TCRP REPORT 138

TRANSIT COOPERATIVE RESEARCH PROGRAM

Sponsored by
the Federal
Transit Administration

Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects

Part 1: Guidebook
Part 2: Final Report

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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C O O P E R A T I V E   R E S E A R C H   P R O G R A M S

FOREWORD

By Dianne Schwager
Staff Officer
Transportation Research Board

TCRP Report 138: Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects: Part 1: Guidebook; Part 2: Final Report is an important resource that addresses the costs for professional services for major transit investments. The *Guidebook* is a resource intended for project managers and cost estimators working for transit agencies or other organizations in the early phases of planning a major fixed guideway public transportation project. It defines and describes soft costs and provides a new methodology to estimate soft costs based on historical projects. The *Final Report* presents more detailed technical information about this project's data collection, methodology, and statistical analysis. While the *Final Report* may be used by transit agencies, it will also be used by regional governments, state and national departments of transportation, researchers, project sponsors, and cost estimators.

The costs of a new fixed guideway public transportation project line are extremely important in the public deliberation over whether to build the project. While considerable information is available on the "hard costs" of transit capital construction (such as steel, concrete, rail cars and buses, or construction labor), prior to this research, transit systems had few resources that addressed professional services or "soft costs." These costs have ranged from as low as 11% to as high as 54% of hard costs for U.S. light and heavy rail transit projects. On average, soft costs for federally funded fixed guideway transit projects account for about 30% in additional cost above hard costs—a significant part of the ever-important estimate of total project cost.

The ***Guidebook*** is designed to help practitioners in two ways:

1. ***By Providing Information.*** The first sections supply basic information about what soft costs are, how transit agencies and their contractors estimate soft costs, how the estimates fit into the Federal Transit Administration's New Starts process, and how project characteristics such as guideway length or project delivery method have tended to drive soft costs up or down in the past.
2. ***By Presenting a Soft Cost Estimation Methodology.*** The final sections of the Guidebook provide a new tool to estimate project soft costs, based on both the characteristics of the project and the organizational attributes of its sponsor agency. This methodology is based on industry surveys, interviews, and an extensive analysis of the "as-built" costs of nearly 60 rail transit projects over the past three decades.

The ***Final Report*** presents the research, data sources, and analysis underlying the *Guidebook*. To support the development of the *Guidebook* on soft costs, this report:

- Identifies a working definition of soft costs through a literature review and industry outreach;
- Describes the current industry practice of estimating soft costs through a questionnaire of the transit industry and interviews with industry professionals; and
- Statistically analyzes the as-built costs of 59 past transit projects to determine how project characteristics have driven soft costs historically.

CONTENTS

PART 1

Guidebook

CONTENTS

Introduction

The purpose of TCRP Project G-10 was to research soft costs in major public transportation infrastructure projects, with the goal of producing a guide for transportation project sponsors to learn more about these costs and better estimate them in the future. This Guidebook is one of two final products from the project and is intended to summarize how the project's research can be applied to practice. For more detailed information about Project G-10's data collection, methodology, and statistical analysis, please refer to the Final Report in Part 2, which follows the Guidebook.

CHAPTER 1

What Are Soft Costs and Why Do They Matter?

The price tag of a new urban fixed guideway transit line is one of the most visible and critical pieces of information in the public deliberation over whether to build the project. The project's cost factors prominently in deciding mode and alignment during the project's alternatives analysis (AA) and preliminary engineering (PE) phases, is repeated in the media, is debated by the stakeholders, and is a crucial input to the "cost-effectiveness" evaluation that forms the basis for the project's eligibility and recommendation for federal funds.

But what do these cost estimates really consist of? Most professionals are familiar with the "hard costs" of transit capital construction such as steel, concrete, rail cars and buses, or construction labor. But what about costs for designing the project, obtaining permits, and managing the construction project? What about the cost of settling a real estate legal issue or testing a mechanical system before the project opens? These are included in the category called professional services or "soft costs" and have ranged from as low as 11% to as high as 54% of hard costs. On average, soft costs for federally funded transit projects account for about a 30% additional cost above hard costs—a significant part of the ever-important estimate of total project cost.

Despite the importance and magnitude of professional services or soft costs, project managers may not always understand precisely why soft costs' percentage of total project cost can span such a broad range, how to best estimate them early in project development, or even what types of soft costs there are. Furthermore, transit agencies may face tough public scrutiny over the accuracy and consistency of their cost estimates, scrutiny that is driven by perceptions that transit project capital costs have been underestimated in the past. Finally, while a great deal of research has targeted hard cost estimation techniques, very little literature exists on the composition and estimation of soft costs for transit projects.

This Guidebook is designed to help fill that gap. It is intended to help transportation project sponsors better understand and estimate soft costs, especially during the initial phases of developing a rail project.

CHAPTER 2

How and Who This Guidebook Helps: Audience and Circumstances

This Guidebook is geared toward project managers and cost estimators working for transit agencies or other organizations attempting to plan and construct new rail transit projects. Projects will benefit most from this Guidebook during early planning phases, typically during alternatives analysis or preliminary engineering as the draft environmental impact statement (DEIS) is prepared. Exhibits 1 and 2 describe this document's intended audience and circumstance. The definition and discussion of soft costs presented here is relevant to almost all kinds of major public transit capital infrastructure projects, but the methodology to estimate soft costs in Chapter 6 applies only to new rail construction projects.

This Guidebook is designed to help practitioners in two ways:

1. **By providing information.** The first sections of this document supply basic information about what soft costs are, how transit agencies and their contractors estimate soft costs, how the estimates fit into the Federal Transit Administration's New Starts process, and how project characteristics such as guideway length or project delivery method have tended to drive soft costs up or down in the past.
2. **By presenting a soft cost estimation methodology.** The final sections of this Guidebook provide a new tool to estimate project soft costs, based on both the characteristics of the project and the organizational attributes of its sponsor agency. This methodology is based on industry surveys, interviews, and an extensive analysis of the "as-built" costs of nearly 60 rail transit projects over the past three decades.

By the end of this Guidebook, the reader should be armed with a clear understanding of what soft costs are and how they are estimated, a new way to approximate soft costs for themselves using a blend of art and science, and a resulting estimate of soft costs for a given project firmly rooted in historical experience.

This Guidebook is intended for:
- A project manager or cost estimator
- An employee or contractor for a transit agency or other sponsor agency (department of transportation, airports authority, planning board, etc.)
- Anyone responsible for high-level budgeting and/or New Starts application

Exhibit 1. Who this Guidebook addresses.

This Guidebook addresses the following types of projects:
- Urban public transit construction projects
- Projects that are early in planning stages, such as alternatives analysis or preliminary engineering
- Heavy or light rail
- Projects that potentially need federal funding

Exhibit 2. Projects this Guidebook addresses.

CHAPTER 3

What Are Soft Costs?

Generally, soft costs are the capital expenditures that are required to complete an operational transit project, but which are not spent directly on activities related to brick-and-mortar construction, vehicle and equipment procurement, or land acquisition. Instead, these expenses are incurred on professional services that are necessary to complete the project.

Generally, soft costs are the capital expenditures that are required to complete an operational transit project but that are not spent directly on activities related to brick-and-mortar construction, vehicle and equipment procurement, or land acquisition. Instead, these expenses are incurred on professional services that are necessary to complete the project, as described under the Standard Cost Categories (SCCs) below. Soft costs are the expenditures necessary to *plan, design,* and *manage* the project, while hard costs are the expenditures required for *construction.*

As an analogy, a homeowner planning to build an addition to his or her house might hire a surveyor to measure the land and an architect to design the project and oversee construction. Fees for these professional services are soft costs to the project. Similarly, a transit agency seeking to expand or renew its infrastructure will hire surveyors, planners, engineers, architects, project and construction managers, and other professionals to plan, design, and develop the transit construction project.

Standard Cost Categories

The Federal Transit Administration (FTA) requires that all candidate and recipient projects for New Starts funds organize and report their project cost estimates in the same way, using the Standard Cost Category structure. This structure consists of ten major cost *categories* (as shown in Exhibit 3), each of which is further broken down into *components.* For example, the SCC 50 Systems cost category includes separate components for Train Control, Traction Power, Communications, and Fare Collection. This common cost-estimating structure allows FTA to compare cost estimates from different kinds of projects across the country on a consistent basis.

Standard Cost Category 80, Professional Services, consists of eight separate components (see Exhibit 1), which together encompass all services and activities commonly associated with project soft costs (although some exceptions are discussed below). For this reason, this Guidebook has adopted the definition and structure of FTA SCC 80, Professional Services, as being equivalent to the definition of soft costs. Based on a review of existing literature, this definition is reasonable, consistent, and comprehensive for estimation purposes. Furthermore, using the SCC structure and the definition of SCC 80 is consistent with the historical analysis that underpins the new soft cost estimation methodology discussed later.

Definition of Soft Costs

This Guidebook considers soft costs to be equivalent to SCC 80 Professional Services, which FTA (U.S. Federal Transit Administration, 2008) defines as follows:

> [Soft costs include] all professional, technical and management services (and related professional liability insurance costs) related to the design and construction of fixed infrastructure during the preliminary

10	Guideway & Track Elements (route miles)
20	Stations, Stops, Terminals, Intermodal (number)
30	Support Facilities: Yards, Shops, Admin. Bldgs
40	Sitework & Special Conditions
50	Systems
60	ROW, Land, Existing Improvements
70	Vehicles (number)
80	Professional Services
90	Unallocated Contingency
100	Finance Charges
Total Project Cost (10–100)	

80.01	Preliminary Engineering
80.02	Final Design
80.03	Project Management for Design and Construction
80.04	Construction Administration and Management
80.05	Professional Liability and Other Non-Construction Insurance
80.06	Legal; Permits; Review Fees by Other Agencies, Cities, etc.
80.07	Surveys, Testing, Investigation, Inspection
80.08	Start Up

Exhibit 3. FTA Standard Cost Categories with Category 80 components.

engineering, final design, and construction phases of the project. This includes environmental work, design, engineering and architectural services; specialty services such as safety or security analyses; and value engineering, risk assessment, cost estimating, scheduling, before and after studies, ridership modeling and analyses, auditing, legal services, administration and management, etc. by agency staff or outside consultants.

The FTA directs applicants to classify any professional services directly related to right-of-way (ROW) acquisition (such as for appraisals and legal services) and vehicle procurement (such as engineering and design work) in their respective categories (SCC 60 and 70), *not* in SCC 80.

What Are the Components of Soft Costs?

Following the FTA's Standard Cost Category structure, most rail transit project soft costs are divided into the eight components of Category 80 shown in Exhibit 3. While all costs in SCC 80 are primarily for professional services, they may be incurred by agency staff or outside consultants, depending on the project. Soft costs are classified into components based on either the timing or purpose of the cost, as follows:

- **80.01–Preliminary Engineering**—All costs are included in this stage of the project development process. This includes the costs of early design, negotiations for operations and/or maintenance, developing financial plans, and ridership studies. Under alternative project delivery arrangements, the contractor's soft costs for preliminary engineering should be captured here, and the project sponsor may request that the contractor invoice and report costs under the SCC structure.
- **80.02–Final Design**—All costs associated with the final design (FD) stage. Costs for services similar to the above description are captured here.
- **80.03–Project Management for Design and Construction**—Project management oversight costs. Costs to support design, management, and administrative efforts for legal, technical, and environmental consultants are reported here.

- **80.04–Construction Administration and Management**—Quality control, quality assurance, and construction management during the construction phase.
- **80.05–Insurance**—Project insurance to cover professionals' liability insurance, owner-provided builder's risk, other agency insurance, etc. This component does not include construction contractors' liability or general insurance. All construction contractors' insurance costs should be reported in a corresponding hard cost category.
- **80.06–Legal; Permits; Review Fees by Other Agencies, Cities, etc.**—Costs associated with the local and state project approval process, and any legal costs.
- **80.07–Surveys, Testing, Investigation, Inspection**—Costs of alignment and facility surveys, security and safety inspections, material and geological testing, and inspection services.
- **80.08–Start Up**—Costs associated with the operational initiation of services and training of operations, maintenance, and supervisory staff.

Timing of Soft Costs

While some components of soft costs tend to relate to specific phases of project development over time, others tend to reflect costs incurred throughout the life of the project. For instance, most projects will incur all of their Preliminary Engineering expenses (SCC 80.01) early in their lifecycle, and Startup costs (SCC 80.08) will be spent near the end of the project. In contrast, Insurance costs (SCC 80.05) may be incurred over the life of the project.

Typical versus Less Typical Soft Costs

The types of soft costs encountered in rail transit construction projects in the United States can vary widely depending on project characteristics, local and state regulations, and the project administration practices and experience of the sponsor agency. As shown in Exhibit 4, certain typical soft cost components are normally required for any new rail construction project, while other soft cost components are encountered less frequently and may be unique to the project. As a result, some projects may incur no costs in some components, while other projects may incur costs in many or even all components.

For example, most projects will incur significant soft costs for hiring a contractor or assigning employees to prepare preliminary engineering and design plans and help obtain environmental approval for a project. Similarly, nearly all projects require project administration and management.

To take a contrasting example, most agencies take on significant soft costs to manage the construction project once the "shovel hits the dirt." However, the exact nature of these costs depends on the agency: these costs could include salaries and wages of employees in the transit

TYPICAL SOFT COSTS INCURRED IN MOST PROJECTS	LESS TYPICAL SOFT COSTS INCURRED IN SOME PROJECTS, DEPENDING ON CHARACTERISTICS
Design and engineering services for preliminary engineering and final design	Professional services to support acquiring real estate for right-of-way
Transit agency staff managing project, development, construction, and customer information	Third-party contractor managing construction
Reimbursement to external entities such as police, utilities, and other costs of local and state government	Design and engineering services to re-design a project, due to unforseen circumstances
Insurance	

Exhibit 4. Types of soft costs encountered in rail transit construction.

agency's construction department or could be for an outside contractor managing construction. For projects that must connect with existing transit service when complete, such as a line extension, agency staff time may be required for train safety and testing procedures. The form and type of soft costs are not always applicable to all projects.

Issues in Categorization

Despite FTA's clear classification of soft costs within SCC 80, situations may arise where it is not clear how or where a specific cost should be recorded, or whether a cost is considered soft. Much of this uncertainty is driven by inconsistencies in how certain types of costs have been understood and categorized in past projects and, by extension, how to budget for these costs in the future. Several potential issues arise. Two key examples are discussed below:

Force Account

Different agencies account for the salaries and wages of their employees supporting a new capital project (sometimes called "force account") in different ways. Force account costs can range from a construction department manager in charge of the project, to a bus operator who works a weekend to provide alternative bus service around a temporary disruption caused by the project's construction, to administrative employees who work primarily on capital projects, to rail maintenance-of-way employees who connect the new project to existing track. Some agencies will choose to pay these expenditures from their operating budget, while others will charge the costs directly to the capital project. In addition, the distinction between an employee overseeing overall construction and an employee directly supporting construction can be a difficult one and can affect whether the cost is assigned to SCC 80 or to a construction category (SCC 10–50). Regardless of past practices, FTA directs grantees to classify the costs of agency staff for flagging, alternative bus service, and access/protection costs in SCC 10–50 (or SCC 40.08, Temporary Facilities and Other Indirect Costs During Construction), *not* in Professional Services (SCC 80).

In addition, the distinction between an employee overseeing overall construction and an employee directly supporting con-struction can be a difficult one.

Real Estate and Vehicle Soft Costs

Many new rail projects incur the cost of professional services associated with acquiring real estate and procuring vehicles, which are typically distinct from the construction project. Examples of these services include agency staff overseeing and administering procurement, real estate and relocation consultants, vehicle engineers, property assessors, legal counsel, court expenses, insurance, warranty costs, and so on.

These professional services are comparable to those found in SCC 80 in that they represent service costs that do not directly support construction. However, current FTA guidance requires that all soft costs related to real estate and vehicle procurement should be assigned to their respective cost categories (SCC 60 and 70, respectively), *not* Professional Services (SCC 80).

FTA's guidance, by excluding the costs for professional services associated with real estate and vehicles, establishes a relationship between soft costs or Professional Services (SCC 80) and costs for fixed infrastructure (SCC 10 through 50) that is comparable to the relationship found in any building project.

What Soft Costs Are Not: It Depends on Perspective

The term "soft costs" can mean different things to different people, depending on their institutional—or contractual—perspective. For example, the project sponsor will likely view soft costs as all expenditures on those professional services identified in Standard Cost Category 80.

The term "soft costs" can mean different things to different people, depending on their institutional—or contractual—perspective.

Expenditures in other categories reflect the sponsor's expenditures on direct activities, perhaps primarily composed of payments to construction contractor(s) or a vehicle vendor.

In contrast, general construction contractors may view their costs of contract administration, overhead, and related expenses as soft costs for *their* organization. Although these activities sound very similar to the types of services identified in SCC 80, they are the contractor's (not the sponsor's) costs and are therefore considered hard costs outside of SCC 80.

To keep matters clear, this Guidebook defines soft costs from the perspective of the project sponsor.

Note that in design–build (DB) or other turnkey contracting situations where the division between a contractor's design and construction costs may be less transparent to a project sponsor, FTA still directs grantees to report design costs incurred by the design–build contractor in SCC 80.

CHAPTER 4

How Does the Federal New Starts Process Relate to Soft Costs?

The FTA's New Starts grant program makes available new funding per year to project sponsors (also called grantees) to construct transit infrastructure. The FTA requires candidate projects to adhere to a well-defined development and planning process, meeting multiple requirements and following a structured schedule of set milestones that can affect soft costs. Major transit capital project planning in the federal process involves the development of projects from an initial concept through final design, construction, and operation, and continuing through the eventual replacement of the project.

The FTA requires candidate projects to adhere to a well-defined development and planning process, meeting multiple requirements and following a structured schedule of set milestones that can affect soft costs.

Along with estimating hard project costs comes the estimation of soft costs. Over time, as a project becomes better defined, the soft cost estimation process increases in sophistication from the proportionate approximation to the more detailed or "bottom up" estimation for each functional aspect of soft costs.

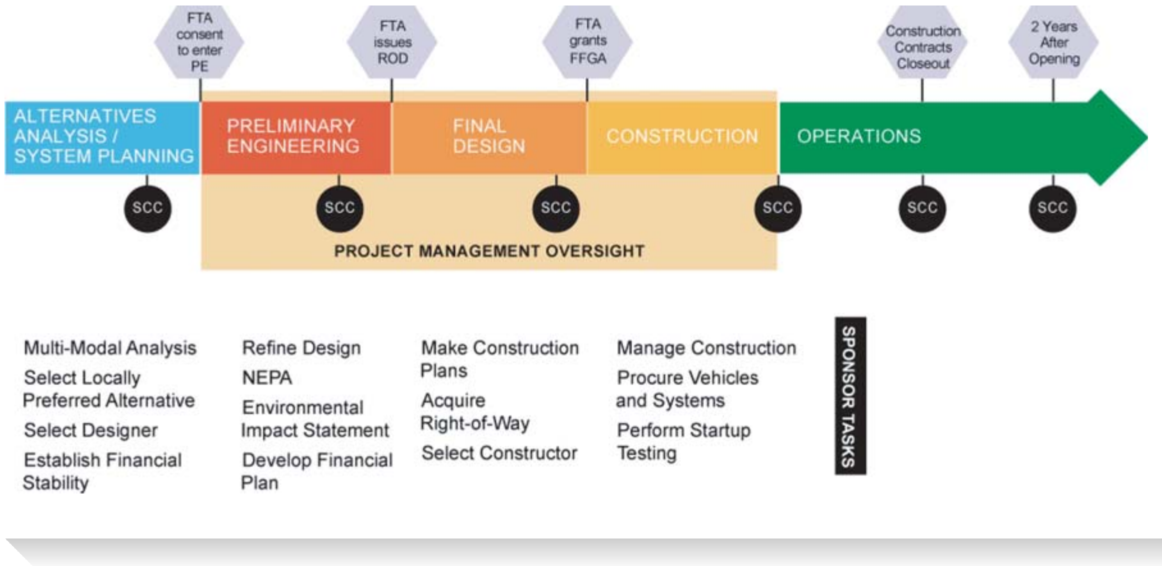
Sponsors seeking federal funds, typically from FTA's New Starts or Small Starts grant program, usually follow a structured process to define, plan for, and build a transit project. Projects join a pipeline of other candidate projects to compete for federal funds, submitting a New Starts application every year in which the project and its sponsor are evaluated on a variety of criteria. Provided that grantees meet certain requirements, FTA periodically authorizes project sponsors to proceed to the next stage of planning or design, often funded in part by federal funds.

Exhibit 5 describes these phases schematically and indicates where in the process the sponsor typically makes an estimate of all project costs, including soft costs, with the FTA Standard Cost Category workbook structure. FTA New Starts, the largest federal program for funding major new capital investments in public transportation, has several decision points for proceeding, also shown here. Each of these decision points requires an estimate of project capital costs, including the estimation of soft costs.

Prior to these decision points, stages of technical analysis are required as shown in the development of each project. Sponsoring agencies are required to submit documentation, including detailed estimates for project capital costs, for evaluation by the FTA under the New Starts criteria process and the Project Management Oversight (PMO) process. Other initiatives, such as the Fixed Guideway Modernization Program, provide funds for rehabilitation or improvement of existing transit systems through similar means.

When Does FTA Ask for Soft Cost Estimates?

FTA requests cost estimates in the SCC format at each of the stages of project development: Planning, Alternatives Analysis, Preliminary Engineering, Final Design, and Construction. As noted above, grantees report soft cost estimates in SCC 80, Professional Services. Specific federal



ROD = Record of Decision
FFGA = Full Funding Grant Agreement

Exhibit 5. Phases in FTA New Starts process timeline.

Specific federal requirements trigger the estimation of soft costs, such as the project evaluations required at each stage before approval to enter the next stage of project development. In addition, the ongoing project oversight and evaluation process requires additional project support efforts, which are included in soft costs.

requirements trigger the estimation of soft costs, such as the project evaluations required at each stage before approval to enter the next stage of project development. In addition, the ongoing project oversight and evaluation process requires additional project support efforts that are included in soft costs. These include, for example, project performance measure reporting, financial planning, environmental impact review, and stakeholder outreach efforts.

FTA first asks grantees for an estimate of project cost, including soft costs, before they allow the project to enter into PE. This initial estimate is typically a rough approximation. Sponsors usually issue a cost estimate once the project is in the PE phase as well, where again the soft cost estimates are typically conceptual in nature. Later, if and when the project progresses into final design, estimates of project cost become more accurate and well developed as the project itself becomes better defined. Chapter 5 describes how the industry normally estimates soft costs at these stages.

Characteristics of the Federal Process That Affect Soft Costs

The FTA's New Starts (and Small Starts) process affects soft costs in several ways.

First, as the project advances into PE, the FTA typically has discretion over when "the clock starts" and early planning costs begin to be attributed to the project. Many New Starts candidate projects grow out of broad transportation planning activities covering an entire metropolitan region, or an alternatives analysis analyzing a range of modes and projects within a transportation corridor. Because of this, the time at which a general planning activity becomes a singular project with a Locally Preferred Alternative is not always clear. Any costs incurred before FTA approves a grantee to enter PE are not included in a Full Funding Grant Agreement and the project's SCC estimate. Because the FTA helps pinpoint this time, the federal process can "define in or out" some early soft costs.

Second, the federal process for new transit capital projects imposes some unique requirements on project sponsors that usually result in soft costs. For example,

- The FTA requires grantees to estimate “transportation system user benefits” of the project by following certain procedures, typically resulting in some professional services soft costs for travel demand modeling.
- During PE, the federal process tends to encourage grantees to analyze environmental impacts in concert with developing engineering plans, which can advance some engineering soft costs.
- The FTA requires grantees to analyze the environmental justice impacts of a project, conduct a risk assessment process, and develop a project management plan, usually resulting in some soft costs.

Even if a project sponsor chooses to forego federal funds, the project may face state and local requirements, which may affect soft costs in very similar ways to the FTA’s process throughout the project’s life.

Federal versus Non-Federal Projects

Despite the impact of the FTA’s New Starts project development process on soft costs, its impacts are probably not unique. Even if a project sponsor chooses to forego federal funds, the project may face state and local requirements that can affect soft costs in very similar ways to the FTA’s process throughout the project’s life:

- During PE, the environmental reviews required at the state level can be as stringent as federal requirements. However, the sponsor may not be required to estimate ridership or develop a project management plan in the same way.
- During final design, the amount of time required to develop construction plans is typically the same, although state and local review times can be shorter than federal.
- In the construction phase, the major soft costs for managing the construction project are probably equivalent to a federal project.

CHAPTER 5

How Does the Construction Industry Estimate Soft Costs?

Sponsors of major new transit projects approach estimating soft costs differently, depending on how far along the project is in the planning process.

Early Phases

During the early phases of planning (alternatives analysis or preliminary engineering), a transit project is only conceptually defined, as are the soft costs. At these early stages, transportation planners usually identify a single corridor for construction but develop a range of options for more specific details such as mode, alignment, station locations, and, as a result, construction costs.

Therefore, soft costs are usually treated as percentage add-ons to estimates of hard construction costs, as shown in Exhibit 6. Cost estimators apply default unit costs to approximate construction quantities, remediation, and other hard costs, and then simply add a percentage of hard costs for an initial soft cost estimate.

How do cost estimators choose these percentages? They typically apply values for each soft cost component from a range based on historical experience and project characteristics, or soft cost "drivers." For example, most estimators will choose higher multipliers for heavy rail than for bus rapid transit and lower multipliers if the sponsor plans to contract the project with an alternative delivery mechanism such as design–build. Exhibit 7 provides a more complete list, and Chapter 6 demonstrates a technique to tailor a soft cost estimate to a project.

How large are the soft cost percentages? Based on a survey of cost estimators at transit agencies and consultants across the country, most cost estimators start with a midpoint for these add-ons representing around 25–35% of construction costs, as Exhibit 8 indicates. However, cost estimators almost always adjust up or down from these midpoints, so the ranges from which estimators choose the percentages extend higher or lower than these midpoints.

Later Phases

During the final design phase and as construction begins, estimates of soft costs based on a percentage of construction cost are replaced with more closely tailored, bottom-up estimates that are based on a more detailed understanding of the project than was available in earlier stages. Rather than simply multiplying a construction cost estimate by a percentage, project managers usually develop their own soft cost estimates based on project characteristics that are known with better certainty at this stage, such as the project's work breakdown structure, staffing plans, design contract(s), and even the number and complexity of design drawings. For instance, administration costs may be estimated based on an estimated headcount and project duration, which are in turn based on the construction schedule and number of contracts.

Construction Cost	
Guideway	$
Stations	$
Maintenance Yard	$
Etc.	$
TOTAL	$
Soft Costs	
x Percentage =	**$**
Vehicle Cost	
Vehicles	$
Vehicle Soft Costs	$
TOTAL	$
Real Estate Cost	
Acquisitions	$
RE Soft Costs	$
TOTAL	$
TOTAL PROJECT COST	**$**

Exhibit 6. Cost estimation in early project phases.

Since the project's specific characteristics are more well-defined in these later stages, sponsors also have a better idea of soft costs that are highly dependent on the specific project sponsor, such as:

- Whether a third party will be managing construction;
- How the sponsor will account for agency staff salaries and wages;
- Who will bear insurance costs (sponsor agency or contractors); and
- If the project will require significant effort for environmental work, permits, or public involvement.

	LOWER % SOFT COSTS	MIXED/MID-RANGE % SOFT COSTS	HIGHER % SOFT COSTS
MODE	Bus Rapid Transit	Commuter Rail Light Rail	Heavy Rail
PROJECT DELIVERY	Design–Build Design–Build–Operate–Maintain Full Turnkey	Design–Bid–Build	
ALIGNMENT		Elevated Alignment	Tunnel Alignment
OTHER CONDITIONS		New Right-of-Way	Differing Subsurface Conditions

Exhibit 7. Project characteristics guiding soft cost percentage estimates within a range.

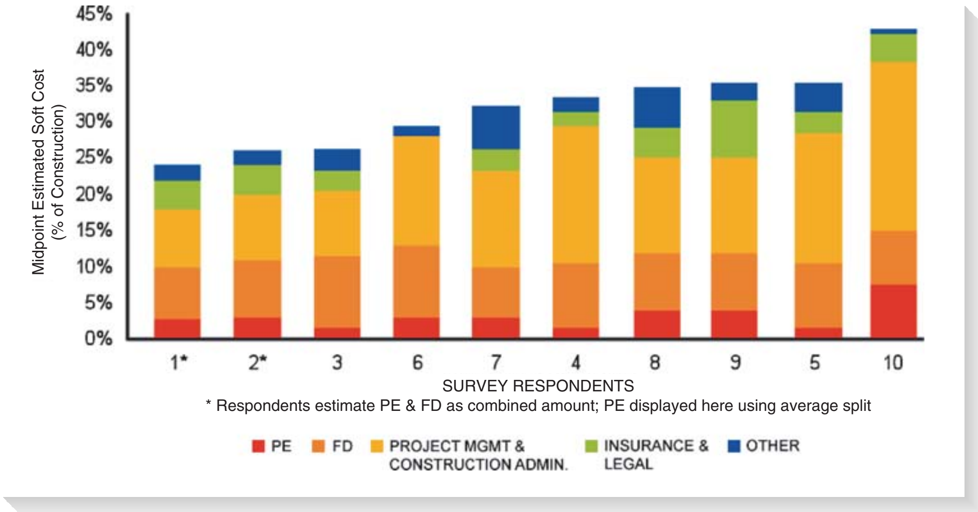


Exhibit 8. Midpoint soft cost estimates for all components during project planning phases.

By entry into final design, the costs for PE are known, and the costs for final design, bidding, and construction should be estimated or quantified through an assessment of the projects' contracting methodology, the contract packages anticipated, the staff or consultants required, the project length, and other factors.

In sum, the industry currently takes two different approaches to estimating soft costs, depending on how far along the project is, as illustrated in Exhibit 9.

How Does This Practice Compare with Actual Costs?

On average, the construction industry's current approach to estimating soft costs in early project phases corresponds fairly well to actual historical soft costs in past projects. This Guidebook relies on an examination of actual as-built cost data for 59 urban heavy and light rail transit projects

IN EARLY PHASES (PLANNING & PE)	IN LATER PHASES (FD & CONSTRUCTION)
More art than science	More science but still art
Top down	Bottom up
Use default percentage add-ons to construction costs Change from the default within a range based on prior experience and knowledge of project characteristics	Use real data available • Most design/engineering costs already spent • Headcount • Construction schedule and traffic impacts • Number of drawings • Quantity and value of real estate
Uncertain—could be within margin of error of the construction cost estimate itself	More certain—major changes to total SCC 80 line item are rare, but some components introduced later

Exhibit 9. Soft cost estimation approach by project phases.

	SURVEY* Average of Midpoints Used	AS-BUILT COST DATA** Average Actual
Preliminary Engineering	2.6%	2.7%
Final Design	9.0%	9.7%
Project Management & Construction Administration	14.1%	15.1%
Insurance	3.5%	2.2%
Other Costs	2.9%	1.6%
TOTAL	32.0%	31.3%
Range of Total	24% to 43%	11% to 54%
	*Representing 10 responses	**Representing 51 past projects (outliers removed)

Exhibit 10. Comparing industry practice to actuals: Soft costs as a percentage of construction costs.

adapted from capital cost databases developed for the FTA. As shown in Exhibit 10, this dataset shows that, on average, transit construction projects have historically incurred soft costs amounting to 31.3% of construction costs. The average survey response had as a beginning estimate a midpoint of 32.0% of construction costs for soft costs. The components of soft costs are fairly consistent as well.

However, past projects have shown a much wider range of actual soft costs than estimators report. Most estimators surveyed for this Guidebook use ranges, or an "uncertainty band," of total soft cost estimates of around 10% of construction costs. In fact, past transit construction projects have shown a much wider range of actual costs of around 20%.

How can such a wide range of actual soft costs be explained so that a project manager can better estimate them? The answer lies in the differences between projects, and the next section presents a tool to address these differences.

CHAPTER 6

How to Estimate Soft Costs for a New Project

This Guidebook presents a new method, firmly rooted in historical experience, for estimating soft costs for a planned transit project. This section demonstrates a step-by-step process to estimate the relationship between hard costs and soft costs of a given transit project, based on certain known characteristics about the project and its sponsor.

What This Method Is for and When to Use It

It is important to note the kinds of projects this method is designed for:

- **Heavy and light rail.** This method was developed based on actual historical costs for heavy and light rail projects, with only limited data for commuter rail and Bus Rapid Transit (BRT) projects. *Therefore, the following mathematical steps should not be applied to other public transportation capital infrastructure projects, such as commuter rail or BRT projects.*
- **A project in early, conceptual phases.** This method is best applicable to projects in early planning phases, approximately until the project has completed an environmental impact statement. After that time, more defined information is likely available for a more bottom-up estimate tailored to the project. This Guidebook's process can then offer a "test of reasonableness" on the detailed, bottom-up estimate.

Art versus Science

Just as a homeowner cannot tell precisely how much an architect will charge for designing a new kitchen until the kind of remodeling desired is determined, a transit agency cannot tell exactly how much its hard and soft costs will be until the project is defined down to the last turnstile. In addition, every new rail construction project will be slightly different from the last and will encounter unforeseen events along the way, making it impossible to estimate future costs based on historical costs with absolute precision.

Therefore, soft cost estimation must blend art with science. Part of a soft cost estimate can be built up in a fairly objective and numerical way by relying on past experience and the known relationships between a project's characteristics and historical costs, and this methodology applies such relationships. For example, a statistical analysis of historical costs demonstrates that heavy rail incurs higher soft costs as a percentage of construction cost—about 6% more (as demonstrated later in Exhibit 27), all other things being equal, so cost estimators can comfortably adjust their figures accordingly.

Still another part of an estimate can be generated based on known cost relationships, using some judgment about the project and its context. For instance, history shows that an unusually long planning phase typically drives up soft cost's percentages. A long planning phase indicates that a higher soft cost percentage may be warranted. But how can an estimator know how long the planning process will take if that phase is still underway? Judgment, or art, is required.

In the end, historical evidence and relationships cannot tell the whole story. Statistical analysis alone cannot explain the entire range of soft cost percentages shown in past projects, nor should it be relied on alone when developing a comprehensive estimate. Experienced construction managers have indicated that an estimate from a planning process cannot predict some important causes of soft costs, like the working relationship between a sponsor and contractor in the field. A good soft cost estimate needs the art of human judgment to complement the science of cost relationships.

The cost estimating tool described in this Guidebook is based on an extensive analysis of the primary drivers of soft costs in past transit projects and the strength of the relationship between drivers and actual soft cost expenditures for projects constructed over the past four decades in the United States.

Soft Cost Drivers

To better quantify soft costs, it is important to understand what characteristics or variables can explain the relationship between construction costs and soft costs. This Guidebook takes as a starting point a survey of cost estimators and follows up with analysis of actual historical costs.

The cost estimating tool described in this Guidebook is based on an extensive analysis of the primary drivers of soft costs in past transit projects and the strength of the relationship between drivers and actual soft cost expenditures for projects constructed over the past four decades in the United States. With soft cost data on 59 urban rail transit projects adapted from capital cost databases developed for the FTA, the Guidebook analysis measures the cumulative effect of how changes in a variety of project attributes affect resulting soft cost expenditures.

In particular, this Guidebook identifies three different kinds of drivers of soft costs, which correspond to steps in this new methodology:

- Some drivers of soft costs in past projects can be measured **mathematically,** and their effects on soft costs can be statistically analyzed (e.g., mode, length, construction cost estimate, delivery method, or the percent of the project's alignment below grade).
- Some soft cost drivers must be measured **categorically** or qualitatively with some degree of judgment based on knowledge of the project (e.g., whether the project development phase is unusually long or the degree of political influence).
- Some drivers are very difficult to measure objectively and can only be measured **with judgment,** since industry experience shows that they can have significant impacts on soft costs (e.g., the working relationship between agency and contractors, the quality of engineering expertise, or agency accounting policies).

Although a multitude of characteristics were tested to develop this Guidebook, only the combination of attributes that best explained the changing relationship between construction and soft costs is presented here.

Although a multitude of characteristics were tested to develop this Guidebook, only the combination of attributes that best explained the changing relationship between construction and soft costs is presented here.

Quantifying Soft Costs

First, how should soft costs be measured for cost estimating purposes? Soft costs can be expressed in different terms: as a percentage of the total project, as a percentage of hard costs, as a nominal dollar amount, or in nominal dollars per linear foot of guideway constructed in the project. Soft costs can easily be quantified in nominal terms, but predicting future soft costs using such a measure may not account for differences in project size. In addition, predicting soft costs as a share of the overall project cost is arithmetically problematic since the project manager typically has only a construction cost estimate at this stage.

Category	SCC 80 Component
PE	80.01 Preliminary Engineering
FD	80.02 Final Design
PM/CA	80.03 Project Management for Design and Construction
	80.04 Construction Administration and Management
Ins.	80.05 Professional Liability and Other Non-Construction Insurance
Other	80.06 Legal; Permits; Review Fees by Other Agencies, Cities, etc.
	80.07 Surveys, Testing, Investigation, Inspection
	80.08 Start Up

Exhibit 11. Mapping SCC 80 components to categories applied in this Guidebook.

Therefore, while each of these indicators quantifies soft costs in some way, it is suggested that the most appropriate measure for a soft cost *estimate* is as a percentage of hard construction costs (excluding real estate and vehicle costs).[1]

Four-Step Process

The recommended estimation technique contains four steps:

1. **Begin with default averages.** As a starting point, begin with average actual historical soft costs for each component.
2. **Adjust based on mathematical relationships.** Next, adjust the soft cost estimate following the numerical relationship between the project's characteristics and historical soft costs.
3. **Adjust based on categorical relationships.** Next, increase or decrease the soft cost percentages based on how the project fits into any of several unique situations.
4. **Apply judgment.** Finish the estimate by applying some degree of discretion based on knowledge about the unique and intangible qualities of the project and its sponsor.

To simplify the analytical procedure, this technique consolidates the eight components in FTA's Standard Cost Category 80 into five basic components for estimation purposes, as shown in Exhibit 11. Once estimation of these components is completed, the five categories are converted back into FTA's structure.

The five components broadly align with FTA's SCC structure, but they combine some categories that are either a relatively small cost (e.g., Other) or are so similar to other categories that many agencies lump them together for estimating purposes (e.g., Project Management for Design and Construction, and Construction Administration and Management).

The following describes the four steps in more detail:

Step 1: Begin with Default Averages

As a first step in estimating soft costs, begin with the default soft cost percentages as defined in Exhibit 12. These values are based on average actual historical as-built costs. They are consis-

Begin with 29.5% TOTAL for the starting default soft cost:

COST TYPE	COST %
PE	2.0 %
FD	12.0 %
PM/CA	12.5 %
Insurance	2.0 %
Other	1.0 %
TOTAL	29.5 %

Exhibit 12. Default soft cost averages.

[1]Because the FTA instructs project sponsors to classify professional services costs related to vehicles and real estate into SCC 60 and 70, it is inappropriate to include real estate and vehicle costs as hard costs for the purposes of this Guidebook.

tent with average midpoint estimates currently used in the industry, and so provide a safe and well-established starting point for estimation purposes.

It is important to continue past this step, however. These default averages only begin to estimate a project's expected soft costs. The averages are a "naïve" starting point from which to quantify soft costs, because they only describe a "typical" project sponsored by a "typical" agency in "typical" conditions. Transit construction projects and their sponsors come in all shapes and sizes, and no project is entirely "typical."

Step 2: Adjust Based on Mathematical Relationships

In this step, adjust the default percentages based on the project's characteristics that have been shown mathematically.

Alignment Length

Transit capital projects with alignments (length of track or guideway) that stretch for longer distances tend to incur somewhat higher soft costs as a percentage of construction cost. Recommended adjustments to the default values are summarized in Exhibit 13. Add 1.3% to the total soft costs percentage estimate for every 10,000 linear feet of guideway[2] constructed, with 0.9% added to PM/CA and 0.4% to Other. Be sure to perform this calculation proportionately if the project would construct more or less than 10,000 linear feet of guideway. For example, for 5,000 linear feet, add 0.45% to PM/CA and 0.2% to Other.

Add 1.3% TOTAL for every 10,000 feet of guideway:

COST TYPE	COST %
PM/CA	+ 0.9 %
Other	+ 0.4 %
TOTAL	+ 1.3 %

Exhibit 13. Alignment length formula.

Construction Costs

Other things being equal, more expensive construction projects tend to display somewhat smaller soft cost percentages than less costly projects, mostly because their construction administration, project management, insurance, and other costs do not rise proportionally to construction costs. Recommended adjustments to the default values are summarized in Exhibit 14. For every $1 billion in construction cost estimate, subtract 6.0%: 4.5% from PM/CA, 1.0% from Insurance, and 0.5% from Other.

It may seem counterintuitive to adjust up for alignment length and down for construction cost, since both measures broadly describe the magnitude of the project. Historically, however, these two measures in tandem are good predictors of soft costs and will capture the special cases where short, expensive projects (such as a tunnel project) or long, less-expensive projects (such as service on existing right-of-way or in less developed areas) tend to demonstrate differing soft costs.

Subtract 6.0% TOTAL for every $1 billion in estimated construction costs:

COST TYPE	COST %
PM/CA	- 4.5 %
Insurance	- 1.0 %
Other	- 0.5 %
TOTAL	- 6.0 %

Exhibit 14. Construction costs formula.

Mode

Heavy rail projects tend to incur somewhat higher soft costs than light rail, perhaps due to their relative complexity. Heavy rail projects can typically involve constructing guideway and systems that have been designed to more rigorous engineering standards that support more complex systems, move higher passenger volumes, and operate at higher speeds relative to light rail. Therefore, recommended adjustments to the default values are summarized in Exhibit 15. If the project is heavy rail, add 6.0% to the total soft cost percentage: add 1.5% to PE, 3.5% to PM/CA, and 1.0% to Insurance.

Add 6.0% TOTAL for heavy rail:

COST TYPE	COST %
PE	+ 1.5 %
PM/CA	+ 3.5 %
Insurance	+ 1.0 %
TOTAL	+ 6.0 %

Exhibit 15. Mode formula.

[2]Length of guideway should measure only the length of the construction from beginning to end, regardless of double tracking, track miles, etc.

Subtract 4.0% TOTAL for project installation under no active adjacent or adjoining rail service:

COST TYPE	COST %
PE	- 3.0 %
FD	- 1.0 %
TOTAL	- 4.0 %

Exhibit 16. Installation conditions formula.

Installation Conditions

A project to construct a new, stand-alone transit line that is not adjacent to any previous service will usually require less design costs than projects to extend or expand an existing rail line. When a construction project interacts with existing transit service in any way, more engineering and design work has typically been required in the final design phase. Working on or near an active rail right-of-way poses additional logistical challenges that must be planned for, and may also trigger additional safety requirements. Extending a rail line will mean integrating the new track and station(s) into the older infrastructure, and additional work is usually required to ensure that signal, power, safety, and other systems operate compatibly. Recommended adjustments to the default values are summarized in Exhibit 16. If the project is to be installed under no active adjacent or adjoining rail service, subtract 4.0%: 3.0% from PE and 1.0% from FD.

Delivery Method

Follow the formula below for non-traditional delivery methods:

COST TYPE	COST %
PE	+ 1.0 %
FD	- 1.0 %
PM/CA	- 7.0 %
TOTAL	- 7.0 %

Exhibit 17. Delivery method formula.

When sponsors choose to procure their projects through an alternative delivery mechanism such as design–build, design–build–own–maintain, or construction manager/general contractor, these projects have historically incurred lower soft costs. In addition, these alternative delivery methods tend to frontload more design and planning costs in preliminary engineering.

However, these project's lower soft costs may be partially the result of differences in measurement rather than a real reduction in cost. Contractors may simply categorize their costs in different ways than transit agencies (in the construction line item, for example), which makes that project's soft costs as a percent of construction appear low. Recommended adjustments to the default values when estimating soft costs in early project phases are summarized in Exhibit 17. If the project is to be delivered through a non-traditional (i.e., outside of design–bid–build) mechanism, add 1.0% to PE, subtract 1.0% from FD, and subtract 7.0% from PM/CA.

Note that in a design–build or other alternative project delivery method where the division between a contractor's design and construction costs may be less transparent to a project sponsor, FTA still directs grantees to report design costs incurred by the design–build contractor in SCC 80.

A word of caution on delivery method: alternative project delivery methods entail a cultural shift in the way the sponsoring agency develops and executes these projects. Because these alternative methods are not yet very common in the United States, the project's sponsor may not fully understand them. For example, being unfamiliar with the required level of design or the heavy focus on performance-based/functional specification under a design–build, some transit agencies may continue to work in a more traditional mode (i.e., prescriptive specifications and higher level of design), unknowingly duplicating soft costs.

If the alternative delivery method is relatively new to the project sponsor, subtract a lower percentage (e.g., 3.0 or 4.0%) from PM/CA, depending on the level of project sponsor support required.

Economic Conditions

The overall health of the economy, as well as the level of construction activity, can affect the construction bids a transit project sponsor can expect to receive. If the construction sector or economy at large is in a downturn when a project sponsor accepts bids, contractors may reduce their bids due to economic forces. In this case, soft costs computed as a percentage of the engineered construction cost estimate might look relatively higher simply because the bid construction cost is lower. Historically, some change in soft costs can be attributed to the rate of Gross Domestic Product (GDP) growth when construction contracts are bid, after accounting for other variables. Although GDP growth rises and falls with the economy, it has historically risen an average of 2.5% to 3.0% per year.

It is difficult to use this driver to estimate soft costs for a project years away from construction since future GDP growth is difficult to predict. If the project is to be advertised for bid within a year, however, for every percentage point the U.S. GDP has grown since the previous year, subtract 1.5% from the soft cost percentage: 1.0% from FD and 0.5% from PM/CA. Conversely, for every percentage point the U.S. GDP has shrunk since the previous year, add 1.5 percentage points to the soft cost estimate to the same components. These recommended adjustments to the default values are summarized in Exhibit 18.

Subtract 1.5% TOTAL for every percentage point the U.S. GDP has grown since the previous year, if project to be advertised for bid within one year:

COST TYPE	COST %
FD	- 1.0 %
PM/CA	- 0.5 %
TOTAL	- 1.5 %

Exhibit 18. Economic conditions formula.

For example, suppose a project will be advertised within months, but the economy is strong and this year's GDP is 4% higher than last year's. A transit agency sponsor might expect relatively higher construction bids because of the market demand for construction expertise. If construction costs are high, soft costs as a percent of construction costs will likely fall, so an estimator using this methodology might subtract up to 4 × 1.5% = 6.0% from the soft cost estimate.

Step 3: Adjust Based on Categorical Relationships

In this step, adjust the soft cost percentages based on characteristics of the project or its context. These characteristics may be more difficult to assess for a given project, and cannot always be measured as a "yes" or "no." Therefore, with this methodology it is recommended to adjust percentage estimates up to a certain limit. Deciding to what degree any project fits into the categories shown in this section will require some degree of judgment and professional experience.

Unusually Long Project Development Phase

A significant component of engineering and design cost is simply the salaries and benefit costs of planners working on the project. When the early project development phases for a project take an unusually long time, these costs tend to continue to be charged to the project, increasing overall soft costs. Historically, when more than approximately five to seven years elapse between entering preliminary engineering and the beginning of construction, projects have shown higher soft cost percentages on the order of 7.0% of construction costs.

Some judgment will be required to predict a construction date and determine when the planning stages begin. If the overall project development phases will likely continue longer than seven years, and if planning and engineering work continue steadily, make the recommended adjustments to the default values summarized in Exhibit 19. Add up to 1.0% to PE costs and up to 6.0% to FD. Apply fewer percentage points depending on the length of the planning process.

Add up to 7.0% TOTAL if the overall planning phase will continue longer than five to seven years. Apply fewer percentage points for shorter planning phase:

COST TYPE	COST %
PE	+ 1.0 % max
FD	+ 6.0 % max
TOTAL	+ 7.0 % max

Exhibit 19. Unusually long project development phase formula.

Unusual Political Influence

When public involvement or political pressures are high, such as in a contentious design and planning process, soft costs tend to rise relative to construction costs, as much as 6.0%. When, for example, multiple planning boards, citizen advisory councils, and officials must approve the design, and could even call for a redesign, make the recommended adjustments to the default

Add up to 6.0% TOTAL when public involvement or political pressures are high:

COST TYPE	COST %
FD	+ 1.5% max
PM/CA	+ 4.5% max
TOTAL	+ 6.0% max

Exhibit 20. Unusual political influence formula.

values summarized in Exhibit 20. Add up to 6.0%: up to 1.5% to FD and up to 4.5% to PM/CA. While intuitively a more contentious planning process would tend to drive up costs earlier in project development (such as PE), the data on which this Guidebook is calibrated indicate that actual cost percentage increases occur earlier—in FD and PM/CA.

Agency Tendency to Minimize Capital Charges

When a transit agency sponsors a construction project, it usually contributes some of its own labor and even materials. Agency employees often inspect construction activities, monitor safety, administer the contract, acquire property, manage the project, and perform many other tasks. As opening day approaches, agency staff contribute time coordinating testing, training, safety inspections, and shared tasks with other agencies. The agency chooses whether to charge these expenditures to the capital project (either directly or as an overhead-type allocation) or to absorb them into the operating budget, and project sponsors each have different internal policies for this. In the past, agencies that have strongly tended to minimize capital expenditures have shown a reduction of up to 6.0% in soft costs as a percentage of construction. Recommended adjustments to the default values are summarized in Exhibit 21. Depending on the sponsor agency's internal policy on capitalizing costs, subtract 3.0% from the PM/CA, 1.0% from Insurance, and 2.0% from Other.

Subtract up to 6.0% TOTAL depending upon the sponsor agency's internal cost capitalization policy:

COST TYPE	COST %
PM/CA	- 3.0% max
Ins.	- 1.0% max
Other	- 2.0% max
TOTAL	- 6.0% max

Exhibit 21. Capital minimization formula.

Step 4: Apply Judgment

At this point, this methodology has produced a set of five soft cost percentages for PE, FD, PM/CA, Insurance, and Other that are tailored to a given project based on its characteristics and some judgment about its context. However, these more objective techniques must always be tempered with some degree of discretion based on knowledge about the unique and intangible qualities of the project and its sponsor. Rely on the characteristics in Exhibit 22 to add to or subtract from the resulting soft-cost percentage estimate.

However, these more objective techniques must always be tempered with some degree of discretion based on knowledge about the unique and intangible qualities of the project and its sponsor.

If this methodology has resulted in an unintuitive or unusually low percentage estimate, use judgment to adjust to a more reasonable percentage. For example, any negative values could

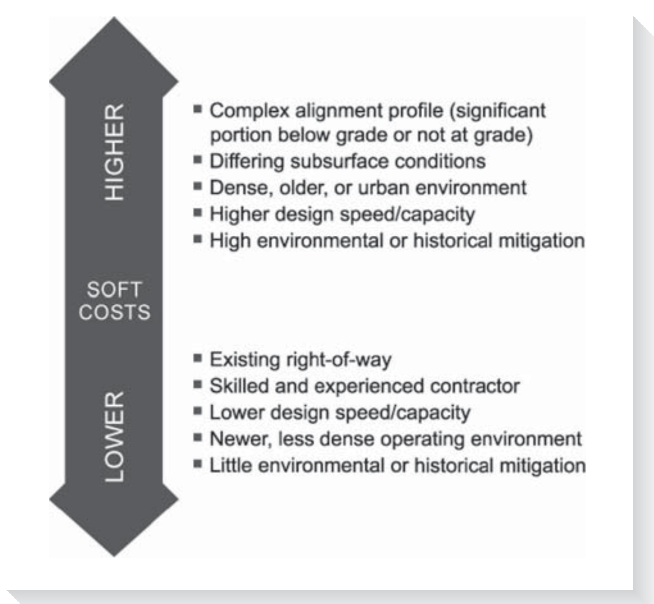


Exhibit 22. Characteristics influencing soft cost percentages.

be restored to zero. Further, if the net effect of adjustments suggested here results in soft cost estimates below 15% or above 50%, apply judgment as well. In the decades of historical experience analyzed to support this Guidebook, no transit project has shown soft costs lower than 11% or higher than 54% of construction costs.

Finally, convert the soft cost percentages from the five components estimated here back into the eight components called for in FTA's SCC structure.

- For Project Management and Construction Administration, divide the soft cost percentage estimate between SCC Components 80.03 and 80.04, 60% of the estimate to Project Management, and 40% to Construction Administration. This ratio is based on a consistent pattern with historical projects over time.
- For Other soft costs, some judgment will be required based on knowledge of the project sponsor. However, this estimate is relatively small, making the sub-allocation to SCC components less precise. Begin by dividing the soft cost percentage estimate for Other costs developed here into even thirds between SCC components 80.06, 80.07, and 80.08. Then, adjust using the following guidelines:
  - *80.06 Legal; Permits; Review Fees by Other Agencies, Cities, etc.* If the project falls under the purview of multiple municipalities, counties, or other political jurisdictions, or if the project requires multiple difficult permits, increase this component's share. Otherwise, leave this component with roughly one-third of the Other costs.
  - *80.07 Surveys, Testing, Investigation, Inspection.* The base one-third allocation is likely sufficient for this component.
  - *80.08 Start Up.* If the sponsor agency capitalizes startup and operations testing, maintain or possibly increase the estimate. Otherwise, decrease this component's share, potentially to zero.

Applying These Steps: Two Example Projects

How might this four-step process be applied to a real project? The following provides a case study on two hypothetical but nevertheless "typical" situations:

Shelbyville Light Rail

Springfield's Metropolitan Transit Authority (MTA) has just finished an alternatives analysis on the Shelbyville corridor. As a result of this process, the MTA has selected light rail as a Locally Preferred Alternative and believes that the project can use an existing freight right-of-way. This will be Springfield's first rail transit service. The planned 7.5-mile alignment begins at an intermodal hub in downtown Springfield with connections to Amtrak, and extends north through several neighborhoods in another county before terminating in Shelbyville. The new rail service will leave downtown on a new flyover from the terminal, and then the new tracks will be laid parallel to an existing freight line, with additional grade crossings constructed or reconstructed as needed, as shown in Exhibit 23. The project will require some re-grading and mitigation work that will impact the Pockomock Swamp, an environmentally sensitive area.

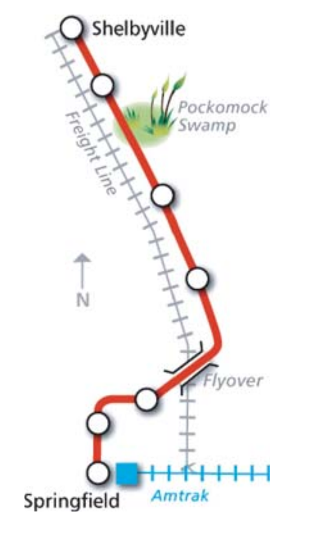


Exhibit 23. Schematic map of Shelbyville Light Rail.

MTA plans to construct the project using a construction manager/general contractor (CM/GC) project delivery approach with a guaranteed maximum price, and hopes to open the line for service by 2014.

MTA has a preliminary construction cost estimate of $425 million based on construction quantities and unit costs, and a ridership forecast from a forecasting model from the design consultant team. The construction cost estimate includes a contingency and is expressed in year-of-expenditure dollars, escalated at 3.75% per year.

MTA feels the project may be a good candidate for federal New Starts funds. Therefore, the project manager's next task is to assemble a capital cost budget in FTA's SCC format. But while MTA has chosen an alignment, many details are still left to be decided. . . . To estimate a value for SCC 80, MTA turns to this Guidebook's methodology.

Based on this information, MTA feels the project may be a good candidate for federal New Starts funds. Therefore, the project manager's next task is to assemble a capital cost budget in FTA's SCC format. But while MTA has chosen an alignment, many details are still left to be decided, such as the exact location of the new rail maintenance facility, coordination with the existing freight railroad, and traffic impacts downtown from the flyover construction. To estimate a value for SCC 80, MTA turns to this Guidebook's methodology.

Step 1: Begin with Default Averages

Begin with the default averages suggested in Exhibit 12, totaling 29.5 percentage points.

Step 2: Adjust Based on Mathematical Relationships

- *Alignment length.* The Shelbyville line will be approximately 39,200 linear feet, so MTA adds 3.92 × 1.3% = 5.1% to PM/CA and Other, for a total of 34.6%
- *Construction costs.* A construction price tag of $425 million implies a reduction of 0.425 × 6.0% = 2.6% points across PM/CA, Insurance, and Other, to total 32.0%.
- *Mode.* This project is light rail, so no adjustment is necessary.
- *Installation conditions.* The project is sharing the right-of-way with an active railroad, which may create challenges for design and construction teams. Therefore, MTA makes no reduction to the soft cost estimate.
- *Delivery method.* Since MTA expects to hire a CM/GC, this will likely reduce MTA's costs of project oversight but may require some extra effort during preliminary engineering. Deduct 8.0% from PM/CA and FD, and add 1.0% to PE, for a total of 25.0%.
- *Economic conditions.* The project manager hopes to advertise the project for bid within the next year, and the economy is currently growing after recovering from a fairly strong recession. The project manager looks up the U.S. GDP from the U.S. Bureau of Economic Analysis website. Since the latest quarter's data shows that the GDP has increased by 1% since last year, MTA subtracts 1.5% from FD and PM/CA, for a new total of 23.5%.

Step 3: Adjust Based on Categorical Relationships

- *Long development phase.* This project has so far been progressing quickly, so no adjustment is necessary.
- *Political influence.* This project is subject to review from both the Shelbyville and Springfield City Councils, who have historically disagreed on many issues. Because of this uncertainty, MTA adds 2.0%, 1.51.% to PM/CA and 0.5% to FD, for a new total of 25.5%
- *Agency tendency to minimize capital charges.* This is MTA's first rail project, and the project manager has no reason to expect this tendency of the agency, so no adjustment is necessary.

Step 4: Apply Judgment

After arriving at an estimate of soft costs at 25.5% of construction costs, MTA's project manager reviews the estimate for reasonableness based on the project sponsor's knowledge. Relying on judgment, the project manager makes the following changes:

- Deducts 2.0% from FD because of existing right-of-way. The existing freight railroad company has so far been a cooperative partner in the project, and the project manager expects to rely

SCC	COMPONENT	SOFT COST ESTIMATE AS PERCENTAGE OF CONSTRUCTION COST
80.01	Preliminary Engineering	3.0%
80.02	Final Design	8.5%
80.03	Project Management for Design and Construction	5.5%
80.04	Construction Administration and Management	3.6%
80.05	Professional Liability and Other Non-Construction Insurance	1.6%
80.06	Legal; Permits; Review Fees by Other Agencies, Cities, etc.	1.0%
80.07	Surveys, Testing, Investigation, Inspection	1.0%
80.08	Start Up	0.4%
80.00	Total Professional Services	24.5%*

*Total slightly off due to rounding.

Exhibit 24. Hypothetical Shelbyville Light Rail soft cost estimate.

on their technical expertise throughout the project, saving some professional service costs. The new total is 23.5%.

- Adds 1.0% to PE to account for environmental mitigation. The project manager is uncertain about what the state's Department of Environmental Protection will require to mitigate any impacts on the Pockomock Swamp and expects the planning process will take time and money. The MTA's new total is now 24.5%.

Finally, the five component estimates need to be split between SCC 80 components. The estimate of 9.1% for PM/CA is split 9.1% × 6.0% = 5.5% to SCC 80.03, and 9.1% × 4.0% = 3.6% to SCC 80.04.

MTA splits the base estimate of 2.4% for Other as follows: 1.0% to SCC 80.06, 1.0% to SCC 80.07, and 0.4% to SCC 80.08. MTA's final estimate is shown in Exhibit 24.

West County Light Rail Project

The XYZ Transit Agency (XTA) is planning a light rail transit project to serve communities in parts of West County. The project, known as the West County Light Rail Transit (WCLRT) project, is a 10.4-mile extension of the existing XTA Light Rail Transit North/South Line, including seven new stations. Planning initially began in 1998 when XTA envisioned the project as a busway along an arterial roadway, but the original design met with some public opposition and controversy. XTA has since refined its plans and is now advancing the project.

Exhibit 25. Schematic map of XTA's West County Light Rail transit project.

The design is at the conceptual level. After XTA circulated the draft environmental impact statement (EIS) and held public hearings, the light rail build alternative was selected as the Locally Preferred Alternative in October 2003. Since then, XTA designers and planners have revisited and refined the build alternative, have begun detailing stations, and have decided on two-track operations. The project will extend from the 3400 South/Main Station, follow the lead track to the Central Maintenance Facility, proceed along XTA right-of-way through several cities, and then turn south for the final two stations, as shown on Exhibit 25. The project will include 18 additional light rail vehicles and additional storage tracks at the Central Maintenance Facility. This configuration requires the light rail system to share tracks with freight trains in several areas, necessitating a temporal separation of passenger and freight operations.

XTA plans to complete preliminary engineering and final design under a traditional design–bid–build delivery method. XTA hopes to complete design by October 2004, sign a full funding grant agreement with the FTA in June 2005, and complete construction by June 2008. Most of the guideway is at the street level, with only a very short tunnel (about 400 feet) near one of the stations.

In March 2004, at the end of the conceptual design phase, XTA prepared a cost estimate that established a target budget of $302 million for SCC 10–70 (expressed as year-of-expenditure dollars escalated at 3.75% per year).

Now, XTA wants to apply the methodology described in this Guidebook to estimate the WCLRT project's soft costs as a percentage of the construction costs:

Step 1: Begin with Default Averages

As a first step in estimating soft costs for the project, XTA begins with the default soft cost percentages as defined in Exhibit 12, totaling 29.5% of construction costs. These numbers are based on average actual historical as-built costs.

As a first step in estimating soft costs for the project, XTA begins with the default soft cost percentages as defined in Exhibit 12, totaling 29.5% of construction costs. These numbers are based on average actual historical as-built costs.

Step 2: Adjust Based on Mathematical Relationships

- *Guideway alignment length:* The project is 10.4 miles long, or approximately 54,900 linear feet. This will require an upward adjustment of 5.49 × 1.3% = 7.1% to the soft-cost percentage estimate.
- *Construction costs:* Construction costs for the project (the sum of SCC 10–70) are estimated at $302 million; however, SCC 70 accounts for $55 million to purchase 18 new vehicles, and no costs are estimated for real estate in SCC 60. Therefore, the construction cost estimate (SCC 10–50) totals $302 − $55 = $247 million. Since the Guidebook calls for subtracting 6.0% for every $1 billion in construction costs, XTA decreases the soft cost estimate by 0.247 × 6.0% = 1.5%.
- *Mode:* This is a light rail project, so no adjustment is necessary.
- *Installation conditions:* Since this project will share a freight right-of-way in some areas and will connect with existing light rail service on the North/South line, no adjustment is made.
- *Delivery method:* The project is using a traditional design–bid–build delivery method, so no adjustment is made.
- *Economic conditions:* The economy in West County is in relatively good shape, and construction companies have steady business. GDP has grown 3% over the past year, so XTA deducts 3 × 1.5% = 4.5%, suspecting that construction bids may be somewhat high.

Step 3: Adjust Based on Categorical Relationships

In this step, XTA adjusts soft cost percentages based on certain characteristics of the project that may be more difficult to measure.

- *Unusually long project development phase:* Given the past delays and controversy, XTA does not know if the project will progress as quickly as it would hope. Therefore, XTA decides to add 2.0% to the soft cost estimate for final design.
- *Unusual political influence:* No extraordinary political influence is expected, so no adjustment to soft cost is necessary.
- *Agency tendency to minimize capital charges:* The XTA has constructed light rail projects before and supports a fairly large construction staff through its operating budget. (These costs are not charged to specific capital projects.) Because of this, a −3.0% adjustment is applied.

SCC	COMPONENT	SOFT COST ESTIMATE AS PERCENTAGE OF CONSTRUCTION COST
80.01	Preliminary Engineering	2.0%
80.02	Final Design	11.0%
80.03	Project Management for Design and Construction	8.0%
80.04	Construction Administration and Management	5.3%
80.05	Professional Liability and Other Non-Construction Insurance	1.3%
80.06	Legal; Permits; Review Fees by Other Agencies, Cities, etc.	0.7%
80.07	Surveys, Testing, Investigation, Inspection	0.7%
80.08	Start Up	0.0%
80.00	Total Professional Services	29.0%

Exhibit 26. Hypothetical XTA West County Light Rail soft cost estimate.

Step 4: Apply Judgment

XTA refers to Exhibit 16 and judges that the WCLRT project has several attributes that could increase or decrease soft costs as a proportion of construction costs.

On the one hand, the West County area is fairly dense and growing rapidly, and the short tunnel section near one of the stations is under a historic district. These characteristics could increase soft costs.

On the other hand, no environmental mitigation is required, the alignment is fairly straightforward, and differing subsurface conditions present only a moderate risk.

Therefore, XTA uses its judgment and does not consider any adjustment to its soft cost estimate at this step. Finally, XTA converts the resulting estimate for Other into the SCC components 80.06, 80.07, and 80.08. Because XTA does not normally capitalize startup and operations testing, SCC component 80.08, Start Up, is reduced to zero.

Based on its analysis so far, XTA estimates soft costs for the WCLRT project at 29.6% of construction costs, as shown in Exhibit 26.

APPENDIX A

FTA Capital Cost Database

The starting percentages and numerical adjustments established in this Guidebook were developed from univariate and multivariate regression analyses based and calibrated on detailed cost and project data for 59 past transit capital projects. The 59 projects in this database represent a wide range of rail projects constructed in the United States over the past four decades, with detailed costs roughly conforming to the SCC structure developed from FTA Capital Cost Databases. The projects:

- Comprise 29 light rail and 30 heavy rail projects;
- Have construction dates ranging from 1974 to 2008;
- Have capital costs ranging from around $50 million to $2 billion in the year of construction, equivalent to a range of $90 million to over $5 billion in constant 2008 dollars; and
- Are new rail lines, extensions of existing networks, and rehabilitation projects.

Because this dataset contains soft costs for a broad distribution of projects, it provides a reasonable statistical basis for the estimation of future rail projects based on the analysis of actual, as-built soft costs for completed projects.

Analytical Approach

The analytical process applied to examine these past projects to develop a new soft cost estimation methodology is briefly summarized below. For a more detailed description, please see the Final Report in Part 2, which follows this Guidebook.

First, the projects were plotted on a frequency distribution of soft costs as a percentage of construction costs, resulting in several projects being rejected as outliers due to extraordinarily high costs or other circumstances. Please refer to the Final Report for further details.

Second, a set of characteristics was gathered for the projects, including the following:

1. Physical attributes, such as alignment length, profile (below grade, at grade, aerial, etc.), number of stations, or whether the project initiated new service or extended an existing line;
2. Installation conditions, such as whether the project interacted with other active rail transit lines;
3. Schedule information, including major milestones in the project lifecycle;
4. Characteristics of the project sponsor, such as experience level, internal policies on capital costs, and use of outside contractors; and
5. The context of the project development process, such as the level of public involvement, delivery method, or whether a significant redesign was necessary.

For these last two characteristics, the definition and determination of values required some judgment based on knowledge of the project development process.

VARIABLE NAME	UNIT	COEFFICIENT	t-STAT*
Guideway Alignment Length	10,000 linear feet	1.4%	2.69
Construction Costs	Billions, 2008$	-5.9%	-2.49
Mode	Dummy, Heavy Rail = 1	6.0%	1.64
Installation Conditions	Dummy, No Active Service = 1	-3.8%	-1.25
Delivery Method	Dummy, Non-DBB = 1	-7.2%	-2.10
Economic Conditions	GDP % Annual Growth	-1.4%	-2.34
Unusually Long Project Development Phase	Dummy, Yes = 1	7.1%	2.08
Unusual Political Influence	Dummy, Yes = 1	6.6%	2.22
Agency Tendency to Minimize Capital Charges	Dummy, Yes = 1	-6.0%	-1.65

*Higher absolute value of t-Stat implies a stronger statistical relationship.

Exhibit 27. Multivariate regression results on soft costs as a percentage of hard costs.

Third, many additional measures were derived from this primary dataset that were intended to capture other project characteristics, such as project magnitude (e.g., construction costs per linear foot), complexity (e.g., percent of alignment below grade), unique circumstances (e.g., real estate acquisition costs, project occurred prior to certain federal requirements), and many others.

Fourth, this research analyzed each indicator's statistical ability to predict the project's actual soft costs, in total and as individual components. After several hundred univariate and multivariate regressions, a single multivariate regression was developed that can explain approximately 60% of the change in soft cost percentages by variations in the projects' characteristics ($R^2 = 0.58$). Exhibit 27 shows the resulting coefficients from this regression, where the dependent variable is total soft costs as a percentage of construction costs.

Using the projects contained in this FTA Capital Cost Database, the strongest correlation that could be produced is the regression described above. After testing many combinations of explanatory independent variables, these nine could best predict the relationship between soft and hard costs. Although the strength of this correlation is not ideal, the relationship does highlight the importance of judgment in cost estimation. In addition, as more projects are included in this cost database, it may be possible to perform analysis with stronger cost relationships.

Fifth, alternative multivariate regressions were examined that used different actual soft cost components (rather than total soft costs) as the dependent variable. The coefficient from the overall soft cost analysis was distributed to the soft cost components that correlated to the project characteristics in a statistically significant way. For example, alignment length showed an overall coefficient of around 1.4% per 10,000 linear feet regressed against overall soft costs, and this relationship was strongest when regressed against project management and other soft costs, so this Guidebook recommends adjusting the percentage estimate for those two components to a total of 1.4% per 10,000 linear feet.

Finally, the starting points and recommended percentage adjustments were validated against the original projects to gauge how far off this Guidebook's new methodology would have been. Some minor adjustments to the coefficients were made to minimize the sum of each component's root mean square error (defined in the Glossary in Appendix C) for all projects.

APPENDIX B

Soft Cost Estimation Worksheet

This worksheet describes the methodology for estimating soft costs for a transit infrastructure project outlined in *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects.* The worksheet begins with a default soft cost estimate as a percentage of construction costs, and makes several adjustments based on the characteristics of the project and its sponsor. Finally, the worksheet converts these percentages into the components of Standard Cost Category 80, Professional Services.

Note: The Guidebook text forms an integral part of the calculations described below. Please refer to that document for more detailed instructions for completing this soft cost estimation.

	Input	PE %	FD %	PM/CA %	Ins. %	Other %
Starting Defaults		2.0	12.0	12.5	2.0	1.0
Alignment Length Enter one-way length of alignment in linear feet divided by 10,000 (not track-miles)	A			0.9 ×A = J		0.4 ×A = K
Construction Cost Estimate Enter SCC 10 through 50 only, in $ billions	B			-4.5 ×B = L	-1.0 ×B = M	-0.5 ×B = N
Mode Enter 1 for heavy rail, zero for light rail	C	1.5 ×C = O		3.5 ×C = P	1.0 ×C = Q	
Installation Conditions Enter 1 if project will be installed under no active adjacent or adjoining transit service	D	-3.0 ×D = R	-1.0 ×D = S			
Delivery Method Enter zero for Design-Bid-Build, 1 for other non-traditional delivery method	E	1.0 ×E = T	-1.0 ×E = U	-7.0 ×E = V		
Economic Conditions Enter percentage point annual change in U.S. GDP for the latest quarter (e.g., "2.5" for 2.5%)	F		-1.0 ×F = W	-0.5 ×F = X		
Long Project Development Phase If planning phase likely to continue longer than 5-7 years, enter up to 1	G	1.0 ×G = Y	6.0 ×G = Z			
Unusual Political Influence If public involvement or political pressures are high, enter up to 1	H		1.5 ×H = AA	4.5 ×H = AB		
Tendency to Minimize Capital If sponsor agency's internal policies tend to minimize capital charges, enter up to 1	I			-3.0 ×I = AC	-1.0 ×I = AD	-2.0 ×I = AE
TOTAL Soft Cost Component Estimate		O + R + T + Y = PE	S + U + W + Z + AA = FD	J + L + P + V + X + AB + AC = PM/CA	M + Q + AD = Ins.	K + N + AE = Other

Convert to SCC Components

80 PROFESSIONAL SERVICES	
80.01	Preliminary Engineering
80.02	Final Design
80.03	Project Mgmt. for Design and Const.
80.04	Construction Administration & Mgmt.
80.05	Insurance
80.06	Legal; Permits; Review Fees
80.07	Surveys, Testing, Investigation, Insp.
80.08	Start up

Multiply Soft Cost Percentage by Construction Cost Estimate

PE
FD
PM (60% of PM/CA)
CA (40% of PM/CA)
Ins.
Legal
Survey
Startup

Other: Divide into even thirds, then adjust (see text)

TOTAL Soft Cost Estimate: PE + FD + PM/CA + Insurance + Other = TOTAL

APPENDIX C

Glossary

Alignment: The specific route or path of a new transit line (horizontal alignment), and whether the line travels through a tunnel, at grade, or is on an aerial structure or other infrastructure (vertical alignment).

Alternatives Analysis (AA): An early phase in planning for a major new transit construction project, where a project sponsor, with local community involvement, evaluates a transportation corridor and considers a range of fixed guideway and other transit alternatives.

Construction Manager/General Contractor (CM/GC): Sometimes referred to as CM-at-Risk, a project delivery method whereby the construction manager acts as a consultant to the project sponsor for all pre-construction activities (e.g., project development and design phases), but as an equivalent of a general contractor during the construction phase. In most cases this project delivery method entails a commitment by the construction manager to deliver the project within a guaranteed maximum price.

Cost-Effectiveness (CE): One metric by which FTA evaluates a potential New Starts project for funding. The measure is defined as: incremental annualized capital cost, plus incremental operating and maintenance cost, divided by the Transportation System User Benefits the project would provide. (Previously termed by the FTA as the Cost-Effectiveness Index, or CEI)

Delivery Method: The structure and timing of a project sponsor's relationships with its contractor(s) for design and construction. These methods describe how a project sponsor intends to implement a project, and typically include design–bid–build, design–build, and others.

Design–Bid–Build (DBB): A traditional project delivery method whereby a project sponsor produces and finalizes design before receiving bids to construct the project.

Design–Build (DB): A less traditional project delivery method whereby a project sponsor advances design work to a preliminary stage, and then the contractor (design builder) agrees to complete the work of finishing the design and then the building, facility, or systems installation to the point of readiness for operation or occupancy.

Design–Build–Operate–Maintain (DBOM): Under this project delivery method, the design builder is also responsible for the operation and maintenance of the project, usually for a specified period of time.

Dummy Variable: A type of variable included in a multivariate regression to represent a value of true (1) or false (0).

Environmental Impact Statement (EIS): When planning a major federally funded transit project, the project sponsor may be required by the National Environmental Policy Act to study and predict environmental impacts resulting from the project.

Final Design: A project planning phase where the project sponsor brings preliminary engineering plans and designs to a finer level of detail before construction begins.

Fixed Guideway Modernization: A federal capital grant program managed by the FTA designed to assist grantees to invest in existing rail and other fixed guideway infrastructure. Grants are apportioned by formula.

Force Account: The compensation and benefits of a transit agency's employees who are supporting a new capital project.

Gross Domestic Product (GDP): The total value of goods and services produced by a nation. GDP is a measure of a country's national income and outputs, and a good indicator of broad economic performance.

Locally Preferred Alternative (LPA): The alignment and mode of a new transit project chosen during an alternatives analysis.

New Starts: A federal capital grant program managed by the FTA designed to assist grantees to construct new public transportation infrastructure.

National Environmental Policy Act of 1969 (NEPA): A comprehensive federal law requiring project sponsors to analyze the environmental impacts of any federally funded action, such as a New Start transit project.

PM/CA: Abbreviation used in this Guidebook for project management and construction administration soft costs.

Preliminary Engineering (PE): The initial phase in the project development process where the project sponsor brings conceptual designs to a finer level of detail, to approximately 30% design.

Professional Services: FTA's SCC 80, Professional Services, covers all of those services and activities commonly associated with project soft costs. This Guidebook considers FTA's definition of professional services and soft costs as being equivalent.

Project Management Oversight (PMO): The process by which the FTA oversees grantees' project development process to ensure the grantee is meeting all federal requirements.

Project Management Plan (PMP): A plan that documents the roles, responsibilities, procedures, and processes in place to manage and deliver a federally funded transportation project.

Right-of-Way (ROW) Acquisition: The process of acquiring the real estate or property easements necessary for the transit project's alignment.

Root Mean Square Error: A statistical measure of the differences between actual values and the values predicted by a model.

Small Starts: A federal capital grant program managed by the FTA, similar to New Starts but aimed at smaller transit infrastructure projects.

Sponsor: The agency or organization with the responsibility of planning and constructing a major new transit infrastructure project.

Standard Cost Categories (SCC): FTA's standard structure for reporting and managing project costs. In the SCC, a project's total capital budget is broken down into categories and components of expenditures.

Transportation System User Benefits: One metric FTA examines when evaluating an application for New Starts funds; the incremental estimated mobility impacts (in terms of weighted travel time) as compared to a baseline of a proposed New Starts project.

Turnkey: A variation of a design–build project delivery method that includes financing or leasing mechanisms.

Work Breakdown Structure: A structure to break down the work (and resulting costs) of a new transit project into discrete work elements or tasks.

PART 2

Final Report

CONTENTS

SUMMARY

Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects

This report presents the research, data sources, and analysis underlying *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects, Part 1: Guidebook*, which came out of TCRP Project G-10. This Final Report is one of two final products from the project and is intended to support the information summarized in the Guidebook in Part 1. Please refer to the Guidebook for a summary of how the results of the research presented here can be applied to practice, including an introduction to "soft costs" and a new methodology to estimate these soft costs based on historical projects.

To support the development of a guidebook for agencies on soft costs, this report:

- Identifies a working definition of soft costs,
- Describes the current industry practice of estimating soft costs through a questionnaire of the transit industry and interviews with industry professionals,
- Statistically analyzes the as-built costs of 59 past transit projects to determine how project characteristics have driven soft costs historically, and
- Introduces a new methodology for estimating soft costs based on actual past expenditures, presented in the Guidebook.

S.1. Definition of Soft Costs

Generally, soft costs (or indirect costs) are the capital expenditures that are required to complete an operational transit project but that are not spent directly on activities related to brick-and-mortar construction, vehicle and equipment procurement, or land acquisition. Instead, these expenses are incurred on ancillary professional services that are necessary to complete the project.

After reviewing a variety of financial, engineering, academic, and other literature, this study concludes that the Federal Transit Administration's (FTA) definition of Standard Cost Category (SCC) 80, Professional Services, is an equivalent operational definition of soft costs for the purposes of this project. FTA (U.S. FTA, 2008) defines SCC 80 as follows:

> *[Soft costs include] all professional, technical and management services (and related professional liability insurance costs) related to the design and construction of fixed infrastructure during the preliminary engineering, final design, and construction phases of the project. This includes environmental work, design, engineering and architectural services; specialty services such as safety or security analyses; and value engineering, risk assessment, cost estimating, scheduling, before and after studies, ridership modeling and analyses, auditing, legal services, administration and management, etc. by agency staff or outside consultants.*

Table 1. Types of soft costs encountered in rail transit construction.

TYPICAL SOFT COSTS INCURRED IN MOST PROJECTS	LESS TYPICAL SOFT COSTS INCURRED IN SOME PROJECTS, DEPENDING ON CHARACTERISTICS
Design and engineering services for preliminary engineering and final design	Professional services to support acquiring real estate for right-of-way
Transit agency staff managing project, development, construction, and customer information	Third-party contractor managing construction
Reimbursement to external entities such as police, utilities, and other costs of local and state government	Design and engineering services to re-design a project, due to unforseen circumstances
Insurance	

The kinds of soft costs encountered in rail transit construction projects in the United States can vary widely depending on project characteristics, local regulations, and the administration practices of the sponsor agency. Most new rail construction projects will incur certain "typical" soft cost expenditures, while other soft cost components can be unique to the project, as shown in Table 1.

Evidence suggests that European cost estimators are also trying to standardize a definition of soft costs, but the term is rarely comparable to how it is used in U.S. practice. The definition of soft costs to a transit agency can differ from a construction contractor or other stakeholders, depending on institutional context. The point of view of a U.S. transit agency is taken in this report.

S.2. Soft Cost Estimation: State of the Practice

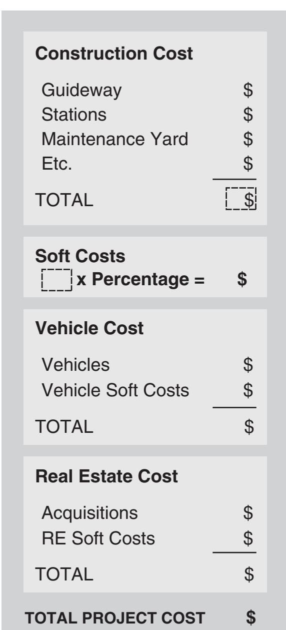


Figure 1. Cost estimation in early project phases.

Interviews with and a questionnaire administered to estimators revealed that cost estimators for transit construction projects follow different approaches to estimating soft costs depending on the phase of the project.

During early phases of planning [alternatives analysis (AA) or preliminary engineering (PE)], a transit project is only conceptually defined, and the soft costs are as well. At these early stages, transportation planners usually identify a single corridor for construction but develop a range of options for more specific details such as mode, alignment, station locations, and, as a result, construction costs. Most attention is on construction costs at this phase since soft costs are difficult to predict given the conceptual nature of the project. Estimators apply default costs to approximate construction quantities, remediation, and other "hard" costs, and then simply add a set of percentages of hard costs (e.g., 30%) to approximate an initial soft cost estimate, as shown in Figure 1.

At this phase, the central question is what percentages to apply. Based on interviews and an industry questionnaire, most estimators report that they choose percentages from within a range for each soft cost component based on historical experience and project characteristics. Figure 2 shows the midpoint percentages used by 10 cost estimators representative of the transit industry, broken down by the soft cost component. Typically, these "add-ons" represent an additional cost to the project of around 25–35% of construction costs.

However, these midpoints are not applied blindly. Estimators may begin with these averages but choose higher or lower percentages from within a range based on their knowledge

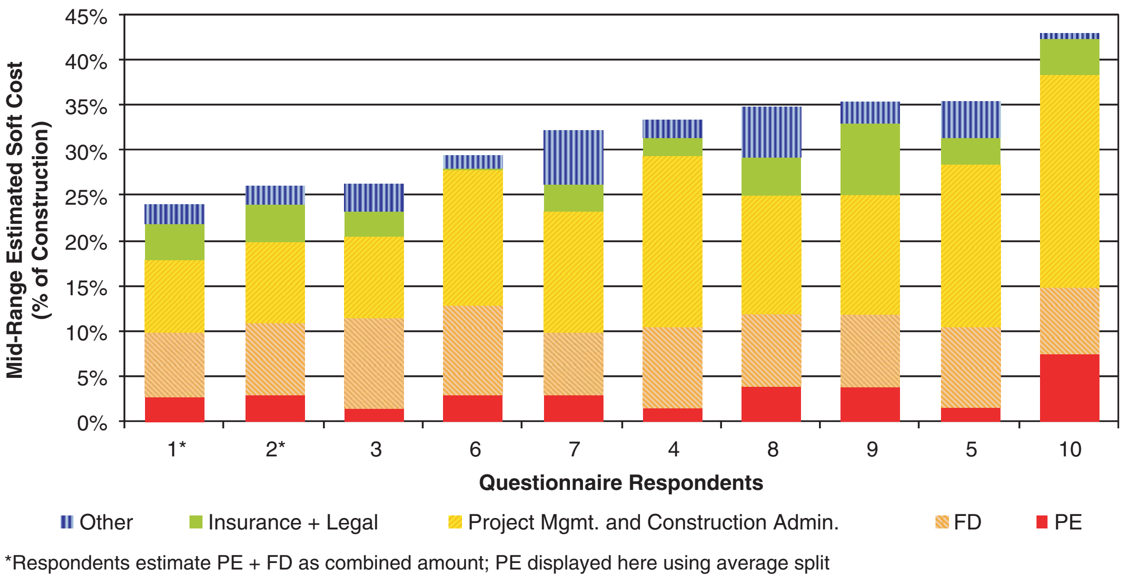


Figure 2. Midpoint soft cost estimates for all components during project planning phases.

of the project, the sponsor, and their experience with similar past projects. Table 2 lists some of the project characteristics that estimators generally use to guide their choice of a percentage within a range during planning phases. Estimators report that they may choose figures up to 10% higher or lower than their starting points based on judgment and the characteristics of the project.

During the final design (FD) and construction phases, estimates of soft costs based on a percentage of construction cost are replaced with more closely tailored, bottom-up estimates relying heavily on past experience with similar projects. For instance, administration costs may be estimated based on headcount multiplied by the duration of the project, as determined from construction schedules. Also at this stage, more costs are known: preliminary engineering work is largely complete, and the sponsor's contracts for construction management and any remaining design work may already be executed for an agreed-upon cost.

Table 2. Project characteristics guiding soft cost percent estimates within a range.

	LOWER % SOFT COSTS	MIXED/MID-RANGE % SOFT COSTS	HIGHER % SOFT COSTS
MODE	Bus Rapid Transit	Commuter Rail Light Rail	Heavy Rail
PROJECT DELIVERY	Design–Build Design–Build–Operate–Maintain Full Turnkey	Design–Bid–Build	
ALIGNMENT		Elevated Alignment	Tunnel Alignment
OTHER CONDITIONS		New Right-of-Way	Differing Subsurface Conditions

S.3. Soft Cost Expenditures: As-Built Analysis

This report analyzes a database assembled by the Federal Transit Administration of as-built costs for 59 rail transit construction projects in the United States over the past four decades (summarized in Figure 3) and concludes that:

- The current industry practice of using percentage add-ons for soft costs appears to be a valid approach to estimating soft costs. Project characteristics such as complexity, magnitude, mode, context, and others identified by industry estimators are correlated with soft costs in dollar and percentage terms.
- Soft cost expenditures have averaged around 30% of construction costs, with a range across all projects of between 11% and 54%, depending on the characteristics of the project, as Figure 3 indicates (outliers excluded).
- Cost estimators typically begin estimating soft costs with average percentages that correspond closely to historical averages for each soft cost component, as Table 3 shows.
- However, actual soft costs in past projects have shown a wider range of variability than estimators currently use. While estimators report choosing from within a range of around 20 percentage points, past projects have varied within a range of around 40 percentage points (outliers excluded).
- Some variability in soft costs cannot be explained solely with information available to the estimator prior to construction. The statistical analysis applied in this research was able to explain around 60% of the changing relationship between hard and soft costs with data available during planning phases. This suggests that the remaining variability in soft costs must be estimated with a blend of science, judgment, and art.

S.4. A New Approach to Estimate Soft Costs

This report is accompanied by a guidebook that presents a new method to estimate soft costs for a planned transit project that is firmly rooted in historical experience. The Guidebook also serves as a primer on soft costs and takes the reader through a step-by-step process to estimate the relationship between a given transit project's hard costs and its likely soft costs, given certain characteristics about the project and its sponsor.

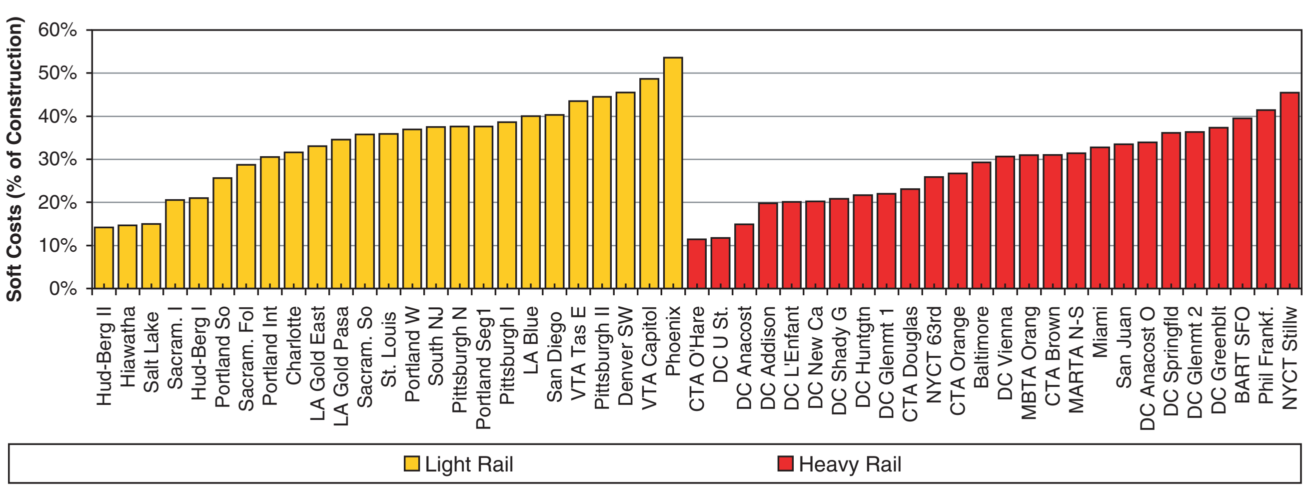


Figure 3. Historical soft costs by project and mode (outliers excluded).

Table 3. Comparing industry practice to historical actuals: soft costs as a percentage of hard costs.

	SURVEY* Average of Midpoints Used	AS-BUILT COST DATA** Average Actual
Preliminary Engineering	2.6%	2.7%
Final Design	9.0%	9.7%
Project Management & Construction Administration	14.1%	15.1%
Insurance	3.5%	2.2%
Other Costs	2.9%	1.6%
TOTAL	32.1%	31.3%
Range of Total	24% to 43%	11% to 54%
	*Representing 10 responses	**Representing 51 past projects (outliers removed)

S.5. Future Research Direction

This report and the accompanying Guidebook give transit agencies and other project sponsors a better understanding of what soft costs are, how they are estimated, and what has caused changes in soft costs in past projects. The Guidebook synthesizes the research and analysis from this technical report into a straightforward primer on soft costs and introduces a new methodology to estimate soft costs based on a review of historical drivers and costs.

More in-depth research into the documentation of one or more recent construction projects will enhance the understanding of the exact composition of soft costs and cost drivers. Future research might further examine the more-detailed elements of soft costs below the Standard Cost Category component level and document more of the estimation techniques used in later project phases. Given the specificity of this work, the research may need to be more closely tailored to a specific mode or operating environment (e.g., streetcar versus light rail on exclusive right-of-way). Moreover, a comprehensive industry outreach program will provide further insight on context-specific soft-cost estimation practices.

Finally, the methodology to estimate soft costs for public transportation infrastructure projects developed here is based on past heavy and light rail construction projects and is therefore not entirely applicable to other prevalent public transportation capital infrastructure projects such as bus rapid transit (BRT), commuter rail, streetcar, or state-of-good-repair projects to repair or replace aging infrastructure. Additional data and research would help estimate soft costs for these kinds of projects.

CHAPTER 1

Introduction

1.1. Purpose of This Report

This Final Report presents the research, data sources, and analysis underlying *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects, Part 1: Guidebook,* which came out of TCRP Project G-10. The purpose of TCRP Project G-10 was to research soft costs in major public transportation capital infrastructure projects, with the goal of producing a guide for project sponsors to learn more about these costs and better estimate them in the future.

This Final Report is one of two final products from the project and is intended to support the information summarized in the Guidebook in Part 1. Please refer to the Guidebook for a summary of how the results of the research presented here can be applied to practice, including an introduction to soft costs and a new methodology to estimate these soft costs based on historical projects.

1.2. Background

When a new rail transit project is proposed in the United States, its capital cost is one of the most visible and important characteristics in the public deliberation over whether to build the project. The capital cost of a rail project factors prominently when deciding alignment and mode during the alternatives analysis and preliminary engineering phases. It is reported in the press, debated by stakeholders, influences the public's perception of a sponsoring transit agency, and ultimately helps determine whether the project is ever constructed. The capital cost is also a crucial input to the cost-effectiveness indicator that helps determine the project's eligibility for federal funds. In addition, the transit industry has recently come under scrutiny for perceived persistent underestimating of capital costs and its ability to contain such costs. While research on the transit industry has focused primarily on hard construction costs and estimation techniques, relatively little literature exists on the composition and estimation of soft costs for transit projects.

Historically, soft costs have accounted for a significant portion of a capital project's total expenditures, yet many agencies know little about soft costs. As this report discusses, most rail transit projects' soft costs have ranged from as low as 11% to as high as 54% of hard construction costs. Given the importance and public scrutiny of transit capital costs and the relative inattention to a cost category that makes up a significant portion of expenditures, the transit industry may benefit from improved information on soft costs.

Therefore, the research team for TCRP Project G-10 hopes to help the transit industry better understand:

- The definition, importance, composition, and timing of soft costs;
- How the industry currently estimates soft costs, depending on project phase;

- What has driven soft cost expenditures in the past; and
- How soft costs can be estimated in the future.

Increasing the integrity, accuracy, and reliability of soft cost estimates will improve the industry's public perception and deliver public transportation infrastructure more cost-effectively. The ultimate objective of the researchers was a guidebook for estimating soft costs for major transit capital projects that walks a project sponsor through each step in building up a soft cost estimate.

1.3. Definition of Soft Costs

Generally, soft costs are the capital expenditures that are required to complete an operational transit project but which are not spent directly on activities related to brick-and-mortar construction, vehicle and equipment procurement, or land acquisition. Instead, these expenses are incurred on ancillary professional services that are necessary to complete the project. Soft costs are the expenditures necessary to develop and manage the project, whereas hard costs are the expenditures required for construction. Soft costs are a necessary part of a construction project because building or rehabilitating transit infrastructure requires more than the direct payments made to a general construction contractor or a vehicle vendor.

The Federal Transit Administration requires that all candidate and recipient projects of New Starts funds organize and report their project cost estimates in the same way, using the Standard Cost Category structure. This structure consists of ten major categories (as shown in Table 4), each of which is further broken down into components. For example, the SCC 50 Systems cost category includes separate components for Train Control, Traction Power, Communications, and Fare Collection.

Standard Cost Category 80, Professional Services, consists of eight separate components that together encompass all services and activities commonly associated with project soft costs (although some exceptions are discussed below).

In addition, a literature review on soft costs concludes that the existing engineering, technical and international professional literature on the definition of soft costs is consistent with the FTA's description of SCC 80, Professional Services, in the *Standard Cost Category Workbook* (U.S. FTA,

Table 4. FTA Standard Cost Categories and Category 80 components.

10	Guideway & Track Elements (route miles)
20	Stations, Stops, Terminals, Intermodal (number)
30	Support Facilities: Yards, Shops, Admin. Bldgs
40	Sitework & Special Conditions
50	Systems
60	ROW, Land, Existing Improvements
70	Vehicles (number)
80	Professional Services
90	Unallocated Contingency
100	Finance Charges
Total Project Cost (10–100)	

80.01	Preliminary Engineering
80.02	Final Design
80.03	Project Management for Design and Construction
80.04	Construction Administration and Management
80.05	Professional Liability and Other Non-Construction Insurance
80.06	Legal; Permits; Review Fees by Other Agencies, Cities, etc.
80.07	Surveys, Testing, Investigation, Inspection
80.08	Start Up

2008). Furthermore, using the SCC structure and the definition of SCC 80 is consistent with the historical analysis that underpins the new soft-cost estimation methodology discussed later.

For this reason, the researchers for this project adopted the definition and structure of FTA SCC 80, Professional Services, as being equivalent to the definition of soft costs. The FTA's characterization (U.S. FTA, 2008), restated below, is therefore a reasonable and consistent definition and has been used throughout the project:

> *[Soft costs include] all professional, technical and management services (and related professional liability insurance costs) related to the design and construction of fixed infrastructure during the preliminary engineering, final design, and construction phases of the project. This includes environmental work, design, engineering and architectural services; specialty services such as safety or security analyses; and value engineering, risk assessment, cost estimating, scheduling, before and after studies, ridership modeling and analyses, auditing, legal services, administration and management, etc. by agency staff or outside consultants.*

It is important to keep in mind institutional or contractual perspective when referring to soft costs. Although this research views soft costs from the perspective of the project sponsor or FTA, the classification of soft costs within the construction industry can take on somewhat different meanings, depending on institutional context.

As Figure 4 illustrates, the project sponsor will likely view soft costs as the non-construction professional services costs identified in Standard Cost Category 80. Expenditures in other cost categories reflect the sponsor's expenditures on direct activities, perhaps primarily composed of payments to the vehicle vendor or construction contractor.

The construction contractor, in turn, may view some portion of their total construction contract as indirect or soft costs for *their* organization, such as the cost of contract administration, home office overhead, and related expenses that are built into the contract amount. These indirect costs represent real costs of doing business to the construction contractor, but since they cannot be clearly attributable to a specific project, the construction contractor is likely to charge various projects in some proportional manner.

In addition, some costs that are clearly attributable a specific project cannot be attributed to physical components of the project (such as concrete or steel), and these may be referred to as "general conditions." While these activities sound similar to the types of services identified in SCC 80, they are the contractor's (not the sponsor's) costs and are therefore considered hard costs outside of SCC 80. These multiple perspectives on indirect or soft costs are illustrated schematically in Figure 4.

To keep matters clear, this research assumes the perspective of a transit agency sponsoring major construction where at least some design and all construction work is to be performed by

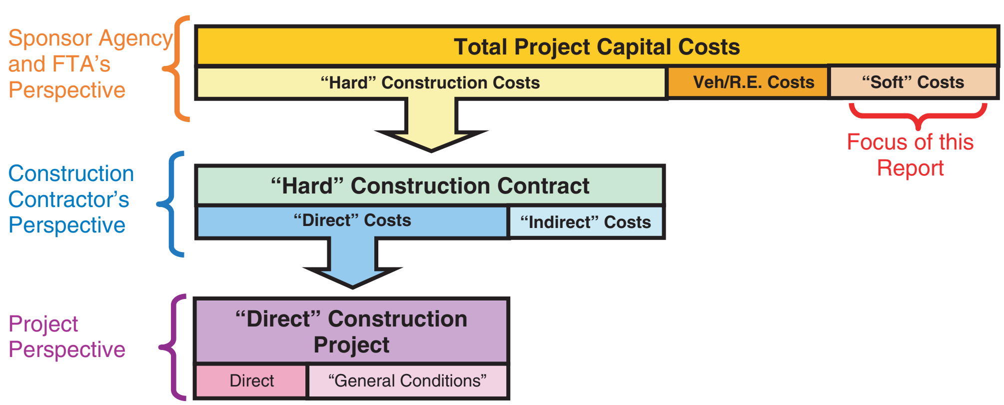


Figure 4. Capital costs from sponsor, contractor, and project perspectives.

outside contractor(s). For example, while a construction contractor might build their expected overhead costs into their bid, their total bid price from the transit agency's perspective, and according to the definition above, is a hard construction cost.

1.4. Organization of This Report

This report consists of five broad sections:

- A literature review on the definition and components of soft costs;
- Results from an industry questionnaire and interviews about how soft costs are estimated;
- Analysis of the relationship between project characteristics and actual as-built soft costs from 59 past rail projects, including univariate and multivariate analyses;
- A summary of the analysis underlying the Guidebook's new soft-cost estimation technique; and
- Concluding remarks and directions for future research.

CHAPTER 2

Literature Review on Soft Cost Definition and Components

The objective of this literature review is to find a consistent definition for the term "soft costs" in the context of capital construction projects and to decide what cost items fall under this term. The following general sources of information were reviewed:

- Technical and scholarly articles published in archival U.S. journals;
- Articles presented in various U.S. professional conferences and published as part of the proceedings;
- Internet sources;
- Books, and specifically, engineering textbooks;
- U.S. Army Corps of Engineers publications; and
- European cost estimation sources.

2.1. Papers and Websites

Many organizations and industry groups publish definitions of soft costs on the Internet or in readily available literature. It is important to note that the term "soft cost" is not used commonly in the technical literature. However, many of the cost items associated with soft costs are covered under the definition of indirect costs.

- The Association of Physical Plant Administrators (APPA, 2005) has the following definition:

> *Soft costs include such items as architecture, design, engineering, permits, inspections, consultants, environmental studies and regulatory demands needing approval before construction begins. Soft costs do not include construction, telecommunications, furnishings, fixed equipment and expenditures for any other permanent components of the project. . . . . These costs are related to those items in a project that are necessary to prepare and complete the non-construction needs of the project.*

While the main components are the same, there is a distinction in this terminology that limits the definition of soft costs to costs incurred *prior* to construction. In the FTA SCC definition, soft costs include professional and managerial services during the construction phase as well.

- KRG Insurance Group (2002) defines soft costs for building and entrepreneurial projects as follows:

> *"Soft Costs" may be defined as those indirect additional expenses that form part of the construction or repair of property. They not only impact on building cost but on business revenues. . . . In a typical accounting summary of construction costs on a new project it is normal for soft costs to comprise up to 30% of total expenses.*

Here is a partial listing of soft costs incurred in building construction: Architect and engineer fees, audit and bookkeeping charges, realty taxes/assessments, advertising and promotional expenses, real estate commissions, tenant inducement expense, premiums—Insurance/bonds, license and permit fees, increased mortgage costs, additional loan expenses, legal expenses, cost of vacancy, increased cost of labor, security expenses, and penalties.

- Constructionplace.com (as of 10/5/2007) has the following definition for soft costs:

Soft Costs are cost items in addition to the direct Construction Cost. Soft Costs generally include architectural and engineering, legal, permits and fees, financing fees, construction interest and operating expenses, leasing and real estate commissions, advertising and promotion, and supervision.

Further, this source contends that the terms indirect costs and soft costs are synonymous.

2.2. Indirect Costs

Few professional publications have used the term "soft costs," instead discussing many elements of soft costs at some length under indirect costs. However, extending the search to include the term "indirect costs" yielded more information regarding various elements of soft costs. In considering indirect costs it is important to identify the relevant perspective. As an example, a cost item that is considered an indirect cost for a *project* (general conditions) may be categorized as a direct cost from a *contractor's* perspective. In the same way, a cost that can be considered a direct cost for a *provider* of professional services (such as labor cost) could be considered an indirect cost from the *owner's* or *sponsor's* perspective.

- For example, the Association for the Advancement of Cost Engineering (AACE, 2007) offers the following definition for indirect costs:

Costs [that] are not directly attributable to the completion of an activity. Indirect costs are typically allocated or spread across all activities on a predetermined basis. In construction, all costs which do not become a final part of the installation, but which are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, startup costs, contractor's fees, insurance, taxes, etc.

This definition is from the perspective of the *contractor*. For the sponsor of a capital project, such as a transit agency dealing with multiple contracts in the same project, the contractor's *general conditions* and *home office overhead* could be considered direct costs because they are clearly attributable to that specific contract. It is therefore conceivable that the whole construction contract could be considered a hard cost. Since the purpose of this guide is to help project sponsors estimate project soft costs with greater accuracy, this analysis takes the perspective of the project sponsor and treats the general conditions and home office overhead as construction costs.

2.3. Textbooks and Technical Books

Ten construction management textbooks were also selected for review because they have been commonly used in various universities and other academic settings for years. The term "soft costs" was only used in one of these textbooks (Bartholomew, 2000, p.252) as follows:

In development, as distinct from actual construction, direct costs are the hard costs, the total construction costs that include what we call in estimating both direct and indirect construction costs. The indirect, or soft, costs in development include the costs of financing, advertising and sales, fees, insurance, ground rent and taxes during construction, and the costs of land rights.

2.4. U.S. Army Corps of Engineers Publications

U.S. Army Corps of Engineers publications on the Internet addressing the subject of construction costs included no reference to the term "soft costs." However, the Corps' estimating sources deal with non-construction costs, and these sources can be used in the current research.

As an example, the U.S. Army Corps of Engineers document *Engineering Instructions—Construction Cost Estimates* (1997) describes the process of cost estimating as prescribed by the Corps. This document does not use the term "soft costs"; however, costs are divided into construction costs and the non-construction activities costs for real estate; planning, engineering, and design; and construction management. This document also provides a work breakdown structure (WBS) for organizing the cost estimate; several categories of this WBS include soft cost items as defined in the FTA SCC description of Category 80. The document can be used for obtaining information on the Corps approach for estimating non-construction costs even though the main emphasis is on construction costs.

2.5. European Sources

Research was conducted to evaluate the European approach to cost classification and to see how European countries keep track of project soft costs. Sources were reviewed in places including Germany, the United Kingdom, and Switzerland. It appears that the term "soft costs" is not used to identify non-construction costs.

However, one useful source was the European Committee for Construction Economists (CEEC) *Code of Measurement for Cost Planning* (CEEC, 2004). The CEEC was established over 20 years ago as a European organization in the field of real estate economy. A working group of this committee focused on the problem of differences between national codes for the measurement of quantities and classification of construction costs (Stoy and Wright, 2006). This working group created the CEEC *Code of Measurement for Cost Planning* as a high-level standard summary for the classification of costs in construction and real estate. Table 5 provides general categories of costs (cost groups) according to the CEEC.

CEEC's *Code of Measurement for Cost Planning* applies the codes of Belgium, Switzerland, Germany, Netherlands, Ireland, and the United Kingdom to arrive at a uniform approach for categorizing construction costs. In this cost breakdown, general conditions costs (project overhead) can be found under cost group A (in Table 5). Items that may be classified as soft costs are found mainly under cost groups L, M, O, and X. As an example, cost group M, "ancillary costs and charges," is described as follows:

> General incidental costs to the client including the costs of models, documentation, copies of drawings, etc., laying of foundation stone, topping out, inauguration, competitions, permits, planning charges, connection charges for utilities, insurances, third party compensation, client's involvement, legal fees in association with construction, compensation payments due to statuary requirements.

The titles of cost groups can sometimes be misleading. As an example, project management and project administration costs are listed under cost group L, "design team fees." Insurance costs can be captured under items "779—general incidental building costs, other items" and "790—other incidental building costs" (cross-referenced from German DIN 276/1993).

Legal fees for land acquisition are under category U. Categories J and N are reserved for contingencies, and category V is reserved for finance.

There is a major effort in Europe to standardize construction cost categories across European nations. The general approach is not unlike the U.S. approach where the costs are divided into

Table 5. Breakdown of cost categories according to the CEEC.

CONSTRUCTION COSTS	
A	Preliminaries
B	Substructure
C	External superstructure/envelope structure
D	Internal superstructure
E	Internal finishings
F	Services installations
G	Special equipment
H	Furniture and fittings
I	Site and external works
J	Construction contingencies
K	Taxes on construction
DESIGN AND INCIDENTAL COSTS	
L	Design team fees
M	Ancillary costs and charges
N	Project budget contingencies
O	Taxes on design and incidental costs
COSTS IN USE	
P	Maintenance
Q	Operation
R	Disposal
S	Decommissioning
T	Taxes
LAND AND FINANCE	
U	Land costs
V	Finance
W	Grants and subsidies
X	Taxes on land

construction and non-construction costs, although the term "soft costs" is not used even in English speaking nations (the United Kingdom and Ireland).

2.6. Summary and Conclusion

In general, despite minor differences, the various definitions of soft costs in the professional publications are generally consistent. Methods of estimating or allocating these costs vary and change from organization to organization. From this literature review the researchers conclude that the definition provided by the FTA in Standard Cost Category 80 is a comprehensive definition consistent with most of the sources that were reviewed.

CHAPTER 3

Soft Cost Estimation: State of the Practice

Industry practices for developing soft cost budgets were assessed using a questionnaire completed by construction cost estimators at a variety of transit agencies, and in-depth interviews were conducted with experienced professional cost estimators in public transportation.

3.1. In-Depth Interviews with Professional Cost Estimators

To develop an initial picture of how the transit industry estimates soft costs, in-depth interviews were conducted with professional cost estimators. The following sections describe the findings of these interviews.

3.1.1. General Approach

From the interviews, it is clear that sponsors of major new transit projects approach estimating soft costs differently depending on how far along the project is in the planning process. Over time, as a project becomes better defined, the soft-cost estimate process increases in sophistication from a proportionate approximation to a more detailed or "bottom-up" estimation for each functional aspect of soft costs.

3.1.2. Soft Cost Estimation during Early Planning Phases

Early in the project development phase, such as during alternatives analysis or preliminary engineering, a transit project is only conceptually defined, as are the soft costs. At these early stages, transportation planners may identify a single corridor for construction but develop a range of options for more specific details such as mode, alignment, station locations, and, as a result, construction costs.

At this stage, capital cost estimates are very important, especially because they are a crucial input to the project's cost effectiveness, which can help determine eligibility for federal funding. However, despite the early importance of capital cost estimates, soft cost estimates are approximations at best in such early phases. Soft costs are generally approached as a percentage add-on to capital costs during alternatives analysis and are an approximation only. As a result, most attention focuses on hard costs, not soft costs, at this stage.

Because of the conceptual nature of the project and the emphasis on hard costs at this stage, soft costs are usually treated as percentage add-ons to estimates of hard construction costs. Estimators begin by estimating each soft cost component as a percentage of construction costs, choosing a percentage for each component within a range depending on a variety of factors. For instance, during conceptual design a sponsor might begin by estimating final design costs as 9% of construction costs, but then increase that estimate to 11% if they know the project is likely to require a more complex design due to special circumstances. Cost estimators interviewed for this study identified the following project characteristics as cost drivers:

- Mode (generally, soft cost percentages for highway projects are lower than for transit projects, which tend to be more complex with more unknowns);
- Vertical alignment (underground segments usually add to soft cost percentages);
- Traffic impacts and relocations around the construction site;
- Level of public support and acceptance of the project; and
- Local and regional politics that can complicate the project development process, including alignments, delays, local funding share and methods, and other concerns.

The project characteristics that were identified in the interviews as cost drivers, listed above, are very similar to those identified in the questionnaire (as shown in Table 8).

3.1.3. Soft Cost Estimation during Later Design and Construction Phases

If a project proceeds into preliminary engineering and final design and becomes better defined, the soft-cost estimation approach changes, and percentages are rarely used. Instead, percentage estimates are replaced with more closely tailored, bottom-up estimates relying on a more detailed understanding of the project than was available in earlier stages and relying on past experience with similar projects. For example, an estimator might forecast design costs using a standard number of drawings per station and drawings per linear foot of guideway and apply a standard per-drawing cost. Agency administration and management costs might be based on headcount, staff salaries, and project duration, in combination with the project's operational requirements. Third-party reimbursement and other costs in SCC 80.06 might be estimated based on construction duration per station as well as headcount. Right-of-way soft costs might apply assessed actual property values rather than a gross estimate of acquisition and real estate costs.

Importantly, the project faces external pressure to adhere to whatever soft cost estimate is assigned to the project during final design. The public, agency staff, FTA, and other oversight bodies tend to expect that the SCC budget line items as defined at final design will not change. In particular, FTA wants to avoid major budget revisions after final design and highly scrutinizes soft cost estimates at this stage. As a result, the cost estimator will typically approach each soft cost component with a conservative estimate.

During the construction phase, project management has little influence on the incurrence of soft costs. Due to the prior attention to the major SCC budget, the project sponsor might be reluctant to change the major SCC line items at the category level, although budget revisions within components are less difficult. To a great degree, the sponsor may be "stuck with the number" once construction begins. Some redesign may be necessary for differing or unexpected site conditions.

Once construction is underway, the management interface between agency and contractor is the most important determinant of soft cost expenditures; other potential factors have relatively little influence on soft costs at this point. The FTA's oversight, local regulations and building codes, and other potential complexities will have only minimal effect on soft cost expenditures. The effect of project delay (for whatever reason) can be mixed: some soft costs, such as manager salaries, are calendar-based and will continue regardless of progress, while other soft costs can be slowed or halted altogether as the project demands, such as when the design contractor temporarily reduces ongoing work on a project.

The market for construction management and design professional services itself can have an impact on construction costs and thereby the relative magnitude of soft costs. Contractors may bid lower if the market is weak, and vice versa.

3.2. Questionnaire of Transit Cost Estimators

To supplement the interviews, a questionnaire on soft cost estimation was completed by transit professionals and cost estimators at several consulting and engineering firms and transit agencies. The questionnaire was intended to build on the qualitative information gathered from the interviews by adding more quantitative information. The questionnaire had three objectives: to summarize the spectrum of soft cost percentages used in the industry by soft cost components, to identify the characteristics (or cost drivers) of a project that would change those percentages, and to measure how much the percentages might change within the range based on project characteristics. The questionnaire was transmitted to nine transit industry members of various sizes, from which 7 data points were collected—5 from transit agencies and 2 from agencies' planning consultants working on a specific capital project. Several respondents reported different estimation techniques and percentages at different project phases; this yielded a total of 10 data points for analysis.

3.3. Questionnaire Results: Magnitude of Estimated Soft Costs

Results from the first section of the questionnaire revealed that most agencies and contractors estimate soft costs as a percent of construction costs roughly consistent with the SCC structure; however, they use a fairly wide range of percentages, depending on context. These results are presented in Table 6.

The questionnaire asked respondents to report a midpoint as well as a high and low percentage for each cost component; however, some respondents supplied only a range or only an approximate midpoint. Where only a midpoint was noted, ranges are omitted, and where only high and low ranges were given, the mathematical average is shown. Some agencies provided percentage estimates that varied depending on project phase, resulting in multiple data points in the results presented in this document.

Several respondents noted other soft costs that are estimated on some basis other than a fixed percentage of construction costs. For example:

- Respondent 7 usually reserves around $1 million for a before-and-after study, regardless of relative project magnitude;
- Respondent 9 estimates resource needs for agency force account and flagging work on a project-specific basis, without using a percentage; and
- Similarly, respondent 10 estimates startup costs not as a percentage of construction costs but on a project-specific basis.

While most questionnaire respondents roughly followed the FTA SCC structure when estimating costs, there were some exceptions. For example, respondents 3, 4, and 5 use a single value to address both SCC 80.03, Project Management for Design and Construction, and 80.04, Construction Administration and Management. Respondents 1 and 2 estimate preliminary engineering and final design with a single value as well. Some respondents noted a percentage multiplier to estimate planning efforts in the early phases of project development, such as alternatives analysis, whereas many did not. This may be because these costs are already largely spent by the time

Table 6. Summary of soft cost percentages reported in questionnaire.

Questionnaire Respondent:		1	2	3	4	5	6	7	8	9	10
	Planning and Feasibility	---	---	---	---	---	---	---	2% for Environmental	---	---
80.01	Preliminary Engineering	*(included in Final Design below)*		1-2% (<1 to 2+%)	*(complete, same as at left)*	*(complete, same as at left)*	3% (2.3 to 3.8%)	3%	4% (3 to 6%)	(3 to 5%)	7.5% (7 to 8.5%)
80.02	Final Design	10% (6-15%)	11% (7-16%)	9-11% (<8 to 11+%)	9% (7% to 10%)	*(complete, same as at left)*	10% (7.5 to 12.5%)	7%	8% (7 to 12%)	(6 to 10%)	7.5% (7 to 8.5%)
80.03	Project Management for Design and Construction	8% (5-12%)	9% (6-12%)	8-10% (<8 to 10-12%)	18-20% (15 to 20+%)	17-19% (15 to 20%)	10% (7.5 to 12.5%)	12% of PE, then 12% of FD for PMC	8% (4 to 8%)	(4 to 6%)	9% (8.5 to 9.5%)
80.04	Construction Administration & Management	---	---	*(included in Project Management above)*			5% (3.8 to 6.3%)	12%	5% (2 to 5%)	(6 to 10%)	14.5% (14 to 15%)
80.05	Insurance	4% (2-6%)	4% (2-6%)	1.5-2% (<1 to 2.5+%)	1.5-2.5% (<1 to 2.5+%)	2% (1 to 3%)	0.1% (0.0 to 0.1%)	3% for Insurance and Legal	4% (3 to 6%)	(3 to 7%)	1%
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	---	---	0-2% (0 to 2+%)	---	0-2% (0 to 2+%)	0.7% (0.5 to 0.9%)		0.25%	(2 to 4%)	3%
80.07	Surveys, Testing, Investigation, Inspection	2% (1-4%)	2% (1-4%)	0-2% (0 to 2+%)	---	0-2% (0 to 2+%)	1% (0.8 to 1.3%)	---	2.5% (2 to 3%)	(2 to 3%)	0.5%
80.08	Start up	---	---	2% (0 to 2+%)	2% (0 to 2+%)	3% (2 to 4%)	0.6% (0.5 to 0.8%)	6%	3% for Start up and Artwork	---	Not estimated with %
	Other	---	---	---	---	---	---	$1m for Before/After Study	4% of SCC 60 for ROW Engineering; 7% of SCC 60 for Agency ROW Costs; 12% of SCC 70 for Vehicle Design and Agency Costs	Agency Force Account Work - Flagging Costs: As Needed	

Note: Midpoint reported first, figures in parentheses indicate upper and lower bound of range

Table 7. FTA Standard Cost Categories combined to report questionnaire results.

FTA SCC Category	Shown Here
80.01 Preliminary Engineering	Preliminary Engineering
80.02 Final Design	Final Design
80.03 Project Management for Design and Construction	Project Management and Construction Administration
80.04 Construction Administration and Management	
80.05 Professional Liability and other Non-Construction Insurance	Insurance and Legal
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.	
80.07 Surveys, Testing, Investigation, Inspection	Surveys, etc.
80.08 Start Up	Start Up

an estimate is made or because the FTA directs agencies to exclude these costs in the SCC worksheet instructions (U.S. FTA, 2008).

This report combines several cost categories, as shown in Table 7 above:

The following section compares the questionnaire responses for each cost component, again with some FTA SCC components combined for reporting purposes.

Figure 5 shows the estimates for preliminary engineering provided by questionnaire respondents. Most agencies report a range of approximately 2–4%.

Questionnaire respondents reported using a fairly consistent range of between 7 and 11% of construction costs to estimate final design costs, as shown in Figure 6. However, these estimates go as high as 16%. Note that the percentages for respondents 1 and 2 include an estimate of preliminary engineering soft costs as well.

Responses were more varied as to the percentage of construction costs estimated for project management, construction management, and administration, as Figure 7 shows. Most estimates were in a range of around 7–19%, but some were as low as 5% and some were as high as 23%.

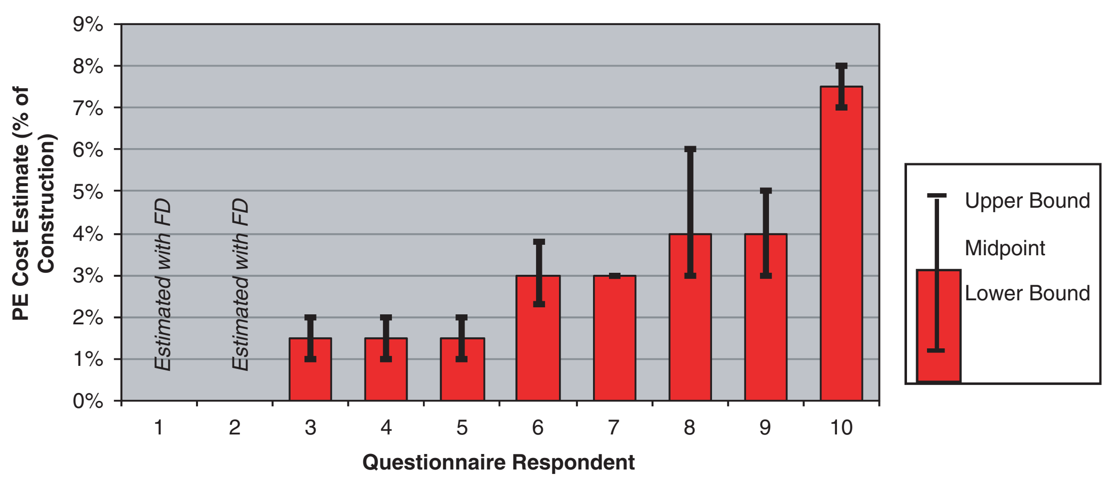


Figure 5. Preliminary engineering soft cost estimates.

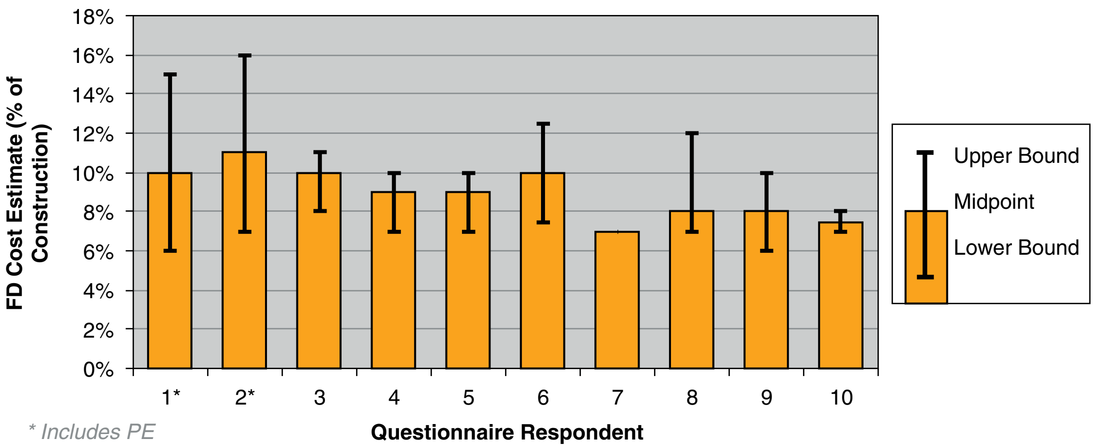


Figure 6. Final design soft cost estimates.

The relatively wider variance between respondents here may be due to the definition of management costs in major infrastructure projects involving a sponsoring public entity and multiple contractors, and the demarcation of where agency oversight ends and contractor oversight begins. As the literature review indicated, the definition of soft costs can often depend on institutional perspective or a project sponsors' decision regarding how much oversight and management to retain for agency staff and how much to contract out. If an agency expects a construction contractor to assume more management responsibility, these costs might appear to the agency as a higher construction bid. Alternatively, a transit agency might segment a large construction project into multiple contracts and hire a third-party construction manager to be responsible for their coordination and integration. The division of management labor between agency staff, management contractor, and construction contractor can differ depending on the sponsor agency.

Figure 8 and Figure 9 show that sponsors typically estimate around 2–4% of construction costs for insurance and legal soft costs, and another 1–2% for the cost of surveys, testing, and other costs. Similar to administration and management costs, however, these types of costs, particularly

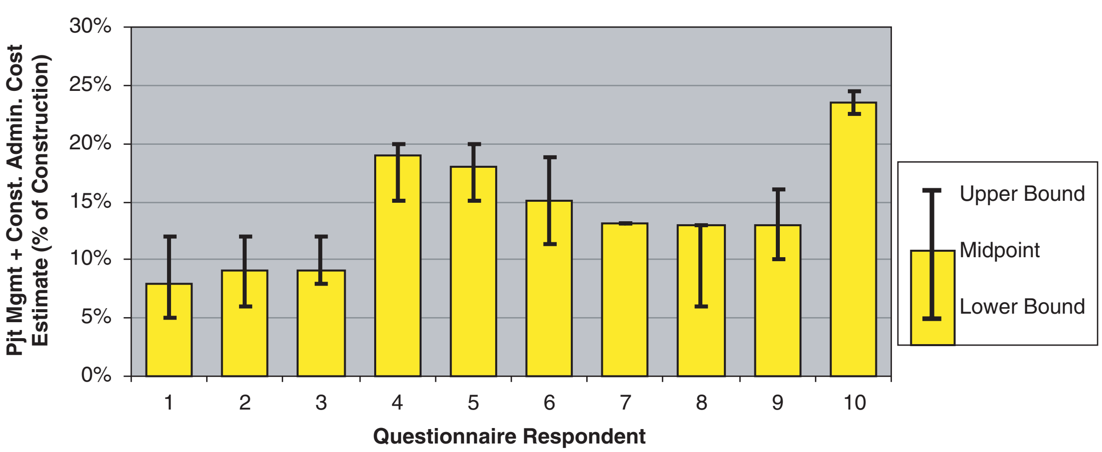


Figure 7. Project management and construction administration soft cost estimates.

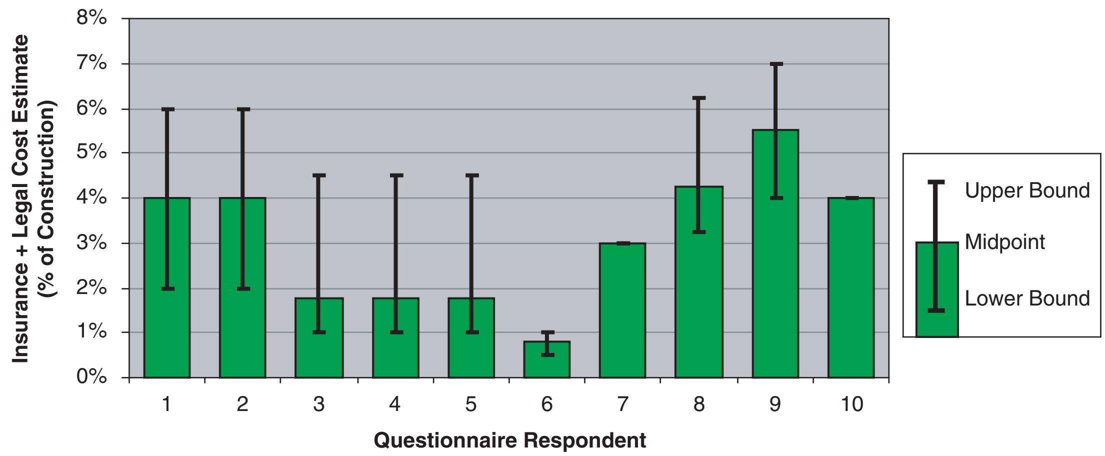


Figure 8. Insurance and legal soft cost estimates.

insurance, can depend on the practice of the agency and local circumstances, and it can be difficult to characterize industry-wide estimation patterns for these cost categories.

Sponsors appear to estimate startup costs quite differently, with estimates ranging from 0% to 7% for this category, as Figure 10 shows. Note the wide range given by respondents 1 and 3, further supporting this uncertainty.

When viewed as individual components or groups of components, as Figures 5 through 10 show, some estimators use fairly consistent soft cost percentages, while others vary more widely. However, some of the differences at the component level may be somewhat offset at the aggregate level. Figure 11, therefore, shows the sum of all soft cost components for each questionnaire response. The stacked bars represent midpoint estimates, while the error bars show the sum of the range of all elements. The midpoints of each soft cost component sum to approximately 25–35% of construction costs fairly consistently, even though the individual soft cost components may differ somewhat from respondent to respondent.

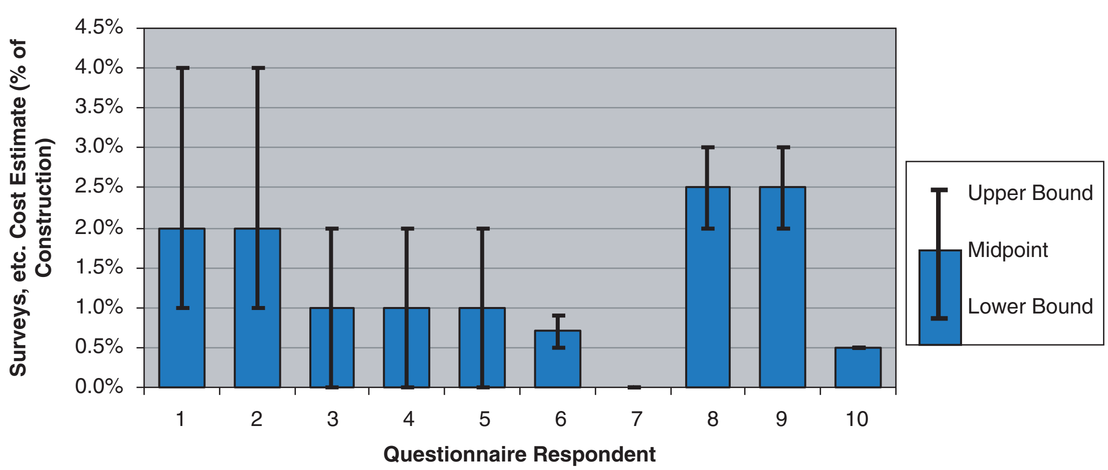


Figure 9. Surveys and other soft cost estimates.

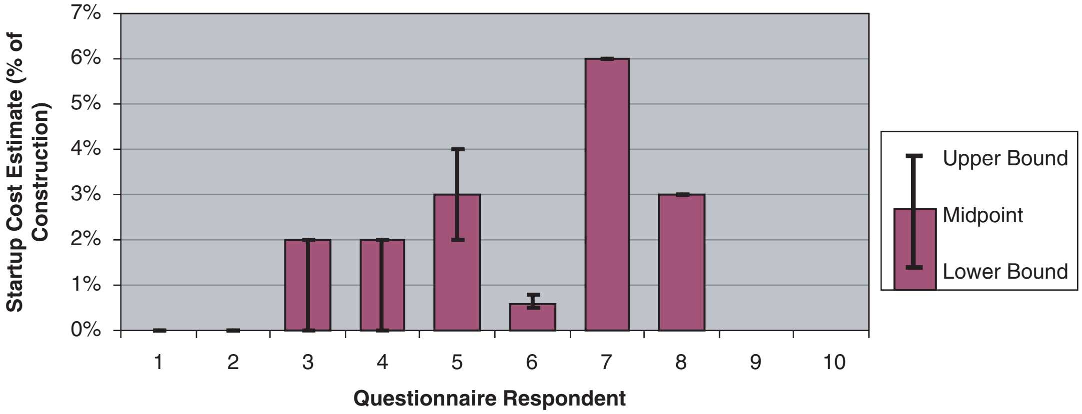


Figure 10. Startup soft cost estimates.

3.4. Questionnaire Results: Drivers Identified

Cost estimators were asked in an open-ended format to identify the kinds of project characteristics or circumstances that would ultimately impact their choice of percentages and that have impacted soft costs for past projects. The questionnaire suggested several attributes, but estimators were free to make their own responses as well. For each soft cost component (following the FTA SCC structure), estimators were requested to identify "cost drivers" that would have high, moderate, or minimal/no impact on soft costs in percentage terms. The results of this part of the questionnaire are presented in Table 8.

Respondents generally identified a wide variety of soft cost drivers, and this research uses these as a starting point for its historical analysis presented later. Some drivers relate to the physical

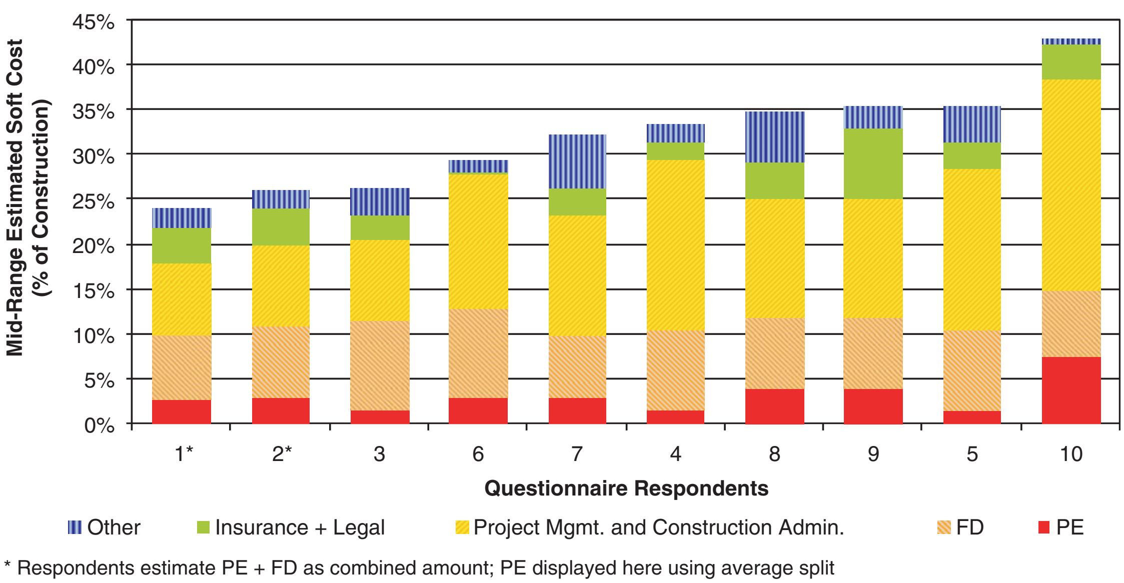


Figure 11. Midpoint soft cost estimates for all components.

Table 8. Soft cost drivers identified by questionnaire respondents.

SCC		Cost Impact	QUESTIONNAIRE RESPONDENT			
			1 and 2	3, 4, and 5	6	10
80.01	Preliminary Engineering	High	Alignment Grade; City v. Rural	Alignment Grade; City v. Rural	Alignment Profile	Alignment Grade, City v. Rural
		Moderate	Vehicle Quantity; Design Speed	Project Delivery; Mode	Quantity and Type of Stations	Vehicle Quantity, Design Speed
		None/ Minimal	Mode	Peak Throughput	Procurement Strategy	Mode
80.02	Final Design	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Completeness of P.E.; City v. Rural	Community Outreach	Alignment Grade, City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Deviation from P.E. Decisions; Alignment Grade	Value Engineering	Vehicle Quantity, Design Speed
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Peak Throughput	Budget	Mode
80.03	Project Management for Design and Construction	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Ability and Experience of Contractor	City v. Rural	Vehicle Qty., Design Speed, Stations per LF; City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Alignment Grade	Special Design Skills	Project Delivery Method
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Peak Throughput	Available Engineering Pool	---
80.04	Construction Administration & Management	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Ability and Experience of Contractor	Available Resources	City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Alignment Grade	Available Skills	Alignment Grade
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Peak Throughput	Avoid Owner / Contractor Duplication	---
80.05	Insurance	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Market Forces	Risk Assessment	City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Owner's experience; Brownfield v. Greenfield; City v. Rural	Risk Assessment	Alignment Grade
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Project Delivery Method	Safety Record	---
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Brownfield v. Greenfield	Requirements Identification	City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	City v. Rural	Schedule	Station Density
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Vehicles; Design Speed	Agency Coordination	Brownfield v. Greenfield
80.07	Surveys, Testing, Investigation, Inspection	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	Elevated or Tunnel	Necessary Balance of Requirements	City v. Rural
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Vehicles; Design Speed; Mode	Avoid Duplication	Brownfield v. Greenfield
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	---	Share Historical Information	Alignment Grade
80.08	Start up	High	Tunnel and Aerial Guideway; Quantity of Stations; Mode	New Line v. Extension	Operation Coordination	Vehicle Quantity, Design Speed
		Moderate	City v. Rural; Project Delivery Method; Mitigation	Elevated or Tunnel; Design Speed	Skill Level Available	Station Density
		None/ Minimal	Design Speed; Grade; Peak Period Throughput	Vehicles	Schedule and Warranty Issues	---

characteristics of the project, the setting and circumstances in which the project is built, the skills and experience of the sponsor and its contractors, and mitigation and unexpected issues. Looking ahead to how these drivers might be used to estimate future soft costs, some of these drivers are relatively straightforward to predict (e.g., alignment grade), while others are much more difficult to foresee (e.g., agency coordination).

3.5. Questionnaire Results: Impact of Drivers

Finally, cost estimators were asked to quantify the impact of 11 project characteristics on soft costs within the following scenario:

- First, consider 7 project attributes that were designed to reflect increasing technical complexity;
- Second, consider 4 additional attributes highlighting different institutional arrangements between the public sponsor and private contractor;
- Third, consider a hypothetical base-case project: a simple light rail construction project, fully at grade, using an existing right-of-way, and delivered with a traditional design–bid–build method; and
- Fourth, consider changes from the base case and report whether the soft cost estimate for each soft cost element would go up or down in percentage terms, using a scale of from 1 to 5, 1 meaning "significant reduction," 3 meaning "no impact," and 5 meaning "significant increase."

To help visualize patterns in the data, the color scheme presented in Figure 12 was applied to the responses.

Table 9 shows the impact of mode on soft cost estimates, using light rail as the base case. Many respondents did not give information here or the response was not complete, perhaps because they lacked historical experience to respond. However, the table shows that, relative to light rail, estimators generally estimate higher soft costs for heavy rail projects, and only moderately higher for commuter rail projects. The results for BRT are mixed; one respondent predicted higher costs in some areas but lower in others, while another respondent predicted lower costs generally. However, these two questionnaire respondents should be interpreted within the context of their sample size.

Cost estimators generally reported that higher project complexity, as measured by a number of indicators in Table 10 below, will tend to increase soft cost expenditures. Most respondents noted that an elevated alignment increases soft costs only moderately compared to at grade, but that tunneling tends to increase soft costs more significantly. Respondent 10, however, noted that soft costs might decline in some categories when tunneling. Estimators at all agencies surveyed predicted rising costs, especially in design and construction management, when subsurface conditions differ from original plans. Results were mixed on the creation of a new right-of-way (versus the base-case existing ROW): some respondents foresaw no change, others predicted uneven increases, and others predicted significant increases.

The final three project attributes included in the questionnaire describe alternative project delivery methods, which generally intend to shift risk from the public agency to the private contractor. Table 11 shows that cost estimators generally estimate that soft costs to the transit agency will go down as more risk is borne by the constructor. However, it is unclear whether this pattern describes a real reduction in costs or merely a shifting of soft costs out of the transit agency's view and into a different cost category. Contractors bidding on a design–build contract, for example, might build soft costs into their bid.

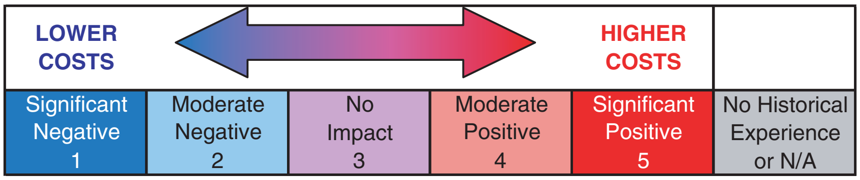


Figure 12. Questionnaire measurement system to quantify impact of cost drivers.

Table 9. Impact of mode on soft cost estimate.

Project Characteristic Change from Base Case	SCC	SCC Description	Questionnaire Respondent [1, 2] 1, 2	3, 4, 5	6	10
Mode: Heavy Rail	80.01	Preliminary Engineering	5	N/A	4	N/A
	80.02	Final Design	5	N/A	4	N/A
	80.03	Project Management for Design and Constructio	5	N/A	4	N/A
	80.04	Construction Administration & Management	5	N/A	4	N/A
	80.05	Insurance	5	N/A	5	N/A
	80.06	Legal; Permits; Review Fees by other agencies,	5	N/A	5	N/A
	80.07	Surveys, Testing, Investigation, Inspection	5	N/A	5	N/A
	80.08	Start up	5	N/A	3	N/A
Mode: Commuter Rail	80.01	Preliminary Engineering	4	N/A	4	N/A
	80.02	Final Design	4	N/A	3	N/A
	80.03	Project Management for Design and Constructio	4	N/A	3	N/A
	80.04	Construction Administration & Management	4	N/A	3	N/A
	80.05	Insurance	4	N/A	3	N/A
	80.06	Legal; Permits; Review Fees by other agencies,	4	N/A	3	N/A
	80.07	Surveys, Testing, Investigation, Inspection	4	N/A	3	N/A
	80.08	Start up	4	N/A	3	N/A
Mode: Bus Rapid Transit	80.01	Preliminary Engineering	2	N/A	4	N/A
	80.02	Final Design	2	N/A	5	N/A
	80.03	Project Management for Design and Constructio	2	N/A	4	N/A
	80.04	Construction Administration & Management	2	N/A	4	N/A
	80.05	Insurance	2	N/A	3	N/A
	80.06	Legal; Permits; Review Fees by other agencies,	2	N/A	5	N/A
	80.07	Surveys, Testing, Investigation, Inspection	2	N/A	4	N/A
	80.08	Start up	2	N/A	3	N/A

Notes:
Base case is light rail.
[1] Respondents 3, 4, 5, and 10 provided partial responses due to lack of experience; lack of response is noted as "N/A."
[2] Respondents 7, 8, and 9 did not provide responses and are omitted.

Table 10. Impact of project complexity on soft cost estimate.

Project Characteristic Change from Base Case	SCC	SCC Description	Questionnaire Respondent[1, 2]			
			1, 2	3, 4, 5	6	10
Alignment: Elevated	80.01	Preliminary Engineering	4	4	4	4
	80.02	Final Design	4	4	5	4
	80.03	Project Management for Design and Constructio	4	3	4	3
	80.04	Construction Administration & Management	4	3	4	4
	80.05	Insurance	4	4	3	3
	80.06	Legal; Permits; Review Fees by other agencies,	4	3	5	4
	80.07	Surveys, Testing, Investigation, Inspection	4	4	3	4
	80.08	Start up	4	3	3	3
Alignment: Tunnel	80.01	Preliminary Engineering	5	3	5	3
	80.02	Final Design	5	4	5	4
	80.03	Project Management for Design and Constructio	5	4	4	N/A
	80.04	Construction Administration & Management	5	4	4	N/A
	80.05	Insurance	5	4	5	4
	80.06	Legal; Permits; Review Fees by other agencies,	5	3	5	2
	80.07	Surveys, Testing, Investigation, Inspection	5	4	5	2
	80.08	Start up	5	4	5	3
Differing Subsurface Conditions	80.01	Preliminary Engineering	5	3	4	4
	80.02	Final Design	5	5	5	4
	80.03	Project Management for Design and Constructio	5	4	4	5
	80.04	Construction Administration & Management	5	4	4	5
	80.05	Insurance	5	4	4	3
	80.06	Legal; Permits; Review Fees by other agencies,	5	4	4	5
	80.07	Surveys, Testing, Investigation, Inspection	5	4	5	5
	80.08	Start up	5	3	3	3
New Right-of-Way	80.01	Preliminary Engineering	5	3	5	5
	80.02	Final Design	5	3	5	5
	80.03	Project Management for Design and Constructio	5	3	3	5
	80.04	Construction Administration & Management	5	3	3	5
	80.05	Insurance	5	3	3	4
	80.06	Legal; Permits; Review Fees by other agencies,	5	3	5	5
	80.07	Surveys, Testing, Investigation, Inspection	5	3	5	5
	80.08	Start up	5	3	3	5

Notes:
[1] Respondents 3, 4, 5, and 10 provided partial responses due to lack of experience; lack of response is noted as "N/A."
[2] Respondents 7, 8, and 9 did not provide responses and are omitted.

Table 11. Impact of project delivery method on soft cost estimate.

Project Characteristic Change from Base Case	SCC	SCC Description	Questionnaire Respondent[1, 2]			
			1, 2	3, 4, 5	6	10
Procurement: Design-Bid-Build (DBB)	80.01	Preliminary Engineering	3	3	4	3
	80.02	Final Design	3	3	5	4
	80.03	Project Management for Design and Constructio	3	3	4	4
	80.04	Construction Administration & Management	3	3	5	4
	80.05	Insurance	3	3	3	3
	80.06	Legal; Permits; Review Fees by other agencies,	3	3	4	4
	80.07	Surveys, Testing, Investigation, Inspection	3	3	5	4
	80.08	Start up	3	3	3	3
Procurement: Design-Build (DB)	80.01	Preliminary Engineering	3	3	5	3
	80.02	Final Design	3	2	3	4
	80.03	Project Management for Design and Constructio	1	2	5	2
	80.04	Construction Administration & Management	2	2	3	2
	80.05	Insurance	2	3	3	3
	80.06	Legal; Permits; Review Fees by other agencies,	2	3	4	2
	80.07	Surveys, Testing, Investigation, Inspection	2	2	4	2
	80.08	Start up	3	3	4	3
Procurement: Design-Build-Operate-Maintain (DBOM)	80.01	Preliminary Engineering	3	N/A	N/A	3
	80.02	Final Design	3	N/A	N/A	4
	80.03	Project Management for Design and Constructio	1	N/A	N/A	2
	80.04	Construction Administration & Management	2	N/A	N/A	2
	80.05	Insurance	2	N/A	N/A	3
	80.06	Legal; Permits; Review Fees by other agencies,	2	N/A	N/A	2
	80.07	Surveys, Testing, Investigation, Inspection	2	N/A	N/A	2
	80.08	Start up	2	N/A	N/A	2
Procurement: Full Turnkey	80.01	Preliminary Engineering	3	N/A	N/A	N/A
	80.02	Final Design	3	N/A	N/A	N/A
	80.03	Project Management for Design and Constructio	1	N/A	N/A	N/A
	80.04	Construction Administration & Management	2	N/A	N/A	N/A
	80.05	Insurance	2	N/A	N/A	N/A
	80.06	Legal; Permits; Review Fees by other agencies,	2	N/A	N/A	N/A
	80.07	Surveys, Testing, Investigation, Inspection	2	N/A	N/A	N/A
	80.08	Start up	2	N/A	N/A	N/A

Notes:
[1] Respondents 3, 4, 5, and 10 provided partial responses due to lack of experience; lack of response is noted as "N/A."
[2] Respondents 7, 8, and 9 did not provide responses and are omitted.

CHAPTER 4

As-Built Soft Cost Analysis

This report has thus far summarized efforts to assess the practice of soft cost *estimation,* as revealed through interviews and a questionnaire of cost estimators. To complement this research, this section examines *actual soft cost expenditures* from past construction projects. This as-built analysis also assesses the relationship between characteristics of transit infrastructure projects and actual soft cost expenditures for as-built projects.

4.1. Approach

This analysis has three major objectives:

- Describe the magnitude and range of soft cost expenditures in previous projects;
- Analyze the relationship between these soft costs and other project characteristics as cost drivers, such as project complexity, mode, year, size, delivery method, and economic conditions; and
- Form the ultimate basis of a new historically based methodology to estimate soft costs for future rail transit construction.

4.2. Data Source: FTA Capital Cost Database

To examine historical costs, this analysis used as-built cost data and characteristics on 59 urban rail transit projects constructed over the past four decades in the United States. This cost data has been adapted from the capital cost databases developed for the FTA. In addition to this dataset, this study also relied on project schedule data adapted from the final report of TCRP Project G-07, *Managing Capital Costs of Major Federally Funded Public Transportation Projects* (Booz Allen Hamilton Inc., 2005), and developed some additional data on project characteristics such as public involvement, installation conditions, and sponsor agency capitalization policies.

4.2.1. About the Projects Included

The projects included in this database were constructed by transit agencies in major urban centers and distributed throughout the various geographic regions across the United States. Over the period of 1984 through 2008, 29 light rail projects were constructed, and 30 heavy rail projects date from 1974 through 2005. This project cost database includes the costs of 59 projects of various sizes, ranging from $100 million to over $2 billion, and represents new rail line segments, extensions of existing networks, and several rehabilitation and replacement projects. This wide range of rail projects provides a good distribution of projects to examine the soft cost requirements needed in their development and offers a reasonable representation of the requirements for professional services and soft costs for passenger rail construction in the United States.

4.2.2. About the Cost Data Format

All project expenditures are reported in standardized formats for individual light and heavy rail project segments. The light rail database reports as-built costs in the same format as the Federal Transit Administration's current SCCs, while the heavy rail data is reported using a prior SCC format. Both formats use common element definitions and consistent structures to document the as-built costs of these passenger rail projects. Costs were adjusted to an average of the 38 largest U.S. metropolitan areas and then escalated to a common base year of 2008 using *Means Construction Cost Index* (Murphy, 2008) for this consistent dollar value.

The cost categories for these two datasets are listed below in Table 12 using the present FTA SCC category format in order at left and the corresponding heavy rail categories at right.

Most capital cost categories examined in this section are comparable between the two data structures, with minor exceptions. In addition, this analysis took several steps to prepare and standardize the cost data:

1. All dollar costs were inflated to constant 2008 dollars;
2. All dollar costs were adjusted for local–national cost variations using the *Means Construction Cost Index* (Murphy, 2008); and
3. Outlier data points were eliminated.

The details of these adjustments can be found in Appendix C.

4.2.3. Project Development Schedule Database

The project development schedules used in this analysis have been adapted from the results of the contractor's final report from TCRP Project G-07 entitled *Managing Capital Costs of Major Federally Funded Public Transportation Projects* (Booz Allen Hamilton Inc., 2005). The G-07 report examined the various strategies, tools, and techniques available to better manage major transit capital projects and developed another separate project development schedule database to examine project schedule delays and their impacts on project costs. The evaluation of soft costs relies on Project G-07's schedule database to measure the relationship between project schedule and soft costs incurred.

4.2.4. Drivers Tested

Table 13 presents the non-financial data items that are tested here as potential cost drivers for actual soft cost expenditures. Some of these results are shown in Appendix C.

Table 12. Light and heavy rail capital cost categories correspondence table.

Light Rail	Heavy Rail
10 Guideway and Track Elements	1.00 Guideway Elements
20 Stations, Stops, Terminals, Intermodal	4.00 Stations
30 Support Facilities: Yards, Shops, Admin.	2.00 Yards and Shops
40 Sitework and Special Conditions	6.00 Special Conditions
50 Systems (Signals, Power, Communications)	3.00 Systems
60 ROW, Land, Existing Improvements	7.00 Right-olf-Way
70 Vehicles	5.00 Vehicles
80 Professional Services (Soft Costs)	8.00 Soft Costs
90 Unallocated Contingency	
100 Finance Charges	

Table 13. Project characteristics tested as cost drivers.

Mode
Guideway length (linear feet)
Percentage of guideway below grade
Percentage of guideway not at grade
Percentage of guideway at grade
Percentage of guideway at grade (incl. built-up fill and retained cut)
New line/extension of existing line/rehabilitation
Procurement or delivery method (design–build, etc.)
Midpoint of expenditures (year)
Planning/draft environmental impact statement (DEIS) midpoint (year)
Preliminary engineering/final environmental impact statement (FEIS) midpoint (year)
Final design midpoint (year)
Construction midpoint (year)
Revenue service begins (year)
Number of stations
Total project cost estimated at preliminary engineering
Total project cost – actual
Economic conditions at estimated bid date (U.S. GDP growth)
Experience level of sponsor
Installation conditions (active service, no active service, etc.)
Public or political involvement
Use of contractors in management or development
Unusual delays in project planning phases
Agency tendency to minimize capital charges

4.3. Potential Issues in Soft Cost Categorization

As described in Chapter 2, this project considers soft costs to be equivalent to professional services as defined in FTA's Standard Cost Category 80, Professional Services, in the *Standard Cost Category Workbook* (U.S. FTA, 2008). Refer to Section 1.3 for a definition of soft costs. According to the FTA definitions, however, other SCC categories besides Category 80 may contain expenditures that may be very similar to soft costs. This analysis has addressed these cases as follows:

- Construction costs (Categories 10 through 50) contain some indirect costs that could be considered soft costs, such as project and construction supervision, general conditions, contractor's general liability, insurance, overhead, and profit, plus comparable subcontractors' costs. Because these soft costs are more associated with direct construction functions, they are treated as hard construction costs.
- ROW, Land, Existing Improvements (Category 60) may include professional services associated with the real estate component of the project such as agency staff oversight and administration, real estate and relocation consultants, assessors, legal counsel, court expenses, and insurance. These costs have been considered separately in this analysis.
- The Vehicles category (Category 70) includes supporting services associated with the vehicle procurement aspect of the project. These costs may include agency staff oversight and administration, vehicle consultants, design and manufacturing contractors, legal counsel, and warranty and insurance costs that, like real estate soft costs, have been considered separately in this analysis.
- Unallocated Contingency (Category 90) includes some costs that could depend on other costs. These costs are essential to cost estimates in earlier project phases, but by the completion of the project, these costs are zero in the as-built cost. This cost category was therefore excluded from this soft cost analysis.
- Finance Charges (Category 100) contains costs that could be considered soft costs. These financing charges have been excluded from this analysis of soft costs because these costs are more project specific and depend on the availability of funding. They have more in common with the financing plan than the overall project development process.

Table 14. Capital cost definitions of soft cost analysis terms.

Term Used Here	Light Rail Cost Categories Applied from Table 12	Heavy Rail Cost Categories Applied from Table 12
Soft costs as % of total costs	[80] ÷ ([10] + [20] + [30] + [40] + [50] + [60] + [70])	[8] ÷ ([1] + [2] + [3] + [4] + [5] + [6] + [7])
Soft costs as % of construction costs	[80] ÷ ([10] + [20] + [30] + [40] + [50])	[8] ÷ ([1] + [2] + [3] + [4] + [6])
Vehicle costs	[70]	[5]
ROW costs	[60]	[7]
Engineering soft costs	[80.010] + [80.020]	[8.02] + [8.03]
Management soft costs	[80.030] + [80.040]	[8.03] + [8.04] + [8.05] + [8.06]

This analysis uses terminology that implies certain groupings of cost categories from the two datasets for light and heavy rail. The numerical definition of these groupings is presented in Table 14. Project year in this analysis means the midpoint of expenditures, derived as the average year of expenditure for each individual cost element, weighted by expenditure amount. Other schedule years used in the analysis to denote project phases (e.g., preliminary engineering, design, construction and operations) mean the midpoint of that phase within the project schedule.

This analysis relies on FTA's prior categorization of costs for projects constructed prior to the current SCC structure and clarifying guidance. Therefore, users of this analysis must be mindful of potentially inconsistent classification of costs within the data. This is because of a number of possible reasons, including:

- Inconsistent reporting across agencies
  - At a basic level, some judgment is required to classify specific expenditures within the SCC structure, even with the available guidance from FTA. Broad categories such as the demarcation between vehicle and systems costs are likely to be more consistently comparable among the reporting agencies, while detailed cost items such as the difference between "Project Management for Design and Construction" and "Construction Administration and Management" are likely more susceptible to inconsistencies in reporting definitions. Since this dataset includes projects from across the country and across decades of construction, the data may be susceptible to some level of inconsistent definitions of cost categories.
  - Of particular relevance to this study is the reporting of professional service soft costs for vehicles and rights-of-way. These were initially reported into a database structure that was unclear about some of these related vehicle and right-of-way soft costs. More recent database structure and instructional guidance expressly defines the cost elements for vehicle and right-of-way soft costs. These more category-specific soft costs have been segmented from this analysis of construction-related soft cost.
- Refinements to the cost structure
  - The structure of FTA's SCC capital cost database has evolved over the past 20 years. This evolving framework for the cost data and varying levels of detail directly and indirectly affect some of the more detailed reporting and thereby the resulting relationships.
  - The FTA Standard Cost Categories have clarified the right-of-way and vehicle cost categories to include those categories related to soft costs. However, prior structures may not have been as clear and vehicle and right-of-way associated soft costs could be mixed into the general soft cost category.
- Agency capital program policies
  - The financial and administrative policies of the sponsoring agency can affect how soft costs are reported for a capital project, which could affect the amount and proportion of soft costs

when comparing projects across agencies. For example, staff and contractor soft cost charges can be funded through separate grants and are not always reported into the project budget.
  - The salaries of some agency staff who support engineering, design, and/or construction may be treated as an operating expense rather than charged to the capital project.
  - Early planning and preliminary engineering costs may be charged to a general planning grant rather than attributed directly to the capital project.
  - Insurance may be carried by the construction contractor or the sponsor agency, and/or it may be embedded into individual cost elements as an overhead cost.
- Project delivery mechanism
  - The varying methods of project development and procurement present unique challenges to the breakdown and classification of project costs because cost classification can depend on institutional perspective. Sections 3.5 and 4.5.3 discuss this issue more thoroughly.

4.4. Historical Soft Costs

This first portion of the soft cost analysis presents the general breakdown of project soft cost attributes within the as-built project cost database. Total project costs are described using the following categories: Soft, Vehicle, and Construction costs. Soft costs are then examined as a proportion of the Construction Costs category and then further examined by individual soft cost components.

4.4.1. Describing the Data

As shown in Figure 13, construction costs made up the largest share of expenses for most projects, vehicle costs range from 0 to 25% of total project cost, ROW costs 0 to 20%, and soft costs 10 to 35%. While all projects incurred construction and soft costs, some projects had no ROW or vehicle procurement costs. For example, the extension of Bay Area Rapid Transit (BART) to San Francisco International Airport (SFO) required the purchase of no additional vehicles, while the extension of the CTA's Blue Line to O'Hare Airport did not entail right-of-way costs. Professional services for the many varied rail transit capital projects in this database usually accounted for around 10–35% of total project costs. This pattern forms the focus of the more detailed segmentation of these costs, presented briefly here and in more detail in Appendix C.

Figure 13 illustrates soft costs, with light bars at the top, expressed as a percentage of total costs. To measure soft costs in a more commonly used format, Figure 14 shows soft costs as a percentage

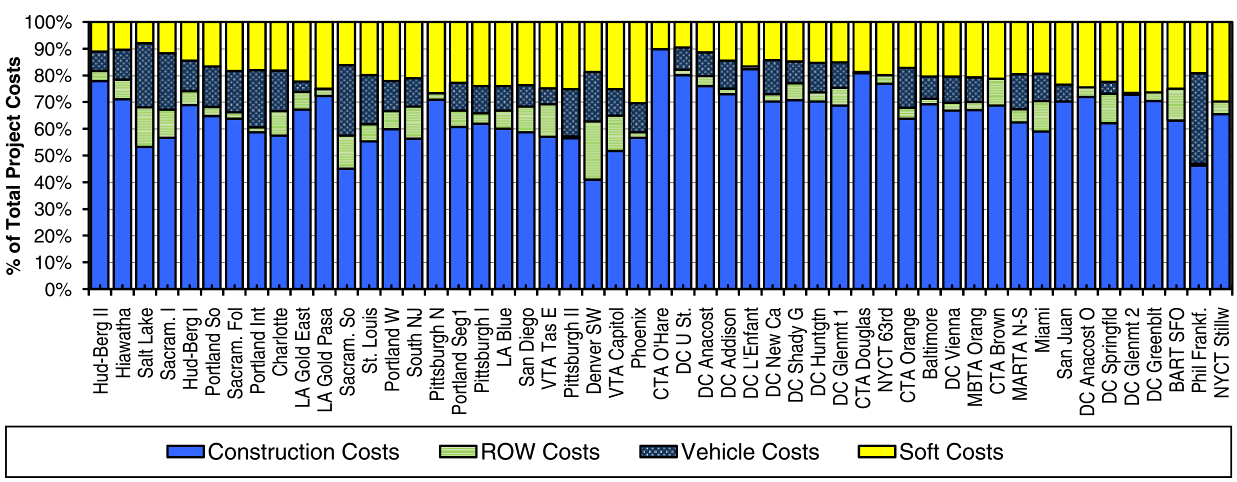


Figure 13. Project costs by category.

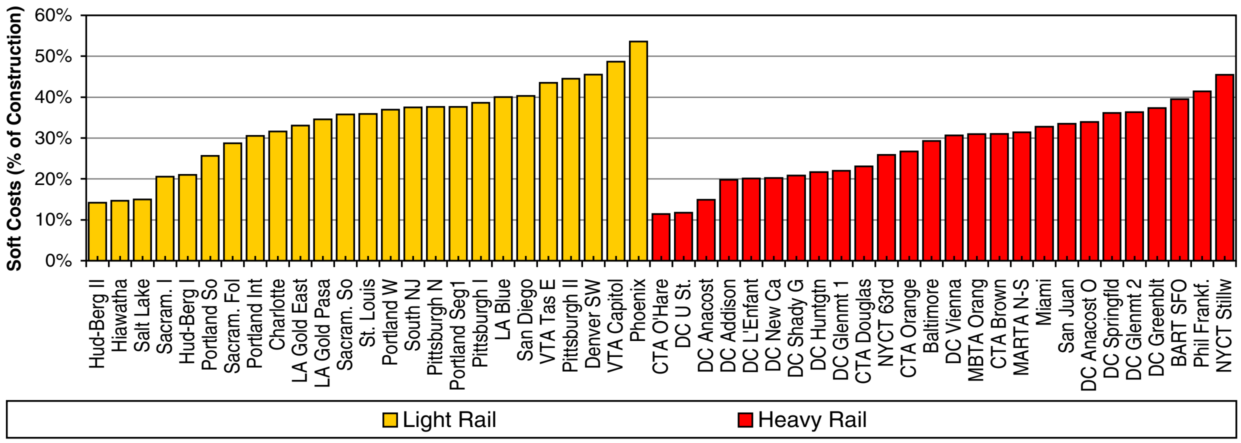


Figure 14. Soft costs percent of construction costs by project and mode.

of construction costs for these same projects. Construction costs include all of the guideway, trackwork, facility, station, systems, sitework, and special conditions costs (refer to Table 14). When expressed as a percentage of construction costs, soft costs vary considerably more across these same projects than when expressed as a percentage of the total cost—from 11% to a high of 54% of construction costs.

Expressing soft costs as a percentage of construction costs is pertinent to this analysis since soft costs associated with the vehicle and right-of-way costs are expressly defined as a separate cost element in each of those associated cost categories. This relatively wide range in soft costs as a percentage of construction costs merits further examination.

Note that in Figures 14 through 18, 20, and 22, the historical projects are ordered in terms of increasing soft costs as a percentage of construction costs, with separate ordering for light rail and heavy rail projects.

To explore the wide range in this soft cost measure, the individual cost components that compose total soft costs were analyzed. Total soft costs can be segmented into six major components, as defined in the FTA SCC structure:

- Preliminary Engineering,
- Final Design,
- Project Management for Design and Construction,
- Construction Administration and Management,
- Insurance, and
- All Other Soft Costs in SCC 80.

These six soft cost components are shown as a percentage of construction costs in the bar chart in Figure 15. The total percentages are consistent with those presented above in Figure 14. The six components are expressed as a percentage of overall soft costs in Figure 16, where the bar chart for each project totals 100%.

The components of soft costs appear to vary considerably across projects, especially as a proportion of overall soft costs. For example, preliminary engineering costs (bottom measure and dark aqua in Figure 15 and Figure 16) are a very small or near-zero proportion of soft costs for some projects, while for others (e.g., Hudson-Bergen Phase 1, Phoenix) these costs are significant expenditures. In projects with little or no reported preliminary engineering costs, there was likely either a missing expenditure or it was rolled into a combined grant with another soft cost component. Insurance can account for almost 10% of construction costs (e.g., CTA Douglas Branch) for some projects, or none at all for others. This may be due to different agencies'

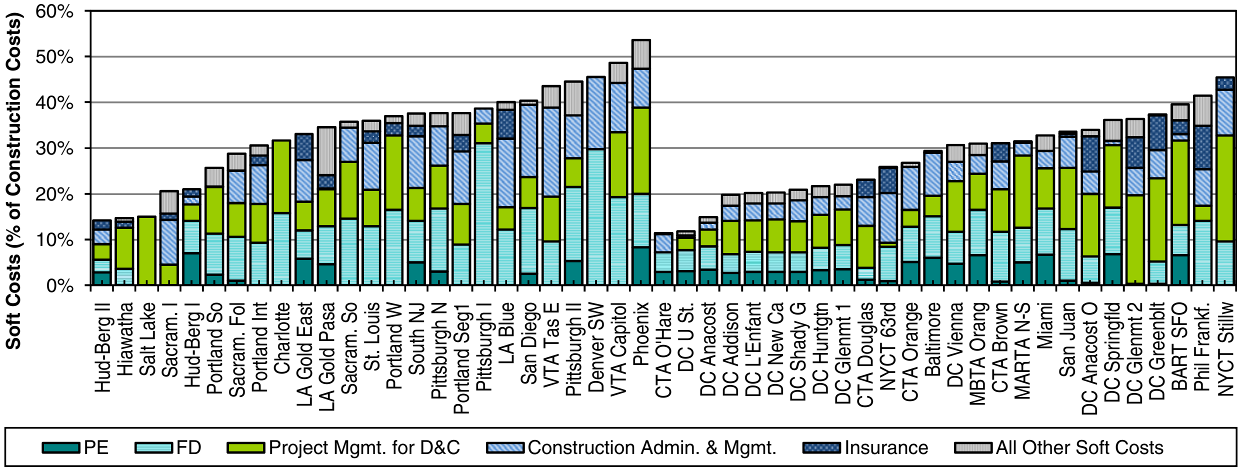


Figure 15. Soft cost components as a percentage of construction costs.

approaches to project development, where one agency may provide project-wide wrap-up insurance and others may require each contractor to provide their own insurance, or some combination of these. In general, individual variances may be due to real differences in expenses incurred as a result of project characteristics, while some variation is probably due to the way in which costs are reported or categorized. The more consistent soft cost components were final design, project management, and construction management.

Some projects appear to have inconsistencies in the reported soft cost experience that may indicate questionable data. For example, some projects show zero engineering or design costs, which is unlikely given the complexity of constructing major transit capital projects. In these cases, expenditures may have been classified elsewhere in the SCC structure or charged to a separate, off-project funding source and not reported into the project budget.

In subsequent analysis in this report, certain outliers were omitted from the more detailed analyses to eliminate the effect of these uncertain data. The decision to remove an outlier was based on analyzing the distribution of projects' soft costs, and is more fully described in Section C.4 in Appendix C.

Figure 17 shows the average soft cost percentages by component for all projects in the dataset (outliers excluded) and the range of percentages encountered. The bars represent average soft-cost

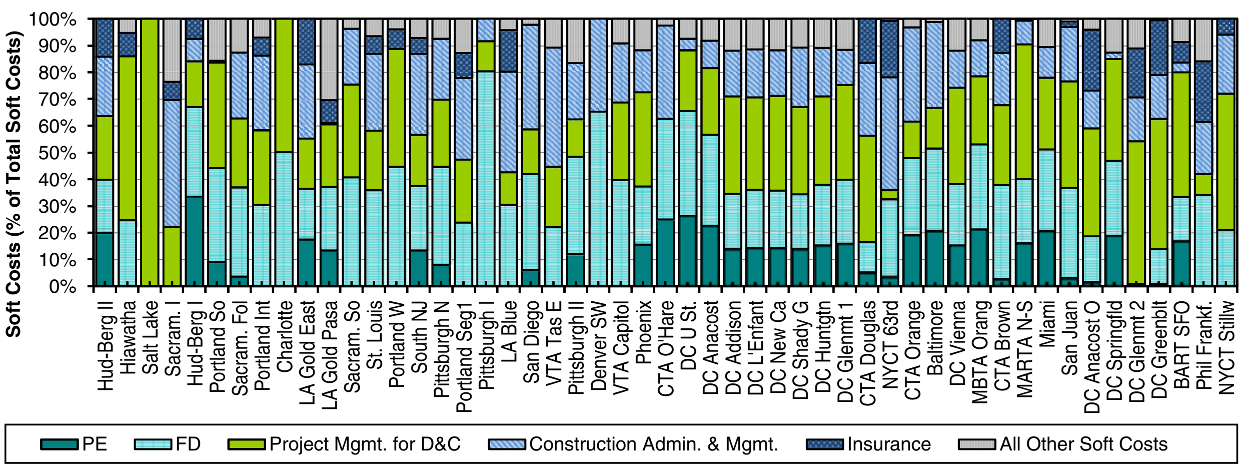
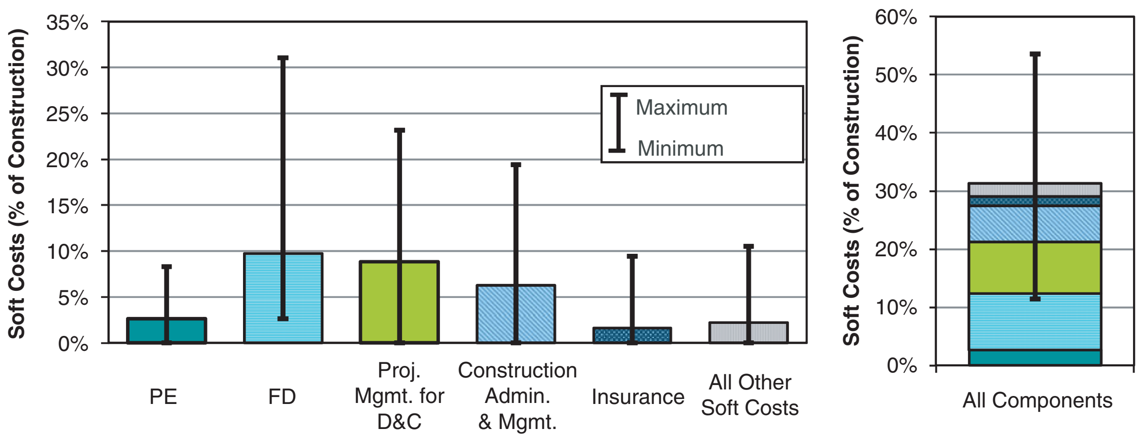


Figure 16. Soft cost components as percentage of total soft costs.



Soft Costs as % of Construction

	PE	FD	Proj. Mgmt. for D&C	Construction Admin. & Mgmt.	Insurance	All Other Soft Costs		All Components
Average	2.7%	9.7%	8.8%	6.3%	1.6%	2.2%		31.3%
Minimum	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%		11.4%
Maximum	8.3%	31.0%	23.2%	19.4%	9.4%	10.5%		53.6%

Figure 17. Average and range of soft cost components as percent of construction.

component expenditures, and the lines indicate the maximum and minimum values in the dataset. For instance, the average project incurred final design expenses of 9.7% of construction costs, but this percentage ranged as low as 2.6% for one project and as high as 31.0% for another. Most categories contained projects with zero expenditures for that category, resulting in the minimum of the range being zero.

Figure 17 also shows that when all components are combined, projects show average soft costs of around 31% of construction costs. However, the range of total soft costs has been as low as 11.4% for one project and as high as 53.6% for another project, after excluding outliers.

To test the hypothesis that soft-cost component costs may have been inadvertently assigned and reported to a related soft cost component, the analysis grouped some related soft cost components and subtotaled them into the following three soft-cost component categories:

- Pre-construction costs (design and engineering),
- Construction expenditures (construction management, administration, etc.), and
- Other costs (insurance, others).

Although an approximation of these project development phases, this broad categorization produces the results displayed in Figure 18 (as a percentage of construction costs) and Figure 20 (as a percentage of total soft costs).

A more consistent soft cost basis appears to emerge from the analysis when soft cost components are grouped by these categories, which approximates the project development phase in which the expenditures were incurred. Figure 19 shows the averages and ranges of these three groups of soft cost components, expressed as a percentage of construction costs. This figure indicates that a typical project incurs preliminary engineering and final design costs of 12.4% of construction, and construction management and project administration soft costs of 15.1% of construction, but that these percentages can range from around 3% to 33% for some projects.

When expressed as a percentage of total soft costs as shown in Figure 20, the resulting cost proportions are more consistent. About 40–50% of soft costs are generally related to engineering and final design, another 40–50% of soft costs are related to construction management and administration, and about 10% are other costs. The first two of these three categories (engineering and final design, and construction management and administration) are sometimes used in subsequent analysis in this report.

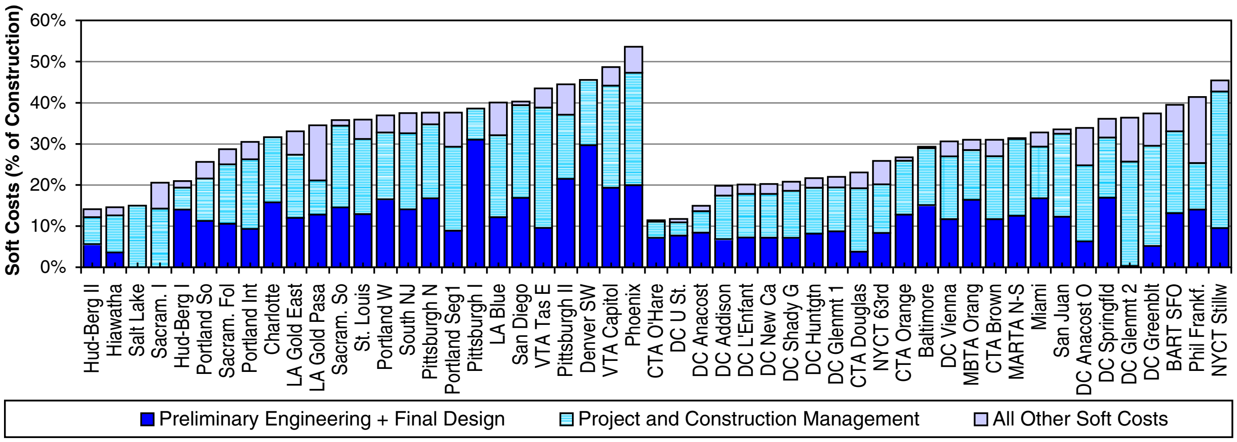
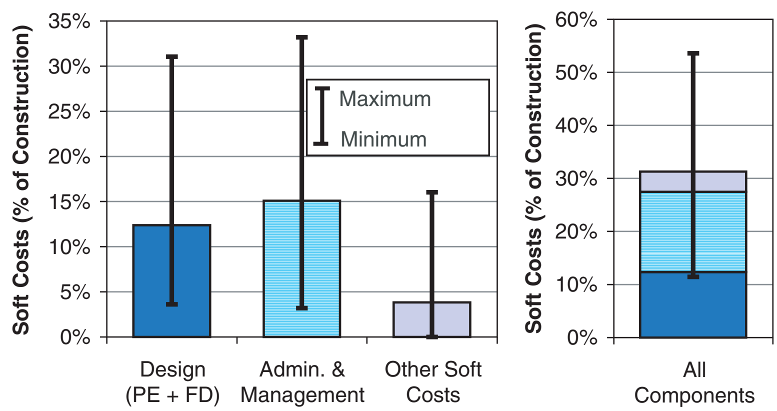


Figure 18. Subtotaled soft cost components as a percentage of construction costs.



Soft Costs as % of Construction

Average	12.4%	15.1%	3.8%		31.3%
Minimum	3.6%	3.2%	0.0%		11.4%
Maximum	31.0%	33.2%	16.0%		53.6%

Figure 19. Average and range of subtotaled soft cost components as a percentage of construction.

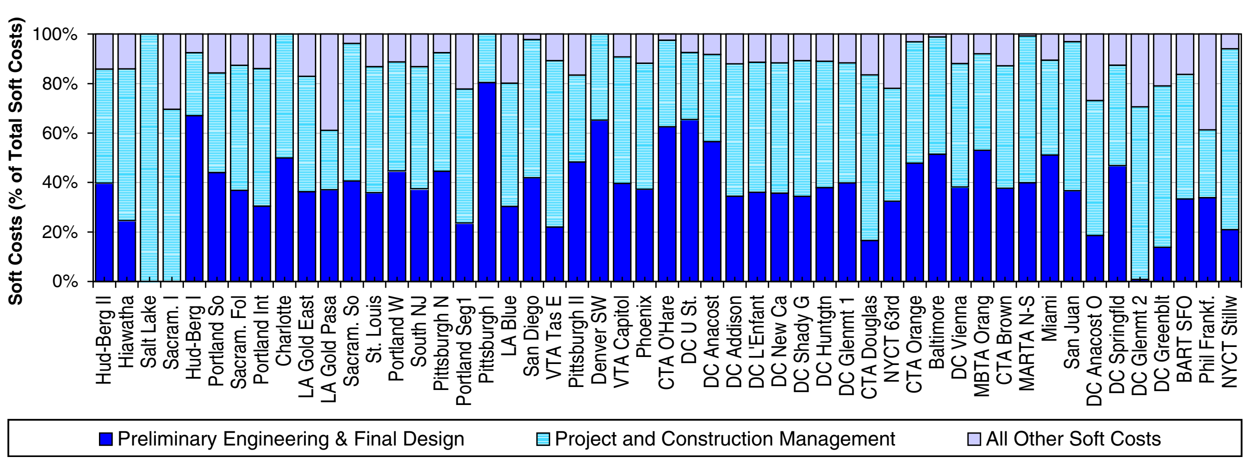


Figure 20. Subtotaled soft cost components as a percentage of total soft costs.

4.4.2. Measuring Soft Costs

Developing a guidebook on the estimation of soft costs requires the identification of specific measures. This section tests a number of different ways to measure soft costs and explores how each may be used in a guidebook context. Soft costs of as-built projects can be measured in the following ways:

- As a percentage of total project cost;
- As a percentage of all other costs, excluding only soft costs;
- As a percentage of construction costs;
- In constant dollar value terms; or
- In constant dollars per linear foot of constructed guideway.

This analysis does not rely on the first and fourth measurements on this list. Figure 13 above showed soft costs as a percentage of total project cost, and this measurement is sometimes used to describe soft costs. However, measuring soft costs as a percentage of total project cost is not an appropriate metric for a cost estimator since the estimator does not know total project cost until the soft cost estimate is complete. Soft costs may also be expressed in dollar value terms, but this measure would fail to account for differences in project size across the dataset. Therefore this analysis focuses on measuring soft costs as a percentage of all other costs, as a percentage of construction costs, and in dollars per linear foot of guideway.

Figure 21 compares measuring soft costs as a percentage of all other total costs (i.e., all other costs besides soft costs themselves) and as a percentage of construction costs (i.e., excluding vehicle and right-of-way costs) and shows that these two percentage-based methods of measurement are highly correlated. This applies to both light and heavy rail modes and the combined analysis of projects of both modes. These results suggest that ROW and Vehicle category costs (those that are excluded when measuring construction costs only) have a relatively small effect on soft costs. This may indicate that their related soft costs (ROW and Vehicle category costs) have been accurately accounted for within each of these categories.

Measuring soft costs per linear foot is another way to measure soft costs. To test the quality of this measure, all project costs were normalized by applying the national average metropolitan area *Means Construction Cost Index* (Murphy, 2008) and then inflating to 2008 dollars. Significant project outliers were excluded from this analysis to focus on the more consistent results. Figure 22 shows this measurement for all included projects.

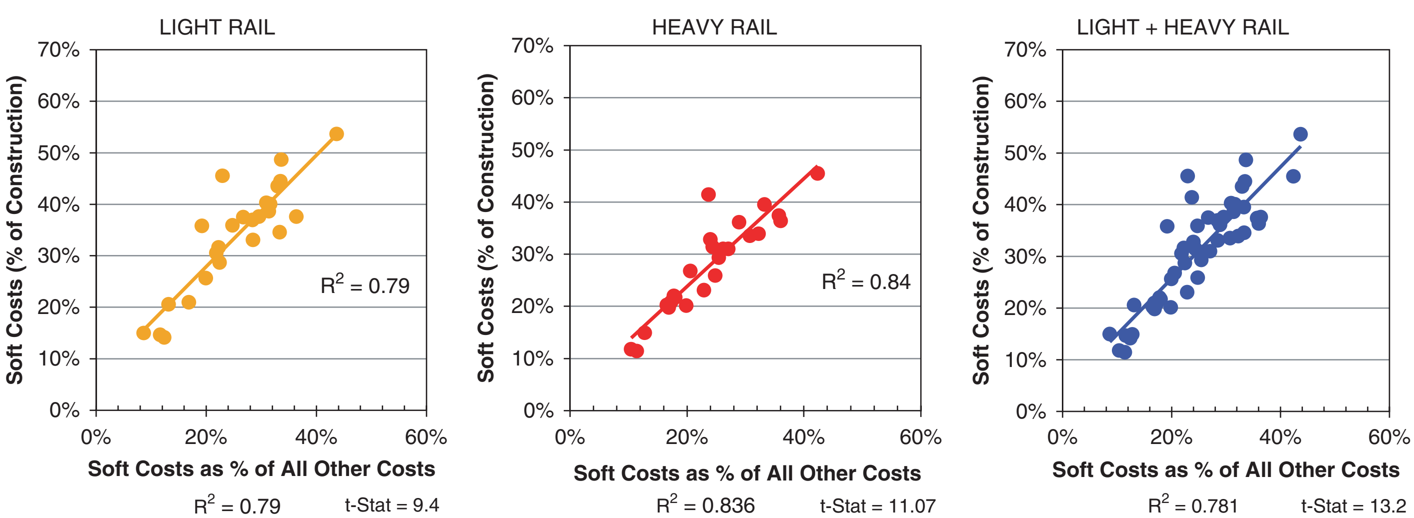


Figure 21. Soft cost percentage of construction costs versus soft cost percentage of total other costs.

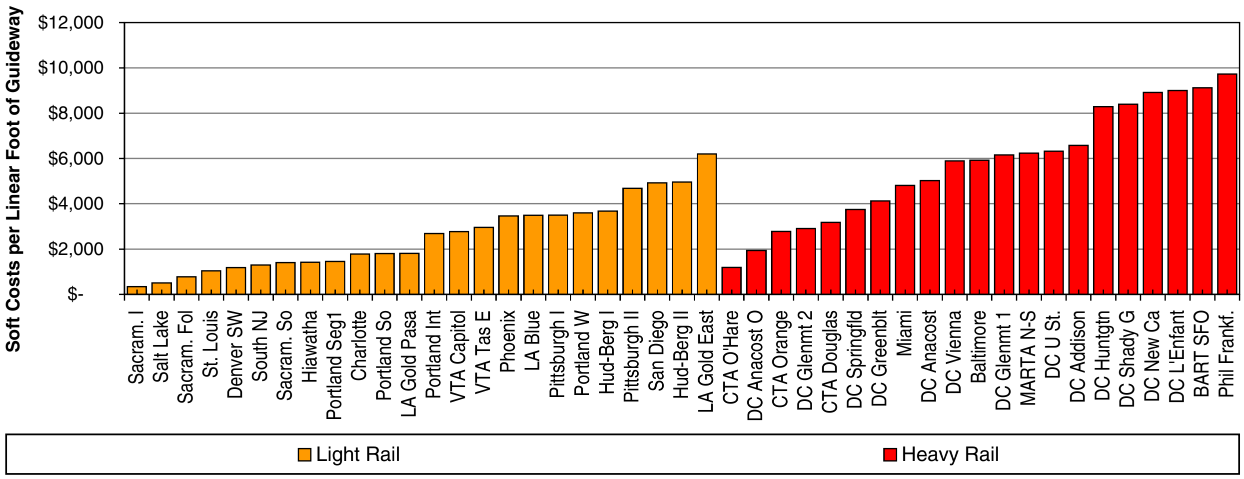
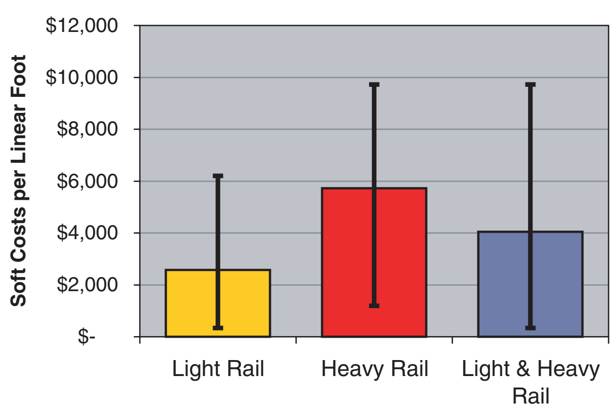


Figure 22. Soft costs per linear foot of constructed guideway by project and mode.

Soft costs on a per-linear-foot basis vary considerably, even with the removal of outliers, from less than $1,000 to nearly $10,000 per linear foot (all costs in 2008 dollars). Specifically, light rail projects averaged $2,572 per linear foot, heavy rail $5,726, and all projects combined $4,044 per linear foot, as shown in Figure 23. The range for soft costs in light rail is somewhat less than for heavy rail projects.

In general, soft costs tend to be higher for heavy rail, consistent with the generally higher cost of heavy rail overall. The soft cost per linear foot measure appeared to offer some consistency with the range estimates noted above. The next step in the analysis was to see if there was any relationship with the soft cost percentage of construction. Figure 24 compares the measurement of soft costs as a percentage of construction cost and as a dollar value cost per linear foot.

As Figure 24 indicates, measuring soft costs as a dollar-value cost per linear foot versus a percentage of construction cost would not yield similar results. The heavy rail projects have a somewhat better relationship that may indicate a greater relationship of increasing complexity of the heavy rail projects with greater soft cost requirements.



Soft Costs per Linear Foot

	Light Rail	Heavy Rail	Light & Heavy Rail
Average	$ 2,572	$ 5,726	$ 4,044
Minimum	$ 335	$ 1,191	$ 335
Maximum	$ 6,201	$ 9,728	$ 9,728

Figure 23. Average and range of soft costs per linear foot of constructed guideway.

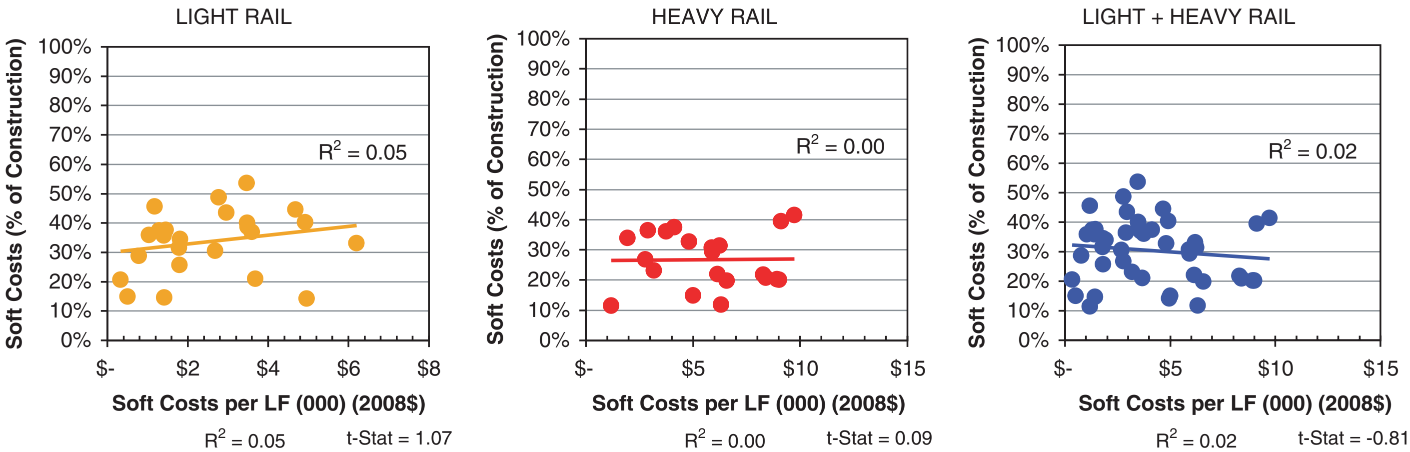


Figure 24. Soft costs as a percentage of construction versus soft cost per linear foot of constructed guideway.

It is unclear from these initial analyses which basic measurement of soft costs (percentage or dollar value terms) is most appropriate. Therefore this analysis shows results with both unless one measure appears more appropriate given the circumstances.

4.5. Relationships between Cost Drivers and Historical Soft Costs

This section tests the relationship between various project characteristics such as mode, alignment, and year (detailed above in Table 13) and actual soft cost expenditures. This research took two approaches to measuring how soft cost drivers have impacted actual soft costs:

- **Univariate testing of soft cost drivers suggested in interviews and the questionnaire.** First, this research began by creating a series of scatter diagrams comparing soft costs with the kinds of project characteristics that estimators currently use to choose higher or lower soft cost percentages. This kind of analysis tests only whether one project characteristic alone influences soft costs. As the results below demonstrate, some of these tests showed that soft costs are correlated with certain project characteristics, while other tests yielded less conclusive results. Many of the less conclusive results are presented in Appendix C. These single-variable results served to guide the research into the next phase described in Section 4.5.7.
- **Multivariate testing of combinations of soft cost drivers.** Second, this research tested a multitude of combinations of soft cost drivers and their effect on soft costs in a multivariate regression. Project characteristics were the independent variables, and soft costs as percent of construction costs acted as the dependent variable. After several hundred tests, a single multivariate regression was developed that can explain approximately 60% of the differences in soft cost percentages by variations in project characteristics ($R^2 = 0.58$), as will be described later. This kind of analysis tests the cumulative effect of how changes in a variety of project attributes have affected resulting soft costs.

4.5.1. Assembling Data on Soft Cost Drivers

A set of characteristics was gathered for the projects to help identify cost relationships, including the following:

- Physical attributes, such as alignment length, profile (e.g., below grade, at grade, aerial), number of stations, or whether the project initiated new service or extended an existing line.

- Installation conditions, such as whether the project interacted with other active rail transit lines.
- Schedule information, including major milestones in the project lifecycle for a subset of projects in the dataset. While each project had a midyear of expenditure, only some projects had full schedule data available.
- Characteristics of the project sponsor, such as experience level, internal policies on capital costs, and use of outside contractors.
- The context of the project development process, such as the level of public involvement, delivery method, or whether a significant redesign was necessary.

For these last two types of characteristics, the definition and determination of values required some judgment based on knowledge of those projects' development process.

Many measures were derived from this primary dataset that were intended to act as a proxy to capture other project characteristics, such as project magnitude (e.g., construction costs per linear foot), complexity (e.g., percent of alignment below grade), unique circumstances (e.g., real estate acquisition costs, project occurred prior to certain federal requirements), and many others.

4.5.2. Soft Costs by Mode and Year

Figure 25 shows the average soft costs as percentage of construction costs across modes and by decade. The amount spent on soft costs appears to vary little depending on mode, as indicated in the left pane. Light rail projects averaged 33.8%, heavy rail projects averaged 28.0%, and the combined database projects averaged 30.9% of soft cost percentage of construction.

Soft costs have been rising over time since the 1970s. The right pane of Figure 25 shows that on average, soft costs for both heavy and light rail have recently amounted to approximately 34.6% of construction costs, and this figure is an increase from about 21.4% three decades ago.

4.5.3. Soft Costs by Project Delivery Method

Project delivery method or procurement strategy also appears to affect expenditures on soft costs. Although most projects in the dataset were delivered via a DBB methodology, evidence for light rail projects indicates that DB projects have lower soft costs, as shown in Figure 26. With only nine design–build projects and one construction management/general contractor (CM/GC) project out of all database projects, these findings need to be considered within the limitations caused by the small sample size.

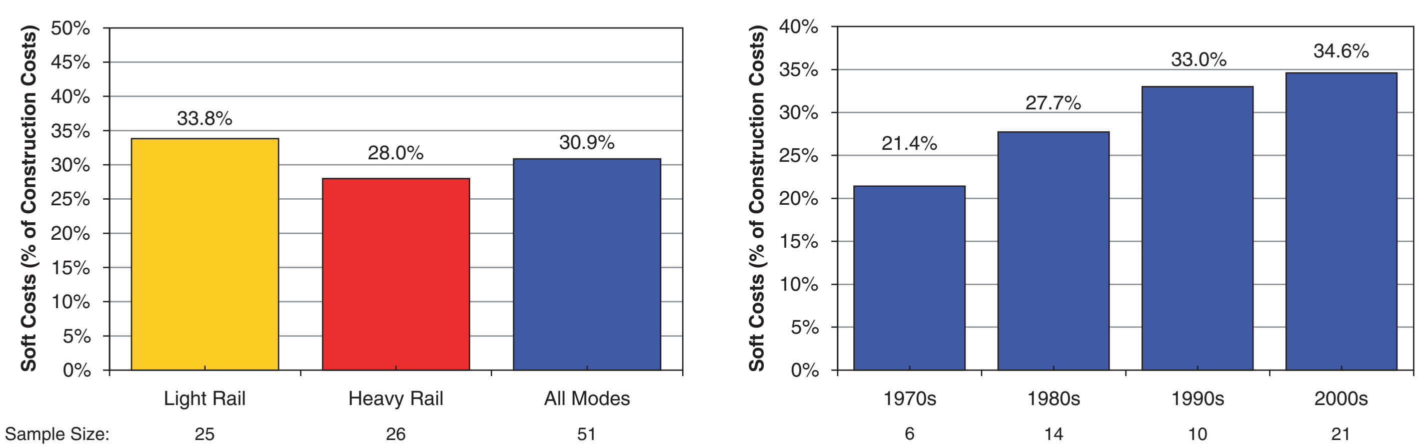


Figure 25. Average soft costs by mode and by decade.

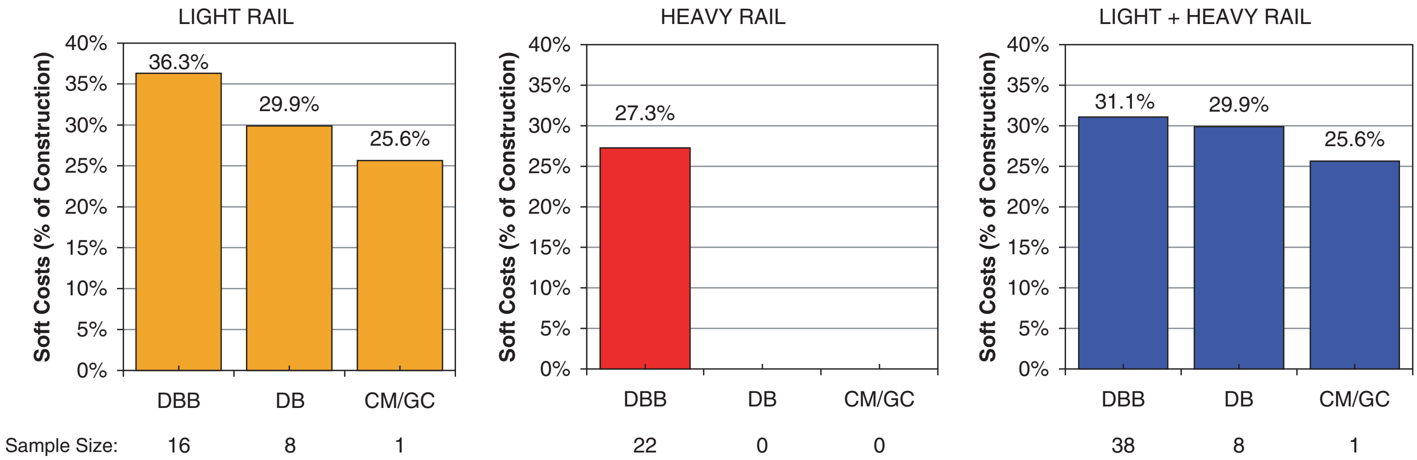


Figure 26. Soft costs as a percentage of construction versus project delivery method.

Projects selected for design–build delivery method may be chosen for their simplicity, however, so care should be exercised when considering the above chart. An agency may choose to advertise for design–build projects that would incur low soft costs regardless of delivery method. The Hudson-Bergen project, for example, was delivered with a design–build contract, which may have contributed to lower soft costs. Alternatively, design–build contractors may classify soft costs in different ways than a public agency (e.g., in the construction line item), which might make soft costs appear lower.

One of the problems with these delivery methods is that they are not yet very common in the United States, and transit agencies may not fully understand them. Some transit agencies may award a design–build or other alternative delivery contract but then continue to perform engineering work in a more traditional project delivery mode, unknowingly duplicating soft costs.

4.5.4. Soft Costs by Project Development Schedule

Figure 27 shows the effect of pre-construction duration (from planning/DEIS to construction phases) on soft costs in dollar terms. Total soft costs are presented in the left pane, and engineer-

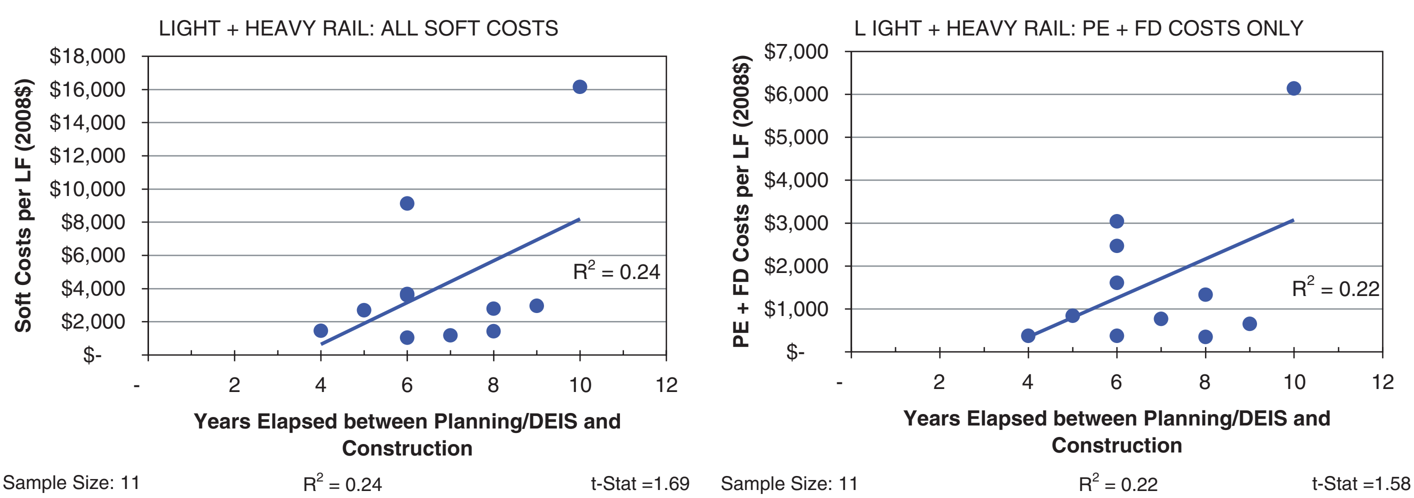


Figure 27. Soft costs per linear foot versus years elapsed between completion of the draft environmental impact statement and construction.

ing costs (preliminary engineering and final design) are presented in the right pane. In the left pane the results are pronounced, from zero soft cost at 4 years to a maximum of about $16,000 per linear foot at about 15 years between the DEIS completion and construction. This relationship holds for engineering soft costs as well, as shown in the right pane.

This finding seems to suggest that the duration of pre-construction phases should be considered within the estimate of soft costs. However, the findings in Figure 27 may simply show that costly projects take longer to plan and design. The relatively small sample size (11) and the role of one relatively costly project in this chart should be recognized in a careful consideration of these findings.

4.5.5. Soft Costs by Project Complexity

The remainder of the univariate analysis focuses on project characteristics that address complexity (such as percentage of guideway not at grade), number of stations, and other factors and the impact of these characteristics on soft costs. In general, indicators of complexity tend to correlate well with soft costs when measured in dollar terms per linear foot. Many of these relationships where soft costs are measured as a percentage of construction costs are presented in the appendices. The following figures compare soft cost percentages to the project's alignment profile and typify many of the other results addressing project complexity.

The alignment profile of new rail construction can substantially influence the technical complexity of the project. In the proposed hypothesis, as the proportion of guideway that is not at grade (in tunnels, on aerial structures, etc.) increases, complexity increases, and soft costs may increase likewise. In the first part of this analysis, "not at grade" is defined as an aerial structure, built-up fill, underground cut and cover, underground tunnel, or retained cut or fill guideway. Figure 28 shows little correlation between the proportion of alignment not at grade and soft costs as a percentage of construction costs. The light rail soft cost percentage is flat at about 40%, while heavy rail shows an increasing trend in the soft cost percentage from 25% to about 35%. The combined project database is flat at about 38%. The statistical trend line for all three relationships shows a very weak correlation (R^2 less than 0.04), and all relationships are statistically insignificant.

The issue of project complexity can be examined in another way, by measuring soft costs in terms of dollar per linear foot. Figure 29 expresses soft costs in dollars per linear foot and shows that soft costs indeed rise as greater portions of the alignment are not at grade.

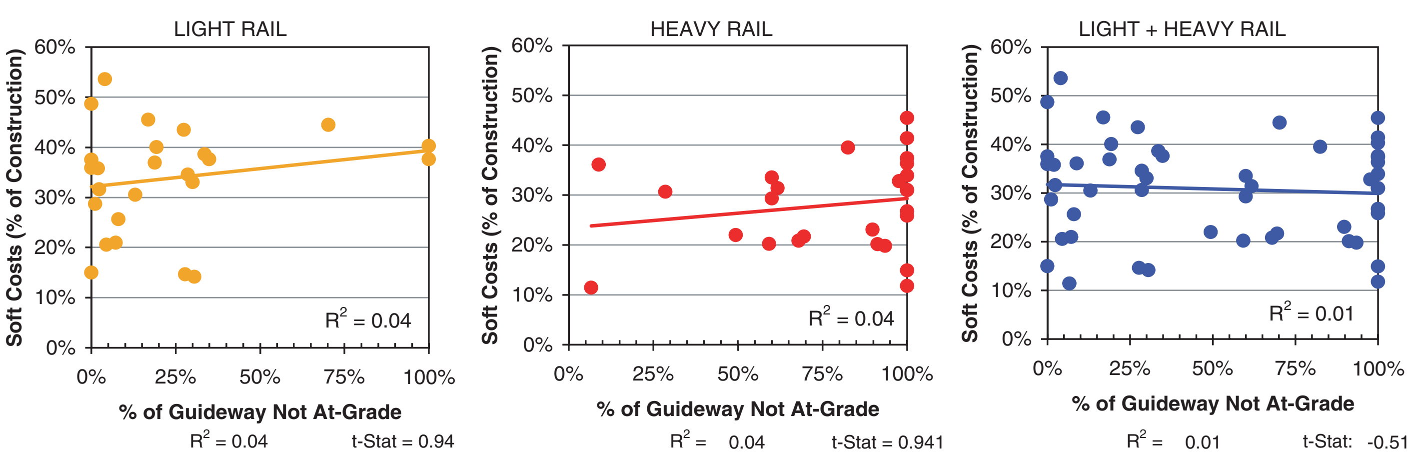


Figure 28. Soft costs as a percentage of construction versus percentage of guideway not at grade.

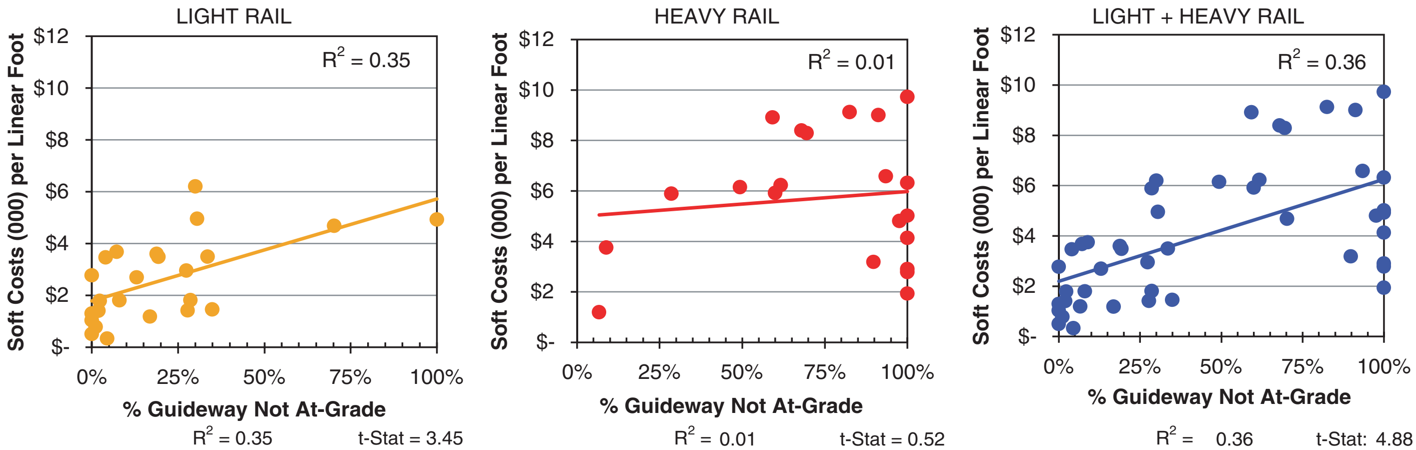


Figure 29. Soft costs per linear foot versus percentage of guideway not at grade.

As Figure 29 shows, the relationship between the percent of guideway not at grade and soft costs per linear foot is statistically significant for light rail, and for both modes combined, but not for heavy rail alone. Indeed, the R^2 value for light rail indicates that the proportion of guideway not at grade can explain about half of the variation in soft costs per linear foot for heavy rail projects. As the not-at-grade percentage of the projects increase, the soft costs as measured in dollar value terms per linear foot increase.

So while the dollar value of soft costs does measurably increase with project complexity as shown in Figure 29, the pattern is not significant enough to increase soft costs in percentage terms, as demonstrated in Figure 28.

Although it is tempting to measure soft costs in dollar value terms because this measure produces more correlation with complexity variables, it is worth exploring the measure further. One benefit of measuring soft costs in percentage terms is that the measure controls for variations in unit costs. Soft cost requirements of more expensive projects can be consistently compared to inexpensive projects in percentage terms. Measuring soft costs in dollars-per-linear-foot terms risks autocorrelation between unit costs—high soft costs could be correlated with higher other costs. In general, Figure 30 tends to confirm this hypothesis: in dollar terms, soft costs increase proportionately to construction costs. The correlations shown are strong and statistically signif-

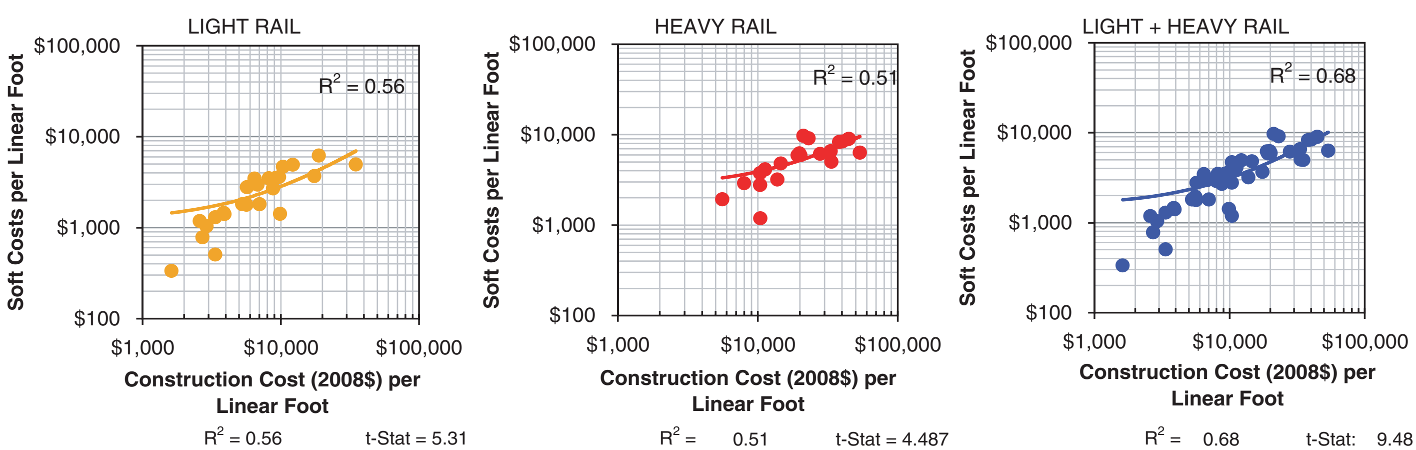


Figure 30. Soft costs per linear foot versus construction costs per linear foot on a logarithmic scale.

icant for both modes and the combined database. This trend may help explain why soft costs measured in percentage terms appear unrelated to many other variables like alignment profile—these other variables may simply drive up construction costs at the same rate.

4.5.6. Soft Costs by Other Characteristics

As the questionnaire responses and interviews with cost estimators indicated, other important determinants of soft costs are the characteristics of the sponsor agency, and the political, operational, or other circumstances under which the project is being developed.

Figure 31 shows the correlation between soft costs and the experience level of the sponsor agency (in the left pane), and the installation conditions of the project (in the right pane). The left pane shows a rough spectrum of experience levels across the x-axis, from inexperienced on the left to fairly experienced with both mode and delivery/procurement method at right. The experience level of the project sponsor has a mixed correlation with soft costs.

The right pane of figure 31 shows how the level of a project's interaction with existing transit service can affect soft costs. Specifically, the more a project must coordinate with and work around other services, the more soft costs tend to increase in percentage terms. A project to construct a new, stand-alone transit line that is not adjacent to any previous service seems to require less design costs than projects to extend or expand an existing rail line. When a construction project interacts with existing transit service in any way, more engineering and design work has typically been required in the final design phase. Working on or near an active rail right-of-way poses additional logistical challenges that must be planned for, and may also trigger additional safety requirements. Extending a rail line will mean integrating the new track and station(s) into the older infrastructure, and additional work is usually required to ensure that signal, power, safety, and other systems operate compatibly.

Figure 32 summarizes the relationship between soft costs and three other project characteristics: whether the project required a direct interface with existing service, whether political or public influence was unusually high, and whether public involvement or opposition was significant.

As Figure 32 shows, a project that requires a direct connection or interface with existing revenue service, such as a line extension, a new branch intersecting an existing line, or the rehabilitation of an existing line, tends to show somewhat higher soft costs. Projects where political influence

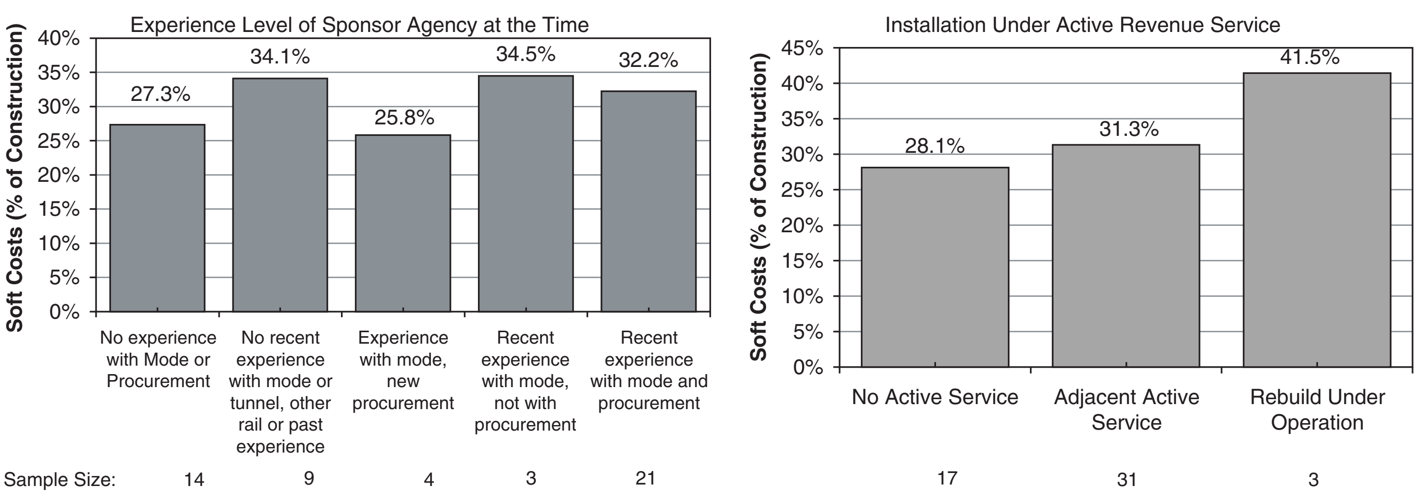


Figure 31. Soft costs versus sponsor experience level and installation conditions.

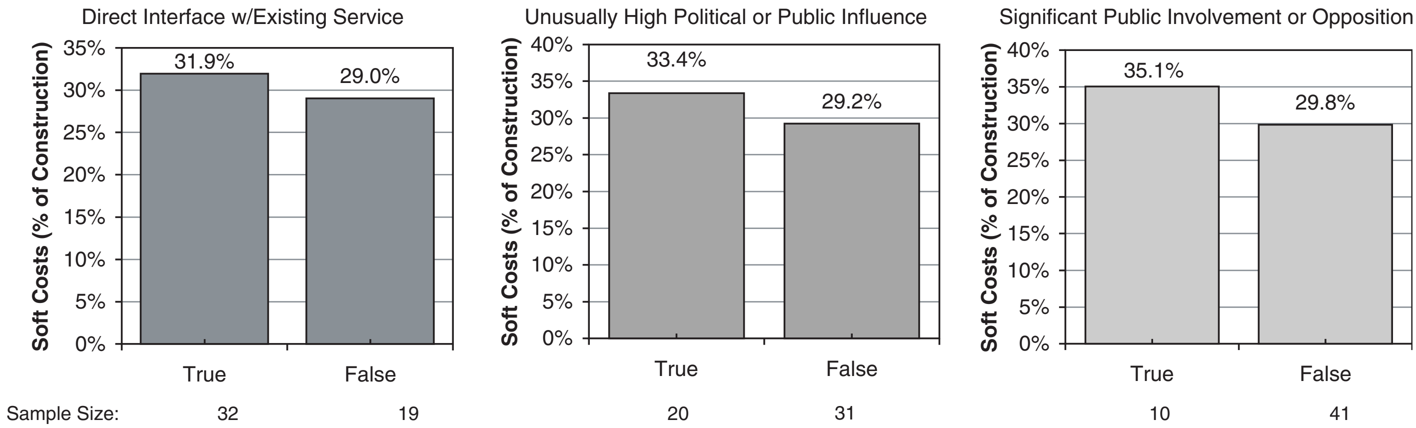


Figure 32. Soft costs versus installation conditions, political influence, and public involvement.

is unusually high or where public involvement or opposition is significant also tend to be correlated with higher soft cost percentages.

Figure 33 compares soft cost percentages to the sponsor agency's tendency to use outside contractors to varying degrees, to whether the project was ever required to be redesigned for any reason, and to whether the project's planning phase was unusually long. As the left pane shows, sponsors that make more extensive use of outside contractors in early project development phases to design and plan tend to incur somewhat higher soft cost expenditures. However, sponsors who use contractors in both the development and construction phases do not typically see significant differences in soft cost percentages.

The middle pane of Figure 33 shows that the two projects in the dataset that had to undergo significant redesign do not show significantly different soft cost percentages.

The right pane of Figure 33 demonstrates that when projects remain in development stages for an unusually long period of time (beyond approximately five to seven years), their soft cost percentages tend to increase. A significant component of engineering and design soft cost is simply the salary and benefit costs of planners working on the project. When the planning phases for a project take an unusually long time, these costs tend to continue to be charged to the project, increasing

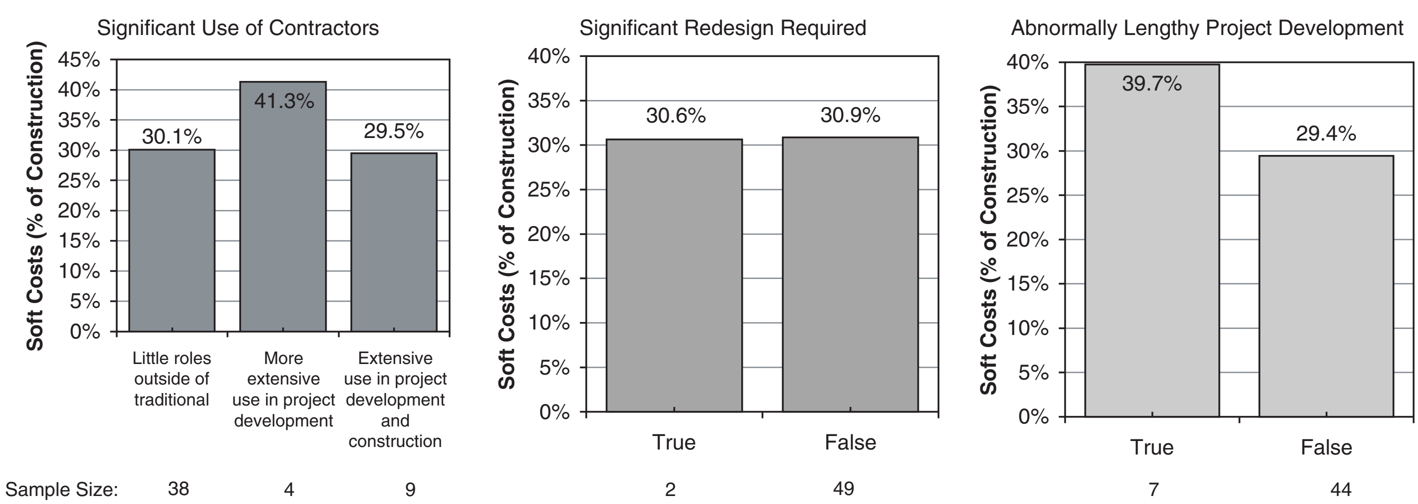


Figure 33. Soft costs versus use of contractors, redesign required, and lengthy project development phase.

overall soft costs. When a significant amount of time elapses between entering preliminary engineering and the beginning of construction, projects incur higher soft cost percentages.

4.5.7. Soft Costs by Multiple Project Characteristics

So far, this analysis has focused on testing the cost relationship between soft cost percentages and a project's characteristics one variable at a time. The next step of this analysis tests the ability of a number of variables in combination to predict the variability in soft costs between projects using multivariate regression techniques.

To do this, various combinations of variables were tested, including those variables that did not show particularly strong correlations in the univariate analysis. Soft costs as a percentage of construction costs was the dependent variable, and different combinations of project characteristics were the independent variables. Variables that described broadly similar project characteristics were grouped, and the relative contribution of each variable to the overall predictive power (R^2) of the regression was measured. In an iterative fashion, one or several variables for each broad facet of the project were retained while many other indicators were left out. The following describes the variables tested and the resulting decision.

Project Magnitude

The variables with the best ability to predict soft cost percentages were *alignment length* (in linear feet) and *construction costs,* adjusted to 2008 dollars.

It may seem counterintuitive that alignment length and construction cost in combination produced opposite signs since both measures broadly describe the magnitude of the project. However, these two measures in tandem are good predictors of soft costs and produce better statistical results together than either of them alone, one divided by another, or other measures of project magnitude such as number of stations or station density. The two variables together capture the special cases where short, expensive projects (such as a tunnel project) or long, less-expensive projects (such as service on existing right-of-way or in less developed areas) may tend to demonstrate differing soft costs.

Several other variables describing the magnitude of a project were tested but were eliminated since they contributed relatively less to the regression analysis:

- Construction costs per linear foot,
- ROW costs as a percentage of construction,
- Vehicle costs as a percentage of construction, and
- Number of stations.

Project Complexity

Of many measures of project complexity, its mode, an indicator of installation conditions (i.e., whether the project is a new standalone line with no active adjacent service or not), and an indicator of an unusually lengthy project development phase were the best predictors of soft cost percentages.

Heavy rail projects tend to incur somewhat higher soft costs than light rail, other things being equal, perhaps due to their relative complexity. This finding contrasts somewhat with that of Figure 25 because this multivariate regression controls for other factors influencing soft costs. Heavy rail projects can typically involve constructing guideway and systems that have been designed to more rigorous engineering standards that support more complex systems, move higher passenger volumes, and operate at higher speeds relative to light rail. This finding in the multivariate analysis confirms the results of the industry questionnaire and the interviews with cost estimators.

A project to construct a new, stand-alone transit line that is not adjacent to any previous service will usually require less design costs than projects to extend or expand an existing rail line. When a construction project interacts with existing transit service in any way, more engineering and design work has typically been required in the final design phase. Working on or near an active rail right-of-way poses additional logistical challenges that must be planned for and may also trigger additional safety requirements. Extending a rail line will mean integrating the new track and station(s) into the older infrastructure, and additional work is usually required to ensure that signal, power, safety, and other systems operate compatibly. Note that this variable is not statistically significant to a high degree of certainty (t-statistic of −1.25).

A significant component of engineering and design cost is simply the salary and benefit costs of planners working on the project. When the planning phases for a project take an unusually long time, beyond approximately five to seven years, these costs tend to continue to be charged to the project, increasing overall soft costs.

Other variables were eliminated due to their relatively low contribution to the regression analysis' predictive power:

- Station density (number of stations per mile of guideway constructed),
- Percentage of guideway below grade,
- Percentage of guideway not at grade,
- Rebuild or rehabilitation under operation (dummy variable),
- Project type (new service, extension of existing service, or rehabilitation of existing service), and
- Direct interface with existing revenue service required.

Delivery Method

A dummy variable indicating whether the project sponsor chose an alternative project delivery method (i.e., a method that is not the traditional design–bid–build) contributed the most to the regression analysis in a statistically significant way. Including the specific effects of a certain kind of alternative delivery method did not strengthen the regression analysis, primarily due to the small sample size of such projects.

When sponsors choose to procure their project through an alternative delivery mechanism such as design–build, design–build–own–maintain, or construction manager/general contractor, these projects have historically incurred lower soft costs. In addition, these alternative delivery methods tend to frontload more design and planning costs in preliminary engineering.

However, the lower soft costs of projects implemented with alternative delivery methods may be partially the result of differences in measurement rather than a real reduction in cost. Contractors may simply categorize their costs in different ways than transit agencies (in the construction line item, for example), which makes that project's soft costs as a percent of construction appear low.

Sponsor Agency Characteristics

An indicator of whether the sponsor agency tended to minimize capital charges contributed the most to the regression. A dummy variable indicating if the sponsor agency tended to rely heavily on outside contractors during project development phases did not demonstrate significant power to predict soft cost percentages, and was excluded.

When a transit agency sponsors a construction project, it usually contributes some of its own labor and even materials. Agency employees often inspect construction activities, monitor safety, administer the contract, acquire property, manage the project, and perform many other tasks. As opening day approaches, agency staff contribute time coordinating testing, training, safety inspections, and shared tasks with other agencies. The agency chooses whether to charge these expenditures to the capital project (either directly or as an overhead-type allocation) or to absorb them into the operating budget, and project sponsors each have different internal policies for this.

External Factors

Of many indicators of the broader circumstances in which a project is developed, two variables stood out: economic conditions and unusual political influence.

The overall health of the economy, as well as the level of construction activity, can affect the construction bids a transit project sponsor can expect to receive. If the construction sector or economy at large is in a downturn when a project sponsor accepts bids, contractors may reduce their bids due to economic forces. In this case, soft costs computed as a percentage of the engineered construction cost estimate might look relatively higher simply because the bid construction cost is lower. Historically, some change in soft costs can be attributed to the rate of gross domestic product (GDP) growth when construction contracts are bid, after accounting for other variables. Although GDP growth rises and falls with the economy, it has historically risen an average of 2.5% to 3.0% per year. However, it is difficult to use this driver to estimate soft costs for a project years away from construction since future GDP growth is difficult to predict. The Guidebook therefore recommends using this cost relationship only when a cost estimator can be reasonably sure the project is to be bid within one year.

When public involvement or political pressures are high, such as in a contentious design and planning process, soft costs tend to rise relative to construction costs. When, for example, multiple planning boards, citizen advisory councils, and officials must approve the design and could even call for a redesign, these external factors were shown to increase soft costs.

Other measures of project context and external circumstances contributed less to the regression analysis and were excluded:

- Unusually high public involvement and/or opposition (dummy variable),
- Major project redesign required (dummy variable), and
- Decade.

The multivariate regression also used midyear of expenditures as an independent variable. As Figure 25 showed earlier, soft costs have been rising over time, so including this variable controls for the effect of the historic rise in soft costs. However, in estimating soft costs for a given project, the Guidebook does not recommend increasing soft cost percentages for future projects.

Extension regression analysis yielded a 10-variable equation that can explain approximately 60% of the difference in soft cost percentages by variations in the projects' characteristics ($R^2 = 0.58$). Table 15 shows the resulting coefficients from this regression, whose dependent variable is total soft costs as percent of construction costs.

Table 15. Multivariate regression results on soft costs as a percentage of construction costs.

Variable Name	Unit	Coefficient	t-Stat
Guideway alignment length	10,000 linear feet	1.4%	2.69
Construction costs	Billions, 2008$	-5.9%	-2.49
Mode	Dummy, heavy rail = 1	6.0%	1.64
Installation conditions	Dummy, no active service = 1	-3.8%	-1.25
Delivery method	Dummy, non-DBB = 1	-7.2%	-2.10
Economic conditions	GDP % annual growth	-1.4%	-2.34
Unusually long project development phase	Dummy, yes = 1	7.1%	2.08
Unusual political influence	Dummy, yes = 1	6.6%	2.22
Agency tendency to minimize capital charges	Dummy, yes = 1	-6.0%	-1.65
Years from 2008	Years	-0.4%	2.22

Using the projects contained in this FTA capital cost database, the strongest correlation that could be produced is the regression described above. After testing many combinations of explanatory independent variables, these 10 could best predict the relationship between soft and hard costs. Although the strength of this correlation is not ideal (the R^2 and t-statistics are relatively small), the relationship does highlight the importance of judgment in cost estimation. In addition, as more projects are included in this cost database, it may be possible to perform analysis with stronger cost relationships.

4.5.8. Preparing Multivariate Results for Use in Guidebook

Alternative multivariate regressions were examined using different actual soft cost components (rather than total soft costs) as the dependent variable. The coefficient from the overall soft cost analysis was distributed to the soft cost components that correlated to the project characteristics in a statistically significant way. For example, alignment length showed an overall coefficient of around 1.4% per 10,000 linear feet regressed against overall soft costs, and this relationship was strongest when regressed against project management and other soft costs, so the Guidebook recommends adjusting the percentage estimate for those two components to a total of 1.4% per 10,000 linear feet.

Finally, the starting points and recommended percentage adjustments were validated against the original projects to gauge the potential error in the Guidebook methodology. Some minor adjustments to the coefficients were made to minimize the sum of each component's root mean square error for all projects.

CHAPTER 5

Conclusion

This Final Report presents the research, data sources, and analysis underlying *Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects, Part 1: Guidebook,* which came out of TCRP Project G-10. This Final Report is intended to support the information summarized in the Guidebook in Part 1. Please refer to the Guidebook in Part 1 for a summary of how the results of the research presented here can be applied to practice, including an introduction to soft costs and a new methodology to estimate these soft costs based on historical projects.

This conclusion section summarizes the key points from previous sections, and presents objectives for future research.

5.1. Literature Review

While the term "soft costs" is often similar to "indirect costs" or other terminology, the FTA's definition of Standard Cost Category 80, Professional Services, is an operational definition considered equivalent to soft costs for this report and consistent with the financial, construction, and related literature.

5.2. Soft Cost Estimation: State of the Practice

Cost estimators for transit construction projects follow different approaches to estimating soft costs depending on the phase of the project.

During alternative analysis through preliminary engineering, soft costs are estimated for each cost component as a percentage of hard construction costs. Estimators begin with a range of percentages for each soft cost component and apply a value within that range to a specific project based on knowledge about the project and its sponsor. Figure 34 shows the percentages used for each cost component by each cost estimator questioned for this research.

For each cost component, estimators choose one percentage from within that range based on historical experience and their knowledge of the specific project characteristics.

During the final design and construction phases, estimates of soft costs based on a percentage of construction cost are replaced with more closely tailored, bottom-up estimates relying heavily on past experience with similar projects, as indicated earlier. Estimators usually perform a resource-driven analysis for each cost element. For instance, administration costs may be estimated based on headcount and construction schedules.

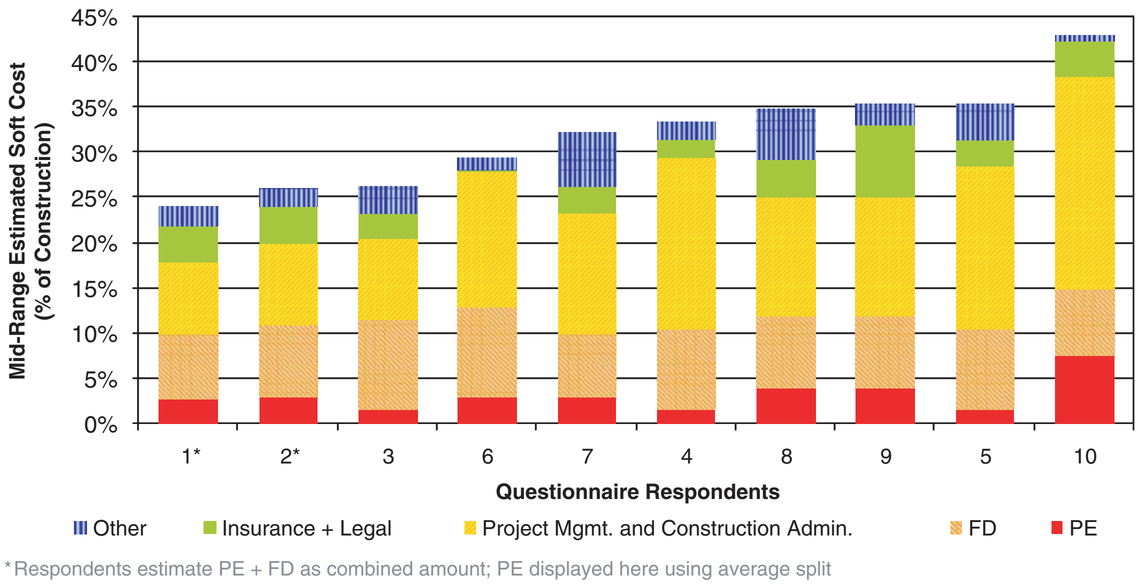


Figure 34. Midpoint soft cost estimates for all components reported by surveyed cost estimators.

5.3. As-Built Cost Analysis

Analyzing the database of actual as-built soft cost expenditures provided the following insights into soft costs:

- Soft costs have historically averaged 31% of construction costs, a value that is consistent with how the industry currently estimates soft costs both in total and at the component level.
- However, the range of variability in past projects has been wider than the range estimators report. While estimators report an uncertainty range of ±10%, actual soft costs have been as low as 11% of hard costs and as high as 54% of hard costs, or an uncertainty range of around ±20%.
- Soft costs have averaged around $2,600 per linear foot for light rail, and around $5,700 per linear foot for heavy rail, with a range between $300 and $10,000 per linear foot of guideway for both modes (2008$, outliers removed).

The as-built analysis also revealed relationships between project characteristics and soft costs:

- Soft costs have been increasing over the past four decades, particularly for heavy rail projects.
- Project complexity, mode, delivery method, magnitude, and context all appear to drive soft costs. Univariate analysis reveals some relationships between these considerations and soft costs, but a more complete and consistent picture emerges through a multivariate regression analysis. A multivariate analysis of 10 variables captured the cumulative effect of a number of variables on soft cost percentages and was able to explain approximately 60% of variability in soft costs.
- Projects where alignments stretch longer distances tend to incur somewhat higher soft costs as a percentage of construction cost.
- More expensive construction projects tend to display somewhat smaller soft cost percentages, other things being equal.
- Heavy rail projects tend to incur somewhat higher soft costs than light rail, perhaps due to their relative complexity and higher engineering standards.
- A project to construct a new stand-alone transit line will usually require less design costs than a project to extend, expand, or interface with existing transit services.

- Projects procured with alternative delivery methods such as design–build appear to have incurred less soft costs.
- The health of the national economy and the level of construction activity can affect the relationships between soft and hard costs.
- Longer project planning phases, unusual political influence, and a sponsor agency's capitalization policies may increase soft cost requirements.
- In the end, cost relationships based in historical evidence cannot explain 100% of the variability in soft costs. Therefore, soft cost estimation must blend the art of human judgment with the science of cost relationships.

5.4. Future Research Directions

More in-depth research into the documentation of one or several recent construction projects will enhance the understanding of soft cost drivers. Moreover, a comprehensive industry outreach will provide further insight on context-specific soft cost estimation practices. Finally, the methodology to estimate soft costs for public transportation infrastructure projects developed here is based on past heavy and light rail construction projects and is therefore not entirely applicable to other prevalent public transportation capital infrastructure projects such as BRT, commuter rail, streetcar, or other state-of-good-repair projects to repair or replace aging infrastructure. Additional data and research would help estimate soft costs for these kinds of projects.

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APPENDIX A

Cost Estimators Interviewed

The following section presents the experience and qualifications of the professional cost estimators interviewed for this research.

Cesare DeRose, a vice president with AECOM Transportation, has over 25 years of experience in the field of heavy construction. Projects Mr. DeRose has worked on have been in the $1 to $200 million range. Typical duties have included cost estimating, scheduling, engineering, design, constructability, project management, site supervision, and project planning in all types of involved engineering tasks. Mr. DeRose has worked on many large projects, including the Lincoln Center Development Corporation, preliminary and final design of the Second Avenue Subway, the New York City Water Tunnel project, the Queensboro Bridge, the Charles River Bridge crossing in Boston, the Amawalk and Titicus dams, rehabilitation of the Brooklyn Battery Tunnel, the Tappan Zee fender replacement, and the Hillview Reservoir wall extension and sediment removal. In addition to this, his involvement has been with bridge, highway, and other heavy construction; sewer and utility work; foundation supports; marine construction; and commercial rehabilitation.

James T. Czarnecky, AICP, a senior project manager with AECOM Transportation, is a nationally certified professional planner (AICP) and Master of Community Planning (MCP), and has 19 years of transportation planning and civil engineering experience. He has managed and participated in all phases of project development, including systems planning, major investment studies (MIS), alternatives analysis, environmental impact statements, preliminary engineering, and final design and construction support. He specializes in the development and analysis of multimodal transportation networks, inclusive of transit and highway components designed to complement the foreseeable socioeconomic conditions and related planning initiatives unique to each community. Mr. Czarnecky is focused on a realistic approach to solving transportation problems with respect to the balancing of costs and benefits.

Raul V. Bravo, president of Raul V. Bravo & Associates Inc., has over 40 years of experience in the design, development, construction, and implementation of transportation vehicles and systems. Since 1974 Mr. Bravo has been primarily involved with guided transportation; first as engineering manager for Rohr Industries and later as Amtrak's director of equipment design and operations planning; since 1979, Mr. Bravo has been managing director of Raul V. Bravo & Associates Inc., transportation planners and engineers, located in the Washington, DC, metropolitan area. Mr. Bravo is a member of the Railroad Safety Advisory Committee (RSAC) assisting the Federal Railroad Administrator in developing new rules and regulations. Mr. Bravo is also a member of TRB committees examining the future of intercity passenger rail in the United States and management structures, and standardization of rail systems and vehicles.

APPENDIX B

Project Names and Descriptions in As-Built Analysis

This appendix provides a key of the abbreviated names for the projects identified in this analysis and offers a short description of each project. The project descriptions and graphics below provide a brief snapshot of the variety of projects contained in the capital cost databases used in this analysis.

B.1. Data Sources for Project Descriptions

While the detailed capital costs are from FTA cost databases, the following descriptions were developed from the following data sources:

- FTA's *Light Rail Transit Capital Cost Study Update,* 2003 (3–6)
- FTA's *Annual Report on New Starts,* various years (2006–2009), Alphabetical List of Projects by Development Phase and State, Full Funding Grant Agreements, Appendix A: New Starts Project Profiles
- Project information and fact sheets from project sponsors
- Transit agency/project sponsor websites
- Internet sources

Table 16. Data on projects included in as-built cost analysis.

Abbreviated Name	Full Project Name	Approx. Length (mi)	Midyear of Expend.	Mode	Delivery Method
Sacram. I	Sacramento Stage I	20.6	1985	Light	DBB
Pittsburgh I	Pittsburgh Light Rail Stage I	24.5	1984	Light	DBB
Portland Seg1	Portland MAX Segment I	15.0	1984	Light	DBB
LA Blue	Los Angeles – Long Beach Blue Line	22.6	1987	Light	DBB
San Jose N	San Jose North Corridor	20.8	1985	Light	DBB
Hud-Berg I	Hudson-Bergen MOS-I	8.7	1999	Light	DB
Hud-Berg II	Hudson-Bergen MOS-II	6.1	2000	Light	DB
Hiawatha	Hiawatha Corridor	11.6	2001	Light	DB
Portland Int	Portland Interstate MAX	5.8	2002	Light	DB
San Diego	San Diego Mission Valley East	5.5	2003	Light	DBB
St. Louis	St. Louis St. Clair County Extension	17.4	1999	Light	DBB
Salt Lake	Salt Lake North-South Corridor	15.0	1998	Light	DBB
South NJ	Southern New Jersey Light Rail Transit System	34.0	2002	Light	DB
Portland W	Portland Westside/Hillsboro MAX	18.0	1996	Light	DBB
Sacram. So	Sacramento South Corridor	6.3	2002	Light	DBB
Sacram. Fol	Sacramento Folsom Corridor	11.4	2002	Light	DBB
LA Gold Pasa	Pasadena Gold Line	13.7	2002	Light	DB
Denver SW	Denver Southwest Corridor	8.5	1999	Light	DBB
Pittsburgh II	Pittsburgh Light Rail Stage II	5.5	2002	Light	DBB
LA Gold East	Los Angeles Eastside Gold Line	5.9	2006	Light	DB
Phoenix	Phoenix Central/East Valley Light Rail Line	19.6	2008	Light	DB
Portland So	Portland South Corridor	6.5	2005	Light	CM/GC
Seattle Cen	Seattle Central Link Light Rail Project	13.9	2006	Light	DBB
Pittsburgh N	Pittsburgh Northshore Light Rail Connector	1.2	2008	Light	DBB

Table 16. (Continued).

Abbreviated Name	Full Project Name	Approx. Length (mi)	Midyear of Expend.	Mode	Delivery Method
Charlotte	Charlotte South Corridor	9.6	2005	Light	DBB
VTA Tas W	VTA Tasman West	7.6	1999	Light	DBB
VTA Tas E	VTA Tasman East	4.9	2004	Light	DBB
VTA Capitol	VTA Capitol Segment – Connected to Tasman East	3.3	2004	Light	DBB
VTA Vasona	VTA Vasona Segment	5.3	2005	Light	DBB
MARTA N-S	Atlanta MARTA North-South Line	22.2	1984	Heavy	DBB
MARTA Dun	Atlanta MARTA North Line Dunwoody Extension	7.0	1998	Heavy	DBB
MBTA Orang	Boston MBTA Orange Line	4.7	1983	Heavy	DBB
Baltimore	Baltimore MDMTA Metro Sections A and B	15.0	1982	Heavy	DBB
CTA Orange	Chicago CTA – Southwest Orange Line	9.0	1990	Heavy	DBB
CTA O'Hare	Chicago CTA – O'Hare Extension Blue Line	7.1	1981	Heavy	DBB
CTA Brown	Chicago CTA Brown Line (Ravenswood) Rehabilitation	9.1	2006	Heavy	DBB
CTA Douglas	Chicago CTA Blue Line (Douglas) Rehabilitation	5.6	2002	Heavy	DBB
LA Red 1	Los Angeles Red Line Segment I	3.4	1988	Heavy	DBB
LA Red 2	Los Angeles Red Line Segments 2A & 2B	6.7	1994	Heavy	DBB
LA Red 3	Los Angeles Red Line Segment III	6.5	1998	Heavy	DBB
Miami	Miami Dade Metrorail	21.0	1982	Heavy	DBB
San Juan	San Juan Tren Urbano	10.7	2002	Heavy	DBB
BART SFO	San Francisco, CA BART SFO Extension	8.7	2002	Heavy	DBB
DC Shady G	Washington, DC – Shady Grove (A Route)	18.0	1977	Heavy	DBB
DC Glenmt 1	Washington, DC – Glenmont (B Route)	5.7	1980	Heavy	N/A
DC Glenmt 2	Washington, DC – Glenmont Outer (B Route)	6.2	1996	Heavy	N/A
DC Huntgtn	Washington, DC – Huntington (C Route)	12.1	1977	Heavy	DBB
DC New Ca	Washington, DC – New Carrollton (D Route)	11.8	1974	Heavy	DBB
DC U St.	Washington, DC – U Street (E Route)	1.7	1988	Heavy	DBB
DC Greenblt	Washington, DC – Greenbelt Mid (E Route)	2.3	1997	Heavy	DBB
DC Anacost	Washington, DC – Anacostia (F Route)	4.3	1988	Heavy	DBB
DC Anacost O	Washington, DC – Anacostia Outer (F Route)	6.7	1999	Heavy	DBB
DC Addison	Washington, DC – Addison (G Route)	3.5	1978	Heavy	DBB
DC Springfld	Washington, DC – Springfield (J,H Route)	3.5	1988	Heavy	DBB
DC Vienna	Washington, DC – Vienna (K Route)	12.0	1980	Heavy	DBB
DC L'Enfant	Washington, DC – L'Enfant (L Route)	1.7	1974	Heavy	DBB
Phil Frankf.	Philadelphia SEPTA Frankford Rehabilitation	5.3	1997	Heavy	DBB
NYCT 63rd	New York NYCT 63rd Street Tunnel	0.4	1977	Heavy	N/A
NYCT Stillw	New York NYCT Stillwell Terminal Rehabilitation	0.3	2000	Heavy	N/A

B.2. Project Descriptions

Sacramento Stage I — Sacramento, CA

Label: Sacram. 1

The Sacramento Stage I project included a 20.6-mile light rail system with two lines, the Northeast (Blue) and Folsom (Gold) lines, which connect the eastern and northeastern suburbs to downtown Sacramento. The segment is mostly single-track, with double-tracking in passing sections for about 40% of its length. The alignment is largely at grade and is located on existing rights-of-way in freeway medians and abandoned railroad corridors.

Pittsburgh Light Rail Stage I — Pittsburgh, PA

Label: Pittsburgh 1

The Stage I Light Rail Transit Program in 1980 to restore light rail transit service on the old trolley routes connecting the South Hills suburbs with downtown Pittsburgh. Stage I consisted of 12.5 miles of new alignment construction and 12 miles of right-of-way rehabilitation. In 1985 the first segment started operating for 1.6 miles underground in the downtown business district and at grade south of the Monongahela River to the South Hills Village.

Portland MAX Segment I — Portland, OR

Label: Portland Seg1

The Portland MAX Segment I construction project resulted in the opening of the first modern light rail line in Portland in 1986. A 15-mile east-west alignment, named the Banfield Corridor, was built mostly at grade with some elevated portions along joint highway alignments. It extended from the Cleveland Avenue station in Gresham to downtown Portland. The Segment I alignment permits trains to operate in reserved rights-of-way in city streets, arterials, and highway medians. Of the 30 stations built, 25 are at grade, less than a mile apart, and have easy access for pedestrians. Stations generally lack park-and-ride facilities but have bus transfer facilities with good intermodal coordination. MAX Segment I was the first segment to open on the present day Hillsboro-Gresham (Blue) line that was extended in 1998 with the opening of the Portland Westside/Hillsboro MAX segment.

Los Angeles—Long Beach Blue Line — Los Angeles, CA

Label: LA Blue

The Blue Line is a modern light rail transit line in Los Angeles and primarily uses the original Pacific Electric right-of-way. It provides riders from the communities of Vernon, Huntington Park, South Gate, Watts, Compton, Carson, and Long Beach with access to downtown Los Angeles and the greater Metro system. The 22.6-mile line required 22 stations and connects at its downtown terminus to the Metro heavy rail lines at the 7th Street/Metro Center station. Its southern termini stations are in the 4-station loop in downtown Long Beach. Approximately 80% of the line is a dedicated alignment, mostly at grade or elevated with an underground portion. Construction began in October 1987 and revenue service commenced in July 1990. This project encountered some complications in planning and design due to unexpected environmental review, state environmental laws, and an active political and stakeholder environment.

San Jose North Corridor — San Jose, CA

Label: San Jose N

Revenue service commenced in December 1987 in a small segment of the San Jose North Corridor that would become the first section built of a longer San Jose Guadalupe Corridor that would require two phases to reach completion. The full 20.8-mile North Corridor was completed and servicing passengers in April 1991. This project's alignment is mainly located along the median area of major roadways and a transitway through downtown San Jose. The alignment is at grade for nearly the full length and required only one bridge, two overpasses, and a short underpass to be built in the new guideway. The guideway is double-tracked for its entirety except for two small sections of single-track operation.

Hudson-Bergen MOS-I — Newark, NJ

Label: Hud-Berg I

The first two lines of the Hudson-Bergen Light Rail began full revenue operations in 2002. (Service had opened in three phases between 2000 and 2002.) The project included 8.7 miles of double-tracking and 14 stations (including intermodal transfer stations). The fully built segment starts at the Hoboken Terminal and runs south towards the Liberty State Park station after which the 22nd Street-Hoboken (Blue) and West Side Avenue-Tonnelle Avenue (Orange) lines separate with the latter running a 3-station spur line to western Jersey City. The alignment of the 22nd Street-Hoboken Terminal line continues south from the Liberty State Park junction parallel with the I-78 and Garfield Avenue corridors and then along Avenue E, terminating at the 22nd Street station.

This project encountered some soft cost complexities when the project underwent an engineering redesign after the sponsor had executed design–build contracts and had begun utility relocation.

Hudson-Bergen MOS-II — Newark, NJ

Label: Hud-Berg II

This project included a new light rail line from the Hoboken Terminal station to North Bergen County (the green-colored Tonnelle Avenue-Hoboken Terminal Line). In addition, a station was added to the Blue Line, moving the southern terminus from the 34th Street station to the 22nd Street station. The completed project required 6.1 miles of track and 7 new stations. The MOS-2 segment opened for revenue service in increments from 2003 to 2006.

Hiawatha Corridor — Minneapolis, MN

Label: Hiawatha

The Hiawatha Corridor LRT project included an 11.6-mile light rail transit line with 17 stations that operates primarily in the Hiawatha Avenue/Trunk Highway 55 Corridor linking downtown Minneapolis to the Mall of America in Bloomington and also servicing the Minneapolis-St. Paul International Airport. The alignment includes a 1.5-mile tunnel under the airport runways. Revenue operations began in December 2004.

Portland Interstate MAX — Portland, OR

Label: Portland Int

The Portland Interstate MAX Light Rail Project included a 5.8-mile, 10-station light rail transit line (Yellow) that extends north from downtown Portland parallel to the I-5 Corridor. The line branches from the existing Blue Line in the Rose Quarter District, follows the median of Interstate Avenue for 4.5 miles, between the Albina and Overlook Park stations, to Kenton, and then is on a separate alignment to the Portland Exposition Center terminus, which is just south of the Columbia River. The original design called for the line to extend across the river to Vancouver, Washington, but Tri-Met scaled back alignment options after Portland voters rejected a bond measure. This project's alignment near an active highway also raised design complexities. The project opened to revenue service in May 2004.

San Diego Mission Valley East — San Diego, CA

Label: San Diego

The Mission Valley East (MVE) project included in a new double-track light rail line that runs from the Mission San Diego Trolley station east of I-15 to the Grossmont Center Trolley station. The new line provides important connectivity between the pre-existing Blue and Orange Lines, as well as San Diego State University, which was an active stakeholder in the design process. The 5.9-mile project required 4 new stations and the renovation of an existing station. The project opened for revenue service in July 2005.

St. Louis St. Clair County Extension — St. Louis, MO

Label: St. Louis

The St. Clair County Metrolink Extension Project is a three-phase light rail construction project that will eventually extend service over 26 miles from East St. Louis, IL, to the MidAmerica

Airport in St. Clair County. The Phase 1 segment opened for revenue service in May 2001. It is a 17.4-mile Minimum Operable Segment (MOS) light rail extension of the existing Red Line from the prior terminus at the 5th & Missouri station in East St. Louis to the College Station. The project required 8 new stations, 7 park-and-ride lots, 20 new LRT vehicles, and a new vehicle maintenance facility.

Salt Lake North-South Corridor — Salt Lake City, UT

Label: Salt Lake

The North-South Corridor included construction of the SLC-Sandy line, which opened for revenue service in 1999 from the Arena Station to the Sandy Civic Center Station. The original 15-mile light rail alignment starts on South Temple, turns right onto Main Street, right at 700 South, left at 200 West, and then follows the Union Pacific (UP) corridor. The remainder of the alignment goes south within the UP corridor to the 10000 South (Sandy Civic Center) station. The original line was mainly built with double-tracking, with two single track sections at the I-215 overpass and the State Street Bridge (U.S. Highway 89), and had 16 stations.

Southern New Jersey Light Rail Transit System — Trenton, NJ

Label: South NJ

The Southern New Jersey Light Rail Transit System, known as the “River Line,” was built for intercity travel in the southwestern part of the state. The line has 20 stations between Trenton and Camden, near Philadelphia. The 34-mile light rail system runs roughly parallel to New Jersey Highway Route 130 in the former Conrail right-of-way adjacent to the Delaware River. The line’s construction required upgrading 50 at-grade crossings on local streets and the reconstruction of 20 bridges. Stations connect to other public transport services offered by NJ TRANSIT, PATCO, SEPTA, and Amtrak to provide passengers with easy connections to New York City, Philadelphia, Trenton, and Atlantic City. Construction began in May 2000, and revenue operations began in 2004.

Portland Westside/Hillsboro MAX — Portland, OR

Label: Portland W

The Westside/Hillsboro extension is an 18-mile light rail extension to the TriMet MAX Blue line from downtown Portland to Beaverton and Hillsboro. While TriMet, the sponsor agency, initially considered designing an alignment that runs at 6% grade to cross the West Hills, which rise 700 feet higher than the downtown area, this plan was eventually changed in favor of a 3-mile twin tube tunnel. The alignment emerges from the twin tube tunnel, which includes the Washington Park Station at 260 feet below ground, to follow Highway 26 to the Sunset Transit Center before turning onto Highway 217. The alignment approach at the Beaverton Transit Center required newly constructed right-of-way. The line eventually ends on 12th Avenue in Hillsboro before terminating on Washington Street. Revenue operation began in 1998.

Sacramento South Corridor — Sacramento, CA

Label: Sacram. So

The Sacramento South Corridor includes a 6.3-mile light rail line with 7 stations that spurs southward at the 16th Street station from the original Sacramento Light Rail alignment. The constructed section originates in downtown Sacramento at the intersection of 16th and Q streets and follows the Union Pacific freight corridor until it terminates at the Meadowview Road station. The extension opened for revenue operation in 2003.

Sacramento Folsom Corridor — Sacramento, CA

Label: Sacram. Fol

The Sacramento Folsom Corridor light rail project was built to extend transit service within a corridor following Highway 50 to downtown Folsom. The 10.7-mile suburban extension required 9 stations between the Mather Field/Mills station and downtown Folsom. In addition, the Sacramento Valley station (adjacent to the Amtrak station) was built and connected via a new 0.7-mile double-track extension to the existing 8th & K station. The connection to Amtrak service required additional boarding platforms to be constructed at existing stations.

Pasadena Gold Line — Los Angeles, CA

Label: LA Gold Pasa

The Pasadena Gold Line runs 13.7 miles, stopping at 13 stations, to connect Chinatown, Highland Park, South Pasadena, and Pasadena to downtown Los Angeles via Union Station (its western terminus). At Union Station this light rail line provides walking connections to the Red and Purple heavy rail lines. Construction commenced in 1994 and revenue operations were scheduled to begin in May 2001. Unfortunately, a lack of funding and other complications resulted in construction stoppage. The state of California authorized the creation of the Metro Gold Line Construction Authority in 1998 with the sole purpose of immediately instituting tighter cost controls and resuming design, contracting, and construction of the Los Angeles to Pasadena Metro Gold Line. The newly formed construction authority completed construction in three years and the line opened for revenue service in 2003.

Denver Southwest Corridor — Denver, CO

Label: Denver SW

The Southwest Corridor line was built to connect the southern portion of Denver with its downtown via the already operational Central Corridor at the I-25 & Broadway station. The extension added 8.5 miles and 5 stations of service to the growing Denver light rail system. The extension is entirely grade-separated from the I-25/Broadway station to the Mineral Avenue station in Littleton, Colorado. This project planning phase spent some time addressing complexities arising from the need to accommodate through-routing of trains. Revenue service on the extension began in 2000.

Pittsburgh Light Rail Stage II — Pittsburgh, PA

Label: Pittsburgh II

The Stage II LRT Priority Project included the reconstruction of the Overbrook line, a 5.5-mile existing rail line, which had closed in 1993 because of the deterioration of old bridges. This included rebuilding the existing light rail track bed, new bridges, and retaining walls through its entire length. The first segment connected with the existing operating light rail system at the South Hills Junction on its northern end and with the Castle Shannon Junction at its southern end. These operational challenges resulted in some design complexities. The service opened in June 2004.

Los Angeles Eastside Gold Line — Los Angeles, CA

Label: LA Gold East

The eastside extension will provide transit access from the east side of Los Angeles to the regional Metro system. The 5.9-mile eastside extension of the Gold Line will be primarily at grade, with a 1.8-mile mid-section tunnel. It will originate at Union Station in downtown Los Angeles, where it connects to the Pasadena extension of the line and the heavy rail lines. The project alignment runs eastward along Alameda Street, 1st Street, and 3rd Street before terminating just before the intersection of Pomona and Atlantic Boulevards. This project was originally designed as a heavy rail line, but was altered to light rail because of funding constraints. Construction began in 2004 and revenue operation is scheduled to begin in late 2009.

Phoenix Central/East Valley Light Rail Line — Phoenix, AZ

Label: Phoenix

After some initial complications in the early planning phases, the City of Phoenix and Valley Metro Rail, Inc., a nonprofit public corporation in charge of the design, construction, and operation of the regional light rail system, partnered to construct a 19.6-mile, 27 station light rail system. The system's alignment, located primarily in the street median from 19th Avenue and Bethany Home Road, starts in north central Phoenix and runs through the City of Tempe to the intersection of Main Street and Longmore in Mesa. The City of Phoenix entered into a Full Funding Grant Agreement (FFGA) in January 2005, construction started the same month, and revenue operations began in December 2008.

Portland South Corridor — Portland, OR

Label: Portland So

The Tri-County Metropolitan Transportation District (TriMet) and Portland Metro, the region's metropolitan planning organization, are constructing 8.3 miles of new light rail transit consisting of two segments connecting to the existing "MAX" LRT system along Interstate 84. The South Corridor Extension will provide a new rail line, "the Green Line," from Clackamas Town Center to Portland State University (PSU). A portion of the Green Line will merge with and share 6.2 miles of the existing Blue Line along I-84 before continuing in the right-of-way of I-205 from the Gateway/NE 99th Avenue Transit Center to a new rail transit center at the Clackamas Town Center. The I-205 alignment is 6.5 miles of double-tracked and at-grade line with several grade-separated roadway crossings. The alignment in downtown Portland will run along the North-South Transit Mall Portland Union Station to the PSU campus while providing connectivity to the Red Line. The project includes 8 bi-directional stations for the I-205 segment and 14 unidirectional stations along the downtown Portland Mall alignment, with 7 on each leg of the one-way loop. Revenue operation is scheduled to begin in September 2009.

Seattle Central Link Light Rail Project — Seattle, WA

Label: Seattle Cen

Central Puget Sound Regional Transit Authority (Sound Transit) is constructing a 13.9-mile double-track light rail system for the initial segment of the Central Link Light Rail transit project. This segment is scheduled to open for revenue operations in July 2009. Its alignment runs from Westlake Center station through downtown Seattle to the Tukwila International Boulevard station. The system will use the existing 1.3-mile Downtown Seattle Transit Tunnel (DSTT), a new 1-mile long Beacon Hill tunnel, and a new 0.1-mile tunnel used for crossover and turnback operations. The scope of work includes 7 new stations, the renovation of 4 stations in the DSTT, a maintenance and operations facility, and a park-and-ride lot at the Tukwila International Blvd. station. A 1.7-mile extension to the Seattle-Tacoma Airport is scheduled to open in late 2009.

Pittsburgh Northshore Light Rail Connector — Pittsburgh, PA

Label: Pittsburgh N

The Port Authority of Allegheny County (Port Authority) is constructing a 1.2-mile double-tracked light rail transit extension from the existing Gateway terminus station in the Golden Triangle area of downtown Pittsburgh across the Allegheny River to the rapidly developing North Shore area. While remaining underground along the North Shore, the alignment travels adjacent to Bill Mazeroski Way accessing a station near the PNC Park stadium. The alignment continues below grade adjacent to Reedsdale Street and transitions to an elevated alignment near Art Rooney Avenue to a station along Allegheny Avenue, near the Heinz Field stadium, before terminating near the West End Bridge. The project includes two bored tunnels below the Allegheny River and 3 newly constructed stations, and includes a new Gateway Station that will be constructed adjacent to the current Gateway Station to facilitate the tie-in to the existing system. The first North Shore station (North Side Station) will be located underground, and the terminus at Allegheny Station will be aerial.

Charlotte South Corridor — Charlotte, NC

Label: Charlotte

The Charlotte Area Transit System (CATS) and the City of Charlotte managed the construction of a 9.6-mile and 15-station light rail transit line from the city's central business district (CBD) to I-485 in south Mecklenburg County. A 3.7-mile portion of the system—between the CBD and the Scaleybark Road station—operates in an abandoned Norfolk Southern Railroad right-of-way owned by the City of Charlotte. The remainder of the operating service (5.9 miles) runs on separate tracks parallel to this right-of-way. The single-line system opened for revenue service in 2007.

This project's planning process encountered some difficulties when a redesign was required to meet FTA's cost-effectiveness threshold and other requirements. Construction was stalled because CATS had to remove from the railroad right-of-way a species of flower listed as endangered under the provisions of the Endangered Species Act.

VTA Tasman West — San Jose, CA

Label: VTA Tas W

The VTA Tasman West construction project was the first leg of the Tasman Light Rail Project. The entire project was originally planned as a 12.4-mile expansion of an existing line; however, funding constraints forced the VTA to scale back immediate construction to a 7.6-mile Tasman West segment that opened for revenue service in December 1999. This project had an extensive public outreach and involvement process.

VTA Tasman East — San Jose, CA

Label: VTA Tas E

The Tasman East Project was a 4.9-mile light rail extension from the existing San Jose Guadalupe corridor Baypointe station to the Hostetter station. The alignment runs along Tasman Drive from North First Street to I-880 and then follows the Great Mall Parkway and

Capitol Avenue. Phase I construction from the Baypointe Transfer station to the I-880/Milpitas station aligned the track for 1.9 miles in the median of Tasman Drive between the Baypointe Parkway and Alder Drive to the I-880 in Malpitas. It includes 3 new stations and opened for revenue service in May 2001. The second segment was a 3-mile extension in the median of Capitol Avenue between Alder Drive to just south of Hostetter Road. Both 4 new stations and a 7,200-ft bridge for grade separation were completed in June 2004. This project had an extensive public outreach and involvement process.

VTA Capitol Segment — San Jose, CA

Label: VTA Capitol

The Capitol Light Rail Project was a 3.3-mile light rail extension of the Tasman East Project that continued the alignment in the median of Capitol Avenue to extend service to the present terminus just south of Alum Rock Avenue. It opened simultaneously with Tasman East II for revenue operations in June 2004. This project had an extensive public outreach and involvement process.

VTA Vasona Segment — San Jose, CA

Label: VTA Vasona

The Vasona Light Rail Project is a 5.3-mile light rail extension from downtown San Jose to the Winchester Transit Center. The project added 8 new stations between Woz Way in downtown San Jose and Winchester Station in Campbell. The Vasona Light Rail operates primarily on the existing Union Pacific Railroad right-of-way between the San Jose Diridon Station and Winchester Station. Additionally, the segment between the San Fernando and San Jose Diridon Stations is in a tunnel, and the segment between Bascom Avenue and Route 17 bridges over Hamilton Avenue. This project had an extensive public outreach and involvement process and opened for revenue operations in October 2005.

Atlanta MARTA North-South Line — Atlanta, GA

Label: MARTA N-S

The MARTA North-South Line project included a 22.2-mile heavy rail line from the Hartsfield-Jackson Atlanta International Airport to the Doraville station south of the I-285 Beltway in northeast Atlanta. The alignment runs up Main Street to the Arthur Langford Parkway where it continues on Lee Street SW. The alignment veers east onto W. Whitehall Street SW just south of downtown Atlanta. In downtown the line runs underneath Peachtree Street and follows a railroad right-of-way after the Arts Center station to its northeastern terminus. The complete 18-station heavy rail line became operational in 1992.

Atlanta MARTA North Line Dunwoody Extension — Atlanta, GA

Label: MARTA Dun

The Dunwoody extension project created a spur line off the North-South line’s alignment. It opened for revenue service in 1996. This line and the North-South line are co-aligned from the Airport to the Lindbergh Center station. Its alignment is a 7-mile spur line off of the North-South alignment splitting off north of the Lindbergh Center station and runs to the Dunwoody station north of the I-285 Beltway. The alignment parallels Georgia State Route 400 between the Buckhead and Medical Center stations and ends at Dunwoody between Route 400 and I-295.

Boston MBTA Orange Line — Boston, MA

Label: MBTA Orang

After anti-highway protests stalled the construction of a freeway into downtown Boston through the Southwest Corridor, the Massachusetts Bay Transportation Authority (MBTA) constructed a heavy rail line through the corridor. This double-tracked 4.7-mile line extended and rerouted the Orange Line south of the Chinatown station from the former Washington Street Elevated to the Southwest Corridor right-of-way. The Southwest Corridor alignment runs primarily below grade, with some portions in open-cut and other portions in subway, and primarily serves Boston's South End, Roxbury, and Jamaica Plain neighborhoods.

Baltimore MTA Metro Sections A and B — Baltimore, MD

Label: Baltimore

The Maryland Transit Administration (MTA) built a 15-mile, 12-station heavy rail line in two phases. The first phase of construction built the line from the Charles Center station in downtown Baltimore to the Reisterstown Plaza station in the northwest section of the city along Eutaw Street, Pennsylvania Avenue and briefly on Reisterstown Road before re-emerging at grade in the Western Maryland Railroad (WMR) right-of-way adjacent to Wabash Avenue. Revenue service began in 1983 along this 9-station line. A 3-station extension, which continues in the WMR right-of-way and the I-795 median to the current western terminus at Owings Mills in Baltimore County, opened for revenue service in 1987.

Chicago CTA—Southwest Orange Line — Chicago, IL

Label: CTA Orange

The CTA Orange Line, the first rapid transit line to operate in southwest Chicago, runs 9.0 miles (double-tracked) from the downtown loop to its terminus at Midway Airport (eight stations) along freight rights-of-way. Approximately 2.7 miles of the fixed guideway is aerial structure, and the remaining 6.3 miles is on embankment. It connects the neighborhoods of Burbank, Bedford Park, Bridgeview, Hometown, Justice, Merrionette Park, Oak Lawn, and Summit to the downtown Chicago loop and connections with the other five heavy rail lines. The line opened for revenue service in 1993.

Chicago CTA—O'Hare Extension Blue Line — Chicago, IL

Label: CTA O'Hare

The O'Hare project extended the Blue Line (formerly called the Milwaukee Line) within the median of the Kennedy Expressway in northwest Chicago. Construction began in the early 1980s to extend the line 7.1 miles with 4 new stations from the previous terminus at the Jefferson Park station to the present terminus at the O'Hare Airport station. Revenue service to the Rosemont station began in 1983 and to O'Hare in September 1984.

Chicago CTA—Ravenswood Brown Line Rehabilitation — Chicago, IL

Label: CTA Brown

Persistent crowding on the Brown Line platforms prompted the Chicago Transit Authority (CTA) to begin reconstructing existing platforms and stations to accommodate eight-car trains, along with other related capital improvements

The Ravenswood (Brown) Line extends approximately 9.1 miles with 18 stations from the Kimball Terminal on the north side of Chicago through the "Loop Elevated" section in downtown Chicago. The majority of the heavy rail line operates on an elevated structure (8.0 miles), except for a portion near the northern end of the line that operates at grade (1.1 miles). The project began in late 2004 and is under construction. As of March 2009, 16 of 18 station project renovations have been completed.

Chicago CTA—Douglas Blue Line Rehabilitation — Chicago, IL

Label: CTA Douglas

The Chicago Transit Authority reconstructed 5.6 miles of the Douglas Branch, then a portion of the Blue Line (now operated as the Pink Line). The heavy rail line extends from the Clinton station, to the west of downtown Chicago, to its terminus at the 54th St./Cermak Avenue station. The project required the reconstruction and rehabilitation of 11 stations, aerial structures, upgrading power distribution and signal systems, and the reconstruction of the 54th Street maintenance yard. The rehabilitation project was completed on schedule and the line opened to revenue operation in January 2005.

Los Angeles Red Line — Los Angeles, CA

Labels: LA Red 1, LA Red 2, LA Red 3

The Red Line is a heavy rail line in Los Angeles between Union Station and North Hollywood. This line opened for revenue service in three phases between 1993 and 2000. The line includes a 3.4-mile segment of underground guideway from Union station to Westlake/MacArthur Park station.

Miami-Dade Transit Metrorail — Miami, FL

Label: Miami

Miami-Dade Metrorail built a 21-mile elevated rapid transit line with 21 stations in the early 1980s. Most of the heavy rail line operates on an aerial structure. This rapid transit line opened for revenue service in May 1984.

San Juan Tren Urbano — San Juan, PR

Label: San Juan

The Puerto Rico Highway and Transportation Authority, a division of the Puerto Rico Department of Transportation and Public Works, constructed a 10.7-mile (17.2-km) double-track heavy rail system between Bayamón Centro and the Sagrado Corazon area of Santurce in San Juan. The entire project includes 5.7 miles (9.3 km) of aerial structures and a 0.8-mile (1.4-km) tunnel. When the existing *publico* service was incorporated into the project during planning phases, ridership requirements increased and the design sequence changed, which impacted the project's budget. Approximately 40% of the alignment is at grade or near at grade. Aside from a short below-grade segment in the Centro Medico area, and an underground segment through Rio Piedras, the remainder is elevated track. The project includes 16 stations, 74 vehicles, and a maintenance/storage facility. The project opened for revenue service in June 2005.

Bay Area Rapid Transit San Francisco Airport Extension — San Francisco, CA

Label: BART SFO

After an extended planning process (the project's original EIS occurred in 1985), BART and San Mateo County Transit District (SamTrans) completed a rail extension in 2003. BART and

SamTrans completed this 8.7-mile double track, 4-station, heavy rail extension that runs from the Colma station through the cities of Colma, South San Francisco, and San Bruno along the Caltrain right-of-way to Millbrae. Approximately 1.5 miles north of the Millbrae Avenue intermodal terminal, an east-west aerial "Y" stub branches to the east to service the San Francisco International Airport (SFO). Because this project extended BART service beyond the existing five counties in BART's service area, the project involved coordination with San Mateo County, including the execution of an agreement for the county to fund East Bay projects and to share the operating subsidy. With the support of the airport, the project sponsor was BART and the principal funding sources were San Mateo County and FTA. The extension opened for service in June 2003.

WMATA—Shady Grove Extension (A Route) — Washington, DC

Label: DC Shady G

The Shady Grove (A Route) construction project added 15 stations along 18 miles of heavy rail alignment in the District of Columbia and Montgomery County, MD. This segment of the Red Line extends from the Farragut North station to the present terminus at the Shady Grove station.

Revenue service on the Shady Grove extension began in January 1977 with the opening of the Dupont Circle station. Revenue operations to the Van Ness-UDC station began in December 1981 and the full extension opened in December 1984.

WMATA—Glenmont Extension (B Route) — Washington, DC

Labels: DC Glenmt 1, DC Glenmt 2

The Glenmont and Glenmont Outer (B Route) project was an 11.9-mile extension of WMATA's heavy rail Red Line in northeastern Washington, DC, and eastern Montgomery County, MD. This extension starts in the B&O Railroad right-of-way with an above-grade crossing of U.S. Route 50 (Rhode Island Ave.) right after the Rhode Island Ave-Brentwood station. It continues at grade in the railroad right-of-way through Washington, DC, with grade-elevated crossings through the downtown of the Silver Spring, MD, suburb. It submerges south of the intersection of 16th and Georgia Avenue and continues underground beneath Georgia Avenue to the terminus at the Glenmont station. The extension first opened for revenue service to the Silver Spring station in February 1978 followed by the opening of service to Wheaton in 1990. The full extension began revenue operations in January 1998.

WMATA—Huntington (C Route) — Washington, DC

Label: DC Huntgtn

WMATA's Huntington project included a 12.1-mile new heavy rail line (present-day Yellow Line) that opened for revenue in two phases. In the first phase, which opened in 1983, Yellow Line trains began operating across the Fenwick bridge over the Potomac River, and the Archives-Navy Memorial-Penn Quarter station opened. Later in 1983, the Yellow Line was extended south of Washington National Airport to its current terminus at Huntington.

WMATA—New Carrollton (D Route) and Vienna (K Route) — Washington, DC

Labels: DC New Ca, DC Vienna

The New Carrollton project included 11.8 miles of heavy rail and 14 stations, including a 5-station extension from the Stadium-Armory station in Southeast Washington to New Carrollton, MD. When it opened for revenue service in November 1978, the line originated in suburban Maryland, ran through downtown Washington via Pennsylvania Avenue, D Street, 12th Street and I Street before passing under the Potomac River to the Rosslyn station in Arlington County, Virginia. The original service alignment terminated on the Virginia side at Washington National Airport. The Maryland portion of the alignment proceeds underground from the Stadium-Armory station. It continues above ground after crossing the Anacostia River and follows the Anacostia Freeway (DC 295) and US 50 corridors at grade and on elevated structure before terminating at the New Carrollton station, a major intermodal transfer center.

The Vienna project opened eight new stations on the Orange Line in two phases. In 1979, underground stations on the Wilson Boulevard corridor in Arlington County opened between Rosslyn and Ballston stations. An extension to the Vienna station, which runs primarily at grade in the median of I-66, opened for revenue service in 1986.

WMATA—Green Line (E, F Routes) Washington, DC

Labels: DC U St., DC Greenblt, DC Anacost, DC Anacost O

The Green Line opened for revenue service in several phases between May 1991 and January 2001. The initial Anacostia alignment to be built ran north and south of downtown Washington. The DC U St. Project included a 3-station, 1.65-mile northern section (the "Mid-City line") that runs north underneath 7th Street NW from the Gallery Pl.-Chinatown station before turning west to the U Street/African-American Civil War Memorial/Cardozo station at 13th and U Streets NW. The 3-station, 4.3-mile southern section runs from L'Enfant Plaza along M Street before crossing underneath the Anacostia River to reach the Anacostia station adjacent to Suitland Parkway. The northern section opened for revenue service in May 1991 with the full 6-station line opening for service in December 1991. In September 1999, with two additional stations, the full line was operational.

The Outer Anacostia project extended the line 5 stations and 6.7 miles into southeast Washington, DC, and Prince George's County, MD. The alignment runs underground equidistant between Martin Luther King Jr. Avenue SE and Suitland Parkway to Southern Avenue. It runs at grade parallel with Southern Avenue in a northeastward direction, briefly submerges, and reappears above-grade at Branch Avenue and Naylor Road in Temple Hills, MD. It continues parallel to the Suitland Parkway before terminating east of Branch Avenue in Suitland, MD. Revenue operations on this extension commenced in January 2001.

The 2-station, 2.3-mile Greenbelt extension from the Prince George's Plaza station opened for revenue service in December 1993.

WMATA—Addison (G Route) and Springfield Extensions (J, H Routes) Washington, DC

Labels: DC Addison, DC Springfld

The Addison project extended the Blue Line for 3.5 miles, adding 3 stations, from the previous terminus at the Stadium-Armory station to the Addison Road-Seat Pleasant station in Prince George's County, MD. It continues east under E. Capitol St. NE and follows that major thoroughfare underground until that corridor becomes Central Avenue in Capitol Heights, MD. Revenue service commenced on this extension in November 1980. The 2-station extension to the present terminus at Largo Town Center opened up for revenue service in December 2004. The database costs do not reflect the latest extension to Largo Town Center.

The Springfield project extended Blue Line service 3.5 miles from the King Street station to the present terminus at the Franconia-Springfield station. Service with the Yellow Line south of the National Airport station is shared to the King Street station. Blue Line revenue operations south of the National Airport began in June 1991 with the opening of the Van Dorn Street station. The full extension was opened for revenue service in June 1997.

WMATA—L'Enfant Plaza (L Route) Washington, DC

Label: DC L'Enfant

The L'Enfant Plaza project included 1.71 miles connecting the L'Enfant Plaza station and the Pentagon Station via the 14th Street Bridge. This addition enabled service underground in Washington, DC, in what is today the Yellow Line via 7th Street NW.

Philadelphia SEPTA Frankford Rehabilitation Philadelphia, PA

Label: Phil Frankf.

SEPTA began rebuilding the entire Frankford Elevated Line in 1986 with new track, signal systems, and stations along a 5.25-mile span between Girard Avenue and Bridge Street. In addition to renovating 10 smaller stations, the project transformed the prior terminus into the larger modern intermodal Frankford Transportation Center (FTC) in northeast Philadelphia. The new FTC terminal building was opened on August 4, 2003. This project had an extensive public outreach process.

New York NYCT 63rd Street Tunnel New York, NY

Label: NYCT 63rd

The project included a two-level tunnel. The NYCT F rail service uses the upper level, connecting the IND Queens Boulevard Line in Queens to the IND Sixth Avenue Line in Manhattan via the IND 63rd Street Line. The lower level will be used by the Long Island Rail Road East Side Access project, which will bring LIRR commuter trains to Grand Central Terminal. The tunnel is constructed with immersed tubes in trenches at the bottom of the East River bed. Beyond the river, the tunnel was built using cut-and-cover construction. The tunnel opened in October 1989.

New York NYCT Stillwell Terminal Rehabilitation New York, NY

Label: NYCT Stillw

The New York Metropolitan Transportation Authority (MTA) completed the rehabilitation of its eight-track Stillwell Avenue Terminal station in Brooklyn, NY, in May of 2004. In addition to rehabilitating 90-year-old platforms, the project included a new triple-vaulted glass and steel structure with solar panels on the roof. This project had an extensive public outreach process, including the existing ridership on NYCT service as a significant stakeholder.

APPENDIX C

Supplementary As-Built Cost Analysis

This appendix summarizes additional analysis of historical capital costs performed to support TCRP Project G-10. This appendix describes how the historical data was prepared and analyzed for cost relationships between soft costs and other project characteristics.

C.1. Data Preparation and Standardization

This analysis used actual historical capital cost data from two FTA Capital Cost Databases for light and heavy rail, respectively. This analysis took several steps to standardize and prepare the data in both databases for an accurate comparison. Most capital cost categories in the two data structures are similar, with minor exceptions. For example, vehicle costs are separated as their own category in both systems, although presented in a different numbering category sequence. Otherwise, the full capital costs to complete each project are represented in each dataset and these results are reflected in the analysis.

C.2. Adjustments Addressing Different Cost Categorization

This analysis combines light and heavy rail transit project capital cost databases using slightly different categorization structures for each mode. To correct for small variations in reporting protocols, the following modifications were made.

- **Project Initiation:** Cost category 8.07 in the heavy rail database, Project Initiation, contains two sub-items for Mobilization and Maintenance of Traffic which are reported under 8.00 Soft Costs. The light rail dataset includes these items as SCC 40.073 and 40.074 under 40.000 Sitework and Special Conditions. To ensure comparability, the two heavy rail cost components were reclassified as an element of 40.073 and 40.074 of the Special Conditions category.
- **Planning and Feasibility Costs:** Only a few projects reported these costs. This is for work that is typically carried out early in the initial phase of a transit project's development lifecycle. These efforts are conducted prior to entry into the FTA New Starts Program and have been inconsistently documented at the project level. Therefore, FTA has eliminated these early efforts from the SCC structure. Transit agencies might assign these costs to general planning activities or other grants rather than a specific project budget, and FTA's current SCC worksheet excludes planning costs incurred prior to FTA approval to enter preliminary engineering. To ensure comparability, this cost category (8.01 for heavy rail and 80.090 for light rail) was omitted entirely.
- **Unallocated Contingency:** The light rail dataset reports Category 90, Unallocated Contingency. However, since costs are final as-built expenditures, unallocated contingency is zero

for all projects. The heavy rail dataset does not report contingencies. Therefore, this cost category has no impact on the analysis and was omitted.

- **Finance Charges:** A small number of light rail projects report finance charges. However, these costs are largely a function of the financial structure and policies of the sponsor agency, and do not affect the relationship between project characteristics and construction-related soft costs. To ensure comparability, finance charges (8.08 for heavy rail and 100.00 for light rail) were omitted entirely from the analysis.

These steps help to ensure that this technical analysis is based on a uniformly reported dataset for both light and heavy rail construction projects.

C.3. Adjustment for Inflation and Nationalization

The soft cost analysis adjusted all costs for inflation and local price differentials, and expresses nominal costs in U.S. 2008 dollars. The historical cost index from *Means Construction Cost Index* (Murphy, 2008) was applied to inflate all costs to the study base year of 2008. Differences in local metropolitan area labor, equipment, and material costs were adjusted to U.S. average 2008 dollars based on the *Means Construction Cost Index* (Murphy, 2008) for the 38 largest U.S. metropolitan areas. For example, cost of labor was less expensive in Charlotte than New York, so this analysis factors base-year dollars up in Charlotte and down in New York to the average nationwide value. Each cost amount is also associated with a year of expenditure corresponding to the midpoint of the individual element expenditure.

C.4. Outliers Omitted

Some inconsistencies in the data appear to be a result of conflicting cost reporting or interpretation of the cost element definitions. These projects were omitted because they were considered as non-representative outliers or as reflecting incomplete data. For example, the Chicago Transit Authority Brown Line/Ravenswood Rehabilitation project overhauled an existing rapid transit line and built only minimal new guideway; therefore this project does not offer a consistent cost basis to express the project costs on a per-linear-foot basis and compare that with the other projects in the database.

In other project cases, while the overall soft costs total was in the reasonable range and could be used, the breakdown by individual soft cost element was not and that project was withdrawn from the more detailed analyses. For example, some projects reported zero costs for an individual soft cost component such as preliminary engineering or final design, but the overall soft cost value was in the reasonable range. Therefore, the total soft cost was used, but the cost analysis at the component level was not used. Finally, not all detailed information on project schedule was always available. Wherever data was considered incomplete, questionable, or incomparable to other projects, these projects were omitted from the analysis in situations where appropriate. Table 17 below shows the resulting sample size from removing outliers or incomplete data points.

C.5. Vehicle Soft Costs

This analysis sought to determine if any soft costs were reported in a category outside of SCC 80. FTA instructions for reporting project costs within the Standard Cost Categories guide grantees to report professional services related to vehicle procurement under SCC 70 Vehicles, not the general soft cost category (SCC 80 Professional Services). However, the strict separation

Table 17. Resulting sample sizes for each project characteristic.

Data Analysis Type	Sample Size
All projects in dataset	59
All projects used for analysis	51
Soft costs per linear foot	45
Soft cost subcomponents (engineering, management, etc.)	48
Duration from planning/DEIS to construction	13
Duration from preliminary engineering to construction	13
Duration from construction to operations	12
Duration from preliminary engineering to operations	13
Project delay	15

of soft costs for vehicles from other soft costs may not hold consistently across the dataset. (Section C.1 discusses this potential shortfall.) Therefore, several figures below test for the possibility that vehicle soft costs are included in the directed vehicle-specific category and not the overall soft costs category.

Establishing the clear use of these related terms (soft costs generally and vehicle soft costs) is an important step in evaluating soft costs and developing a soft cost guidebook. Figure 35 shows the effect of vehicle costs on soft costs as percent of construction.

If vehicle soft costs are included mistakenly in overall soft costs, one would expect to see that bigger vehicle purchases cause soft costs as percentage of construction to rise if the underlying guideway construction remains the same. Many of these project cost summaries were collected before there was federal guidance for classifying capital costs into a consistent set of cost categories. Indeed, the data included 59 projects sponsored by numerous different agencies across nearly 35 years of experience. Instead, however, Figure 35 shows that soft costs appeared mostly immune to changing levels of vehicle procurements—the trend was slightly downward in light rail, upward in heavy rail, and zero for both modes, and all correlations were statistically insignificant. This is a good indication that vehicle soft costs are not included or reflected within the general soft costs category (SCC 80).

C.6. Soft Costs by Mode and Year

Figure 36 expands on the analysis of soft costs by decade in Figure 25 by analyzing average soft costs by mode and decade. The pattern shown in Figure 25 of increasing soft costs over time may in part be the result of no light rail projects from the 1970s being included in the dataset.

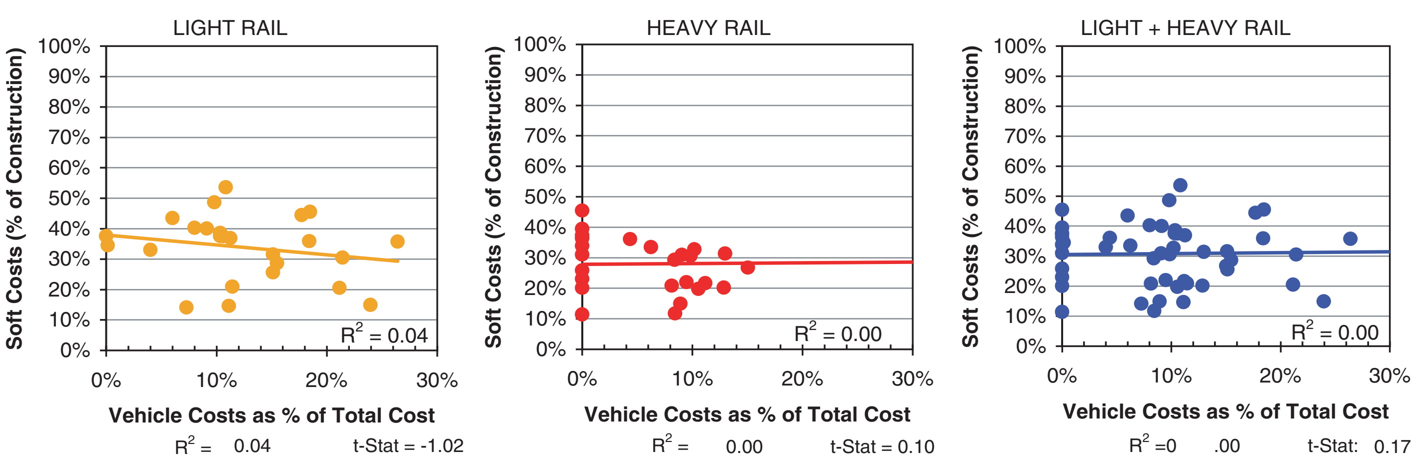


Figure 35. Soft costs as a percentage of construction versus vehicle costs as a percentage of total other costs.

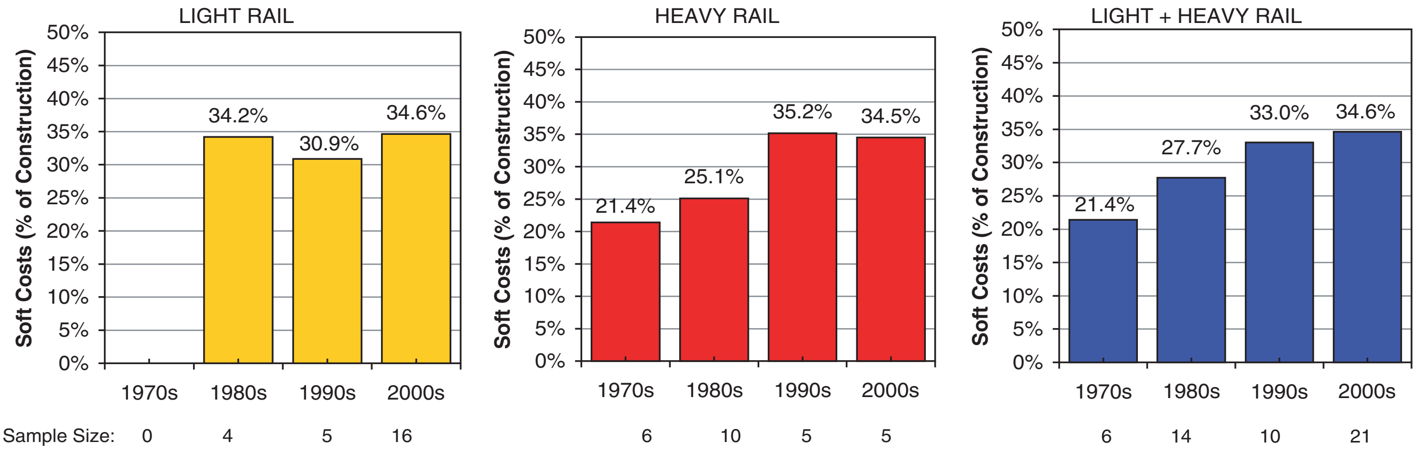


Figure 36. Soft costs as a percentage of construction by decade and mode.

Figure 36 confirms that heavy rail projects are primarily responsible for the pattern of rising soft costs over time. Soft costs for light rail projects have been stable over this same period. However, the higher soft cost percentages are related to light rail projects constructed in the 1980s, possibly by agencies developing their initial segments.

Figure 37 disaggregates the data in Figure 36 further from decade to actual year of construction. This analysis confirms that the overall correlation for all modes combined is statistically significant, but that heavy rail projects are primarily responsible for the pattern of rising soft costs over time.

Although light rail projects show a limited correlation in the increasing relationship, heavy rail projects exhibit a stronger relationship in increasing soft costs over time. *Note that midyear of expenditure represents the midpoint of all project expenditures, which is similar to, but not necessarily the midpoint of, physical construction.*

Figure 38, Figure 39, and Figure 40 present the same analysis as the two previous figures but further disaggregate the soft cost category into several groups of components: PE+FD, FD alone, and construction management and administration. The same overall relationship of rising soft cost percentage of construction costs holds true, but the relationship is weak. The final design soft costs show a stronger relationship and the same increasing relationship over time for both modes combined. The soft costs incurred in construction phases (measured as a percentage of construction

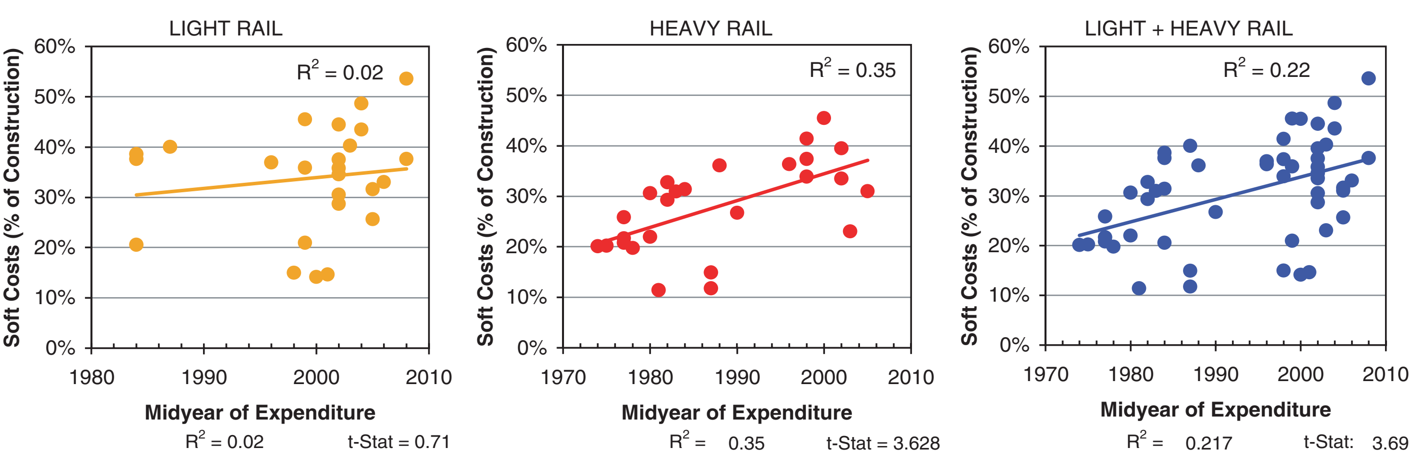


Figure 37. Soft costs as a percentage of construction versus midyear of expenditure.

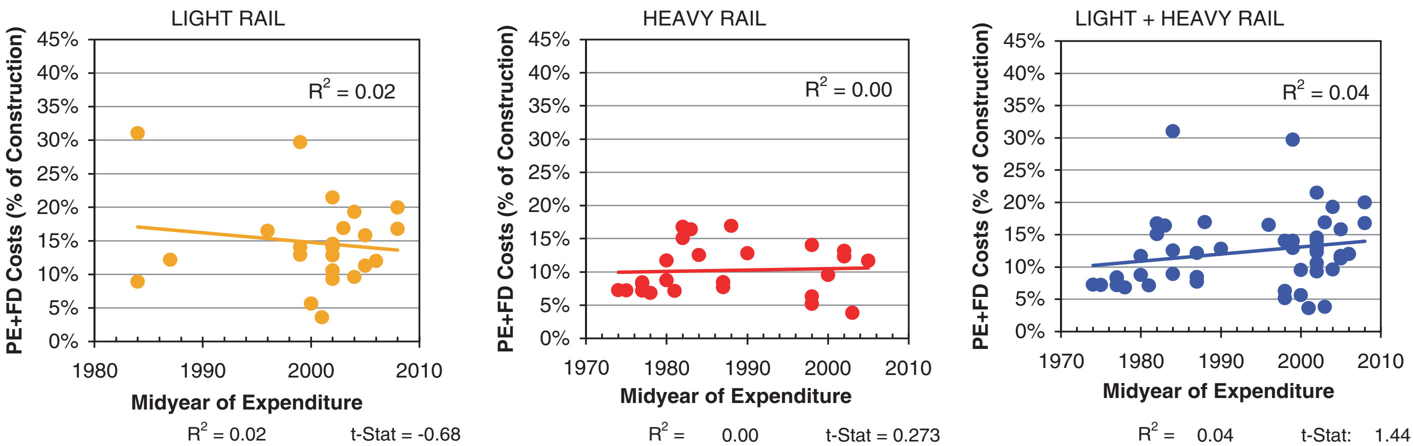


Figure 38. Preliminary engineering and final design costs as a percentage of construction versus midyear of expenditure.

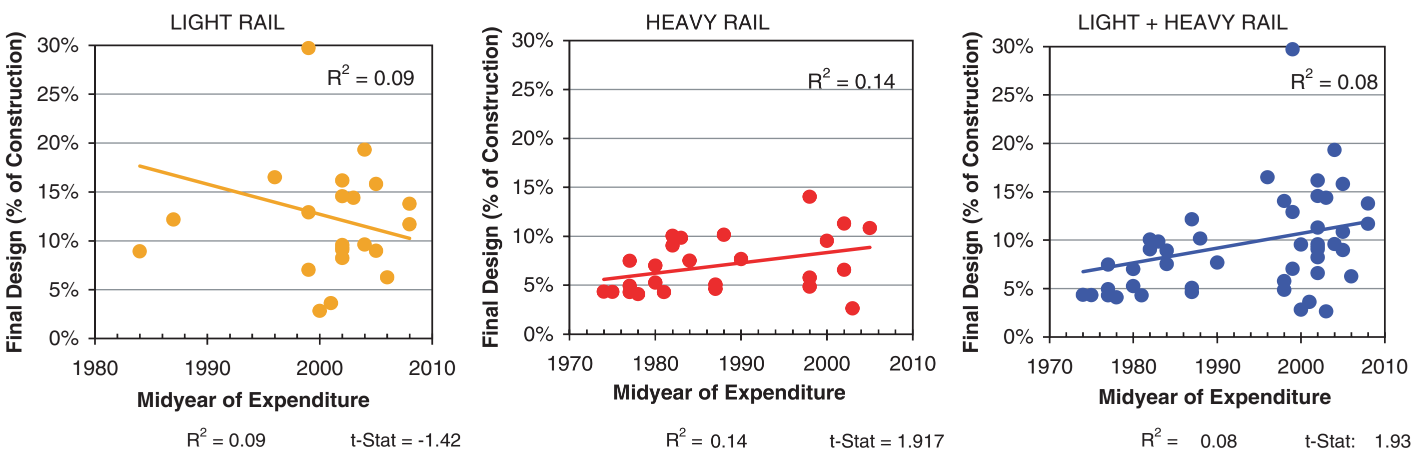


Figure 39. Final design costs as a percentage of construction versus midyear of expenditure.

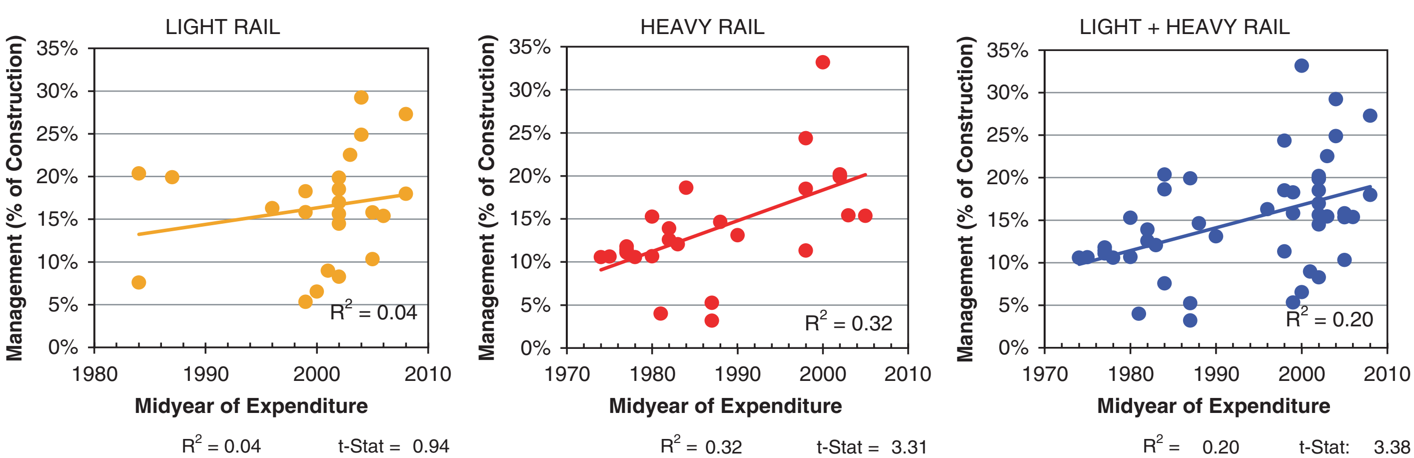


Figure 40. Management and administration costs as a percentage of construction versus midyear of expenditure.

costs) illustrates a higher increasing trend over this time period. This pattern is more prevalent and statistically significant for the heavy rail projects than for the light rail projects.

These soft cost percentages of construction costs by project development phase figures are consistent with the findings of Figure 37. Soft costs of all kinds have risen since the 1970s, but the pattern is strongest in heavy rail projects. Causes of this trend may include increasingly stringent environmental or mitigation requirements, the trend from new construction toward extending existing rail lines, or changing institutional roles or construction management techniques.

The opposite logic is also likely true and may have a greater impact on these results, although in the same direction. Many of the heavy rail projects started in the 1970s were extension projects along already well-established networks and constructed by sponsoring organizations with significant engineering and design capability. Light rail projects, by contrast, were constructed at emerging agencies that had to contract and develop their engineering and design capabilities. The project development demands may have increased for all of the projects; the actual percentage increase was relatively larger for the heavy rail agencies since they started from a lower soft cost percentage due to more limited learning curve effects.

C.7. Soft Costs by Complexity: Overall Project Size

Soft costs can generally be expected to rise with the technical complexity of the project. However, there are myriad ways to quantify complexity, and the choice of soft cost measurement may be important since construction costs can also generally be expected to rise with technical complexity.

Figure 41 shows that soft cost percentage is not dependent on the total cost of the overall project. There is virtually no relationship or correlation of the soft cost percent of construction to the total project expense. This is consistent for each of the light and heavy rail modes and the total project database.

In a similar vein, Figure 42 shows that soft costs do not depend on the total cost for the construction portion of the project either. As noted above, there was no soft cost percentage relationship with total project cost and also here with project construction costs. If anything, soft costs appear to decline as construction costs decline, suggesting some economies of scale in engineering and management. The correlations, however, are not statistically significant.

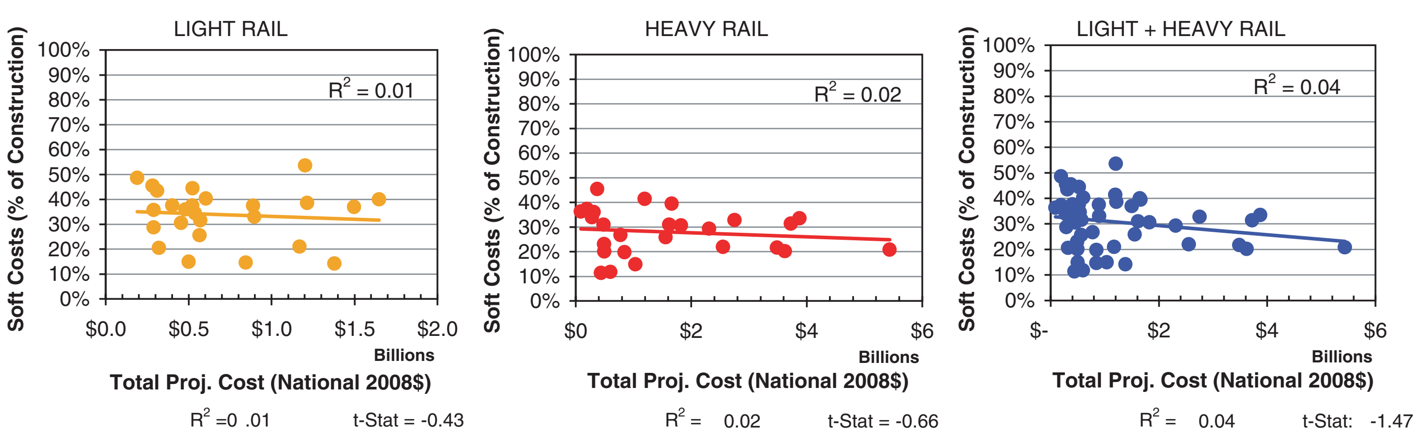


Figure 41. Soft costs as a percentage of construction versus overall project cost.

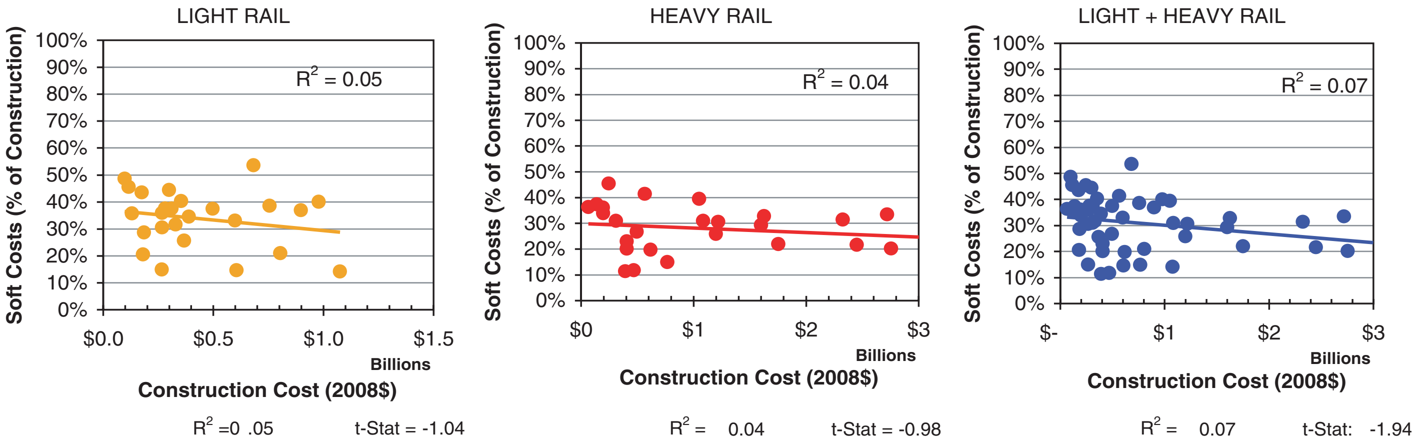


Figure 42. Soft costs as a percentage of construction versus construction cost.

Figure 43, Figure 44, and Figure 45 disaggregate the analysis in Figure 42 summarizing the soft costs by project development phase as defined earlier: preliminary engineering and final design, construction administration and management, and all other soft costs.

Figure 43 presents the combined engineering and design phase costs as a percentage of total construction costs. These subsets combine the project development aspects of the engineering and design phases, the various development functions during the construction phase, and then all of the other supporting project development efforts. The light rail, heavy rail, and combined analysis show no relationship. Heavy rail projects are more complex, especially those with higher project costs. This greater complexity would predict a flat or slightly increasing soft cost percentage of construction costs, yet the combined project database mixes these contrasting relationships with a slightly declining relationship with little statistical reliability. These results confirm that engineering and design costs as a percentage of construction cost do not consistently depend on the total cost of the overall construction project, other things being equal.

Figure 44 presents construction phase soft costs as a percent of construction costs against the dollar value construction cost of a project. In light rail, these project administration and management costs fall in percentage terms as the magnitude of the project grows; however, no statistically significant pattern holds for heavy rail or the combined project database. This finding for light rail is consistent with the same pattern for final design costs and further supports the

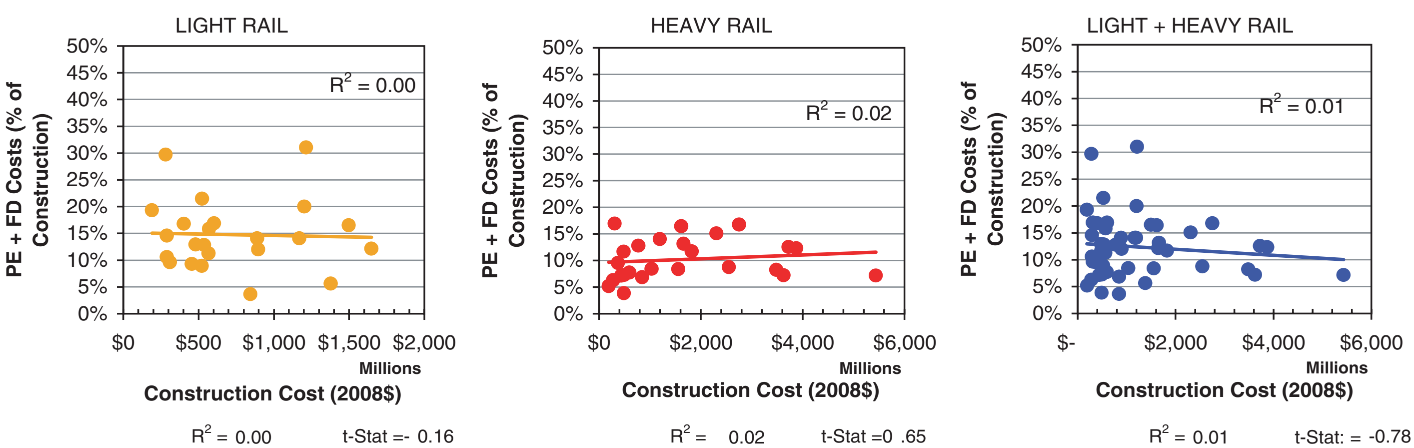


Figure 43. Preliminary engineering and final design costs as a percentage of construction versus construction cost.

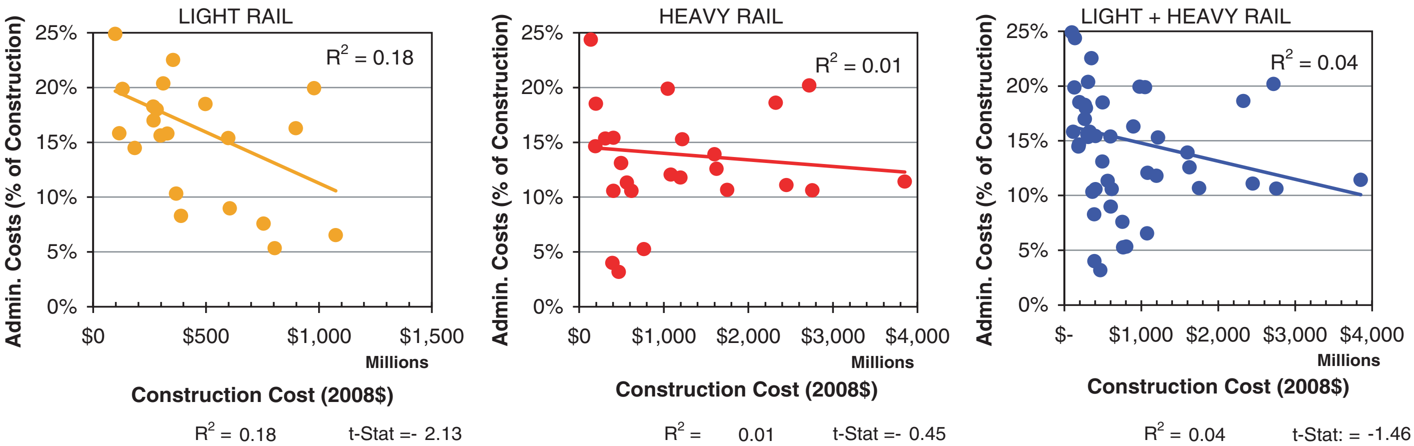


Figure 44. Project administration and construction management costs as a percentage of construction versus construction cost.

hypothesis that light rail is less complex and therefore its soft costs do not scale up with construction costs.

Lastly, Figure 45 completes the analysis by measuring the relationship between dollar value construction cost and all other soft costs not explicitly accounted for in the engineering and construction phases. No relationship is shown, which indicates the relatively inconsistent makeup of other soft costs.

The next refinement of soft costs is to examine the phase breakdown for the engineering and design phases into the preliminary engineering and final design phases. Figure 46 presents the preliminary engineering phase soft costs compared to overall construction costs. The preliminary engineering phase suggests an increase in the soft cost percentage of construction cost with increasing construction costs for both modes, but since the relationship is not significant in statistical terms, it is not clear that the relationship is not zero. Figure 47 presents the same analysis structure for the final design phase. The light rail analysis shows a more (but not profoundly) statistically significant decline in soft cost percentage with the increasing project construction cost. The heavy rail mode results are flat for the full range of construction costs, indicating that the increasing complexity of more expensive heavy rail projects requires greater soft cost resources through a consistent percentage of construction costs.

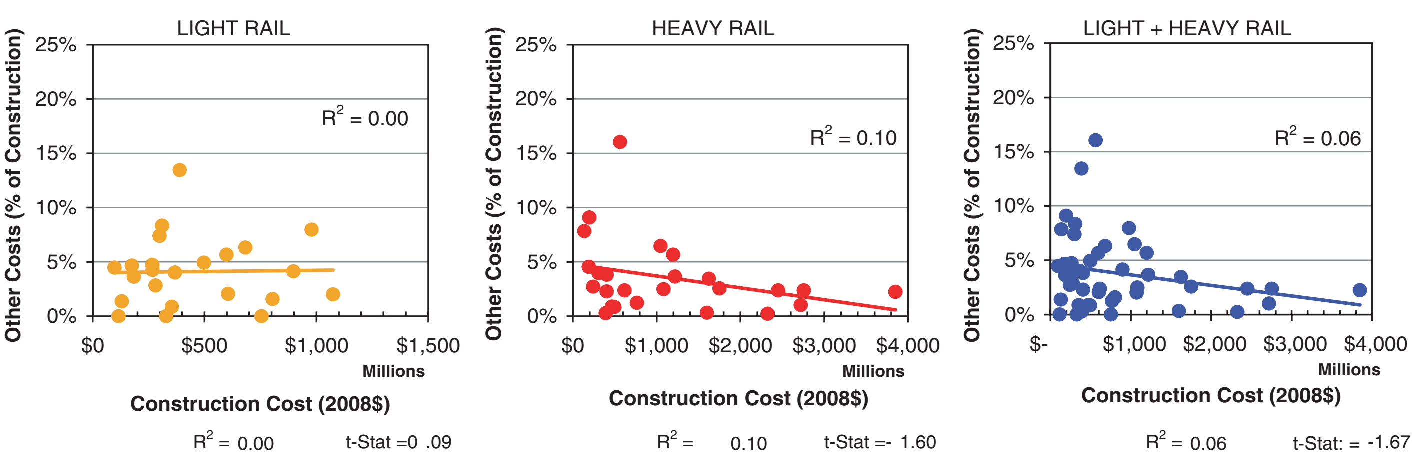
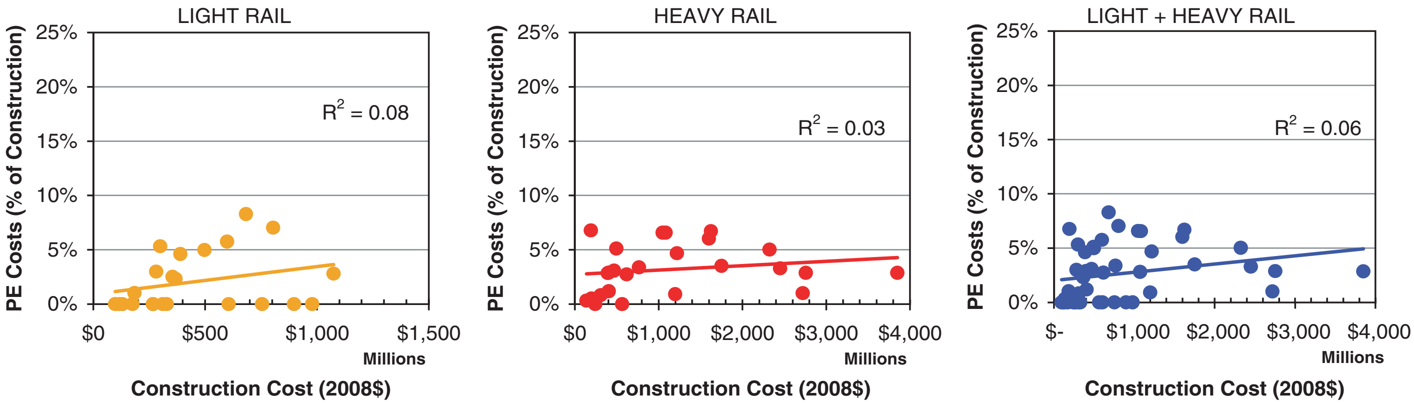


Figure 45. Other soft costs as a percentage of construction versus construction cost.



R^2 = 0.08 t-Stat = 1.33 R^2 = 0.03 t-Stat =0 .88 R^2 = 0.06 t-Stat: = 1.73

Figure 46. Preliminary engineering costs as a percentage of construction versus construction cost.

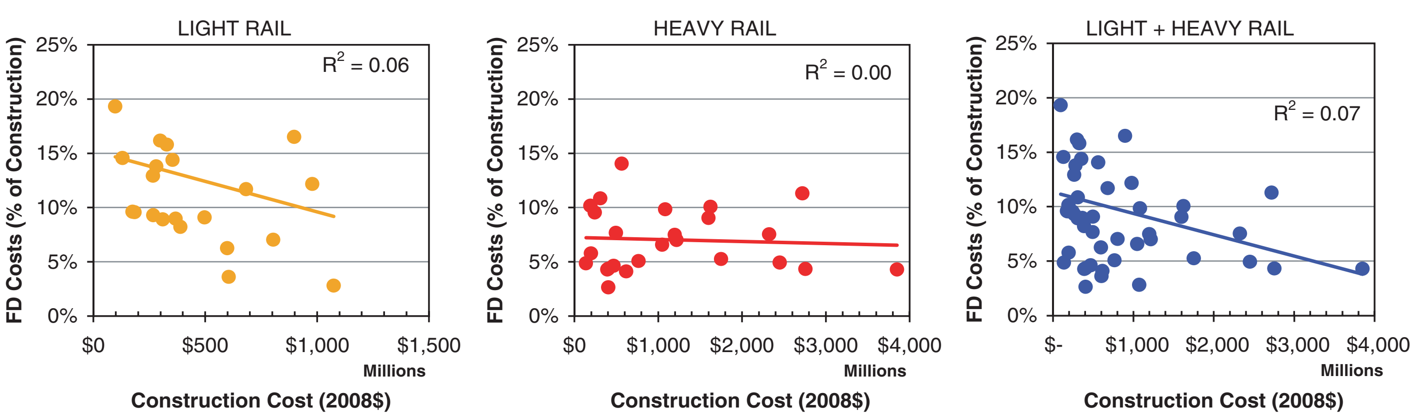
This analysis suggests economies of scale in light rail construction, primarily through the reduction of final design expenses, but the results are inconclusive. Heavy rail shows no such trend, nor does the pattern appear for preliminary engineering.

An alternative explanation for the notion of economies of scale in light rail is that certain construction conditions, such as tunneling and bridging, cause overall construction costs to rise much faster than the design and engineering of these conditions. This would cause engineering costs as percent age of construction to decline, not because of economies of scale but because of the way soft costs are measured. The heavy rail analysis in Figure 47 may not show this pattern because of the complexity of heavy rail. This possibility is explored further in sections below.

The preceding exhibits focused on project magnitude as a proxy for complexity, and have magnitude as overall costs and construction costs. Two alternative ways to measure project magnitude may be alignment length and number of stations, as the following figures explore.

Figure 48 measures project magnitude by alignment length (linear feet of guideway) and shows only a weak and statistically insignificant correlation with percentage soft costs. No conclusion can be drawn here.

Number of stations also indicates overall project size. Locating and designing stations can present challenges to the project development process and could be factors influencing soft costs



R^2 = 0.06 t-Stat = -1.11 R^2 = 0.00 t-Stat = -0.30 R^2 = 0.07 t-Stat: = -1.91

Figure 47. Final design costs as a percentage of construction versus construction cost.

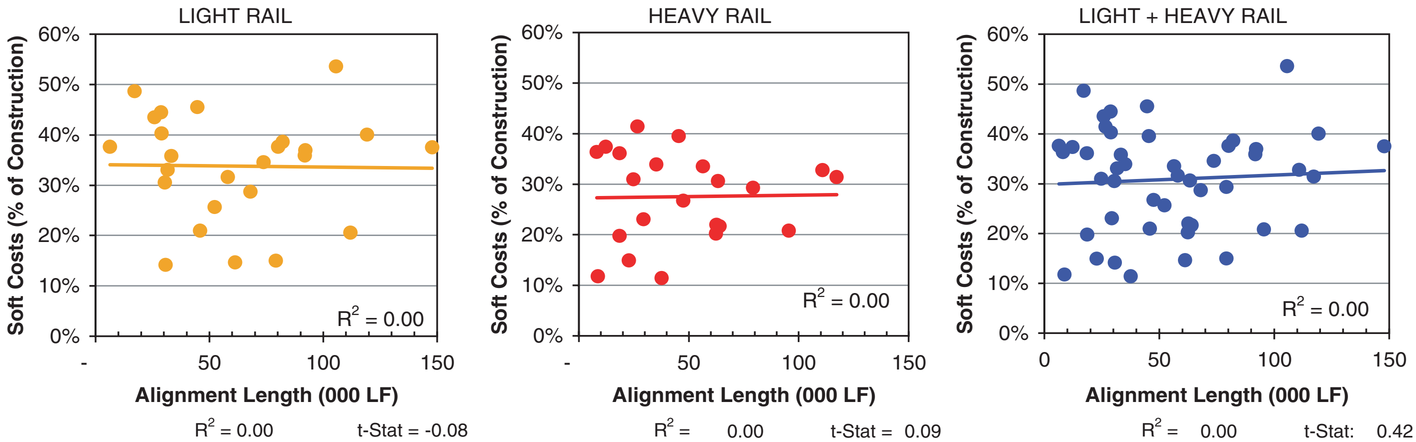


Figure 48. Soft costs as a percentage of construction versus constructed alignment length.

as the design and construction of stations require many professional services functions. Yet, as Figure 49 shows, soft costs do not appear to depend on the number of stations. Soft costs as a percentage of construction appear to decline somewhat weakly with a greater number of stations, but the relationship is not statistically significant. Stations do not appear to have any effect upon soft costs for either mode.

Beyond the simple number of stations, their frequency may also drive technical complexity. Since stations and ancillary facilities (e.g., train control rooms) may require more engineering and design than non-station components, the hypothesis is that a higher mix of stations along the guideway may increase soft costs in percentage terms. Figure 50 compares the number of stations per 10,000 linear feet of guideway to soft costs but finds minimal correlation and no statistical significance.

C.8. Soft Costs by Complexity: New versus Extension

Whether a rail construction project consists of a new line or extends an existing line may influence its soft costs. On the one hand, more professional services or agency staff time may be required, for example, to integrate a guideway extension with existing train control or traction

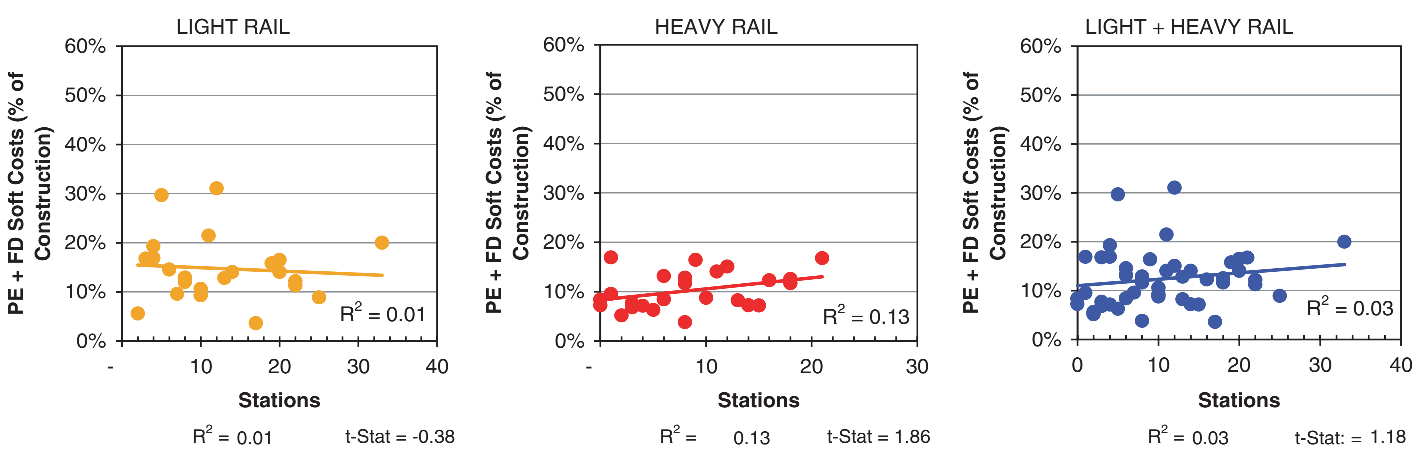


Figure 49. Soft costs as a percentage of construction versus station quantity.

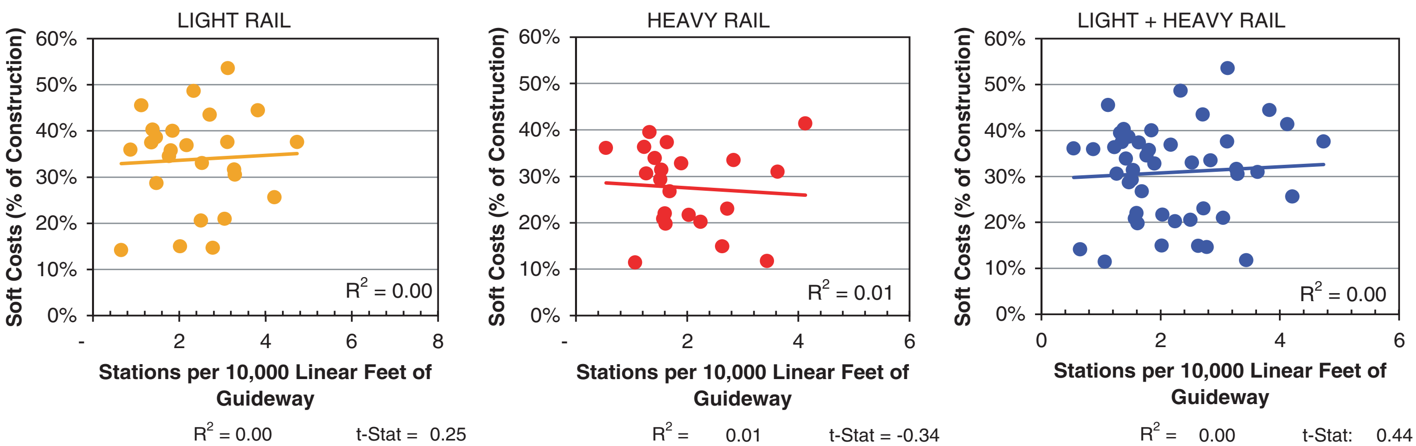


Figure 50. Soft costs as a percentage of construction versus station density.

power systems. On the other hand, a transit agency undertaking an extension project may suggest that relatively experienced agency staff with the necessary expertise be involved, which could result in lower soft costs.

Figure 51 shows average soft costs by mode and by project type (new/extension/rehabilitation). The four rehabilitation projects included in this dataset include: SEPTA Frankford, CTA Brown Line (Ravenswood), CTA Blue Line (Douglas), and NYCT Stillwell Terminal. For both modes, and for both measures, average soft costs do not seem to change whether the project is a new line or an extension. Unexpectedly, extensions, not new rail lines, incurred slightly higher average soft cost percentages. Rehabilitation projects had somewhat higher soft cost percentages, but this sample is limited to four heavy rail projects.

These findings indicate that the provision of professional services may be slightly lower for the initiation of new lines than for the extension or rehabilitation of existing segments.

Figure 52 breaks Figure 51 down into the soft cost components of engineering and design, and project administration and management. Engineering costs appear higher for new and extension light rail projects, while heavy rail engineering costs are fairly consistent between new and extension projects. Heavy rail engineering and design costs are lower for rehabilitation projects.

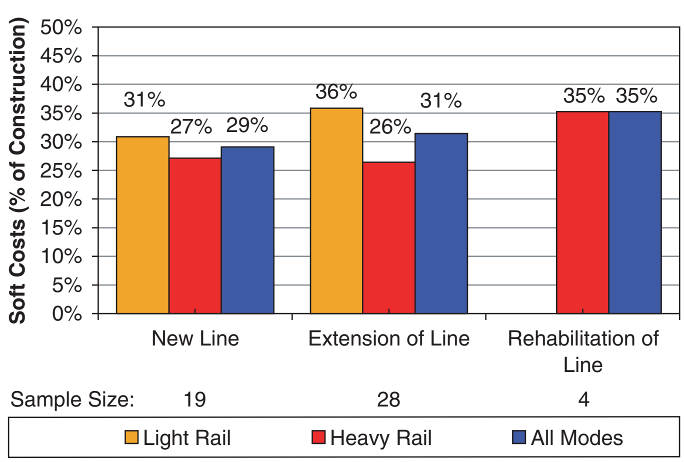


Figure 51. Soft costs as a percentage of construction by project type.

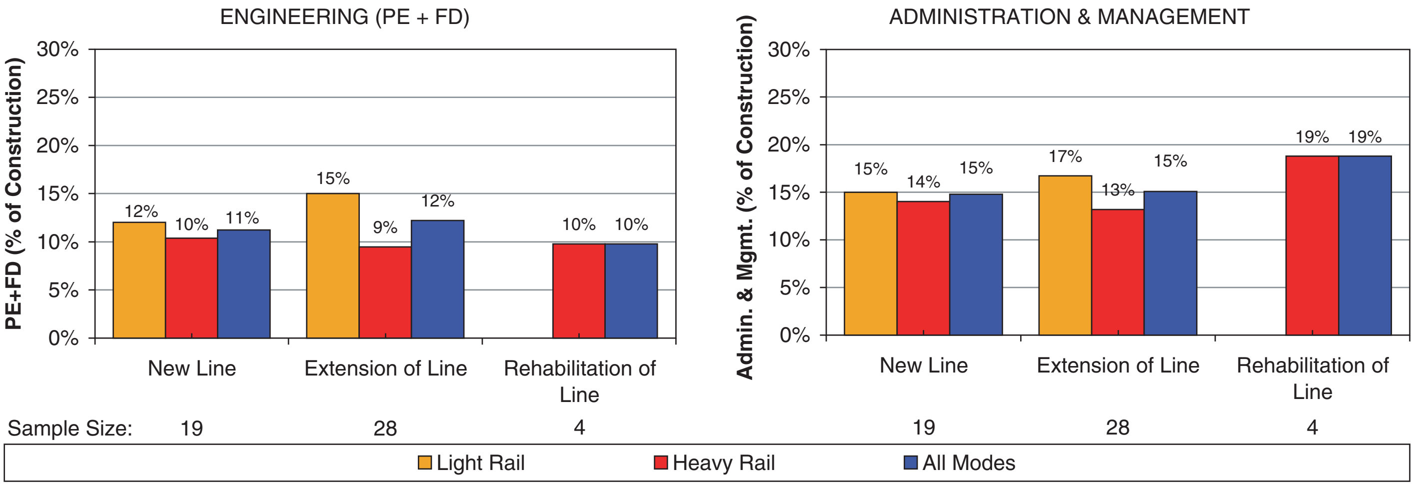


Figure 52. Subtotaled soft cost components as a percentage of construction by project type.

Soft costs for project administration and construction management are higher than engineering-related activities, as shown in the difference between the left and right panes of Figure 52. However, the difference attributable to projects being extensions or new construction appears negligible.

C.9. Soft Costs by Complexity: Percentage of Guideway Not at Grade

Figure 53 extends the examination of project complexity by focusing on preliminary engineering and final design costs, and suggests a similar conclusion. Engineering costs in percentage terms do not appear to be influenced by the extent to which the alignment is not at grade. Light rail projects have a fairly consistent 15% soft cost percent of construction costs. Heavy rail projects are about 10% to 15%, and the combined database is about 13%.

Figure 54 examines the effect of alignment complexity on the construction management and project administration soft costs of a project. Similar to the above findings, the proportion of guideway not at grade does not appear to affect the soft costs as a percentage of construction costs.

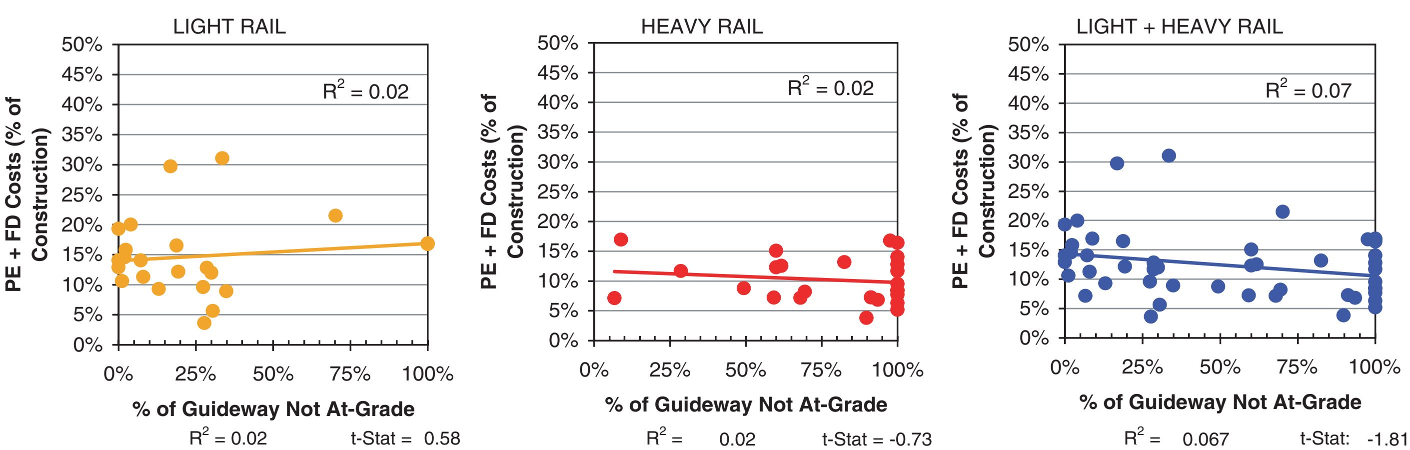


Figure 53. Engineering soft costs as a percentage of construction versus percentage of guideway not at grade.

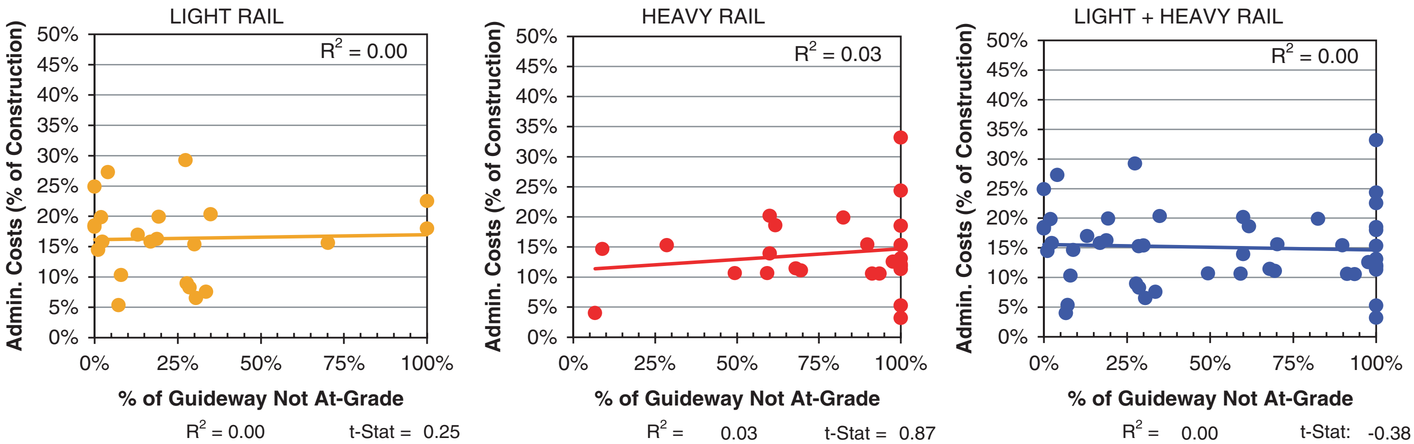


Figure 54. Administration soft costs as a percentage of construction versus percentage of guideway not at grade.

The analysis so far has defined "not at grade" to include aerial structures, underground cut and cover, underground tunnel, retained cut or fill, and built-up fill guideway. Vertical alignment has been applied as proxy for project complexity. However, these three last alignment types (retained cut or fill, and built-up fill) can be designed and constructed with fairly standardized engineering and design requirements that are similar to at-grade alignments. Therefore, Figure 55, Figure 56, and Figure 57 designate these alignment types as "at grade," and re-examine the relationship between soft costs and project complexity. These three figures, then, include only aerial structure, underground cut and cover, and underground tunneling alignments as "not at grade."

Figure 55 is comparable to Figure 28 and produces similarly statistically insignificant findings. Light rail projects are nearly flat at about 39% soft costs as a percentage of construction costs. Heavy rail projects range from about 28% to about 33%. The combined project database is nearly flat at about 35% to 38% soft costs as a percent of construction costs.

Figure 56 and Figure 57 are comparable to the analysis presented in Figure 53 and Figure 54 and are mostly inconclusive. In Figure 56, both rail modes and the combined project database result in a slightly decreasing trend in engineering and design soft costs as a percentage of construction with increasing alignment complexity. The results are mixed for Figure 57, where light

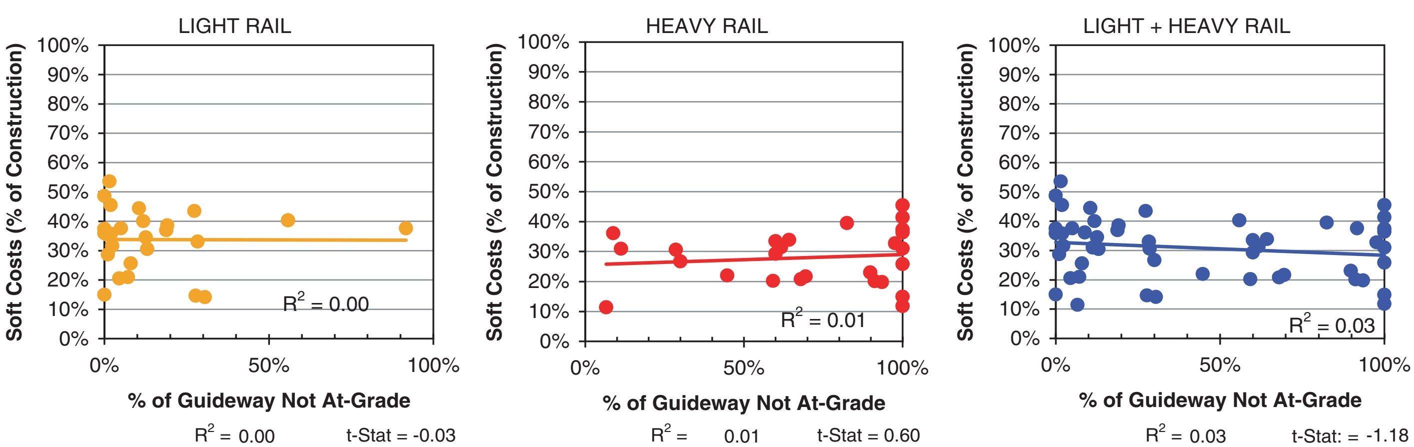


Figure 55. Soft costs as a percentage of construction versus percentage of guideway not at grade (retained cut and built-up fill designated as "at grade").

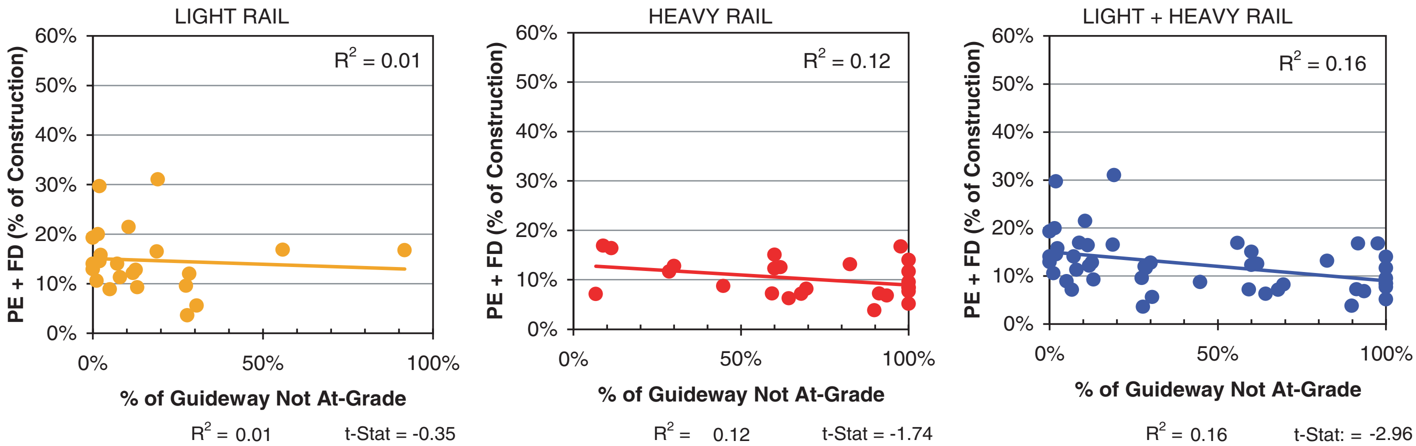


Figure 56. Engineering soft costs as a percentage of construction versus percentage of guideway not at grade (retained cut and built-up fill designated as "at grade").

rail shows a slight downward trend and heavy rail shows a slight upward trend, but the combined project database is flat and all relationships are not statistically significant.

While the relationships are weak, there may be some decline in engineering soft cost percentage with increasing project complexity. The greater capital costs of these more complex alignments results in higher soft costs, even with a slight decline in the soft cost percentage. Combining the two modes produces a weak negative correlation, surprisingly suggesting that soft costs decline as more aerial and tunnel segments are built.

C.10. Soft Costs by Complexity: Percentage of Guideway Below Grade

Underground alignment segments introduce several unique costs that other alignment grades do not, particularly excavation and complex structures. This report so far has used percentage of guideway not at grade as a proxy for complexity; however, the portion of guideway *below* grade may be a useful indicator of complexity as well. Tunneling and excavating may pro-

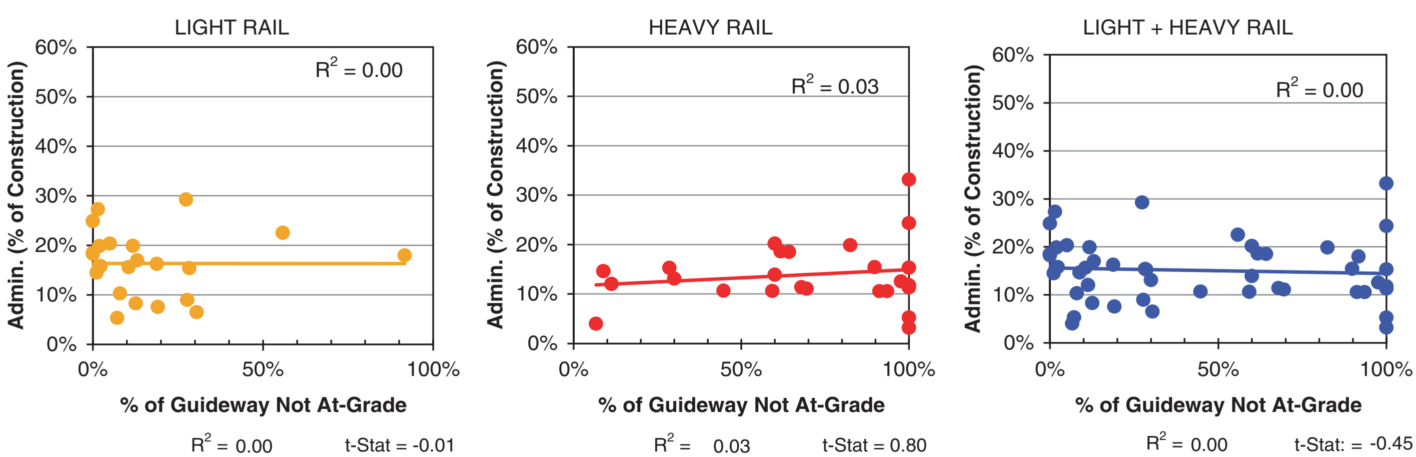


Figure 57. Administration soft costs as a percentage of construction versus percentage of guideway not at grade (retained cut and built-up fill designated as "at grade").

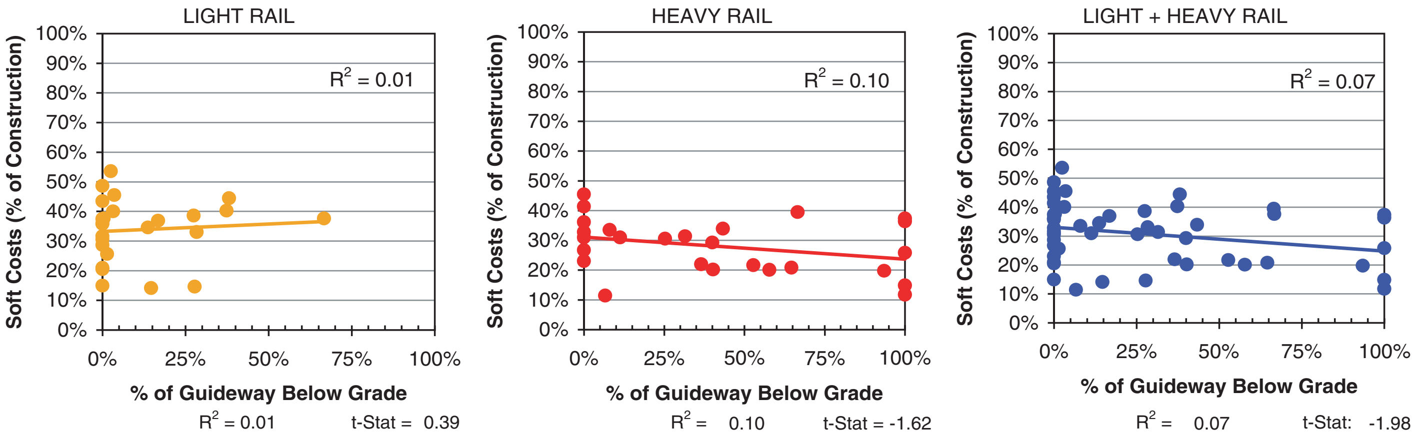


Figure 58. Soft costs as a percentage of construction versus percentage of guideway below grade.

duce a unique set of engineering and management requirements, separate from aerial or built-up fill structures, which might influence project soft costs.

Figure 58 shows that the proportion of the alignment in tunnels (cut and cover or deep-bore) has a mixed effect on soft costs as a percentage of construction. Light rail projects showed a slight increase in soft cost percentages as percentage below grade increased, whereas heavy rail projects showed a slight decrease from 30% to 24% with higher proportions of below-grade guideway. The combined project database shows a decreasing trend as well.

Figure 59 and Figure 60 present this same analysis, but focus solely on engineering and administration soft costs, respectively.

Figure 59 shows that engineering and design soft costs (preliminary engineering and final design) tend to be only slightly negatively correlated to the percentage of guideway below grade, but the pattern is only statistically significant among heavy rail projects. Figure 60 finds a similar general trend for administrative soft costs, but the trend is statistically less significant.

Finally, another view into project complexity and soft costs is presented in Figure 61, which examines the effect of guideway grade on soft costs per linear foot and finds a positive correlation that is statistically significant for light rail and both modes combined. This figure is presented on a logarithmic y-axis scale to more clearly illustrate the relationship. Figure 61 shows that more

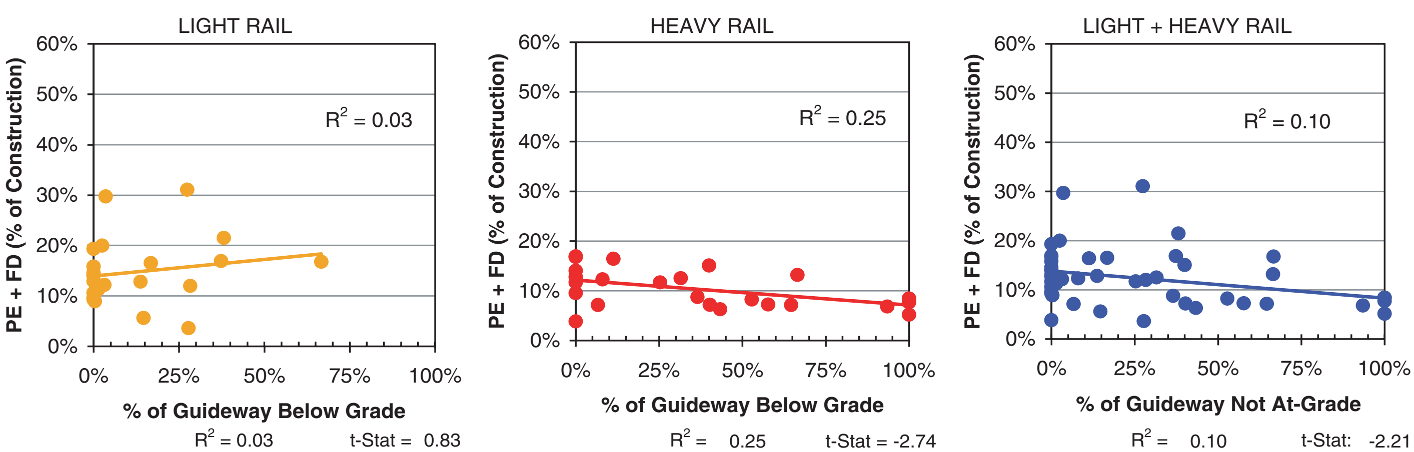


Figure 59. Engineering soft costs as a percentage of construction versus percentage of guideway below grade.

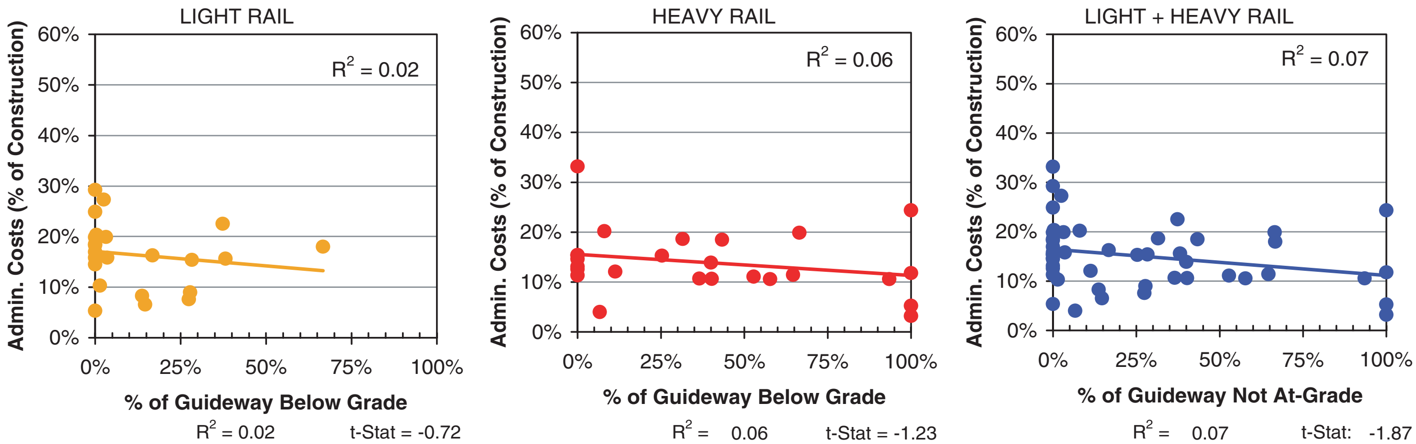


Figure 60. Administration soft costs as a percentage of construction versus percentage of guideway below grade.

complex alignment profiles are consistently tied to higher soft costs per linear foot and that the relationship is statistically significant for light rail and the combined project database.

The percentage of guideway not at grade or below grade therefore appears weakly related to soft costs when measured as a percentage of construction costs. When soft costs are measured in dollar terms per linear foot of guideway, however, a stronger relationship appears: more complex alignment profiles are tied to higher soft costs per linear foot. This finding suggests that more alignment below grade may be driving capital costs in all categories, so that soft costs will rise in dollar value terms but remain unchanged in percentage terms.

C.11. Relationships Among Other Category Unit Costs

Although it is tempting to measure soft costs in dollar value terms because this measure produces more correlation with expected complexity variables, it is worth exploring the measure further. One benefit of measuring soft costs in percentage terms is that the measure controls for variations in unit costs. Soft cost requirements of more expensive projects can be more consistently compared to inexpensive projects in percentage terms. Measuring soft costs in per-linear-foot

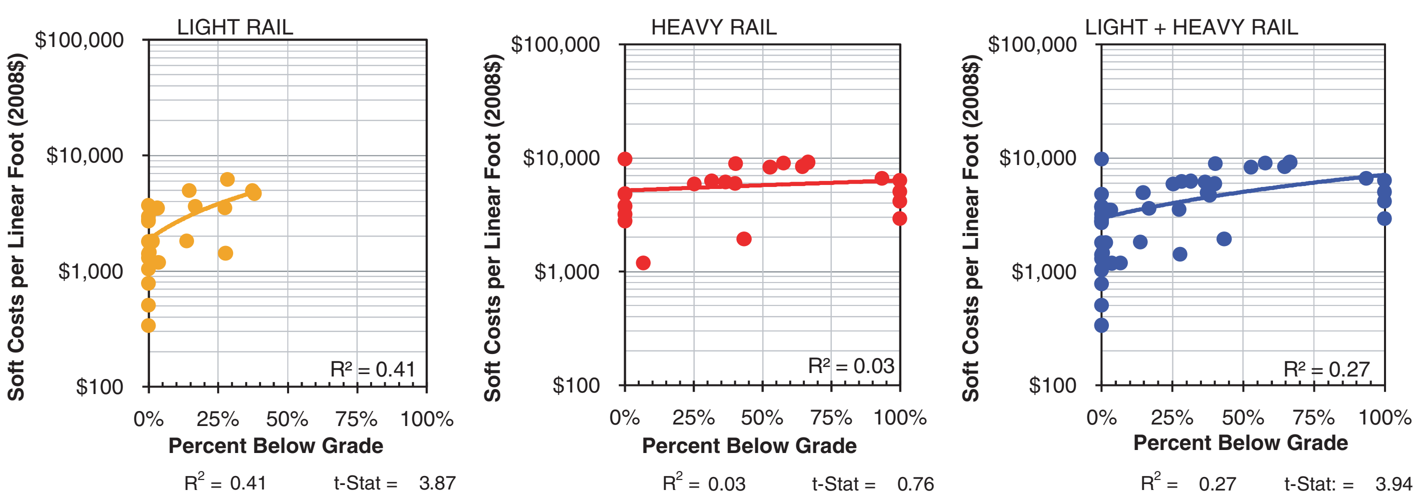


Figure 61. Soft costs per linear foot versus percentage of guideway below grade.

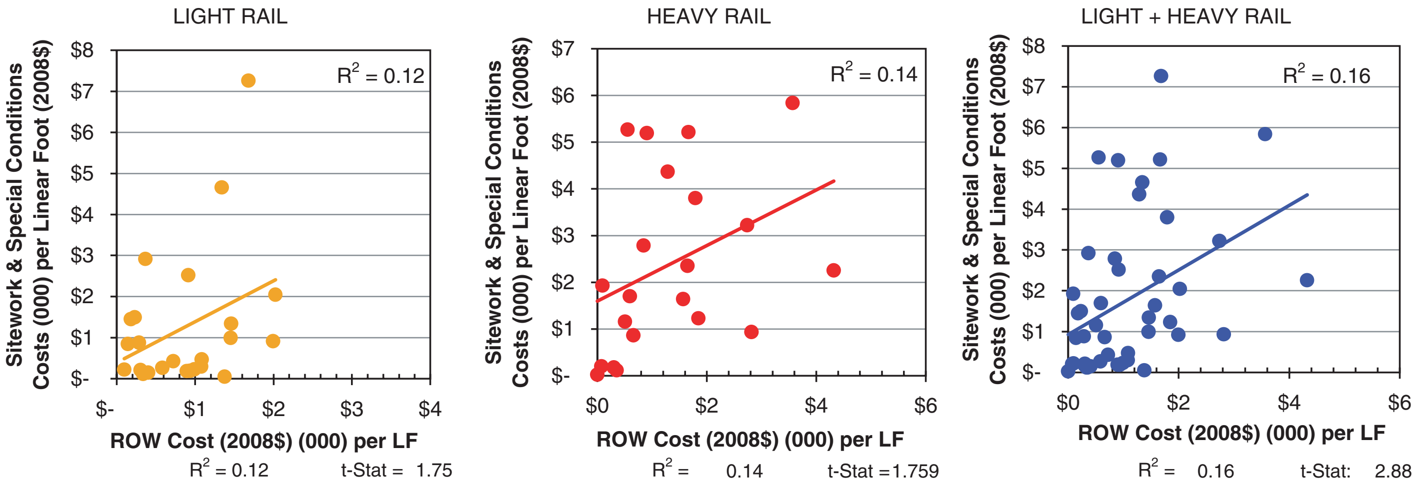


Figure 62. Sitework and special conditions costs per linear foot versus right-of-way costs per linear foot.

terms risks autocorrelation between unit costs—high soft costs could be correlated with higher other costs. In general, the analyses below tend to confirm this hypothesis: in dollar terms, soft costs and most cost categories tend to increase proportionately to construction costs.

Figure 62 shows that right-of-way costs grow along with sitework and special conditions costs. The relationship is weak, but this finding mildly supports the hypothesis that all categories of capital costs may be growing together, which may help explain the previous results showing that soft costs grow in dollar value, but not percentage terms in relation to complexity (i.e., in terms of percent of alignment not at grade or below grade).

Another perspective on the relationships between these soft cost categories is the relationship of guideway costs to right-of-way costs. As shown in Figure 63, these two cost categories appear to be correlated, similar to Figure 30 and Figure 62. The statistical significance is not as pronounced, but the relationship is clear: as right-of-way costs increase, guideway construction costs are also shown to increase. This correlation is best demonstrated for light rail, and the near-zero intercept makes intuitive sense. The heavy rail correlation is statistically insignificant but directionally consistent with light rail. The combined project database also shows a statistical relationship.

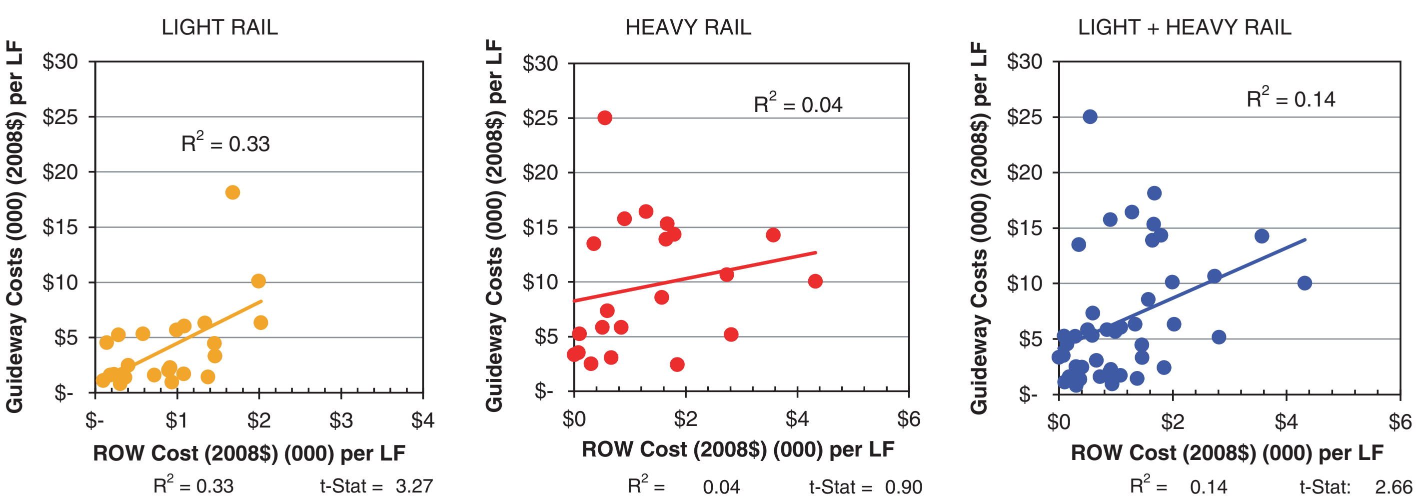


Figure 63. Guideway construction costs per linear foot versus right of way cost per linear foot.

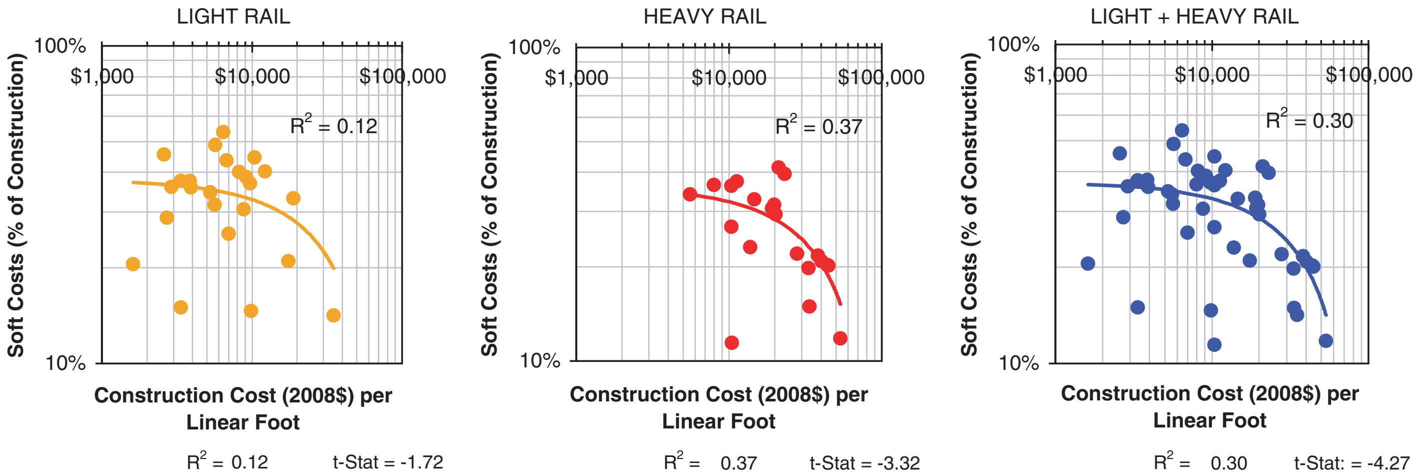


Figure 64. Soft costs as a percentage of construction versus construction costs per linear foot on a logarithmic scale.

In general, Figure 62 and Figure 63 (and Figure 30 in Section 4.5.5) show that all categories of capital costs tend to grow together. These three figures help explain why the data show that soft costs rise in dollar terms but not percentage terms when plotted against expected complexity variables such as alignment profile. To further support this point, Figure 64 can be compared to Figure 30. Both display the same variables on the x- and y-axes; however, Figure 64 measures soft costs as a percentage of construction costs whereas Figure 30 measures these in dollar value terms. When one variable is expressed in percentage terms, as in Figure 64, the correlation is non-existent.

The preceding figures demonstrate that despite the relatively stronger cost relationships produced by measuring soft costs in dollar terms, such a measurement may not provide an accurate understanding of the changing relationship between soft costs and other project characteristics. Indicators of project complexity are correlated with higher soft costs in dollar terms, and with higher costs in all categories.

C.12. Soft Costs by Complexity: Right-of-Way Costs

Right-of-way costs, which are primarily the cost to acquire real estate and relocate existing residences and businesses, appear to be mildly related to soft costs as a percentage of construction costs. High expenditures to acquire real estate and relocate land uses may be correlated with projects in more dense, urban areas where soft costs might be relatively high in proportion to the construction budget. Figure 65 compares soft costs as a percentage of construction cost to right-of-way costs and shows that right-of-way costs as a percentage of total costs appear to explain a small amount of soft cost variation.

Figure 66, however, shows that ROW costs per linear foot are not correlated with soft cost percentages. These relationships indicate that soft cost percentages do not change significantly as right-of-way costs increase per linear foot.

C.13. Soft Costs and Project Development Budget

As a project is developed through the planning and design phases, its budgeted cost is likely to change as the project is further defined. Similarly, a project can face cost overruns during construction phases due to a variety of factors such as unforeseen subsurface conditions, inaccurate

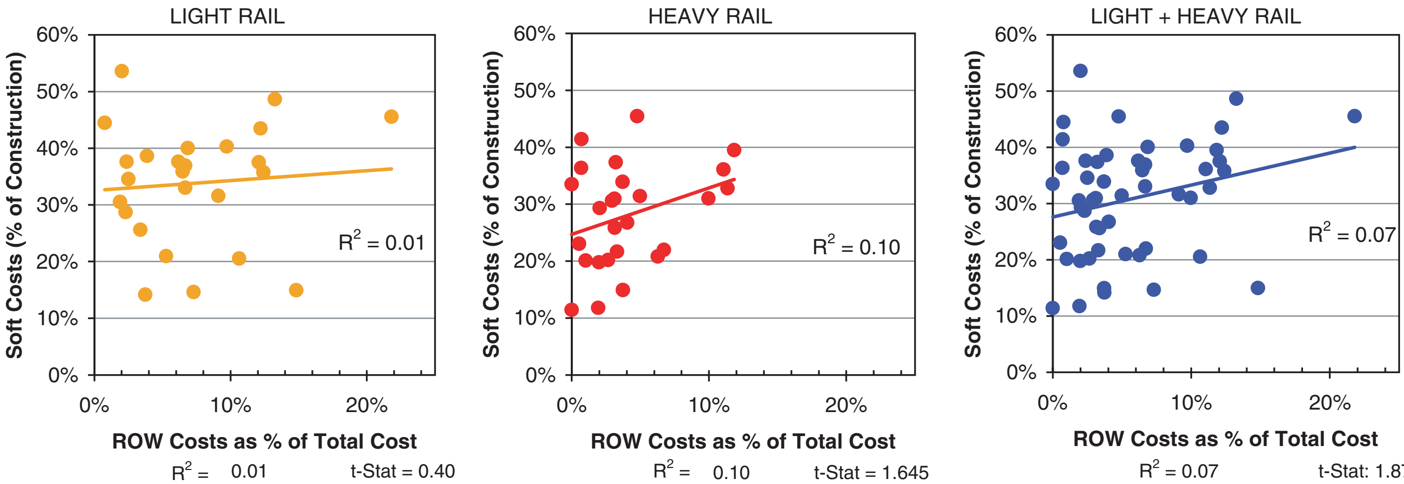


Figure 65. Soft costs as a percentage of construction with right of way costs as a percentage of total cost.

preliminary estimates, and unexpectedly high bids from contractors. To explore the potential effects of early budget estimates on actual soft cost expenditures, this report used data from the report from TCRP Project G-07 (Booz Allen Hamilton Inc., 2005). This data, provided for 22 projects in the original database, is summarized in Table 18.

Figure 67 graphs the data above (outliers removed) and show that budget overruns have little impact on a project's final proportion of soft costs. Cost overruns were measured by dividing the actual as-built cost by the total project cost as it was estimated during the preliminary engineering phase. The outlier shown with significant cost overruns is the Tren Urbano project in San Juan, whose project requirements and design sequence changed substantially during project development, impacting the budget of the project.

Soft costs as a percentage of construction decline slightly as the projects increase in cost escalation, but this trend is not statistically significant. This slight decline was not evident for construction phase project administration costs. This pattern is consistent with the previous figures: since soft costs may tend to grow in relation to other project cost categories, cost overruns have

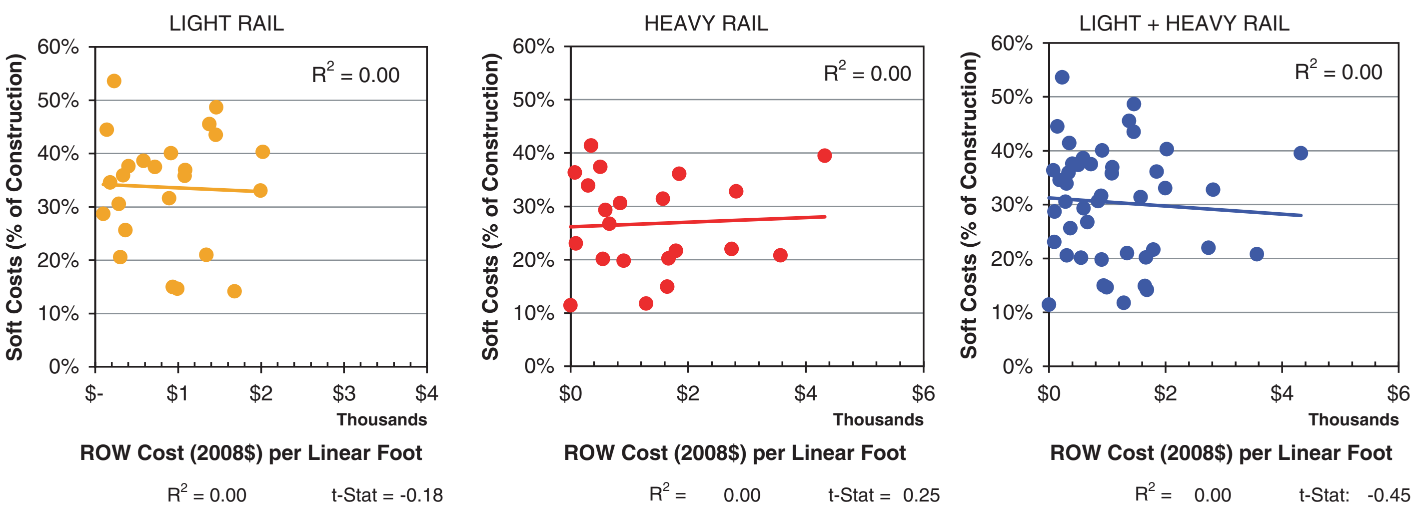


Figure 66. Soft costs as a percentage of construction with right of way costs per linear foot.

Table 18. Project development budgetary database used.

Project	Cost Estimated at PE	As-Built Cost	Actual Cost as % of PE Estimate
Portland MAX Segment 1	$214.0	$246.8	115%
Hudson-Bergen MOS-I	$775.0	$1,113.0	144%
Hiawatha Corridor	$548.6	$715.3	130%
Portland MAX Interstate	$301.8	$349.4	116%
St. Louis Clair County Extension	$359.1	$336.5	94%
Salt Lake North-South	$261.3	$311.8	119%
Portland MAX Westside/Hillsboro	$913.0	$963.5	106%
Pasadena Gold Line	$803.8	$677.6	84%
Denver Southwest Corridor	$142.5	$175.0	123%
Portland South Corridor	$125.0	$127.0	102%
VTA Tasman West	$327.8	$280.6	86%
VTA Tasman East	$275.9	$276.2	100%
VTA Capitol Segment	$147.1	$162.5	110%
VTA Vasona Segment	$269.1	$316.8	118%
MARTA Dunwoody Extension	$438.9	$472.7	108%
CTA Orange Line	$496.0	$474.6	96%
LA Red Line Segment 1	$914.4	$1,417.8	155%
LA Red Line Segment 2	$1,446.4	$1,921.7	133%
LA Red Line Segment 3	$1,310.8	$1,313.2	100%
San Juan Tren Urbano	$950.6	$2,250.0	237%
BART SFO Extension	$1,070.0	$1,550.2	145%
NYCT 63rd Street Tunnel	$537.9	$632.3	118%

Note: all dollar amounts in year-of-expenditure dollars.

little impact on the relative proportion of soft costs. In short, dollar value costs tend to increase together for a given project, regardless of the characteristics of the project.

C.14. Soft Costs and Project Development Schedule

The length of time it takes to plan, design, and construct a rail transit project may impact soft cost expenditures, as may schedule delay during the project development process. As pre-construction project development phases extend, design costs and project management costs may tend to increase. In addition, delay from the original schedule may also increase soft costs, as certain soft costs continue to be incurred steadily through these schedule delays.

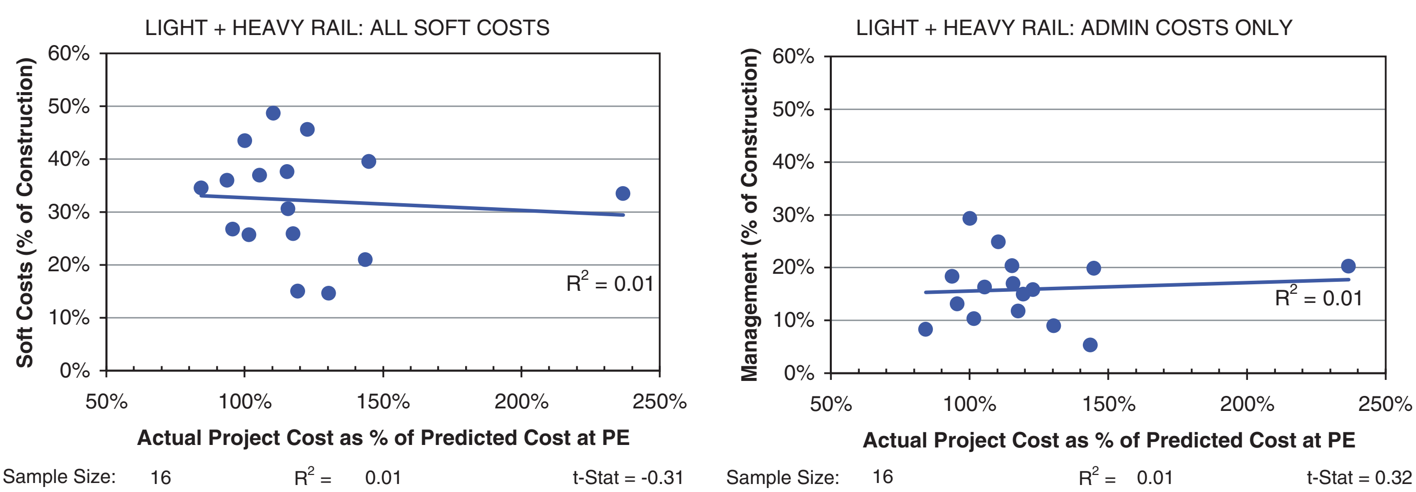


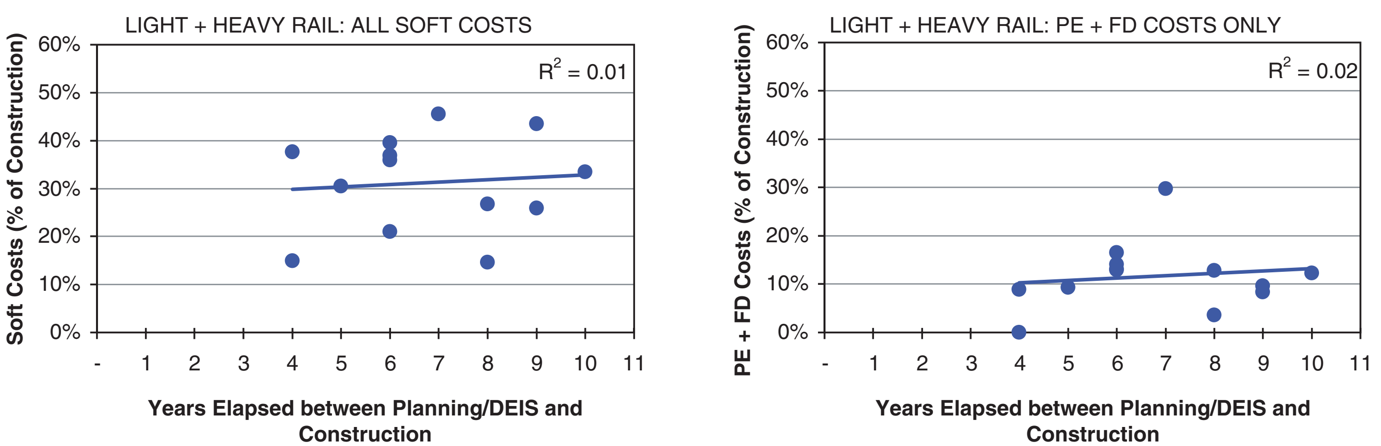
Figure 67. Soft costs as a percentage of construction versus cost overruns.

Table 19. Project development schedule data used.

Project	Planning/ DEIS	PE/FEIS	Final Design	Constr- uction	Operation
Portland MAX Segment 1	1980		1983	1984	1986
Hudson-Bergen MOS-I	1993	1996	1997	1999	2002
Hiawatha Corridor	1993	1999	2000	2001	2004
Portland MAX Interstate	1999	2000	2002	2004	2004
St. Louis Clair County Extension	1995	1998	1999	2001	2001
Salt Lake North-South	1994	1995	1998	1998	1999
Portland MAX Westside/Hillsboro	1990	1991	1994	1996	1998
Pasadena Gold Line	1993	1996	2000		2003
Denver Southwest Corridor	1992	1996	1997	1999	2000
Portland South Corridor		1995	1997		2001
VTA Tasman West	1992	1993	1996	1999	
VTA Tasman East	1992	1995	1999	2001	
VTA Capitol Segment		1999	2000	2004	
VTA Vasona Segment		1999	2000	2005	
MARTA Dunwoody Extension	1990	1991	1994	1998	2000
CTA Orange Line	1982	1984	1986	1990	1993
LA Red Line Segment 1	1983	1988		1989	
LA Red Line Segment 2	1983	1990		1994	
LA Red Line Segment 3	1983	1993		1998	
San Juan Tren Urbano	1992	1995	1996	2002	2004
BART SFO Extension	1992	1996	1997	1998	2002
NYCT 63rd Street Tunnel	1989	1992	1994	1998	2001

To explore this potential, this report again turned to data provided from the report from TCRP Project G-07, *Managing Capital Costs of Major Federally Funded Public Transportation Projects* (Booz Allen Hamilton Inc., 2005). Table 19 shows the project schedule data used in this analysis. This data represents the year in which a project phase began, which is somewhat different from the midyear of expenditure used in other sections of this analysis. When data was not available for all project phases, or when phases appeared to be unreasonable, projects were omitted where appropriate. Resulting sample sizes are noted in the figures, as well as in Table 17.

Figure 68 shows the effect of pre-construction duration (from Planning/DEIS to construction phases) on soft costs as a percentage of construction. Total soft costs are presented in the left pane, and engineering costs (preliminary engineering and final design) costs are presented in the right pane. Note that it may be difficult to identify a single year for the "Planning and DEIS"



Sample Size: 13 R^2 = 0.01 t-Stat = 0.32 Sample Size: 13 R^2 = 0.02 t-Stat = 0.46

Figure 68. Soft costs as a percentage of construction versus years elapsed between completion of the draft environmental impact statement and construction.

phase for a project since the long-range planning process may be very different for each metropolitan area or agency. The correlation is positive, as expected, but the relationship is statistically insignificant.

Measuring soft costs on a per-linear-foot basis, however, produces a stronger relationship, as shown in Figure 69. Total soft costs are presented in the left pane, and engineering costs (preliminary engineering and final design) costs are presented in the right pane. In the right pane, the results are pronounced from an x-axis intercept at four years toward a maximum range of about $20,000 per linear foot at about 15 years between the DEIS completion and construction. This relationship holds for engineering soft costs as well, as shown in the right pane.

These findings seem to suggest that the duration of pre-construction phases should be considered within the estimate of soft costs. However, the findings in Figure 69 may simply show that costly projects take longer to plan and design. Caution should be given due to the relatively small sample size (15) and the role of four relatively costly projects in this chart.

Figure 70 measures the effect of a more narrowly defined pre-construction phase (PE/FEIS to construction) on soft costs, and shows insignificant findings. The relationship shows the correct direction of increasing soft cost percentage with increasing schedule duration but is statistically insignificant. The relative magnitude of soft costs, including engineering costs only, appears to be unaffected by the years elapsed between the preliminary engineering and construction phases.

Figure 71 extends the above analysis to include the duration through construction all the way to operations, and finds similarly inconclusive results. Total soft costs are presented in the left pane, and construction management and administration costs are isolated in the right pane. Administration costs are shown here to test the hypothesis that construction and other administration costs may be more likely to be affected by the duration of the construction phase. Although soft costs do tend to go up for lengthier projects in Figure 71, the relationship is not statistically significant.

The duration of a project may not cause soft costs to increase as much as delay or deviation from a prior schedule. During a delay, if construction costs and project scope remain stable, but administration activities continue steadily, soft costs in relation to construction costs might increase.

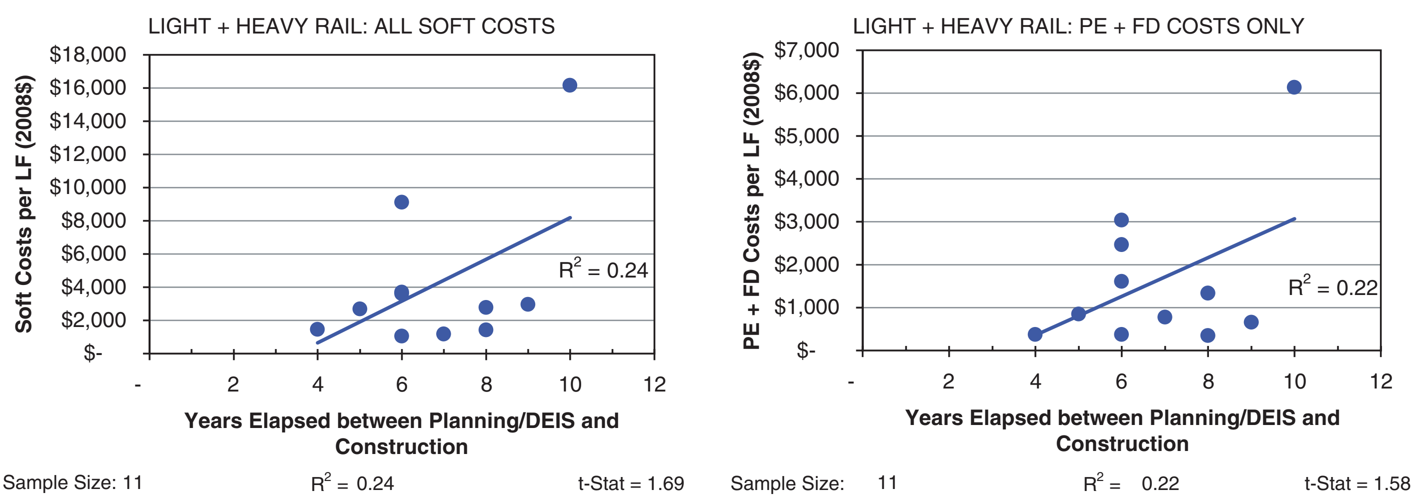
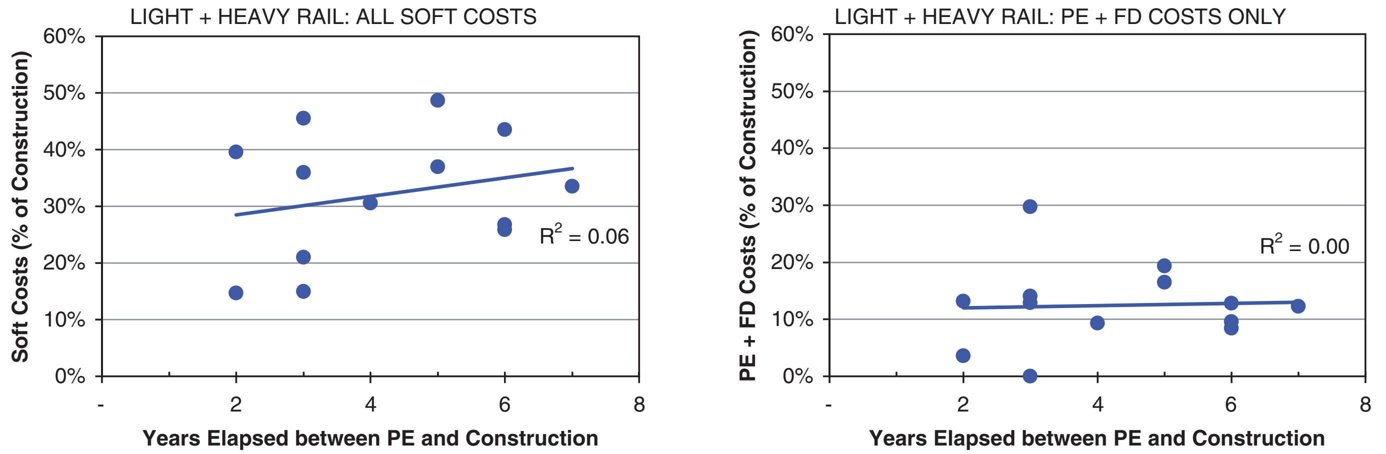


Figure 69. Soft costs per linear foot versus years elapsed between completion of the draft environmental impact statement and construction.



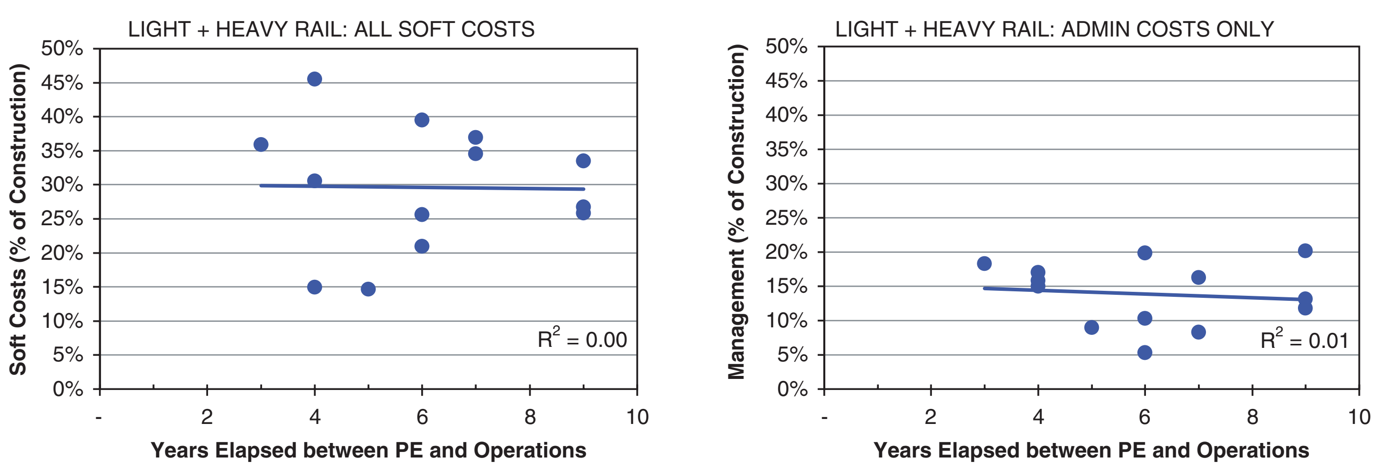
Sample Size: 13 R^2 = 0.06 t-Stat = 0.86 Sample Size: 13 R^2 = 0.00 t-Stat = 0.15

Figure 70. Soft costs as a percentage of construction versus years elapsed between preliminary engineering and construction.

Figure 72 presents the variance between the project opening date projected during the preliminary engineering phase and the actual project opening date and compares this to soft costs as a percentage of construction. Presumably, a deviation from the opening date predicted during engineering phases represents a delay. Note that many projects in this dataset were not delayed at all (zero years), while two actually opened ahead of schedule. Figure 72 shows no strong relationship with years of delay and the proportion of soft costs.

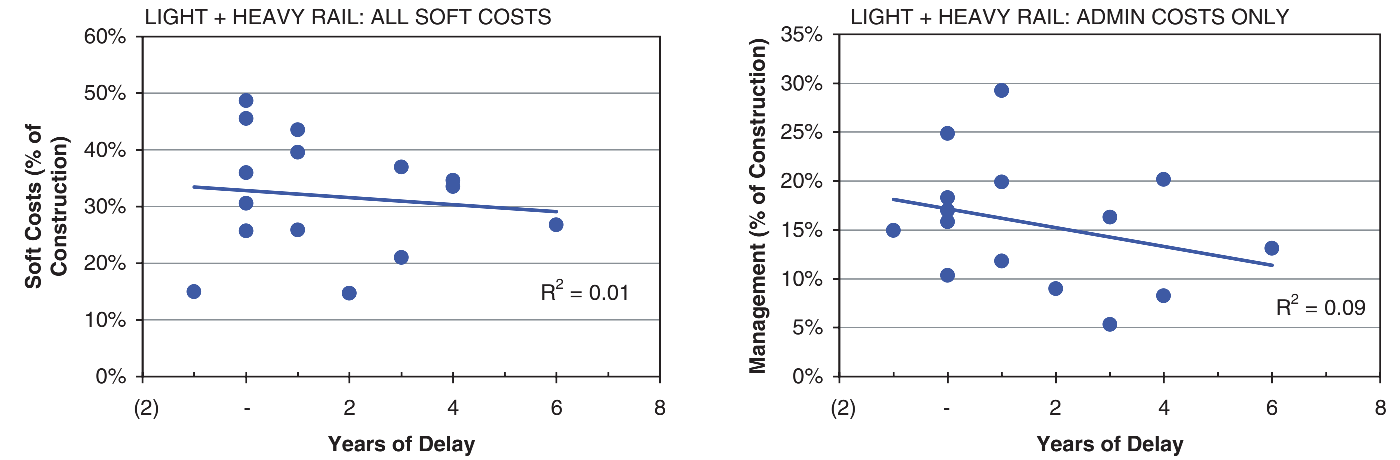
C.15. Vertical Profile and Soft Cost Measurement

Somewhat surprisingly, this soft cost analysis found a relatively weak correlation between vertical profile (and by extension, project complexity) and a variety of soft costs measured as a percentage of construction costs. One possible explanation for this finding is that tunneling and aerial structures increase construction costs so rapidly that soft costs as a share of the project do not change measurably beyond the construction costs and increase the soft cost proportions.



Sample Size: 13 R^2 = 0.00 t-Stat = -0.06 Sample Size: 13 R^2 = 0.01 t-Stat = -0.39

Figure 71. Soft costs as a percentage of construction versus years elapsed between preliminary engineering and operations.



Sample Size: 15 R^2 = 0.01 t-Stat = -0.43 Sample Size: 15 R^2 = 0.09 t-Stat = -1.14

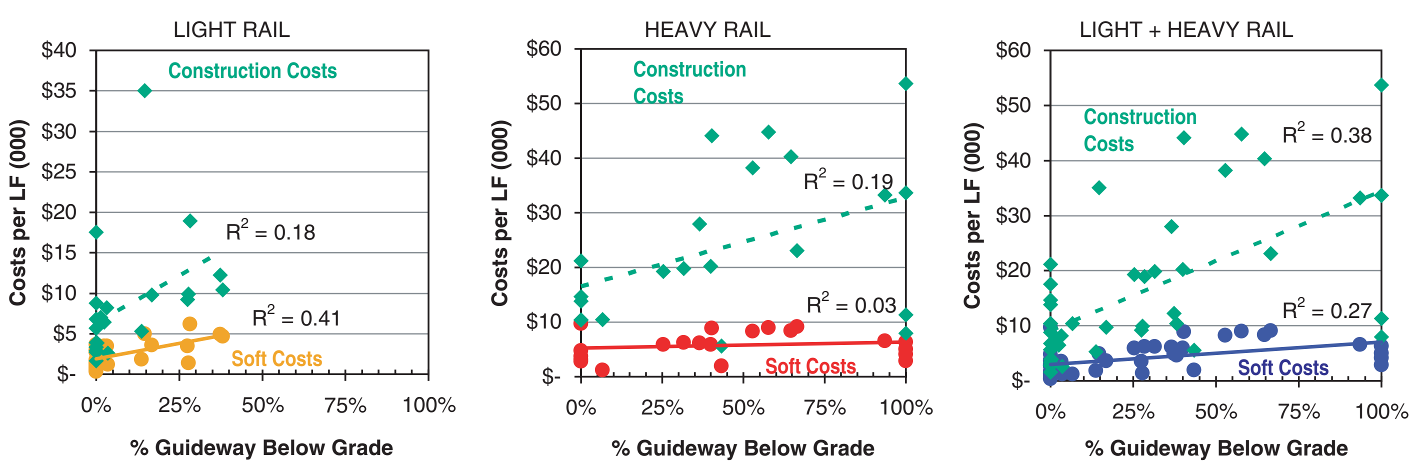
Figure 72. Soft costs as a percentage of construction versus years of delay in opening.

Figure 73 and Figure 74 examine this potential explanation by comparing the rate of growth of soft and hard costs as the vertical profile becomes more complex. Soft and construction costs are on a per-linear-foot basis, and in every pane construction costs are shown as green diamonds, with a green dashed trend line.

Figure 73 shows that for light and heavy rail and both modes combined, as more of the alignment is in cut and cover and tunnels, construction costs rise faster than soft costs. Figure 74 shows a similar trend when alignment is simply not at grade, although the pattern is less strong. These trends affirm that when the alignment moves from at grade to more complex tunnel, bridge, or aerial structures, construction costs expand rapidly, sometimes faster than soft costs.

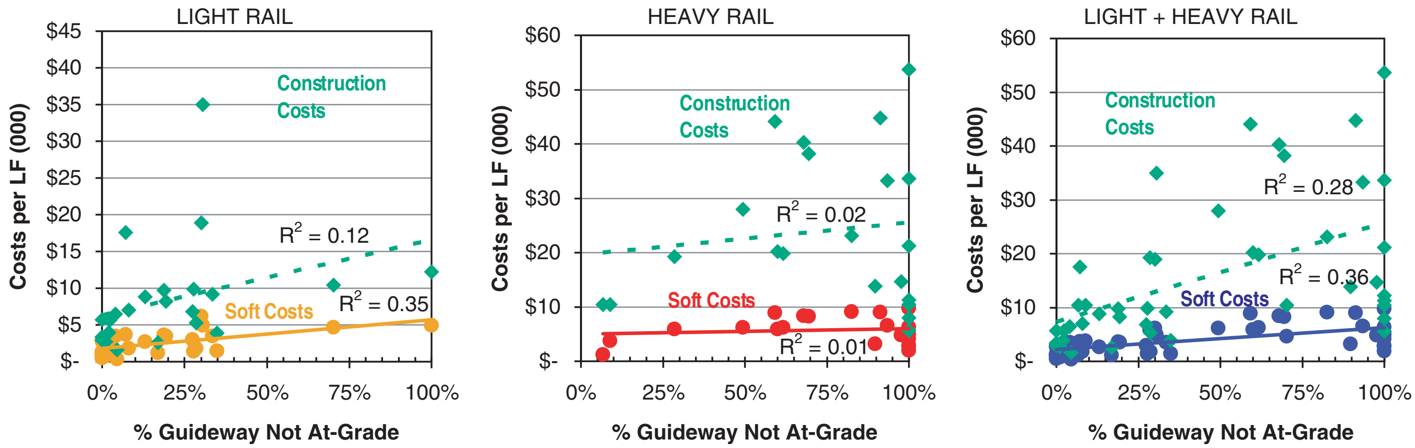
C.16. Isolating Agency-Specific Effects

One potential source of variance within the dataset used here is that financial and construction management practices differ from agency to agency. Where one agency maintains construction inspectors and managers on staff through the operating budget, another agency might



Soft Costs trend: R^2 = 0.41 t-Stat = 3.87 R^2 = 0.03 t-Stat = 0.76 R^2 = 0.27 t-Stat: = 3.94

Figure 73. Soft costs and construction costs per linear foot with percent of guideway below grade.



Soft Costs trend: R^2 = 0.35 t-Stat = 3.45 R^2 = 0.01 t-Stat = 0.52 R^2 = 0.36 t-Stat: = 4.88

Figure 74. Soft costs and construction costs per linear foot with percentage of guideway not at grade.

charge these employees to the project's capital budget, for example. In another case, certain agencies collect internal staff, force account, and contractor staff into separate operating accounts and then allocate them back to specific projects. These differing approaches may have some impact on the soft cost amount used in this analysis.

The philosophy or style of agency management might have just as much impact on soft costs as the alignment profile or number of stations. However, it is particularly difficult to control for agency-specific effects given the range of potential impacts and the generally small number of new rail construction projects per agency.

The dataset contains twelve distinct projects for Washington, DC, presenting an opportunity to try to isolate agency-specific effects. Examining only projects constructed by WMATA means analyzing projects with very similar project development processes and cost allocation practices. WMATA has expanded its Metrorail system incrementally over the past four decades, with each extension or new line treated as a discrete project in the database. This section of the report restates some of the previous analysis for WMATA projects only.

Figure 75 shows that soft costs for WMATA projects have been increasing in percentage terms over time. From the initial Metrorail segments completed in the 1970s through the projects completed in the late 1990s, WMATA has seen an increasing trend in soft costs. The initial segments of Washington DC's rail system had soft cost percentages of construction at about 20%. Through the rail extensions in the 1980s, soft cost percentages were mixed, with projects higher and lower than 20%, with a range from as low as 11% to as high as 38%. The three projects completed in the 1990s, however, had more consistent soft cost values of about 38%.

Figure 76 examines the soft cost percentage of construction costs with the percent of project alignment not at grade. In contrast to the full database for heavy rail, WMATA projects suggest a declining trend in soft costs with more complex alignments. The heavy rail project database showed an increasing trend from 27% to 36% with a statistical relationship, but little correlation. The WMATA statistical relationship is also insignificant, but does result in a declining trend more similar to the combined project database. Analysis of the full project database suggests that this pattern may be caused by other project categories growing faster than soft costs for these alignment types.

Figure 77 presents a similar analysis but is focused on only the proportion of alignment that is below grade for WMATA projects. The results of this WMATA analysis are similar to those

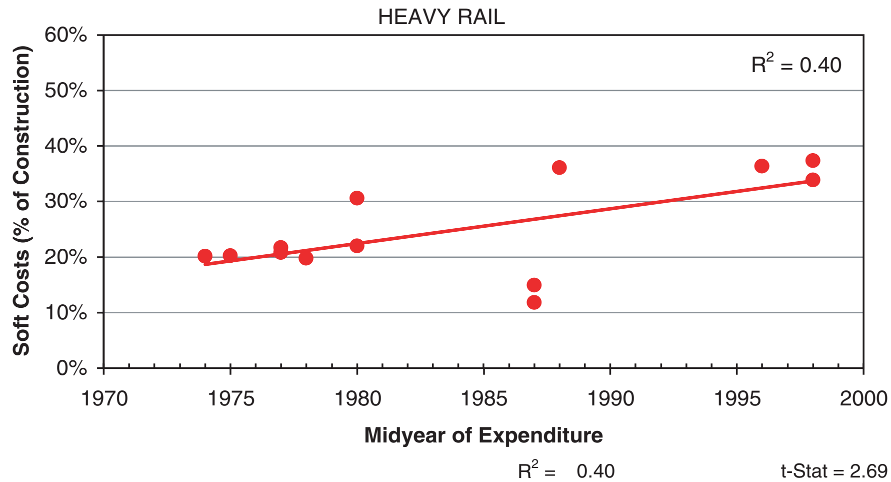


Figure 75. Soft costs as a percentage of construction versus midyear of expenditure, WMATA only.

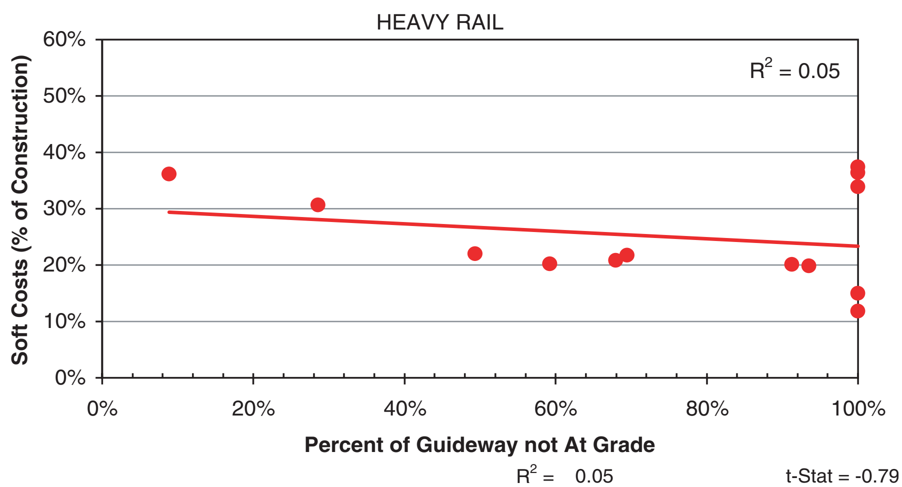


Figure 76. Soft costs as a percentage of construction with percentage of guideway not at grade, WMATA only.

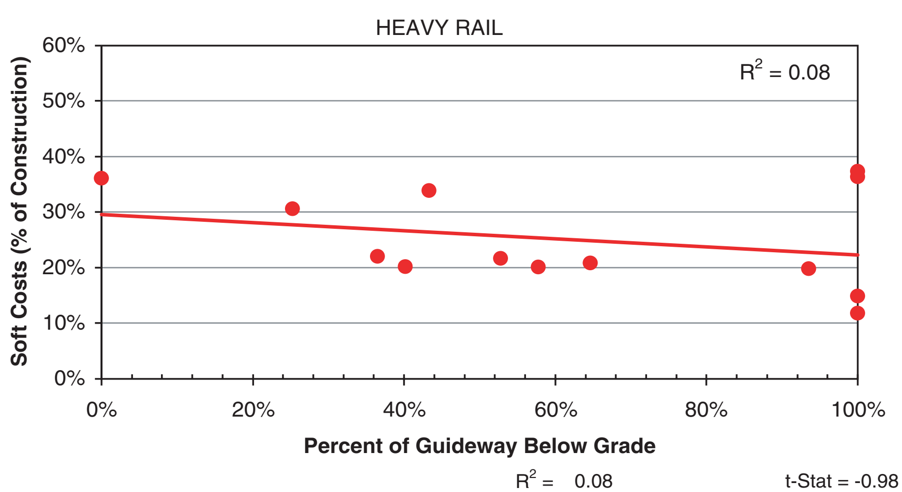


Figure 77. Soft costs as a percentage of construction with percentage of guideway below grade, WMATA only.

from the full database of heavy rail projects. The trend line shows a declining trend from a high of 30% to a low of about 22%, but the relationship is not statistically significant. Note that some WMATA projects are 100% below grade. These results suggest that below-grade alignment has no effect on soft costs as a percentage of construction costs.

These WMATA Metrorail results do not support the full heavy rail database, nor do they demonstrate consistent relationships that may be expected for projects from the same agency.

The results from the preceding WMATA-only data demonstrate the difficulty in identifying project characteristics that can be used to help estimate construction soft costs of major public transportation capital projects.

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