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Capital Cost Estimation Methodology & Preliminary Capital Costs Results Report

Indianapolis Metropolitan Area Rapid Transit Study

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1.0 INTRODUCTION

The Indianapolis Regional Rapid Transit Study (RTS) capital, operations and maintenance cost estimation methodology has been developed to provide cost estimates useful for comparing major transportation investments during planning-level analyses. The specific methodology utilized is intended to provide objective cost estimates, comparable between the various alternatives, and at a level of detail that is consistent with the nature of the alternatives in terms of their design features, and also their state of development. Based on employing actual capital cost data from a number of sources nationwide, this methodology also can serve as the basis for future project planning with the flexibility for further refinement as the level of project engineering advances through future stages of project development.

1.1 Project Description

The Indianapolis Metropolitan Planning Organization (MPO) is sponsoring a Rapid Transit Study (RTS) for the nine-counties that comprise the Indianapolis Metropolitan Statistical Area. The RTS has identified and documented a system plan for the implementation of a rapid transit system to satisfy the needs of the multi-county Indianapolis region through the year 2030. In addition to the system plan, the RTS also has identified the Northeast Corridor as a locally preferred corridor (LPC) to take into the federal Alternatives Analysis (AA) and National Environmental Policy Act (NEPA) Draft Environmental Impact Analysis (DEIS) processes.

The study's goal is to make the Indianapolis region a better place to live, work and do business by achieving a consensus on what type of transportation improvements will best solve the mobility and safety concerns in the area. Within the Northeast Corridor, the first corridor selected for detailed study, a variety of alternatives will be considered, including options for rail transit and the implementation of exclusive bus transitways.

Primary study objectives include relieving lengthy travel times, particularly on public transportation, and supporting community development efforts. Air quality and pedestrian/motorist safety also top the list of concerns. Specifically, the project's goals include:

- Maximize Engineering Feasibility and Public Safety.
- Maximize Community Benefits and Personal Safety.
- Minimize Environmental Impacts.
- Maximize Operational Efficiency.
- Minimize Costs.

The Northeast Corridor includes such radial alignments as the following: Binford Boulevard/I-69, the Hoosier Heritage Railroad, Keystone Avenue, and Allisonville Road, as well as the radial alignments of US 36/SR 67 and the CSX-Cleveland Railroad Line that connect Indianapolis downtown with Anderson. Among the key lateral feeder lines are SR 32 and the Central Indiana & Western Railroad (shortline), SR 38, SR 238, and CR 600W/Mount Comfort Road, which is proposed for a County highway upgrade. Key CBD activity centers in the Northeast Corridor are Fishers, Noblesville, Lawrence, and Anderson with smaller concentrations at McCordsville, Fortville, Pendleton, and Lapel. Major corridor employment centers include the following: Roche Diagnostics Corp.; the Northeast Center at Lawrence; and the Delco Remy Headquarters and the Orchard Industrial Park, both southwest of Anderson. Several high density centers are located in the Northeast Corridor, including the following: the Fort Harrison Reuse Authority's redevelopment program and State Park; Castleton Corporate Park; Castleton Square Shopping Mall/Center; Castleton Park; the Castle Industrial Park; the McCordsville Industrial Park; the Verizon Wireless Music Center; and the Hoosier Business Park southeast of Anderson. In addition, the corridor includes a concentration of high-density housing north of 96th Street and east of the White River. This area includes the Geist Reservoir development area with surrounding high-end housing subdivisions, retail and commercial businesses.

The AA will evaluate a range of potentially viable transportation improvements, including both rail transit and bus rapid transit (BRT) alternatives, by treating them in an unbiased manner in a systematic evaluation process.

1.2 Purpose of Report

This document explains the methodology by which capital; operating and maintenance costs will be estimated for each of the alternatives under consideration in the study. The evaluation of alternatives will be based on a wide range of criteria used in the recommendation of a Locally Preferred Alternative (LPA).

Capital costs are defined as the costs required to engineer, design, and construct a major transportation investment prior to it being ready for passenger operations. The estimation of capital costs at this level of planning is necessary to understand the level of financial resources that would be required to implement a proposed alternative. The estimation of capital costs is also important to evaluate proposed alternatives in terms of their cost-effectiveness and likelihood of funding, as part of cost benefit analyses.

Operating & Maintenance (O&M) costs are defined as the costs required to operate and maintain a system independent of the amount of use of the vehicle, such as insurance costs, depreciation and finance charges; and expenditures which are dependent on the amount of use of the vehicle, such as the cost of fuel or electricity, oil, tires or wheels, and other routine maintenance. In addition, the cost of wages, benefits, and system overhead are placed within this category of costs.

2.0 CAPITAL COST ESTIMATING APPROACH – RAIL ALTERNATIVES

The following sections discuss the methodology used to estimate capital costs for each of the rail transit alternatives.

2.1 Capital Cost Sources

The capital cost estimating approach builds on detailed capital cost estimates and construction experience of national and local departments of transportation and transit agencies for similar projects. Bus and rail capital unit costs are based on a combination of actual capital cost data and recent cost estimates from similar transportation investments nationwide. Sources of capital cost information include:

- Federal Transit Administration (FTA) Fixed Guideway Heavy Rail and Light Rail Capital Cost Studies.
- TARC Transportation Tomorrow (Louisville, Kentucky).
- SkyTrain Millennium Line (Vancouver, British Columbia).
- MetroLink Light Rail (St. Louis, Missouri).
- OC Transpo (Ottawa, Ontario).
- RS Means – Heavy Construction Cost Data.

The FTA's Fixed Guideway Capital Cost Studies include actual capital cost data for several heavy and light rail transportation investments nationwide including Atlanta, Boston, Baltimore, Chicago, Los Angeles, Miami, Portland, San Jose, Sacramento, Pittsburgh and Washington, D.C. The Fixed Guideway Capital Cost Studies were part of a two-year research project sponsored by FTA and include the actual capital cost experience for several recent heavy and light rail transit projects. These studies are among the most recent and complete rail capital cost research efforts undertaken in the transit industry and are widely accepted and recommended by FTA for use in major transportation investment study analyses. All unit capital cost data applied to the AA are inflated to 2004 dollars based on a constant rate of 3.5% which is consistent with other studies and accepted as a reasonable escalation factor in the transportation industry.

2.2 Capital Cost Categories

Capital costs are segregated into specific capital cost categories in an effort to more accurately estimate costs for each alternative. The major capital cost categories and their components are discussed below:

2.2.1 Guideway

This category includes at-grade, cut-and-cover, embedded, tunnel and elevated guideway structures for rail investments. These guideway subcategories include costs for grubbing, excavation, grading, concrete work, ballast, drainage, backfill and restoration of landscaping to original or better form. The completed guideway structures provide the foundation for the installation of trackwork facilities as discussed below. Other guideway subcategories include crash walls (required for use within active freight rail right-of-way), and roadway and rail bridges.

2.2.2 Trackwork

This category includes the basic track assets such as running rail, ties, ballast, direct fixation components, rail fastening systems and rail welding. Special trackwork components such as single and double crossovers, turnouts and grade crossings are also included in this category.

2.2.3 Facilities

This category includes new maintenance facilities as well as expansion or modifications to existing operation control centers. Elements would include vehicle storage yards, vehicle repair and maintenance shops, office support areas, control centers and surveillance center. A maintenance facility would provide the capacity for inspections, repairs, vehicle washing, heavy maintenance, bodywork and painting.

2.2.4 Systems

This category includes costs for traction power, signalization, communications and fare collection systems. The traction power system includes costs for structures, transformers, switchgear, ancillary equipment, substations, tiebreaker stations, third rail and catenary wire. The signalization system also includes needed cab, wayside and control center equipment. It also involves the signals at special trackwork locations such as junctions and crossovers as well as the signaling of apparatus between locations. Communications systems include equipment and materials at stations and on-board trains to install connections between passengers, operators and the central control facility. Fare collection costs include fare collection equipment at rail stations such as ticket vending machines, and the apparatus required to control and operate this equipment.

2.2.5 Stations

This category includes costs for rail stations, bus shelters, parking lots, parking structures, and signage/graphics/artwork. Rail stations include at-grade/side platform, underground/center platform, open-cut/center platform and elevated/side platform types. Station costs include earthwork, foundation structures, platforms, canopies, and elevator/escalator equipment. Bus shelter costs include structures and installation. Parking lot costs include earthwork, paving and striping. Signage, graphics and artwork costs include directional signs, passenger information, maps, and general artwork that are typical in modern rail stations.

2.2.6 Special Conditions

Special conditions are those elements not included in any other capital cost category and not covered by contingency factors, yet large enough to be identifiable at this stage of project development. Utility Relocation, Noise/Environmental Abatement/Mitigation, Maintenance of Traffic, and Urban Design and Landscape costs are examples of special condition costs not covered under other specific categories. Special condition costs are based on an average percentage for similar projects nationwide.

2.2.7 Mobilization

Mobilization costs are typically incurred as a separate bid item and are estimated independently of other cost categories. This category typically includes the contractor's costs for setting up the work site such as trailer/office rentals and heavy equipment movements and storage.

2.2.8 Contingency

Contingency costs are typically included in capital cost estimating for major transportation investments in an effort to plan for presently unknown circumstances that might not become evident at this minimal level of engineering. As major transportation investments move through the project development phase from planning to preliminary engineering to design and construction, contingency factors can be reduced as the project is more completely defined. A contingency factor of 25% will be added to the combined costs of guideway, trackwork, facilities, systems, special conditions and right-of-way.

2.2.9 Soft-Costs

Soft costs include engineering and design, construction management, project management, agency costs and insurance costs. The unit costs for this category will be based on percentage trends obtained form similar transportation projects nationwide.

2.2.10 Vehicles

This category includes costs for revenue vehicles (rail vehicles, buses) and non-revenue vehicles (maintenance-of-way (MOW) vehicles). Subcategories include heavy rail, light rail, bus and MOW vehicles. Revenue vehicles are typically procured separately from other assets, and as a result, their costs are not inflated with contingencies and soft-costs. Both revenue and non-revenue vehicle unit costs will be based on recent peer system procurements for similar vehicle types.

The number of vehicles required will be based on the service plans for each alternative, which are driven by ridership figures from travel demand model and related peak period headways. Rail and bus vehicles will include a 20% spare ratio. FTA allows a maximum spare ratio of 20% for bus fleets and encourages a spare ratio of 20% or less for rail fleets.

2.2.11 Right-of-Way

The right-of-way cost category includes the purchase of property to accommodate placement of the alternative's guideway, facilities and stations. This category includes the costs for purchased property based on assessed values from the local agency records plus a contingency of 30%.

2.3 Capital Unit Costs

Table 2.3.1 provides a list of the capital cost categories and their unit costs that compromise the capital cost database developed for this study. Capital costs are separated into two categories - - hard construction categories (e.g. guideway, trackwork, facilities, systems and stations) and add-on construction categories (e.g. special conditions, mobilization, contingency, soft-costs, vehicles and right-of-way).

Table – 2.3.1 Hard Construction Category Units Costs (Rail)

1.00	Guideway	Unit Type	Unit Cost
1.01	At-Grade – Ballasted – 1T	RF	200
1.02	At-Grade – Ballasted – 2T	RF	300
1.03	At-Grade – Embedded – 1T	RF	120
1.04	At-Grade – Embedded – 2T	RF	230
1.05	Embankment (2'-6') – Ballasted – 2T	RF	250
1.06	Retained Fill (8'-16') – Ballasted – 2T	RF	1,250
1.07	Elevated Structure – 2T	RF	3,100
1.08	Elevated Structure – 1T	RF	2,600
1.09	Tunnel – 2T	RF	19,200
1.10	Cut-and-Cover – 2T	RF	12,800
1.11	Crash Wall	LF	1,200
1.12	Roadway Bridge	SF	230
1.13	Rail Bridge	SF	160
2.00	Trackwork		
2.01	Ballasted Track – 1T	RF	170
2.02	Ballasted Track – 2T	RF	320

2.03	Embedded Track – 1T	RF	310
2.04	Embedded Track – 2T	RF	620
2.05	Direct Fixation Track – 1T	RF	280
2.06	Direct Fixation Track – 2T	RF	560
2.07	Ballasted Turnout	EA	92,000
2.08	Direct Fixation Turnout	EA	120,000
2.09	Single Crossover – Ballasted	EA	92,000
2.10	Single Crossover – Embedded	EA	140,000
2.11	Single Crossover – Direct Fixation	EA	140,000
2.12	Double Crossover – Ballasted	EA	250,000
2.13	Double Crossover – Embedded	EA	420,000
2.14	Double Crossover – Direct Fixation	EA	420,000
2.15	Grade Crossing – Two Track Crossing	EA	13,800
2.16	Remove Track	RF	50
3.00	Facilities		
3.01	Maintenance Facility & Yard	EA	26,000000
3.02	Central Control Facility	EA	4,200,000
4.00	Systems		
4.01	Electrification – Catenary	RF	70
4.02	Electrification – Third Rail	RF	60
4.03	Substations	RF	200
4.04	Signalization	RF	140
4.05	Communications	RF	40
4.06	Fare Collection Equipment	ST	250,000
5.00	Stations		
5.01	At-Grade – Center Platforms	EA	750,000
5.02	Underground – Center Platform	EA	12,000,000
5.03	Open Cut – Center Platform	EA	3,000,000
5.04	Elevated – Center Platform	EA	1,200,000
5.05	Elevated – Center Platform (Terminus)	EA	1,500,000
5.06	Bus Shelter	EA	6,900
5.07	Parking Lots	SP	4,500
5.08	Parking Structure	SP	13,500
5.09	Signage, Graphics, Artwork	ST	200,000

Hard construction costs include those capital items that can be measured and estimated on a unit level. These categories are referred to as "hard" because they encompass the main construction activities required to build the facilities of the proposed transportation investment. Hard costs are typically measured in the following units:

- Linear feet – LF
- Lump Sum – LS
- Rail Foot – RF
- Each – EA
- Station – ST
- Parking Space – SP

Add-on cost shown in Table 2.3.2 include those capital items that cannot be measured and estimated on a unit level such as linear feet or track feet as discussed above. However, they are typically estimated as a percentage of the hard construction costs based on industry experience that is readily available from nationwide peer projects. Special

conditions, mobilization, and soft cost estimates are based on typical percentages from peer projects applied to the hard construction costs. Contingencies are also based on industry standards that typically range from 20% to 30% of the combined hard construction and special condition costs. Soft-costs (e.g. engineering, design, project management) are estimated as a percentage of hard construction, special condition and contingency costs.

Vehicles are typically procured as separate and distinct items based on a competitive low-bid process and are not subject to special conditions and soft costs since these costs are included in their total price, and their quantity is more easily calculated. Right-of-way costs for residential and commercial property are typically based on market values obtained from local databases. The costs for purchasing railroad right-of-way are generally based on similar procurements from other transit projects due to the unique conditions involved in these purchases.

Table – 2.3.2 Add-On Category Unit Costs (Rail)

6.00	Special Conditions	Unit/Hard Type	Unit/% Cost
6.01	Utilities	Cost Items 1-5	3% to 5%
6.02	Environmental	Cost Items 1-5	1%
6.03	Maintenance of Traffic	Cost Items 1-5	5%
6.04	Urban Design/Landscaping	Cost Items 1-5	2%
7.00	Mobilization		
7.01	Mobilization	Cost Items 1-6	3%
8.00	Contingency		
8.01	Contingency	Cost Items 1-7	25%
9.00	Soft Costs		
9.01	Engineering & Design	Cost Items 1-7	11%
9.02	Construction Management	Cost Items 1-7	5%
9.03	Project Management	Cost Items 1-7	7%
9.04	Agency Costs	Cost Items 1-7	3%
9.05	Insurance	Cost Items 1-7	5%
10.00	Vehicles		
10.01	Automated Rail Vehicle	EA	2,600,000
10.02	Light Rail Vehicle	EA	2,900,000
10.03	Bus – 40-foot	EA	340,000
10.04	Non-Revenue Vehicle	Cost Items 10.01-10.03	0.5%
11.00	Right-of-Way		
11.01	Property	LF	200
11.02	Railroad Right-of-Way	LF	450

2.4 Segmentation of Alternatives

The segmentation of alternatives is necessary for the proper application of capital unit costs. Capital unit costs are applied to section of the short-listed alternatives that contain a constant typical section between a beginning and end node. The costs of a typical section is computed by multiplying its length by the applicable capital unit cost and adding the appropriate add-on costs as presented in Section 2.3. The capital costs for each section of the alternative are then summed and system-wide costs, contingencies, and add-on allowances are added to determine the total project cost estimate for each section. This process simplifies and reduces the effort required to produce conceptual level estimates by consolidating many of the cost components into a set of typical sections.

2.5 Annualized Cost Factors

Annualization of total capital cost is necessary to evaluate the cost effectiveness of proposed alternatives as part of the cost-benefit analysis required to select the Locally Preferred Alternative (LPA). The annualization of capital costs allows projects to be evaluated on a level playing field. It is necessary because different capital assets have different life cycles, requiring normalization to allow a comparison among assets on a yearly basis. The useful life of a particular type of capital asset is an important factor in determining annualized costs. Table 2.5.1 contains a list of the various cost categories and their respective normal useful lifetimes and annualization factors. The annualization factors are recommended by the FTA and are based on a 7.0 percent discount rate as prescribed by the Office of Management and Budget. Add-on items such as special conditions, mobilization, contingency and soft costs are proportioned into the hard cost categories to arrive at an annualized cost.

Table 2.5.1 – Annualization Factors (Rail)

Element	Lifetime (Years)	Annualization Factor
Guideway	30	.081
Trackwork	30	.081
Facilities	30	.081
Systems	30	.081
Stations	30	.081
Rail Vehicles	25	.086
Bus Vehicles	12	.126
Special Conditions	Proportioned	Proportioned
Mobilization	Proportioned	Proportioned
Contingency	Proportioned	Proportioned
Soft Costs	Proportioned	Proportioned
Guideway Preparation	100	.070
Right-of-Way	100	.070

3.0 CAPITAL COST ESTIMATING APPROACH – BRT ALTERNATIVES

The following sections discuss the methodology used to estimate capital costs for each of the bus rapid transit (BRT) alternatives.

3.1 Capital Cost Sources

Unit costs for the bus transitway items were determined by comparing costs for items of similar quantity. The Indiana Department of Transportation (INDOT) has issued a Bid Program for which a consultant can input the item, quantity, and location (i.e., County), and the program searches the database of bids on file to determine the quantity closest to the one entered. Sometimes, a higher and lower quantity can be averaged to determine the average unit cost. The Bid Program lists each INDOT contract; the date for which it was let; the project ID; and the low bidder, 2nd bidder, and 3rd bidder for the contract. Each item in the INDOT Items Catalogue can be included in the searches of the database.

3.2 Capital Unit Costs

Table 3.2.1 provides a list of the capital cost categories and their unit costs that comprise the capital cost database developed for this study. Capital costs are separated into two categories - - hard construction categories and add-on categories.

Table 3.2.1 – Hard Construction Category Unit Costs (BRT)

Item	Unit Type	Unit Cost
Excavation	CY	5
Embankment	CY	5
Pipes	LF	70
Inlets	EA	2,500
ROW Fencing, Chain Link	LF	20
ROW Fencing, Wood	LF	40
10" Non-Reinf. Concrete Pavement	SY	30
Sub-base, 6" Depth	SY	7
Bituminous Binder Course	SY	20
Bituminous Surface Course	SY	5
Retaining Wall	SF	28
Concrete Median Barrier	LF	50
Pavement Markings	LF	2
Concrete Header Curb	LF	12
BRT Station	EA	750,000
Parking Lots	SP	4,500
Parking Structure	SP	13,500
Signage, Graphics, Artwork	ST	200,000
Maintenance Facility	EA	20,000,000
Fare Collection Equipment	ST	250,000
Right-of-Way	LF	200

Hard construction costs include those capital items that can be measured and estimated on a unit level. These categories are referred to as "hard" because they encompass the main construction activities required to build the facilities of the proposed transportation investment.

Add-on costs shown in Table 3.2.2 include those capital items that cannot be measured and estimated on a unit level such as linear feet as discussed above. However, they are typically estimated as a percentage of the hard construction costs based on industry experience that is readily available from peer projects.

Table 3.2.2 – Add-on Category Unit Costs (BRT)	
Maintenance and Protection of Traffic (MPT)	5%
Mobilization	3%
Environmental	1%
Urban Design/Landscaping	2%
Utilities	5%
Soft Costs	31%
Contingency	25%

3.3 Annualized Cost Factors

Table 3.3.1 contains a list of the various cost categories and their respective normal useful lifetimes and annualization factors

Table 3.3.1 – Annualization Factors (BRT)		
Element	Lifetime (Years)	Annualization Factor
Structures	30	.081
Systems	30	.081
Pavement	20	.094
Signage	15	.110
Stations	30	.081
Striping	5	.244
BRT Vehicles	12	.126
Special Conditions	Proportioned	Proportioned
Mobilization	Proportioned	Proportioned
Contingency	Proportioned	Proportioned
Soft Costs	Proportioned	Proportioned
Guideway Preparation	100	.070
Right-of-Way	100	.070

4.0 CAPITAL COST SUMMARY FOR ALIGNMENTS AND TECHNOLOGIES

The cost estimating methodology described in the first three sections of this document has been applied to each of the four remaining alignment alternatives in the Indianapolis Regional Rapid Transit Study Alternatives Analysis. In column number 1 of Table 4.1, below, each of the four alternative alignments is briefly described. The balance of Table 4.1 presents summary results (for each of the four surviving AA alignments) for the Bus Rapid Transit (BRT), Electric Multiple Unit Light Rail Transit (LRT), and for Automated Guideway Transit (AGT) technologies. For each of the four surviving alternative alignments, and for each of the three surviving alternative technologies, the following information is provided:

1. Total Cost
2. Total Miles
3. Cost per mile

These preliminary cost estimates have been developed in a fashion prescribed by the Federal Transit Administration for its major New Starts Capital Projects Development Process. Specifically, costs have been estimated for the major cost categories of guideways; track work; facilities; systems; stations; special conditions; mobilization; contingency; soft cost; vehicles; and, right-of-way. The cost category of "facilities" consists of new maintenance facilities and control center cost (a new control center, or an expansion or modification of existing IndyGo control facilities). Although "stations" and "guideways" are considered by some to be generically in the “facilities” classification, these two very important elements of facilities costs are separated in the methodology described in the previous sections.

In developing the preliminary capital cost, contemporary transit system development experience has been utilized. Specifically, important sources have included: FTA guidelines; detailed capital cost estimates recently developed for a light rail New Starts report in Louisville, Kentucky; cost experience associated with the Vancouver SkyTrain (the only North American AGT system deployed in full regional service); St. Louis Metro Link cost experience; Ottawa cost experience for BRT; and, the R. S. Means heavy construction cost estimating catalog. It is important to note that while only the Vancouver AGT system is an AGT deployed in full regional service in North America, numerous successfully operating AGT systems exist around the world, most specifically in Asia.

The preliminary results shown in Table 4.1 generally confirm capital cost parameters utilized in earlier phases of this regional rapid transit study.

Table 4.1 - Capital Cost Estimate Summary

	BRT			LRT			AGT		
	Total Cost	Total Miles	Cost Per Mile	Total Cost	Total Miles	Cost Per Mile	Total Cost	Total Miles	Cost Per Mile
Alignment No.1									
CSX, I-70, Keystone Ave., Binford Blvd., I-69	$ 545.8	25.79	$ 21.2	$ 880.8	25.79	$ 34.2	$ 1,295.0	25.79	$ 50.2
Alignment No.2									
CSX, Nickle-Plate	$ 439.0	25.62	$ 17.1	$ 682.9	25.62	$ 26.7	$ 1,326.2	25.62	$ 51.8
Alignment No.3									
CSX, Nickle-Plate, Allisonville Rd.	$ 816.1	25.08	$ 32.5	$ 1,088.0	25.08	$ 43.4	$ 1,281.6	25.08	$ 51.1
Alignment No.4									
Downtown Streets, Nickle-Plate, Keystone Ave., I-465, Nickle-Plate	$ 726.5	28.33	$ 25.6	$ 1,061.4	28.33	$ 37.5	$ 1,436.6	28.33	$ 50.7

Note: Costs shown are in Millions.