

FTA RESEARCH

FEDERAL TRANSIT ADMINISTRATION

FTA Market Conditions Research

*Recommendations for Improving
Transit Industry Cost Estimation*

FEBRUARY 2019

FTA Report No. 0130
Federal Transit Administration

PREPARED BY

Rizwan Shah, Haley S. Orvedal, and Matthew Gilstrap
Guidehouse (formerly PwC Public Sector LLP)

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FTA, Office of Program Management



U.S. Department of Transportation
Federal Transit Administration

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Metric Conversion Table

| SYMBOL | WHEN YOU KNOW | MULTIPLY BY | TO FIND | SYMBOL |
|--|----------------------|-----------------------------|--------------------------------|----------------|
| LENGTH | | | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| VOLUME | | | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liter | L |
| ft³ | cubic feet | 0.028 | cubic meters | m ³ |
| yd³ | cubic yards | 0.765 | cubic meters | m ³ |
| NOTE: volumes greater than 1000 L shall be shown in m ³ | | | | |
| MASS | | | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| TEMPERATURE (exact degrees) | | | | |
| °F | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |

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TABLE OF CONTENTS

| | |
|----|---|
| 1 | Executive Summary |
| 5 | Section 1 Introduction |
| 5 | Purpose |
| 5 | Document Structure |
| 7 | Section 2 Study Approach |
| 9 | Section 3 Data Findings |
| 9 | New Starts Project Sample Selection |
| 11 | Drivers for Cost Growth and Schedule Overruns |
| 12 | Project Stakeholder Interviews |
| 13 | Market Impacts on Procurement |
| 13 | External Perspective: Validation and Benchmarking |
| 15 | Section 4 Recommendations and Next Steps |
| 15 | Recommendation Focus Areas |
| 18 | Next Steps |
| 20 | Appendix: Data Sources |
| 24 | Acronyms/Abbreviations |

LIST OF TABLES

| | | |
|----|------------|---|
| 2 | Table ES-1 | Enhance Accuracy of Grantee Cost Estimating |
| 3 | Table ES-2 | Enhance Grantee Cost Management and Cost Control |
| 4 | Table ES-3 | Enhance Grantee Emphasis on Creating an Environment of Continuous Improvement |
| 9 | Table 3-1 | FTA New Starts Portfolio Budget Performance, 1976–2016 |
| 10 | Table 3-2 | CIG Project Research Sample |
| 11 | Table 3-3 | Cost Category Cost Variance (\$ Millions, YOY) |
| 13 | Table 3-4 | Case Study Procurement Summary |
| 14 | Table 3-5 | Summary of External Benchmarks |
| 15 | Table 4-1 | Enhance Accuracy of Grantee Cost Estimating |
| 17 | Table 4-2 | Enhance Grantee Cost Management and Cost Control |
| 18 | Table 4-3 | Enhance Grantee Emphasis on Creating an Environment of Continuous Improvement |
| 20 | Table A-1 | Light Rail Project Data Sources |
| 21 | Table A-2 | Heavy Rail Project Data Sources |
| 22 | Table A-3 | Commuter Rail Project Data Sources |
| 23 | Table A-4 | Bus Rapid Transit Project Data Sources |

EXECUTIVE SUMMARY

The Federal Transit Administration (FTA) Office of Program Management (TPM) initiated a research study in Summer 2017 to review the cost estimating methodologies and cost control measures of select Capital Investment Grant (CIG) program New Starts projects. The ultimate research objectives were to determine drivers behind cost growth from the transit industry perspective and to identify tools, processes, and recommendations for improving Grantees' cost estimation and risk management practices.

To inform these objectives, first, TPM worked with FTA stakeholders to select 16 completed (or under construction) CIG projects across 4 modes of transit to perform a quantitative analysis focused on identifying cost growth trends at the Standard Cost Categories (SCCs) level. It then worked with FTA headquarters to select a subset of eight projects for which it conducted interviews to identify common themes that influenced cost growth or schedule delays.

Then, as part of the external review, a wide variety of literature sources related to capital project performance and best practices were surveyed and individuals from several private companies, including a national oil company and a global manufacturing and engineering firm, were interviewed. Discussions with oil & gas, power & utilities, and United Kingdom (UK) transit professionals also helped inform the benchmarking and recommendations.

Based on the findings and insights from the activities highlighted above, three overarching recommendation focus areas for Grantees were identified:

- Enhance Accuracy of Cost Estimating
- Enhance Cost Management and Cost Control
- Enhance Emphasis on Creating an Environment of Continuous Improvement

The following tables summarize key observations noted as a result of this study and potential outcomes with each.

Table ES-1*Enhance Accuracy of Grantee Cost Estimating*

| Observation | Current State | Potential Outcome |
|--|---|---|
| Grantees should place more emphasis on cost estimation best practices and lessons learned. | <ul style="list-style-type: none"> FTA currently facilitates the capital cost workshop and lessons learned database, but both are acknowledged to be in need of improvement. Interviews revealed that information/data sharing specific to cost estimating would assist Grantees. | <ul style="list-style-type: none"> Formally conduct or facilitate more regular workshops focused on how to develop and structure estimates. Require workshop attendance to move to subsequent stage gates. Highlight specific issues (e.g., tunneling, freight agreements, etc.) to draw attention to known challenges from other FTA projects. Poll Grantees to determine best way to facilitate data sharing. |
| Grantees can improve consistency in cost estimate approaches | <ul style="list-style-type: none"> FTA provides limited, indirect guidance related to cost estimating. Cost estimates developed by Grantees vary in consistency. Less-experienced Grantees or those embarking on a “first of its kind” project would benefit from additional guidance. | <ul style="list-style-type: none"> Highlight consideration of tactical items such as material cost adjustment clauses, independent economic advisor review, etc. to address potential market impacts. Discuss impacts of procurement on cost estimating accuracy (e.g., lump sum bids) Provide sample cost breakdown structures. |
| Grantees should collect key/major bids prior to finalizing Full Funding Grant Agreement (FFGA) budget. | <ul style="list-style-type: none"> Interviews revealed that those projects with bidding environment visibility prior to FFGA had more accurate budgets established and generally experienced lower levels of cost growth. | <ul style="list-style-type: none"> Grantees should attempt to have issued at least one major contract to bid prior to entering into FFGA. Alternatively, issue an RFQ/EOI prior to FFGA. |
| Grantees should perform independent constructability review. | <ul style="list-style-type: none"> Constructability Reviews are “encouraged” but not required by FTA. Interviews indicated that constructability reviews may occur only reactively. Constructability Reviews can help reduce consequences of inexperienced design firms. | <ul style="list-style-type: none"> Grantee should pursue review prior to FFGA by an independent third-party design/engineering firm. |
| Grantees would benefit from an independent economic advisor to review market assumptions. | <ul style="list-style-type: none"> Independent advisors can help fill in market knowledge gaps and estimate future scenarios. Interviews revealed that the projects that had engaged an independent economic advisor had lower overall cost growth. | <ul style="list-style-type: none"> Grantee should pursue a review by third-party specialist economic advisor prior to entering into FFGA. |

Table ES-1 (cont.)*Enhance Accuracy of Grantee Cost Estimating*

| Observation | Current State | Potential Outcome |
|--|---|--|
| Grantees should establish and vet P-value used to establish FFGA budget. | <ul style="list-style-type: none"> Benchmarking other capital intensive project industries indicates that P50 is a low level of certainty, increasing the likelihood a project will finish over FFGA budget. If costs and risks are properly vetted and quantified in the OP40/Cost Risk Model exercise, a higher P-value is appropriate. | <ul style="list-style-type: none"> Conduct a cost estimating/risk practitioner workshop and solicit expert opinions on appropriate P-value based on availability and quality of data and information. |

Table ES-2*Enhance Grantee Cost Management and Cost Control*

| Observation | Current State | Potential Outcome |
|---|---|--|
| Grantees can better assess risks and address unknown unknowns. | <ul style="list-style-type: none"> It is not clear if Grantees or Project Management Oversight Contractor (PMOC) can track risk estimates in line with these risk factors/items. Not clear if Grantees or PMOCs can estimate unknown unknowns or if they have specific risk management plans that should be developed to address these. | <ul style="list-style-type: none"> Strongly encourage a risk manager be identified/required for each FTA-funded project. Periodically track and monitor risk costs and forecasts for both known and unknown items and identify risk mitigation plans accordingly. Explicitly address unknown unknowns, including alignment with project contingency. |
| Grantees can improve project data tracking, consideration of project risks and consistency of reporting to FTA. | <ul style="list-style-type: none"> FTA Grantees have experienced significant cost growth across project modes, and FTA is not able to easily determine reasons for cost growth. FTA is not provided project risk data in an easily-interpretable manner, and it cannot determine if Grantees are following best practices. FTA does not have visibility into Grantee contingency management processes and estimates. Construction industry headed towards lifecycle cost management, and unreliable spreadsheets or hard-copy reports are not sufficient for cost control for an entire organization. | <ul style="list-style-type: none"> Grantees should have project cost management software. Define and require key metrics around earned value management principles, including CPI, SPI, cash flow management, resource management, ROI, and production across repeatable scope items (e.g., civil and track work, instrumentation, etc.). Develop active risk management processes for risk identification, collection and reporting to FTA. Require electronic data entry, capture, and reporting rather than hard-copy reports, as is current practice. Leverage FTA Cost Risk Model to serve as basis for cost reporting and updates throughout delivery of project. |

Table ES-3*Enhance Grantee Emphasis on Creating an Environment of Continuous Improvement*

| Observation | Current State | Potential Outcome |
|--|---|--|
| Grantees can create a consistent evaluation framework to assess preparedness to undertake and manage the specific project. | <ul style="list-style-type: none"> • FTA currently conducts Readiness Assessments via PMOCs at various project development stages; however, many questions focus on documentation requirements met rather than quality. Moreover, past readiness reports were difficult to obtain. • PMOCs do not provide FTA with specific insights in terms of how capable a Grantee has been in identifying, forecasting or managing risks. • Future Grantees would benefit from scorecard reviews and recommendations to overcome capability concerns. | <ul style="list-style-type: none"> • Create a benchmark evaluation tool or process relative to a particular industry standard of Grantee’s capabilities to estimate and manage/control costs for the benefit of future projects to be evaluated for funding. • Update Readiness-related OPs if necessary to facilitate data collection that will allow for the creation of the tool/process. • Focus on questions that address quality of readiness rather than binary “yes/no” box-checking. |
| FTA can apply analytics to risk data to assess project management effectiveness during project execution. | <ul style="list-style-type: none"> • Capital project performance varied across all modes and Grantees. • Some Grantees had more effective ability to control costs, leading to conclusion that some are effective at project and risk management when undertaking new capital projects. | <ul style="list-style-type: none"> • Perform analysis of assumptions behind and use of unallocated contingency across historic FTA projects to assess 1) accuracy in assumptions and 2) project management effectiveness in contingency use. • Share analysis with project teams to inform and improve unallocated contingency assumptions and use on future projects. |

Two follow-on research efforts are suggested that may help further FTA’s efforts to identify and enhance guidance to its Grantees to improve project cost estimation and overall project performance:

- **Benchmark Grantor Agencies Outside the US** – National infrastructure agencies that function in a similar capacity to FTA in countries such as the UK and Australia have existing processes, procedures, and guidance related to funding national transit infrastructure. FTA could consider best practices from such agencies as it explores the modification to its own processes and procedures.
- **Collect Contractor Feedback Related to CIG-Funded Transit Projects** – Although this research project collected feedback from a variety of stakeholders involved in FTA-funded transit projects, contractors were not interviewed for feedback related to project challenges associated with a) Grantees, b) FTA requirements, or c) other project stakeholders that may result in change orders or a decision to not bid on a particular project. It is in the interest of FTA and the Grantee to attract a large number of bidders on a project, so feedback from the private sector would be valuable.

Introduction

The United States Department of Transportation (USDOT) Federal Transit Administration (FTA) is responsible for administering capital grants and loans to State and local transit agencies to support the financing, acquisition, construction, reconstruction, and capital improvement of the nation's public transit infrastructure. Federal funds for qualifying projects are appropriated annually through a portfolio assessment process, which is subject to Congressional approval and administered through execution of multi-year grant agreements. Often, these agreements and the cost assumptions and funding commitments therein are finalized before testing local construction markets for competitive pricing or project risk.

The Office of Program Management (TPM), the FTA entity conducting the annual Congressional review and appropriations process, reviews project sponsor funding applications, including project readiness state, cost and risk assumptions, and various management plans. TPM simultaneously manages several groups of oversight contractors that monitor active projects within FTA portfolios. The accuracy, precision, and reliability of Grantee and contractor technical inputs have become more critical due to the increased number of active projects. With finite resources, TPM is increasingly challenged with cost estimate validation and cost growth management within its existing portfolios.

Given the unique nature of major public capital transit projects, FTA-funded projects have encountered project-specific conditions that have driven cost growth and delayed schedules, and these issues are likely to persist. This report summarizes FTA efforts to identify practical measures for avoiding cost growth issues.

Purpose

TPM initiated a research study in Summer 2017 to review the cost estimating methodologies and cost control measures of select Capital Investment Grant (CIG) program New Starts projects. The ultimate research objectives for the effort were to determine drivers behind cost growth from the transit industry perspective and to identify tools, processes, and recommendations for improving Grantee cost estimation and risk management practices.

Document Structure

This document presents recommendations that resulted from a series of research activities in conjunction with TPM stakeholders. The sections of the document and descriptions of the content within each section are as follows:

- **Executive Summary** – Description of the study, objectives, and prioritized recommendation focus areas for achieving target outcomes.
- **Section 1, Introduction** – Background and purpose of the study.
- **Section 2, Study Approach** – Discussion of the approach taken for each research activity.
- **Section 3, Data Findings** – Presentation of findings from New Starts project reviews and stakeholder interviews, as well as literature reviews and stakeholder interviews related to validation of findings from the project reviews and benchmarking efforts.
- **Section 4, Recommendations and Next Steps** – Presentation of prioritized tools and processes for achieving certain outcomes, including detailed observations and practical actions.
- **Appendices** – List of acronyms used in this report and supporting case study materials.
- **References** – Project data sources and summaries of supporting analyses.

Study Approach

To achieve the project objectives, budget and actual spend data were reviewed and project stakeholders for a select sample of CIG New Starts projects were identified, as were common themes across the project sample that influenced cost growth and schedule delays. Capital project management best practices were benchmarked.

TPM worked with a range of CIG program stakeholders, including FTA headquarters and regional staff, project management oversight contractors (PMOCs), and project grantees. The availability and ease of access to organizational records and project data were assessed to establish constraints around the research approach and define the required data elements and gathering methods. Various information resources were collected, including Full Funding Grant Agreements (FFGAs), monthly PMOC construction reports, and selected agency portfolio reports for a unique research sample of transit modes, development timeframes, and locations. Descriptions of the specific research approach activities are as follows:

- **Develop research approach and select project sample** – Leverage available data, experience, and stakeholder insights to design a research approach around a diverse collection of New Starts projects, complemented by interviews with various CIG program stakeholders and capital projects experts to provide external perspective.
- **Perform quantitative assessment** – Gather detailed cost estimate and expenditure data to analyze budget performance of selected New Starts projects, and identify each project's Standard Cost Category (SCC)¹ that experienced cost overruns during construction and start-up.
- **Conduct qualitative assessment** – Interview project stakeholders from a subset of projects selected in #2 above to identify project-level challenges that influenced cost growth. The interviews serve to provide insights related to cost estimation and risk methodology, market effects on procurement and contracting, and cost/schedule management challenges in general.
- **Validate results** – Benchmark transit research findings against external research, interviews, and best practices from other relevant capital projects industries.

¹FTA implemented the SCC system in 2005 to establish a consistent format for the reporting, estimating, and managing of capital costs. SCCs serve as the basis for project cost estimate reviews, risk evaluation, and cost tracking during construction. The categories are 10 – Guideway & Track Elements; 20 – Stations, Stops, Terminals, Intermodals; 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; and 100 – Finance Charges.

- **Prioritize recommendations** – Identify tools and processes applicable to Grantees and recommend best practices.
- **Outline next steps** – Summarize practical next steps that FTA can take following this study.

SECTION

3

Data Findings

TPM reviewed lump sum cost data for more than 100 News Starts projects and conducted focused cost reviews on a selected sample of projects. In addition, it conducted interviews with selected FTA PMOCs and experts from other industries to obtain specific insights related to the study objectives.

The following tables present findings from our analytical research activities:

- Tables 3-1 and 3-2 detail overall budget performance of the New Starts project portfolio and budget and schedule performance for the selected research sample, respectively.
- Table 3-3 details SCC areas in which as-built project costs exceeded estimates, which guided interview discussion topics.
- Table 3-4 presents findings related to the impacts of market conditions on procurement performance.
- Table 3-5 provides findings from external perspective interview-related performance and tools/processes benchmarking.

New Starts Project Sample Selection

Table 3-1 shows overall cost performance for the New Starts project portfolio, which was based on current portfolio cost tracking data sourced from the Office of the Administrator's Microsoft Excel database. The data included lump-sum² cost estimate vs. actual data for 103 New Starts projects funded between 1976 and 2016.

Table 3-1

FTA New Starts Portfolio Budget Performance, 1976–2016

| Budget Performance | Number of Projects |
|----------------------------|--------------------|
| On or under budget | 45 |
| 1–5% over | 4 |
| 6–25% over | 11 |
| 26–50% over | 9 |
| 51–75% over | 1 |
| 76–100% over | 1 |
| More than 100% over | 4 |
| Missing or incomplete data | 28 |

Source: FTA, Office of the Administrator, "New Starts Microsoft Excel database." Data not publicly available.

More than half of the New Starts projects (for which complete data were available) were actually delivered on or under budget, and at least 30 projects experienced some degree of cost growth during construction and start-up. Additionally, expense data points for 28 projects were either missing from the database or not yet available.

²Excludes project financing cost estimates and expenditures.

Results from the New Starts portfolio data were used to survey and propose a research sample that incorporated a variety of transit modes, grantees, development time periods, and locations. Using guidance and insights from TPM stakeholders and members of the Fast and Furious Working Group,³ the study sample was narrowed to 16 projects implemented between the early 2000s and 2017, including two Small Starts Bus Rapid Transit (BRT) systems that were not yet complete as of December 2017.⁴ The combined estimated value of these projects was nearly \$15 billion (in year of expenditure [YOE] dollars).

Table 3-2 lists each project and its location, budget, and schedule performance indicators. The green shading indicates overall performance with expenses less than or up to 5% over the baseline cost estimate and revenue service achieved on or before the date specified in the grant agreement. Yellow indicates expenses up to 25% over the baseline cost estimate and a less-than-six-month schedule impact, and red indicates cost growth and schedule impacts greater than 25% and 6 months, respectively.

Table 3-2*CIG Project Research Sample*

| Project | Location | Budget Performance | Schedule Performance |
|---------------------------|--------------------------|------------------------|-----------------------|
| Light Rail Transit | | | |
| University Link | Seattle, WA | 12% under | Over 13 mo early |
| Central Corridor | Minneapolis-St. Paul, MN | 1% over | Over 6 mo early |
| Mid-Jordan Corridor | Salt Lake City, UT | 2% under | Over 3 mos early |
| West Corridor | Denver, CO | Less than 1% under | Over 1 mo early |
| Heavy Rail | | | |
| Dulles Corridor Phase I | Fairfax, VA | 2% over | On schedule |
| 2nd Ave Subway Phase I | New York, NY | 9% over | Over 30 mo late |
| Ravenswood Expansion | Chicago, IL | 11% over | On schedule |
| Largo Extension | Washington, DC | 60% over | On schedule |
| Commuter Rail | | | |
| Eagle | Denver, CO | 3% under | Over 12 mo late |
| Northstar Corridor | Minneapolis, MN | 1% over | Over 2 mo early |
| Weber to Salt Lake City | Salt Lake City, UT | On budget | Over 5 mo early |
| Oceanside-Escondido | San Diego, VA | 38% over | Over 24 months late |
| Bus Rapid Transit | | | |
| New Britain-Hartford | Hartford, CT | 3% under | Over 1 mo early |
| Euclid Corridor | Cleveland, OH | 17% over | Over 2 mo early |
| Dyer Corridor | El Paso, TX | EACs not yet available | Mid-2018 ^b |
| Southeast Corridor | Jacksonville, FL | 3% over ^a | Mid-2018 ^b |

^aIndicates estimate at completion as of November 2017.

^bIndicated planned completion and full revenue service.

Sources: Refer to data sources in the Appendices.

³The Fast and Furious Working Group includes experienced FTA HQ and regional staff and project management oversight contractors that meet on a frequent basis to discuss relevant program issues.

⁴Two under-construction BRT Small Starts projects ultimately were selected due to lack of completed BRT New Starts projects during the desired development timeframe (1995–2015). BRT projects and development processes were expedited and re-categorized under the Small Starts program following passage of MAP-21 in 2012.

Drivers for Cost Growth and Schedule Overruns

TPM compared the standard cost category estimates from each grant agreement to the final as-built costs or the most current expense figures for active grants, including some estimates-at-completion (EACs). Table 3-3 lists the cost variance from each standard cost category estimate in millions of YOE dollars, with positive values reflecting cost overruns. The total net value of standard cost category variance, which represents the sum of all standard cost category savings and overruns across the project sample, was equivalent to nearly \$1.5 billion in YOE dollars. The net value column indicates that the following standard cost categories experienced the greatest net overruns—Professional Services, Sitework and Special Conditions, and Stations, Stops, Terminals, and Intermodals. Project components, materials, and services included in these categories are listed in Table 3-3.

Table 3-3

Cost Category Cost Variance (\$ Millions, YOE)

| Cost Category Area | Light Rail Transit | | | | Heavy Rail | | | | Commuter Rail | | | | Bus Rapid Transit | | | | Net Value (YOE \$) |
|--|--------------------|-----------------|-----------------------------|---------------|-------------------------|---------------------|----------------------|-----------------|---------------|--------------------|-------------------------|------------------|-------------------|----------------------|--------------------|---------------|--------------------|
| | University Link | Cenrtl Corridor | Mid-Jordan Transit Corridor | West Corridor | Dulles Corridor Phase I | 2nd Ave Sub Phase I | Ravenswood Expansion | Largo Extension | Eagle | Northstar Corridor | Weber to Salt Lake City | Ocside-Escondido | Eudlid Corridor | New Britain-Hartford | Southeast Corridor | Dyer Corridor | |
| Professional Services | 12 | 31 | 2 | (1) | 152 | 592 | 33 | - | (49) | (0.2) | (6) | 50 | 3 | 45 | (4) | N/A | 860 |
| Sitework & Special Conditions | (2) | 67 | 23 | 78 | 23 | 604 | 15 | - | (28) | 1 | 8 | 10 | 32 | 5 | (5) | N/A | 830 |
| Stations, Stops, Terminals, Intermodals | (13) | (21) | (0.3) | (18) | 32 | 379 | 33 | - | (2) | 1 | 7 | 10 | (15) | (2) | (2) | N/A | 389 |
| ROW, Land, Existing Improvements | (42) | 9 | 2 | 8 | 11 | 41 | 1 | - | 96 | 2 | (5) | (3) | 3 | (6) | (3) | N/A | 115 |
| Support Facilities: Yards, Shops, Admin. Buildings | 18 | (10) | 10 | (0.1) | 19 | - | - | - | (2) | (1) | 2 | 15 | 0.2 | - | - | N/A | 51 |
| Vehicles | 0.4 | 43 | (28) | 1 | (17) | (153) | - | 104 | (9) | 5 | 20 | 12 | (1) | - | (6) | N/A | (29) |
| Systems | 33 | (29) | 7 | (12) | 28 | (110) | (5) | 18 | (25) | 8 | 10 | (5) | 10 | (1) | (2) | N/A | (77) |
| Guideway & Track Elements | (166) | (53) | 3 | (41) | (56) | (423) | 6 | 52 | (5) | 0.1 | 0.3 | 52 | 15 | (36) | (0.3) | N/A | (651) |

N/A = not available

Source: Refer to data sources in Appendix.

Project Stakeholder Interviews

New Starts project stakeholders were interviewed, including FTA regional project engineers and PMOCs and four of the eight grantee agencies, including the Connecticut Department of Transportation, Denver Regional Transportation District, Metropolitan Council in Minneapolis-St. Paul, and Metropolitan Washington Airports Authority in Arlington, VA. Survey questions targeted specific organizational policies, processes, and procedures related to cost estimating approach, experience with project delivery methods, risk management, procurement strategies, and experience managing change during cyclical economic conditions. Common themes that reportedly influenced cost growth and schedule delays from the case study analysis were as follows:

- Competitive bidding environments prior to the 2008 recession resulted in contract award delays after grantees received unfavorable bids during initial requests for services, which led to the re-evaluation of scope and procurement strategy.
- Design firms were inexperienced or had limited senior resources for managing competitive, local workloads.
- The agency took on a “first of its kind” project, e.g., a new, more advanced mode or system or an alternative delivery method.
- Organizational and/or project stakeholder issues resulted in schedule delays and scope changes after the FFGA budget and funding commitments were approved and finalized.
- Unfinalized or risk-laden third-party agreements with freight rail operators and/or utilities carried major project risks that required significant coordination efforts at the senior level throughout the development and construction phases and sometimes resulted in unplanned scope changes and delays.

Overall, the majority of projects profiled involved a “first of its kind” effort (e.g., new transit mode), as well as organizational and/or project stakeholder issues that required design and scope changes. Typically, the outcomes of these challenges can require increased levels of effort and resources for the project management team, which, in turn, drive professional services cost growth. In addition, the coordination and execution of construction activities within active freight rail corridors were frequently cited as significant challenges, including for FTA projects currently in development.

Market Impacts on Procurement

Of particular interest to FTA within the context of this study was an understanding of why procurement bids fall significantly above or below engineer’s estimates. Through review of the eight transit projects, a trend of bid results and budget performance relative to particular market conditions, both

before and after the 2008 recession, was identified. Interviews with experienced PMOCs and Grantees revealed a general consensus around significantly higher levels of market competition during the mid-2000s and leading up to 2008. Those interviewed identified the inability of estimators to always accurately capture changing markets as a known challenge, and it was also acknowledged that in strong markets, bidders prefer private sector work over public sector and therefore are likely add a premium to bids when possible.

Data related to the procurement timelines and contracting results for each study are presented in Table 3-4.

Table 3-4

Case Study Procurement Summary

| Project | Construction Procurement Period | Estimated Responses per Major Construction Contract | Construction Bids Relative to Engineer's Estimate |
|----------------------------------|---------------------------------|---|---|
| Euclid Corridor, BRT | July 2003–June 2006 | 2–4 | Generally higher |
| Oceanside-Escondido, CR | December 2003–November 2004 | 4 | 8–23% higher |
| Second Avenue Subway Phase I, HR | March 2007–June 2013 | N/A | Higher |
| Dulles Corridor Phase I, HR | July 2007 | 1 (sole source) | N/A |
| Eagle, CR | August 2008–August 2010 | 2 | 13% lower |
| University Link, LRT | December 2008–late 2010 | 2–6 | 12–34% lower |
| Central Corridor, LRT | August 2009–September 2010 | 4–7 | 4–6% lower |
| New Britain-Hartford, BRT | August 2011–October 2014 | 6–10 | 21% lower |

BRT = Bus Rapid Transit; HR = Heavy Rail; CR = Commuter Rail; LRT = Light Rail Transit

N/A = not available

Sources: Values/estimates provided either via interviews with Grantees/PMOCs or via web research as reported in “Other” column in Appendices.

The data revealed that the projects procured during the strong market period leading up to 2008 all received higher bids for major contracts, and these projects also experienced cost overruns to some degree relative to FFGA budget. Following the recession, however, bids were consistently lower than the Grantee’s engineer estimates, and as-built project costs were consistently delivered at or under FFGA expectations.

External Perspective: Validation and Benchmarking

A wide variety of literature sources related to capital project performance validation and benchmarking were surveyed, and individuals from several

private companies were interviewed, including a national oil company and a global manufacturing and engineering firm. Discussions with oil & gas, power & utilities and UK transit professionals also helped inform the benchmarking and recommendations.

External perspective topics were categorized in terms of project performance and tools and processes. Table 3-5 highlights the major research sources used and key findings/relevance of each.

Table 3-5

Summary of External Benchmarks

| Benchmark | Benchmark Source | Key findings/Relevance |
|-----------------|--|---|
| Performance | <i>California Constriction Market Analysis – Causes of Bidding Trends and Industry Ability to Respond to Increased Department Funding</i> (2005, Caltrans) | <ul style="list-style-type: none"> Market analysis review driven by agency concern of trend in decreasing number of bidders & low bids exceeding engineer’s estimates (EE) during 2003–2005 time period. |
| | <i>Program Review – National Review of State Cost Estimation Practice</i> (February 2015, FHWA) | <ul style="list-style-type: none"> Follow-on effort to address findings that ARRA-related bids were 10–30% below EE from 2008–2010. |
| | AASHTO/FHWA Survey on Construction Cost Increases and Competition 2012 | <ul style="list-style-type: none"> Market data collected showed trend that bid prices decreased or remained flat from 2009–2011 across most State DOTs. |
| Performance | <i>The Effects of the Financial Crisis on Public-Private Partnerships</i> (2009, IMF Working Paper) | <ul style="list-style-type: none"> Examined 2008 recession impact on particular infrastructure projects; found that most significant impact was on project development schedule, not cost, if anything. |
| | <i>The Impact of the Financial and Economic Crisis on Global Energy Investment</i> (2009, IEA) | |
| Performance | “A Tale of Two Tails: Chaos in Estimating Predictability” (2017, AACE Cost Engineering) | <ul style="list-style-type: none"> Development-phase (vs. execution-phase) challenges largely responsible for poor project budget performance. Incomplete scope was prevailing factor to projects finishing significantly above estimate. |
| Tools/Processes | AASHTO/FHWA Survey on Construction Cost Increases and Competition 2012 | <ul style="list-style-type: none"> State DOTs ranked methods of responding to bids falling dramatically outside of engineer estimates. Re-bidding ranked highly. |
| Tools/Processes | <i>Managing Cost Risk & Uncertainty in Infrastructure Projects</i> (2013, Infrastructure Risk Group) | <ul style="list-style-type: none"> Across UK Transit Organizations, best practice to better manage cost risk and uncertainty is focus on organizational collaboration, accountability, and performance. |
| | UK organizations range in P-value use from P50 to P85. | |
| Tools/Processes | Private sector interviews | <ul style="list-style-type: none"> Labor and steel consistently repeated as most vulnerable to market. P-values not widely used, but P80+ most common, if used. |

Recommendations & Next Steps

Recommendation Focus Areas

Based on data findings, three recommendation focus areas are outlined for achieving target outcomes:

- Improve Accuracy of Grantee Cost Estimating
- Improve Grantee Cost Management and Cost Control
- Improve Grantee Emphasis on Creating an Environment of Continuous Improvement

Within these categories, observations and highlight potential associated outcomes are provided. Tables 4-1, 4-2, and 4-3 elaborate on each.

Table 4-1

Enhance Accuracy of Grantee Cost Estimating

| Observation | Current State | Potential Outcome |
|--|---|---|
| Grantees should place more emphasis on cost estimation best practices and lessons learned. | <ul style="list-style-type: none"> • FTA currently facilitates the capital cost workshop and lessons learned database, but both are acknowledged to be in need of improvement. • Interviews revealed that information/data sharing specific to cost estimating would assist Grantees | <ul style="list-style-type: none"> • Formally conduct or facilitate more regular workshops focused on how to develop and structure estimates. • Require workshop attendance to move to subsequent stage gates. • Highlight specific issues (e.g., tunneling, freight agreements, etc.) to draw attention to known challenges from other FTA projects. • Poll Grantees to determine best way to facilitate data sharing. |
| Grantees can improve consistency in cost estimate approaches. | <ul style="list-style-type: none"> • FTA provides limited, indirect guidance related to cost estimating. • Cost estimates developed by Grantees vary in consistency. • Less-experienced Grantees or those embarking on a “first of its kind” project would benefit from additional guidance. | <ul style="list-style-type: none"> • Highlight consideration of tactical items such as material cost adjustment clauses, independent economic advisor review, etc. to address potential market impacts. • Discuss impacts of procurement on cost estimating accuracy (e.g., lump sum bids) • Provide sample cost breakdown structures. |
| Grantees should collect key/major bids prior to finalizing Full Funding Grant Agreement (FFGA) budget. | <ul style="list-style-type: none"> • Interviews revealed that those projects with bidding environment visibility prior to FFGA had more accurate budgets established and generally experienced lower levels of cost growth. | <ul style="list-style-type: none"> • Grantees should attempt to have issued at least one major contract to bid prior to entering into FFGA. • Alternatively, issue an RFQ/EOI prior to FFGA. |

Table 4-1 (cont.)*Enhance Accuracy of Grantee Cost Estimating*

| Observation | Current State | Potential Outcome |
|---|---|--|
| Grantees should perform independent constructability review. | <ul style="list-style-type: none"> Constructability Reviews are “encouraged” but not required by FTA. Interviews indicated that constructability reviews may occur only reactively. Constructability Reviews can help reduce consequences of inexperienced design firms | <ul style="list-style-type: none"> Grantee should pursue review prior to FFGA by an independent third-party design/engineering firm. |
| Grantees would benefit from an independent economic advisor to review market assumptions. | <ul style="list-style-type: none"> Independent advisors can help fill in market knowledge gaps and estimate future scenarios. Interviews revealed that the projects that had engaged an independent economic advisor had lower overall cost growth. | <ul style="list-style-type: none"> Grantee should pursue a review by third-party specialist economic advisor prior to entering into FFGA. |
| Grantees should establish and vet P-value used to establish FFGA budget. | <ul style="list-style-type: none"> Benchmarking other capital intensive project industries indicates that P50 is a low level of certainty, increasing the likelihood a project will finish over FFGA budget. If costs and risks are properly vetted and quantified in the OP40/Cost Risk Model exercise, a higher P-value is appropriate. | <ul style="list-style-type: none"> Conduct a cost estimating/risk practitioner workshop and solicit expert opinions on appropriate P-value based on availability and quality of data and information. |

Table 4-2*Enhance Grantee Cost Management and Cost Control*

| Observation | Current State | Potential Outcome |
|---|---|--|
| Grantees can better assess risks and address unknown unknowns. | <ul style="list-style-type: none"> • It is not clear if Grantees or Project Management Oversight Contractor (PMOC) can track risk estimates in line with these risk factors/items. • Not clear if Grantees or PMOCs can estimate unknown unknowns or if they have specific risk management plans that should be developed to address these. | <ul style="list-style-type: none"> • Strongly encourage a risk manager be identified/required for each FTA-funded project. • Periodically track and monitor risk costs and forecasts for both known and unknown items and identify risk mitigation plans accordingly. • Explicitly address unknown unknowns, including alignment with project contingency. |
| Grantees can improve project data tracking, consideration of project risks and consistency of reporting to FTA. | <ul style="list-style-type: none"> • FTA Grantees have experienced significant cost growth across project modes, and FTA is not able to easily determine reasons for cost growth. • FTA is not provided project risk data in an easily-interpretable manner, and it cannot determine if Grantees are following best practices. • FTA does not have visibility into Grantee contingency management processes and estimates. • Construction industry headed towards lifecycle cost management, and unreliable spreadsheets or hard-copy reports are not sufficient for cost control for an entire organization. | <ul style="list-style-type: none"> • Grantees should have project cost management software. • Define and require key metrics around earned value management principles, including CPI, SPI, cash flow management, resource management, ROI, and production across repeatable scope items (e.g., civil and track work, instrumentation, etc.). • Develop active risk management processes for risk identification, collection and reporting to FTA. • Require electronic data entry, capture, and reporting rather than hard-copy reports, as is current practice. • Leverage FTA Cost Risk Model to serve as basis for cost reporting and updates throughout delivery of project. |

Table 4-3*Enhance Grantee Emphasis on Creating an Environment of Continuous Improvement*

| Observation | Current State | Potential Outcome |
|--|---|--|
| Grantees can create a consistent evaluation framework to assess preparedness to undertake and manage the specific project. | <ul style="list-style-type: none"> FTA currently conducts Readiness Assessments via PMOCs at various project development stages; however, many questions focus on documentation requirements met rather than quality. Moreover, past readiness reports were difficult to obtain. PMOCs do not provide FTA with specific insights in terms of how capable a Grantee has been in identifying, forecasting or managing risks. Future Grantees would benefit from scorecard reviews and recommendations to overcome capability concerns. | <ul style="list-style-type: none"> Create a benchmark evaluation tool or process relative to a particular industry standard of Grantee's capabilities to estimate and manage/control costs for the benefit of future projects to be evaluated for funding. Update Readiness-related OPs if necessary to facilitate data collection that will allow for the creation of the tool/process. Focus on questions that address quality of readiness rather than binary "yes/no" box-checking. |
| FTA can apply analytics to risk data to assess project management effectiveness during project execution. | <ul style="list-style-type: none"> Capital project performance varied across all modes and Grantees. Some Grantees had more effective ability to control costs, leading to conclusion that some are effective at project and risk management when undertaking new capital projects. | <ul style="list-style-type: none"> Perform analysis of assumptions behind and use of unallocated contingency across historic FTA projects to assess 1) accuracy in assumptions and 2) project management effectiveness in contingency use. Share analysis with project teams to inform and improve unallocated contingency assumptions and use on future projects. |

Next Steps

Two follow-on research efforts are suggested that may help further FTA's efforts to identify and enhance guidance to its Grantees to improve project cost estimation and overall project performance:

- **Benchmark Grantor Agencies Outside the US** – National infrastructure agencies that function in a similar capacity to FTA in countries such as the UK and Australia have existing processes, procedures, and guidance related to funding national transit infrastructure. FTA can consider best practices from such agencies as it explores the modification to its own internal processes and procedures.
- **Collect Contractor Feedback Related to CIG-Funded Transit Projects** – Although this research project collected feedback from a variety of stakeholders involved in FTA-funded transit projects, contractors were not interviewed for feedback related to project challenges associated with a)

Grantees, b) FTA requirements, or c) other project stakeholders that may result in change orders or a decision to not bid on a particular project. It is in the interest of FTA and the Grantee to attract a large number of bidders on a project, so feedback from the private sector would be valuable.

Appendix – Data Sources

Table A-1
Light Rail Project Data Sources

| Project | FFGA BCE | Actual Cost | Other |
|-----------------------------|---|---|---|
| University Link | FTA signed FFGA as of January 2009. Grant agreement not publicly available. | Sound Transit, Agency Progress Report, June 2017. Report available at: https://www.soundtransit.org/About-Sound-Transit/News-and-events/Reports/Agency-Progress-Report . | <ul style="list-style-type: none"> • KKCS, Inc., “Final PMOC Monthly Monitoring Report,” December 2016. Report not publicly available. • TunnelTalk, “Strong Competition Starts North Link in Seattle,” December 2008. Article available at: https://www.tunneltalk.com/University-link-low-bid.php. • TunnelTalk, “Low Bid Cuts Cost of University Link,” March 2009. Report available at: https://www.tunneltalk.com/Sound-Transit-Mar09-University-link-bid.php. • TunnelTalk, “Seattle Awards Second Transit Contract,” October 2009. Article available at: https://www.tunneltalk.com/UniversityLink-Oct09-Second-Seattle-U-link-contract-awarded.php. |
| Central Corridor | FTA signed FFGA as of April 2011. Grant agreement not publicly available. | <p>Metropolitan Council, “FTA/PMOC Quarterly Meeting,” March 2016. Presentation not publicly available.</p> <p>Metropolitan Council, “Program Evaluation and Audit: Central Corridor Light Rail Transit Procurement,” October 2010. Available at: https://councilmeetings.metc.state.mn.us/audit/2010/102710/A17.pdf.</p> | <ul style="list-style-type: none"> • Metropolitan Council, “Met Council Awards Last Major Construction Contract for Project,” December 2010. Available at: https://metro council.org/Transportation/Projects/Current-Projects/Central-Corridor/News-Display-Page/Met-Council-awards-last-major-construction-contrac.aspx. • MPR News, “A Rocky First Year for St. Paul Central Corridor Construction,” January 2012. Available at: https://www.mprnews.org/story/2012/01/23/central-corridor. • Civil + Structural Engineer Magazine, “Metropolitan Council Awards Contracts for Central Corridor Light Rail Transit Project,” August 2010. Available at: https://csengineermag.com/metropolitan-council-awards-contracts-for-central-corridor-light-rail-transit-project/. • Metropolitan Council, “Central Corridor Light Rail Transit Procurement,” October 2010. Available at: https://councilmeetings.metc.state.mn.us/audit/2010/102710/A17.pdf |
| West Corridor | FTA signed FFGA as of January 2009. Grant agreement not publicly available. | <p>RTD, “Program Management Lessons Learned West Rail Line Project,” December 2014. Available at: http://www.rtd-fastracks.com/media/uploads/wc/WRL-LL-Final.pdf.</p> <p>RTD CM/GC Overview. Available at: http://www.rtd-fastracks.com/media/uploads/wc/CMGC_fact_sheet.pdf</p> | RTD Monthly Progress Reports from January 2011–November 2012. Available at: http://www.rtd-fastracks.com/wc_97 . |
| Mid-Jordan Transit Corridor | FTA signed FFGA as of January 2009. Grant agreement not publicly available. | FTA Capital Cost Database, 2016. Available at: https://www.transit.dot.gov/capital-cost-database . | N/A |

BCE = baseline cost estimate

Table A-2

Heavy Rail Project Data Sources

| Project | FFGA BCE | Actual Cost | Other |
|-------------------------|---|---|---|
| 2nd Ave Subway Phase I | FTA signed FFGA as of January 2008. Grant agreement not publicly available. | FTA PMOC Monthly Report, August 2017. Report not publicly available. | <ul style="list-style-type: none"> FTA, “Technical Memo on Approval of Amended FFGA,” March 2014. Memo not publicly available. MTA, “First Construction Contract Signed for Second Avenue Subway,” March 2007. Available at: http://www.mta.info/press-release/mta-headquarters/first-construction-contract-signed-second-avenue-subway. New York Post, “Second Ave. Tunnel Vision,” March 2007. Available at: https://web.archive.org/web/20090416232408/http://www.nypost.com/seven/03212007/news/regionalnews/second_ave_tunnel_vision_regionalnews_jeremy_olshan.htm. MTA, “Second Avenue Subway Project History.” Data available at: https://web.archive.org/web/20140408220035/http://web.mta.info/capconstr/sas/background.html. |
| Dulles Corridor Phase I | FTA signed FFGA as of March 2009. Grant agreement not publicly available. | FTA PMOC Monthly Report, April 2015. Report available at: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/2015-03_-_Dulles_Phase_I_-_Comprehensive_Monthly_Report.pdf | FTA PMOC Monthly Reports from January 2010–April 2015. Available at: https://www.transit.dot.gov/foia/dulles-metrorail-phase-i-comprehensive-monthly-reports . |
| Ravenswood Expansion | FTA signed FFGA as of January 2004. Grant agreement not publicly available. | FTA Capital Cost Database, 2016. Available at: https://www.transit.dot.gov/capital-cost-database | N/A |
| Largo Extension | FTA PMOC Monitoring Report, February 2005. Report not publicly available. | FTA signed FFGA Amendment as of December 2006. Grant agreement not publicly available. | N/A |

BCE = baseline cost estimate

Table A-3

Commuter Rail Project Data Sources

| Project | FFGA BCE | Actual Cost | Other |
|--------------------------------|--|--|---|
| Eagle | FTA signed FFGA as of August 2011. Grant agreement not publicly available. | FTA PMOC Monthly Monitoring Report, August 2017. Report not publicly available. | <ul style="list-style-type: none"> • RTD, “RTD Board Selects Denver Transit Partners for Eagle P3,” June 2010. Press release available at: http://www.rtd-fastracks.com/media/uploads/main/MEDIA_RELEASE20100615RTD_Board_Selects_Denver_Transit_Partners_as_Eagle_P3_Concessionaire.pdf. • RTD, “Technical Memorandum on Cost Estimating Methodology,” September 2010. Report not publicly available. • RTD, “Eagle P3 Project Procurement: Lessons Learned,” August 2011. Available at: http://www.rtd-fastracks.com/media/uploads/ep3/Eagle_P3_Procurement_Lessons_Learned_Report.pdf. |
| Oceanside-Escondido | FTA signed FFGA as of February 2003. Grant agreement not publicly available. | Jacobs Engineering, “Final PMOC Monthly Monitoring Report,” September 2009. Report available at: https://www.fra.dot.gov/Elib/Document/14174 . | <ul style="list-style-type: none"> • San Diego Tribune, “Sprinter Bids Higher than Hoped,” July 2004. Available at: https://www.trainorders.com/discussion/read.php?l,758614. • San Diego Tribune, “Transit District Awards Final Sprinter Bid, Despite Being Over Budget,” September 2005. Article available at: http://www.sandiegouniontribune.com/sdut-transit-district-awards-final-sprinter-bid-2005sep24-story.html. |
| Northstar Corridor | FTA signed FFGA as of December 2007. Grant agreement not publicly available. | FTA Capital Cost Database, 2016. Available at: https://www.transit.dot.gov/capital-cost-database . | <ul style="list-style-type: none"> • Detailed project timeline, available at http://www.riemen.net/consulting/NShome/abt_history.html. • Met. Council fact page, available at https://metro council.org/About-Us/Facts/Transportation/FACTS-Northstar-Commuter-Rail.aspx. • FTA Before and After Report, available at https://www.transit.dot.gov/funding/grant-programs/capital-investments/2013-and-after-studies-new-starts-projects. |
| Weber County to Salt Lake City | FTA signed FFGA as of June 2006. Grant agreement not publicly available. | FTA Capital Cost Database, 2016. Available at: https://www.transit.dot.gov/capital-cost-database | FTA Before and After Report, available at https://www.transit.dot.gov/funding/grant-programs/capital-investments/2013-and-after-studies-new-starts-projects |

BCE = baseline cost estimate

Table A-4*Bus Rapid Transit Project Data Sources*

| Project | FPGA BCE | Actual Cost | Other |
|----------------------|--|--|--|
| New Britain-Hartford | FTA signed FPGA as of November 2011. Grant agreement not publicly available. | Connecticut DOT, "CTfastrak Status Update," March 2017. Report not publicly available. | <ul style="list-style-type: none"> Connecticut DOT, "DOT Awards Major Busway Contract as DEEP Permit is Approved," March 12. Available at: http://www.ct.gov/dot/cwp/view.asp?A=1373&Q=501022. Connecticut DOT, "Ctfastrak Contract Information." Contract data available at: http://ctfastrak.com/index.php/en/45-front-page-showcase-construction/51-cedar-street-station |
| Euclid Corridor | FTA signed FPGA as of October 2004. Grant agreement not publicly available. | FTA Capital Cost Database, 2016. Available at: https://www.transit.dot.gov/capital-cost-database . | <ul style="list-style-type: none"> FTA Before and After Report, available at https://www.transit.dot.gov/funding/grant-programs/capital-investments/2012-and-after-studies-new-starts-projects. RTA, "Healthline Press Releases," 2000–2011. Available at: http://www.rtahealthline.com/press-releases.asp |
| Dyer Corridor | FTA signed SSGA as of October 2014. Grant agreement not publicly available. | FTA-provided expenditures to date as of September 2017. Budget expenditures not publicly available. | Sun Metro, "Sun Metro Brio Construction for Dyer Corridor Begins," March 2017. Available at: http://www.sunmetro.net/news/2017/03/13/sun-metro-brio-construction-for-dyer-corridor-begins |
| Southeast Corridor | FTA Signed SSGA as of Nov-15. Grant agreement not publicly available. | FTA-provided EACs as of Nov-17. Cost estimates not publicly available. | Jacksonville Transit Authority, "First Coast Flyer Phases." Available at: http://fcf.jtafla.com/phases/ . |

BCE = baseline cost estimate

ACRONYMS/ ABBREVIATIONS

AASHTO – American Association of State Highway and Transportation Officials
BCE – Baseline Cost Estimate
BRT – Bus Rapid Transit
CR – Commuter Rail
DOT – Department of Transportation
EAC – Estimate at Completion
FFGA – Full Funding Grant Agreement
FTA – Federal Transit Administration
HR – Heavy Rail
LRT – Light Rail Transit
MTA – Metropolitan Transit Authority (NYC)
PMOC – Project Management Oversight Contractor
RTD – Regional Transportation District (Denver)
SSGA – Small Starts Grant Agreement
UTA – Utah Transit Authority



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