I-270 MULTI-MODAL CORRIDOR STUDY
CORRIDOR CITIES TRANSITWAY

Capital Cost Methodology Report

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INTRODUCTION

This document provides a framework for the presentation of methods, cost data and cost assumptions used in the development of AA/EA level capital costs estimates for the alternatives which have been defined, developed and evaluated as part of the Corridor Cities Transitway Study. Comparative capital cost estimates are made at progressive levels of detail as the project development process passes through the various stages of the alternative analysis and environmental analysis process.

This Technical Memorandum presenting the Capital Cost Estimating Methodology is part of a set of common technical methods and guidance that were used for the development and review of the proposed alignment(s) for the corridor. The development of the capital cost estimating methodology is identified in the Project Scope of Services.

Purpose and Scope

The purpose of this technical memorandum is to:

- Describe the methods used to define, quantify and present capital cost estimates required for project evaluation;
- Define the nature and sources for cost data used in the preparation of capital cost estimates;
- Define cost assumptions used in the preparation of capital cost estimates; and
- Explain limitations that are present in capital cost estimates at this stage of project definition.

The capital costing methodology is intended to provide professionally accepted guidelines for accurately and consistently estimating the costs of the capital components of the alignment(s) under consideration in the Corridor Cities Transitway. It will also provide a framework for using the cost estimates by defining the basis for the estimates and the associated level of confidence for the estimated costs for the various components. This will allow decision-makers to effectively evaluate capital costs as one of the significant criteria in their evaluation and selection of the components which will comprise the proposed project. Capital cost estimates also contribute to the assessment of effectiveness and efficiency.

ESTIMATING METHODOLOGY

The methodology used for preparing capital cost estimates has been developed in general accordance with FTA guidelines for estimating capital costs. Part of the FTA guidelines call for cost estimates to be prepared and reported using the latest revision of the FTA's Standard Cost Categories (SCC). In the estimates, cost components for the various alternatives are developed and summarized into the SCC. These cost categories form the basis for the format and structure used for the capital cost detail and summary sheets developed for this project as well. The SCC is described in Section 2.2 below.

General Approach

Each of the alternatives that have been developed have conceptual engineering drawings, typical sections, station locations and/or written descriptions prepared that provide needed definition for each of the major construction cost components. These planning documents form the basis for the identification of the various facility elements used to prepare the capital cost estimates. These facility elements can be classified into one of two broad groups, either typical or non-typical facilities. Typical facility costs are developed for elements that can be defined by a typical cross-section and applied over a given length of alignment or based on a conceptual scope of work developed as appropriate for a specific typical facility. The typical facility composite unit cost is then developed by combining the costs for all of the individual construction elements applicable to a given typical section or facility and creating a representative composite unit cost. Typical sections or facilities were developed for each of the alternatives. Non-typical facility costs were developed based on conceptual engineering and design related to the unique facility under consideration. For those non typical facilities elements that are necessary for overall system operation, but whose costs cannot be allocated to a specific geographic segment of the system (e.g., vehicles, storage and maintenance facility, etc.), these costs are included in at the summary level. After details were prepared for both typical and non-typical facilities and the cost data developed, it was put into a cost stream format based on the stationing of the alignment for each alternative. This format relates the cost directly to the plan and profile drawings and assists in summarizing costs, as well as in the analysis of various alignment segments.

Capital Cost Categories

In accordance with the latest version of the FTA's SCC, the capital cost components of the various alternatives were classified into the following cost categories.

10 Guideway and Track Elements
20 Station, Stops, Terminals, Intermodal
30 Support Facilities: Yards, Shops, Administration Buildings
40 Sitework & Special Conditions
50 Systems
60 ROW, Land, Existing Improvements
70 Vehicles
80 Professional Services

90 Unallocated Contingency
100 Finance Charges

The following provides a brief descriptions of these cost categories and their constituent elements.

Guideway and Track Elements

Guideway and track elements are portions of the transit system that can be assigned costs at a fairly aggregate level with an acceptable level of accuracy. Most commonly these are line portions of each alignment that can be represented by typical cross sections. Guideway and track elements are subdivided into a number of sub-categories which are described below. .

Guideway

The guideway cost category is made up of a number of sub-categories. The following is a list of these sub-categories:

10.01 Guideway: At-grade exclusive right-of-way
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)
10.03 Guideway: At-grade in mixed traffic
10.04 Guideway: Aerial structure
10.05 Guideway: Built-up fill
10.06 Guideway: Underground cut & cover
10.07 Guideway: Underground tunnel
10.08 Guideway: Retained cut or fill

These categories can be described by three primary types of construction, at-grade construction, aerial structure construction, and retained cut or fill/underground construction. For rail based technologies, this cost category includes all of the foundational construction elements up to the point where track construction typically begins and is often described as the subballast level. For bus based technologies, this cost category includes all of the foundational construction elements up to and including the running surface. The guideway cost estimates are based on parametric unit cost information specifically developed for each construction type. In general, all of the parametric guideway cost estimates provide for the following construction elements as appropriate:

- At-Grade Construction
    - Traffic control
    - Site work, including clearing, demolitions and earthwork
    - Erosion control and soil stabilization
    - Drainage systems for the guideway
    - Catenary pole foundations (Rail only)
    - Concrete base slab for embedded guideway construction (Rail only)
    - Subgrade preparation and subballast for ballasted guideway construction (Rail only)
    - Allowance for systems ductbanks, corrosion control, and signage
    - Roadway paving, barriers and striping (Bus only)

- Aerial Structures Construction
    - Traffic control
    - Site work, including demolition and clearing
    - Structural excavation and backfill
    - Foundation support including piling, drilled piers, etc.
    - Concrete footings, columns, pier caps, and superstructure
    - Steel reinforcement
    - Pedestrian access and protection
    - Allowance for systems ductbanks, corrosion control, and signage
- Retained Cut or Fill/Underground Construction
    - Traffic control
    - Site work, including demolition, clearing and restoration
    - Structural excavation and backfill or tunnel excavation
    - Temporary excavation support and dewatering
    - Concrete footings, slabs, retaining or structural walls and roof slabs or tunnel lining
    - Ventilation, drainage, fire protection, lighting
    - Allowance for systems ductbanks, corrosion control, and signage
    - Roadway paving and striping (Bus only)

Separate composite unit prices were developed for various increments in the height or depth of typical sections for embankment, retained cut or fill, and aerial structures.

Track (Rail Only)

The track cost categories include the running rails, ties, ballast, direct fixation concrete plinth, embedded track and special track components (turnouts, crossovers, etc.) associated with the guideway construction. The following is a list of the sub-categories associated with this cost category:

10.09 Track: Direct fixation
10.10 Track: Embedded
10.11 Track: Ballasted
10.12 Track: Special (switches, turnouts)
10.13 Track: Vibration and noise dampening

Track unit costs are divided into the following three types of construction:

- Direct-fixation track (track fixed onto a structural concrete slab, typically used in aerial or underground construction)
- Embedded or paved track (typically used in street-running situations)
- Ballasted track (typically used in at-grade or retained cut or fill construction)

The cost of constructing the supporting subgrade, subballast, or concrete supporting structure will normally be included in the guideway cost category. The standard rail for ballasted and direct-fixation track is continuous welded 115RE rail. For ballasted track, the unit cost includes rail, concrete ties with ballast, rail welding, rail fasteners, and rail anchors. For direct fixation track the rail is attached on a second-pour

concrete plinth pad with a direct fixation rail fastener. The unit cost for embedded track includes rail, rail welding, reinforced concrete track slab, structural running surface, coated tie bars, and rail embedding materials. Track drains for embedded track are included in the guideway unit costs. Special track typically includes single and double turnouts and crossovers, wyes, pocket tracks, and rail crossings. The costs for special trackwork are applied on a per unit basis at specific locations if this information is available or as a percentage allowance calculated on the cost of the various track cost categories. The track costs for the storage yard or maintenance shop facility are included in cost category 30 Support Facilities.

Stations, Stops, Terminals, Intermodal

Station costs represent the fixed facilities and amenities for transit stations. The passenger station cost estimates are based on parametric unit prices developed for each type of station facility anticipated. The station cost category is made up of a number of sub-categories. The following is a list of these sub-categories:

20.01 At-grade station, stop, shelter, mall, terminal, platform
20.02 Aerial station, stop, shelter, mall, terminal, platform
20.03 Underground station, stop, shelter, mall, terminal, platform
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.
20.05 Joint development
20.06 Automobile parking multi-story structure
20.07 Elevators, escalators

Also included in this cost category are structured parking lots and elevators/escalators that are adjacent to and part of a passenger station. Generally, all the parametric station cost estimates include the following construction elements:

- At-grade Stations
    - Station types were either side or center platform. Platform lengths were based on the number and length of transit cars that will make up a train determined from an operational analysis.
    - Site work, including clearing, demolition, and excavation
    - Grading, borrow fill, and soil stabilization
    - Concrete footings, walls, and platform slab
    - Canopy(s) covering a portion of the platform
    - Architectural surface treatment of platform with pavers and tactile warning strips.
    - Allowance for station furnishings and signage.
    - Lighting, electrical, and mechanical allowances
- Aerial or Underground Stations
    - Station types were either side or center platform. Platform lengths were based on the number and length of transit cars that will make up a train determined from an operational analysis.
    - Site work, including clearing, demolition, and excavation
    - Grading, borrow fill, and soil stabilization
    - Concrete footings, columns, pier caps, superstructure, platform slabs, steel reinforcement, and pedestrian barrier

- Canopy(s) covering a portion of the platform
- Architectural surface treatment of platform with pavers and tactile warning strips.
- Allowance for station furnishings and signage.
- Lighting, electrical, and mechanical allowances
- Vertical circulation elements (i.e., stairs, or structural elements to support elevators and escalators. Equipment purchase and installation is included under item 20.07)
- Equipment rooms or operator welfare structures

- Automobile Parking Multi-story Structure
    - Traffic control
    - Site work, including demolition and clearing
    - Structural excavation and backfill
    - Foundation support including piling, drilled piers, etc.
    - Concrete footings, columns, pier caps, decking and superstructure
    - Steel reinforcement
    - Pedestrian access and protection
    - Lighting, electrical, and mechanical allowances

Pedestrian access, artwork, and surface parking lots associated with passenger stations are accounted for under other cost categories described below.

Support Facilities: Yards, Shops, Administration Buildings

This cost category includes vehicle storage and maintenance buildings, trackwork for storage of rail vehicles, vehicle cleaning and painting facilities, office support areas, maintenance of way facilities, and general and major shop equipment. The following is a list of the sub-categories under this cost category:

30.01 Administration Building: Office, sales, storage, revenue counting
30.02 Light Maintenance Facility
30.03 Heavy Maintenance Facility
30.04 Storage or Maintenance of Way Building
30.05 Yard and Yard Track

Sitework and Special Conditions

The development of a functional transit system often requires that a number of ancillary mitigation requirements that may or may not be directly related to the transit system service be addressed. These sitework and special conditions often include items that cannot be adequately represented by a typical cross-section because of complexity, uncertain alignment, special site conditions, or other unique circumstances. The sitework and special condition cost category is sub-divided into the following:

40.01 Demolition, Clearing, Earthwork
40.02 Site Utilities, Utility Relocation
40.03 Hazardous materials, contaminated soil removal/mitigation, ground water treatments
40.04 Environmental mitigation, e.g. wetlands, historic/archaeological, parks

40.05 Site structures including retaining walls, sound walls
40.06 Pedestrian / bike access and accommodation, landscaping
40.07 Automobile, bus, van accessways including roads, parking lots
40.08 Temporary Facilities and other indirect costs during construction

Demolition

This cost category generally includes costs for the demolition of special features such as buildings (if not included as part of right-of-way), large structures (bridges or retaining walls), existing railway trackbeds or other existing features that fall outside of the guideway construction envelope.

Utility Relocations

Generally one of the largest cost elements within this cost category is the relocation of existing utilities from within the guideway construction envelope. These relocations can include both public and private utilities, subject to any agreements that may apply to franchised utilities that exist within public right-of-ways. Typically utility relocation information is not available during the AA/EA phase of project development, therefore, several levels of utility relocation allowances with average unit costs based on historical experience have been defined. These levels were applied along the various transit alignments based on an evaluation of the complexity of the existing utilities and the scope of utility relocations anticipated.

Hazardous Material and Environmental Mitigation

Any special hazardous material or environmental mitigation costs, such as contaminated soil or ground water, wetlands mitigation, etc. would be included under this category. Typically engineering and design information is not available during the AA/EA phase of the project on which to develop a quantity based cost estimate. Therefore, several levels of hazardous material and environmental mitigation allowances, based on historical experience, with average unit costs per route foot were established and used.

Site Structures

This cost category typically includes structures such as retaining walls, sound walls, etc, that are outside of the guideway construction envelope. Structures such as retaining walls for retained cut or fill guideway and bridge or aerial structure used for aerial guideway are included in cost category 10 Guideway and Track Elements. For projects in the AA/EA phase of development, sites structures costs are typically applied on a cost per square foot basis.

Pedestrian Access, Landscaping

Typically pedestrian access and landscaping information is not well developed during the AA/EA phase of project development; therefore, several levels of pedestrian access and landscaping allowances with average unit costs based on historical experience were utilized. Landscaping costs associated with parking facilities are included in the composite cost developed for those particular items and included in other cost categories.

Automobile Accessways, Parking Lots

This cost category can include new and reconstructed roadways, streets, surface parking areas, sidewalks, curbs and gutters, and related roadway facilities associated with construction of the rail or bus guideway. Roadway and parking area cost estimates were based on parametric unit costs applied to quantities developed on location specific data taken from the conceptual engineering alignment plans.

Temporary Facilities

This cost category can include costs for mobilization, demobilization, project phasing; temporary construction associated with weather, construction easements, or temporary site access and mitigate. For the AA/EA phase of project development, these costs are included as a percentage allowance mark-up in the other cost categories.

Systems

This cost category includes the following cost elements.

50.01 Train control and signals (Rail only)
50.02 Traffic signals and crossing protection
50.03 Traction power supply: substations (Rail only)
50.04 Traction power distribution: catenary and third rail (Rail only)
50.05 Communications
50.06 Fare collection system and equipment
50.07 Central Control

Train Control & Signals (Rail Only)

This cost category includes the signaling and control systems required for safe and efficient operations of the transit technology. It includes automatic wayside signals in areas of separate right-of-way, automatic train stop circuitry in the track and vehicles, block supervision where required for street operation.

Traffic Signals & Crossing Protection

For transit systems that are constructed to operate either within existing streets or with at-grade crossing of existing roadways, there is often a need for modifying existing traffic signals or constructing new traffic signals or other crossing protection. This cost category includes the signaling and control systems required for items such as vehicle and pedestrian signals, traffic signal pre-emption, and protection at hazardous guideway/highway at-grade crossings (flashing lights, bells, and signs).

Traction Power Supply: Substations (Rail Only)

The traction power supply system provides the power for all train operations. This cost category consists primarily of the civil and architectural infrastructure along with the mechanical and electrical equipment needed to construct traction power substations.

Traction Power Distribution (Rail Only)

The traction power distribution system is based on a direct current (dc) overhead contact system (OCS). The OCS consists primarily of support poles, brackets arms and hardware, cables, and messenger cable. Signal and communication power needs are also included in the traction power costs. Power supply or distribution for buildings associated with the storage and maintenance facilities or power for passenger stations is not included in this cost category.

Communications

The communications system provides the necessary subsystems to support the total operational requirements of the transit technology. The communications system costs provide for subsystems such as two-way radios, public address, telephone systems, variable message signs, interfaces to the fare collection and ticket vending equipment and equipment for the hearing impaired, etc.

Fare Collection

Costs for elements in this category are based upon a self-service, barrier-free, proof of payment fare collection system. Ticket vending machines (TVM) costs shall be based on a microprocessor controlled coin or bill accepting machine capable of optionally accepting credit, debit, and stored value cards. The unit cost for fare collection includes all equipment costs, and installation costs. The hardware includes provisions for fare vending facilities and access for the physically handicapped.

Central Control

The cost category includes all of the civil, structural, architectural, mechanical, electrical, and systems costs for providing for the remote monitoring of train operations, track conditions, substations, and station support facilities. The need and appropriateness for a central control facility is dependent on the operational analysis and assumptions that were made for the given transit technology.

ROW, Land, Existing Improvements

This cost category covers all land acquisition and acquisition related costs required to obtain various real property needed for the construction, operation, and maintenance of the proposed alignments. Costs include the fee acquisition of permanent and temporary easements, relocation costs, business damages and other miscellaneous costs. Sub-categories include:

60.01 Purchase or lease of real estate
60.02 Relocation of existing households and businesses

Vehicles

This cost category is generally subdivided into revenue (identified by transit mode) and non-revenue vehicles (where non-revenue vehicles include maintenance-of-way vehicles, and agency trucks and automobiles). During the AA/EA phase of project development the unit costs for vehicles will typically include costs for engineering,

procurement, spare parts, etc. and is based on historical data from recent transit projects. This cost category is sub-divided into the following:

70.01 Light Rail (including Streetcar)
70.02 Heavy Rail
70.03 Commuter Rail
70.04 Bus
70.05 Other
70.06 Non-revenue vehicles
70.07 Spare parts

Professional Services

This cost category includes allowances for preliminary engineering, final design, project and construction management, agency program management, project insurance, surveys and testing, and start-up costs. These allowances are computed by applying a percentage to the total construction cost estimated for each cost category (excluding right-of-way and vehicle costs). Right-of-way and vehicle costs typically are calculated to include the management and administration costs associated with these activities and are therefore excluded from the calculation of professional services. The following is a list of the percentage multipliers being applied to the total construction costs to cover these items:

80.01	Preliminary Engineering	4%
80.02	Final Design	6%
80.03	Project Management for Design and Construction	5%
80.04	Construction Administration & Management	8%
80.05	Insurance	2%
80.06	Legal; Permits; Review Fees, etc.	3%
80.07	Surveys, Testing, Investigation, Inspection	3%
80.08	Start up	1%

Unallocated Contingency

Unallocated contingency is similar in nature to allocated contingency in that it is primarily applied as an allowance for unknowns and uncertainties due to the level of project development completed. The major difference is that allocated contingencies are intended to address uncertainties in the estimated construction, right-of-way, and vehicle costs that typically occur as the amount of engineering and design information advances, while unallocated contingencies are typically much broader in nature and often address changes in the project scope and schedule. Unallocated contingency was calculated as 5% of the total of cost categories 10 to 50 and then 2% of cost categories 60 to 80.

COST DATA

Cost data was developed using several sources and was comparable to those seen in the Metro Washington region for similar types of construction. The cost data will be refined and updated throughout the subsequent design phases. The first task in developing the cost data is to prepare a list of work items that are typical based on the scope of work for the transit technology. Unit costs for these work items will then be estimated using various cost references and historical cost data and was compiled into a database format to form a Unit Cost Library (UCL). The key elements of the UCL are an Item Code, Item Description, Unit of Measure, and Unit Cost. This UCL summary will include, but will not be limited to, those items typically found in a project of this scope. All unit costs include contractor's direct construction cost plus all taxes, general expense, overhead and profit. The unit costs do not include items such as engineering, construction management, owner's administrative costs and allowances for contingencies. These costs were included as percentage add-ons to the cost estimate under other cost categories.

Sources of Cost Data

Unit costs to be included in the estimates were derived from multiple resources. Unit cost associated with civil and structural construction elements that are generally common to both transit and highway construction projects will use cost data found in the Maryland Department of Transportation, State Highway Administration (SHA) Item Average Unit Costs. For those unit costs associated with trackwork, stations and systems construction elements that are principally found on transit construction projects, cost data from recent construction bids from other transit systems throughout the United States were compared and adjusted to specific project needs. Unit cost data was obtained from the Parsons Brinckerhoff's historical cost estimating database of completed projects and their respective historical bid information. All cost resources were adjusted to reflect current local Baltimore rates and conditions. Adjustments for differences in geographic locations will use a factor calculated from the current city cost index for the source location and Baltimore, as published by RS Means. Adjustments for differences between the published date of any historical cost data and the current base year of the cost estimates will use an escalation factor calculated using the Producer Price Index for Heavy and Highway Construction (PPI) value published by the US Bureau of Labor Statistics (BLS) for each of the periods in question.

COST ESTIMATING ASSUMPTIONS

The basic assumptions and criteria used in developing the cost data are as follows:

- The estimates were prepared using second quarter 2007 dollars.
- No premium time on labor costs was included.
- Adequate experienced craft labor is available.
- Normal productivity rates as historically experienced were utilized.
- Compatible trade agreements exist in the region.
- No strike impacts will be experienced by the project.
- There are sufficient experienced contractors available to perform the work.
- Normal South Florida area weather impacts to construction schedule and costs.
- Existing state of the art construction technology will be utilized.

Allocated Contingency

Contingency is typically included in an estimate as an allowance for the level of engineering design completed or to address imperfections in estimating methods that are associated with a project's development stage. Contingency, in the statistical sense, is the estimated percentage by which a calculated value may differ from its true or final value. The contingency allowance is used to account for those items of work (and their corresponding costs) which may not be readily apparent or cannot be quantified at the current level of design, such as unknown project scope items, or a potential project change resulting from public/political issues or environmental or technical requirements. For the purposes of this estimating program, contingency was assigned into two major categories – allocated and unallocated.

Allocated contingency was used based on the level of design information available for individual items of work, as well as the relative difficulty in establishing unit prices for these items. The allocated contingency allowance, in the range of 10 percent to 50 percent, was allocated according to the FTA construction or procurement cost categories. The exact percentage selected for each cost category is based on professional judgment and experience related to the cost variability typically seen for items of work within a particular cost category. The percentages shown in

Table 4-1 are the values that will normally be used; however, slightly higher or lower values may be used if a project specific condition warrants.

Table 0-1. Allocated Contingency Percentages for Planning Estimates

FTA Category No.	Description	Allocated Contingency Percentage
10	Guideway and Track Elements	
	Guideway Elements (Except Underground)	25
	Guideway Elements (Underground)	30
	Track Elements	20
20	Stations, Stops, Terminals, Intermodals	20
30	Support Facilities: Yards, Shops, Admin Buildings	20
40	Sitework and Special Conditions	
	Demolition, Clearing, Earthwork	25
	Site Utilities, Utility Relocation	30
	Hazardous Materials, Contaminated Soil Removal/Mitigation, Groundwater Treatments	30
	Environmental Mitigation, e.g., Wetlands, Historic/ Archaeological, Parks	30
	Site Structures including Retaining Walls, Sound Walls	25
	Pedestrian/Bike Access and Accommodation, Landscaping	25
	Automobile, Bus, Van Access including Roads, Parking Lots	25
50	Systems	20
60	Right-of-Way, Land, Existing Improvements	50
70	Vehicles	10

Estimating Procedures

Capital costs are to be developed for each alignment by utilizing both “bottom up” and “top down” estimating approaches. Each approach is described in the following sections.

Bottom Up and Top Down Approaches

The majority of composite unit costs utilized for the capital cost estimates were developed based on a “bottom up” approach. In this approach, the cost of major work elements, as generally defined by typical sections, is determined by totaling the cost of their component parts. Sufficient engineering data is required to reasonably define the scope of work and quantities represented by each typical section. Unit prices, as reflected in the UCL, are developed and combined with the estimated quantities to determine the costs for each major category of work, such as guideway elements, stations, and system elements. The advantage of this approach is the ability to adjust costs for minor changes of scope, as well as the higher confidence level inherent in a bottom up estimate. The disadvantage is the level of engineering and estimating effort required to produce a bottom up estimate and the additional time required to adjust the estimate for revisions.

In the “top down” method, an order-of-magnitude or composite cost is determined, usually derived from data from similar projects, and this cost is used directly or converted to some component unit measure (such as $ per vehicle, $ per route feet, etc.) and applied as a unit cost. This method is faster than the bottom up approach; and, for certain technologies and alignment alternatives, the resulting comparative cost estimates can be sufficiently accurate. This method is used as infrequently as possible. As an example, the cost for transit vehicles is generally derived from data from other projects and is based on a total procurement price that is divided by the number of vehicles purchased and therefore is a “top down” unit cost. Other systemwide elements, such as traction power distribution may also use “top down” unit costs. Historical bids for traction power distribution contracts, which typically would be made up of a hundred or more construction elements and unit prices are used to develop composite unit cost on a dollar per route foot basis. The estimating methodology selected to estimate the alternatives capital cost will use a combination of the two basic procedures described above. The bottom up approach is used to develop parametric unit costs for elements for which discrete quantities can be developed. This approach is typically used for the following cost categories:

10 Guideway and Track Elements
20 Station, Stops, Terminals Intermodal
30 Support Facilities: Yards, Shops, Administration Buildings

The top down approach is typically used to estimate costs for the following categories:

40 Sitework and Special Conditions
50 Systems
60 ROW, Land, Existing Improvements
70 Vehicles

Facilities Costing Procedure

The typical facilities costing procedure begins with a typical cross section or sketch of a typical facility such as at-grade guideway. In most cases these typical facilities represent an element which is used more than once in the construction of the alignment. For elements that can be defined by a typical section, unit quantities (such as cubic yards of excavation, or lineal feet of track) required to construct one route foot of the section are computed and unit costs are applied to determine a base cost for constructing a typical route foot. This base cost is augmented by allowances as needed to provide a complete parametric unit cost. To the extent possible, transit guideway sections were estimated by using typical sections. For certain cost category items a site-specific, non-typical section will require that a unique cost estimate be prepared. For a non-typical facility, the quantities of construction units (such as cubic yards of concrete, or lineal feet of piping required to construct a complete facility are computed and unit costs are applied to determine a base cost for constructing the non-typical facility. This base cost is augmented by allowances as needed to provide a complete parametric unit cost. Special facilities, such as complex structures, major utilities, or special station amenities, were estimated in a similar fashion as the typical facilities. Sketches were prepared when practical. In some cases, historical data may be applied if available. In technically challenging problems, some basic data gathering and design may be required to determine an

appropriate cost. Once a cost is determined, it was assigned to its appropriate cost category.

Organization and Management of Cost Data

The preparation of cost estimates for the alternatives will involve development of a cost information database of considerable size and complexity. Procedures were developed that streamline the estimating process and allow a thorough review and checking of the cost data in order to avoid clerical and mathematical errors. The proposed procedures include:

- Use of proven computer software for data processing and storage; and
- Development of data in a cost-stream format and subsequently summarizing to higher levels.

All capital cost estimates for the Corridor Cities Transitway were prepared using Microsoft Excel. The organization of the cost data into a cost stream format allows a thorough review and checking of the data with respect to the plan and profile drawings.

Cost Estimating Results Format

The cost estimating methodology uses three levels of cost presentation to provide cost information results in increasing levels of detail. The costs were developed by alignment and by segment, with each alignment consisting of several segments. The estimating process originates with the Segment Level Cost Estimates, the lowest level of detail summary, which are used to develop Alignment Level summaries. This approach facilitates responses to different questions and enables users to focus only on the level of detail that meets their needs. These levels provide an efficient and logical flow of data from the most detailed level to the summary level.

The Segment level Cost Estimate is the most detailed level and gives the cost breakdown by category for a single alignment segment. It presents the quantity take-offs in a cost stream format, which keys each element of the estimate to specific locations by stationing. This level relates the quantity take-offs to the plan and profile drawings, helping to document what has been included, thus making reviewing and checking easier than a traditional construction estimate by units. This data is then rolled up to summary level spreadsheets. The summary level Cost Estimate gives cost breakdowns by category for each segment within an alignment. It is at this level that the estimate add-ons were applied with the appropriate percentages assigned to the various cost categories. The summary will provide a total project cost for a single alignment.

Cash Flow and Escalation

The current FTA SCC excel workbook includes several worksheets that assist in the preparation of a cash flow projection for the project as well as the calculation of the Year of Expenditure (YOE) value of the total project cost. The preparation of the cash flow projection for the project involves developing a conceptual project schedule for each of the standard cost categories that includes a start date, by

month and year, and an estimated duration in months. Using formulas for standard output production S-curves, the project cost for each of these cost categories is distributed according to the project schedule and forms the cash flow projection. Once the cash flow projection is developed, the results are placed into the SCC inflation worksheet. Escalation factors for this worksheet are selected based on a review of published construction cost escalation projections during the assumed project durations.

Annualized Cost Factors

The evaluation of the cost effectiveness of an alternative requires that all evaluation measure (capital costs, operations and maintenance costs, non-Federal funding and user benefits) be expressed in annual terms. Since capital costs are estimated as a total expenditure of constant (base year) dollars, an annual payment will be computed that is equivalent to what is in reality a one-time expenditure of capital funds. For each capital cost item, the annualized equivalent will be computed through application of the following annualization factor:

$$\text{Annualization Factor} = \frac{i \times (1+i)^n}{(1+i)^n - 1}$$

where i = discount rate; and

n = economic life.

The annualized cost of the line item is the total cost of that line item multiplied by its annualization factor. The summation of all annualized line item costs gives the overall annualized cost for the alternative. Table 4-2 contains a list of the various cost categories and their respective economic lifetime and annualization factors. These annualization factors have been determined based on a FTA-prescribed seven percent discount rate.

Table 0-2. Annualization Factors

Description	Lifetime (Years)	Annualization Factor
10.01 Guideway: At-grade exclusive right-of-way	125	0.070
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)	30	0.081
10.03 Guideway: At-grade in mixed traffic	20	0.094
10.04 Guideway: Aerial structure	80	0.070
10.05 Guideway: Built-up fill	80	0.070
10.06 Guideway: Underground cut & cover	125	0.070
10.07 Guideway: Underground tunnel	125	0.070
10.08 Guideway: Retained cut or fill	125	0.070
10.09 Track: Direct fixation	30	0.081
10.10 Track: Embedded	20	0.094
10.11 Track: Ballasted	35	0.077
10.12 Track: Special (switches, turnouts)	30	0.081
10.13 Track: Vibration and noise dampening	30	0.081
20.01 At-grade station, stop, shelter, mall, terminal, platform	70	0.071

	Description	Lifetime (Years)	Annualization Factor
20.02	Aerial station, stop, shelter, mall, terminal, platform	70	0.071
20.03	Underground station, stop, shelter, mall, terminal, platform	125	0.070
20.04	Other stations, landings, terminals: Intermodal, ferry, trolley, etc.	70	0.071
20.05	Joint development	70	0.071
20.06	Automobile parking multi-story structure	50	0.072
20.07	Elevators, escalators	30	0.081
30.01	Administration Building: Office, sales, storage, revenue counting	50	0.072
30.02	Light Maintenance Facility	50	0.072
30.03	Heavy Maintenance Facility	50	0.072
30.04	Storage or Maintenance of Way Building	50	0.072
30.05	Yard and Yard Track	80	0.070
40.01	Demolition, Clearing, Earthwork	125	0.070
40.02	Site Utilities, Utility Relocation	125	0.070
40.03	Hazardous materials, contaminated soil removal/mitigation, ground water treatments	125	0.070
40.04	Environmental mitigation, e.g. wetlands, historic/archeologic, parks	125	0.070
40.05	Site structures including retaining walls, sound walls	80	0.070
40.06	Pedestrian / bike access and accommodation, landscaping	20	0.094
40.07	Automobile, bus, van accessways including roads, parking lots	20	0.094
40.08	Temporary Facilities and other indirect costs during construction	100	0.070
50.01	Train control and signals	30	0.081
50.02	Traffic signals and crossing protection	30	0.081
50.03	Traction power supply: substations	50	0.072
50.04	Traction power distribution: catenary and third rail	30	0.081
50.05	Communications	20	0.094
50.06	Fare collection system and equipment	25	0.086
50.07	Central Control	30	0.081
60.01	Purchase or lease of real estate	125	0.070
60.02	Relocation of existing households and businesses	125	0.070
70.01	Light Rail	25	0.086
70.02	Heavy Rail	25	0.086
70.03	Commuter Rail	25	0.086
70.04	Bus	12	0.126
70.05	Other	12	0.126
70.06	Non-revenue vehicles	12	0.126
70.07	Spare parts	12	0.126

ESTIMATE LIMITATIONS

A reoccurring issue in the estimation of capital cost during the conceptual phase of a project is the evaluation and treatment of uncertainty. Uncertainty can result in a "difference" between the estimated cost of a project as defined during the concept phase and the actual cost of the project that is ultimately implemented. Four potential sources of uncertainty are generally recognized.

- Changes in Project Scope
- Changes in Design Standards
- Incorrect Unit Cost/Quantity Assumptions
- Unforeseen Problems in Implementation

Changes in Project Scope

During the corridor study phase, preliminary decisions on project scope are made on such issues as vertical and horizontal alignment, degree of grade separation and other significant alignment items. As a project progresses through the various stages of evaluation many of the original project scope definitions that formed the basis of the cost estimate will be updated or revised during the various screening of alternatives.

Changes in Design Standards

Similar to the broader uncertainties on project scope but generally more specific in nature, changes in design standard during later phases of project development can lead to changes in project cost. Examples of changes in design standards would be replacing high floor vehicles with low floor vehicles, using a more sophisticated signal system, or changing from a barrier free fare collection to fare gates, and so forth.

Incorrect Unit Cost / Quantity Assumptions

A variety of potential problems exist in the assumptions used in selecting unit cost or unit quantities. Issues that can affect the accuracy of unit cost include local demand for construction labor and its impact on wage rates, bid climate during the construction period and fluctuations in basic material prices. Errors in quantity assumptions are often related to changes in design standards as discussed above.

Unforeseen Problems in Implementation

Perhaps one of the largest sources of uncertainty is the difficulty in anticipating problems that will only be uncovered in later stages of project development. Areas that appear to be most susceptible are right-of-way acquisition, utility relocations, hazardous materials, and soil conditions. The estimating methods described in Section 2 represent professionally accepted standards for preparing capital cost estimates to a level of accuracy that is consistent with the level of project definition. Accuracy is traditionally expressed as a +/- percentage range around the point

estimate that has been produced. The percentage variance factors are greatest in the early stage of project definition and progressively decreases as project definition increases. For example, for typical transit projects, the expected accuracy range of an estimate prepared from final design documents is approximately +10/-5 percent. For projects at a level of project definition from 1 to 15 percent complete, the expected accuracy range is approximately +30/-25 percent.

One of the primary techniques used to address the uncertainties inherent in the estimating process at this phase of project development is the application of appropriate design allowances. The use and application of design allowance is further discussed in Section 4. As a project progresses through subsequent phases, the level of detail in the design will increase and the type, quantity and location of system elements can be better estimated. As that happens, the accuracy of the cost estimates will improve and the design allowance will decrease.

CAPITAL COST ESTIMATES

The Corridor Cities Transitway Project has several representative alignments currently under study. The following are the estimated capital costs, 2007 dollars in millions, for each of these representative alignments:

Corridor Cities Transitway Study

AA / Draft EIS

BRT and LRT Alternatives

Capital Cost Estimate

(2007 Dollars in Millions)

	Description	TSM	BRT	LRT
	Length (Mile):	17.62	13.40	13.40
	Number of Stations:	13	13	13
	Number of Revenue Vehicles:	16	45	29
10	**GUIDEWAY & TRACK ELEMENTS**	$0.00	$140.90	$202.12
20	**STATIONS, STOPS, TERMINALS, INTERMODAL**	$17.03	$17.03	$20.29
30	**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**	$0.00	$14.49	$55.21
40	**SITEWORK & SPECIAL CONDITIONS**	$27.25	$87.99	$88.02
50	**SYSTEMS**	$4.94	$21.52	$90.18
	Construction Subtotal (Sum Categories 10 - 50)	**$49.22**	**$281.93**	**$455.82**
60	**ROW, LAND, EXISTING IMPROVEMENTS**	$7.38	$35.00	$35.00
70	**VEHICLES**	$11.36	$25.66	$112.20
80	**PROFESSIONAL SERVICES**	$15.75	$90.22	$145.86
90	**UNALLOCATED CONTINGENCY**	$3.15	$17.11	$28.65
	Total Project Cost	**$86.86**	**$449.92**	**$777.53**