippers may talk of a decreased need to hold inventory and a DOT may refer to system efficiency) these stakeholders are all, in essence, concerned with enhancing the capacity of the freight system within the following four typical project types:

- **Physical infrastructure projects** that enhance the capacity, design speed, or volume of freight infrastructure;
- **Productivity projects** that increase the size, weight, or volume of freight vehicles;
- **Reliability and density projects** that affect the utilization or safety of freight vehicles; and
- **Integration and consolidation projects** that allow for more efficient communication or transfer of materials between freight vehicles, infrastructure, and facilities.

Dividing projects into these four types allows viewing the many types of freight investments in a simpler context that focuses on effective core functionality, rather than long lists of project types. Sample projects that may be included for different modes for each of these four project types are summarized in Table 2.3.

2.3 Evaluating Projects of Differing Scales

The size, scope, and timeline of freight investment projects can vary considerably. In the past, freight projects have been completed by stakeholders working independently and on an as-needed basis—for example, railroads have traditionally prioritized investments and fully funded their most pressing capital projects and rolling stock purchases as their revenue streams allowed. However, the increased prevalence of new institutional arrangements and strategies, such as multistate coalitions and public-private partnerships, has created new opportunities to engage multiple stakeholders on projects of varying scope, timeline, and cost. Projects such as the Alameda Corridor, although a rail infrastructure project, are able to bring other public and private partners into coordination with the railroads to plan and finance a large infrastructure project with benefits to numerous stakeholders.

The project team has categorized freight investments according to three different scales, described as follows and in Table 2.4.

- **Site and local—**Projects that involve a single site/facility or infrastructure element, or otherwise benefit freight mobility on a local scale;
- **Statewide and regional—**Projects that involve statewide or regional operations or infrastructure, or benefit freight mobility on a statewide or multicounty scale; and
- **Multistate or national—**Projects that involve infrastructure or operations that span several states or the nation, or that benefit regional or national freight mobility.

Table 2.3. Capacity enhancement project types.

Project Type	Sample Project Types across Different Transportation Modes
Physical Infrastructure	• Expanding marine terminals • Increasing highway-lane width/adding highway capacity • Redesigning interchanges or addressing localized bottlenecks • Lengthening railway sidings • Developing parallel lanes, tracks, or terminal slots • Increasing the number or length of runways
Productivity	• Operating longer combination vehicles or larger vessels • Lengthening trains
Reliability and Density	• Enhancing turn-outs and emergency pull-outs • Implementing controls for vehicle separation, design, and channelization • Using information services to reduce vehicle interactions, plan routing, and avoid congestion and incidents • Improving incident management techniques
Integration and Consolidation	• Improving/streamlining logistics services • Improving efficiency of cross-modal transfers • Ensuring interoperability of technology applications • Developing shared-use corridors

2.4 Accounting for Different Costs, Benefits, and Impacts

The types of benefits received by different stakeholder groups also have been discussed in previous studies and research efforts. However, many of these previous efforts tended to focus only on a handful of stakeholder and project types, typically public-sector transportation planning agencies (DOTs, MPOs) or a single carrier mode (such as benefits from Class I and short-line freight railroads). It is important to identify benefits that are of concern to the broader set of freight stakeholders, including infrastructure developers, investment bankers, industrial site selection analysts, supply chain professionals, and others. In general, the types of benefits that are meaningful to these freight stakeholders can be summarized in two categories: cost factors, and benefit and other impact factors.

1. Cost factors include
   - **Facility capital costs,** which tend to be dictated by site location and design, as well as the partners involved in the planning process;
   - **Facility maintenance costs,** or the ongoing costs of maintaining a facility to ensure safe operations and upkeep; and
   - **Operating costs,** such as labor, fuel, and equipment costs, as well as the time lost to congestion or to the breakdown of efficient supply chains.

Table 2.4. Project scales and sample project types.

Project Scale	Sample Projects Typical for Stakeholder Type
Site and Local	• Roadway enhancement projects • Enhanced signals or use of Intelligent Transportation System (ITS) • Site access enhancements or operational improvements • Warehouse/development center site development • Terminal expansion at nonstrategic land, air, or marine ports • Class I classification yard improvements
Statewide and Regional	• Statewide or regional ITS projects • Bottleneck alleviation projects • Bridge safety or capacity enhancement projects
Multistate or National	• Trade corridor improvement projects • Projects to enhance capacity or throughput at strategic land, air, or marine ports that serve as key national entry points • Class I railroad double-tracking projects

2. Benefit and other impact factors include
   - **Capacity,** which includes alleviating the impact of highway and rail system bottlenecks, as well as the throughput attainable on any transportation infrastructure or facility access point;
   - **Productivity,** such as the ability to operate a supply chain from start to finish with maximum efficiency;
   - **Loss and damage,** or maximizing the safety and security of freight operations and movements to minimize loss to the shipper, carrier, or community;
   - **Scheduling/reliability,** or the ability to have predictable and timely delivery of goods, allows for streamlined inventories, less disruption in the manufacturing or supply process, and a more efficient supply chain;
   - **Tax revenue,** such as that received by new industrial land development, distribution centers, or other freight-intensive land uses;
   - **Wider economic development,** including increased jobs that result from a distribution center, transload, or intermodal facility, as well as the multiplier effects to regional economies;
   - **Safety,** such as minimizing of impacts of freight land uses on neighboring communities, and the safe operation of freight vehicles and facilities; and
   - **Environmental quality,** including mitigation of air or water quality impacts, reduction of truck vehicle miles traveled (VMT), and noise or vibration reduction.

Although some benefits, such as safety, are likely to be considered by all freight stakeholders, it is certainly the case that each stakeholder group will be interested primarily in just a few benefits or impacts. The scale of the benefits or impacts received by a particular freight investment strategy will likely be the determining factors as to whether a freight stakeholder chooses to participate in a freight investment strategy or not. As shown in Table 2.5, the primary considerations for most freight stakeholder types can be summarized by about two to four benefits. For example, although it is likely that a service provider considers a wide range of variables when determining participation in a freight investment project, the ultimate decision generally is determined by the underlying impact on operating costs and system capacity.

It is important to note that government agencies can be considered as both an asset provider and holder of the general public interest, and must make decisions that reflect regional mobility goals and the safety, security, and environmental concerns of the communities that the agency represents. In addition, some benefits are felt by numerous groups—for example, tax revenue impacts are created by both increased income to service carriers and additional income generated to end users. Nevertheless, it is possible to generalize the primary benefits considered by each of the four freight stakeholder types.

Understanding the benefits felt by each stakeholder group has several practical applications. First, by understanding

Table 2.5. Stakeholder types and benefits.

	Type of Beneficiary			
Benefit Category	**Asset Provider**	**Service Provider**	**End User**	**Other Impacted Party**
Cost Factors				
Facility Capital Costs	●	○	○	○
Facility Maintenance Costs	●	○	○	○
Operating Costs	●	●	○	○
Benefit and Other Impact Factors				
Capacity (Includes Bottleneck Congestion)	●	●	○	◑
Loss and Damage	○	◑	●	○
Scheduling and Reliability	○	●	●	○
Business Productivity	○	○	●	○
Tax Revenue	○	○	○	●
Wider Economic Developments	○	○	◑	●
Safety	◑	◑	◑	●
Environmental Quality, Sustainability, or Energy Use	◑	◑	◑	●

Key: Less Important ○ → ◑ → ● More Important who benefits from a freight improvement project, it is easier to assign responsibility for a project at a level that is proportionate to the benefit received. This is very useful when entering into a project where several different stakeholder types, including carriers, public agencies, and communities, are involved in project planning, approval, and financing. In addition, understanding the benefits received by user groups can help to highlight those situations where there may be a compelling public interest in supporting freight network improvements.

2.5 Assessing Risk

Risk assessment has been a critical component of private-sector investment decision-making for a long time. Monitoring safety, regulatory compliance, and emissions is important because the costs associated with risk experience can be very high, and sizable loss can be devastating to small firms. Risk management metrics also have a role in customer satisfaction, potential market development, and market access. All of the functions in this category can have a direct cost—insurance, employee safety and retention, financial penalties and downtime, etc. On the public-sector side, risk management techniques are typically included in asset management strategies for pavements, bridges, and other investments. Rarely are risk management techniques employed as part of the investment decision-making activities of these agencies, including freight investments.

However, risk assessment has taken on more importance among public-sector agencies given recent interest in utilizing public-private partnerships (PPP) or shared asset activities. The emphasis placed on financial evaluation is typical for private-sector projects, but the degree of analysis devoted to risk assessment stands out, and (according to players in this market) exceeds that to which the public sector is accustomed. PPPs provide a route to funding and operating a project by accessing private-sector funds and support. It is a partnership that is marked with differences, however, because the public sector is responsible for promoting projects for the good of its constituents, and the private sector functions and operates based on its bottom line. Financially, they have evolved separately and rely on different sources of funds. For the private sector to participate, the public-sector agency should have established policies, processes, and frameworks that facilitate a partnership, including the following:

- **Structure—**A functional regulatory and institutional framework acts as a roadmap for proceeding;
- **Public need—**A demonstrated need for such a partnership adds purpose and mutual goals;
- **Feasibility —**Demonstrable feasibility with respect to economic market, technical, environmental, financial, and risk allocation aspects is important;
- **Risk management—**A clear understanding between the allocation of risk and benefits/rewards is critical;
- **Transparency in procurement—**Good access to relevant materials allows for accurate evaluation of benefits and costs, which in turn reduces the need for estimating values of withheld information;
- **Proper due diligence—**Verifying actual and projected volumes/turnover, costs, revenues, and risks;
- **Public-sector "buy-in"—**Identifying issues pertaining to permitting and acquisition;
- **A strong and "true" partnership—**Should be set forth in a clear contractual framework; and
- **Innovation—**In handling costs, risks, and revenues.

Understanding the risks associated with a project involves evaluating design and construction, market risk, operation and maintenance risk, financing risk, insurance, and termination risk. The private sector often is interested in understanding the uncertainty that surrounds forecasts and projects. A number of tools can be consulted to address these risks, including a risk allocation matrix and due diligence financial and technical risk analysis through statistical means.

When engaging in PPPs, a common practice is to develop a risk allocation matrix that clearly outlines categorical risks and the responsibilities of each party. Risks are allocated and quantified to clearly describe the various scenarios, costs, and responsibilities involved. Areas of concern may include insurance, permitting, design, and construction, among others. Table 2.6 outlines the general types of risks that are accounted for, and which parties may take responsibility for these risks.

Each conceived risk should be collected and quantified in a detailed risk matrix as shown in Table 2.7. The basic elements may include

- An explicit explanation of the risk event or scenario, accompanied by logical and achievable remedies and solutions;
- A rating of the potential of the occurrence of such a risk;
- The party primarily responsible for the risk; and
- The percent share of the risk by party, along with the dollar value of the cost.

As a part of evaluating investments, a common practice is to develop forecasts; these carry an obvious degree of uncertainty. Risks can be technical and financial, including cost overruns and benefit shortfalls. Monte Carlo methods can be used to simulate the various sources of uncertainty that affect the outcome of projects, with respect to costs or benefits, and calculate an average expected value for the given possible values of the components.

Table 2.6. Types of risks and risk allocations.

Risk	Private	Public
Legislative (Existing and Future)	Sharing within defined parameters	Major responsibility
Acquisition and Environmental	Sharing within defined parameters, with public-sector assistance	Major responsibility
Permitting and Planning	Sharing within defined parameters	Major responsibility
Design and Construction	Major responsibility	–
Operation and Maintenance	Major responsibility	Sharing within defined parameters
Financing	Major responsibility	–
Termination	Major responsibility, unless demonstrably caused by public	–
Insurance	Major responsibility	Sharing based on availability of commercial rates
Force Majeure	Sharing based on event and availability of insurance	Sharing based on event and availability of insurance

Source: Halcrow, Inc.

Table 2.7. General template of risks.

Risks	Input
Overall Risk Characteristics	
Category of Risk	Risk type
Description	Event/scenario being addressed
Party Primarily Bearing Risk	
Party 1 Risk Share	Y percent
Party 2 Risk Share	X percent
Risk Value (in USD)	Dollar value
Annualized Value at Risk ($k/year)	Dollar value
Optional Additional Risk Controls	Remedies and proposed solutions
Party Best Able to Direct Mitigation	Party X
Effect of Additional Risk Controls on Level of Risk	High, medium, low
Residual Risk	Percentage
Annualized Residual Value at Risk ($k/year)	Dollar value
Basis for Risk Allocation	Unit of measure
Party-Specific Risks	
Party 1	***Percent Share of Risk***
Pre Mitigation Risk	Dollar value
Post Mitigation Risk	Dollar value
Party 2	***Percent Share of Risk***
Pre Mitigation Risk	Dollar value
Post Mitigation Risk	Dollar value

Source: Halcrow, Inc.

CHAPTER 3

Current Practices in Freight Investment Decision Making

An important first step of this research was to develop a more detailed understanding of the processes used to evaluate freight investment decisions, how these processes differ among various stakeholder types, and the data and tools used to inform the process. This information was critical in helping to ensure that the Freight Evaluation Framework reflected the types of benefits that are important to different stakeholders, how and when they are evaluated, and the strengths and limitations of current practices.

3.1 Case Study Approach

The research team reviewed all available material related to the freight transportation decision-making process, paying particular attention to how public and private benefits are assessed and incorporated, as well as the tools and models currently used to assess freight benefits or prioritize improvement projects. The researchers supplemented this information with in-person interviews with key players—from both public and private sectors—involved in the development, evaluation, prioritization, financing, and implementation of freight improvement projects. These interviews, the locations of which are shown in Figure 3.1 (available on the project webpage), focused on the following:

- **The freight transportation decision-making process,** particularly how the process differs between the public and private sectors (and among different public- and private-sector agencies/entities) and the key decision points along the way; and
- **Current practices used to evaluate freight investments,** particularly how potential public and private benefits are calculated, how cost allocations are made, and how investments are evaluated and prioritized.

As discussed in Chapter 2, freight projects can affect four types of stakeholders: asset providers, service providers, end users, and other impacted parties. The following sections describe the processes used by these stakeholder types in evaluating freight investment decisions as well as the data and tools used to support them.

3.2 Decision Processes

This section presents an overview of the freight investment decision-making practices and techniques used by different stakeholder types throughout the country. Case studies are provided for each stakeholder type to illustrate "real world" examples of freight improvement decision processes and practices, as well as the tools used to calculate public and private benefits.

Infrastructure Provider

As discussed, infrastructure providers develop, lease, maintain, or finance freight investments. The following case studies describe the processes, data, and tools used by four infrastructure providers (Washington State DOT, the Bank of Montreal, the Burlington Northern Santa Fe [BNSF] Railway, and the Port of Portland [in Oregon]) to evaluate infrastructure investments.

Case Study—Washington State DOT Rail Investments

Overview. Like many states, Washington has a history of participating in the private rail system, particularly in those projects where benefits accrued to strong state industries such as agriculture. However, state participation has historically been on a case-by-case basis, and until recently the state lacked a formal policy that spelled out when and how public tax dollars should be invested in the rail system.

To address this situation, in 2005, the Washington State Legislature commissioned the *Washington Statewide Rail Capacity and System Needs Study.* One of the outcomes of the study was a systematic framework for evaluating freight and passenger

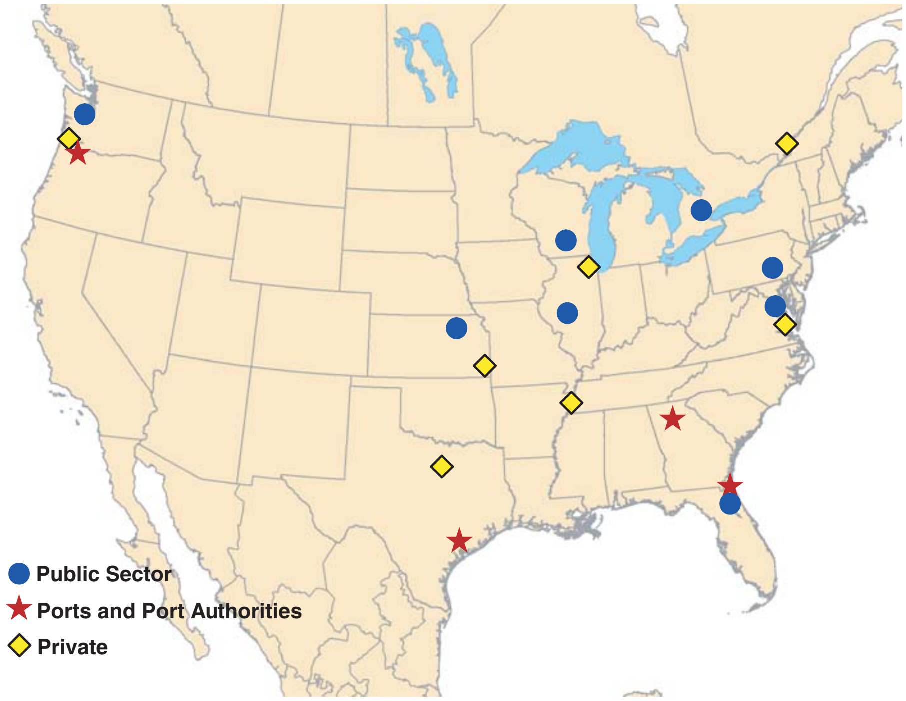


Figure 3.1. Interviews completed throughout the research process.

rail improvement projects for potential state funding. Following completion of the study, the legislature directed Washington State DOT to develop and implement the framework recommended in the study.

Evaluation Process. Washington State DOT developed a statewide rail benefit/impact evaluation methodology (*1*) to evaluate rail grant and loan applications. The methodology consists of seven steps, as outlined and shown in Figure 3.2.

- **Application review/information gathering—**Rail projects are initiated by the receipt of a completed grant or loan application from the project sponsor. Washington State DOT can act as project sponsor when the Legislature directs that a certain project be undertaken.
- **Conduct a benefit/cost analysis—**Following Washington statute (RCW 47.76), freight rail projects seeking public funding are required to conduct a benefit/cost analysis. If the benefit/cost ratio is less than 1 (indicating that costs exceed benefits), the evaluation is terminated and the project is not considered further for state funding. If the benefit/cost ratio is greater than 1, the evaluation proceeds to the next steps.
- **Legislative priority matrix tool—**This is a spreadsheet tool developed to implement the Washington State Legislature's six priorities for the benefit/impact evaluation methodology. Measures for each priority are assigned a numerical score between 4 (highly likely to satisfy the priority) and -1 (has a negative impact on the benefit). The scores are weighted based on the relative importance of the priority. The six priorities are as follows, in order of importance:
  - Economic, safety, or environmental benefits of freight movement by rail compared to other modes;
  - Self-sustaining economic development that creates family wage jobs;
  - Preservation of rail corridors that would otherwise be lost;
  - Increased access to efficient and cost-effective transport to market for Washington's agricultural and industrial shippers;
  - Better integration within the regional, national, and international freight transportation system; and
  - Mitigation of the impacts of increased rail traffic on local communities.
- **Project management assessment—**This tool is used to determine the current status of the project, and the likelihood it will be completed on time and within budget. Scores are based on factors such as project readiness, partner funding, budget, and schedule.
- **User benefit levels matrix—**This matrix qualitatively apportions project costs and benefits to different user groups, including the State, ports, trucking companies, shippers, railroads, and local communities. For each benefit, the project evaluator determines the percentage benefit accruing to each user. This can be used to inform decisions about cost allocation among different public- and private-sector partners.

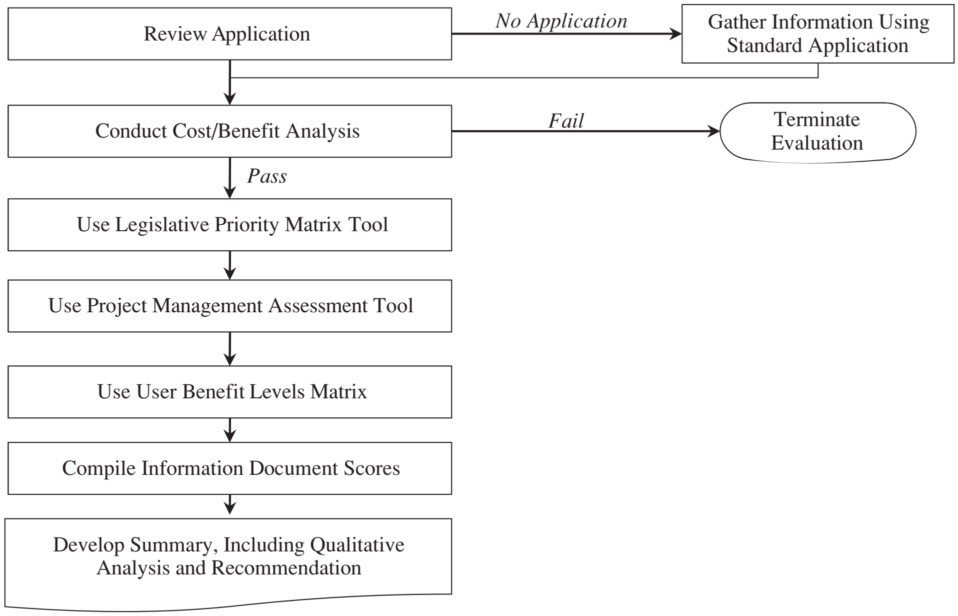


Figure 3.2. Washington State DOT freight rail decision-making process.

- **Compile information/document scores—**Using information derived from the benefit-cost analysis, Legislative Priority Matrix, Project Management Assessment, User Benefit Levels Matrix, and any other relevant information, the evaluator generates an overall project score and documents how all factors were evaluated.
- **Develop summary report and recommendations—**Taking all available information into consideration, the evaluator writes a summary report and makes a formal recommendation about whether to fund the project.

Benefit Estimation. The benefit/cost analysis utilizes the Statewide Rail Benefit/Cost Calculator, a sketch planning tool that estimates the public and private benefits of rail investments to the citizens and businesses of Washington State. Unlike many rail evaluation tools, the calculator does not rely on rail simulation modeling tools and extensive data that must be obtained from the railroads. Rather, it provides quantitative estimates of benefits based on documented standards, research, and common practice. The method can therefore be used as a basis for allocating project costs between private firms (such as shippers, receivers, and railroads) and the public sector. The following three main types of benefits are included:

- Transportation and economic benefits;
- Economic impacts; and
- External impacts.

Table 3.1 describes the benefits in more detail, including information on how they are measured.

The shipper savings are treated as pure private benefits that would be paid for by the private sector. All other benefit types (e.g., increases in employment, taxes, and output, as well as reductions in freight impacts such as road maintenance costs) are treated as public-sector benefits that would be paid for by the public sector.

Case Study—Bank of Montreal Financial Group

Overview. Established in 1817, the Bank of Montreal (BMO) is Canada's oldest and fifth largest bank (by deposits). The bank played a major role in the development of the country and financed the first transcontinental railway in the 1880s. BMO has over 900 branches in Canada. Although the official legal corporate head office is in Montreal, the chairman, president, and most senior division executives work out of the company's Toronto headquarters. The bank is a member of BMO Financial Group, the 10th largest diversified financial services provider in North America with total assets of $361 billion (U.S.) and 37,000 employees (as of January 31, 2009).

The company has three primary client groups that serve different markets.

1. Personal and Commercial Client Group focuses on retail banking and life insurance. Retail banking in the United States is represented by Harris Bank, headquartered in Chicago;
2. Investment Banking Group (operated as BMO Capital Markets); and

Table 3.1. Benefit categories included in Washington State DOT's benefit/cost calculator.

Benefit/Cost	Measurement of Benefit/Cost
Reduced Maintenance Costs	Based on expected number of rail carloads versus semis and the weight of the shipments
Reduction in Shipper Costs (for Shipments Originating in State) – Freight Only	Comparison of the cost of shipping the goods via rail compared to truck
Reduction in Automobile Delays at Grade Crossings	Value of motorist time (usually a function of average wages) multiplied by expected reduction in delay
New or Retained Jobs	Average wages for the region from the Bureau of Labor Statistics multiplied by an economic multiplier to gauge total impacts
Tax Increases from Industrial Development	Estimated assessed property value after project multiplied by property tax rate
Safety Improvements	Estimated money saved by not having to make highway safety improvements
Environmental Benefits	Total distance traveled by trucks diverted to rail multiplied by a standard environmental cost per mile
Track Maintenance	Estimated cost of track maintenance discounted to net present value
Equipment Maintenance	Estimated cost of equipment maintenance discounted to net present value

Source: Washington State DOT, *Freight Mobility Joint Report*, Appendix A, Exhibit 8.

3. Private Client Group (BMO Nesbitt Burns), which focuses on wealth management.

BMO Capital Markets provides corporate, institutional, and government clients access to equity and debt underwriting, corporate lending and project financing, merger and acquisitions advisory services, merchant banking, securitization, treasury management, market risk management, debt and equity research, and institutional sales and trading.

Evaluation Process. Investment banks, such as BMO Capital Markets, have become an important element in the financing of freight improvement projects, and government agencies increasingly recognize that in order to attract private capital to a project, there must be a payoff for private-sector investors. The private-sector organizations, such as investment banks, carriers, shippers, terminals, etc., are frequently courted by public agencies because of their expertise in business and in financing large projects. The public sector wants the private-sector partners to pledge capital and to take on some of the risks that have traditionally been absorbed by the public sector. Given limitations in funding from local, state, and federal grants, the public sector often seeks private-sector capital in order to complete a project.

BMO, like all infrastructure investors, is concerned about the following two types of risk:

1. Construction and start-up risk, and
2. Revenue risk from operations.

Construction and startup risk depends on how sound the planning is for a project, the severity of environmental impacts, and the degree of support or opposition from environmental groups, elected officials, and other stakeholders. In public-private partnerships, investors are typically leery of greenfield projects that are in the early stages of development. Projects that already have received environmental approval and that have been fully designed present significantly less start-up risk. From an investor's standpoint, projects built under design-build authority are often viewed as having less start-up risk because a firm price of the project is known early.

In general, the private sector sees lower risk in purchasing an existing asset, such as an existing toll bridge, as opposed to a project that is still in the planning stages. For example, in 2005, a consortium of Cintra Concesiones de Infraestructuras de Transporte S.A. and Macquarie Infrastructure Group purchased the 7.8-mile Chicago Skyway for $1.83 billion, which was 63 times earnings before interest, taxes, depreciation, and amortization (EBITDA). The consortium has a 99-year lease.

Revenue risk is far more troubling, because of the uncertainties in long-term demand for the service provided. For example, when a toll road is built, will drivers shun the new roadway in order to avoid the toll? Are there alternatives to using the new facility? Will recessions dampen the demand for the service provided?

Benefits Assessment. BMO uses due diligence analysis to answer several key questions related to proposed investments, all of which serve to better understand the risks of the project.

- **What is the overall travel demand?** BMO's technical advisors document or measure actual traffic conditions, using traffic counts, synthetic travel demand models, and origin-destination studies. Investment-grade analysis typically involves origin-destination studies to demonstrate the real world potential for the project.
- **How will that demand change over time?** For projects in the early stages of development, existing forecasts by government planning agencies are usually sufficient, although some review of potential concerns in growth forecasts is often appropriate. At the investment-grade level, independent forecasts are typically developed. Analysts consider the engines that drive the regional economy of a proposed project, as well as where within the region growth may occur—looking at constraints to growth and other internal competitive factors. Another key driver of future travel demand is changes to the transportation system. The overall goal of the due diligence analysis is to discover all committed, as well as planned or under-discussion projects, to evaluate their potential impact on future traffic.
- **What share of the demand will use the toll facility at different toll rates?** For toll projects, a number of analyses are developed, including localized evaluation of willingness to pay, whether people are familiar with tolling or not, incomes, and types of trips being made along the proposed project.

Case Study—Burlington Northern Santa Fe Railway

Overview. BNSF is one of the largest railroads in the United States, with 32,000 route miles in the central and western parts of the country. The railroad employs 40,000 people and owns 6,700 locomotives. At any given time, approximately 220,000 rail cars are moving on the BNSF system. Major commodities hauled include coal, grains, fertilizer, chemicals, forest products, minerals, metals, and consumer goods (which are most often shipped in intermodal containers). The following sections describe how BNSF evaluates capacity improvement projects for funding within its own capital program, as well as how it makes decisions about whether to enter into public-private partnerships to share the costs of capacity improvements.

Evaluation Process. BNSF makes capacity investment decisions based on a four-step process. Each step is conducted by a separate unit within the company and is the same regardless of project scale, location, or type.

1. The Railroad Traffic Controller (RTC—as described earlier, RTC is a model used by freight railroads for forecasting and service planning purposes). The Modeling Group evaluates the project to calculate the likely capacity, velocity, and reliability improvements that would result from project implementation.
2. The Strategic Group evaluates the project's expected outcomes against the railroad's strategic plan to determine how well the proposed improvement conforms to the company's overall business goals.
3. The Investment Activities Group determines the net present value (NPV) of the project using a cost/benefit analysis process. For some projects, this group determines whether public-private partnership scenarios might be appropriate, and the degree to which these scenarios could impact financial viability.
4. The Capital Committee makes a final decision on whether to fund the project.

Figure 3.3 describes the issues evaluated within each step of this process.

If the Investment Activities Group determines that a public-private partnership is appropriate and/or would make

1. Determine Project Benefits

Decision-Maker: RTC Modeling Group
Tools: RTC Model
Issues Evaluated: Capacity – The additional number or weight of train cars that can be transported
Velocity – Travel time reductions
Reliability – Reduced travel time variability

2. Evaluate Project Within Business Context

Decision-Maker: Strategic Group
Tools: Strategic Plan
Issues Evaluated: The project's congruity with the performance and market goals outlined in the strategic plan

3. Determine Net Present Value of Project

Decision-Maker: Investment Activities Group
Tools: Cost-Benefit Analysis
Issues Evaluated: Whether the Net Present Value of the project warrants RR investment under various public funding scenarios

4. Final Investment Decision

Decision-Maker: Capital Committee
Tools: Findings generated in prior steps
Issues Evaluated: All – Capital Committee makes the final investment decision

Figure 3.3. BNSF investment evaluation process.

a borderline capacity improvement more financially viable for the railroad, BNSF employs a separate process, shown in Figure 3.4, for finalizing public-private partnership opportunities. This process starts between Steps 3 and 4 of the process described in Figure 3.3, and includes planning, programming, and implementation strategies both for BNSF and the public-sector partner(s).

Benefit Estimation. BNSF, like other railroads, typically uses benefit/cost analysis to evaluate potential capacity improvement projects because BNSF considers NPV to be the single most important indicator of a potential project's viability. The NPV is calculated over a 30-year timeframe, and the railroad uses a standard discount rate across all proposed projects so NPVs can be compared consistently across the network. Therefore, the process for selecting potential projects to be funded by BNSF's own capital improvement program is relatively straightforward. Those projects that have a desirable NPV and are consistent with the strategic goals of the railroad are selected for completion; those that do not meet either of those criteria are not.

The process is more nuanced when potential public-private partnership opportunities are evaluated because public funding can make some borderline projects (as evaluated by BNSF) more viable for completion if the public and private benefits are commensurate with costs. When evaluating a public-private partnership project, there are four benefits that BNSF considers:

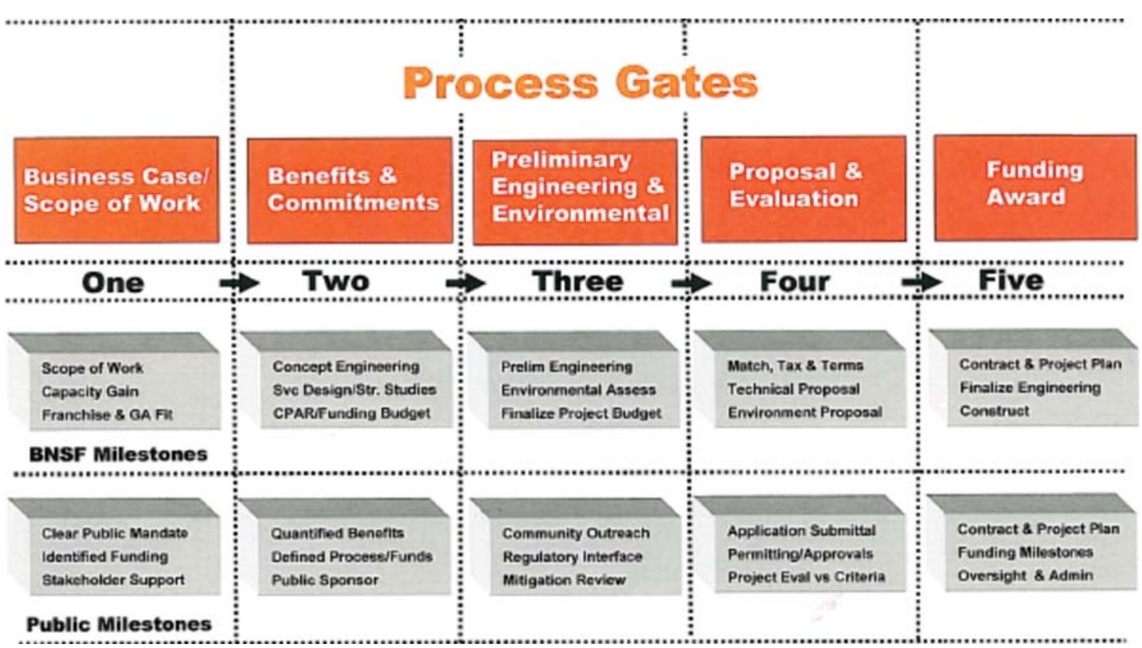
1. Capacity improvements,
2. Reliability and velocity improvements,
3. Opportunities to implement positive train control, and
4. Increased rapport and understanding between BNSF and the public sector.

These benefits, their measurements, and the tools used to measure them are summarized in Table 3.2.

Case Study—Port of Portland, Oregon

Overview. Created by the Oregon Legislature in 1891, the Port of Portland now operates four airports, four marine terminals, and four industrial parks in the Portland metropolitan area. The port also is charged with maintaining the navigation channel on the lower Columbia and Willamette Rivers. The port is organized as a regional government, with a jurisdiction that includes Clackamas, Multnomah, and Washington Counties. It is governed by a nine-member commission, members of which are appointed by the governor and confirmed by the Oregon Senate. Board members serve 4-year terms and may be reappointed. Day-to-day port operations are handled by an executive director hired by the commission, who oversees a staff of division directors for various business units, such as Marine and Industrial Development and Aviation.

The Port of Portland directly employs about 800 people and operates 24 hours a day, 7 days a week. Its transportation



Source: BNSF, July 2007.

Figure 3.4. BNSF public-private partnership evaluation process.

Table 3.2. Benefits weighed by BNSF when considering a public-private partnership.

Benefit	Measurement of Benefit	Tools Used
Capacity Improvements	The impact of the proposed project on the capacity of the BNSF network	RTC Simulation Model
Reliability and Velocity Improvements	Improvements in travel time, reliability, and average train speed	RTC Simulation Model
Opportunities to Implement Positive Train Control Technology	Expanded use of positive train control technologies across the network	N/A
Increased Rapport and Understanding between BNSF and the Public Sector	Enhancing the relationship between the railroad and government agencies	N/A

infrastructure and real estate assets are worth about $1.6 billion, and generate about $250 million in revenue each year. Indirectly, port operations support over 33,000 jobs with $1.92 billion in employee earnings, and generate more than $180 million in property taxes in the region.

Evaluation Process. The Port of Portland relies on the following two planning documents to guide its investment decisions:

- **The Port Transportation Improvement Plan (P-TIP)** serves as the long-range, multimodal planning document for the port and is updated annually. The purpose of the plan is to organize transportation improvement needs on port property into one place; its goal is to maintain the strategic advantage of Portland's transportation system by meeting the surface transportation access needs of businesses and passengers. The key objectives of the P-TIP are the following:
  – To identify the surface transportation needs of the port over a 5-, 10-, and 20-year timeframe; and
  – To develop a long-range vision of the financial implications of transportation system investments, to be integrated into the 5-year capital plan (described below).
- **The Five-Year Capital Plan** is used to implement the strategies identified within the P-TIP. It serves as a 5-year capital improvement plan for the port. Any project that benefits the port and is expected to cost more than $5,000 must be included in the 5-year capital plan. Projects appearing in the Capital Project Plan go through a rigorous evaluation process. The first step is for the project sponsor to fill out a Project Setup Form, which consists of the following four elements:
  – **Scope and justification,** which includes a description of the project, its justification, and why it currently is important, as well as business impacts and risk identification, project objectives, fixed assets created, and any alternatives that exist for the project;
  – **Cash flow and financial analysis,** which describes the projected cash flow associated with the project and financial indicators, such as NPV, modified internal rate of return (MIRR), and discounted payback period;
  – **Authorization Form,** which combines the financial information summary with an engineering estimate and approvals from different port managers; and
  – **Project Setup Form,** which compiles all of the above and includes organizational information for the project, such as the personnel required to complete it and when they would be needed.

Benefit Estimation. Once the Project Setup Form is complete, port staff rank the project using two indices and a project status classification, which are shown in Table 3.3.

Although these indices and project classification schemes are helpful for organizing possible projects, they are not the primary determinant in prioritizing projects. Rather, the process to select projects for the 5-year capital plan uses the indices and classification system to organize the projects into an easy-to-understand framework. Once they are organized, the following steps are taken:

- The quantitative merit of the project is evaluated using the Primavera Prosight tool.
- A series of teams and commissions discuss available projects, consider the preliminary quantitative benefits of the projects, and prioritize them into the 5-year capital plan. A subteam is responsible for putting together the project budgets and estimating their costs and benefits. Once the preliminary list is put together, the subteam brings it to the port directors for approval. Finally, the list is put in front of the port commission for discussion, possible alteration, and approval.

Table 3.3. Port of Portland project evaluation and ranking tools.

Rankings	Description
Priority Index	
High	Projects that are critical to meet legal, regulatory, and customer contractual commitments and that the port already has approved
Medium	Projects that address the specific business plan of the department and are needed to maintain and build the port's assets
Low	Projects that are discretionary in nature and are not vital to maintain the health of the organization
Category Index	
Category 1	Legal/regulatory/contractual/mandate
Category 2	Maintenance/replacement
Category 3	Business development (discretionary)
Category 4	Indirect benefit to the port (benefits to the community or region)
Project Status	
Open	Projects that are approved for expenditure
Candidate Yes	Projects that have resources devoted to them to develop their business case
Candidate No	Projects that are primarily theoretical, with no business case or quantitative data to support them

Service Provider

As discussed earlier, service providers provide transportation or logistics services for freight shipments. The following case studies describe the processes, data, and tools used by Watco Companies (focused on its shortline rail operations) to evaluate infrastructure investments.

Case Study—Watco Companies

Overview. Watco Companies, Inc. is an integrated transportation service provider, offering services, including transload and intermodal services, property management, switching services, and railroad service. Currently, Watco Companies also owns and operates 20 railroads, comprising some 3,500 miles of shortline railroad track in 17 different states.

Evaluation Process. Watco railroad operations conduct different processes to evaluate maintenance and operational projects and capital improvements and growth projects. For maintenance and operations improvements, Watco assesses the status of the railroad system as a whole, as well as every link within the system. This effort results in an average rating of the system as a whole, as well as a "risk ratio" for each individual link. The system risk analysis process allows the railroad to highlight problematic or potentially problematic segments, and identify portions of the system that require maintenance or operational improvements. The analysis is performed at least twice a year, although Watco prefers to perform it on a quarterly basis, if possible.

Watco has developed a separate process to assess capital improvement and growth projects. Typically, this process starts at the regional marketing manager level, when projects are identified and brought to the attention of the general manager and a regional analyst. This analyst proceeds to populate and run a return on investment (ROI) model to assess the financial worthiness of the project. This tool first considers the various costs to the railroad that will be caused by the project, and then compares them to a series of financial performance indicators.

If the project makes it past this first analysis, it is brought to the regional controller. If approved regionally, it is put in front of the executive team, which is composed of the Watco Companies management team, including the CEO, president, CFO, COO, etc. The management team is then responsible for prioritizing the projects and creating a list of projects that are feasible within the yearly capital budget.

Benefit Assessment. To help guide maintenance and operational investments and to calculate the track risk ratio, Watco railroad created and uses a Track Risk Analysis tool, which has three primary impacts:

1. **Traffic** (i.e., the capacity of the system, and flow of traffic over it);
2. **Safety,** including derailments, injuries, and experience of staff; and
3. **Commodities,** including the type of commodity being carried (i.e., hazardous material [hazmat], special needs commodities), as well as the value of the commodity, and the value of the equipment being used to haul the commodity.

Each of these factors is weighted to allow Watco to focus investments on high-density lines, or on lines that handle specific (or higher-revenue) commodities. It is important to note that safety is weighted higher than the other two impacts when creating a ratio for each link. One of Watco's core beliefs is that it should operate with injury and derailment rates that are lower than average. In addition, they have found that lowering the rate of injuries and derailments is a significant cost savings to the company.

As discussed, Watco uses an ROI model to assess capital improvement and growth projects. The costs and financial performance measures considered within this tool are summarized in Table 3.4.

End User

As described earlier, end users include both shippers/consignees, as well as end customers for finished goods. Although these stakeholders are critical in influencing freight demand, previous research efforts have not fully documented the process they employ when making freight investment decisions and what role they play in the process. The following sections describe the processes used by two end users—a commercial site selection firm and a major shipper—in evaluating freight investments.

Case Study—Grubb & Ellis Strategic Consulting Group

Background. The Grubb & Ellis Strategic Consulting Group (G&E) provides business location services, expansion or relocation analyses, and advice on optimal locations for businesses (both goods dependent and service-related). The group is not involved in real estate transactions. However, they provide strategic advice to businesses, including manufacturing businesses, that could lead to transactions in the future. In effect, they provide the planning function in advance of a transportation infrastructure investment.

Evaluation Process. Clearly, every G&E client is different and has different needs—the site location requirements of a cookie manufacturer are much different than those of a call center or other service-related industry. However, the "big three" elements that G&E considers when advising clients are labor, transportation access, and tax structure. Regardless of business type, however, clients are interested in being located close to the Interstate System, and rail access and service are becoming increasingly important. The specific evaluation process is described in Figure 3.5 and is guided by the following three principles:

- **Understand client needs—**As described, each client has different locational needs, depending on factors like distance from distribution points, current and future markets, shelf life of products, locations of key suppliers, and even potential workforce/labor pool turnover. For instance, some clients will only locate in areas that have a population greater than 50,000. In other areas, relative location to key markets is critical. Still others like to locate close to suppliers (cookie manufacturers close to grain suppliers, for instance). The first step G&E makes is to develop a detailed understanding of client needs and requirements.
- **Conduct locational analysis—**Using the information collected in Step 1, G&E will conduct a locational analysis, which helps identify the most desirable location for expansion/relocation. Several elements are taken into account, including:
  - **Demographics,** such as workforce availability, education levels, commuting times, etc. Data to guide this element are derived from Claritas, a proprietary data set that takes 2000 Census data, updates it (to current year), and provides disaggregated information on a variety of demographic areas.
  - **Average wages/cost of living,** which is used to paint a picture of potential cost structure for labor.
  - **Transportation,** specifically travel time (to key distribution points, shippers, etc.). G&E uses drive-time software

Table 3.4. Costs and financial performance indicators considered in the Watco ROI model/tool.

Costs	Financial Performance Indicators
Additional Equipment Needed for New Infrastructure/Service	Additional cash flow
Jobs Created or Lost	Timeframe to pay back investment
Additional Crew Times Needed	Revenue
Additional Fuel Usage and Costs	Performance economic value added*
Additional Maintenance Costs	
Construction Costs	

* Economic Value Added (EVA) represents a more accurate accounting of profit, and can be calculated as [net profit] – [opportunity cost].

1. Location Analysis

Decision-Maker: Grubb & Ellis analysts
Tools: Logistics network analysis
Issues Evaluated: Optimal location without regard to costs

2. Qualitative Community Analysis

Decision-Maker: Grubb & Ellis analysts
Tools: Preferences and requirements for suitable locations, provided by clients
Issues Evaluated: Vary according to client needs. Primary areas of evaluation include:
- Labor Pool – Availability, competition, labor laws, etc.
- Quality of Life/Business – Cost of living, climate, crime, etc.
- Accessibility/Logistics – Distance from key locations, distance from potential employees, security, etc.
- Operating Environment – Infrastructure, support services, market growth potential

3. Community Cost Analysis

Decision-Maker: Grubb & Ellis analysts
Tools: Analysis of total operating costs in selected communities, associated with the following:
- Wage rates and payroll expenses
- Transportation
- Corporate income, property, and inventory taxes
- Utilities and telecom
- Lease rates
- State and local development incentives

Issues Evaluated: Overall operating costs in potential locations

4. Delivered Costs Analysis

Decision-Maker: Grubb & Ellis analysts
Tools: Pro-forma financial analysis based on operating costs in potential communities
Issues Evaluated: Total delivered costs per unit for potential distribution centers located in each community

5. Final Decision

Decision-Maker: Company Executives and Board of Directors
Tools: Delivered Cost Analysis prepared by Grubb & Ellis
Issues Evaluated: Total business costs in potential locations

Figure 3.5. G&E site selection evaluation process.

called Freeway, although other options exist. G&E supplements this information with a variety of other sources. For instance, some clients like to be close to major airports, so G&E collects data from trade groups, Bureau of Transportation Statistics (BTS), and other public sources to develop a comprehensive picture of transportation system performance in a region and at a particular site.

  – **Tax structure and utility costs,** which are available from local economic development agencies and other sources. Utility service boundaries are important to know. Utility costs can be difficult to obtain from areas without regulated utilities.
  – **Other elements (depending on client),** including crime rates, day care availability, number of restaurants, etc. All this information is brought into a GIS system to show locational preferences.

- **Decide and negotiate—**Following a pro forma financial analysis, a location decision is made and negotiations begin. Interesting local or statewide incentives, even access improvements, usually are not deal makers or deal breakers. Instead, they are sweeteners. Most decisions are driven by the aforementioned big three (labor, transportation, and taxes); and are not appreciably influenced by incentive programs.

Case Study—Large International Shipper/Beneficial Cargo Owner

Overview. This case study is based on discussions with an interviewee that requested anonymity and will be referred to as Beneficial Cargo Owner (BCO). The business model of BCO is to sell and ship its product to retailers within the United States and globally. Although BCO does some direct retailing, this only accounts for about 12% to 15% of its annual business. The vast majority is distributed/sold to retailers around the world, including almost 160 countries. BCO is responsible for the shipment of about 60,000, 40-foot equivalent units (FEU) annually, of which about one-half remain within the United States.

BCO is mostly involved in contract manufacturing, and minimizes its ownership of manufacturing or distribution facilities. The company believes that its core competencies are product development and marketing, and attempts to minimize the infrastructure or facilities that it owns or operates. However, the company does maintain two distribution centers in the United States, which are located strategically close to large population centers/markets.

Due to the multinational nature of this BCO, the decision-making process has been divided into four regions (Americas, Asia/Pacific, Africa, and Europe), however, all responses and information contained in this section pertain to the supply chain and processes for the Americas.

Evaluation Process. Most of the freight investment decisions made by this company involve changes or improvements to their supply chain—from source to delivery at the customer. BCO seeks to maximize the efficiency of its supply chain and employs many logistics professionals who are dedicated to minimizing the time and costs of the international and national supply chains. Given the size and complexity of this company's supply chains, there is not one, single evaluation process that is used prior to making decisions. In fact, the company stresses the flexibility of its evaluation process to respond to the different types of investment decisions that may arise. However, there are certain steps that are generally included in the process, as follows:

- **Tracking and monitoring supply chain performance—**The tracking of supply chain performance currently is one of the BCO focus areas, and is growing steadily in sophistication. BCO recognizes that delays and unpredictable shipments have significant impacts on the inventory requirements of different shippers, and has therefore acquired the tools by which to track the on-time performance of various supply chain segments. Understanding current performance is one of the most important parts of any evaluation process, since it allows BCO to pinpoint where the inefficiencies are in its system.

- **Timeline planning—**Once an issue has been identified, BCO determines an appropriate timeline on which to study or address the issue. For example, a decision to build, site, or operate a distribution center is a very large undertaking, and will be planned on a correspondingly long (strategic) timeframe. However, other decisions—such as the contracts to provide air cargo or marine services—are evaluated every year and are changed to reflect the best combination of costs and service.
- **Ensure that good partnerships are in place—**BCO recognizes the importance of strong, enduring relationships with a broad range of stakeholder types. In addition to maintaining longstanding relationships with manufacturers and retailers, BCO plays a visible role in the transportation and shipping industries. They are active in multiple professional organizations, including the Retail Industry Leaders Association, the Waterfront Coalition, and the Coalition for Responsible Transportation.
- **Ensure that decisions made are as efficient as possible—**BCO recognizes the importance of efficient transportation system performance. The company estimates that 25% of its efforts to maximize supply chain performance are focused on transportation system improvements. In addition, BCO strives to make decisions that are as environmentally efficient as possible. Whether it is in the selection of partners or in the transportation mode selected, BCO evaluates investments with an eye to waste reduction, efficient use of energy, and lessening of emissions of harmful pollutants.

Benefits Assessment. BCO is involved in shipping time-sensitive cargo to many different locations. Although BCO evaluates many variables when considering an investment into its supply chain process, there are three benefits that stand out as being most important: (1) cost; (2) delivery times; and (3) commitment (of the transportation or logistics provider or other partner). Table 3.5 summarizes some of the categories of benefits that are most important to BCO, as well as the specific benefits that are tracked, and the tools used to do so.

In short, the BCO currently uses a single, sophisticated tool for much of its freight investment tracking and decision-making needs. In addition to the quantitative measures evaluated in the freight investment decision-making process, BCO considers some qualitative performance measures, including speed and efficiency of customer service, the strength of customer relationships, and careful and safe management of freight.

3.3 Key Issues and Challenges of Existing Decision-Making Processes

Different freight stakeholders value different types of benefits, which necessarily leads to different evaluation processes.

Different stakeholders clearly use different tools and methods to answer the question "is this a good investment?" Although some benefits are considered by all freight stakeholder groups, each stakeholder group is primarily interested in just a few benefits or impacts. On the private-sector side, freight investment stakeholders are focused primarily on financial benefits, NPV, and ROI. Although these stakeholders *consider* a wider range of variables when determining their participation in a freight investment project, the ultimate decision is generally driven by the project's underlying impact on operating costs and system capacity. On the public-sector side, the list of benefits typically includes economic development, tax revenue, and social/environmental benefits (or disbenefits).

Table 3.5. Primary benefits considered by BCO.

Category	Specific Benefits Tracked	Tool Used
Cost	Late shipments Inventory Cash to delivery cycle	SAP Production/ Supply Chain Software
Delivery Times	Port-to-port time performance Congestion or bottlenecks and their effects on delivery times	SAP Production/ Supply Chain Software
Commitment	Viability of partner companies	SAP Production/ Supply Chain Software
	Environmental sustainability of partner companies	Qualitative Comparisons

Because government agencies often act both as infrastructure providers and holders of the general public interest, they often make decisions that reflect regional mobility goals and the safety, security, and environmental concerns of the communities that the agency represents.

These differences in the types of benefits considered by different stakeholders necessarily lead to different types of freight investment decision processes. The decision-making process employed by public-sector stakeholders is much more "democratic," and focuses on building consensus on a wide range of issues. In many situations, the number of stakeholders with a vote at the table is quite large; the multiple objectives (and impacts) of a proposed freight investment often may be muddled; the funding sources and mechanisms are numerous and complex; and the final decision to move forward or not with any given proposal rarely rests with a single agency or decisionmaker. This complex process has many positive aspects; for example, it has given many people a voice in what happens in their communities, and is more "fail safe" than the early days of publicly funded transportation investments. At the same time, this highly participatory process often drags out the timeframe for planning and implementation of any significant improvements, and may ultimately kill a project or program through death by a thousand cuts.

In comparison to the public-sector process, the private-sector process is much more narrowly focused on projects that directly relate to business goals and objectives. The process is much less inclusive, and stakeholders and decision makers are brought into the process only to address specific issues (e.g., permits, approvals) or to provide specific areas of support (e.g., funding, incentives). As opposed to the public process, the final decision to move forward or not with any given proposal often rests with a single decisionmaker or collection of senior executives.

Benefits are assessed at different points in the process, using different types of tools.

In addition, different stakeholders assess benefits at different points in the process. The public-sector process typically consists of five key steps:

1. **Needs identification—**When system needs and deficiencies are identified and potential approaches are identified;
2. **Plan development—**When transportation vision, goals, and strategies are documented;
3. **Project programming—**When the process of actually implementing transportation improvement projects begins;
4. **Project development—**When more detailed design and a more formal assessment of the necessary permitting and approval activities occurs; and
5. **Project implementation—**When final approval is obtained, detailed construction plans are developed, and right-of-way (if necessary) and construction permits are acquired.

Within this process, public-sector stakeholders (e.g., infrastructure providers, state DOTs and impacted parties) typically begin developing a detailed understanding of potential investment benefits only within the project programming and project development stages. However, with the exception of a handful of states (e.g., Washington State rail investment process), this benefit assessment occurs *after* a proposed project has entered the pipeline, and is generally used to decide among competing investments (both freight-related and non-freight-related) to build support for an investment or suite of investments among impacted parties, and/or to allocate costs and benefits across different stakeholder types.

Among private-sector freight stakeholders (e.g., railroads, shippers, and industrial site developers), potential investment benefits are assessed as a first step in the process. Railroads, for example, immediately assess a project's potential impact on operations and revenue, and calculate NPV of potential investments very early in the process. Similarly, one of the only factors a financial investor or concessionaire will consider within the decision-making process is financial returns, typically via due diligence studies that involve third-party confirmation of market demand and revenue assumptions.

This mismatch on when benefits are assessed within the decision-making process can make it difficult for all types of investment stakeholders to focus attention on freight investments that might have benefits for all parties.

3.4 Existing Data and Tools

There are a number of distinct classes of tools that correspond to the needs of different stakeholder types and their decision-making processes. These tools provide different functions at different points in time, as shown in Figure 3.6.

There are several classes of tools used by different stakeholders to assess these types of benefits, including the following:

- **Strategic planning tools—**These include tools used to assess long-term needs and deficiencies impacting the transportation system and the lifecycle costs of operating and maintaining transportation infrastructure (for asset providers), as well as longer-term market analyses, production, and site selection alternatives (for service providers and end users).
- **Carrier cost and performance analysis tools—**These operational analysis tools, which estimate the operational performance and cost of freight carrier operations under alternative scenarios to represent the impact of transportation projects, programs, or policies, are primarily used by freight infrastructure providers and carriers.

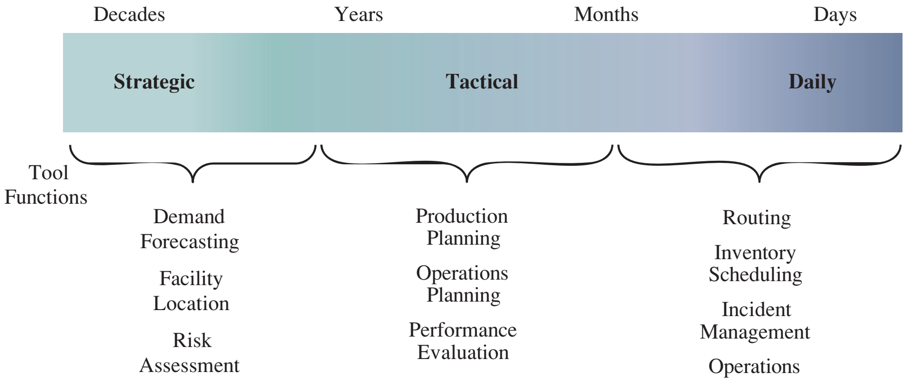


Figure 3.6. Benefit assessment spectrum.

- **Shipper cost and performance models—**These tools estimate the cost and time characteristics of alternative freight mode and service options, and are intended to represent the total logistics time, cost, and safety/reliability tradeoffs available for a shipment so that optimal shipping decisions can be made. These tools are primarily used by end users (i.e., the businesses that generate outgoing freight or the consignees who receive the freight and ultimately pay the shipper cost).
- **Transportation system efficiency models—**These tools, often defined as benefit/cost analysis systems, are intended to evaluate the benefit and cost streams over a specified period of analysis to determine whether a proposed investment will yield benefits in excess of its cost.
- **Economic development impact models—**These tools estimate impacts of transportation projects on income and jobs in the economy, and are primarily used by public-sector (local, regional, or state) transportation agencies to explicitly consider business productivity and economic development impacts that are not represented by transportation system efficiency tools.
- **Financial impact accounting tools—**These tools, typically used by those that have a direct stake in the cost of a project, provide estimates on how the proposal will affect outgoing cost streams, incoming revenue streams, cash flow, borrowing or bond requirements, net profit or loss over time, upside/downside risk, and rate of return.
- **Risk assessment tools—**These tools assist private-sector asset providers and end users in understanding and quantifying critical areas of uncertainty related to making investment decisions.

These tools have varying degrees of importance to different stakeholders, as shown in Table 3.6.

The following sections describe the types of analysis tools within each of these categories used by freight stakeholders to evaluate freight investments. Specific attention currently is given to tools that are sensitive to features of freight transportation, and public-private sector interaction that is inherent in multimodal freight planning and policy.

Table 3.6. Importance of analysis tools to freight investment stakeholders.

	Tool Types						
Stakeholder Types	**Strategic Planning**	**Carrier Cost and Performance**	**Shipper Cost and Performance**	**Transportation System Efficiency**	**Economic Development Impact**	**Financial Impact**	**Risk Assessment**
Asset Provider	●	●	○	●	●	●	●
Service Provider	●	●	◑	●	○	◑	●
End User	◑	◑	●	◑	○	◑	◑
Impacted Party	○	○	○	◑	◑	○	○

Less Important ○ → ◑ → ● More Important.

Strategic Planning Tools

Strategic planning occurs on a long time horizon (20 to 30 years for asset providers and 2 to 5 years for service providers), and is the place where the most costly investment decisions are made. Strategic planning extends beyond 5 years for public-sector agencies and entities, as well as for large freight service providers or end user companies with stable markets. Long-term strategic planning horizons also are typical for those asset providers making right-of-way or new capacity investments.

Strategic planning for public-sector agencies is typically accomplished through the development of the long-range transportation plan, which describes the vision, goals, and associated policies to guide investment in the statewide or regional transportation system over a 20-year timeframe. This document is normally updated every 3 to 5 years. However, there are other important strategic planning activities in which these agencies, particularly state DOTs, are engaged. For instance, cost-effective management of transportation infrastructure is an increasingly important activity of public-sector transportation agencies, particularly as some key infrastructure components (roadways, bridges, locks, and dams) are nearing the end of their useful lives. Most states have developed long-range asset management strategies to help ensure the smooth and cost-effective movement of passengers and goods. Many of these strategies entail specific designs, operations, and maintenance budgeting activities. In addition, many states are beginning to pay close attention to bond rating scores from the nation's credit rating services, such as Moody's, Standard & Poor's, and others. To ensure top ratings, states are paying close attention to long-term stability of the revenue streams, cost-effective management strategies, maintenance activities, and public support for transportation investments.

On the private-sector side, the planning horizon may be shorter, particularly for service providers who must respond to conditions created by their end users and their asset providers or those operating in markets with high degrees of fluctuation. The useful lives of many freight assets extend beyond these ranges; certainly for connector links and activity hubs, and for many kinds of mobile equipment as well. Although financial evaluations allow for this, fleets, service networks, and supply chains are adjusted frequently, and assets are moved into secondary markets (right-of-way being the most illiquid).

Typical tools used in strategic planning include travel demand forecasting and network optimization. The technology application to support forecasting and the strategic plans include data available from financial systems, operations management systems, and others. These are the tools that are used to make long-range investment decisions.

Forecasting is a central aspect of the planning process for all types of freight stakeholders. This is where infrastructure needs are determined, market estimations are made, and facility locations, equipment specifications, or carrier requirements are evaluated. From the public freight planning perspective, this is where the greatest opportunity lies for developing the environment that will attract or deter freight and supply chain facilities to locate or expand in a particular area. This is the time in the product lifecycle where the private sector will evaluate all of the data that it has available, not only in terms of potential markets, but also considering operating history, financial performance specific to an area, and future development plans not only for the company but also within an operational zone or location.

Carrier Cost and Performance Analysis Tools

Systems and metrics for operations are one of the most important investments made in the private sector relative to service networks and supply chains. These are the technologies, equipment, and software that measure cost and revenue that define the utilization of capital in a variety of forms. Private-sector entities are motivated to manage two things: the utilization of assets (which drives revenue) and the reduction of operating costs.

Operations tools are employed to manage asset investments, and through that capability they also predict performance and the quality of opportunities. These tools are used in each of the time horizons described earlier in Figure 3.6. Historical data are important to the planning process and these tools also provide input to daily tactical decisions of shippers and carriers in response to short-term needs that are revealed via the metrics. In general, there are separate types of tools and models for each transportation mode—railroad, aviation, and trucking operations—although a common feature of all of these models is the estimation of speed, reliability, capacity, and cost for operating a given modal freight service, under alternative scenarios for infrastructure capacity and usage rules.

Typical tools include the following:

- **Routing tools** for truck movements that allow a unit to change routes for congestion avoidance, to make toll choices, and to improve overall fuel efficiency. On the end user side, product and transportation tracking allows a shipper to shift a product quickly to an alternate point of sale while the goods are still in transit. Tools of this sort are very powerful in the tactical realm.
- **Railroad operations tools** that estimate how a given rail infrastructure improvement would actually change volumes, speeds, and reliability. The source data include specific track, siding and yard conditions, plus road, local and work train characteristics, and schedules that are proprietary to the railroads. Nevertheless, such data have been forth-

coming in cooperative ventures, and there are some generally recognized software tools that work with the data. Rail Traffic Controller (Berkeley Simulation Software), RAILS 2000 (CANAC/Savage Industries), and RAILSIM (Systra) are all forms of simulation systems used by railroads to prioritize routing of trains through the network, identify conflicts, and measure effectiveness. Besides the simulation systems, there also has been some work on parametric rail capacity models that develop capacity curves for various operating characteristics, and identify areas with capacity constraints.(*2*) In addition to these tools, FRA has developed a General Train Movement Simulator (GTMS) designed to support evaluations of new Positive Train Control (PTC) systems and capacity enhancements. As a newly available tool, GTMS is being tested by Class I railroads, and should be available for general use soon for public- and private-sector stakeholders.

- **Airport operations tools** that estimate the capacity of runway systems and the level of delay that they present when faced with alternative demand levels. These include Total Airport and Airspace Modeler (TAAM) System, the Airfield Capacity Model (ACM) from MITRE Corporation, the FAA's Airport and Airspace Simulation Model (SIMMOD), and the LMI Runway Capacity Model from the Massachusetts Institute of Technology (MIT). There also is the Airport Capacity Analysis Through Simulation (ACATS) model, which is an attempt to improve on the ACM framework.(*2*)
- **Marine port operations tools,** many of which have been refined by university researchers, typically account for both passenger and freight traffic, recognizing local differences in types of freight (bulk, break bulk, and containers), mix of ship characteristics, water depth and wave motion, and positions of terminals. Typical port planning tools include computer simulation models for port operations, port terminal container handling, and terminal expansion and development (including investment in quays, quay cranes, and storage space). Newly developing models are attempting to integrate traditional performance measures—such as time savings, safety, and operating costs—with wider measures that include the cost of vehicle emissions and monetized health benefits.

Shipper Cost and Performance Models

These tools, typically used to approximate the aggregate decisions made by end users (freight shippers, consignees, or their agents) include various forms of shipping choice, supply chain, or total logistics cost models. In general, these tools estimate the cost and time characteristics of alternative freight mode and service options. They are intended to represent the total logistics time, cost, and safety/reliability tradeoffs available for shipments, so that optimal shipping decisions can be made. Tools include the following:

- **Modal diversion models** that forecast how freight movements shift in response to changes in the availability, cost, and/or time performance of available modal alternatives. Most modal diversion models used in transportation facility planning are focused on truck-rail-intermodal options, because there are very real tradeoffs that shippers face when considering ground transportation options for medium- and long-distance travel. On the other hand, air and marine options focus more exclusively on long-distance shipping and offer more distinctly different cost, performance, and availability features. These tools are of interest primarily to public-sector entities.
- **Total logistics cost models** predict how shippers respond to changes in the costs of modal and service alternatives. They actually estimate the total logistics cost of shipping, including direct transportation expense and inventory cost associated with modal lot sizes and service profiles. The models assume that customers (shippers) select the lowest cost option, and they depend on information about logistical factors in transportation and industry. Shipments are assigned to one mode or another, while allowing for probability uncertainty associated with inventory risk, carrier performance, or unmeasured factors. Sometimes, these models are based on detailed commodity-specific data. Other times, the models may be simple spreadsheet tools to estimate tons switching mode and resulting cost and travel-time differences under different project assumptions.
- **Intermodal Transportation and Inventory Cost (ITIC) Model** is a freight mode choice model from FHWA's Office of Freight Management and FRA. It attempts to calculate the logistics cost and decision tradeoffs seen by shipper logistics managers and then assigns the truck/rail diversion to alternatives that minimize total logistics cost. It is based on an earlier model developed for FRA in 1995.
- **Spreadsheet Logistics Model** developed by MIT estimates the truck/rail mode choice for 48 typical types of customers. This is done on the basis of given customer characteristics (use rate and trip length); commodity characteristics (value/pound); and mode characteristics (e.g., price, trip time, and reliability) for rail, truck, and intermodal options.(*3*)
- **Market share models** are an alternative predictor of freight shipper choices. They do not estimate logistics costs. Instead, they are based on a statistical correlation between modal performance factors and traffic capture (revealed preferences), and they then project traffic swings when relative performance changes. Stated-preference models have similar purposes, but are developed statistically from structured interviews with freight transportation buyers

about the tradeoffs they would make if faced with hypothetical choices. A statistical process is then applied to these responses to infer decision points and probable traffic diversions in response to changes in competitive service offerings. For instance, one such model estimates truck-rail diversion based on a combination of the (1) Uniform Rail Costing System, (2) TRANSEARCH commodity-flow database, and (3) a demand elasticity model calibrated from historical carrier price and volume data. The elasticities distinguish price sensitivity by traffic type, geographic region, and commodity group, and the model forecasts the specific freight flows that would likely be diverted to rail, given changes in railroad or intermodal service characteristics.

- **The Uniform Rail Costing System (URCS) Model** (Surface Transportation Board) can estimate the changes in shipper productivity associated with rail system performance changes. The URCS model uses data on average carrier cost and performance measures to estimate the cost of providing service, so it can estimate how a change in facility capacity or speed (affecting rail cars per day) would translate into average shipper dollar savings per ton-mile.

Transportation System Efficiency Models (Benefit/Cost Systems)

These tools are intended for use by public-sector (local, regional, or state) transportation planners. They are defined as benefit/cost analysis systems, intended to evaluate the benefit and cost streams over a specified period of analysis to determine whether a proposed investment will yield benefit in excess of its cost (after monetizing all streams and discounting to present value). In current practice, benefits are most commonly defined in terms of *transportation system efficiency*, reflecting estimated savings in travel time, safety, and vehicle use costs that a project can provide for vehicle movement through the transportation network. These savings are typically defined in terms of the savings accruing to vehicle owners, drivers, and passengers.

The public-sector benefit/cost tools grew out of the urban transportation planning process and, accordingly, they tend to focus on road and transit systems with greatest detail on passenger movements. For instance, the handling of car and transit travel typically includes an accounting of the number of riders and trip purposes. On the other hand, the handling of freight vehicles seldom includes any information on either the type of cargo or amount being carried. The direct benefit calculation in these tools is often referred to as a measure of user cost savings, although freight planners often prefer the label *traveler cost savings* to highlight that these calculations include costs associated with travelers and vehicles, but not shippers and consignees, who are the true users of freight transportation systems and direct beneficiaries of improvements in freight movement. Externality impacts on the environment (primarily air quality impacts) are sometimes also added as a broader societal impact. Typical tools are described in the following sections.

Traditional Benefit/Cost Tools

There are several modeling tools that are widely used to assess transportation system efficiency impacts (in terms of traveler benefits) for highway investments. They share common features—the valuation of travel-time savings for different classes of travel, as well as vehicle operating costs, safety, and air quality impacts. Commonly used benefit/cost tools include the following:

- **Cal-B/C,** developed by the California DOT (Caltrans), is a spreadsheet model for benefit/cost analysis of highway and transit projects in a corridor that already contains a highway facility or a transit service. Highway projects may include high-occupancy vehicle (HOV) and passing lanes, interchange improvements, and bypass highways. Transit improvements may include enhanced bus services, light rail, and passenger heavy-rail projects. Default data are given for California conditions.
- **MicroBENCOST** is designed to analyze seven types of highway improvements in a corridor: (1) capacity enhancement, (2) bypass construction, (3) intersection or interchange improvement, (4) pavement rehabilitation, (5) bridge improvement, (6) highway safety improvement, and (7) railroad grade crossing improvement. Highways may contain HOV facilities. This tool was originally developed by NCHRP as a computerized implementation of recommended practice set out by AASHTO.(*4*)
- **Surface Transportation Efficiency Analysis Model (STEAM)** is designed to assess multimodal urban transportation investment and policy alternatives at the regional and corridor levels. Transportation system alternatives may include up to seven modes. Peak and off-peak periods and multiple trip purposes may be considered. The model is closely linked to outputs from the four-step urban transportation modeling process.
- **Highway Economic Reporting System (HERS)** is a system-level optimization framework for analyzing investment strategies to maintain and improve an existing highway network. New highway construction is not considered. The program automatically generates candidates for highway improvements, which may be combined with user-specified improvements. It then determines the best combination of projects. HERS is closely linked to the Highway Performance Monitoring System (HPMS).

- **StratBENCOST** is a strategic-level evaluation method to analyze investment alternatives for expanding and improving a highway system. This tool represents an upgrade from previous analysis methods by incorporating cost calculations from MicroBENCOST and HERS, and adding consideration of risk and uncertainty. A particular strength of this model is its explicit consideration of the random nature of input parameters. New highway projects, as well as improvements to existing highways, may be considered. Nonhighway modes are not considered. The program is used to compare an investment alternative to a base condition, which may be another investment alternative. The program can perform either a single-segment analysis with or without induced traffic, or a network-level evaluation with traffic diversion; the latter typically requires linkage to the four-step transportation modeling process.

BCA.Net

This system was developed for the FHWA Office of Asset Management as a Web-based tool for benefit/cost analysis of highway projects. The tool is freely accessible over the Internet, and requires no user-installed software other than a Web browser. The tool compares and evaluates alternative highway improvement projects (e.g., preservation, lane-widening, lane additions, new alignments, addition of traffic control devices, intersection upgrades). Projects for comparison in BCA.Net are multiyear, full lifecycle investment and maintenance strategies. Work zone costs (e.g., user costs associated with construction-related delay) are included in the calculation of net benefits.

The benefits considered by BCA.Net include highway user costs (travel time and vehicle operating costs, safety) and environmental impacts. Benefits in BCA.Net are calculated based upon changes in traffic flow, given improvements in volume and capacity relationships as defined in *Highway Capacity Manual 2000.*(*5*) User cost calculations (given average hourly traffic, speed, and roadway parameters) are based on the HERS model (not MicroBENCOST, as has been reported elsewhere). BCA.Net includes the calculation of costs and benefits due to induced demand. BCA.Net has built-in risk analysis capabilities, and benefit/cost and intermediate results can be viewed in charts and reports as probabilistic ranges.

In BCA.Net, the user specifies forecast demand in the base year and rates of growth in the near term and long term. For three user-defined years in the period of analysis, users specify time-of-day distribution of traffic (e.g., peak, peak shoulder, off-peak) and traffic mix by vehicle type (e.g., auto, truck, bus). In a BCA.Net analysis, users divide the year into as many seasonal traffic patterns as required. If roadway saturation limits are reached in peak periods, BCA.Net will spread traffic to peak shoulder and off-peak periods. From the freight perspective, BCA.Net accounts for the impact of trucks on traffic flows and benefits, while permitting users to specify—at a high level of granularity—the amount of trucks among total traffic over the period of analysis.

GradeDec.Net

This tool, sponsored by FRA, is a Web-based system for evaluating the safety impacts and the benefit/cost of improvements to highway-rail grade crossings in a corridor or region. The tool is freely accessible over the Internet, and requires no user-installed software other than a Web browser. The tool has been used by DOTs, railroads, MPOs, and consultants for projects in dozens of jurisdictions. The benefits considered by GradeDec.Net include the array of highway user costs (travel time and vehicle operating costs), safety effects for highway and rail users, and environmental impacts.

From a freight planning perspective, it can be important to consider the fact that growth in railroad traffic near rail-highway intermodal facilities and large railroad traffic diversions due to system improvements often result in more frequently blocked crossings and blocks of longer duration, which are a focus of GradeDec.Net. Congestion and environmental effects due to queued vehicles at crossings are a major concern when considering rail system upgrades to accommodate increased flows of freight in the vicinity of metropolitan areas. GradeDec.Net includes a number of features for evaluating the benefit/cost of roadway capital improvements at crossings (i.e., grade separations, approach improvements) and traffic management mitigating measures (i.e., one-way restrictions, redirection of traffic to adjacent crossings, signal synchronization). The tool permits the specification of percentage of trucks in the traffic mix. GradeDec.Net allows for the evaluation of multiyear capital improvements in a corridor. GradeDec.Net has built-in risk analysis capabilities and benefit/cost calculators. Intermediate results can be viewed in charts and reports as probabilistic ranges.

FHWA Highway Freight Logistics Reorganization Benefits Estimation Tool

This tool seeks to quantify certain freight improvement benefits that are not captured in traditional benefit/cost analysis (BCA). The FHWA tool seeks to measure the second-order benefits, that come about when firms direct the money saved on logistics expenses away from maintaining inventory, and toward other more productive uses. These benefits can then be added to those estimated through BCA to arrive at a complete picture of total benefits.

Beginning with a national estimate of highway freight demand to delay (i.e., the price), the analysis then estimates national second-order benefits that would arise out of highway freight improvement projects. Finally, these results are disaggregated for use in local and regional highway investment studies to provide accurate estimates of second-order benefits for smaller areas, such as MPOs or states, and encapsulated within a spreadsheet model. The Highway Freight Logistics Reorganization Benefits Estimation Tool consists of the following four basic components:

1. **Estimation inputs,** which gather data from the user describing the specific highway segment under consideration, initial (pre-improvement) conditions, and anticipated changes due to the improvement. Initial conditions data include standard transportation performance measures (such as annual truck-miles on the corridor, percentage of trucks in the traffic mix, and average speeds), as well as estimates of the value of time, freight vehicle operating costs, and travel-time reliability. Anticipated changes involve expected savings in operating costs and travel times, and changes in reliability of travel time. For multistate projects, users can select a two-state model configuration, which utilizes input data from both states. Users can opt for predefined values for the various parameters, or they can override the predefined values with their own inputs. The predefined values are based on research and may be state specific, national averages, or calculated from other inputs.
2. **Conventional BCA freight benefits input,** which allows users to input the freight benefits estimates from a conventional highway cost/benefit analysis into the tool. These would be the freight-specific benefits, which begin to accrue in a certain year (defined by the user), and continue through the total number of years in the analysis. The tool can accommodate any type of monetized units (e.g., thousands, millions, or billions of dollars) in either nominal or real terms.
3. **Summary of results,** which summarizes the results of the analysis as calculated based on the input values, and requires no user input. The screen provides charts and tables showing generalized truck travel cost and truck transport demand before and after the improvement, and the additional benefit obtained through firms reorganizing their logistics processes. It therefore shows the total additive benefits associated with an improvement (i.e., conventional cost/benefit estimates plus firm reorganization benefits).
4. **Summary of inputs,** which provides a summary of all the data inputs used in the analysis, which is useful for recordkeeping in case analysts need to enter future updates for a specific project.

Economic Development Impact Models

These tools are intended for primary use by public-sector (local, regional, or state) transportation agencies that desire to explicitly consider business productivity and economic development impacts that are not represented by the transportation system efficiency tools. They are sometimes referred to as models of wider economic impacts or economic development impacts. In general, they estimate impacts of transportation projects on income and jobs in the economy. The drivers of these economic impacts may be changes in spending patterns, changes in the relative costs of transportation, or improved market access. As part of their analysis process, these models can recognize business productivity impacts related to logistics, production, and agglomeration economies, as well as trade and business attraction effects that are not included in the transportation system efficiency tools. On the other hand, they typically exclude the value of personal time savings or environmental effects to the extent that they are valued, but do not affect the flow of money in the economy.

An important aspect of economic impact tools is that they trace economic impacts of transportation projects by industry. They generally translate impacts on travel time and operating cost into commodity-specific freight flows and industry-specific income flows as a necessary step in the process of calculating impacts on the flow of money between industries, workers, and households. To varying degrees, most of these tools also incorporate measures of access and connectivity, including labor markets; truck delivery markets; airport service areas; and access to intermodal rail/truck terminals, airports, marine ports, and border crossings.

From the viewpoint of freight investment decisionmakers, these economic impact tools are particularly important because they also can cover productivity effects that span carrier, shipper, and consignee impacts. In some models, these effects are added together in the calculation of overall economic impact, so that the allocation of impact among the various classes of stakeholders may not be well distinguished. However, there are exceptions where business productivity effects are explicitly shown. From the viewpoint of local and statewide decisionmakers, wider economic impact analysis tools can also help answer questions from constituents that benefit/cost analysis fails to address—particularly the extent to which a proposed project may positively or negatively affect the overall business environment of a community and resulting changes in jobs and income. They may further assist economic development agencies to identify how proposed projects may affect their efforts to diversify the area economic base and attract target industries—shifting the quality and pay level of available jobs, reducing dependence on declining industries, or improving business stability by enhancing supporting and complementary activities.

Economic impact models are discussed in terms of two aspects—the core economic model and the analysis framework that translates freight-related transportation impacts into economic model inputs.

Input-Output Models

Input-output (I-O) models have limited application for transportation impact analysis. In the United States, the two most widely used I-O tools are IMPLAN and RIMS-II. Both are regional impact systems built on the basis of the same national U.S. Department of Commerce accounting system, and trace how direct changes in the flow of purchases or sales of one industry lead to broader indirect and induced changes in purchases and sales (and ultimately jobs and income) in other industries in that region. That makes them very useful for estimating the local impact of industry openings, closings, expansions, and contractions.

As a result, both IMPLAN and RIMS-II are widely used to show the job and income impacts of operating or expanding airport and seaport facilities. However, neither tool can estimate the impact of changes in costs or market access, which are the two key impacts of most freight rail and highway projects. For such applications, it is necessary to utilize an external methodology or tool to translate changes in transport costs or access characteristics into direct impacts on the behavior of transportation system users before an I-O model can be used to assess broader impacts.

In practice, the necessary front-end tool can take three forms. First, a market study can be conducted to estimate how a new access route will lead to direct changes in ongoing industry activity. Second, it can just be assumed (rather naively) that all transport cost changes translate into corresponding percentage growth in income and output for those industries. Third, an external cost-elasticity response tool may be employed. All three methods have been used outside the United States and Western Europe, where I-O models are the only available economic impact analysis tools. However, in the United States and Europe, the norm is to rely on economic impact simulation models that have inputs representing changes in transport cost and market access.

Regional Simulation Models

These are tools that forecast future changes in jobs, income, value added, and business output by industry. These models are set up for single or multiple regions and often track the flow of jobs, income, and business activity between regions. They are like I-O models, in that they incorporate representation of inter-industry and interregional flows to show effects of spending changes, but they also add a capability to show time series impact of changes in transport costs. Regional simulation models used in current practice include the following:

- **Computable CGE models—**In Europe, there has been substantial effort to develop computable general equilibrium (CGE) models of the economy for large regions and nations. Typically, these models have a spatial component that tracks transportation connections (and travel times) and trade (industry product flows) among regions, and an industry component that tracks the cost of freight transportation by commodity group between regions. The CGE element estimates the economic impact of transportation projects and policies through a process that first calculates their impact on interregional freight transport cost, effective labor supply, value of capital stock, and overall factor productivity. This can include effects of changing travel times, congestion levels, reliability, accident rates, and operating costs. The macroeconomic response is then estimated as changes in industry growth and associated changes in commodity trade between regions. A notable example for large-scale impact estimation is ASTRA—a systems dynamics simulation model that also models commodity movements in a multimodal context but is spatially limited to major regions within Europe. ASTRA has been used to estimate economic growth effects of projects proposed for the Trans-European Network (TEN), a Europe-wide program for developing new multimodal trade corridors across the continent. For that analysis, the ASTRA model was implemented with the TIPMUC (Transport Infrastructure and Macroeconomic) process that calculated effects of proposed projects on generalized transportation costs by industry.(*6–7*) On a much smaller scale, another European example is PINGO—a spatial CGE model for Norway with 20 regions and 10 commodities.
- **REMI Policy Insight—**In the United States, the REMI Policy Insight Model emerged during the 1980s as a structural simulation model for regional and statewide estimation of economic impacts. It shares many of the features of the spatial CGE model, combining inter-industry I-O equations with transport price response and additional impacts on labor supply/demand and migration rates. To estimate impacts of transport projects or policies, there are REMI Policy Insight inputs, including generic transport cost and overall business operating cost by industry. Changes in effective distance between regions also can be used to calculate changes in generalized transportation costs by industry, which then can affect interregional trade. REMI Policy Insight is flexible and can be built for relatively small areas (counties) or for larger regions. In practice, REMI Policy Insight also needs a front-end tool to translate freight-related transportation impacts into economic model inputs. One option is REMI TranSight. TranSight directly links results of a road network and travel demand model to the REMI Policy Insight macroeconomic model. This front end, used in Oregon and Connecticut, allows the user to change inputs to the transportation model (affecting car/transit mode split, vehicle volumes, speeds, or distances) to represent alternative

future scenarios. However, the modal choices are limited to highway modes and rail transit; there is no separate freight rail mode and no ability to differentially affect truck versus rail impacts on either transport cost or effective distance. Over the past decade, a variety of other analysis systems have emerged that provide a more useful interface for use of REMI Policy Insight. They all share a greater ability to assess economic impacts, benefits, and costs of transportation network alternatives at a statewide level and include the following:

  - **MCIBAS** (Major Corridor Impact-Business Analysis System)—A system developed for Indiana DOT for corridor analysis;
  - **HEAT** (Highway Economic Analysis Tool)—A system developed for Montana DOT for corridor analysis; and
  - **BEST** (Benefits Estimation System for Transportation) spreadsheet tool—A methodology developed for Michigan DOT for corridor analysis.

- **TREDIS with CRIO-IMPLAN—**Web-based tools for small area transportation impact analysis emerged in 2007 with the CRIO-IMPLAN model, offered as part of the TREDIS system. CRIO-IMPLAN follows the concept of Occam's Razor as "a reduced form regional model that adds a strong set of features for estimating the incremental effects of transportation improvements at the local and regional levels, but shaves off broader macroeconomic factors that do not normally come into play for these types of situations."(*8*) It combines an interregional I-O model with trade flows, together with a time series framework for estimating economic growth forecasts over time, and "a series of econometrically derived functions relating transportation access and travel cost changes to shifts in local industry output and employment growth."(*8*) The access factors include same-day truck delivery, labor market, and intermodal air, rail, marine, and truck freight terminal access. Interregional trade (and associated costs) are represented by both commodity code and mode, with alternatives for utilizing HIS/Global Insight's TRANSEARCH commodity flow database, FHWA's Freight Analysis Framework (FAF), or other freight flow data sources. It has been used with the broader TREDIS front-end system in Texas, Kansas, Wisconsin, Illinois, Massachusetts, and 20 other states.
- **Global Insight Economic Model—**For state-level freight policy studies, the Global Insight freight model provides a specialized economic impact analysis system. Leveraging the short- and long-term forecasting macroeconomic models of Global Insight, this system provides highly detailed responses to changes in transport costs by mode and commodity. It utilizes econometric (statistical) equations that are sensitive to changes in transport costs per ton for transporting a wide range of commodities by all available freight modes. It also includes detailed information on freight flows by commodity and mode. The model forecasts changes in wages, prices, and spending patterns. This model option currently is available at a state or multistate level, working with the TREDIS front-end system.

Spatial Access Impact Models

These are tools that forecast impacts of local changes in transport access and connectivity on future attraction of business activity to an area. They originated in the economic development field as regional business attraction analysis tools, and have since migrated to mainstream transportation planning. Examples of relevance to freight transportation planning are discussed below.

- **The University of Maryland spatial econometric model** estimated, at the zip code level, the effect of highway projects on the level of economic activity and growth in a zone, based on a wide variety of transportation indicators. These included network density and spatial agglomeration, as well as changes in access times to airports, intermodal rail/truck freight terminals and rail transit, and the size of labor, consumer, and supplier markets. This model was used to analyze expected impacts of a proposed highway corridor development in Maryland.
- **LEAP (Local Economic Assessment Package)** was originally developed by the Appalachian Regional Commission for business attraction analysis in the 13 Appalachian states. It explicitly showed how costs of land, labor, energy, and taxes interacted with transport costs and access (including ground access time to intermodal rail, air and marine ports, and highways) to differentially affect the attraction of various industries to an area. It was subsequently applied by consultants to highway impact studies in a dozen Appalachian states. A commercial version of LEAP also was incorporated into the Montana DOT's HEAT system and the TREDIS framework as applied for regional freight access analysis in Portland (Oregon), Vancouver (British Columbia), Chicago (Illinois), and Houston (Texas).

Integrated Frameworks

These combine economic simulation models, front-end tools to translate travel model data into economic models, and back-end tools that translate the economic model results into information for freight project planning and decision making. There are both low-end (general approach) and high-end (tailored approach) options.

- **Generic Approach: TREDIS—**This is a modular framework operating through a Web-based server to integrate various tools for travel impact analysis, spatial access impact analysis,

regional economic impact analysis, and benefit/cost analysis. The primary benefit of TREDIS is that it provides a flexible off-the-shelf methodology for regional or state agencies to conduct economic impact and benefit/cost analysis in a consistent manner spanning road, rail, air, and marine modes. It has been applied with various combinations of road and pavement management systems, travel demand and network models, land use models, commodity flow databases, and economic models (the latter, including REMI, CRIO-IMPLAN, and HIS/Global Insight).
- **Tailored Approach: HEAT—**This is a modular system that integrates a statewide highway network model and a statewide economic impact model together through a geographic information system (GIS) to provide a high degree of spatially detailed information. It is a custom-built system, tailored to the needs of the specific state, providing graphical map-based information on (1) economic conditions among communities, (2) transportation dependence and commodity-specific impacts among industries, and (3) commuting and freight flows along highway networks. It also provides both economic impact and benefit/cost analysis results. However, it focuses specifically on highway networks. Since the core access and economic impact modules in TREDIS and HEAT are essentially the same, it is possible for a state DOT to start using TREDIS and later upgrade to the GIS-based HEAT system for highway analysis.

Financial Impact Accounting Tools

These tools are intended for primary use for financial analysis by stakeholders that have a role in transportation project development or ongoing operation, or that operate services using the infrastructure. They may be public agencies, private operators, or public-private partnerships. They are commonly used as decision-support tools to assess how much alternative projects and scenarios will affect outgoing cost streams, incoming revenue streams, cash flow, borrowing or bond requirements, net profit or loss over time, upside/downside risk, and rate of return.

The private sector utilizes a number of different financial tools that are centered on systems that feed general ledger and income statements. These tools are both commercially available or home grown and are often a combination of the two. The general ledger builds on input from the transactional systems such as receivables, payables, and the operating systems that track cost items like fuel economy, maintenance costs, production efficiency, network routing, etc. Systems are applied to determine the effectiveness of pricing strategies, risk management, and other ancillary functions. Often, these systems include equipment investments for tracking, process monitoring, and efficiency. Utilization of the physical assets and resources is reported via the financial data.

Another category of financial analysis tools deals not with freight generation or freight flows, but rather with the economic viability of transportation infrastructure projects and the freight services that use that infrastructure. These tools are related to economic impact analysis tools only in the sense that (1) both are driven by common assumptions about the transportation project costs and demand response and (2) direct impacts on productivity and wider impacts on the economy also will affect financial performance of stakeholders. However, they become particularly relevant for freight because of the involvement of private companies as developers and operators of many freight facilities (particularly rail and port, but also increasingly air and highway facilities). Private companies providing shipping services also are major users of both publicly and privately operated freight facilities.

There are several types of financial models:

- For **public agencies,** fiscal impact models calculate impacts on public tax and fee revenues, as well as requirements for increasing expenditures to serve new population and economic growth that may result from the projects (including public safety, education, and other municipal and state services).
- For **private entities,** pro forma models calculate risk and rate of return associated with proposed, new investment projects. A due diligence study (involving third-party confirmation of market demand and revenue assumptions) is commonly required for private-sector financing.
- For **public-private partnerships,** a combination of both types of models is necessary. These are commonly developed on an ad hoc basis to meet the needs of the specific situation.

Risk Assessment Tools

As described, risk assessment has been a critical component of private-sector investment decision-making for a long time and has taken on more importance among public-sector agencies given recent interest in utilizing public-private partnerships or shared asset activities. Although infrastructure and public projects do not fall into a standard process, the tools used to determine private-sector investment benefits are fairly generic and include due diligence tools and risk assessment tools, described below.

Due Diligence Tools

Due diligence tools include economic demand estimation, technical review, and financial modeling. The common goal of these tools is to verify the information and potential of a particular project. Typical types of tools or methods used include the following:

- **Economic demand estimation and forecasting—**Economic demand estimation is a statistical tool that allows for determining the level of demand for a service or good based on a host of independent variables. Variables to forecast a dependent variable such as truck volume may include local demographics, fuel prices, tolls, regulations, and local shocks and events. Such a forecast exercise may generate the revenue and cost factors that may feed into a financial analysis model.
- **Technical advisory—**In the case of private concessionaires, a technical advisor may review documentation and perform on-site inspections of physical infrastructure and facilities in order to understand the state-of-good-repair standards, which in turn contribute to the overall understanding of costs associated with maintenance, rehabilitation, and replacement. By thoroughly reviewing all factors related to operations and maintenance, costs can be optimized. The quantitative product of a technical advisory exercise may include a thoroughly developed cost model that feeds into the private party's financial model.
- **Financial model—**A financial model combines the economic and technical aspects for developing a baseline scenario, which provides measures of the feasibility and health of a project. A key indicator from the financial model is the internal rate of return (IRR), which is the discount rate that sets the NPV of all cash flows equal to zero. It is a common measure for investments that may produce multiple cash flows over a period. As such, it can be found not only for equal, periodic investments but for any series of investments and returns. This makes IRR an attractive approach in the private sector. However, this method is problematic, because it assumes that all of the intermediate cash flows can be discounted/reinvested at the IRR. This is particularly unrealistic when the IRR is very high. This method also is sensitive to the sequencing and timing of investments and returns.(*2*)

Risk Evaluation Tools

Understanding risks associated with a project involves evaluating design and construction, market risk, operation and maintenance risk, financing risk, insurance, and termination risk. The private sector often is interested in understanding the uncertainty that surrounds forecasts and projects. A number of tools can be consulted to address these risks, including a risk allocation matrix and due diligence financial and technical risk analysis through statistical means.

When engaging in public-private partnerships, a common practice is to develop a risk allocation matrix that clearly outlines categorical risks and the responsibilities of each party. Risks are allocated and quantified to clearly describe the various scenarios, costs, and responsibilities involved. Areas of concern may include insurance, permitting, design, and construction, among others. Table 3.7 outlines the general types of risks that are accounted for and the parties that may take responsibility.

Each conceived risk should be collected and quantified in a detailed risk matrix as shown in Table 3.8. The basic elements may include

- An explicit explanation of the risk event or scenario accompanied by logical and achievable remedies and solutions,
- A rating of the potential of the occurrence of such a risk,
- The party primarily responsible for the risk, and
- Percent share of the risk by party along with the dollar value of the cost.

As a part of evaluating investments, a common practice is to develop forecasts, which carry an obvious degree of uncertainty. Risks can be technical and financial, including cost overruns and benefit shortfalls. Monte Carlo methods can be used to simulate the various sources of uncertainty that affect the outcome of projects, with respect to costs or benefits, and calculate an average expected value for the given possible values of the components. Risk analysis involves the following steps:

- Identification of the key input variables that affect the baseline forecasts,
- Definition of the probability distributions around each key variable,
- Definition of the sensitivity functions for each variable, and
- Running iterations of the model to determine the average outcome.

3.5 Data and Tools Summary

Table 3.9 provides a summary of the utility of existing data and tools to estimate the benefits most important to different freight investment stakeholders at different project scales (local/site, statewide/regional, and multistate/national).

Key Issues and Challenges of Existing Data and Tools

Existing evaluation tools have limitations that hinder their ability to fully assess freight investment benefits.

There are a number of issues that limit the effectiveness of existing evaluation tools in assessing benefits across all freight investment and stakeholder types. For instance, the reliability measures used for public investments, which are calculated by the transportation efficiency tools described above, often do not do justice to freight investments. The reliability measures embedded within these tools often use average measures of delay and, as a result, can miss that sometimes an addi-

Table 3.7. Types of risks and risk allocations.

Risk	Private	Public
Legislative (Existing and Future)	Sharing within defined parameters	Major responsibility
Acquisition and Environmental	Sharing within defined parameters, with public-sector assistance	Major responsibility
Permitting and Planning	Sharing within defined parameters	Major responsibility
Design and Construction	Major responsibility	–
Operation and Maintenance	Major responsibility	Sharing within defined parameters
Financing	Major responsibility	–
Termination	Major responsibility, unless demonstrably caused by public	–
Insurance	Major responsibility	Sharing based on availability of commercial rates
Force Majeure	Sharing based on event and availability of insurance	Sharing based on event and availability of insurance

Source: Halcrow, Inc.

Table 3.8. General template of risks.

Inputs	Input
Overall Risk Characteristics	
Category of Risk	Risk Type
Description	Event/Scenario Being Addressed
• Party Primarily Bearing Risk	
- Party 1 Risk Share	Y%
- Party 2 Risk Share	X%
• Risk Value (in USD)	Dollar Value
- Annualized Value at Risk ($k/yr)	Dollar Value
• Optional Additional Risk Controls	Remedies and Proposed Solutions
- Party Best Able to Direct Mitigation	Party X
- Effect of Additional Risk Controls on Level of Risk	High, Medium, Low
- Residual Risk	Percentage
- Annualized Residual Value at Risk ($k/yr)	Dollar Value
- Basis for Risk Allocation	Unit of Measure
Party-Specific Risks	
• Party 1	Percent Share of Risk
- Pre-Mitigation Risk	Dollar Value
- Post-Mitigation Risk	Dollar Value
• Party 2	Percent Share of Risk
- Pre-Mitigation Risk	Dollar Value
- Post-Mitigation Risk	Dollar Value

Source: Halcrow, Inc.

Table 3.9. Adequacy of existing data and tools to measure benefit types (by stakeholder).

		Stakeholder Types			
Benefit Type	Benefit Scale	Asset Provider	Service Provider	End User	Other Impacted Party
Capital Costs	Local/Site	●	–	●	–
	Statewide/Regional	●	–	◑	–
	Multistate/National	◑	–	◑	–
Maintenance Costs	Local/Site	●	–	●	–
	Statewide/Regional	●	–	◑	–
	Multistate/National	◑	–	◑	–
Operating Costs	Local/Site	●	●	●	–
	Statewide/Regional	●	◑	◑	–
	Multistate/National	◑	◑	◑	–
Capacity	Local/Site	●	●	–	●
	Statewide/Regional	●	◑	–	●
	Multistate/National	◑	◑	–	◑
Loss/Damage	Local/Site	–	●	●	–
	Statewide/Regional	–	●	●	–
	Multistate/National	–	●	●	–
Scheduling/Reliability	Local/Site	–	●	●	–
	Statewide/Regional	–	◑	●	–
	Multistate/National	–	◑	◑	–
Business Productivity	Local/Site	–	–	●	–
	Statewide/Regional	–	–	●	–
	Multistate/National	–	–	●	–
Tax Revenue	Local/Site	–	–	–	●
	Statewide/Regional	–	–	–	●
	Multistate/National	–	–	–	◑
Economic Development	Local/Site	●	–	–	●
	Statewide/Regional	●	–	–	●
	Multistate/National	◑	–	–	◑
Environmental Quality	Local/Site	●	●	●	●
	Statewide/Regional	●	●	●	●
	Multistate/National	◑	◑	◑	◑

● Data/Tools Adequate ◑ Data/Tools Inadequate – Data/Tools Not Required for This Stakeholdder

tional minute or two of delay for freight causes a "missed day" or a "missed shipment," resulting in impacts that are much larger than the additional minute would imply.

In addition, these tools do not effectively integrate complex freight and passenger shared use issues and implications, particularly for rail investments. Although freight and passenger shared use is a given on the highway system, passenger needs often drive public-sector highway investment decisions and few existing tools assign any difference in time or cost savings associated with empty versus full trucks, or differences by type of commodity being carried—factors that are significant when assessing public and private benefits. In order to arrive at an agreement for shared use on the rail system, the operational impacts of both passenger and freight interests must be addressed, often under alternative scenarios of capacity enhancement (i.e., added sidings for meets and overtakes, double-tracking, general track upgrades to permit higher speeds, traffic control improvements). Existing evaluation tools do not effectively manage these and other types of shared use issues and impacts.

Finally, the tools available for use by public-sector agencies often rely on data that are proprietary to private-sector service providers. When evaluating rail projects, for instance, these tools need detailed information on volumes, commodity types, track speeds, and operational strategies. In addition, these models rely on an accurate, validated network replication—with all of the appropriate attributes—in order to provide useful information and outputs. As a result, many public-sector agencies cannot effectively utilize these tools, making it challenging to develop independent assessments of potential benefits for use in public-private partnerships, negotiations with carriers, or the support of freight-specific investment decisions.

Assessing multijurisdictional benefits is difficult.

It remains difficult to determine how costs, risks, and benefits should be shared among different public-sector participants. This is particularly true for nationally or regionally significant infrastructure investments, which often involve a number of federal, state, regional, and local agencies, authorities, and entities.

There are some limited examples of multijurisdictional tools or processes that could be used to evaluate multijurisdictional tradeoffs and benefits. The I-95 Corridor Coalition's ICAT tool, for example, is an effort to consolidate and standardize existing transportation data, offering a single source of information to guide multistate transportation planning efforts. In addition, there are a number of regional economic models (described previously) that are useful in identifying the regional economic impacts and benefits associated with freight system improvements. However, there does not yet exist a common framework for evaluating cross-jurisdictional benefits and impacts with which all levels and types of stakeholders are comfortable. In addition, the institutional arrangements to facilitate multistate analysis and investment decision-making do not yet exist, making it difficult for such regional improvement projects to move beyond the planning stage.

There is no single analytical tool that is useful to all of the participants in the freight investment decision-making process.

Differences in the types of benefits assessed by different types of freight investment stakeholders, as well as differences in when these benefits are assessed within the decision-making process, naturally result in a number of different tools to support the freight investment decisions of different stakeholders. There does not exist a single analytical tool to meet the benefit assessment needs of the full array of public and private freight stakeholders. In addition, there is no common framework or set of coefficients and measures that allow for an apples-to-apples comparison of projects among different stakeholders. Each stakeholder uses its own, independent analysis of potential projects using its own measures.

CHAPTER 4

Development of the Freight Evaluation Framework

The Freight Evaluation Framework, described in detail in this chapter, provides a consistent approach to evaluating freight investments that is sensitive to the different spatial scales of freight improvement projects, the different benefits between the public and private sectors, and the different planning and investment decision-making process used by private- and public-sector entities, all of which were described earlier. This chapter describes the principles used to guide Framework development, introduces the Framework concept and methodology, and describes how risk was incorporated within the Framework.

4.1 Developing the Framework

Guiding Principles

The literature review, interviews, and case studies described earlier led to the development of several principles that were used to steer the development of the Freight Evaluation Framework. These guiding principles are described as follows:

1. **The Freight Evaluation Framework should be capable of evaluating freight investments competing with other freight investments across modal boundaries.** Many freight investment stakeholders have developed and implemented approaches to evaluate different freight investments occurring on the same mode (i.e., deciding between competing rail investments or highway projects). Missing is an approach that will allow stakeholders to evaluate the potential benefits of highway, rail, seaport, and intermodal connector projects on an apples-to-apples basis. This requires the development of common metrics that are meaningful across all of the modes and from the perspective of the affected stakeholders.
2. **The Freight Evaluation Framework should be capable of evaluating projects that span all of the different freight modes, across all different levels of geography (local/site, regional/state, and national).** As described earlier, the scale of freight projects can vary enormously—from localized projects completed over several weeks, to regional or national mega-projects that are measured in terms of years or decades. The Freight Evaluation Framework must be sensitive to these different scales, and be capable of being applied to local, statewide/regional, and multistate/national scales.
3. **The Freight Evaluation Framework must use existing data and tools to the degree possible.** Substantial public- and private-sector investment has gone into the development of various tools, methods, and approaches for assessing the benefits of freight investments. The Framework must complement and enhance these previous efforts without reinventing the wheel. The Framework should be developed in a manner that builds upon existing tools and leverages investments made to date (by U.S.DOT, NCHRP, AASHTO, various state DOTs, and universities) rather than appearing to compete against them.
4. **The Freight Evaluation Framework must be consistent with existing decision-making processes used by freight stakeholders.** As described earlier, different stakeholders clearly use different methods and processes to answer the question "Is this a good investment?" Similar to Guiding Principle No. 3, the Framework must *not* be developed in such a way that it competes with, or usurps, these existing processes. Rather, it should be developed so that it supports the investment decision-making processes already employed by different freight stakeholders. The Framework should be a decision-support tool, not the ultimate decisionmaker.
5. **The Freight Evaluation Framework should use a few good measures.** Although the Framework should use quantitative performance measures, these measures should reflect the impact or benefit categories that are likely to be most important to different freight stakeholders in determining whether the project is beneficial

from that group's perspective. Although it may be tempting to expand the number of overall indicators to more comprehensively understand the potential benefits and impacts of a proposed freight investment, some prospective measures may be too peripheral to offer value and actually reduce the overall effectiveness of the assessment.

6. **The Freight Evaluation Framework should allow for qualitative assessment of investments.** Although it is critically important to allow quantitative assessments of project benefits to drive the Framework, it also needs to be flexible enough to incorporate qualitative assessments. These qualitative assessments will be helpful in fatal flaw analyses—reviews to ensure that the proposed project is practical and fits within the goals of affected stakeholders (particularly those without a direct financial stake in the investment).
7. **The Freight Evaluation Framework should target freight investments that are on the left side of the benefit assessment spectrum.** This spectrum, described in Figure 3.6, describes the types of investment decisions made by freight stakeholders and their associated timeframes. Because the types of tools and processes used by different freight stakeholders within this spectrum varies considerably, the Framework should be developed to meet the decisions that are strategic or tactical in nature, with a timeframe measured in years or decades.

Framework Concepts and Elements

Using these principles as a guide, the Freight Evaluation Framework consists of four key elements: identify benefit categories and metrics, calculate project costs, calculate benefits and impacts, and assess risks. Figure 4.1 describes how these individual elements link to the guiding principles described above; Figure 4.2 provides a more detailed description of the entire framework.

A detailed overview of these four modules is provided in the following sections.

Benefit Categories and Metrics

The guiding principles underlying the development of the Framework call for the identification of a few good measures that represent the benefits that are most important to the various stakeholders. In addition, the measures should be comparable across modes and types of investments to allow for apples-to-apples comparisons of investment opportunities.

The benefit types that are meaningful to the various stakeholders have been identified previously. Table 4.1 presents potential metrics to capture the benefits that are of concern to different freight investment stakeholders. There are a few measures, such as transportation cost savings, crash reductions, emission reductions, and pavement/track conditions that will be important across a wide array of stakeholders. Others, such as maintenance savings and asset velocity, will be relevant to a small set of stakeholders but are likely to drive that stakeholder's decision on whether to participate in the investment.

Costs

The costs of a constructed facility or implemented technology to the owner include both the initial capital cost and the subsequent operation and maintenance costs. Each of these major cost categories consists of a number of cost components. The magnitude of each of these cost components depends on the nature, size, and location of the project as well as the owning organization (i.e., public or private).

- **Capital costs** for a project include the expenses related to the initial establishment of the facility, such as
  - Land acquisition, including assembly, holding, and improvement;
  - Construction, including materials, equipment, and labor;
  - Field supervision of construction;
  - Construction financing;
  - Insurance and taxes during construction; and
  - Inspection and testing.
- **Operation and maintenance costs** in subsequent years over the project lifecycle typically include
  - Land rent, if applicable;
  - Operating staff;
  - Labor and material for maintenance and repairs;
  - Periodic renovations;
  - Insurance and taxes;
  - Financing costs;
  - Utilities; and
  - Owner's other expenses.

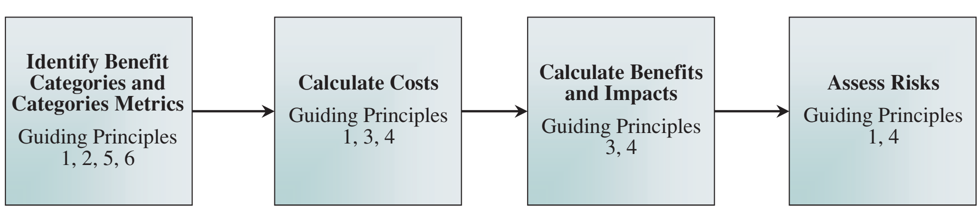


Figure 4.1. Framework elements and guiding principles.

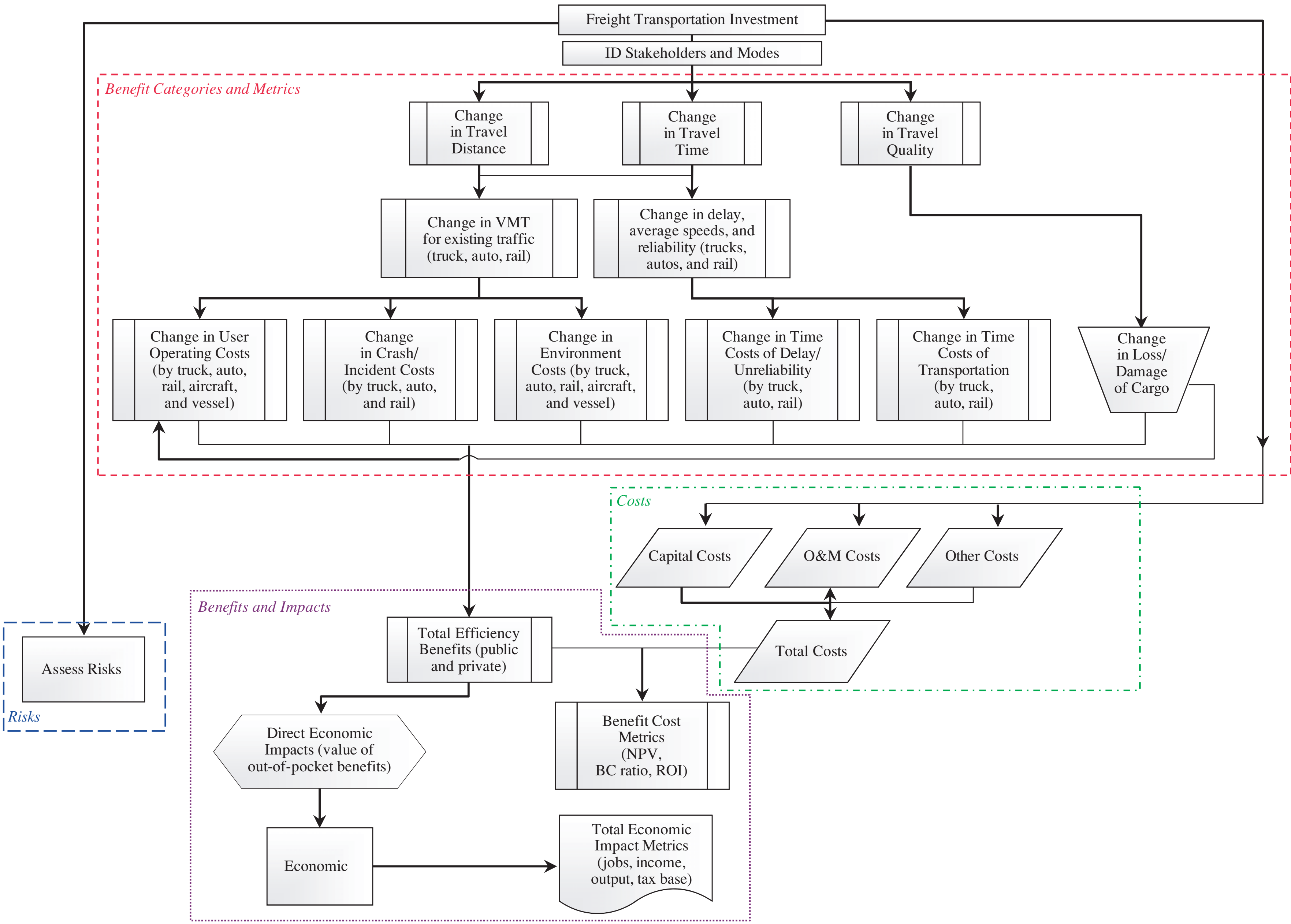


Figure 4.2. Freight Evaluation Framework.

Table 4.1. Benefit metrics by benefit and stakeholder type.

Benefit Type	Benefit Metric	Public Sector	Service Provider	Shipper/ End User	Other Impacted Party	Private-Sector Asset Provider
Capacity	Transportation Cost Savings	●	●	●	●	●
Safety	Crash Reductions	●	●		●	●
Environmental Quality	Emission Reductions	●	●	●	●	●
Scheduling/ Reliability	Reliability Improvements		●	●		
Facility Maintenance Costs	Pavement/Track Maintenance Savings	●				●
Loss and Damage	Pavement/Track Conditions	●	●	●		●
Productivity	Asset Velocity		●	●		
Economic Development	Jobs, Income, Industry Output	●			●	●
Tax Revenue	Tax Base Impact	●			●	
Facility Capital Costs	Facility Costs	●				●

The Freight Evaluation Framework recognizes that although construction cost may be the single largest component of capital cost, other cost components are not insignificant. For example, land acquisition costs are a major expenditure for building new or expanding existing facilities in high-density urban areas, and construction financing costs can be significant. From the owner's perspective, it is equally important to estimate the corresponding operation and maintenance cost of each alternative for a proposed facility in order to analyze the lifecycle costs. The large expenditures needed for facility maintenance, especially for publicly owned infrastructure, necessitate the need to include operation and maintenance cost in the design stage. Cost information changes depending on the stage of the planning process. There are three categories of cost estimates—design, bid, and control. Design estimates will be the most common source of cost data for use in the Framework.

Design Estimates

In the planning and design stages of a project, various design estimates reflect the progress of the design. At the very early stage, the screening estimate or order-of-magnitude estimate is usually made before the facility is designed, and must, therefore, rely on the cost data of similar facilities built in the past. A preliminary estimate or conceptual estimate is based on the conceptual design of the facility at the stage when the basic technologies for the design are known. The detailed estimate or definitive estimate is made when the scope of work is clearly defined and the detailed design is in progress so that the essential features of the facility are identifiable. The engineer's estimate is based on the completed plans and specifications when they are ready for the owner to solicit bids from construction contractors.(*9*) Design-level cost estimates can be calculated using unit costing (e.g., cost per mile), historical cost data, or computer-aided costing.

To account for risks involved in cost estimating, most construction cost estimates include an allowance for contingencies or unexpected costs occurring during construction. This contingency amount may be included within each cost item or may be included in a single category of construction contingency. The amount of contingency is based on historical experience and the expected difficulty of a particular project. Examples of various risk factors in cost estimating include the following:

- Design development changes,
- Schedule adjustments,
- Cost of materials,
- Site conditions that differ from those expected, and
- Third-party requirements imposed during construction (such as new permits).

Calculating Benefits and Impacts

Freight transportation investments are designed to bring about changes in travel patterns, and these changes can yield benefits and economic impacts locally, regionally, and nationally. To properly account for these effects and to account for the benefits most relevant to various stakeholders and geographic interests, the Freight Evaluation Framework proceeds in two parallel tracks: benefit/cost analysis (BCA) and economic impact analysis (EIA). Benefit/cost analysis identifies the benefits of investing (as compared with not investing), and compares these to the project costs. It includes both actual or out-of-pocket cost savings (e.g., reduced spending on fuel) and the broader social benefits (e.g., reduced vehicle emissions). Benefits and costs can be analyzed based on geography and to whom the benefits and costs accrue. Moreover, the direct travel efficiencies represent productivity gains that are a net benefit to the national economy, making BCA an appropriate analysis for national or federal investment decisions. In addition, conducting parallel benefit/cost analyses based on travel efficiency analysis for alternative projects using common metrics allows for the comparison of investments across modes.

Economic impact analysis, in contrast, compares the overall economic growth (e.g., employment, income, and output) in the specified study region with or without investing. Because this method focuses on regional economic growth, certain classes of benefits accounted for in benefit/cost analysis are excluded. Specifically, only those travel changes that affect the actual flow of dollars through the regional economy are considered, thus excluding social benefits and personal travel-time savings. Generally, EIA is useful for local-, regional-, and state-level analysis because the measures in economic growth often represent a redistribution of economic activity from one location to another resulting from increased competitiveness. The Framework addresses both BCA and EIA because utilizing both types of analysis provides two sets of metrics for evaluating freight investments to meet the needs of various stakeholders and to reflect local-, regional-, and national-level benefits.

As illustrated in Figure 4.2, there are significant distinctions between benefit/cost analysis and economic impact analysis. First, BCA weighs the costs of a given investment initiative against the benefits it provides to their users. It involves identification and estimation of all private, public, and social costs and benefits of an investment to derive a measure of net benefit or a benefit/cost ratio that measures the value of benefits received per dollar in costs.

Another major distinction is that private and public expenditures/investments and business output and jobs that result from those expenditures are viewed as costs in BCA. This is because they consume societal resources that could have alternative uses. Other possible costs include ongoing operation and maintenance costs, as well externalities such as pollution, noise, and reduction of property values. Reduction of these (or other) costs is viewed as a benefit, and a reduction of some existing benefits is viewed as a cost. In EIA, the cost of the investment is often regarded as an injection of construction spending that gives rise to immediate, short-term increases in employment and other economic benefits.

For the purpose of both BCA and EIA, all costs and benefits are measured over the project lifecycle to capture the timing of costs and benefits. Then the NPV of the costs and benefits is calculated using the appropriate discount rate.

4.2 Incorporating Risk

The incorporation of risk into the Freight Evaluation Framework represents a significant enhancement to the freight investment analysis tools, methods, and processes that have been developed by U.S.DOT, NCHRP, AASHTO, various state DOTs, and universities. Risk in the context of a freight investment refers to downside outcomes due to uncertainty. From a financial perspective, investors or bond holders may experience weaker-than-anticipated returns on their investment. Weak returns can be the result of weaker-than-expected demand for a facility's services, or higher-than-expected capital or operating costs, or a combination of the two. From the public's perspective, the project may not yield its anticipated benefits in the form of congestion mitigation or job creation.

Risk Factors

Risk assessment has been a critical component of private-sector investment decision-making for a long time because sizable losses can be devastating to firms of all types and sizes. Risk management metrics also have a role in customer satisfaction, potential market development, and market access. All of the functions in this category can have a direct cost—insurance, employee safety and retention, financial penalties and down time, etc. On the public-sector side, risk management techniques are typically included in asset management strategies for pavements, bridges, and other investments. Rarely are risk management techniques employed as part of the investment decision-making activities of these agencies, including freight investments.

Although considering risk in the Freight Evaluation Framework does add a degree of complexity, it is warranted. Although simplicity in analysis is desirable, the research team also sought to avoid analyses that are more simple than necessary in order to arrive at a decision. The "correct" level of detail is one that addresses the problem while not overburdening the analysis. To provide this balance, the Framework assesses a limited number of risk factors that most significantly impact freight investment decisions. These include the following:

- **Market risks,** or those that relate to overall demand on the potential investment. Factors to consider include confidence in forecast growth in population and business activity, development of competing facilities and services, application of new technology, or other external factors (i.e., relative prices).

- **Cost risks,** or those that relate to cost overruns associated with scope creep, cost overruns associated with price increases of raw materials or labor availability, or unanticipated delay costs.
- **Methodological risks,** or those that significantly affect the conclusions of an analysis, such as approximation introduced by the level of aggregation or level of detail included in the analysis (e.g., assumptions about "peaking," spatial resolution of geography); value judgments and policy variables (e.g., prices assigned to emissions or the value of life); or uncertainties about technical, economic, and political quantities (e.g., future vehicle fuel burn and emission rates, future inflation rates, potential impacts of new regulations).
- **Moral hazard risks,** or those related to an individual or organization's inadequate incentive to guard against a risk when there is protection against it. For instance, in a public-private partnership where the government funds the investment and the private partner manages and operates it, there is some likelihood that the private partner will not adequately represent the public sector's interests. It is crucial that the selection of the private partner and the public-private partnership contract ensure that the public's interests are not compromised. One of the problems inherent in public-private partnerships is that the pre-decision analysis will typically assume that an identity of interests exists among the partners. However, this will only be the case in practice if contracts and incentives are structured in a way that supports this goal.

Accounting for Risk

The following two cases of risky outcomes are incorporated within the Freight Evaluation Framework:

- Case 1: The project is operational, but disappoints at least one stakeholder and fails to realize the hurdle rate that was established in the planning stage and upon which the decision to proceed was based. (Hurdle rate refers to a breakeven threshold—in the case of benefit/cost analysis, NPV=0 is the hurdle rate that a project is expected to exceed. A private entity will typically seek a rate of return in excess of some value equal to the entity's opportunity cost of capital.)
- Case 2: The project fails overwhelmingly so that it is either abandoned or bailed out with unanticipated public funding to keep it operating.

The process for assessing risk in the Framework screens and rejects grand failures of the Case 2 type. Projects that pass the first level of screening will be subject to additional scrutiny and risk analysis, permitting informed decisions on the level of risk and its acceptability to the project stakeholders.

The risk assessment component of the Framework is shown in Figure 4.3. This process conducts an initial screen for potential Case 2 failure to identify these potential catastrophic failures early in the process. The analysis of Case 1 risk is an additional dimension to the evaluation and the go/no-go bottom line analytic metrics for each stakeholder group and is expressed as risk analysis results (i.e., a range of results with an associated probability for attaining a particular result).

Risk Case Scenarios and Stakeholder Impacts

Case 1 risk analysis screening involves assessing different project alternatives for downside risk using different scenarios. The scenarios correspond to specific future outlooks in which a combination of unanticipated negative events, or risk cases,

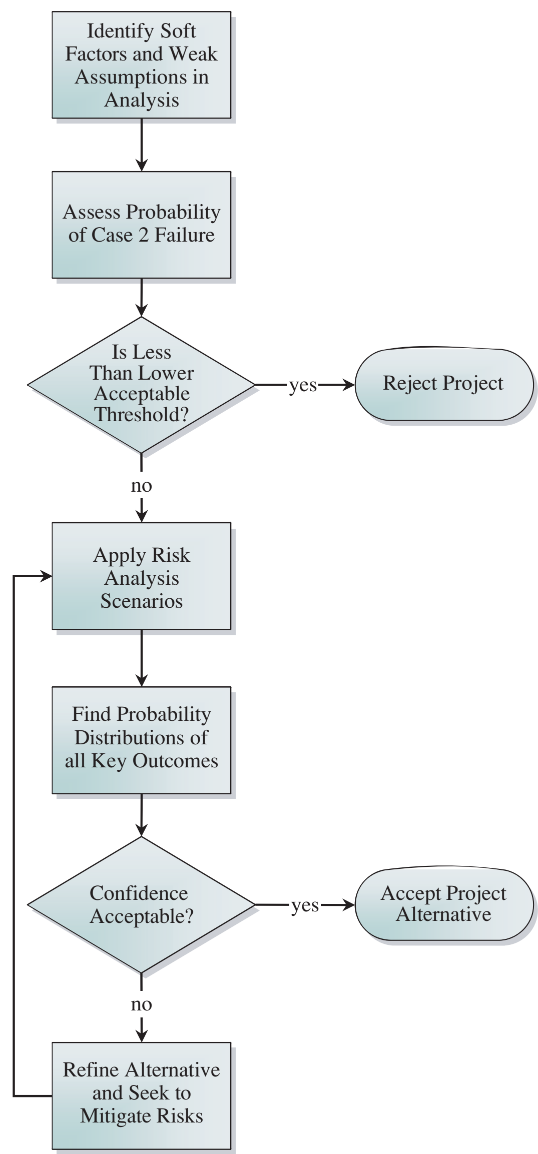


Figure 4.3. Freight Evaluation Framework risk assessment component.

Table 4.2. Risk scenarios and stakeholder impacts.

		Stakeholders and Impacts of Downside Risk			
Risk Case	**Scenario Example**	**Asset Provider**	**Service Provider**	**End User**	**Other Impacted Party**
Case 1 Operational, but Falls Short of Expectations	Weak demand due to economic conditions or competing modes and facilities	●	○	○	○
	Price shocks	●	●	◑	○
Case 2 Fails Overwhelmingly	Demand dramatically less than forecast	●	○	○	◑
	Projected local componennt of demand fails to materialize	◑	◑	○	○
	Region fails to proceed with complementary projects that were critical success components	●	◑	○	○

○ Minimal Impact ◑ Slight Impact ● Severe Impact

occur with adverse impacts on the project. Evaluating different scenarios also allows for an assessment of how different risk cases impact different stakeholder types. This is critically important because downside risk may not be borne equally among different stakeholders and the decision-making process will need to ensure that the opportunities for each party and the risks assumed by each are acceptable.

Table 4.2 describes sample alternative scenarios for a freight transportation investment being funded by the private sector and the severity of the downside risk on various parties. (The indicators of severity are illustrative. In principle, contractual arrangements could shift risk across parties. For instance, an infrastructure provider could have contractual guarantees that cover its prospective losses in the event of facility underutilization.) These examples show that the asset provider (who builds and operates the new facility) has the most at stake. In the event of a catastrophic failure with little or no return on its investment, the asset provider's financial loss could be very large. At the other end of the spectrum, prospective facility users may have little at stake should a project fail because there may be existing alternatives or the users may be able to shift their activity so that the impact is minimal. Because the different tolerances for risk across different project and stakeholder types factor significantly into eventual decisions, such risk scenario assessments are a critical component of the overall implementation of the Framework.

CHAPTER 5

Testing the Framework

To gauge the utility of the Freight Evaluation Framework, it was important to apply it to actual freight improvement projects to evaluate the interrelationships among freight benefit types, determine whether there are significant differences in the Framework's application across different types and scales of freight investments, and assess its overall strengths and weaknesses. The study team tested the Freight Evaluation Framework in two different ways. First, the team applied the Framework to six case studies of actual freight improvement projects. Second, the team conducted a hands-on workshop to provide feedback on the Framework; identify how it can and should be used to support investment decisions, financing, or public-private partnership structuring; and describe how it could be useful in supporting partnerships for funding freight infrastructure investments. The following sections describe the case study testing process and results in detail, and provide a summary of the workshop.

5.1 Case Study Testing

Selection of Potential Case Studies

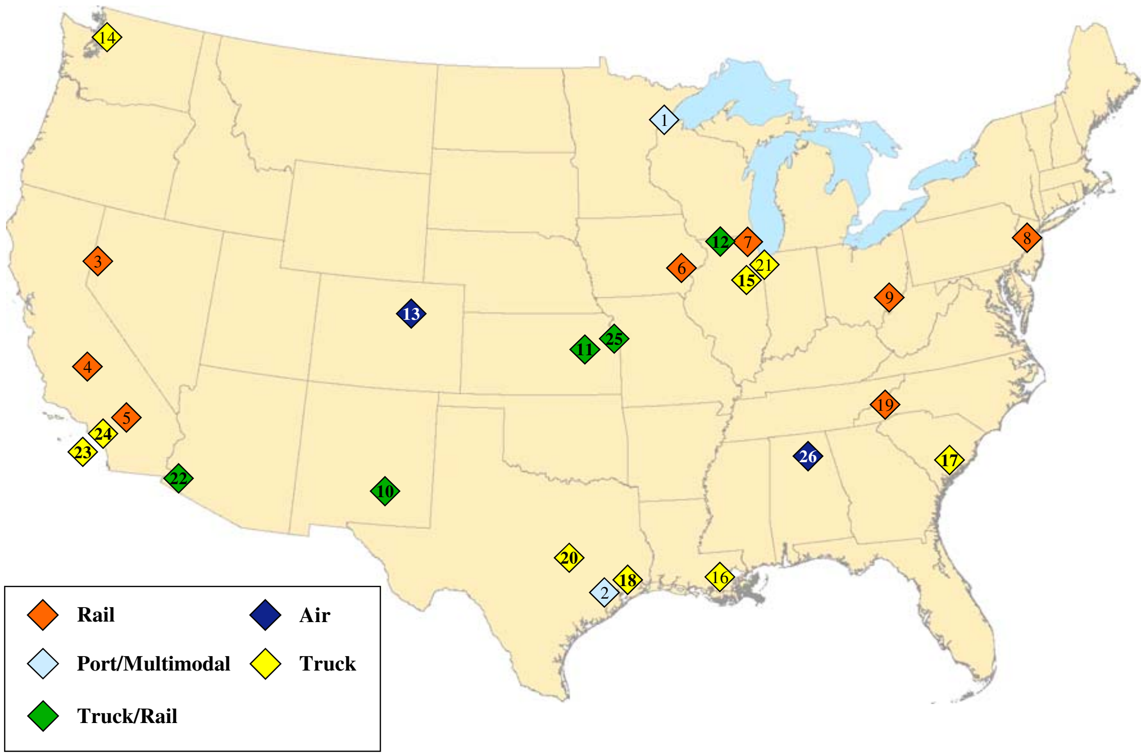
Figure 5.1 shows the locations of the potential case studies originally identified through the study team's discussions with freight investment stakeholders and the team's review of current practices.

As well as geographic diversity, several other criteria were used to ensure that the final set of case studies represented a broad array of freight project types, including the following:

- **Project scale,** such as local-scale freight projects that may have national or regional impacts, improvements that impact multiple states, and international port or gateway projects.
- **Project type and mode,** including highway or rail capacity chokepoints, at-grade crossings, intermodal connector improvements, and warehouse/distribution center facilities.
- **Project value and funding arrangement,** with values ranging from $1.4 million (Port of Superior/General Mills S/X Elevator Project) to several billion dollars (New York Cross Harbor Freight Rail Tunnel) and funding sources, including strictly public (Rochelle Intermodal Center), strictly private (Gardner Intermodal Terminal), and various types of public-private partnership arrangements (Denver International Airport).
- **Geography,** including urban (Port of Seattle SR 519 Intermodal Access) and rural (Strauss Intermodal Yard) and projects that are local in nature versus those that impact multiple states or MPOs.
- **Data availability,** including transportation demand, benefit, cost, and other appropriate information. It was critical that sufficient data exist (or be obtained) so that a rigorous, realistic test could be conducted.

Following discussions with the NCFRP-05 Panel, the research team identified six case studies on which to focus. These six case studies, as follow, provided a cross section of project types, scales, locations, and modes that proved useful in evaluating the key components of the Freight Evaluation Framework.

1. **Reno Transportation Rail Access Corridor,** a 2.3-mile-long, below-ground Class I rail mainline through downtown Reno, Nevada;
2. **Denver International Airport WorldPort,** which included one-half million square feet of building and warehouse space, a new taxiway, and an aircraft ramp;
3. **Tchoupitoulas Corridor Improvements,** a series of highway capacity improvements and rail rehabilitations to improve access to the Port of New Orleans, Louisiana;
4. **Heartland Corridor Clearance Initiative,** a multistate rail capacity improvement project to develop a direct route for double-stacked Norfolk Southern container trains moving from the Port of Virginia to Columbus, Ohio;
5. **Port of Huntsville (Alabama) Inland Port,** which includes the Huntsville International Airport, the International Intermodal Center, and the Jetplex Industrial Park; and
6. **Bayport Container Terminal,** a newly opened terminal within the Port of Houston, Texas.



1. Port of Superior General Mills S/X Elevator Project
2. Bayport Container Terminal
3. Reno Transportation Rail Access Corridor (ReTRAC)
4. Tehachapi Trade Corridor
5. Colton Crossing
6. IA Interstate Railroad Rehabilitation and Locomotive Purchase
7. Chicago Region Environmental and Transportation Efficiency Program (CREATE)
8. NY Cross Harbor Freight Rail Tunnel
9. Heartland Corridor Clearance Project
10. Strauss Intermodal Yard
11. Gardner Intermodal Terminal
12. Rochelle Intermodal Center/UP Global III
13. Denver International Airport Cargo Facility
14. Port of Seattle SR 519 Intermodal Access Project
15. I-55 Access to CenterPoint Intermodal Center at Deer Run
16. Tchoupitoulas Corridor Improvements
17. Cooper River Bridge Replacement
18. Wal-Mart Baytown Distribution Complex
19. Norfolk Southern Crescent Corridor
20. Trans-Texas Corridor 35
21. Illiana Expressway
22. Arizona Multimodal Logistics Complex
23. Ports of LA/LB Clean Trucks Program
24. Interstate 710 Truck Lanes
25. Kansas City SmartPort
26. Port of Huntsville

Figure 5.1. Freight investments—potential case study locations.

These six case studies allowed the research team to test different project types and geographic scales, modal combinations, and combinations of benefit types, as shown in Table 5.1.

In addition to assessing the overall performance, strengths/weaknesses, and areas of improvement of the Freight Evaluation Framework, the team's testing process focused on a number of key issues that were identified through the interview process described in Chapter 3, including

- **Identifying limitations of existing data and tools—**There are a number of issues that limit the effectiveness of existing evaluation tools in assessing benefits across all freight investment and stakeholder types, as described in Chapter 4. As part of the research team's evaluation process, researchers paid particular attention to these and other weaknesses of existing tools in facilitating use of the Freight Evaluation Framework and supporting freight investment decisions.
- **Linking project attributes, benefits, and stakeholder types—**Previous sections identified stakeholder types that are involved in the identification, planning, financing, and implementation of freight improvement projects, as well as their interest points and perspectives (i.e., what "stake" these stakeholders have in the success of a freight improvement project). One focus area of the team's testing process was to ensure that the Freight Evaluation Framework adequately captured the impacts and benefits to different stakeholders—and how these can change depending on the type of project, its attributes, and/or role the stakeholder is playing in the project development.
- **Ensuring usefulness across different scales—**Investment evaluations (including the data and tools used, the level of

Table 5.1. Modes, project types, scales, and benefits of case studies.

	Modes Included				Project Type							
Case Study	Highway	Rail	Port	Air	Air Impacting Highway	Cargo Handling	Highway Improvements	Intermodal Connector	Rail Improvements	Grade Crossings	Port Expansion	Barge Services
Reno Transportation Rail Access Corridor (Nevada)		✓				✓			✓	✓		
Denver International Airport WorldPort (Colorado)				✓		✓		✓				
Tchoupitoulas Corridor Improvements (New Orleans, Louisiana)	✓	✓					✓	✓	✓	✓		
Heartland Corridor Clearance Initiative (Columbus, Ohio)		✓				✓		✓	✓	✓		
Port of Huntsville (Alabama) Inland Port	✓	✓		✓	✓	✓	✓	✓	✓			
Bayport Container Terminal (Houston, Texas)		✓	✓			✓		✓	✓		✓	

	Scale and Operation			Project Characteristics					Highway Benefits		
Case Study	Geography	Constructed	Beginning Year of Operations	Used Existing Data and Tools	Multi-jurisdictional	Multiple Beneficiaries	Significant Risk Factors	Broader Supply Chain Impacts	Change in Delay/ Reliability	Change in Loss/ Damage	Supply Chain Benefits
Reno Transportation Rail Access Corridor (Nevada)	Regional	✓	2006	✓	✓	✓		✓	✓		✓
Denver International Airport WorldPort (Colorado)	Regional	✓	2006	✓		✓					
Tchoupitoulas Corridor Improvements (New Orleans, Louisiana)	Regional	✓	2004	✓		✓	✓		✓		✓
Heartland Corridor Clearance Initiative (Columbus, Ohio)	Multistate	Underway	N/A	✓	✓	✓	✓	✓			✓
Port of Huntsville (Alabama) Inland Port	Regional	✓	1974	✓		✓					✓
Bayport Container Terminal (Houston, Texas)	Local	✓	2007	✓		✓	✓	✓			✓

(continued on next page)

Table 5.1. (Continued).

Case Study	Rail Benefits			Port Benefits			Cargo Handling Benefits		
	Asset Utilization	Capacity Enhancement	Supply Chain Benefits	Congestion Reduction	Trade Attraction and Time to Market	Change in Employment and Port Volumes	Change in Cargo Volumes	Change in Employment	Measures of Regional Competitiveness
Reno Transportation Rail Access Corridor (Nevada)	✓	✓	✓						
Denver International Airport WorldPort (Colorado)							✓	✓	✓
Tchoupitoulas Corridor Improvements (New Orleans, Louisiana)	✓	✓	✓	✓					✓
Heartland Corridor Clearance Initiative (Columbus, Ohio)	✓	✓	✓						
Port of Huntsville (Alabama) Inland Port			✓		✓	✓	✓		✓
Bayport Container Terminal (Houston, Texas)					✓	✓	✓	✓	✓

detail analyzed, and the performance metrics used) that are appropriate for one scale of project (e.g., project- or site-specific) might not be adequate for larger scale (e.g., corridor or multijurisdictional) projects. A third focus area of the team's evaluation was to assess the adequacy of the Freight Evaluation Framework to assess costs and benefits of a variety of project types across a variety of geographic scales.

5.2 Case Study Results

Case Study 1—Reno Transportation Rail Access Corridor (ReTRAC)

Background

This project was constructed earlier and has been fully operational since 2006. Union Pacific (UP) Railroad's Central Corridor between Oakland, California, and the Midwest runs through the downtown area of Reno, Nevada. The line is part of a shared-use corridor that serves both passenger and freight trains. The downtown area of Reno is traversed by this rail line, which divides the city. This was partially responsible for disparate economic conditions in the city. The numerous grade crossings between the UP tracks and city streets presented safety hazards, created highway congestion, and deterred pedestrians from the downtown area.

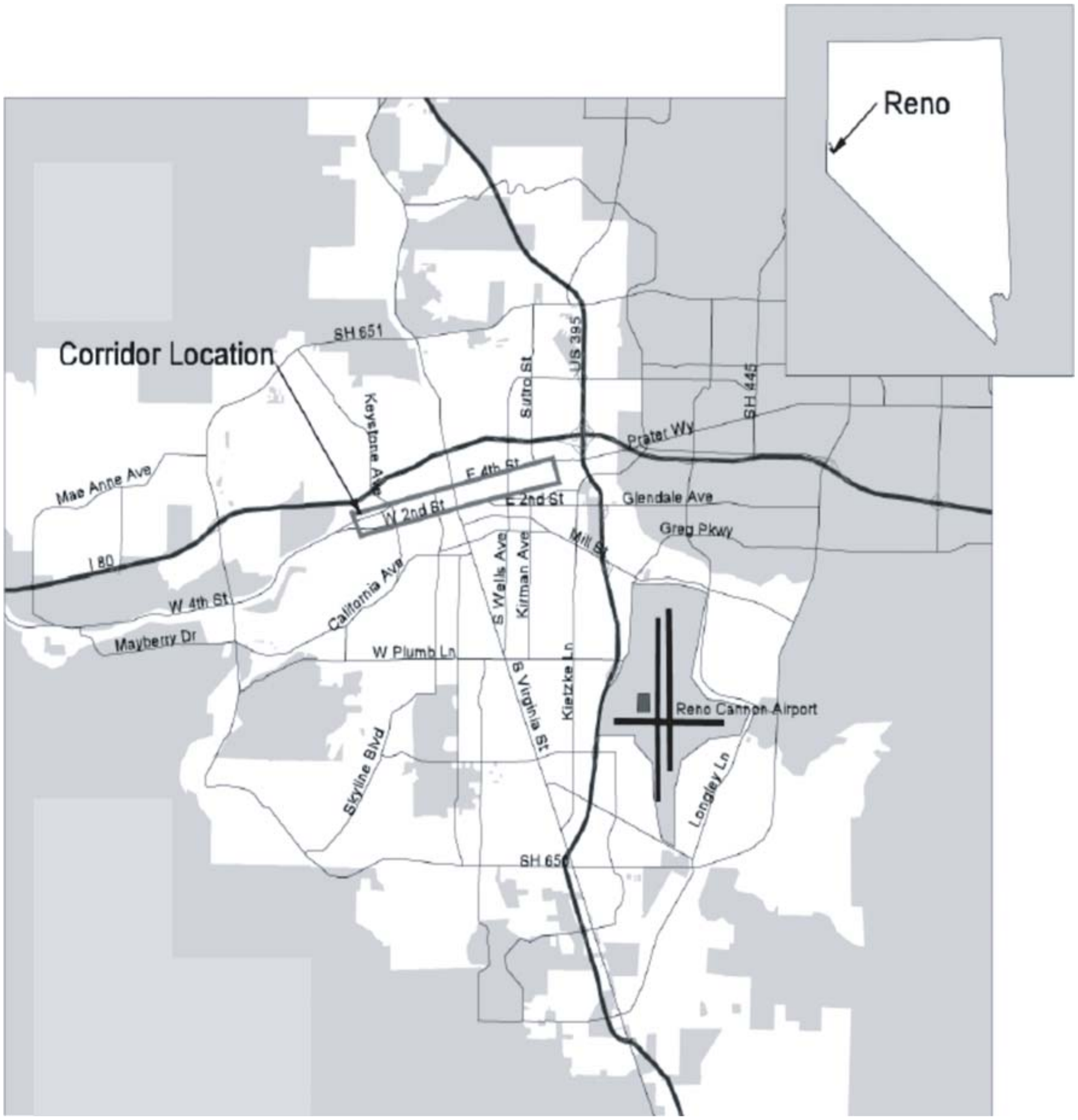
In 1996, the City of Reno, Nevada, approved ReTRAC in an attempt to mitigate concerns from the 1995 merger of Union Pacific (UP) and Southern Pacific (SP) railways. The merger would increase corridor traffic from 14 to 24 daily trains, creating increased safety risk at grade crossings, while contributing to an escalation of road congestion. The City of Reno therefore recognized the potential for significant impacts on ground transportation and developed the ReTRAC initiative.

The project consisted of the following three main components:

1. Depressing of the UP mainlines running through the downtown area of the city;
2. Converting 10 existing grade crossings to overpasses above the UP mainlines; and
3. Creating of a temporary "shoo-fly" track to limit the disruption of corridor traffic during the construction phases of the project.

The project area is located in the downtown district of Reno, Nevada. The project was performed on the UP Railroad's Central Corridor dual mainline between Oakland, California, and the Midwest. The corridor section of interest is the 2.3-mile line that follows Nevada State Route 647, between Keystone Avenue and Lake Street. The dual above-ground mainline is traversed by highway roads at 10 gated grade crossings. Each grade crossing allows for bidirectional road traffic. The ReTRAC corridor location is depicted in Figure 5.2.

The ReTRAC Project consisted of two depressed mainline tracks, a temporary single line "shoo-fly" track adja-



Source: Myra L. Frank & Associates, Inc., 2000.

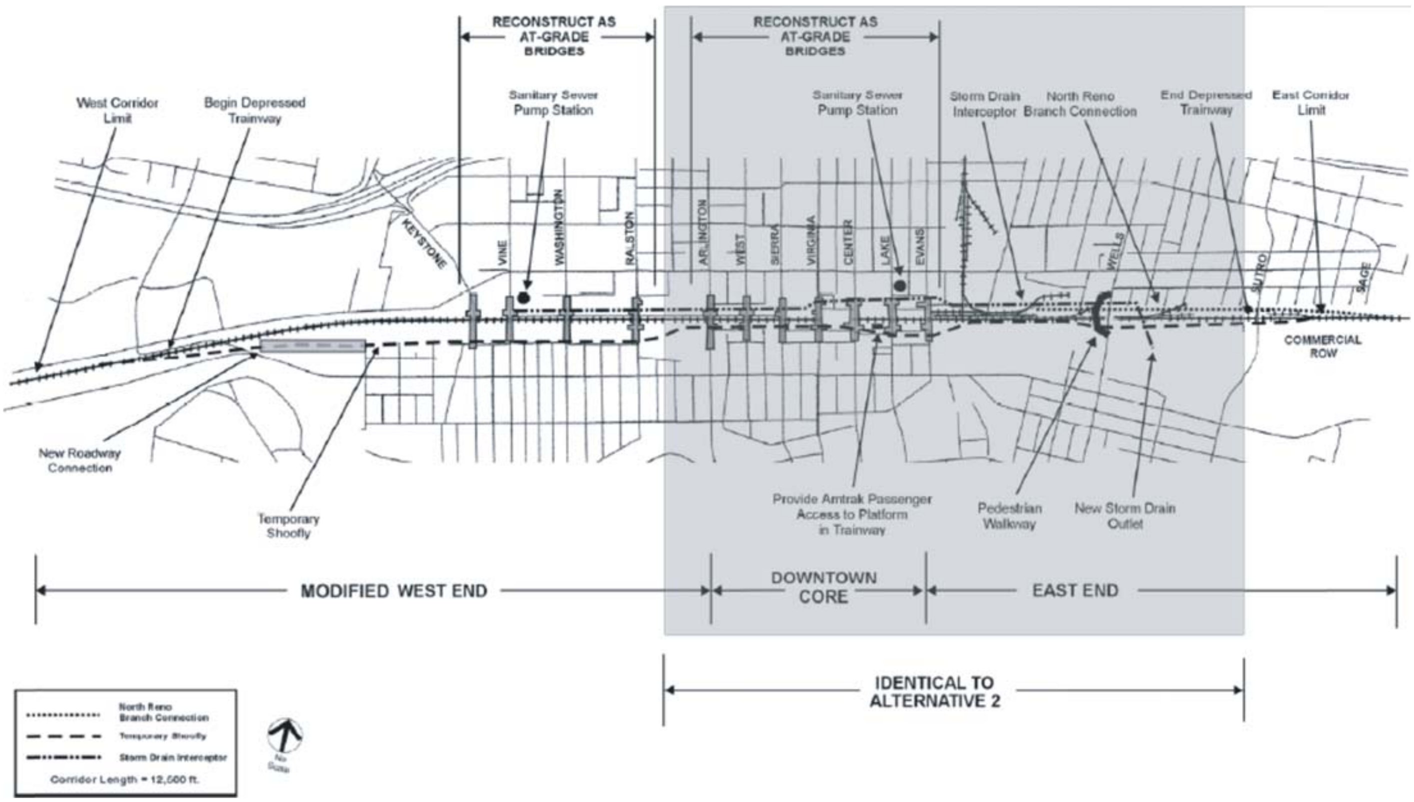
Figure 5.2. ReTRAC corridor location.

cent to the UP tracks, and the reconstruction of 11 (10 existing and 1 approved but unbuilt) street crossings built as street "bridges" across the top of the depressed trench. The entrenched dual mainline was constructed to standards permitting maximum train speeds of 60 mph. The project area and proposed freight infrastructure improvements are illustrated in Figure 5.3.

The 2.3-mile mainline is part of a shared use corridor on which Amtrak runs its twice-daily service between Chicago and San Francisco. The project included the construction of a 1.75-mile-long, 54-foot-wide by 33-foot-deep trench to contain the double rail lines. During construction, rail traffic was diverted on an adjacent temporary shoo-fly track to limit service disruption. The project scope also included the conversion of 10 grade crossings into overpasses above the depressed tracks. These grade crossings are located on Keystone Avenue, Vine Street, Washington Street, Ralston Street, North Arlington Avenue, West Street, North Sierra Street, North Virginia Street, North Center Street, and Lake Street.

Period of Analysis, Discount Rate, and Key Assumptions

The benefit/cost analysis considers the performance of transportation facilities given forecast traffic. Although the design life of many facilities is 40 years or more, there are several reasons for selecting a shorter period of analysis (e.g., 30 years).



Source: Information Delivery Service, 1999; Myra L. Frank & Associates, Inc., 2000.

Figure 5.3. ReTRAC project extent.

One reason is that with discounting, the relative magnitude of benefit and cost streams in excess of 20 years is generally small and has limited impact on the analysis. Second, traffic is typically forecast for an out-year of the analysis and as the analysis extends beyond 30 years forecasts will be more uncertain and less reliable.

This benefit/cost analysis uses a 30-year period of analysis, from 2002 through 2031. In the first 4 years, the new facilities will be under construction in the alternative case. During this time, highway users will operate on a similar roadway network to the base case, while rail traffic will operate on a temporarily modified rail network. The analysis will, therefore, take into account all disruption costs associated with the project construction in the alternate case.

The analysis was conducted for two different discount rates: 3% and 7%. With the lower rate, benefits occurring in out-years will have greater weight in the analysis. If the project fails the benefit/cost hurdle (NPV > 0) with the 3% rate, it is likely that the project as planned is either ill-advised or its execution is too early.

Project Stakeholders

The study focuses on six stakeholders: UP Railroad, Washoe County, the State of Nevada, the City of Reno, regional businesses, and the project area community. For the purposes of this case study, groups identified as other stakeholders were omitted from the benefit/cost analysis since a lack of data prohibited the assessment of their involvement in the decision-making process. It is important to note that since the freight infrastructure investment is a partnership between public- and private-sector agents, stakeholders often hold dual roles.

- **Union Pacific** owns the trackage rights and the area surrounding the Central Corridor. The infrastructure improvement takes place directly on that main line in the downtown area of Reno, Nevada. UP has a direct financial stake in the program since it provided about $58 million in cash and in-kind contributions toward the completion of the freight investment project. Following the construction phase, UP provides maintenance of way and traffic control, and carries freight in the corridor. This qualifies UP as an asset provider through its capital and financial investment, and as a service provider.
- **Regional governments** will have a direct financial stake in the project, because they will provide a portion of the funding for the construction and maintenance of the ReTRAC initiative. These governments include the State of Nevada, Washoe County, and the City of Reno. The funding will be

collected from various sources at a national and regional level. In addition, the public sector is responsible for the roadway work related to the project. This direct financial stake qualifies the regional governments as asset providers. The regional governments are a beneficiary of economic development benefits that flow from the project. Through increased economic activity and property tax revenue, the regional governments will have a stake in the initiative. Consequently, these local governments are classified as other stakeholders through their ancillary stake in the project. The U.S. government provides finance to the project and benefits indirectly as the benefits to the region contribute to the strengthening of the national economy. This qualifies the federal government as an asset provider and other stakeholder.

- The Reno ReTRAC Project enhances capacity and efficiency on the corridor, thus allowing for increased throughput. The consignees of goods shipped through intermodal means are often manufacturers or distributors; for the purposes of this study they are both considered regional businesses. These **local and regional businesses** enjoy business benefits from the project (e.g., lower costs, more timely deliveries). Local and regional business will ship intermediate and finished products using the services of the railroad. Regional businesses are therefore classified as end user stakeholders due to their transient role and as other stakeholders due to their role as receivers of shipped goods. The principal beneficiaries from the removal of at-grade crossings will be roadway users. These also are end users (passenger and commercial travelers who do not necessarily have a freight connection). These users benefit from increased roadway safety, reduced travel time, more predictable trip time, and reduced vehicle operating costs.
- The **community** surrounding the construction area will benefit from an amelioration of its environmental quality. The project will mitigate noise and vehicle emissions through the removal of 10 grade crossings. By consequence, the community surrounding the project area will become a major nonfinancial stakeholder in the freight infrastructure investment. This qualifies the community to become an other stakeholder in the project. The region benefits from economic development that stems from the removal of a barrier to commerce and expanded opportunities for land use. The value of reclaimed land from the project and the redesignation of land for higher-valued uses due to the project benefit the regional economy. The region is an other stakeholder of the project. Table 5.2 identifies all of the stakeholders for the Reno ReTRAC project by type.

Benefits

The project benefits can be grouped into three principal categories: benefits from grade crossing removal, economic benefits, and railroad benefits, as shown in Table 5.3.

Benefits from Grade Crossing Removal.

- **Safety benefits—**The Reno ReTRAC Project eliminated 10 at-grade crossings, and thus effectively brought the predicted accidents at the crossings to zero. The present value (PV) of safety benefits from the project are $4,004,490 using a 3% discount rate and $2,085,172 using a 7% discount rate.

Table 5.2. ReTRAC project stakeholders.

Stakeholder	Stakeholder Type	Stakeholder Interest
Union Pacific Railroad	• Asset Provider • Service Provider	• Direct Financial Stake
Washoe County	• Asset Provider • Other	• Direct Financial Stake • Indirect Stake
State of Nevada	• Asset Provider • Other	• Direct Financial Stake • Indirect Stake
City of Reno	• Asset Provider • Other	• Direct Financial Stake • Indirect Stake
Regional Businesses	• End User • Other	• Direct Business Stake • Indirect Stake
Businesses and Residents in Immediate Vicinity of Project	• Other	• Major Nonfinancial Stake
Roadway Users	• End User	• Major Nonfinancial Stake
The Region	• Other	• Direct Economic Stake
The Nation	• Other	• Indirect Economic Stake

Table 5.3. ReTRAC project stakeholders and benefits.

Benefit	Affected Stakeholder Type	Affected Stakeholder
Benefits from Grade Crossing Removal		
Elimination of Accidents at Grade Crossing	• All Stakeholder Types	• All Stakeholders
Travel Time Savings	• End User • Other	• Businesses and Residents in Immediate Vicinity of Project and the Region
Vehicle Operation Cost Savings	• End User • Other	• Businesses and Residents in Immediate Vicinity of Project and the Region
Emissions Savings	• All Stakeholder Types	• All Stakeholders
Noise Reduction	• Other	• The Region and Businesses and Residents in Immediate Vicinity of Project
Reduction in Emergency Medical Services (EMS) Response Time	• All Stakeholder Types	• Union Pacific Railroad, Washoe County, State of Nevada, City of Reno, Businesses and Residents in Immediate Vicinity of Project, and the Region
Economic Benefits		
Reclaimed Land	• All Stakeholder Types	• Washoe County, State of Nevada, City of Reno, Businesses and Residents in Immediate Vicinity of Project, and the Region
Higher Value Land Use	• All Stakeholder Types	• Washoe County, State of Nevada, City of Reno, Businesses and Residents in Immediate Vicinity of Project, and the Region
Railroad Benefits		
Lower Shipping Cost	• Asset Provider Service Provider	• Union Pacific Railroad
Reduced Liability	• Asset Provider Service Provider	• Union Pacific Railroad

- **Travel-time savings—**The removal of 10 grade crossings in downtown Reno alleviates congestion, promotes timely and efficient travel, and increases business productivity. The travel-time savings are a monetization of the passenger, truck, and bus time delay that is eliminated with the project. The PV travel-time savings benefits from the project is $75,520,910 using a 3% discount rate and $30,543,960 using a 7% discount rate.
- **Vehicle operational costs—**The elimination of queuing at blocked crossings leads to a decrease in consumption of fuel and other vehicle operating costs realized in the base case. All roadway users on the affected roadways experience this benefit. The PV of vehicle operational costs benefits from the project is $8,114,428 using a 3% discount rate and $3,276,058 using a 7% discount rate.
- **Reduction of emissions—**A reduction in idling time and speed cycling by road vehicles contributed to a decrease in emissions. The reduction of emissions is beneficiary to all stakeholders because environmental quality is an interest for all stakeholders. The PV of reduced emission benefits from the project is $331,313 using a 3% discount rate and $133,765 using a 7% discount rate.
- **Noise mitigation—**FRA's Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings requires trains to sound a horn when approaching a grade crossing. The removed grade crossings for the project were located in the downtown commercial district of the city. The residential west end of the city was regularly affected by the noise created by train horns approaching the 10 downtown grade crossings. There have been extensive studies on the effects of transportation noise (mostly noise from aircraft) on property values. These studies indicate that the effect of noise reduces property values by 0.05% for each decibel (dB) of noise. Assuming that the properties one-half mile on either side of the track were affected by noise in excess of 50 dB, then the affected area is 1.75 square miles in size. The study team estimates that the value of real estate in the affected area is $975 million, and concludes that the benefit of noise mitigation from the project is about $14,636,160 at a 3% discount rate and $5,908,618 at a 7% discount rate.

- **Emergency vehicle response time—**The blocked grade crossings prior to the ReTRAC Project caused delays to EMS vehicles, preventing them from effectively serving the region. These benefits are difficult to quantify, but result in fewer deaths and better outcomes for those requiring emergency services.

Economic Benefits

- **Reclaimed land—**The ReTRAC Project reclaimed approximately 120 acres of land used to develop numerous commercial and residential facilities. The reclaimed land, according to the City's report, is valued at $11.5 million.(*10*)
- **Higher value land use—**Through the residential and commercial revitalization of downtown Reno following ReTRAC, property value increased in the study area. This direct economic benefit of the project affects the local residents, businesses, and governments. The case study estimates the value of real estate in the immediate vicinity of the project to be $975 million. Following the construction of the project, a new baseball stadium was built just adjacent to the project, and a new entertainment district is planned. These developments would not have occurred at this location without the project. Through the development of reclaimed land, as well as increased economic activity in the downtown area, the case study analysis estimates that property values will increase by 10% in the years following the project. The increase in property value over the period of the team's analysis amounts to $95.7 million using a 3% discount rate and $38.7 million using a 7% discount rate.

Railroad Benefits

- **Railroad operating-cost benefit—**The project scope enabled freight trains to travel at a higher average speed through the corridor with less speed cycling and more fuel efficiency. The railroad can better manage rail traffic without worrying about grade crossings. These effects should result in a decrease in its overall operating costs. These savings are estimated at PV $5,300,000 using a 3% discount rate and $2,139,610 using a 7% discount rate.
- **Reduced liability—**By grade separating the rail and highway modes, the project reduces the railroad's liability of operations in the corridor. These savings are estimated at PV $2,300,000 using a 3% discount rate and $928,510 using a 7% discount rate.

Table 5.4 outlines the benefit and stakeholder types.

Costs

Capital Costs. The construction costs for the Reno ReTRAC project are included in this benefit/cost assessment. The construction tasks include the depression of a 1.75-mile-

Table 5.4. Present value of benefits ('000 dollars).

	Infrastructure Provider		Users		Service Provider		Public	
Benefit Metric	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR	3% DR	7% DR
Elimination of Accidents at Grade Crossing	–	–	$4,005	$2,085	–	–	–	–
Travel-Time Savings	–	–	$75,521	$30,544	–	–	–	–
Vehicle Operation Cost Savings	–	–	$8,114	$3,276	–	–	–	–
Emissions Savings	–	–	–	–	–	–	$331	$134
Noise Reduction	–	–	–	–	–	–	$14,636	$5,909
Reclaimed Land	–	–	–	–	–	–	$11,500	$11,500
Higher Value Land Use	–	–	–	–	–	–	$95,754	$38,656
Operating Cost Savings*	–	–	–	–	$5,300	$2,140	–	–
Reduced Liability*	$2,300	$929	–	–	–	–	–	–

Notes:
DR stands for discount rate.
*UP is both the infrastructure provider and service provider of freight services on the corridor. The classification to stakeholder categories roughly corresponds to each of these roles.

Table 5.5. ReTRAC funding and financing summary.

Funding Sources	Total Funding (Millions)	Notes
Bond Proceeds	$111.5	Revenue bonds backed by the City of Reno
TIFIA Direct Loans	$50.5	To be repaid from one-eighth cent sales tax and 1% hotel occupancy tax
	$5.0	To be repaid from lease income derived from UP properties
	$18.0	To be repaid from tax assessments from properties within downtown special assessment district
Federal Grants	$21.3	TEA-21
Railroad Contribution	$17.0	Track and ballast work
Other	$56.6	Includes cash on-hand and interest earnings
Total	**$279.9**	

long, 54-foot-wide by 33-foot-deep trench to contain double rail lines, the construction of an adjacent temporary shoo-fly track, and the conversion of 10 grade crossings into overpasses above the depressed tracks. These capital costs were financed through a public-private partnership between UP, the City of Reno, Washoe County, and the State of Nevada. The funding sources for the ReTRAC Project included FHWA TIFIA loans, bonds issued by the City of Reno, TEA-21 federal grants, as well as cash and in-kind contributions by UP. These costs are expanded in Table 5.5. In the 4 years of construction, the project capital costs are $279.9 million.

Operations and Maintenance Costs. The project scope did not specify the creation of a sinking fund to provide funding for the operation and maintenance of the new infrastructure. The operation and maintenance costs are shared between UP and the City of Reno. The track ballast is maintained by UP. The drainage of the trench and the maintenance of city roads are handled by the City of Reno. It is estimated that the City of Reno funds $100,000 annually for the operation and maintenance costs. In the study team's assessment, this cost is used starting year 5 of the assessment since it is the first year the new infrastructure is operational. The NPV of operation and maintenance costs for the period of analysis is $731,680 using a 3% discount rate and $485,927 using a 7% discount rate.

Benefit/Cost Analysis and Other Performance Metrics

Table 5.6 details the results of the team's analysis of the Reno ReTRAC Freight Infrastructure Investment using the Freight Evaluation Framework.

Risk Assessment

Table 5.7 provides the risk assessment results. The principal risk drivers are growth rates of railroad and highway traffic, which were assumed to vary (80% confidence) between 6% to 12% and 2.0% to 2.8% in the near term.

Case Study 2—Denver International Airport WorldPort

Background

With capacity nearing its limit in 2000, Denver International Airport's (DIA) WorldPort LLC developed 100,000

Table 5.6. Benefit/cost analysis summary (thousands of dollars).

Category	Discounted Sum 3%	Discounted Sum 7%
Total Costs	$269,476	$255,619
Total Benefits	$217,462	$95,172
B/C Ratio	0.81	0.37
Net B-C	($52,014)	($160,447)

Table 5.7. Risk analysis results of total benefits (thousands of dollars).

	90% Probability of Exceeding	10% Probability of Exceeding
Total Benefits (3%)	96,950	399,600
Total Benefits (7%)	43,457	175,944

square feet of office and cargo warehousing space in order to accommodate expected growth, which was forecasted to increase significantly through years of 2000 through 2010. The intended value proposition was to provide additional air cargo service in the Denver metropolitan area to capture future cargo that would likely be diverted to other airports because of the expected capacity constraints at DIA. The original plans for development included eight buildings for a total of 495,000 square feet; however, the economic recession of 2000–2001 and the effects of September 11 significantly reduced demand and the subsequent need for additional capacity at DIA. After the recession, several high-tech firms that heavily relied on air shipments went out of business or were merged/consolidated with other companies outside of Colorado, which further decreased demand for air cargo.

WorldPort DIA is located south of the main passenger terminal, which is close to the dedicated freight operations of DHL, UPS, and FedEx, as well as the passenger airline Joint Use Facility. It is accessed directly from Pena Boulevard by way of 75th Avenue, as depicted in Figure 5.4.

The WorldPort air cargo facility at DIA was originally planned to be a total of eight buildings equaling 495,200 square feet near the air cargo section of the airport (Figure 5.5). DIA entered into a 30-year ground lease with WorldPort to design, construct, and operate the facilities on 51 acres of land owned by the airport. The project was organized as a PPP between the City of Denver, WorldPort at DIA Owners LLC, and Lehman Brothers. It was originally planned to be completed in 2002, and was intended to provide additional capacity to handle air cargo volume that was anticipated to increase significantly from 1999 through the next 10 years. Several high-tech and biotech firms within the Denver metropolitan area experienced rapid growth and increased their reliance on DIA for air shipments of their products. A surge in purchases made through electronic retailing also contributed to the rising demand for air shipments. It was believed, given current trends in growth and insufficient capacity, that WorldPort would provide warehouse, distribution, cross-dock, and office space to meet the rising demand.

Period of Analysis, Discount Rate, and Key Assumptions

The benefit/cost analysis incorporates the original forecasts of expected cargo volume that were made through 2009. However, to provide a more comprehensive view of the project, a 25-year period of analysis was used. Cargo forecasts beyond 30 years have limited impact on the analysis because of uncertainty and the relative weight of discounting future costs and benefits. Construction was originally planned to take place from 2000 to 2002.

A number of assumptions regarding savings from airport diversions were made in order to facilitate the analysis. These include

- **Truck time savings and operating-cost savings—**Using the same percentages of air cargo shipments at Hartsfield-Jackson Atlanta International Airport (H-JAIA) with 36% of cargo volume domestic and 64% international, Los Angeles International Airport (LAX) and Dallas/Fort Worth International Airport (DFW) were selected as viable alternative airports because of the breadth of their international destinations. Using a truck tractor-trailer operational cost per mile of $1.18 (based on the FHWA Truck Size and Weight Study, with cost/mile ranging from $1.03 to $1.38, depending on speed), a truck crew cost of $25.02 per hour,(*11*) an average distance of 917 miles, and assuming an average of five tons per truck (*12*)—the average cost of transporting one ton of freight per trip equaled $292. This represents the additional cost of transporting one ton to either airport, assuming that DIA is at its maximum air cargo capacity and, therefore, unable to ship any additional air cargo freight.
- **Alternative airport shipping rates—**Since LAX is closer to Asian markets and DFW is closer to South American and European markets, the cargo shipping rates were anticipated to be slightly less expensive than rates from DIA. An average of $200 per ton was estimated to be the difference in international shipping rates between these airports and DIA, which lowers the overall benefit.
- **Belly versus dedicated cargo rates—**With the decline of belly cargo space on passenger carriers, more shippers will

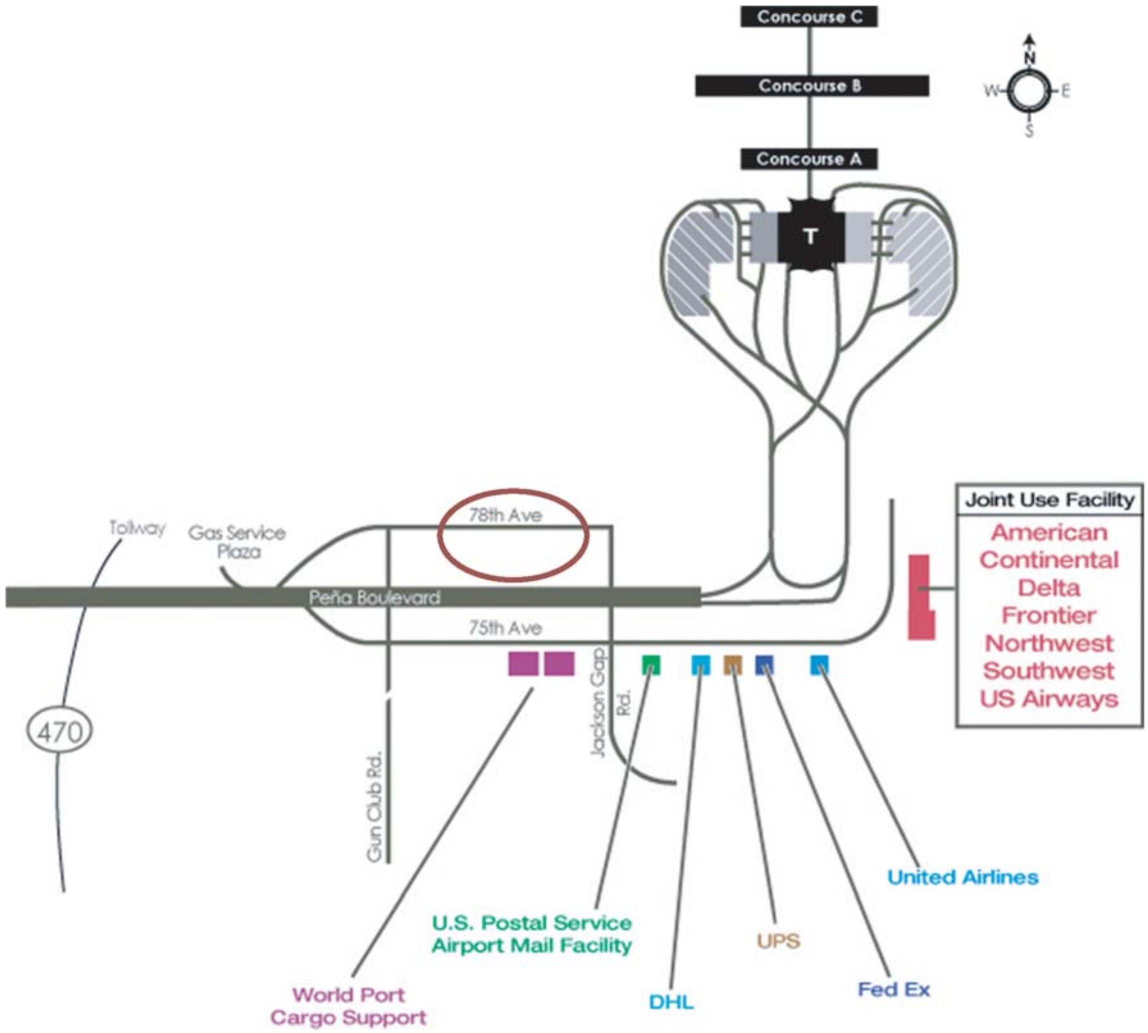


Figure 5.4. DIA air cargo facilities.

use dedicated air freight services. This change in carrier type has two types of impacts. The first is that dedicated air freight is likely to be less expensive either because of its efficient operations and volume or because of reliability. Belly cargo on passenger planes is subject to external factors, such as time delays, baggage space, and other noncargo-related influences. The tradeoff is between time/reliability and cost. Therefore, the study team included the benefit of additional cost of switching from passenger plane belly to dedicated air cargo. Using data from Hartsfield Atlanta, the following estimates were made:

– Average tons per employee: 85 (dedicated freight/number of employees);
– Average wage for passenger airlines: $94,851;
– Average wage for freight forwarders/area commercial carriers: weighted-average wage was calculated based on the wage and number of employees in each type of industry ($77,369); (*13*)
– Average cost per air cargo-ton for passenger airlines: $1,115 per ton;
– Average cost per air cargo-ton for dedicated airlines: $910 per ton; and
– Savings by shipping via dedicated airlines: $205 per ton.

The amount of cargo shipped in passenger carriers declined at a rate of 14.6% per year from 2000 to 2009, reaching its lowest level at 54,500 tons in 2009 at DIA. This decline was extrapolated through 2025. Since shipping by dedicated carriers has a savings rate of $205 per ton, this savings was applied to the actual and forecasted amount of belly cargo from 2003 to 2025. These assumptions were based on information from the Hartsfield-Jackson Atlanta International Airport, and additional research efforts were made to verify cost comparisons. Frontier Airlines publishes the rate of $1,500 per ton for domestic shipments on the 2010 cargo rate sheet listed on their website.(*14*) For UPS, an average 2-day shipment is quoted as $3,240 per ton, a difference of $1,740. However, rates could be substantially lower through company account discounts, depending on the frequency of volume. Additional carrier contacts will need to be made to verify the cost per air shipment.

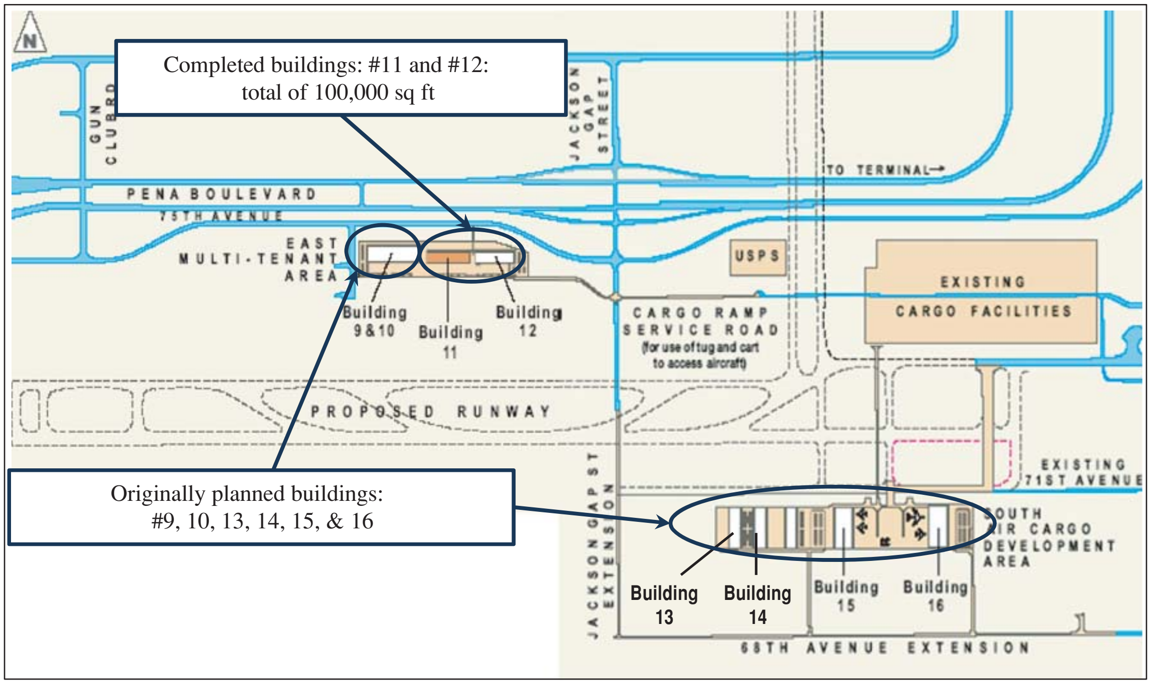


Figure 5.5. WorldPort at DIA, planned buildings.

- **Freight inventory and reliability—**Passenger belly cargo is thought to be less reliable than dedicated freight because of the external factors and circumstances present from priority of passenger movements and baggage requirements. Although recognizing that there is a high likelihood of benefits by improved reliability, no current estimates for the reliability of belly cargo versus dedicated cargo have been made. However, shipping out of DIA instead of trucking cargo to alternative airports provides a freight inventory and reliability savings measured using a freight logistics factor, which represents the business opportunity cost of freight delay, including inventory cost to shippers, carriers (dock handling), and/or those caused by overall schedule disruption. (Freight logistics cost is estimated on the basis of values assigned for recurring travel-time delay, based on literature review and interviews with DIA stakeholders.) The major commodity groups that are transported through the port have varying cost sensitivities per hour of delivery delay, which include major categories such as computers ($3.93/hour) and precision instruments ($5/hour).
- **Safety and environmental benefits—**Estimates are calculated by applying travel volumes to a ratio of accidents to vehicle miles traveled (VMT) and environmental costs per VMT. With the development of WorldPort, cargo is now shipped out of DIA instead of being trucked to alternative airports, which reduces VMT and provides accident and environmental savings. Accident to VMT ratios default values (accident rates per 100M VMT: property damage: 206, personal injury: 90, and fatality: 1.5) were based on information from the Bureau of Transportation Statistics and environmental values of $.057 per mile for the cost of air pollution, and greenhouse gases per VMT were derived from FHWA (*15*) and Victoria Transport Policy Institute.(*16*)

Project Stakeholders

The study focuses on four primary stakeholders: DIA (owned by the City of Denver), WorldPort at DIA Owners LLC, cargo tenants, and regional businesses. All of these stakeholders are classified by their respective roles in Table 5.8.

- **WorldPort at DIA Owners** is a Delaware limited liability joint-venture company that was formed in 1998 for the purpose of developing air cargo, warehousing, office, and distributional facilities at DIA. The joint venture includes subsidiaries of Aviation Development Services, Lehman Brothers Holdings, and the Neenan Company. At that time, air cargo growth in Denver was expanding and expected to continue while the current facilities were approaching maximum capacity. Although the ground lease was contracted with the airport, WorldPort provide the leasing and contract services for tenants and, therefore, is classified as the private-sector asset provider.
- **Cargo tenants** include freight forwarders, cargo airlines, and government agencies; all of which were identified as potential customers to lease the developed facilities. These organizations provide goods movement service for shippers and, therefore, are classified as service providers.
- **The City and County of Denver** operate DIA, which is the 12th busiest airport in the world by passenger traffic.(*17*)

Table 5.8. Stakeholder classifications.

Stakeholder	Public Sector	Service Provider	Shipper/ End User	Other Party	Private Asset Provider
WorldPort at DIA	●				●
Cargo Tenants		●			
City/County of Denver	●			●	
Regional Businesses			●		

Being owners of the land and enacting a ground lease with WorldPort at DIA qualifies the city and county as asset providers, even though WorldPort performed that actual development. The city and county also provided a financial asset with the issuance of special facility bonds, which are intended for privately owned projects yet exempt from federal taxes. This type of bond issuance lowers the overall cost of capital and provides an incentive for development. However, no city or county taxpayer money was used or pledged in the repayment of the bonds. Additional revenues from property, sales, and other tax mechanisms due to increased business activity also categorize local and regional governments as other stakeholders.

- WorldPort was developed with the transportation needs of **regional businesses** in mind. Additional capacity for air shipments benefits businesses that heavily rely on timely shipments of either input components or their final outputs, which is why they are classified as end users. From an economic development perspective, providing operational air cargo services to handle increasing volumes can be viewed as an incentive to attract and retain business in the Denver metropolitan area that rely on time-sensitive shipments for their products.

Benefits

The primary benefit measures due to the construction of WorldPort are the foregone costs that would have occurred, if cargo was required to be shipped to an alternative airport or transported via passenger cargo, instead of using dedicated cargo. The cost of shipment using an alternative airport includes the cost of trucking the cargo to the airport minus any difference in the air cargo rate. The difference between the passenger cargo rate and the dedicated cargo rate also is considered to be a benefit due to the project at DIA. The following sections provide a more detailed description of the benefit measurements with a summary of all categories in Table 5.9.

Despite an optimistic future outlook, not long after 2000, the economy declined following the "Dot Com Era." The events of 9/11 drastically reduced commercial flights. At the same time, passenger airlines began rightsizing their aircraft—

Table 5.9. Present value of benefits (millions of dollars).
25-Year Timeframe

Benefit Metric (in Millions of Dollars)	User (Shipper)	Service Provider	Infrastructure Provider (WorldPort)	Infrastructure Owner (DIA)	Public
Truck Travel-Time Savings	–	$0-$39.2	–	–	–
Truck Operating Cost Savings	–	$0-$39.8	–	–	–
Alternative Airport Shipping Rates	$0-$86.6	–	–	–	–
Freight Inventory/ Reliability	–	$0-$8.5	–	–	–
Accident Savings	–	–	–	–	$0-$3.2
Emissions Savings	–	–	–	–	$0-$4.5
Rental Revenues (Transfer)	–	-$12.9	$12.6	$.3	–

a trend in which passenger airplanes transitioned to airplane models that have less belly space, which lowers operating costs but also reduces the space available for cargo shipments on passenger flights. These combined events decreased the volume and capacity of air cargo in Denver, which eliminated any present demand for planned buildings. Only two buildings (totaling 100,000 square feet) were actually completed in 2002. One building currently has the TSA and U.S. Customs & Border Protection as tenants while the other is vacant.

Since the market decline in air cargo reduced overall volume below capacity levels, a logical conclusion would be that there was no benefit from the project, since only two out of eight buildings were actually developed and do not have any current private-sector tenants. However, as evidenced by past recoveries, the air cargo market will likely rebound in the future. Based on this assumption, the current WorldPort buildings will be in a position to support that growth by providing needed capacity. To determine the overall benefit the project could have provided, the study team estimated the additional costs that would have been incurred if WorldPort had not been developed. For air cargo volume forecasts that are higher than current capacity, additional costs would have been incurred for truck shipments to alternative airports and to use belly cargo rates charged by passenger airlines (instead of dedicated rates). Using this rationale, and assuming WorldPort was developed, these costs would not have been incurred and, therefore, are considered benefits, understanding that air cargo volume estimates were based on pre-project forecasts.

In 2000, air cargo volume at DIA reached its pinnacle at 519,000 tons. The total cargo/mail facility is estimated to be 381,000 square feet, which equates to 381,000 tons using the industry-accepted utilization ratio of one U.S. ton per square-foot of cargo building space.(*18*) Although the volume that DIA could handle was not determined through interviews and research, it is known that the 2000 volume was handled given the capacity at that time and, therefore, the study team hypothesized that this volume was the maximum amount of air cargo that DIA could ship and receive. Dividing the maximum air cargo volume by the cargo/mail facility equals a utilization ratio of 1.36. Adding 100,000 additional square feet and applying the utilization ratio would increase the maximum capacity to 655,000 tons of air cargo. The study team used the most conservative of the original forecasts that cargo volume would grow to 800,000 tons by 2009. The cost differential of shipping out of DIA versus using another airport only applies to volume greater than the no-build capacity scenario (519,000 tons) and less than the build scenario (655,000 tons). This is because any volume above 655,000 tons would be beyond DIA's capacity. However, given that this scenario is hypothetical, volume forecasts in this analysis could range from 519,000 tons or lower (no benefit), or up to 655,000 tons and higher (full benefit).

Costs

This project was unique because it was the first third-party cargo development to acquire financing, based on forecasts and financial projections according to the economics of the air cargo industry. The original financing structure included $46 million in equity and $54 million in special facility bonds (SFB) issued by the City of Denver and underwritten by Lehman Brothers Inc. In the terms of the deal, WorldPort at DIA would repay the bonds from tenant leases, and the bonds were guaranteed by a letter of credit issued by Morgan Guaranty Trust Company of New York. No city property or airport revenues were pledged as security for the repayment of the bonds.

Capital costs were originally estimated to be $100 million for the 495,000 square feet of capacity. However, only $30 million was spent for the two buildings that combine for a total of 100,000 square feet ($25 million came from Lehman equity and $5 million from bonds). Operations and maintenance costs were estimated to be $0.20 per square feet, which equals $200,000 (starting in 2000) per year for both buildings. It was estimated that these costs would appreciate at 2% per year.

Benefit/Cost Analysis and Other Performance Metrics

The latitude of ranges described earlier provides a broad discretion on what is considered to be a rational forecast given expected market conditions. Therefore, in Table 5.10,

Table 5.10. Benefit/cost analysis summary.

Category	Discounted Sum (3%)	Discounted Sum (7%)
Total Benefit	$0–$53 million	$0–$32 million
Total Cost	$26 million	$28 million
B/C Ratio	0–2.36	0–1.14
Net B-C	$0–$36 million	$0–$4 million

the benefits are presented as ranges that depend on the volume selected in the analysis.

Other important components of the project include costs and performance measures that describe the estimates and assumptions that went into the project analysis. Summaries of these categories also are listed in Table 5.11, and they include

- **Jobs at port—**The 2003 *Economic Impact of Airports in Colorado* (*19*) lists the total (direct, visitor spending, and spin-off [multiplier effect]) jobs at DIA as 193,229. The updated 2008 study (*20*) shows an increase to 217,459 and indicates that 76,092 of those jobs are directly related to on-airport businesses and tenants (including those related to airlines, ground transportation providers, terminal concessionaires, government agencies, the military, FBOs, maintenance and repair providers, flight instructors, air charter operators, agricultural sprayers, and others). Because of a lack of specific information for jobs associated with air cargo (e.g., carriers and freight forwarders), estimates were made for DIA. An industry planning axiom of 20 to 30 jobs for every 1,000 tons of air cargo was used in conjunction with the total cargo imported and exported at DIA in 1999 and 2009 to estimate a range of the number of air cargo jobs at DIA for both passenger belly and dedicated air cargo. The estimates were the following:
  - For 1999: 515,595 tons = 10,312 to 15,468 jobs; and
  - For 2009: 224,423 tons = 4,948 to 7,421 jobs.
- **Airport capacity—**An industry-accepted utilization ratio of one U.S. ton per square-foot of cargo building space was used and, according to a feasibility report, the existing air cargo space at DIA is 325,000 square feet.(*18*) The feasibility study outlines the original plans for a total of eight buildings that cover 495,200 square feet, which would have increased the total square footage to 876,444 or 1.2 million tons using a utilization factor of 1.36. Ultimately, only two buildings (Number 11—cross docking and Number 12—GSE support) were built, which added only 100,000 square feet of air cargo space.
- **Passenger capacity—**Passenger airline carriers also provide air freight services and transport cargo within the belly of the plane. A list of the total amount of belly capacity for DIA was not located. However, several trends have indicated that this amount of space is slowly decreasing, for several reasons, including the following:
  - After 9/11 the number of commercial flights dropped;
  - The FAA restricted the type of cargo that could be carried in passenger aircraft;
  - Passenger carriers have rightsized their aircraft, replacing wide-body aircraft with narrow bodies to lower operational costs and increase load factors; and
  - Restrictions on personal carry-on possessions has forced additional baggage into the cargo belly.
- **Airport volume—**When WorldPort was being considered, air cargo shipments at DIA were dramatically increasing with forecasts for continued growth. The contrast between the expected future growth and the current handling capacity at DIA was the catalyst for developing additional facilities. In the Denver metropolitan area, companies that specialized in hard drives, switch gears, computer chips, and biotech heavily used air shipments to transport their products and in the late 1990s and early 2000s these industries were experiencing phenomenal growth (according to an interview with DIA Director of Planning Rick Bush). The rise in just-in-time inventory practices and electronic commerce (retailing) created strong demand for fast service that heavily relied on air cargo. According to the FAA, air cargo traffic nationwide increased 6.7% annually from 1988 to 1998.(*18*) These trends were further supported by forecasts that indicated a promising future for the cargo market. Boeing forecasted that worldwide air cargo would

Table 5.11. Other performance metrics.

Performance Measures	Pre-Project (2000)	Post-Project (2009)
Jobs at Port	10,300 to 15,400	4,900 to 7,421
Airport Square Footage	381,000 square feet	481,000 square feet
Airport Capacity	471,000 square feet	525,000 square feet
Airport Volume — Actual	471,000 tons	224,400 tons
Airport Volume — BCA Scenario	471,000 tons	595,000 tons (2025)
DIA Operations Revenue	$438.3 million per year	$540.7 million per year (2008)
DIA Incremental Air Cargo Revenue	N/A	$1.28 million per year
DIA Operations Cost	$191.4 million per year	$373.8 million per year (2008)

increase at a rate of 6.4% from 1998 to 2007, while Airports Council International forecasted U.S. cargo to increase at an annual rate of 5.8% from 1997 to 2010.(*18*) However, with the economic recession after the Dot Com bubble burst and the events of 9/11, a large portion of high-tech companies in Colorado were acquired, merged, or went out of business. With lagging sales and a decrease in customers' willingness to pay for expedited products, other companies switched to 2-day truck service; further exacerbating the drop in air cargo. Volume in 2009 (224,423 tons) was significantly below the capacity of 591,000 tons. However, DIA is well positioned to accommodate additional air cargo when the economy begins to recover.

- **Operating revenues and costs—**In the 2008 DIA financial report, operating costs and revenues are listed for the entire airport.

Risk Assessment

The element of risk is included in the analysis due to uncertainty in future port growth. Uncertainty can come from events such as 9/11 or Hurricane Katrina, or be classified as cyclical and random risk (e.g., business cycles, exchange rates, or industry fluctuation). Table 5.12 provides the risk assessment results that were based on the risk drivers of cargo growth rates. Because the project centers on providing additional capacity, the downside risk of investment can be substantial if the capacity is not used. The range of benefits is based on international growth rates of 3.3% to 9.6%, which are reflective of the trends during the late 1990s and early 2000s. In 2009, international shipments made up only 3% of total cargo shipments.

Case Study 3—Tchoupitoulas Corridor Improvements

Background

After relocating the Port of New Orleans from the inner harbor out to the Mississippi River, a new port access roadway was built to remove trucks coming into the port from the local neighborhood (especially from the major thoroughfare of Tchoupitoulas Street). The new access road was named the Clarence Henry Truckway (also known as, the Tchoupitoulas Truckway); and is a two-lane, 3.5-mile heavy-duty road that provides dedicated access to the Port of New Orleans for truck-transported cargo. The Tchoupitoulas Corridor Improvements Project included widening Tchoupitoulas Street from a two- to three-lane highway with accompanying sewer, drainage, and flood wall improvements to provide security and protection for the port.

New Orleans has been a center for international trade since 1718, when it was founded by the French. Today, the Port of New Orleans is at the center of a busy port complex—Louisiana's lower Mississippi River. Its proximity to the American Midwest via a 14,500-mile inland waterway system makes New Orleans the port of choice for the movement of cargo to, and from, the region. The port is located between, and runs parallel to, Tchoupitoulas Street and the Mississippi River. Pontchartrain Express (Highway 90) provides highway access to the west (Figures 5.6 and 5.7).

There is one entry/exit security gate located at the intersection of Tchoupitoulas and Felicity Streets with a variety of warehouse and intermodal facilities located nearby (Figures 5.8 and 5.9).

There are 50 ocean carriers, 16 barge lines, and 75 truck lines that serve the Port of New Orleans. Seventy-three percent of cargo goods are imports, and it is the top port of entry for steel, natural rubber, plywood, and coffee in the United States. The port handled 38 million tons of cargo in 2000, including 12.2 million tons of general cargo, which included more than 224,000 containers (equaling more than 346,000 20-foot equivalent units [TEU] and 26.8 million tons in bulk cargo).

With the rise in truck traffic surrounding the port, issues surrounding traffic flow began to arise with the traffic concentrated on two-lane Tchoupitoulas Street, which was in poor condition. Port traffic spread out and traveled through the local neighborhood, including areas such as the New Orleans' historic Garden District, parks, universities, and retail establishments. Concerned citizens expressed the need to improve safety and minimize damage to historic buildings caused by the large volume of commercial traffic. In 1983, the

Table 5.12. Risk analysis results of total net benefits (thousands of dollars).

	10% Lower	Mean	10% Upper
Total Net Benefit (3%)	$26,831	$32,879	$33,987
Total Net Benefit (7%)	-$16,417	-$5,767	$982

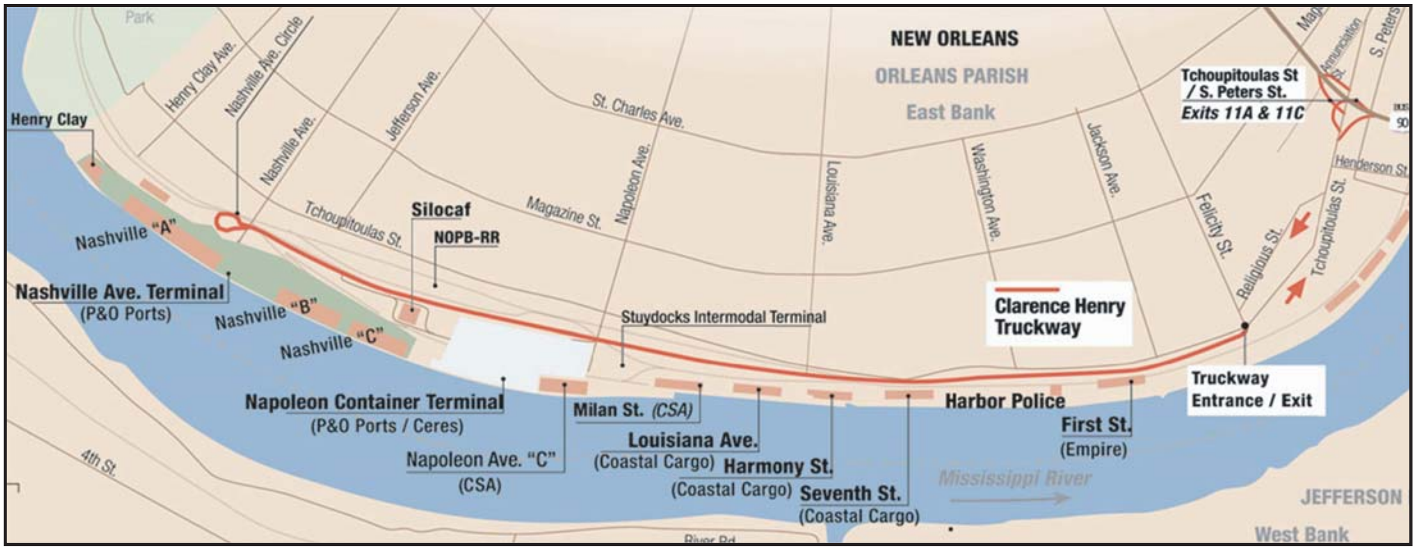


Figure 5.6. Port of New Orleans.

Figure 5.7. Extent of Tchoupitoulas Corridor Improvements.

Figure 5.8. Port of New Orleans entry gate.

Figure 5.9. Port of New Orleans entry gate (street view).

city mandated certain restrictions, including the removal of trucks from historic neighborhoods, reconstructing the local roadway and constructing a new dedicated truckway for port traffic. Enforcing the truck restrictions was difficult, however, and funding for the project did not begin until 1989. Construction commenced in 1994, and the final stage was completed in 2003.

The purpose of the project was to provide a roadway that improved access to the port while removing heavy-vehicle traffic from the surrounding neighborhood streets. The objective of the project also was to stimulate residential and commercial development in the surrounding area, and redevelop vacant and underutilized land and facilities at the port.

Funding for the project came from the Transportation Infrastructure Model for Economic Development (TIMED) Program that was created by the Louisiana Legislature in 1989. The program was funded by a 4-cent-per-gallon tax on gasoline and special fuels for 15 years (January 1990 to December 2004). The Tchoupitoulas corridor project is one of 16 projects funded by the program.

Period of Analysis, Discount Rate, and Key Assumptions

Historical container volumes at the port from 1994–2008 were used in the analysis. Volume for break bulk and containers was 10 million tons in 1994 and 5.9 million tons in 2008. Using a timeline of 25 years, the study team assumed that by 2019 cargo volume would return to its 1994 volume, which implies a zero growth rate from 1994, but implies a growth rate of 5.23% from 2008. Cargo forecasts beyond 30 years have limited impact on the analysis because of uncertainty and the relative weight of discounting future costs and benefits. Construction of the dedicated truckway started in 1994 and was completed in 2003.

Project Stakeholders

The study focuses on four primary stakeholders: the Port Authority of New Orleans, local/state governments, cargo carriers/freight forwarders, and regional businesses, all of which are classified by their respective roles in Table 5.13.

- **The Port of New Orleans** is governed by a board of seven commissioners, who are nominated by local business, civic, labor, education, and maritime groups, and selected by the Governor of Louisiana. The principal funding of the port's operating revenues primarily comes from terminal operations (dockage, rentals, and harbor fees), which equaled $28.4 million in 2008. The port provides the service of loading and unloading cargo from berthed vessels; however, it is through the dedicated truckway that cargo is

Table 5.13. Stakeholder classifications.

Stakeholder	Public-Sector Asset Provider	Service Provider	Shipper/End User	Other Party	Private Asset Provider
Port of New Orleans	●				
Local/State Governments				●	
Carrier/Freight Forwarder		●			
Regional Businesses			●		

transported to and from the port, creating efficient goods movement. Since the port provides the use of this asset, it is classified as the public-sector asset provider.

- **State and local governments,** such as the Louisiana Department of Transportation and Development (DOTD) and the New Orleans Regional Planning Commission, are beneficiaries of the project due to (1) additional economic activity and corresponding tax revenues; and (2) reduced accidents and maintenance costs from removal of commercial trucks from Tchoupitoulas Street. Because of these benefits, state/local governments have an interest in the project, and therefore are classified as other stakeholders.
- **Cargo carriers/freight forwarders** who use the facilities at the port are the organizations that provide the transportation services for shipping customers and therefore are classified as the service providers. The benefit from the time savings is provided by the dedicated truckway.
- **Regional businesses** potentially may have additional volume because the dedicated truckway provides time savings and efficient goods movement, which translates into costs savings. Businesses that rely on these transportation services at the port for their production input or output are accordingly classified as end users.

Benefits

The primary benefits of the dedicated truckway are the time savings for trucks that can access the port unencumbered by neighborhood traffic and intersections along Tchoupitoulas Street. This is accompanied by other directly related benefits, including reliability, reduction in accidents, and safety. The following sections provide a detailed description of the benefit measurements with a summary of all benefits in Table 5.14. Without information on the percentage of break bulk volume being transported by truck or rail, the research team assumed that 50% of break bulk cargo is transported by truck, and that all of the container cargo is transported to and from the port by truck.

- **Time savings—**After the relocation of the Port of New Orleans to the Mississippi River, trucks were able to access the port through four truck routes using various entry points; however, this required a portion of the trip be on Tchoupitoulas Street, which is used by local neighborhood traffic. With the construction of the dedicated truckway, commercial trucks were able to bypass local traffic and the accompanying traffic lights in accessing the port. It was difficult to identify drivers that had made deliveries to the port prior to the construction of the truckway, which started in 1994. Therefore, to estimate the approximate amount of savings per truck trip, the research team analyzed the speed and distance while factoring in the number of traffic intersections. With these assumptions, it was estimated that using the dedicated truckway would reduce a trip from 1.5 hours to 1.0 hour. Time savings translates into cost savings for carriers in categories of both crew costs and vehicle operating costs. Using a truck operational cost per mile of $4.50 per hour (based on FHWA estimates), a truck crew cost of $25.02 per hour from published BLS values for truck drivers, (*11*) plus fringe benefits, and assuming an average typical cargo loading of 10 tons (*12*) per truck yields an average cost savings of $14.78 per truck or $1.48 per ton. Drivers did communicate that certain security has been implemented at the entry gate, which has increased the turnaround time entering and exiting the port. However, these security measures would have been implemented regardless of the creation of the truckway, and therefore were not factored into the overall time estimates.
- **Reliability cost (buffer time)—**Reliability is a measurement that takes into account congestion and variability. Congestion occurs when the current volume of traffic approaches the maximum capacity of the highway (measured by the metropolitan average of the fraction of VMT subject to a volume/capacity ratio greater than 0.95). The unexpected level of congestion contributes to variability. To accommodate anticipated congestion, drivers often include additional trip time—known as buffer time or scheduled

Table 5.14. Present value of benefits (millions of dollars).
25-Year Timeframe

Benefit Metric (in Millions of Dollars)	User	Service Provider	Infrastructure Provider (Port of New Orleans)	Public
Truck Travel-Time Savings	–	$15.9	–	–
Truck Operating Cost Savings	–	$99.3	–	–
Freight Inventory/Reliability	$21.0	–	–	–
Accident Savings	–	–	–	$1.6
Emissions Savings	–	–	–	$0.6
Noise Savings	–	–	–	$6.4

padding. Reducing the truck delivery time from 1.5 hours to 1 hour decreases the likelihood of unexpected congestion/delay and, consequently, the amount of buffer time. The reduction of buffer time is considered a time savings for both crew costs ($25.02 per hour) and transported freight ($2.25 per ton).

- **Freight inventory and reliability savings** are measured using a freight logistics factor, which represents the business opportunity cost of freight delay, including inventory cost to shippers, carriers (dock handling), and/or those caused by overall schedule disruption. (Freight logistics cost is estimated on the basis of values assigned for recurring travel-time delay from Highway Economic Analysis Tool (HEAT) documentation, based on literature review and additional research by Cambridge Systematics and EDR Group.) The major commodity groups that are transported through the Port of New Orleans have varying cost sensitivities per hour of delay; assumptions for total value of delay in this study (derived by the Transportation Economic Development Impact System [TREDIS] model) include rubber ($0.89/ton-hour), coffee ($.53/ton-hour), and plywood ($0.99/ton-hour).

Safety and Environmental Benefits. Safety and environmental improvement estimates are calculated by applying travel volumes to a ratio of accidents to VMT and environmental costs per vehicle-hour traveled (VHT) per hour. By permitting only commercial trucks, having no stoplight intersections, and taking less time to make a delivery, driving on the dedicated truckway compared to using Tchoupitoulas Street provides both safety and environmental savings. These savings are measured by the reductions in VMT and VHT along Tchoupitoulas Street. Environmental costs were estimated to be $.21 per hour.(*16*) The following safety category ratios were reduced to reflect the removal of trucks from the highway (per 100 million VMT):

- Fatalities: 0.4 to 0,
- Personal injury: 12 to 4, and
- Property damage: 198 to 99.

Accident to VMT ratios were based on information from BTS, and environmental values per VHT were derived from FHWA and the Victoria Transport Policy Institute.

Noise reduction benefits also were calculated. Research into monetary valuations of noise costs have centered on the depreciation in property values that are exposed to noise. Findings from a study by INFRAS using a Noise Depreciation Index estimate that reductions in property value from truck noise amounted to $0.026 per ton-mile or $0.26 per VMT.(*21*) A TranSafety article (*22*) estimated damages for a 5-axle semitrailer operating at 65,000 lbs at $0.08 and $0.15 per VMT for urban business districts and urban fringe areas, respectively. A midpoint of $0.20 per VMT was used in the analysis.

Costs

The original capital costs of the project ranged from $70 million to $75 million, with 4% coming from the port and 96% coming from public sources. Actual capital costs were $60.4 million, which are listed by category and source in Table 5.15.

Operations and maintenance costs of the dedicated truckway were estimated to be approximately $400,000 per year in 1996, growing at a rate of 3% per year.

Benefit/Cost Analysis and Other Performance Metrics

Using a discount rate of 3% or 7% and a time horizon of 25 years, the total discounted benefits are shown in Table 5.16.

Other Performance Metrics. Other important components of the project include costs and performance measures that describe the estimates and assumptions that went into the project analysis. Summaries of these categories also are listed in Table 5.17, and they include the following:

- **Jobs at the port**—According to a 2004 economic impact report, the number of direct jobs at the port was estimated

Table 5.15. Actual capital costs by category and source.

Funds	Category	Source
$20,000,000	Roadway	TIMED Funds
$15,000,000	Floodwall, utilities, and railroad track relocation	TIMED Funds
$15,424,690	Reconstruction of corridor	Surface Transportation Program (STP)
$10,000,000	Miscellaneous	Port of New Orleans
$60,424,690	Total	

Table 5.16. Benefit/cost analysis summary.

Category	Discounted Sum (3%)	Discounted Sum (7%)
Total Benefit	$141 million	$86 million
Total Cost	$47 million	$44 million
B/C Ratio	3.02	1.96
Net B-C	$94 million	$42 million

at 12,331. Reports and estimates for previous years were not made available.

- **Port capacity—**Port container capacity estimates were sourced from a strategic advisory report authored by Parsons Brinckerhoff,(*23*) indicating that the maximum practical capacity (MPC) of the port was 594,000 tons (based on the limits of the storage space). In discussions with port officials and freight forwarders, there were no indications of any constraints or bottlenecks based on current volume.
- **Operating revenue and costs—**Operating revenues for cargo operations at the port totaled $41.2 million; and operating costs were $53.2 million in 2008.

Risk Assessment

The element of risk is included in the analysis due to uncertainty in the future port growth. Uncertainty can come from certain events such as 9/11 or Hurricane Katrina, or be classified as cyclical and random risk (e.g., business cycles, exchange rates, or industry fluctuation).

In 1996, after the major section of the truckway was built, cargo volume was 10 million tons. Since volume decreased down to six million in 2008 and was forecasted to rise back up to 1996 levels in 2019, a very small growth rate of estimate of 0.1% was used in the analysis. To account for fluctuations and uncertainty of cargo growth, a range of 0.1% to 3.0% was used to calculate the upper and lower bounds presented in Table 5.18.

Case Study 4—Heartland Corridor Clearance Initiative

Background

The Heartland Corridor Clearance Initiative began in 2006, and at the time of this writing is in its final stage of construction. The project, scheduled to be complete in the fall of 2010, involves improvements to the rail network, as well as access to intermodal facilities and maritime ports, which have been deemed essential to accommodate the growth in rail

Table 5.17. Other performance metrics.

Benefit Metric	Pre-Project (1993)	Post-Project (2008)
Jobs at Port	Not Available	12,331 (2004)
Traffic ADT: Tchoupitoulas Street	12,957 (3,200 trucks) (1997)	10,367 (2009)
Traffic ADT: Dedicated Truckway	0	465 (2004)
Trains per Day	16	16
Port Capacity (TEUs)	250,000 per year	594,000 per year
Port Volume (TEUs)	250,000 per year	300,000 per year
Port Operations Revenue	$38.2 million per year	$41.2 million per year
Port Operations Cost	$22.8 million per year	$53.2 million per year

Table 5.18. Port of New Orleans cargo growth rate (risk analysis).

	10% Lower	Mean	10% Upper
Total Net Benefit (3%)	$115,260	$119,560	$122,690
Total Net Benefit (7%)	$58,425	$60,102	$61,227

intermodal freight. Access to intermodal facilities has allowed producers to maintain smaller inventories while providing a competitively high level of service through fast and efficient delivery of manufactured goods to end users.

The area formed by West Virginia's southern and western panhandles, eastern Kentucky, and southern Ohio is not served by a local intermodal facility. Generally, containers are transported by truck to and from intermodal facilities outside of the region. These containers are then hauled on a single-stack train to their destination. Containers travel from the Norfolk Marine Terminal in Virginia toward the Chicago and Detroit freight hubs through the region. There are five main rail freight routes along which containers are transported; these routes are operated by CSX Transportation and Norfolk Southern (NS) Railroad.

The Heartland Corridor Double-Stack Initiative enables hauling piggybacked containers, thus facilitating increased capacity and shortened travel times to meet demand for freight rail transport. Intermodal freight transport was a constraint for regional economic expansion. Moreover, serious congestion on I-81 and other routes due to truck traffic growth was impeding regional travel. To increase truck-rail transfers and make freight transportation more efficient, the Heartland Corridor Double-Stack Initiative was created as a public-private partnership between local governments, the federal government, and NS Railroad.

Construction for the Heartland Corridor Double-Stack Initiative takes place on NS' Norfolk and Western Route that originates in Norfolk, Virginia, and Cincinnati, Ohio, to Columbus, Ohio. The rail line traverses three states—Virginia, West Virginia, and Ohio (Figure 5.10). The line entrance in the east is located in Norfolk, Virginia, and continues west through Roanoke, Virginia. At Bluefield, Virginia, the line shifts direction to northwest through much of West Virginia along the Kentucky state line until Columbus, Ohio. The rail tracks are part of the NS Virginia Division until Bluefield, Virginia, at which point they become part of the NS Pocahontas Division. The 667 miles of the line are predominantly double track and are entirely equipped with a block signaling system. In most areas, the system operates under centralized traffic control. The route offers favorable grades and curvature for double-stack freight transport.

In the past, this line has benefited from numerous capital investments for maintenance and improvements due to the higher daily volume of trains that use this route. This line transports about 50 coal and freight trains daily. This route also represents the shortest freight rail distance between Norfolk, Virginia, and Columbus, Ohio.

The Heartland Corridor Double-Stack Initiative was created to increase capacity and decrease travel time on the Norfolk and Western 667-mile route. The initiative modifies the route to allow for double-stack container intermodal freight transport. It also shortens container transit routes between many freight terminals in the East and the Midwest. This reduction in distance allows for a reduction in the average transit time for goods transported along this route.

The project scope includes the modification of 28 tunnels and the removal of 26 overhead obstructions in West Virginia, Ohio, and Kentucky to allow for double-stack freight transport. The project is anticipated to take 5 years from 2006 to 2010.

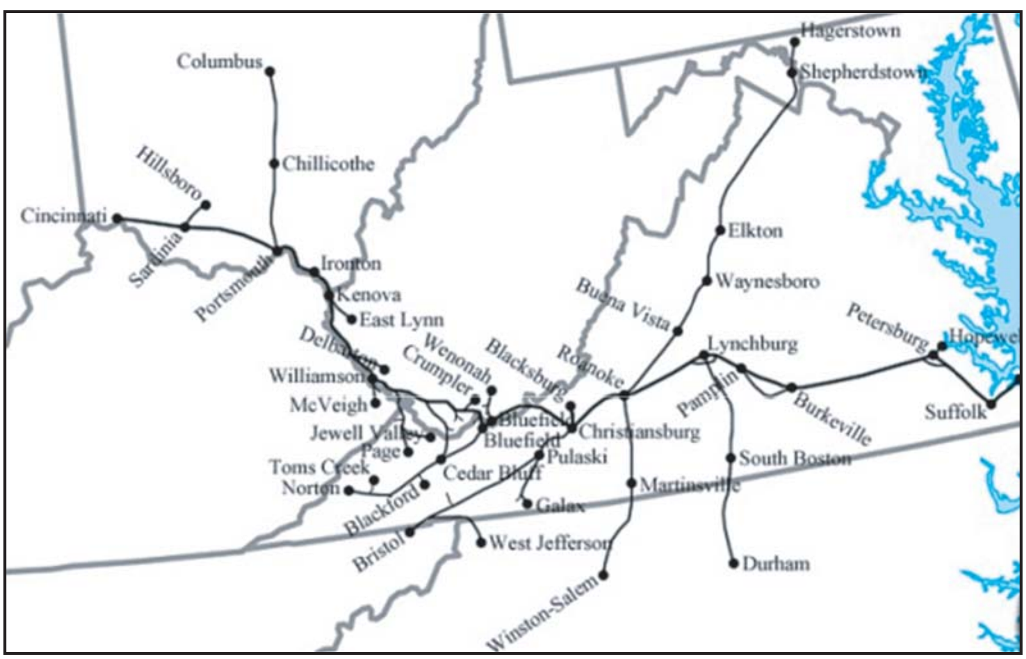


Figure 5.10. NS Norfolk and Western freight route.

Period of Analysis, Discount Rate, and Key Assumptions

The benefit/cost analysis considers the performance of transportation facilities given forecast traffic. Although the design life of many facilities is 40 years or more, there are several reasons for selecting a shorter period of analysis (say, 30 years). One reason is that with discounting, the relative magnitude of benefit and cost streams in excess of 20 years are generally small and have limited impact on the analysis. Second, traffic is typically forecast for an out-year of the analysis and as the analysis extends beyond 20 years, forecasts will be more uncertain and less reliable. The benefit/cost analysis captures the benefit of the remaining useful life of the facility that extends beyond the period of analysis (called the "residual value"), so that a properly constructed benefit/cost analysis will be fully reflective of an asset's contribution, even if the period of analysis is less than the asset's design life.

This benefit/cost analysis uses a post-construction 30-year period of analysis, from 2011 to 2040. In the 5 years prior to our analysis, the new facilities will be under construction in the alternative case. Realized benefits will be taken into account beginning in 2011.

The following two key assumptions were made to facilitate the analysis:

- **Traffic Growth—**This case study considered three scenarios with varying rates of intermodal traffic growth for double-stack trains along the Heartland Corridor. Container traffic at U.S. ports has increased by 6% with an associated standard deviation of 2%. Accordingly, traffic growth along this corridor was modeled at the mean and one standard deviation above and below that value. The case study was, therefore, performed using three traffic growth scenarios—low (4%), medium (6%), and high traffic growth (8%). In all scenarios, we assumed traffic growth dropped to 1% in 2025. Single-stack traffic was allowed to grow at a maximum annual rate of 3%, which is lower than double-stack traffic growth rates. Freight not accommodated by rail in the base case will, by assumption, be shipped by truck.
- **Discount Rate—**The discount rates used in this case study were 3% and 7%. The higher discount rate implies a lower value of future benefits compared to discounted benefits using a lower discount rate. These two rates allowed for a balanced evaluation of the project and protect against overly optimistic project assessments.

Project Stakeholders

This study focused on six stakeholders: the federal government, the regional governments of Ohio and Virginia, NS Railroad, regional businesses, and the regional population. It is important to note that since this freight infrastructure investment is a public-private partnership, stakeholders often hold dual roles. Table 5.19 identifies all of the stakeholders for the Heartland Corridor Double-Stack Initiative by type.

- **Norfolk Southern** is the owner of the rail line and the area surrounding the Norfolk and Western Line. The infrastructure improvement is set to take place directly on the railroad's tracks. NS will, therefore, have a direct financial stake in the program because it plans to fund much of the construction, operation, and maintenance costs. Following construction, NS provides maintenance of way, traffic control, and freight service in the corridor. This qualifies NS as an asset provider through its capital and financial investment, and as a service provider.

Table 5.19. Heartland Corridor double-stack initiative stakeholders.

Stakeholder	Stakeholder Type	Stakeholder Interest
Norfolk Southern	• Asset Provider • Service Provider	• Direct Financial Stake • Indirect Stake
The Nation	• Asset Provider • Other	• Direct Financial Stake • Indirect Economic Stake
Virginia Department of Rail and Public Transportation	• Other • Asset Provider	• Direct Financial Stake
Ohio Rail Development Commission	• Other • Asset Provider	• Direct Financial Stake
Regional Businesses	• End Users • Other	• Direct Business Stake • Indirect Stake • Direct Economic Stake
The Region	• Other	• Major Nonfinancial Stake • Direct Economic Stake

- **The U.S. government,** acting through FHWA, provides finance to the project and benefits directly from it since it contributes to strengthening the national economy. This qualifies the federal government as an asset provider and other stakeholder.
- **Local governments** were represented in this study by two regional transportation organizations. The Virginia Department of Rail and Public Transportation (VDRPT) will be responsible for funding the majority of construction in Virginia. The Ohio Rail Development Commission (ORDC) will finance all of the construction in Ohio. Both states will have a direct financial stake in the project; therefore, they are classified as asset providers. It is expected that this project will catalyze business and manufacturing activity in the area of interest; therefore, these two local governments may be classified as other stakeholders.
- **Local and regional businesses** enjoy business benefits from the project (e.g., lower costs, more timely deliveries) because the Heartland Corridor project enhances capacity and efficiency on the corridor, thus allowing for increased throughput. The consignees of goods shipped through intermodal means are often manufacturers or distributors; for the purposes of this study, the researchers considered them both as regional businesses. These businesses also experience the economic impact generated by this investment and, therefore, have an economic stake in the project. Therefore, regional businesses are classified as end users and other stakeholders.
- **The region surrounding the project area** will benefit from an amelioration of its environmental quality. The lower cost of shipment will entice a diversion of container traffic from trucks to intermodal freight rail. In doing so, emissions from trucks will be reduced as more end users decide to transport their goods via rail. The reduction in highway truck traffic relieves congestion on the adjacent routes of the Heartland Corridor. The diversion reduces emissions output while alleviating congestion on adjacent highway roads. This qualifies the region to become an other stakeholder in the project.

Benefits

The freight investment generates benefit streams to the project stakeholders. As shown in Table 5.20, the project benefits can be grouped into the following three principal categories:

1. Grade crossing elimination,
2. Economic development, and
3. Improved railroad operations.

Railroad Benefits

Transportation Savings. The selected route for the double-stack initiative would represent the shortest distance and travel time between Norfolk, Virginia, and Columbus, Ohio. The use of the Norfolk and Western Line to ship goods, as opposed to using adjacent routes, yields significant savings in distance traveled. This is reflected as a savings in travel time. Figure 5.11 compares the Heartland Corridor route to two other competing routes from Norfolk, Virginia, to Columbus, Ohio.

Table 5.20. Heartland Corridor double-stack initiative stakeholders and benefits.

Benefit	Affected Stakeholder Type	Affected Stakeholder
Railroad Benefits		
Reduced Shipping Cost	• Asset Provider • Service Provider	• Norfolk Southern Railway
Reduced Inventory Carrying Cost	• Shippers • End Users	• Regional Businesses and the Region
Diversion Benefits		
Travel-Time Savings	• All Stakeholder Types	• The Nation, VDRPT, ORDC, Regional Businesses, and the Region
Reduced Vehicle Operating Costs	• All Stakeholder Types	• The Nation, VDRPT, ORDC, Regional Businesses, and the Region
Safety Benefits	• All Stakeholder Types	• All Stakeholders
Emissions Savings	• All Stakeholder Types	• All Stakeholders
Economic Impact		
Regional Economic Benefit	• All Stakeholder Types	• All Stakeholders

	From Norfolk, via Heartland Corridor	From Norfolk, Using Original Rt. 1	Distance Saved	Travel Distance Reduction	From Norfolk, Using Original Rt. 2	Distance Saved	Travel Distance Reduction	Average Travel Distance Reduction, per Route
To Chicago	1,049	1,169	-120	-10%	1,251	-202	-16%	**-13%**
To Detroit	875	1,164	-289	-25%	1,078	-203	-19%	**-22%**
To Columbus	667	967	-300	-31%	1,038	-371	-36%	**-33%**

Figure 5.11. Freight rail routes from Norfolk, Virginia, to Columbus, Ohio.

The research team used unit cost information from NS to assess transportation savings on the corridor for the period of analysis. The association of container volume to traveling distance to NS freight costs permitted an interpretation of transportation savings as a reduction in transportation unit costs for NS, and not annual aggregate transportation savings.

To assess the transportation savings, the research team used a per ton-mile cost for single-stack shipping on the line in the base case. The per ton-mile cost to ship goods from Norfolk, Virginia, to Columbus, Ohio, on a single-stack train is $0.05. With the reduction of travel distance and the increase of capacity in the alternative case, NS would experience transportation savings of $0.02 per ton-mile for containers shipped on the Heartland Corridor. For all traffic growth scenarios, the per ton-mile cost to ship goods on the Heartland Corridor is $0.03 for double-stacked trains.

Inventory Carrying Costs. The Heartland Corridor Double-Stack Initiative reduces the average travel time for goods to travel between Norfolk, Virginia, and points west. In doing so, the reduction in travel-time affects end users in their business decisions with regard to inventory. Quicker shipment of goods allows businesses to manage their inventory levels in an attempt to make production scheduling more efficient. Usually, a quicker turnover of goods allows these organizations to maintain a lower inventory level, thus approaching an economic order quantity. The cost savings stem from the reduction in inventory carrying costs, which represents the cost of holding inventory. This includes rent, insurance, utilities, perishability, and opportunity costs. The Heartland Corridor project will, therefore, allow business managers to more efficiently manage their inventory levels and allow these businesses to experience inventory carrying costs savings as a benefit of this initiative.

Benefits from Container Traffic Diversion. The Heartland Corridor project is expected to generate numerous benefits for the railroad through improvements in capacity and throughput. This, in turn, is expected to a create a number of other benefits, including the following:

- **Diversion benefits—**Traffic diversion of containers from truck shipping to rail is expected to relieve congestion on adjacent highways because fewer trucks will be needed to transport goods from Norfolk, Virginia, to points west. The container truck diversion will, therefore, allow roadway users to experience travel-time savings on previously congested roads.
- **Reduced vehicle operating costs—**The reduced congestion on highways adjacent to the Heartland Corridor leads to a decrease in consumption of fuel and other vehicle operating costs realized in the base case. All roadway users on the affected roadways experience this benefit.
- **Safety benefits—**A decrease in volume of trucks on highways due to container traffic diversion to freight rail reduces roadway safety hazards. Consequently, highway vehicle accidents are reduced, creating a benefit shared among roadway users adjacent to the Heartland Corridor.
- **Emission reductions—**A reduction in idling time and speed cycling by road vehicles contributes to a decrease in emissions. The reduction of emissions is beneficiary to all stakeholders because environmental quality is an interest for all stakeholders.

Economic Benefits. The total present values of benefits from the Heartland Corridor Double-Stack Initiative with 4% expected traffic growth are presented in Table 5.21.

Costs

Capital Costs. The aggregate costs for this study take into account capital costs for the construction of the project and operations and maintenance costs. Prior to 2005, NS prepared preliminary cost estimates that did not consider each individual type of improvement and its location on the corridor. Instead, it used a fixed unit cost for all construction work derived from another project. In this study's costing

Table 5.21. Present value of benefits assuming 4% traffic growth (thousands of dollars).

	Infrastructure Provider		User		Service Provider		Public	
Benefit Metric	**3% DR**	**7% DR**	**3% DR**	**7% DR**	**3% DR**	**7% DR**	**3% DR**	**7% DR**
Reduced Shipping Cost	–	–	–	–	$738,630	$376,820	–	–
Reduced Inventory Carrying Cost	–	–	$468,439	$228,852	–	–	–	–
Travel-Time Savings	–	–	$1,191,735	$614,626	–	–	–	–
Reduced Vehicle Operating Costs	$16,631	$10,985	–	–	–	–	–	–
Safety Benefits	–	–	–	–	–	–	$209	$ 91
Emissions Savings	–	–	–	–	–	–	$1,996	$1,318

Note: DR denotes the discount rate.

method, the research team looked at every type of modification to tailor a cost estimate for improvements for each independent location using prices from contractors currently performing similar work.

The majority of the infrastructure improvements in the project area occur on tunnels. Table 5.22 provides a breakdown of costs by modification type for each tunnel. Additional infrastructure costs, such as non-tunnel clearance, are applicable to the total capital costs. Total capital costs for the duration of the project are estimated at $159.94 million.

Operations and Maintenance Costs. Following the completion of construction, maintenance costs are to be incurred, and accounted for, in the freight investment benefit/cost analysis. These costs are incurred by NS and calculated using base case operations and maintenance costs on the 667-mile project area. The maintenance costs include the expenses to maintain way and structure. Maintenance costs will vary with traffic growth in each of the scenarios described above.

Benefit/Cost Analysis and Other Performance Metrics

Using the evaluation framework, the research team's analysis of the Heartland Corridor Clearance Initiative generated the following results shown in Table 5.23.

Risk Assessment

The risk assessment results are illustrated in Table 5.24. The principal risk driver is the reduction in unit shipping cost achieved through double-stacking intermodal freight in the corridor.

Case Study 5—Port of Huntsville Inland Port

Background

The Port of Huntsville is a multimodal inland port located at the Huntsville International Airport, nine miles southwest of Huntsville, Alabama, in Madison County. The port is situated south of 565 and west of the U.S. Army Garrison Redstone Arsenal (see Figure 5.12). The port offers rail and air cargo transportation services through connections to the NS rail line and Huntsville International Airport. It is composed of three entities: the airport (Figure 5.13), International Intermodal Center (IIC) (Figure 5.14), and Jetplex Industrial Park (Figure 5.15). The intermodal center also is a U.S. Customs port of entry that handles cargo via air, highway, and rail.

From 1991 to 1999, international freight/express cargo increased by 8.8% per year. International revenue ton-mile (RTM) forecasts indicated 46% growth for international cargo by year from 1990 to 2011. From 1990 to 2000, cargo carrier activity at the Port of Huntsville increased by 116%. With a goal of serving as a regional intermodal cargo center, the Port of Huntsville identified the need to serve nonstop flights to Europe, Latin America, and other international destinations. Exemplifying this growth, Panalpina was contracting 2 weekly flights in 1995, which grew to 11 flights in 2000. Panalpina, which selected the Port of Huntsville as their North American air cargo hub, currently serves Asian and African markets by connecting through its European hub in Luxemburg, but expressed a desire to provide direct service to Asia and the Pacific Rim to keep pace with shipper's demands and expand its marketplace. A rising trend in the air cargo industry was the use of very large aircraft (e.g., the Boeing 747-400) that require long runways of at least 12,600 feet,

Table 5.22. Tunnel modification costs.

	Tunnel Name	Milepost	Liner/ Removal	Notching	Daylighting	Notes
1	Pepper	N 305.4	$11,389,669	$5,441,884	N/A	
2	Eggleston No. 1	N 316.2	N/A	N/A	N/A	Realign to center
3	Eggleston No. 2	N 317.0	$2,512,371	$1,637,878	N/A	
4	Pembroke	N 319.8	$583,760	$288,145	$1,738,133	
5	Cooper	N 374.3	$3,078,317	$1,053,064	$7,788,322	
6	West Vivian	N 392.1	$3,075,166	$1,122,889	$5,118,276	
7	Big Four No. 1	N 394.2	$2,849,517	$1,016,995	$5,686,980	
8	Big Four No. 2	N 395.1	$780,143	$278,688	$631,009	
9	Huger (No. 1 Main)	N 395.6	$993,057	$116,454	N/A	
10	Huger (No. 2 Main)	N 395.6	$1,259,203	$499,347	N/A	
11	Welch	N 398.9	$5,788,835	$2,048,995	N/A	
12	Hemphill No. 1	N 400.2	$3,871,754	$1,267,657	$5,831,760	
13	Hemphill No. 2	N 400.4	$4,973,067	$1,364,149	$11,702,138	
14	Antler No. 1	N 403.7	$2,671,095	$955,706	$4,181,886	
15	Antler No. 2	N 405.1	$2,727,301	$953,093	$4,080,529	
16	Twin Branch No. 1	N 407.7	$3,292,345	$1,092,696	$6,146,107	
17	Twin Branch No. 2	N 408.1	$3,955,320	$1,400,227	$8, 897,175	
18	Vaughn	N 412.1	$4,945,145	$1,704,279	N/A	
19	Roderfield	N 413.1	$3,879,211	$1,105,460	$9,559,781	
20	Laurel	N 414.1	$3,463,048	$1,178,413	$4,023,981	
21	Gordon	N 415.1	$5,925,129	$2,112,911	N/A	
22	Glen Alum	N 439.5	$5,703,090	$2,052,831	N/A	
23	Hatfield (No. 2 Main)	N 462.1	$3,787,191	$1,656,798	N/A	
24	Williamson	N 471.6	$2,813,790	$1,128,773	$5,959,880	
25	Big Sandy No. 1	NA 3.3	$9,305,782	$5,365,928	N/A	
26	Big Sandy No. 2	NA 6.0	$1,161,241	$523,139	$1,189,727	Can bypass
27	Big Sandy No. 3	NA 6.8	$6,862,020	$3,347,961	N/A	
28	Big Sandy No. 4	NA 12.7	$6,708,833	$2,545,644	N/A	

Table 5.23. Benefit/cost analysis summary.

	Discounted Sum	
Category	3%	7%
Total Costs	$203,809	$165,812
Total Benefits	$2,417,639	$1,232,691
B/C Ratio	11.9	7.4
Net B-C	$2,213,830	$1,066,879

Table 5.24. Risk analysis results of total benefits (thousands of dollars).

	10% Lower	Mean	10% Upper
4% Annual Intermodal Traffic Growth			
Total Benefits (3% discount rate)	$531,139	$1,343,082	$1,810,574
Total Benefits (7% discount rate)	$263,273	$678,210	$904,766
6% Annual Intermodal Traffic Growth			
Total Benefits (3% discount rate)	$661,931	$1,740,961	$2,310,995
Total Benefits (7% discount rate)	$329,307	$857,737	$1,157,525
8% Annual Intermodal Traffic Growth			
Total Benefits (3% discount rate)	$808,511	$2,225,677	$2,904,620
Total Benefits (7% discount rate)	$415,192	$1,063,958	$1,423,059

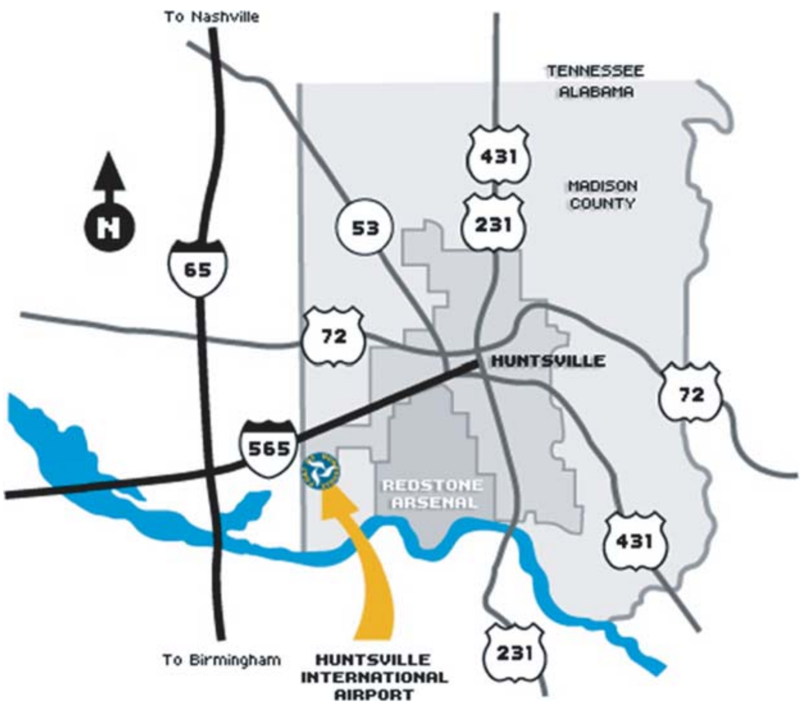


Figure 5.12. Port of Huntsville.

Figure 5.13. Huntsville International Airport and JetPlex facility.

Figure 5.14. International Intermodal Center—air cargo operations.

Figure 5.15. Jetplex Industrial Park.

to provide nonstop service to international destinations within a range of 7,000 nautical miles. To meet Panalpina's request, a runway extension from 8,000 feet to 12,600 feet was proposed. This extension was expected to increase payload capacity, operational efficiency, and activity.

Industries in the Huntsville region that rely on air shipments include chemicals, automated equipment, technology, computers, well drilling, aeronautics, helicopters, and automotive suppliers and manufacturers. The region has developed a strong base of auto assembly and parts facilities that include companies such as Hyundai, Mercedes-Benz, Toyota, and Volkswagen. Often, German companies such as Mercedes-Benz and Volkswagen will fly in needed parts or will send car prototypes back to Germany for inspection and testing.

Period of Analysis, Discount Rate, and Key Assumptions

The benefit/cost analysis incorporates FAA terminal area forecasts (TAF) for cargo volume from 2000 to 2023, which were extended to 2025 using the TAF growth rate of 4.3%. Although recent economic volatility has resulted in less cargo volume than forecasted, the research team believes that the trend will be corrected in the long run and will be in line with FAA estimates. Cargo forecasts beyond 30 years have limited impact on the analysis because of uncertainty and the relative weight of discounting future costs and benefits. Construction of the runway started in 2000. Because the runway was completed in May 2004, representing only 41% of the year, 2003 was used as the construction end date for the analysis.

Project Stakeholders

The study focused on four primary stakeholders: the Port of Huntsville, regional governments, cargo carriers/freight forwarders, and regional businesses, all of which are classified by their respective roles in Table 5.25.

- **The Port of Huntsville** is organized as an Alabama public corporation governed by a five-member board made up of local citizens and business representatives called the Huntsville Madison County Airport Authority. The principal funding of the port's operating revenues comes from both passenger and air cargo operations, which were $17 million and $3.5 million, respectively, in 2005. The airport collects landing, handling, and other cargo processing fees for carriers that ship and receive product through their facilities. By building and maintaining the runway, and leasing cargo space and handling facilities, the Port of Huntsville is classified as the public-sector asset provider.
- **Regional governments** are beneficiaries of the economic development benefits that the project provides due to increased business activity, which generates revenues from property, sales, and other tax mechanisms. Since regional governments have a beneficiary interest in these types of projects, they are classified as other stakeholders.
- **Cargo carriers/freight forwarders** who use the facilities at the port are the organizations that provide the actual freight movement and transportation services for shipping customers and, therefore, are classified as service providers. Time savings due to the reduction in fueling stops because of the runway extension translate into cost savings.
- **Regional businesses** that rely on air shipments for their products or for critical input components for their production cycles are classified as end users. The runway extension provides access to additional international destinations and also increased volume capacity which benefits regional businesses. From an economic development perspective, additional service destinations and volume can be viewed as an incentive to attract and retain business in the Huntsville metropolitan area.

Table 5.25. Stakeholder classifications.

Stakeholder	Public Sector Asset Provider	Service Provider	Shipper/ End User	Other Party	Private Asset Provider
Port of Huntsville	●				
Regional Governments				●	
Carrier/Freight Forwarders		●			
Regional Businesses			●		

Benefits

The primary benefit measures due to the extension of the runway are the reduced operational costs and the increased payload capacity per plane. Based on interviews with the Port of Huntsville, elevation and temperature conditions in Huntsville during parts of the year affect the lift factor, which requires weight limits for shorter runways, necessitating additional fuel stops instead of direct-destination flights. Extending the runway to accommodate larger aircraft eliminates additional time needed to refuel and is considered a benefit. Increasing the cargo capacity with a larger aircraft allows additional cargo and corresponding revenue for relatively the same operating costs. This increase in overall productivity also is considered a benefit of the runway extension. The following sections provide a detailed description of the benefit measurements and a summary of all categories in Table 5.26.

Time Savings. During the summer months, the elevation and average temperatures in Huntsville reduce the air lift factor, which requires limitations on fuel weight that, in turn, force aircraft to make additional fuel stops to reach their final destination. These conditions during this season are estimated to occur during approximately 20% of the year. Large aircraft with heavier fuel loads are able to fly directly to more distant markets, and this reduces overall cargo ton-hours. To measure the value of time savings, block hour operating costs were used, which were estimated by the FAA.(*24*) The Boeing 747-400 and 747-200 airplane models were selected as most representative of the types of aircraft used by Panalpina for shipping goods to Huntsville. After adjusting for inflation, the block hour operating costs for the Boeing 747-400 were $11,311 and $8,695 for the 747-200.

Panalpina estimated the time interval between fueling stops lasted between 90 to 120 minutes, however a conservative estimate of 30 minutes was used in the analysis based on the conservative estimate of a sensitivity study commissioned by the port. Panalpina's forecasted operations were based on FAA TAF activity and the current cargo market in Huntsville. Panalpina's schedule in 2000 was nine weekly international flights, which was forecasted to increase to 24 flights in 2023 (and trended out to 2025 using the annual growth rate of 4.3%). Based on interviews with Panalpina, the newer 747-400 was estimated to handle 81% of future operations while the 747-200 was estimated to transport the remaining 19% of freight. Both of these airplane models reflect the appropriate aircraft fleet mix since block hour operational costs vary by aircraft type.

Freight inventory and reliability savings are measured using a freight logistics factor which represents the business opportunity cost of freight delay, including inventory cost to shippers, carriers (dock handling), and/or those caused by overall schedule disruption. (Freight logistics cost is estimated on the basis of values assigned for recurring travel-time delay from HEAT documentation, based on literature review and additional research by Cambridge Systematics, Inc. and EDR Group.) The major commodity groups that are transported through the Huntsville airport have varying cost sensitivities per hour of delay; assumptions for total value of delay in this study (derived by the TREDIS model) include computer equipment ($3.93/ton-hour), transportation equipment ($1.69/hour), and machinery ($3.93/ton-hour).

Productivity. The length of the runway and the climate also place restrictions on the aircraft cargo weight, and this prevents payload maximization. According to interviews with Panalpina, when climate conditions are factored into operating capacity, shipments from Huntsville average 85% of their capacity. The difference between the actual aircraft capacity and the potential capacity was used to determine how much additional cargo could be shipped out of Huntsville with an extended runway. Freight rates were estimated by compiling and applying a composite rate from markets in Houston, Memphis, and Atlanta that included handling, transfer, and fuel surcharges. The composite shipping rate was estimated to be $2.64 per kilo based on a 1,000-kilo shipment. The standard aircraft payload volume for the Boeing 747-400 was estimated at 120 tons, or 109 metric tons, and volume for the Boeing 747-200 was estimated at 100 tons, or 91 metric tons.

Table 5.26. Present value of benefits (millions of dollars).
25-Year Timeframe

Benefit Metric (in Millions of Dollars)	User (Shipper)	Service Provider	Infrastructure Provider	Public
Air Travel-Time Savings	–	$19.6	–	–
Air Operating Cost Savings	–	$111.7	–	–
Freight Inventory/Reliability	$0.70	–	–	–
Accident Savings	–	–	–	$0.0
Emissions Savings	–	–	–	$0.0

Table 5.27. Benefit/cost analysis summary.

Category	Discounted Sum (3%)	Discounted Sum (7%)
Total Benefit	$132M	$80M
Total Cost	$30M	$32M
B/C Ratio	4.33	2.51
Net B-C	$102M	$48M

Costs. The capital costs to extend the runway by 4,600 feet were approximately $27 million ($33.7 million in 2008 dollars) over 3 years (from 2000 to 2003) and included a parallel taxiway extension of 750 feet. Operations and maintenance of the runway and taxiway were estimated to be approximately $120,000 ($150,036 in 2008 dollars) per year, growing at a rate of 3% per year.

Benefit/Cost Analysis and Other Performance Measures

Using a discount rate of 3% and 7%, and a time horizon of 25 years, the total discounted benefits, costs, and benefit/cost ratio are shown in Table 5.27.

Other Performance Metrics

Economic Impact. The Huntsville project leads to regional economic growth through two mechanisms: (1) an increase in profitability and productivity for area producers and shippers due to transport time, cost and reliability savings; and (2) an increase in local transport and freight forwarding employment due to the increase in the volume of freight flowing through Huntsville. If air cargo activity increases over the next 15 years at the forecast average growth rate of 4.3% per year, then regional economic impacts are projected to reach the following levels in the year 2025:

- Business output (sales volume): + $44.3 million/year;
- Gross regional product (value added): + $17.9 million/year;
- Worker wages: + $12.2 million/year; and
- Long-term jobs (recurring): + 262.

The present value of the long-term (25-year) time stream of wider economic impacts and costs also was calculated, using a discount rate of 3%. The results were that the present value of future gross regional product (GRP) is projected to increase by $96 million and the present value of project costs is projected to amount to $30 million, representing a GRP/cost ratio of 3.14. These impacts were calculated using the TREDIS framework, employing the cost response input-output (CRIO) economic impact forecasting model, together with the IMPLAN multiregional trade flow model.

Other Performance Metrics. Other important components of the project include cost and performance measures that describe the estimates and assumptions that went into the project analysis. Summaries of these categories also are listed in Table 5.28. They include the following:

- **Jobs at the port**—The 2008 economic study (*25*) indicated that there were 761 jobs at the airport and that these jobs were filled by employees of the airport, airlines, shippers, intermodal services, and concessions. Jobs specifically devoted to cargo were not highlighted.
- **Airport capacity**—In May 2009, an air cargo building measuring 92,000 square feet was opened, and this increased the air cargo capacity of the International Intermodal Center (IIC) by 30%.(*26*) According to the Port of Huntsville website, there currently is 300,000 square feet for receiving, stor-

Table 5.28. Other performance metrics.

Performance Measures	Pre-Project (1999)	Post-Project (2008)
Jobs at Port	N/A	761
Airport Capacity (Square Feet)	N/A	N/A
Airport Volume	48,200 tons	73,500 tons
Operations Revenue	N/A	$22.9 million per year
Operations Cost	N/A	$11.7 million per year

Table 5.29. Risk analysis results of total net benefits ('000 dollars).

	10% Lower	Mean	10% Upper
Total Net Benefit (3%)	$98,100	$102,120	$109,880
Total Net Benefit (7%)	$45,053	$47,263	$51,415

ing, transferring, and distributing domestic and international air cargo.(*27*) In discussions with port officials and freight forwarders, there were no indications of any constraints or bottlenecks due to lack of facility space.

- **Operating revenue and costs—**Operating revenues for both passenger and air cargo operations at the airport totaled $22.9 million and operating costs were $11.7 million in 2008.

Risk Assessment

The element of risk is included in the analysis due to uncertainty in the future airport cargo growth. Uncertainty can come from certain events such as 9/11 or Hurricane Katrina, or be classified as cyclical and random risk (e.g., business cycles, exchange rates, or industry fluctuation). Table 5.29 provides the lower and upper bounds of the risk assessment in reference to the mean based on the cargo growth range of 2% to 7%. The TAF of 4.3% provides additional confirmation that the growth range is a reasonable guess of future growth.

Case Study 6—Bayport Container Terminal

Background

The Port of Houston is a 25-mile-long public-private maritime industrial complex located along the Houston Shipping Channel, a few hours' sailing time to the Gulf of Mexico. As of 2008, the port was first in the United States by foreign tonnage, and seventh by containers, with approximately 1.8 million total TEUs. The Port of Houston Authority (POHA) owns the port's container terminals, Barbours Cut Container Terminal (Barbours Cut), and, more recently, Bayport Container Terminal (Bayport).

Barbours Cut (Figure 5.16) lies 3.5 hours north of the Gulf of Mexico, and offers six container ship berths (6,000 feet of quay), and is serviced by 13 container cranes. The facility also features a roll on-roll off (Ro-Ro) platform, a lighter aboard ship (LASH) dock, and a single-berth cruise terminal. Barbours Cut is accessible by 26 truck lanes (15 scales) leading to 4 gates as well as an intermodal railyard with 4 working and 5 storage tracks (162,000 TEU/year capacity). The marshaling area is 230 acres, and storage can accommodate almost 25,000 grounded TEUs. Before the development of Bayport, 80% of the containers moving to and from Texas were handled at Barbours Cut, amounting to 50% of the Gulf's total containers. By 2004, the facility was handling 1.4 million TEUs, up from 700,000 in 1995—20% more than its capacity. Often, every berth at Barbours Cut was occupied, resulting in as much as an additional day at sea for waiting vessels.

For a time, the Galveston Terminal, a two-berth container terminal, was used by POHA to alleviate the strain on Barbours Cut. However, given that approximately 55% of containers received at POHA facilities are bound for Harris County or surrounding locales, even a 45% rate reduction failed to make up for additional land transportation costs. Figure 5.17 depicts the location of the Galveston terminal relative to Harris County and the City of Houston. POHA allowed the Galveston Terminal lease to expire after volumes remained low despite significant discounts.

Bayport, situated less than 10 miles south of Barbours Cut, was conceived as a long-term solution to the port's capacity shortfall (see Figures 5.17 and 5.18). Bayport was master planned for implementation between 2007 (opening of Phase 1) through 2030. Eventually, the facility is expected to attain 526 acres, offer 7 berths, and include a 123-acre intermodal facility. Phase 1 is shown in Figure 5.19 and is composed of 65 acres featuring 2 berths sharing 6 cranes. In addition to a three-berth cruise terminal (not currently operating). Bayport is able to handle significantly larger vessels than Barbours Cut:

Figure 5.16. Barbours Cut container terminal.

Figure 5.17. Bayport in context.

18 wide, expandable to 22, as opposed to 13, with an air draft of 120 feet.

Period of Analysis and Key Assumptions

Phase 1 of the Bayport Container Terminal opened in 2007. Since the objective of the current analysis is to assess the benefits of projects that have been implemented, the study time period is 2007–2009. This allows for the testing of key assumptions and analytical tools used to conduct the pre-construction projection of benefits. In addition, results from an analysis are presented that project the benefits to 2030, based on the lessons learned in the post-construction period analysis. Cargo forecast for the long-term analysis on the build-out forecast from the POHA incorporates the most recent economic downtown and subsequent fall in cargo. The remaining assumptions are based on data derived from realized benefits to date.

Project Stakeholders

The study identified five primary stakeholders: the Port of Houston Authority, local and regional governments, carriers and freight forwarders, and regional businesses (see Table 5.30).

Figure 5.18. Bayport—Houston Shipping Channel.

Figure 5.19. Bayport Phase 1.

- **The Port of Houston Authority** is headed by seven commissioners. Two each are appointed by the City of Houston and the Harris County Commissioners Court. POHA's day-to-day operations are managed by a CEO, who is appointed by these two government bodies. The Harris County Mayor and Councils Association and the City of Pasadena (Bayport's host city) each appoint one commissioner. The port both leases and operates berths and equipment within the new Bayport terminal.
- **Local and regional governments** control POHA through the appointment of leadership and derive tax income and jobs through the port's activities. The primary benefit to the local and regional governments is increased port revenues and tax-base expansion through land development and business attraction based on close proximity to the port.
- **Carriers and freight forwarders** are the direct users of the port's cargo facilities, and benefit from the port's ability to handle large vessels with less wait time. For trucking companies and freight forwarders, this translates to faster, more reliable pick-ups and drop-offs due to both reduced terminal congestion and improved roadway connections. For railroads, the additional port capacity translates to increased volumes.
- **Local and regional businesses** benefit from reduced shipping costs due to greater certainty experienced by carriers and shippers. In addition, local developers benefit from increased opportunities to attract shippers, warehousing and distribution, and other industrial and commercial opportunities.

Benefits

The primary benefit measures attributable to the addition of the Bayport Container Terminal are (1) greater carrying capacity and more reliable unloading windows for ocean going

Table 5.30. Stakeholder classifications.

Stakeholder	Public Sector Asset Provider	Service Provider	Shipper/ End User	Other Party	Private Asset Provider
Port of Houston Authority	●				
Local and Regional Governments	●			●	
Carrier/Freight Forwarders		●			●
Local and Regional Businesses			●		●

vessels; (2) greater gate reliability and reduced on-terminal time for truckers, both of which should result in lower costs for local and regional businesses; and (3) local land development opportunities. Other benefits include reduced maintenance costs due to the use of 30-year pavements (at a premium of 4%), increased safety from improved highway access, and reduced emissions due to the diversion of long-haul truck trips (after the intermodal facility opens at a later phase).

The following sections provide a detailed description of the benefit measurements with a summary of all categories in Tables 5.31, 5.32, and 5.33.

Time Savings and Reliability

- Ocean-going vessels (OGV) are expected to save a full day between dwell time savings (due to advanced equipment and reduced terminal congestion) and berth congestion at

Table 5.31. Project attributes and benefit categories by party.

Project Attributes	Benefit Categories	Affected Party
Phase 1: 2 additional berths, 4 additional cranes	Container volumes, reliability, productivity, efficiency, security, jobs, tax revenues	POHA, shippers, warehousing, businesses/industry, consumers, workers
Roadway enhancements and rail access	Travel times, reliability, vehicle maintenance costs, mode shift	Trucking companies, railroads (subsequent phases), businesses, public
ISO 14001, mitigation (e.g., sight and sound berms), land conservation	Emissions, ecological systems, public health, worker health	Adjacent residents, the public, workers
Land development in areas in close proximity to the port	Business attraction, construction activity, jobs, tax revenue	Land developers, land owners, local and state governments, workers, businesses

Table 5.32. Present value of benefits (2007–2009).

Benefit Metric	Millions (2009 Dollars)
Travel-Time Savings	$29.5
Vehicle Operating Cost Savings	$26.9
Logistics Cost Savings	$25.7
State of Good Repair	$0.9
Emission Benefits	$5.7
Safety Benefits	$14.6
Indirect and Induced Benefits	$68.3
Total Benefits	**$172.3**

Table 5.33. Present value of benefits (2007–2030).

Benefit Metric	Millions (2009 Dollars)
Travel-Time Savings	$565.4
Vehicle Operating Cost Savings	$532.3
Logistics Cost Savings	$498.87
State of Good Repair	$16.6
Emission Benefits	$109.8
Safety Benefits	$282.7
Indirect and Induced Benefits	$1,320.3
Total Benefits	**$3,325.8**

Barbours Cut. A total of 969 and 809 ships called on Barbours Cut in 2007 and 2008, respectively. A total of 97 and 225 ships called on Bayport during those years. That equates to 2,100 days saved for OGVs.

- The pickup/drop-off times for trucks have decreased from 60 minutes or more to 30–40 minutes. Drayage operators confirmed the information provided by POHA authorities and said that average cost per drayage trip has decreased by an average of $15–$20.
- Shippers and carriers were interviewed to assess the impact of reliability enhancements. Although it was recognized that travel times and turnaround times had improved, there were no measurable reliability impacts. The congestion did not lead to unreliable turnaround times, just longer ones. In terms of reliability for OGVs and port tenants, no discernable benefits could be isolated. This is primarily because at about the same time that the Bayport terminal came on-board, the Houston Port Bureau, a private port research firm, introduced a vessel tracking and monitoring system that allows port users to know exactly when a vessel will be docking and alerts of any delays. In terms of enhancing reliability and resulting monetary benefits, the stakeholders agree that this technology far outweighed any benefits accruing as a result of the new terminal itself.

Capacity

- Barbours Cut was operating at or above capacity in 2007 when Bayport opened. With the Houston region projected to grow by more than 4 million people, cargo bound for the region would have had to be diverted to gateways farther away, increasing the cost of delivered goods. In addition, significantly larger (post-Panamax) OGVs can now be unloaded at POHA facilities, enabling shippers to take advantage of lower transit costs.
- There also have been increases in surface transportation capacity. Surrounding roadways, including access to the Bayport Terminal and Barbours Cut have been built and/or expanded. In addition, TxDOT has completed a flyover that provides improved connectivity for both terminals to SR 146. Also, there are plans for on-dock rail access at Bayport that will further improve transit times and turnaround.

Environmental

- **Emissions reduction—**A reduction in truck idling time on terminals and on congested roadways contributes to reduced emissions. In addition, reduced OGV dwell time and on-dock rail capabilities will reduce emissions.
- **Reduced fuel consumption—**The reduced wait time for OGV and reduced idling for trucks also give rise to fuel savings. This also provides private benefits in terms of reduced vehicle operating costs.

Safety

- **Improved roadways—**Widening from four to six lanes and reduced congestion lead to fewer accidents and safety benefits.

Costs

The capital costs for Phase 1 have amounted to about $400 million, and final costs at build-out are expected to be $1.2 billion. Operations and maintenance costs were approximately $6.2 million for the 2007–2009 time period and are projected to be $71.3 million for the time period of 2007–2030.

Benefit/Cost Analysis and Other Performance Measures

Using a discount rate of 3%, the total discounted benefits and costs are estimated for both time periods. As shown in Table 5.34, the benefit/cost ratios range from 0.41 for the 2007–2009 timeframe to 2.62 for the 2007–2030 timeframe. This illustrates the importance of considering long-term benefits and costs in completing an assessment of freight investments. It also demonstrates that initial estimates of the benefits may be overstated due primarily to the fall in cargo levels

Table 5.34. Benefit/cost analysis, 3% discount rate.

Category	2007–2009 (Millions of Dollars)	2007–2030 (Millions of Dollars)
Total Benefit	$165.8	$4,710.2
Total Cost	$407.0	$1,797.8
B/C Ratio	0.41	2.62
Net B-C	($241.2)	$2,912.4

resulting from the current economic downturn. Therefore, incorporating risk assessment is a key element in conducting these analyses.

Other Performance Measures

Other important components of the project include costs and performance measures that describe the estimates and assumptions that went into the project analysis. Summaries of these categories are listed in Table 5.35, and they include the following:

- **Jobs at the port—**The 2002 economic study (*28*) performed by Martin Associates projects an increase of 2,017 jobs at the port at the opening of Bayport Phase 1 (2007), and 29,255 at full build-out (2030).
- **TEU capacity—**At full project build-out, Bayport is expected to add 2.3 million TEUs of capacity to the Port of Houston.
- **Business revenue and costs—**At the opening of Phase 1, business revenue was expected to increase by $82.2 million, with an additional $1.1 billion by full build-out.
- **Land development—**The region and especially Chambers County anticipates additional land development to occur as the region attracts warehousing and distribution operations tied to the new container terminal and the opening of the Panama Canal. Wal-Mart, Home Depot, and Seapak all located within the county prior to the opening of Bayport. Since construction began on Bayport, developers have assembled nearly 20,000 acres of land for future industrial development. To complement this growth pattern, the county is restricting residential development in prime freight development areas and working with TxDOT to ensure that the newly constructed Grand Parkway remains untolled to encourage truck usage.

Risk Assessment

The element of risk is included in 2030 analysis due to the uncertainty of cargo volumes in the future. Uncertainty can come from several factors, including general economic climate, natural disasters, community resistance, global trends, and random risks. Table 5.36 provides the upper and lower bounds of risk assessment in reference to the mean based on cargo growth ranges of 4% to 9%. The ranges of growth are based on historical growth patterns of containerized cargo and are consistent with North American trends from the 1990s to early 2000s. The ranges are also in line with recent cargo growth forecasts for North American ports.

5.3 Case Study Lessons Learned

The completion of these six case studies provided a number of lessons about the ability of the Freight Evaluation Framework to evaluate the interrelationships among freight benefit types, determine whether there are significant differences in the Framework's application across different types and scales of freight investments, and assess the overall strengths and weaknesses of the Framework. In general, the

Table 5.35. Other performance measures.

Performance Measures	2007	Full Build-Out
Projected Increase in Cargo Jobs at Port	2,017	29,255
Projected Increase in TEU Capacity	600,000	2,300,000
Projected Increase in Business Revenue	$82.2 M	$1.1 B
Projected Increase in State/Local Tax (from Port Activities)	$8.3 M	$121.3 M
Land Development	4,000 acres	20,000 acres

Table 5.36. Risk analysis results for total benefits for 2007–2030 (millions of dollars).

	10% Lower	Mean	10% Upper
Total Net Benefit (7%)	$1,874.5	$3,325	$5,946.2
Total Net Benefit (3%)	$2,248.2	$4,544.8	$6,375.0

Framework appeared to perform adequately across the set of six case studies. However, there are a number lessons learned from the case study testing process, and these are summarized in the following sections.

Need for Clearly Defined Project and Alternative Cases

The six case studies all involve capital investment, although they vary in the following four dimensions:

- **Modes affected—**Various combinations of truck, rail, air, and marine transport;
- **Types of facilities—**Routes (e.g., road or rail corridors), vehicle access (e.g., docks, runways, yards, or terminals) and/or freight handling facilities (e.g., intermodal transfer or transload facilities, warehouses, etc.);
- **Types of improvement—**To enhance the performance of a facility, expand the range of use that it can serve, and/or expand its capacity; and
- **Functional status—**Currently facing capacity, use, or performance limitations, or currently functioning well, but facing the prospect of demand growth or changes leading to expected future capacity/use/performance limitations.

In the cases presented here, some of the projects have been completed while others are still being implemented. Thus, some describe the project (build) and alternative (no-build) scenarios in the past tense, while others describe them in the expected future tense. In yet other cases, the projects were built but demand patterns and business conditions changed from original expectations. In those cases, the case studies describe both current short-term outcomes and projected long-term future outcomes.

Regardless of the situation, these case studies demonstrate that all uses of the Freight Evaluation Framework must define both a project scenario and an alternative scenario (representing what would likely occur with or without the project being implemented). All such scenarios should be sufficiently defined to address all four of the above-referenced categories (mode affected, types of facilities, types of improvement, and functional status).

General Methods Work Better for High-Level Problems

The six case studies used to test the Freight Evaluation Framework represented a mix of system-level solutions (e.g., Heartland Corridor) that had costs and benefits that often crossed jurisdictional boundaries and very localized projects (e.g., Tchoupitoulas Corridor Improvements) whose costs and benefits were limited. The Freight Evaluation Framework showed that broad measures and assumptions, such as vehicle-miles traveled, vehicle-hours traveled, and general emissions and safety assumptions, appear defensible for quantifying systems-level benefits.

However, methods become challenging at more localized levels, where broad measures might not completely reflect the costs and benefits of site-specific projects. In some cases, problems can be isolated to very specific locations, possibly with different results than yielded by more generalized methods. Examples include reducing crashes at rail-grade crossings, mitigating noise pollution, or eliminating localized safety hot spots. In these cases, the researchers found it absolutely critical to supplement quantifiable data and information with input and information from local experts and stakeholders, who can often add value to site-specific or neighborhood impacts and benefits.

It Is Appropriate to Offer Slightly Different Forms of the Overall Structure for Projects of Different Scales

The Freight Evaluation Framework is (and should be) flexible in its analysis methods in order to be useful to different types of projects as follows:

- **High-level/systems (i.e., Heartland Corridor Clearance Initiative)—**Generalized analysis methods based on large-scale VMT, VHT, or travel-time/emissions estimates are appropriate;
- **Regional or market-area (i.e., Huntsville Inland Port, DIA WorldPort)—**Specific drive times, competing routes, facilities, or modes become relevant and may warrant specific data and analysis; and

- **Subarea/community-level projects (i.e., ReTRAC, Tchoupitoulas)**—A manageable set of specific bottlenecks, noise receptors, intersections, and pathways to and from locations can be mapped and analyzed.

The supporting documentation for the Framework should be clear that this type of flexibility is important (and encouraged) and, as noted earlier, users should be encouraged to confer with local technical and community experts when applying the Framework to subarea or community-level projects.

Solutions to Existing Problems Are Easier to Measure and Assess Than "New Opportunities"

The case studies showed that the Freight Evaluation Framework works well when there is a clearly defined problem to be solved. In these cases, there are clearly defined goals for the project, clearly defined benefits that are expected, and clearly defined success elements or performance measures. For instance, the Framework is very easy to apply to projects such as the Heartland Corridor or the Tchoupitoulas Corridor Improvements that were designed to solve a particular problem or issue (limited double-stack clearance and truck access through local neighborhoods, respectively). In these cases, it is straightforward to identify the specific baseline conditions and current costs or disbenefits to be resolved.

Application of the framework becomes more challenging for projects that are designed to take advantage of new opportunities, e.g., the DIA WorldPort or Huntsville Inland Port projects. In many cases, the primary benefit of these types of new (not expanded) capacity investments (where there are no existing users) is the ability to accommodate additional traffic. Analytical models used to support the original market justification for such projects often were based on unconstrained forecasts and just assumed that operating conditions would worsen without the capital investment. In the real world, that is often not a realistic assumption. For instance, as congestion rises under a no-build scenario, a variety of different outcomes may occur and hence may be represented by an alternative scenario. There could be cases where, without the new investment

- Businesses will merely stay in place and endure continuing growth of congestion delays and costs;
- Business activity shifts to other shipping modes, routes, or facilities that can offer a second-best solution for remaining in place; or
- Some businesses will just move out and relocate to some other place where costs are not as high as they would incur if they stayed in place.

The six case studies show that it is both necessary and possible to define project scenarios and alternative scenarios to represent the expected changes in freight demand patterns and business responses to them. In addition, the risk analysis method used in these cases shows how alternative assumptions about key factors, such as freight demand growth, can be explored and represented in a report on benefit/cost findings.

The Framework Identifies Stakeholders at the Outset, but Assigning Benefits to Them Can Become Challenging

As described earlier, the Freight Evaluation Framework has developed a more nuanced understanding of the types of freight stakeholders involved in freight investment decisions, as well as their concerns and interests. Understanding and evaluating the costs and benefits of, and to, these different stakeholder groups is a critical element of the Framework. However, the research team's testing process uncovered a number of issues related to how freight stakeholders are engaged throughout the application of the Framework, including the following:

- **Need for a feedback loop**—The Freight Evaluation Framework emphasizes the importance of identifying potential stakeholders early in the process, but does not include a method for reengaging the group during the evaluation process. The study team found that reaching out to stakeholders throughout the testing process added significant value to the application of the Framework, particularly for local or site-specific projects whose benefits are not always completely captured using existing data and tools. It is critical to add such a feedback loop, not only to capture this kind of information, but also to ensure that there is a clear understanding of how different results might be interpreted by different stakeholder groups.
- **Disaggregating benefits by stakeholder type**—The Framework identifies and classifies stakeholders into different groups (asset providers, service providers, end users, and other impacted parties) and then adds a table to assign or allocate the various elements of benefit and cost to specific stakeholder groups. However, in carrying out the analysis, it can become a challenge to effectively assign various classes of benefits to specific stakeholders when there are dynamic interactions among them. This is illustrated by the DIA WorldPort case, where freight transport firms were projected to gain net revenue from expanded facility capacity, but their actual gain would be reduced to the extent that they have to pay ground lease payments to the air freight facility operator, which in turn has to pay a share of its revenue to the property owner (airport authority). Tracking the string of payments can be challenging and estimating their final allocations may require the type of risk analysis that is included in the Framework.

- **Consistency among stakeholders and benefits**—Maintaining consistency with how stakeholders are identified and how they might benefit from particular projects will add value to the Freight Evaluation Framework. For instance, the results and findings from a study can look very different depending on the level of detail in which stakeholders are defined and the degree of depth to which their interactions are traced. Both detail and consistency are required to generate useful results.
- **Accounting for sensitivity differences**—Finally, there are potentially large differences in the sensitivity to cost, benefits, and risk among different stakeholder types that are not all captured within the Framework. This becomes important if the framework is used to help rank projects from the perspectives of various stakeholder groups. In some cases, there may be issues of such importance to a particular stakeholder group that they outweigh any and all other possible costs and benefits to that particular agent. In such cases, group preferences may include factors that are not all captured in the current Framework. It may be possible for the Framework to be expanded to account for, and incorporate, these types of preferences. Alternatively, it may be necessary to note cases where the Framework does not (or cannot) encompass other major considerations.

Data and Tools Need to Be Tailored to the Economics of Freight Industry Markets and Account for Reliability and Supply Chain Benefits

Industry Groups

A critical element of the Freight Evaluation Framework involves assessing the potential benefits of freight investments to different stakeholder groups and, in some cases, different industries. This can be a particularly difficult task since each industry has different supply chain management practices, tradeoffs, and appetites for risk and cost-sharing. Among the cases examined here, the Huntsville and Tchoupitoulas cases illustrate how analysis can be tailored to show different transport cost, delay time, and reliability sensitivity factors for specific classes of freight. In this case, Huntsville involved Asia-bound air freight for technology equipment products, while Tchoupitoulas involved marine shipments of rubber, coffee, and wood materials. The valuation of inventory, time delay, and reliability factors used for the case studies varied by commodity and were accordingly greater for the air freight shipments. These cases illustrate the importance of identifying affected freight mode and commodity classes, and then tailoring analysis (within the Framework) to those freight classes.

Modal Differences

Another key aspect of the Freight Evaluation Framework is the explicit recognition that many freight projects directly involve (or indirectly affect) multiple transportation modes. The tools that were used to capture these impacts within the case studies included a range of mode-specific and multimodal simulation, forecasting and benefit/cost assessment products. For instance, the Reno (ReTRAC) case used GRADEDEC to assess grade crossings; the Heartland Corridor assessed truck/rail diversion, and the Denver case assessed air/truck diversion using the multimodal TREDIS model. None of the cases examined in this study involved only highway impacts, but in such cases it would be possible to rely on other highway-oriented tools (such as FHWA's BCA.Net). In yet other cases, the broader range of tools may also be relevant for use within the Framework.

Reliability and Connectivity

Increasing congestion can affect not only average travel times but also the size of market delivery areas and schedule reliability for intermodal connections. Among the cases examined here, the Tchoupitoulas case illustrated the impact of reducing congestion on a port access route, while the Denver case illustrated the potential for improved reliability by enabling greater local air freight capacity and avoiding trucking to more distant airports (which bring greater variability in delivery times). Analysis for these cases made use of available tools for multimodal freight impact analysis. None of the cases involved changes in market delivery areas. However, such impacts could occur in cases where access routes are improved for terminal or distribution facilities. In such cases, the Framework can make use of existing tools that relate economic development (business location/attraction) to changes in available market size.

Vehicles and Trip Lengths

The type of affected vehicles and trip lengths also can affect analysis findings using the Framework. For instance, error can occur if tools used to capture travel-time savings for trucks are monetized using a single value for all truck trips. After all, if the truck is long haul, earning revenue by the mile, savings in travel time may have no out-of-pocket costs or benefit. If the truck trip is a drayage trip (paid per trip), the travel-time savings only generate savings (or revenue) if enough time is saved throughout the course of a day to make an additional trip. The case studies conducted for this study distinguished the types of trips and the sizes and types of vehicles involved, using available tools. For instance, the Heartland Corridor case involved shifts between single-stack container on flat car (COFC), double-stack COFC and truck shipments for container travel. In contrast, Huntsville involved fully loaded versus less-than-fully loaded Boeing 747-400 freight aircraft. These cases illustrate the importance of implementing the Framework in sufficient detail to capture differences in modal and trip characteristics among affected classes of vehicles and trips.

Wide Economic Impacts

All of the cases involved projects leading to savings in the cost of doing business (for at least some industries at some locations). These transport efficiency and business productivity enhancements typically lead to broader impacts on local economic growth. One of the cases—Huntsville—was selected to illustrate how a regional economic impact model can be applied successfully to assess the broader job and income growth impacts of a freight facility improvement project.

Taken together as a group, the case studies demonstrate both the feasibility and value of relying on a uniform Framework for analysis of freight project benefits. Differences among the cases illustrate how a range of analysis tools can be applied within the common framework, as appropriate, given the range of different modes, project types, commodity classes, and applicable stakeholder groups. However, those differences also point to both the need for, and the importance of, carefully tailoring analysis to the circumstances of different situations.

5.4 Freight Investment Workshop

In addition to utilizing a case study approach to evaluate the usefulness of the Framework, the research team worked with AASHTO, TRB, and the NCFRP-05 Project Panel to conduct a hands-on workshop, *Partnerships for Funding Freight Infrastructure Investments,* to provide feedback on the Freight Evaluation Framework; identify how it can and should be used to support investment decisions, financing, or public-private partnership (PPP) structuring; and describe how it could be useful in supporting partnerships for funding freight infrastructure investments. Four roundtable discussions were held, as described in the following.

- **Roundtable 1, Case Studies of Freight Infrastructure Investments—**The purpose of this roundtable was to discuss how the Freight Evaluation Framework can be applied to real-life freight investments and used to support investment decisions, financing, or PPP structuring. Panel members Glen Weisbrod (EDRG), Michael Fischer (Cambridge Systematics, Inc.), Daniel Brod (DecisionTek), and Paula Dowell (Cambridge Systematics, Inc.) described the Freight Evaluation Framework in detail, as well as how it was applied to the case studies described earlier in this chapter.
- **Roundtable 2, Usefulness of the Freight Evaluation Framework—**The purpose of this roundtable was to discuss the strengths and weaknesses of the Freight Evaluation Framework and how it might be modified. Panel members Bob Wilds (Greater Vancouver Gateway Council), Eric Madden (Pennsylvania DOT), and Darrell Wilson (Norfolk Southern) described how the Framework could be useful (or not) within their own freight investment evaluation discussions.
- **Roundtable 3, How to Sell Freight Investments—**The purpose of this roundtable was to allow stakeholders to share experiences in identifying, measuring, and highlighting freight project benefits and selling them to the public so that there is greater understanding and support for investment in freight projects. Panel members Maura Twomey (California Transportation Commission) and Karen Schmidt (Washington State Freight Mobility Strategic Investment Board) described their evaluation programs and how benefits are considered within application and funding requests.
- **Roundtable 4, Benefit Estimation Tools and Their Limitations—**The purpose of this roundtable was to discuss the strengths, weaknesses, and limitations of existing data and tools used to estimate the benefits of freight investments and how they might be improved. Gill Hicks (Cambridge Systematics, Inc.), Bill Burgel (HDR, Inc), Glen Weisbrod, Joe Bryan (Halcrow), and Jack Wells (U.S.DOT) described what existing tools were used within the Framework and what gaps might exist.

Workshop Summary and Lessons Learned

Following the roundtable discussions, Dr. Michael Meyer (Georgia Tech University) summarized the discussions in three key areas:

- **Affirmation of the essence of the Framework—**Workshop participants affirmed the usefulness of the Framework, particularly its ability to identify, account for, and categorize costs, benefits, and potential beneficiaries. Both public- and private-sector participants noted the Framework would be useful for evaluating freight investments.
- **Strengths—**Participants identified a number of positive attributes of the Framework, as currently constructed, including the following:
  - The ability to identify cross-modal impacts and provide good analysis capability in a multimodal sense;
  - Strong stakeholder identification;

- Provision of a structure for models, providing feedback for benefits and costs;
- Acts as an effective decision support tool, which helps inform the "smell test" by project evaluators/investors; and
- Could be used to accelerate project development, if early benefits can be identified.

• **Concerns—**Participants also identified a number of concerns with the Framework and how it could be applied, as follows:
  - The Framework is a good first approximation of benefits and impacts, but might struggle when identifying pass-through benefits and potential inequities among parties.
  - Assigning benefits when one of the potential partners is not interested in participating in the project might run the risk that the entire project fails.
  - The Framework focuses on congestion benefits and impacts, and may not fully address potential safety, economic development, and access benefits.
  - Some of the analytical tools the Framework needs for implementation are proprietary.
  - The Framework seems too complex for some stakeholders to implement.
  - The Framework might be missing some stakeholders, particularly those that want to maintain the status quo.
  - The Framework needs to include long-, medium-, and short-term investment timeframes.
  - Should consider how to incorporate political risk and the collaborative nature of investments within the Framework.

Choice of value of time for freight movements is a critical input.

CHAPTER 6

Using the Framework

This chapter describes how the Freight Evaluation Framework can be used in actual practice to evaluate a wide range of freight-project investment decisions. It begins with a general discussion of the types of situations in which the Framework may need to be used and identifies special considerations that are appropriate for each of these situations. In so doing, it also describes the structure of modal modules that have been developed with the Framework in order to take the more general approaches described earlier and make them more specific. This is followed by a series of step-by-step examples of how the Framework can be applied, drawing on the case studies discussed in Chapter 5, and providing information about some of the types of tools that are available for use when implementing the Framework for specific project applications.

6.1 When and How the Framework Should Be Applied

Types of Applications

In discussions with various prospective users during the course of the research for this project, the research team identified three primary applications that were of interest. Each is discussed briefly in the following sections.

Making an Investment Decision on a Specific Project

This is a decision made by a user on whether or not to invest in a particular project. In most cases, the comparison that will be evaluated with the Framework is a scenario with the proposed project and one in which nothing is done (no-build). In some cases, particularly where the decision is exclusively a public-sector decision, there may be a need to compare various alternatives that may include addressing the issue through an investment in a modal alternative to the proposed project. By providing benefit metrics that are applicable to multiple modes and presenting methodologies for computing benefit metrics for each of the modes, the Framework provides an approach to conducting these multimodal comparisons.

As noted in previous chapters, when the investment will include private funding, the framework identifies the types of metrics that typically are used by private entities (such as ROI). The decision processes are fairly well-defined by these organizations to account for costs and benefits that accrue to the investing entity. Public decision criteria are more complex and may take the following factors into account:

- Does the project deliver positive net benefits when all public and private benefits and costs are taken into account?
- Does the project deliver net public benefits when only public benefits and costs are taken into account?
- Is there a need to weight benefits and costs based on a set of explicit decision criteria?

Each of these decision criteria can be applied when comparing the project to the alternative scenario(s).

Prioritizing Investments

Quite a few public-sector agencies consulted for this research would like to apply the Freight Evaluation Framework to the prioritization of a number of potential projects beyond a go/no-go decision on any individual project. The Framework provides a number of advantages for this type of application, as follows:

- The Framework can be used to rank a multimodal collection of projects using a single common metric (project net benefits of benefit/cost ratio), focusing on cost-effectiveness to achieve a particular policy or performance objective, or within a portfolio approach.
- The portfolio approach might seek to balance the projects in a portfolio by spreading investments across modes,

geographies, or particular policy objectives. This is facilitated by the explicit consideration of benefit categories and the relationship between different types of benefits and the stakeholders to whom they accrue.

- Another feature of the Framework that can be used in prioritizing projects in a portfolio is the risk/uncertainty analysis feature. A group of projects can be analyzed with the same set of risk/uncertainty scenarios and portfolios of projects can be selected that either give priority to those projects that are the least sensitive to project uncertainties or that hedge risk and uncertainty.

Allocating Cost Responsibility

Freight projects are increasingly the subject of complex public-private funding negotiations and many prospective users have expressed the need to have a tool that can assist them in these negotiations. The feature of the Framework that identifies stakeholders—and the benefits that are most critical to each stakeholder group—was developed as a way of beginning the discussion of who should be responsible for paying for a project. Typically, the initial discussion would be based on allocating costs of a project in proportion to the allocation of benefits, and both public and private stakeholders could then reevaluate the investment from the perspective of their own net benefits (based on allocated costs).

In addition to the allocation of cost responsibility between public- and private-sector participants, the Framework also allows for consideration of how costs should be allocated for a project that has multijurisdictional impacts. The discussion of project geographic scale earlier in this report indicates how this can be done to show when benefits accrue outside of the immediate jurisdiction of the investment. This can be useful in structuring funding partnerships between state and local governments, as well as in multistate agreements in state/federal agreements.

Framework Modules and Investment Types

The Freight Evaluation Framework was developed in modules that are mode-specific, recognizing that the specific benefit evaluation tools are often structured this way. However, the Framework also recognizes that many projects will have multimodal impacts and, as described above, many project evaluations may involve multimodal tradeoff decisions. Table 6.1 displays a matrix illustrating the modules of the Framework to be used when evaluating different types of freight investments.

The following sections describe the general analytical approach of the highway, rail, port, and cargo handling modules. Later in this section, examples are provided of the types of data and tools that are available to implement the key steps of benefit, cost, and risk assessment.

Highway Investments

Highway investments will impact both freight and passenger travel. Highway investments are expected to lead to travel efficiencies, including reductions in travel time and distance (and thus vehicle operating costs), as well as potential safety and environmental enhancements. These investments also have the potential to improve access to multimodal transportation facilities, distribution centers, and economic markets for freight travel as well as work and other destinations for passenger travel. The module within the Framework to be used when assessing highway investment impacts is presented in Figure 6.1. The most direct effect of highway investments

Table 6.1. Framework modules by investment type.

	Module in Framework			
Project Type	**Highway**	**Rail**	**Marine Port**	**Airport**
Highway Improvements	●			
Intermodal Connector	●	◑	◑	◑
Rail Improvements	◑	●	◑	
Grade Crossings	●	●		
Highway to Rail Diversion	●	●		
Port Expansion Impacting Highway and Rail	●	●	●	
Barge Services Diverting from Highway and Rail	●	●	●	
Air Impacting Highway	●			●
Cargo Handling Facility	●	◑	◑	◑

● Primary Impact Module ◑ Potential Secondary Impact Module

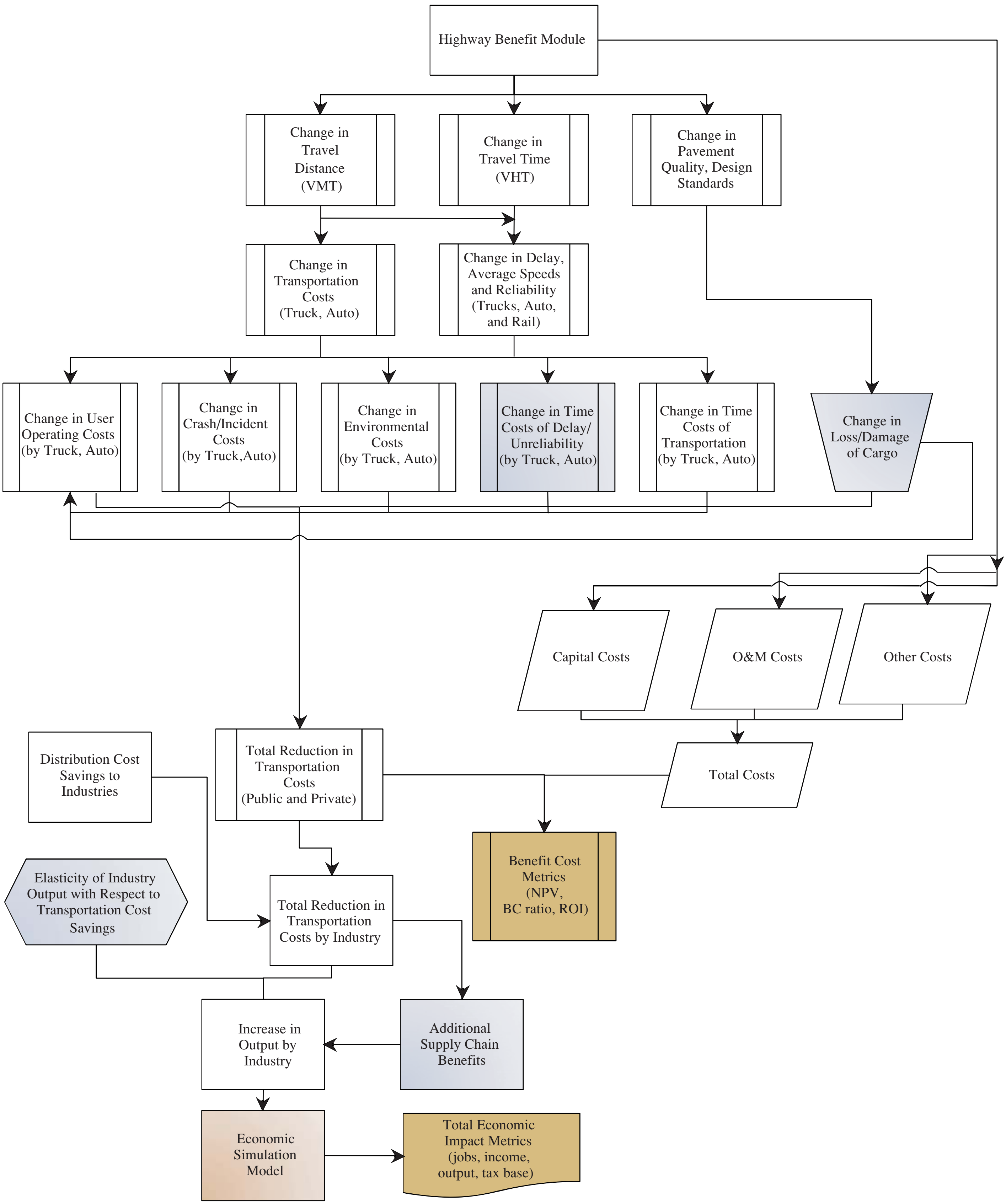


Figure 6.1. Highway investment evaluation.

is captured through changes in the level of total VHT and VMT by trip purpose.

The analytical approach to calculating highway benefits consists of several key steps, described below. Additional detail on the specific tools that could be utilized is provided in Appendix A.

- Identify origin-destination patterns for trucks and autos and calculate changes in vehicle miles of travel (VMT) and vehicle hours of travel (VHT). This will typically involve the use of travel demand models but in the case of freight analysis may need to be supplemented with data on routed commodity flows on/through the facility that is the subject of the investment. To the extent that the investment also involves changes in pavement quality or roadway design standards that could lead to reduced loss and damage of cargo transported over the facility, this also should be incorporated in the analysis.
- Apply parameters reflecting operating costs per mile and value of time per hour to the VMT and VHT results in the previous step, differentiated by vehicle type and trip purpose. Sources for operating costs and value of time can be found in tools such as the Highway Economic Requirements System (HERS) or a variety of literature on truck value of time.
- Calculate total reduction in transportation costs due to highway efficiency improvements by vehicle type and trip purpose. These results are derived from the individual estimates of reductions in transportation costs (in dollar values) from the previous step.
- Estimate other cost savings, including reduced vehicle operating costs, emissions reduction, safety savings, potential changes in pavement costs, and changes in cargo loss and damage. Guidance for monetizing the nonmonetary benefits can be found in a variety of literature but recent guidance was provided in the Transportation Investment Generating Economic Recovery (TIGER) grant programs.
- Distribute business-related transport-cost reductions (truck trips, business auto) to industries based on the size of the industry and their demand for trucking services. These transportation-cost savings, along with additional supply chain benefits serve as the direct user benefits for BCA and as input into an economic simulation model to estimate the economic development impacts of the investment.

This process results in an estimate of total direct transportation user benefits, as well as estimates of total employment, income, output, and tax base expansion impacts. These benefits can be compared to total costs in order to assess the overall return on investment.

Rail Investments

Similar to the highway impact module, rail investments can result in faster speeds, increased productivity, lower costs, and better access to markets and gateways. Examples of rail investment projects that give rise to these types of benefits include double-tracking, clearance projects that allow for double-stack trains, sidings, signalization, and track upgrades. Rail investments may change time and distance (potentially increasing for some and reducing for others) for both rail and highway traffic. Therefore, the rail module also includes the highway impact module. This is especially important if there is potential for truck-to-rail diversion or vice versa. The Framework module used to assess rail investment impacts is presented in Figure 6.2.

The analytical approach to calculating rail benefits consists of several key steps, described as follows:

1. Estimate service and market impacts of rail improvement by assessing impacts of improved speed, market share, and reliability. In the best case, this would be done using detailed rail simulation models. However, there is a growing body of literature on how to estimate these benefits using simplified tools such as parametric capacity models. Business-related transport-cost reductions (primarily freight rail) are distributed to industries based on the size of the industry and their demand for rail services. Data on commodity flows for specific rail lines may be able to be estimated with data sources such as the Rail Waybill Sample or other routed commodity flow databases.
2. Estimate additional supply chain and logistics benefits that also may accrue due to improved reliability or cost savings related to reduced shipping costs.
3. Estimate highway system costs and benefits using the highway module (described above).
4. For the BCA, combine the direct transportation efficiency benefits with project costs to determine the net present value of the benefits. For the EIA, these direct effects serve as input into an economic simulation model to estimate increased business output, employment, income (wages), and tax revenues.

Port Investments

Investments in airports and marine ports are combined in a single evaluation module. Investments in port facilities are generally aimed at expanding market share via productivity and efficiency enhancements. Growth in trade can be forecast based on how the investments expand capacity and change total costs, where total costs are composed of a combination of travel time/delay, costs, reliability factors, vessel turnaround

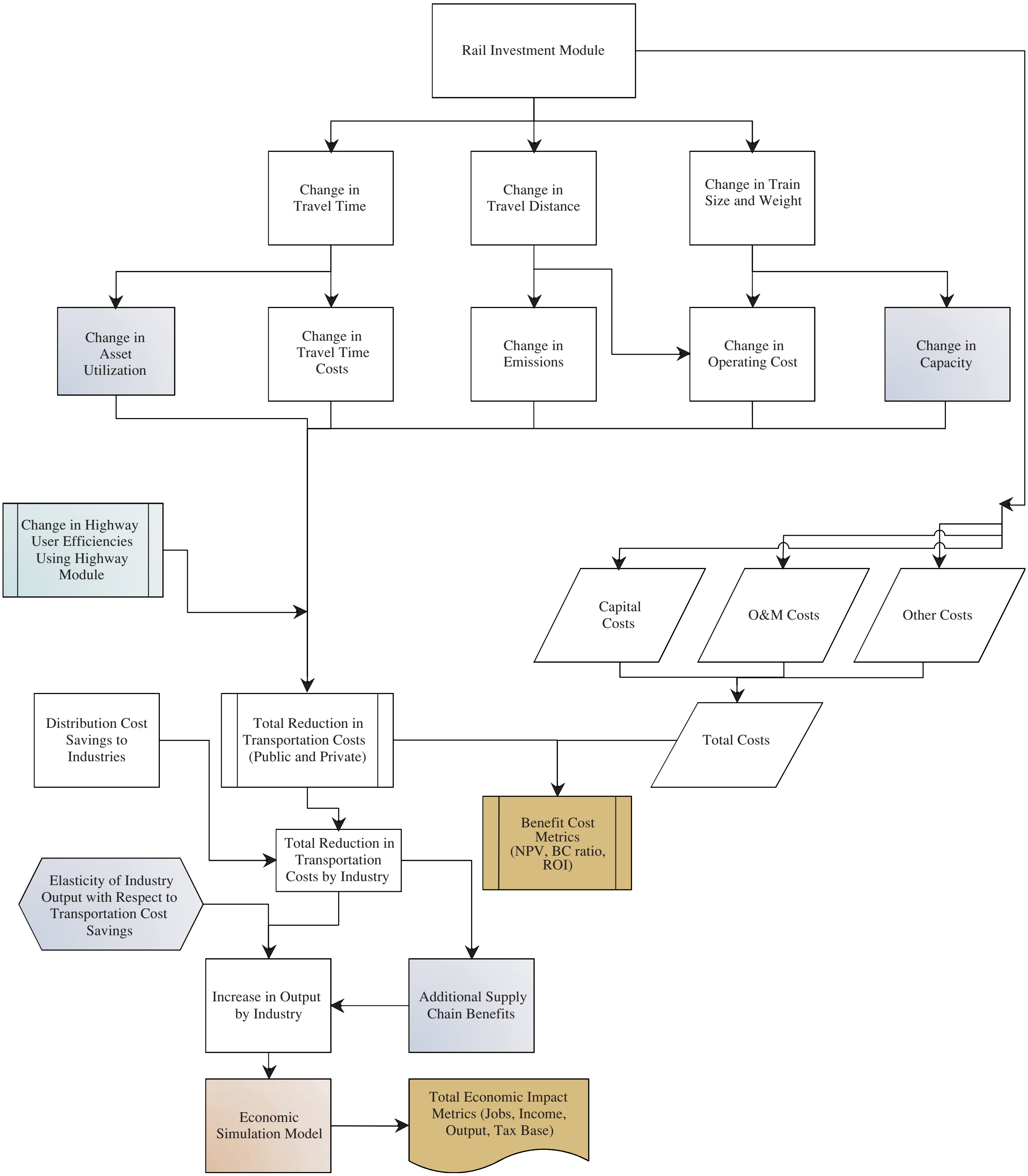


Figure 6.2. Rail investment evaluation.

time, and port fees and charges. Improvements at ports, including landside connections to major highway and rail routes, may lead to increased market share for the port and lead to increases in total freight volumes in the port region, including both import and export trade flows. Therefore, this evaluation module focuses on two distinct sets of impacts. First, the more localized effects on the volume of cargo and trade in terms of expanding trade-related economic activity (which may be more relevant for local and regional stakeholders as opposed to national stakeholders) are evaluated. Second, it is recognized that port investments may lead to increases in surface transportation traffic for a given region. To capture those impacts, the highway and/or rail investment modules may need to be included within the port module. The Framework module used to assess port investment impacts is presented in Figure 6.3

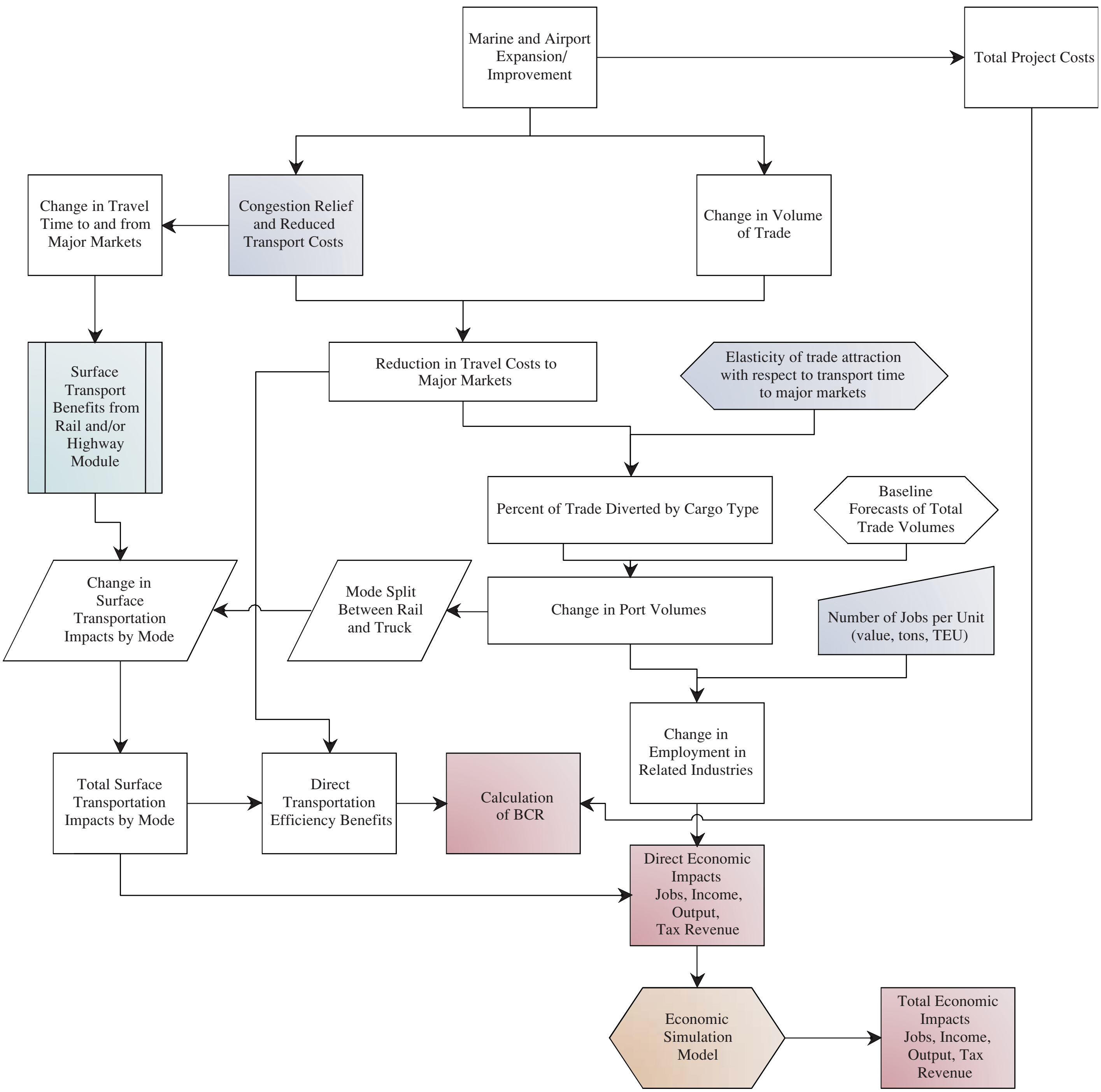


Figure 6.3. Port investment evaluation.

The analytical approach to calculating port benefits consists of several key steps, described as follows:

1. Estimate reduced travel times and costs compared to alternative ports of entry or modes (i.e., highway or rail) based on major freight markets.
2. Estimate mode splits for traffic moving to/from the affected port. A key factor that determines the total reduction in transportation costs from trade diversion is the mode split. The mode split will vary by commodity and market segment and will determine the volume of induced trade handled on the highway and rail systems (which present different per mile costs). The impacts of this increased surface transportation volume is estimated using the highway and rail investment modules.
3. Estimate industry-level and economywide effects by combining the effects arising from all of the relevant modes.

Cargo Handling Facility Investments

Increasingly, states and local governments are being faced with investment decisions related to cargo handling facilities, especially intermodal railyards. Sometimes these decisions are based on a request by a private-sector freight stakeholder or developer; at other times the investments are being pursued as a catalyst for local or regional economic development. Whatever the motivation of the project, it is important that public policymakers undertake a rigorous analysis of the potential benefits, both public- and private-sector benefits. The potential for private-sector benefits will drive the demand for the facility and in turn, the demand will drive the public sector benefits (and in some cases, the disbenefits). As with port investments, investments in cargo handling facilities are likely to have spillover impacts on the highways and rail corridors linking those facilities to markets. Thus, the evaluation of the impacts of these facilities also should include an evaluation of the effects on the surface transportation system. The Framework module used to assess cargo handling investment impacts is presented in Figure 6.4.

The analytical approach to calculating cargo handling facility benefits consists of several key steps, as follows:

1. Estimate the size of economic activity arising from facilities by a combination of trade volumes forecasts as well as findings from qualitative interviews with stakeholders (particularly shippers/end users) throughout the region.
2. For the EIA, estimate the number of jobs at each location based on case study analyses of other inland port/intermodal facilities throughout the United States. Jobs are distributed to industries based on trade activity (i.e., largely transportation, distribution center, and warehousing sectors).
3. Estimate the direct user impacts for highway and rail users.
4. Calculate total economic impacts (including multiplier effects) from increased employment and wages, and changes in travel efficiencies.
5. Calculate improved access to markets derived from improvements in freight logistics by applying elasticities to estimate how reductions in travel time to major markets, along with regional competitiveness effects, lead to broader economic development opportunities.

Impacts on the surface transportation system are estimated using the framework for highway and rail investments. The output of these analyses will feed into both the BCA and EIA.

6.2 Key Elements of the Framework with Examples of Use

In order to help illustrate how the Framework is used, a step-by-step description is provided for the key elements. Examples are drawn from the case studies to illustrate how each step is implemented and the types of data and tools that can be applied.

Step 1—Identify Project Type, Modes, and Geographic Scale

The first step in using the Framework is to identify the project type, affected modes, and geographic scale of the project. The project type and affected modes will determine which framework modules should be applied and the types of benefits that will need to be evaluated. The Framework classifies project type by the following general categories:

- Air impacting highway,
- Cargo handling facility,
- Highway improvements,
- Intermodal connector,
- Rail improvements,
- Grade crossings;
- Port expansion, and
- Barge services.

Other categorizations may be useful in recognizing that the primary purpose of identifying the project type is to determine the type of improvements being made, the specific performance improvements that are expected, the modes that will be affected, the types of shipments/freight that will be impacted, and the relevant stakeholders. Typically, large freight investments will fall into multiple categories and will affect multiple modes. For example, the Tchoupitoulas Corridor Improvement Project at the Port of New Orleans (described in the previous chapter) was primarily a highway improvement project that created a dedicated truckway increasing capacity accessing

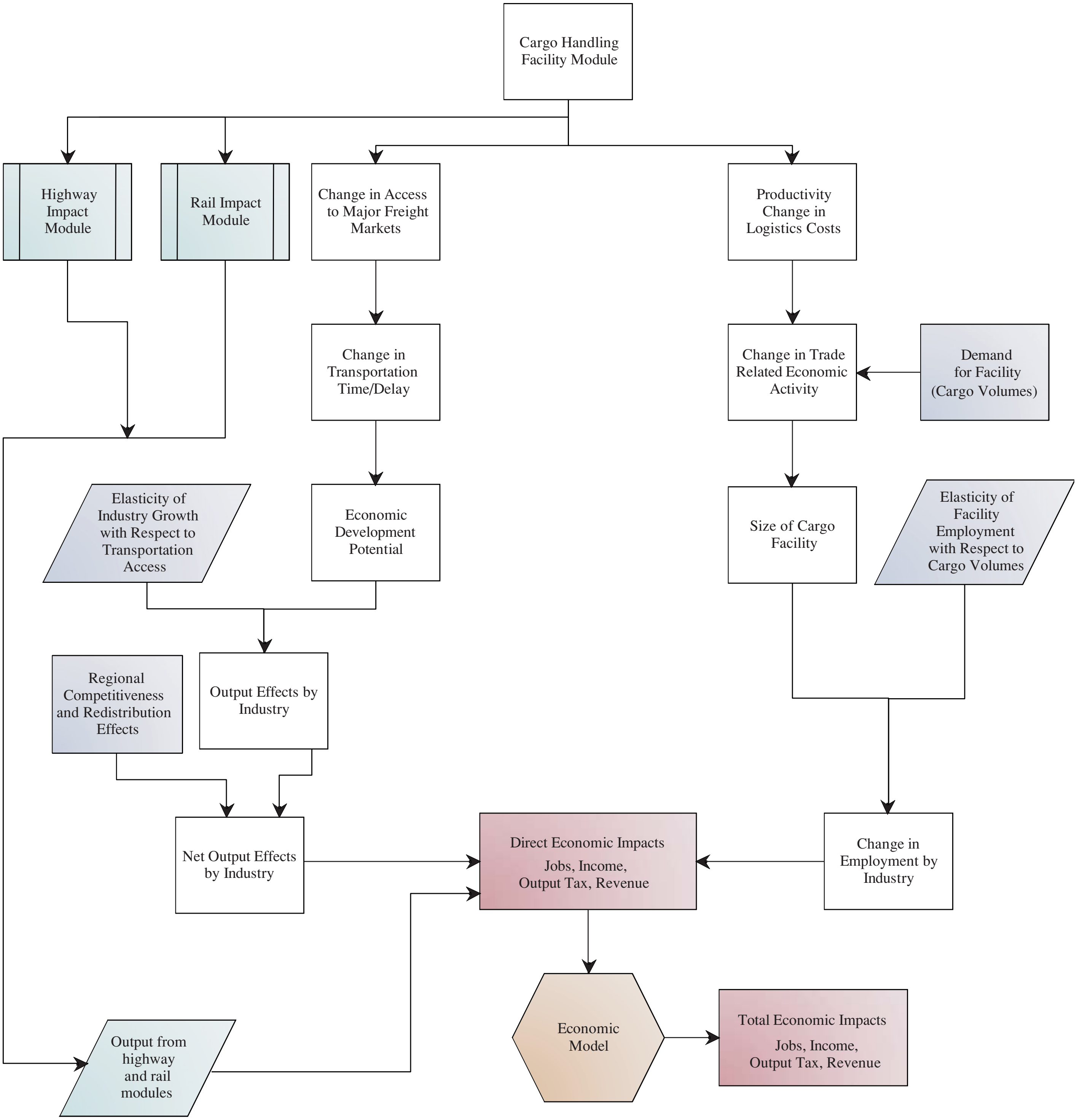


Figure 6.4. Cargo handling facility investment evaluation.

the port. This also served as a critical intermodal connector improving port access. In addition to the truckway, the project included the implementation of a chassis pool, warehouse consolidation, and port expansion that increased port capacity; and rail track realignment that, in addition to providing general rail operational improvements, eliminated a number of at-grade rail crossings. The project clearly affected highway, rail, and port modes, and would require use of each module in the benefits evaluation.

The scale of the project in terms of the area over which investments are being made will affect the type of data and tools that are needed to evaluate the project benefits. The scale of freight investments can range from high-level systems projects, such as the Heartland Corridor case study, down to community-level projects, such as the Tchoupitoulas Corridor Improvement case study. In the case of a high-level systems project, benefits are estimated in terms of system-level VMT and VHT impacts and can make use of aggregate measures of impact and project use, which may be obtainable from national data sets. For example, in the case of the Heartland Corridor, data on corridor usage levels, potentially divertible truck traffic, and shipper inventory reduction costs all can be obtained from data sets such as the national commodity flow databases and national industry inventory cost data. In the case of a community-level project, more detailed assessment of project impacts using local traffic models (both travel demand models and traffic operations models), along with interviews with local shippers and carriers, is necessary to get an accurate picture of benefits that exist at a much smaller scale.

Step 2—Identify Stakeholder Types

This is an important step in the Framework and one that distinguishes it from many other approaches to benefit/cost analysis and project evaluation. Understanding who all of the stakeholders are helps focus the analysis on measurement of appropriate benefits and also determines who has an interest in the project when it comes time to allocate cost responsibility. As described earlier, the Framework identifies the following broad categories of stakeholder types: asset providers, service providers, end users, and other impacted parties.

Freight projects often involve varied and complex stakeholder interests that can extend beyond the immediate project boundaries. Since understanding who the key stakeholders are is an important first step in identifying the critical benefit metrics that need to be considered, some care should be taken with this step. An example is provided by the ReTRAC case study. The case study focused on six stakeholders: Union Pacific (UP) Railroad, Washoe County, the State of Nevada, the City of Reno, regional businesses, and the project area community. It is important to note that since the freight infrastructure investment is a partnership between public- and private-sector agents, stakeholders often hold dual roles.

Step 3—Identify and Assess Benefits

As noted earlier in this section and in Chapter 4, the analysis of benefits of freight investments needs to focus on those benefit categories and metrics that are most important to each stakeholder group because these are the benefits upon which decisions will be based. Determining the relationship between benefits and stakeholder types also is important when project decisions involve allocation of cost responsibility or when the participation of particular stakeholders is essential for the project to be done (for example, a rail project that has tremendous value to the community and state based on associated economic benefits may not ever be developed if the railroad that owns the line has no interest in the project—even if the public sector is willing to pay all of the costs). Therefore, the first part of this step involves identifying the critical benefit types and metrics and their relationship to specific stakeholder types. Table 6.2 presents recommended benefit types, metrics, and the stakeholders for whom these benefits are important.

Data and Tools

Presented below is a summary of some of the commonly used data and tools for assessing some of the most common categories of benefits in freight projects. In general, there are many existing benefit/cost analysis and economic impact analysis tools that provide monetization factors for converting standard transportation user benefits into dollar values. Examples include

- Guidance that recently has been issued for the U.S.DOT Transportation Investment Generating Economic Recovery (TIGER) Grant Program.
- FHWA has published benefit/cost analysis handbooks for highway evaluation projects that are accessible through the FHWA website.
- Many state DOTs require benefit/cost analysis for highway and other transportation projects and have compiled their own tools and monetization factors. These often provide a library of source citations that can be used for further research into monetization factors.
- FRA's GradeDec.Net System includes BCA tools for grade crossing analysis.
- FHWA's ITS Deployment Assessment System (IDAS) is a benefit/cost analysis tool developed primarily for the analysis of ITS investments but does include a library of data for monetizing many standard transportation system benefits.
- TREDIS Multimodal Benefit/Cost Module is a proprietary benefit/cost analysis tool that is a product of Economic Development Research Group and was used in several of the case study analyses described in this report.

Examples of other data and tools that have been used to analyze project benefits for a wide range of projects are described in detail in Appendix A. A summary of some of the common data used to assess benefits is summarized below.

Travel-Time Savings. To estimate route-specific delays in a highway network, travel demand models often are used because they can provide forecasts of changes in VHT as a measure of delay reductions. It is not always necessary to use a travel

Table 6.2. Benefit metrics by benefit and stakeholder type.

Benefit Type	Benefit Metric	Public Sector	Service Provider	Shipper/End User	Other Impacted Party	Private-Sector Asset Provider
Capacity	Transportation Cost Savings	●	●	●	●	●
Safety	Crash Reductions	●	●		●	●
Environmental Quality	Emission Reductions	●	●	●	●	●
Scheduling/ Reliability	Reliability Improvements		●	●		
Facility Maintenance Costs	Pavement/Track Maintenance Savings	●				●
Loss and Damage	Pavement/Track Conditions	●	●	●		●
Productivity	Asset Velocity		●	●		
Economic Development	Jobs, Income, Industry Output	●			●	●
Tax Revenue	Tax Base Impact	●			●	
Facility Capital Costs	Facility Costs	●				●

demand model to estimate delay reductions resulting from an improved facility. In some cases, it may be possible to use current conditions to calculate speeds without the project and estimate future free-flow speeds on the improved facility by applying a forecast of cargo volumes. The difference between the future free-flow speeds and existing conditions can be used to estimate delay reductions.

For rail projects, the general approach is to estimate an average speed on a route based on general track rating (average rated speed), train type, and route distance multiplied by either the number of trains or the tons per train to get travel times with and without the project. This may be a function of current values (which can be observed or obtained from participating railroads) and the project design standards. In a more detailed analysis, train operations can be simulated to obtain changes in train delays.

For grade crossing projects, a significant benefit is the reduced delay to vehicles queued at the rail crossing. There are a number of standard formulas for computing delay based on gate downtime (which is itself a function of average speed through the crossing and train volumes and lengths). FRA's GradeDec.Net tool provides calculation algorithms and data for making these calculations. Grade crossings also may result in reduced delays for the operating railroad, particularly if a number of grade crossings are addressed along a corridor. In this case, benefits would be calculated based on the operating speeds allowed with and without the grade crossing separations and applied to the volume of trains and length of trains experiencing the delay.

In cases where a new cargo handling facility is being constructed, an important benefit may be greater accessibility to a particular cargo market. In this case, estimating the amount of affected cargo and the average distance/travel time to the new and alternative cargo handling facilities can be used to estimate travel-time savings.

Vehicle Operating Cost and Shipping-Rate Savings. In addition to travel-time savings, projects also may produce operating cost savings that are a function of reduced VMT. Energy costs are an example of costs that may be a function of mileage rather than time. Energy use per mile can be calculated based on average fuel economy by mode. There are a variety of sources that can be obtained from DOE and EPA to calculate these savings. ATA and the Association of American Railroads (AAR) provide sources for truck and rail operating costs.

In a number of the case studies, if shipping from an alternative port or airport was the goal of a project (either by expanding capacity at a local port/airport or by improving access to a nearby port/airport) it may be possible to survey the alternative facilities to obtain rates to/from typical origins/destinations to obtain an assessment of potential changes in shipping costs at the new or expanded facility.

Inventory and Reliability Savings. Reduced delays associated with delivery uncertainty can translate into reduced inventory carrying costs. Various benefit/cost analysis tools approach the estimation of reliability benefits differently, but in the case of highway projects, reliability often is estimated as a function of congestion levels (speed or VMT being the appropriate indicator as both can be estimated with a standard travel demand model). New techniques are being developed that measure buffer time, or the amount of time that must be built into a trip to ensure on-time arrival for a desired percentage of trips. By examining speed variability at different locations as a function of congestion levels, it may be possible to develop a predictor of buffer time. Several studies have made an attempt to estimate the value of inventory costs associated with nonrecurrent delay as a function of the type of commodity being shipped. One such approach that was cited in a number of the case studies was the Freight Logistics Factor from the Highway Economic Analysis Tool (HEAT).

Modal Diversion. Modal diversion can lead to logistics costs savings for shippers who realize savings by being able to ship by a less expensive mode, but also may result in savings in reduced pavement maintenance costs, reduced emissions per ton-mile, and reduced highway congestion. There are a variety of techniques for estimating potential truck-rail diversion. Most require some knowledge of commodity shipments by truck and major origin-destination (O-D) pairs within the corridor of interest and at least some estimate of the capacity for the new modal service to expand its market share for a particular commodity/O-D pair. One tool is U.S.DOT's Intermodal Transportation and Inventory Cost (ITIC) Model, described in Appendix A.

Safety Benefits. In the case studies, estimates of safety benefits were generally provided for highway projects and grade crossing separation projects. In the case of grade crossing projects, a simple approach is based on assuming that currently reported accidents of various types will drop to zero if the grade crossing is separated. An accident rate per train hour at the gate can be estimated from current year data and can be used with forecast train volumes to estimate potential future benefits of the grade crossing separation.

In the case of highway safety benefits, a variety of sources provide average crash rates per VMT (for example, these data are available for national averages from BTS). Alternatively, route-specific estimates of crash rates can be estimated from local data sources based on comparable facilities.

Emission Reduction Benefits. A variety of sources can be used to estimate an emission factor or rate per vehicle mile to estimate highway emission changes as a function of changes in VMT. These factors are available from standard emission factor models, such as EPA's MOBILE model. A more sophisticated analysis would take into account changes in vehicle speeds that result from improvements in highway capacity or operations. The emission factor models have the ability to estimate emission rates as a function of average speed or speed bins. EPA also has published data on railroad emission rates per ton-mile assuming a particular duty cycle (or mode of operation). These also do not take into account potential operational improvements that could result from a freight investment. A more sophisticated analysis of railroad emissions benefits would take into account the change in duty cycle and average speed that could be obtained by upgrading track or increasing average running speed and reducing speed cycling. Data on emission rates by power level for different locomotives have been published in various EPA sources.

Step 4—Identify Cost Categories and Estimate Costs

The costs of a constructed facility or implemented technology to the owner include both the initial capital cost and the subsequent operation and maintenance costs, as described earlier. Although there are many sources of costs, it is critical to calculate both capital costs (i.e., the expenses related to the initial establishment of a facility) and operations and maintenance costs (i.e., costs that accrue over the entire project lifecycle).

The Heartland Corridor case study in the previous chapter provides a useful illustration of how cost components are calculated and included in the analysis. Norfolk Southern had prepared preliminary cost estimates prior to 2005, which did not consider each individual type of improvement and its location on the corridor. Instead, it used a fixed-unit cost derived from another project for all construction work. In the costing method included within the Freight Evaluation Framework, every type of modification is considered to tailor a cost estimate for improvements for each independent location using prices from contractors currently performing similar work.

Step 5—Risk Analysis

As described in Chapter 4, the Freight Evaluation Framework includes explicit analysis of risk impacts on the investment decision. Assuming that the risk profile does not suggest the potential for catastrophic failure of the project, the risk analysis techniques that should be used will simulate the range of potential outcomes of the benefit/cost analysis given a set of risk scenarios. The major types of risks that will typically be considered are market risks (demand for the project does not meet expectations, thus reducing project benefits) and cost risks (cost overruns or other causes of cost increases relative to initial estimates). In either case, the downside risk will result in lower benefit/cost ratios that might not meet the investment decision hurdle established for the project.

The basic technique is to define a set of risk scenarios that bound the likely range of variation in the key risk variables, assume a probability density for this key input variable, and then run various probability-based simulations to determine the probable range of outcome variation. Risk variables are usually developed around a key demand growth rate, cost escalation variable, or other demand and cost variables.

An example from the Tchoupitoulas Corridor Improvements case study is illustrative of this approach to risk analysis. The element of risk is included in the analysis due to uncertainty in future port growth. A close look at the base case benefit analysis indicates that the benefits from the project depend on both the volume and mix (container versus break bulk split) of port activity. An examination of historic port tonnage and the cargo mix at the port shows considerable year-to-year variation over the past 15 years. Therefore, there is a risk of insufficient benefit due to uncertainty in future port growth. Uncertainty can come from certain events such as 9/11 or Hurricane Katrina, or be classified as cyclical and random risk (e.g., business cycles, exchange rates, or industry fluctuation).

In 1996, after the major section of the truckway was built, cargo volume was 10 million tons. Since volume decreased down to 6 million in 2008 and was forecasted to rise back up to 1996 levels in 2019, a very small growth rate estimate of 0.1% was used in the analysis. To account for fluctuations and uncertainty of cargo growth, a range of 0.1% to 3.0% was used to calculate the upper and lower bounds, as was described in Chapter 5.

CHAPTER 7

Lessons Learned and Suggested Topics for Future Research

7.1 Critical Lessons Learned from Phase I Research

This section highlights some of the more critical lessons learned throughout the development and testing of the Freight Evaluation Framework as a prelude to a proposed approach for further research to refine, test, and implement the Framework to support freight investment decisions.

There are numerous available tools that can be used to assess benefits, costs, and risk of freight investments. What is needed are clear procedures that help analysts and decisionmakers integrate these tools and that guide the analysis to ensure consistency from project to project.

As described earlier, there is a wide variety of investment decision-making techniques and tools that are used to assess user benefits, conduct return on investment assessments, and perform benefit/cost analysis, economic impact analysis, and risk analysis. Yet, there was general agreement at the Freight Investment Workshop that the Framework was very useful to help frame an investment decision analysis, even when there are multiple stakeholders and decision processes involved. Many analysts find it difficult to wade through the variety of tools and data and determine which are the most appropriate for their particular situations. They also felt that having a structure that guides the analyst through steps of an analysis would be very useful.

Some specific features of the Framework that were felt to be particularly useful included the following:

- The identification of stakeholders and relationships between benefit categories and stakeholders, which helps in allocation of costs among potential beneficiaries.
- The categorization of benefits and relationships among benefits, project types, and modes. This essentially provides a checklist for the analysts to make sure they have considered all appropriate benefit types for a particular project type.
- The ability to conduct multimodal comparisons as well as to consider cross-modal impacts of projects.
- Incorporation of risk analysis, which is a critical element of private-sector decision-making, but is not often explicitly accounted for in public-sector analyses. Incorporating a risk analysis module also can help compensate for uncertainty introduced as a result of data or methodology weaknesses.
- The incorporation of case studies as part of the Framework testing process, which provided how-to examples as well as examples of the different data and tools that are available for conducting analysis.

Users would benefit from more detailed procedures and guidance to facilitate using the Framework.

Many participants in the Freight Investment Workshop described in Chapter 5 were concerned that the Framework as currently configured was complex and difficult to follow. Some were looking for "cookbook" procedures that provided detailed examples of how the Framework could be applied in practice. One participant suggested a guided approach that would walk the user through an analysis based on a series of questions about the nature of the project and the types of information available. Other participants felt that it would be difficult to develop a procedure that was this deterministic and wanted to maintain the flexibility inherent in the idea of a framework.

Despite this range of opinions on how to do it, there was near universal agreement that more detailed procedures and examples would be beneficial to potential users of the Freight Evaluation Framework. This might include worksheets, sample problems, and references on analytical tools and data sources organized in a guidebook format with users in mind.

Analysis of small-scale local projects would benefit from more detailed information about current and prospective users of the project.

The analyses suggested by the Framework are most effective when the analyst has some information about the types of industries/commodities that will use the project. This is particularly important in the analysis of supply chain, reliability, and inventory cost impacts. Some participants in the workshop lamented the state of the practice in subnational commodity flow data and freight forecasting that could produce this kind of information. Given this problem, more focus on local data collection may be justified for significant investments. Some of the case studies did involve this type of local interviewing or data collection to enhance the type of information that was available from models. This kind of supplemental data and information collection is a critical component of the successful implementation of the Framework.

There are a variety of multimodal issues that need to be incorporated in any freight investment decision.

The Freight Evaluation Framework was initially structured around modal modules, primarily because the analytical techniques tend to be slightly different for different modes. However, in actual practice (as was made clear from the case studies in Chapter 5), most projects will require the use of multiple modal modules. This is a feature of freight investments that tends to distinguish them from passenger transportation investments. Reasons multimodal analysis is so critical include the following:

- **Projects often have explicit intermodal dependencies or multiple modes are present in the project.** This is especially true in cases involving cargo handling facility and port (air and marine) projects. Even though the investment may focus on one mode, the interaction of all the modes present at a facility requires a comprehensive intermodal analysis.
- **Projects often have cross-modal impacts.** The most obvious case is one in which modal diversion is an explicit objective or expected outcome of the project (e.g., the Heartland Corridor Clearance Initiative). But there are cross-modal interactions in most projects. Developing a new air cargo facility will affect trucking access routes and transportation costs associated with connecting to the facility. Grade crossing projects clearly affect highway modes at the crossing as well as rail operations through the crossing.
- **Supply chains typically are integrated across multiple modes and reliability and inventory-cost impacts must be considered from one end of the supply chain to the other.** This is one of the most challenging aspects of freight investment analysis because if done properly, it almost always requires consideration of secondary impacts of a project well beyond the jurisdictional boundaries of the investing entities. However, if the users of the project can be identified by industry type, it may be possible to focus on how the project affects nearby intermodal links and relate this to overall supply chain performance.

Allocation of benefits and costs among stakeholders is a critical feature of the Framework but could be enhanced in future research.

The research team's testing process uncovered a number of issues related to how freight stakeholders are engaged throughout the application of the Framework, including the following:

- **Disaggregating benefits by stakeholder type.** The Framework identifies and classifies stakeholders into different groups (asset providers, service providers, end users, and other impacted parties), and then adds a table to assign or allocate the various elements of benefit and cost to specific stakeholder groups. However, in carrying out the analysis, it can become a challenge to effectively assign various classes of benefits to specific stakeholders when there are dynamic interactions among them. This is illustrated by the DIA WorldPort case, where freight transport firms were projected to gain net revenue from expanded facility capacity but their actual gain would be reduced to the extent that they have to pay ground lease payments to the air freight facility operator, which, in turn, has to pay a share of its revenue to the property owner (airport authority). Tracking the string of payments can be challenging and estimating their final allocations may require the type of risk analysis that is included in the Framework.
- **Consistency among stakeholders and benefits.** Maintaining consistency with how stakeholders are identified and how they might benefit from particular projects will add value to the Framework. For example, the results and findings from a study can look very different depending on the level of detail in which stakeholders are defined and the degree of depth to which their interactions are traced. Both detail and consistency are required to generate useful results.
- **Accounting for sensitivity differences.** There are potentially large differences in the sensitivity to cost, benefits, and risk among different stakeholder types that are not all captured within the Framework. This becomes important if the Framework is used to help rank projects from the perspectives of various stakeholder groups. In some cases, there may be issues of such importance to a particular stakeholder group that they outweigh any and all other possible costs and benefits to that particular agent. In such cases, group preferences may include factors not all captured in the Framework as currently configured. It may be possible for the Framework to be expanded to account for, and incorporate, these types of preferences. Alternatively, it may be necessary to just note cases where the Framework does not (or cannot) encompass other major considerations.

Freight investment analyses need to be structured to ensure that they capture the wider economic effects of a project that may extend well beyond traditional study area boundary definitions.

All of the case studies involved projects leading to savings in the cost of doing business (for at least some industries at some locations). These transport efficiency and business productivity enhancements typically lead to broader impacts on local economic growth. One of the cases—Huntsville—was selected to illustrate how a regional economic impact model can be successfully applied to assess the broader job and income growth impacts of a freight facility improvement project.

The Framework could benefit from a more consistent approach to identifying the sources of risk and uncertainty that should be incorporated in the analysis.

As described earlier, risk analysis often is focused on the market and cost risks that create the greatest uncertainties and that could lead to different project outcomes. The market risks may be a result of normal fluctuations (such as business cycles), which may be reasonably predictable, whereas other random events may be important to consider.

Guidance could be developed to help identify the most typical sources of each type of risk and uncertainty for different types of projects. In addition, guidance could be provided for how to account for methodological uncertainty in the analysis. Given that there are a number of key performance attributes of freight investments that are difficult to predict with currently available tools and data, having a way to assess the level of uncertainty this introduces into investment decisions would be helpful.

7.2 Proposed Phase II Research Approach [Unfunded]

In discussions with the NCFRP-05 Research Panel immediately after the Freight Investment Workshop, it was clear that a number of the initial ideas about the focus of future research needed to be revisited. Although there clearly are areas where analytical tools and data that are necessary to assess specific freight investment benefits could use further development, these would be more appropriate for other ongoing research projects (e.g., improvements to freight forecasting and subnational commodity flow data development are, or have been, the subject of several NCFRP or Strategic Highway Research Program [SHRP] research projects).

In general, the panel, the research team, and the workshop participants agree that there are many tools that already exist that can be used in a freight investment decision analysis. Where the Framework developed as part of this research effort adds most value is in providing a structured approach to conducting analysis, integrating existing tools and data, relating the benefit analysis to stakeholder perspectives, and introducing risk analysis into the freight investment decision. Therefore, the researchers recommend that the focus of future research be shifted to accomplish the following:

- Work with prospective users to **identify any critical gaps in the Framework** beyond those identified in this report. The Framework should be updated and modified to address these gaps and the critical lessons learned (as described in Chapter 5 and Section 7.1 of this report).
- Develop a more **detailed set of procedures for using the Framework** and prepare a guidebook that includes these procedures and reference links to data and tools. The guidebook format should be determined with additional user input but could include both a hard copy and Web-based tool.
- Provide the draft procedures to a number of users to **further test the procedures in actual practice.** During this test, the research team should be available to provide technical support and assistance. Based on the test, recommendations would be made to the consultant team for modifying and finalizing the guidebook.
- **Conduct outreach** workshop and presentations at key user group meetings to ensure that the guidebook gets out to the widest audience.

Each of these elements is described in additional detail below as a series of tasks for Phase II.

Task 1—Identify and Correct Gaps in the Framework

This task would begin with the identification of gaps/lessons learned from Phase I and identified in this report. These would include

- Draft an outline of more detailed procedures, including a quick reference to specific data sources and tools that already have been identified in Phase I. The draft outline would serve as a quick roadmap of the Framework to review with prospective test users and could provide a basis for finalizing the procedures that would be tested.
- Review the benefit categories identified by stakeholder type and project type to ensure a final consistent set of benefit categories to be used in the final Framework. Ensure that these benefit categories are consistent across modes and that mode-specific performance metrics can be reported in a consistent multimodal format.
- Investigate ways of incorporating various sensitivities of stakeholders to the importance of specific benefit categories. This could include the possibility of introducing a multiattribute weighting procedure in addition to standard benefit/cost analysis.
- Develop a more detailed reference list of tools and data sources for each type of analysis recommended in the project drawing on those already identified as part of this research. This would be reviewed by the panel and the test users.
- Review the risk analysis procedures and develop a list of risk categories by project type to ensure consistency in risk analysis across project types.

While the research team is conducting this review of priority refinements to the Framework, three beta testers will be identified. These testers will be agencies or entities that are willing to work closely with the research team to further refine and test the Framework in actual use. The beta testers should be selected, to the maximum extent possible, to reflect the following three primary application types:

1. Need to make a go/no-go decision on a project,
2. Need to develop a project prioritization methodology, and
3. Need to determine cost allocation for a public-private partnership.

To the extent that testers can be selected who have real project decisions and who have at least some data already compiled for their projects, this would facilitate testing. It would also be beneficial if the testers represent cases in which both state DOTs and MPOs are involved and in which projects involve some cross-section of different modes. The research team believes that it would be relatively easy to identify prospective test users from the Freight Investment Workshop participants.

Once the testers have been identified and have agreed to participate, the research team will provide the results of the initial review of refinements to the test users and will meet in one-on-one interviews to identify any additional gaps or issues that the beta testers feel need to be addressed prior to the testing of the Framework.

Task 2—Develop Procedures and Draft Guidebook

Working with the beta testers, the research team and the NCFRP-05 Panel will agree upon a format for a draft set of procedures to facilitate testing. This format may not be the final format of the guidebook in order to facilitate quicker completion of the draft, but will need to have sufficient detail for the test users to be able to conduct analysis with limited assistance from the consultant team.

The research team will then develop detailed procedures and links to existing data, tools, and other resources for each step in the procedures for as many project types as can be reasonably assembled (including all of the project types that will be the subject of the tests), and will prepare a guidebook to be tested by the test users. This guidebook will incorporate the revised Framework, a summary of analysis tools, and other associated information within a how-to approach to allow freight stakeholders to more consistently and effectively assess freight benefits and evaluate freight investment decisions.

The research team has led the development of a number of guidebooks for NCHRP, AASHTO, FHWA, and others. This experience has allowed us to understand five key elements of successful guidebooks, as follows:

1. **Start with an annotated outline—**The team will first develop an annotated guidebook outline to share with the panel and the beta testers (as appropriate). This outline will document the proposed structure and organization of the guidebook and allow the research team to ensure that the information will be presented in an easy-to-use format.
2. **Understand the target audience—**When developing a guidebook, it is critical to understand who will be using it and, by extension, how it will be used. Understanding the target audience for this guidebook will allow us to develop its structure and content appropriately and in a way that meets the needs of its intended users.
3. **Ensure that the guidebook complements existing resources—**As described earlier, there are a number of existing guidebooks and other resources describing freight planning and programming and the use of freight benefit assessment tools and data. The guidebook developed as part of this task will be designed to be used in conjunction with these other resources and will provide links to additional data and information.
4. **Use case studies to provide how-to examples—**Freight planning practitioners can benefit tremendously from understanding lessons learned and critical success factors from other agencies that already have undertaken such activities. Our experience working with a wide range of state DOTs, MPOs, and regional coalitions has shown that case study examples are effective ways to demonstrate how freight concepts—including the use of analytical tools to evaluate potential investments—can be used to address real-life problems. The techniques, processes, and practices described within this guidebook will be supported with case study vignettes derived from the case studies described in Chapter 5 of this report and others, as appropriate.
5. **Organize the guidebook so that it is useful to both novice and advanced freight planning practitioners—**Freight investment activities differ among different stakeholder types, as well as geographic scale. To become a meaningful resource to a wide range of freight stakeholders, the guidebook will be developed so that it provides useful information and techniques for both novice users and those users who are interested in more sophisticated freight techniques. The guidebook will be organized so that those that may be new to freight planning or to assessing freight benefits planning can obtain general guidance and information, while advanced users (or those wanting guidance on specific investment scenarios) will be pointed to specific tools or methods.

The research team will develop the guidebook so that it is consistent with the key elements described above and meets the needs of its intended audience. The beta testers will receive an early copy of the draft to ensure that it is being developed in a manner that will best facilitate testing.

Task 3—Test the Draft Guidebook

The beta testers will be provided with a copy of the draft guidebook for use in an actual implementation test case. At the initiation of the test, the research team and the testers will specify a test plan that will describe exactly how the test will be accomplished (i.e., the specific application of the guidebook), particular elements of the guidebook that will need to be evaluated as related to the particular application covered by the test case, and the schedule for the test.

During the test, the users should be encouraged to attempt to use the guidebook without assistance first. However, during the duration of the test, the research team will be available to provide technical assistance to the test users on an as-needed basis. At regularly defined intervals during the test, the research team will conduct telephone check-in interviews with the test users to ensure that the test is proceeding and to answer any questions that may have emerged during the test. The research team will record the results of these check-ins and provide them as part of the monthly progress reports.

At the conclusion of the test, the research team will meet with each beta tester and conduct an exit debriefing that will obtain detailed feedback on what worked and what did not, as well as specific recommendations for improvements in the final guidebook.

Task 4—Revise the Draft Guidebook

Based on the input received from the test users, the research team will prepare a work plan for making revisions to the guidebook and preparing it in the final format agreed upon with the panel. Prior to undertaking these revisions, the research team will meet with the panel and present the proposed changes. In addition, at this meeting, the NCFRP-05 Panel and the research team will discuss plans for outreach.

After receiving approval from the panel, the research team will prepare a draft final guidebook that will be submitted to the panel. The research team will respond to any comments from the panel in the final version of the guidebook. The team also will prepare presentation materials that summarize the approach, key findings, important concepts, and notable conclusions of the research. These materials, which will include detailed speaker notes, will be designed to be used by states, MPOs, regional coalitions, industry groups, and others as an off-the-shelf summary of the research and its importance.

Task 5—Finalize, Publicize, and Conduct Outreach

Upon completion of the guidebook, the research team will implement and disseminate it, working with the members of the NCFRP Project 05 Panel and other interested parties. There are a variety of stakeholders that could take an active role in implementing/disseminating the final product. At the federal level, FHWA has an established freight program, and supports many of the tools and datasets that are likely to be included within the investment framework developed as part of this research. Because of the multijurisdictional nature of freight movements, freight investments, and freight benefits, multistate coalitions, such as the I-95 Corridor Coalition, the Mississippi Valley Freight Coalition, the West Coast Corridor Coalition, and others will be important leaders in implementing the product.

There also are opportunities for focused outreach by interested parties at key conferences/gatherings, such as the Association of Metropolitan Planning Organizations (AMPO), National Association of Regional Councils (NARC), TRB, and the Intermodal Association of North America (IANA). This would require individual champions, such as the research team and panel members.

Key implementation activities would consist of coordinated outreach through established federal freight programs such as the "Talking Freight" seminar series, conference presentations and workshops, and ongoing promotion by panel members and identified leadership. One key opportunity may be to leverage FHWA's investment in *Financing Freight Improvements* (*29*) and associated workshops. The results of this research could be a logical "add-on" to this effort that uses the workshop process to gain wider dissemination. In addition, the presentation materials and speaker notes developed as part of Task 4 will facilitate presentation in multiple forums.

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APPENDIX A

Traditional Benefit/Cost Tools

There are a number of distinct classes of benefit/cost analysis tools that correlate to the needs of different stakeholder types, study goals, and data resources. These tools provide diverse functions for use at different points in the freight project planning and development process. Descriptions of each set of tools are included in the following section and summaries describing each of the various tools are provided in Tables A.1 through A.7.

A.1 Strategic Planning Tools

These include tools used to assess long-term needs and deficiencies impacting the transportation system and the life-cycle costs of operating and maintaining transportation infrastructure (for asset providers), as well as longer-term market analyses, production, and site selection alternatives (for service providers and end users).

A.2 Carrier Cost and Performance Analysis Tools

These operational analysis tools, which estimate the operational performance and cost of freight carrier operations under alternative scenarios to represent the impact of transportation projects, programs, or policies, are primarily used by freight infrastructure providers and carriers.

A.3 Shipper Cost and Performance Models

These tools estimate the cost and time characteristics of alternative freight mode and service options, and are intended to represent the total logistics time, cost, and safety/reliability tradeoffs available for a shipment so that optimal shipping decisions can be made. These tools are primarily used by end users (i.e., the businesses that generate outgoing freight or the consignees who receive the freight and ultimately pay the shipper cost).

A.4 Transportation System Efficiency Models

These tools, often defined as benefit/cost analysis systems, are intended to evaluate the benefit and cost streams over a specified period of analysis to determine whether a proposed investment will yield benefits in excess of its cost.

A.5 Economic Development Impact Models

These tools estimate impacts of transportation projects on income and jobs in the economy, and are primarily used by public-sector (local, regional, or state) transportation agencies to explicitly consider business productivity and economic development impacts that are not represented by transportation system efficiency tools.

A.6 Financial Impact Accounting Tools

These tools, typically used by those who have a direct stake in the cost of a project, provide estimates on how the proposal will affect outgoing cost streams, incoming revenue streams, cash flow, borrowing or bond requirements, net profit or loss over time, upside/downside risk, and rate of return.

A.7 Risk Assessment Tools

These tools assist private-sector asset providers and end users in understanding and quantifying critical areas of uncertainty related to making investment decisions.

Table A.1. Summary of strategic planning tools.

Tool	Description	Source
Travel demand forecasting and network optimization tools	The technology application to support forecasting and the strategic plans include data available from agency or company financial systems, operations management systems, and others. Forecasting, a central aspect of the planning process, is where infrastructure needs are determined, market estimations are made, and facility locations, equipment specifications, or carrier requirements are evaluated.	Caliper (http://www.caliper.com/tcovu.htm) INRO (http://www.inro.ca/en/index.php) Citilabs (http://www.citilabs.com/)

Table A.2. Summary of carrier cost and performance analysis tools.

Tool	Description	Source
Routing Tools	Monitor truck movements that allow a unit to change routes for congestion avoidance, toll choices, and to improve overall fuel efficiency. On the end user side, product and transportation tracking allows a shipper to shift product quickly to an alternate point of sale while the goods are still in transit.	TMW Systems (http://www.tmwsystems.com), ALK Associates' PCMiler (http://www.alk.com/pcmiler), Manhattan Associates' X-Suite (http://www.manh.com/solutions/x-suite-solutions)
Railroad Operations Tools	Estimate how a given rail infrastructure improvement would actually change volumes, speeds, and reliability. The source data include specific track, siding and yard conditions, plus road, local, and work train characteristics, and schedules that are proprietary to the railroads.	Berkeley Simulation Software's Rail Traffic Controller (http://www.berkeleysimulation.com/rtc/rtc.html), CANAC/Savage Industries' RAILS 2000 (http://www.canac.com/index.php?page=products-rail2000), Systra's RAILSIM (http://www.railsim.com), Federal Railroad Administration's General Train Movement Simulator (http://www.decisiontek.com/Solutions/RailSafetyandCapacityAnalysiswithGTMS/tabid/72/Default.aspx)
Airport Operations Tools	Estimate the capacity of runway systems and the level of delay that they present when faced with alternative demand levels.	Total Airport and Airspace Modeler (TAAM) system (http://www.jeppesen.com/industry-solutions/aviation/government/total-airspace-airport-modeler.jsp), Airfield Capacity Model (http://web.mit.edu/aeroastro/www/labs/AATT/reviews/acm.html), Federal Aviation Administration's Airport and Airspace Simulation Model (SIMMOD) (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/nextgen/research_tech_dev/at_sys_con_dev/sim_analysis_team/models/simmod), Massachusetts Institute of Technology's LMI Runway Capacity Model (http://web.mit.edu/aeroastro/www/labs/AATT/reviews/lmircm.html)
Marine Port Operations Tools	Typically account for passenger and freight traffic, recognizing local differences in types of freight (bulk, break bulk, and containers), mix of ship characteristics, water depth and wave motion, and positions of terminals. Typical port planning tools include computer simulation models for port operations, port terminal container handling, and terminal expansion and development (including investment in quays, quay cranes, and storage space).	Aurigo (http://www.aurigo.com/Ports.aspx) PortOps (http://www.aecom.com/What+We+Do/Transportation/Ports+and+Marine/Port+Operations+Simulation) Flexsim (http://container-port-simulation.com/) Simio (http://www.simio.com/applications/port-simulation-software/port-simulation-software.htm)

Table A.3. Summary of shipper cost and performance models.

Tool	Description	Source
Modal Diversion Models	Forecast how freight movements shift in response to changes in the availability, cost, and/or time performance of available modal alternatives. Most modal diversion models used in transportation facility planning are focused on truck-rail-intermodal options, due in large part to the tradeoffs that shippers face when considering ground transportation options for medium- and long-distance travel.	IHS Global Insight Intermodal Diversion Model (http://www.ihsglobalinsight.com/ProductsServices/ProductDetail1025.htm) Intermodal Competition Model (http://www.fra.dot.gov/downloads/Policy/ITIC-IM%20documentation%20v1_0.pdf)
Total Logistics Cost Models	Predict how shippers respond to changes in the costs of modal and service alternatives. They actually estimate the total logistics cost of shipping, including direct transportation expense and inventory cost associated with modal lot sizes and service profiles.	SAP (www.sap.com)
Intermodal Transportation and Inventory Cost (ITIC) Model	Attempts to calculate the logistics cost and decision tradeoffs seen by shipper logistics managers, and then assigns the truck/rail diversion to alternatives that minimize total logistics cost.	Federal Railroad Administration (http://www.fra.dot.gov/rpd/freight/1543.shtml)
Spreadsheet Logistics Model	Estimates the truck/rail mode choice for 48 typical types of customers. This is done on the basis of given customer characteristics (use rate and trip length), commodity characteristics (value/pound), and mode characteristics (e.g., price, trip time, and reliability) for rail, truck, and intermodal options.	Massachusetts Institute of Technology (http://stuff.mit.edu/afs/athena/course/urop/uic/www/uic-TRF.PBTS.2002.revised.pdf)
Market Share Models	An alternative predictor of freight shipper choices based on a statistical correlation between modal performance factors and traffic capture (revealed preferences), and project traffic swings when relative performance changes.	IHS Global Insight (http://www.ihsglobalinsight.com/ProductsServices/ProductDetail1025.htm)
The Uniform Rail Costing System (URCS) Model	Estimates changes in shipper productivity associated with rail system performance changes. The model uses data on average carrier cost and performance measures to estimate the cost of providing service, so it can estimate how a change in facility capacity or speed (affecting rail cars per day) would translate into average shipper dollar savings per ton-mile.	Surface Transportation Board (http://www.stb.dot.gov/stb/industry/urcs.html)

Table A.4. Summary of transportation system efficiency models (benefit/cost systems).

Tool	Description	Source
Cal-B/C	Spreadsheet model for benefit/cost analysis of highway and transit projects in a corridor that already contains a highway facility or a transit service.	California Department of Transportation (Caltrans) (http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/models/calbc.html)
MicroBENCOST	Tool designed to analyze seven types of highway improvements in a corridor: (1) capacity enhancement, (2) bypass construction, (3) intersection or interchange improvement, (4) pavement rehabilitation, (5) bridge improvement, (6) highway safety improvement, and (7) railroad grade crossing improvement.	National Cooperative Highway Research Program (http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/models/microbencost.html)
Surface Transportation Efficiency Analysis Model (STEAM)	Model designed to assess multimodal urban transportation investment and policy alternatives at the regional and corridor levels.	Federal Highway Administration (http://www.fhwa.dot.gov/steam)
Highway Economic Reporting System (HERS)	System-level optimization framework for analyzing investment strategies to maintain and improve an existing highway network.	Federal Highway Administration (http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm)
StratBENCOST	Strategic-level evaluation method to analyze investment alternatives for expanding and improving a highway system. This tool represents an upgrade from previous analysis methods by incorporating cost calculations from MicroBENCOST and HERS, and adding consideration of risk and uncertainty.	National Cooperative Highway Research Program (http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/models/stratbencost.html)
BCA.Net	Tool compares and evaluates alternative highway improvement projects (e.g., preservation, lane-widening, lane additions, new alignments, addition of traffic control devices, intersection upgrades). "Projects" for comparison in benefit/cost analyses.	Federal Highway Administration (http://www.fhwa.dot.gov/infrastructure/asstmgmt/bcanet.cfm)
GradeDec.Net	Tool is a Web-based system for evaluating the safety impacts and the benefit/cost of improvements to highway-rail grade crossings in a corridor or region.	Federal Railroad Administration (http://gradedec.fra.dot.gov/Default.aspx)
Highway Freight Logistics Reorganization Benefits Estimation Tool	Tool measures second-order benefits that come about when firms direct the money saved on logistics expenses away from maintaining inventory and toward other more productive uses. These benefits can then be added to those estimated through BCA to arrive at a complete picture of total benefits.	Federal Highway Administration (http://ops.fhwa.dot.gov/freight/freight_analysis/cba/index.htm)

Table A.5. Summary of economic development impact models.

Tool	Description	Source
Input-Output Model (IMPLAN or RIMS II)	Regional impact systems trace how changes direct the flow of purchases or sales of one industry lead to broader indirect and induced changes in purchases and sales (and ultimately jobs and income) in other industries in that region. That makes them very useful for estimating the local impact of industry openings, closings, expansions, and contractions.	Minnesota IMPLAN Group (MIG) (http://IMPLAN.com/V4/Index.php), Bureau of Economic Analysis (https://www.bea.gov/regional/rims/index.cfm)
Regional Simulation Models (Computable General Equilibrium [CGE] Models)	Models have a spatial component that tracks transportation connections (and travel times) and trade (industry product flows) among regions, and an industry component that tracks the cost of freight transportation, by commodity group, between regions. The CGE element estimates the economic impact of transportation projects and policies through a process that first calculates their impact on interregional freight transport cost, effective labor supply, value of capital stock, and overall factor productivity.	ASTRA (spatially limited to major regions within Europe), PINGO (spatial CGE model for Norway)
Regional Simulation Models (REMI Policy Insight)	REMI models share many of the features of the spatial CGE Model, combining interindustry IO equations with transport price response and additional impacts on labor supply/demand and migration rates. The models have an ability to assess economic impacts, benefits, and costs of transportation network alternatives at a statewide level.	Regional Economic Models, Inc. (http://www.remi.com/)
Major Corridor Impact-Business Analysis System (MCIBAS)	MCIBAS is an example of an analysis system that provides a more useful interface for use of REMI Policy Insight macroeconomic models. They have an ability to assess economic impacts, benefits, and costs of transportation network alternatives at a statewide level.	Cambridge Systematics Inc, Economic Development Research Group, Inc, Indiana DOT (http://www.edrgroup.com/pdf/mcibas-system-intro.pdf)
BEST	BEST is an example of an analysis system that provides a more useful interface for use of REMI Policy Insight macroeconomic models. This particular tool is spreadsheet-based and was developed for the Michigan DOT to perform corridor analysis.	Michigan DOT (http://www.michigan.gov/documents/mdot/MDOT_economicbenefitreport_202828_7.pdf)
HEAT (Highway Economic Analysis Tool)	Custom-built, modular system that integrates a statewide highway network model and a statewide economic impact model together through a geographic information system (GIS) providing graphical map-based information on: (1) economic conditions among communities, (2) transportation dependence and commodity-specific impacts among industries, and (3) commuting and freight flows along highway networks.	Cambridge Systematics, Inc, Montana DOT (http://www.camsys.com/pro_planpro_heat.htm)
Regional Simulation Models (TREDIS with CRIO-IMPLAN)	CRIO-IMPLAN combines an interregional IO model with trade flows, together with a time series framework for estimating economic growth forecasts over time, and "a series of econometrically derived functions relating transportation access and travel cost changes to shifts in local industry output and employment growth." The access factors included same-day truck delivery, labor market and intermodal air, rail, marine, and truck freight terminal access.	(http://www.tredis.com/product-info/modules-and-structure/economic-adjustment-module.html)
Global Insight Economic Model	Provides highly detailed responses to changes in transport costs by mode and commodity. It utilizes econometric (statistical) equations that are sensitive to changes in transport costs per ton for transporting a wide range of commodities by all available freight modes. Also includes detailed information on freight flows by commodity and mode and forecasts changes in wages, prices, and spending patterns.	IHS Global Insight (http://www.ihsglobalinsight.com/ProductsServices/ProductDetail1081.htm#solutions)
University of Maryland spatial econometric model	Models the effect of highway projects on the level of economic activity and growth in a zone, based on a wide variety of transportation indicators. Includes network density and spatial agglomeration, as well as changes in access times to airports, intermodal rail/truck freight terminals and rail transit, and the size of labor, consumer, and supplier markets.	University of Maryland (http://www.econ.umd.edu)
LEAP (Local Economic Assessment Package)	Shows how costs (of land, labor, energy, and taxes) interact with transport costs and access (including ground access time to intermodal rail, air and marine ports, and highways) to differentially affect the attraction of various industries to an area.	Economic Development Research Group, Inc, Appalachian Regional Commission (http://www.leapmodel.com)
TREDIS (Transportation Economic Development Impact System)	Modular framework operating through a Web-based server to integrate various tools for travel impact analysis, spatial access impact analysis, regional economic impact analysis, and benefit/cost analysis.	Economic Development Research Group, Inc. (http://www.tredis.com)

Table A.6. Summary of financial impact accounting tools.

Tool	Description	Source
Fiscal Impact Models	Calculate impacts on public tax and fee revenues, as well as requirements for increasing expenditures to serve new population and economic growth that may result from the projects (including public safety, education, and other municipal and state services).	Fishkind Fiscal Impact Model (http://www.fishkind.com/fiam/home.html) Many others developed in house by public agencies
Pro Forma Models	Calculate risk and rate of return associated with proposed, new investment projects. A due diligence study (involving third-party confirmation of market demand and revenue assumptions) is commonly required for private-sector financing.	Typically developed by private entities for each project

Table A.7. Summary of risk assessment tools.

Tool	Description	Source
Due Diligence Tools (Economic Demand Estimation and Forecasting)	Economic demand estimation is a statistical tool that allows for determining the level of demand for a service or good based on a host of independent variables. Variables to forecast a dependent variable such as truck volume may include local demographics, fuel prices, tolls, regulations, and local shocks and events.	DecisionTek Risk Analysis Engine(http://www.decisiontek.com/Home/tabid/37/Default.aspx) Ad hoc spreadsheet tools for probability distributions
Due Diligence Tools (Technical Advisory)	In the case of private concessionaires, a technical advisor may review documentation and perform on-site inspections of physical infrastructure and facilities to understand the state of good repair standards that, in turn, contribute to the overall understanding of costs associated to maintenance, rehabilitation, and replacement. By thoroughly reviewing all factors related to operations and maintenance, costs can be optimized, and the quantitative product of a technical advisory exercise may include a cost model that feeds into the private party's financial model.	DecisionTek Risk Analysis Engine (http://www.decisiontek.com/Home/tabid/37/Default.aspx) Ad hoc spreadsheet tools for probability distributions
Due Diligence Tools (Financial Model)	A financial model combines the economic and technical aspects for developing a baseline scenario, which provides measures of the feasibility and health of a project. A key indicator from the financial model is the internal rate of return (IRR), which is the discount rate that sets the Net Present Value (NPV) of all cash flows equal to zero.	DecisionTek Risk Analysis Engine (http://www.decisiontek.com/Home/tabid/37/Default.aspx) Ad hoc spreadsheet tools for probability distributions
Risk Evaluation Tools	Risks are allocated and quantified to clearly describe the various scenarios, costs, and responsibilities involved. Areas of concern may include insurance, permitting, design, and construction among others.	Ad hoc risk allocation matrices, typically developed in house

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation