RISK AND CONTINGENCY REVIEW REPORT

Durham-Orange Light Rail Transit Project

Grantee: Research Triangle Regional Public Transportation Authority
Durham, North Carolina

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OPs Referenced:	01 - Administrative Conditions and Requirements
	40c - Risk and Contingency Review

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EXECUTIVE SUMMARY

This is the Risk Assessment Report in accordance with FTA OP 40c_Risk and Contingency Review for the Durham Orange Light Rail Transit Project (D-O LRT). The Project Managemet Oversight Contractor (PMOC) and the Project Sponsor, GoTriangle (GoT), held a series of joint meetings and Pre-Risk Workshop reviews in August, September, and October 2018 leading to the Risk Workshop conducted during the week of November 25, 2018 to further understand the D-O LRT Management Capacity and Capability, the basis of the Project Scope, Project Schedule and associated constraints, Project Costs and the project Risks with associated mitigation measures. The sponsor project team provided clarifications on various issues during the workshop.

PMOC Reviews

FTA Oversight Procedures (OPs) assigned to the PMOC for the purpose of the Risk Review include:

- OP 21 – Management Capacity and Capability Review
- OP 32C – Project Scope Review
- OP 33 – Capital Cost Estimate Review
- OP 34 – Project Schedule Review
- OP 40c – Risk and Contingency Review

The detailed findings and recommendations related to the Risk and Contingency review are provided in this document. Summaries of the separate report for the Management Capacity, Scope, Cost, and Schedule reviews are included here.

Project Description

The D-O LRT Project will implement light rail transit service covering approximately 17.81 miles between the University of North Carolina (UNC) Hospitals in Chapel Hill and North Carolina Central University (NCCU) in Durham, North Carolina, with new dual light rail tracks: 12.84 miles at-grade and 4.89 miles on elevated structure and 0.08 miles underground cut & cover. The Project includes a total of nineteen (19) stations: sixteen (16) at-grade and three (3) elevated. The light rail system will operate at 10-minute peak headways and 20-minute headways during off-peak hours and weekends. End-to-end travel time is estimated to be approximately 44 to 46 minutes. The double-track alignment would operate primarily at-grade in a dedicated right-of-way parallel with existing roadways, but with elevated sections throughout, due to local topography, avoidance of potential traffic conflicts by grade separating, or mitigation of impacts to environmental features as required.

Management Capacity and Capability, Scope, Cost, Schedule Review Summary

A separately-provided report on the status of the Project's management capacity and capability, scope, cost and schedule is available; those reports provide essential information upon which the analysis of risk as presented in this report is based. A summary of the findings of those reports is provided in the body of this report.

Risk Review Synthesis of findings and conclusions

The PMOC reviewed the D-O LRT Project scope, schedule, cost estimate, risk register and supporting documentation in accordance with FTA OP 40c with a focus on the elements of uncertainty and risks associated with GoT's project implementation.

The PMOC participated in a joint FTA/PMOC/GoT Risk Workshop for the D-O LRT Project in November 2018 and reviewed the updated D-O LRT Risk Register (January 2019). The PMOC found that GoT has been diligent in its efforts to track and update the risk register through their internal risk management processes. During the GoT Risk Workshop, key project risks were reviewed and amended as appropriate. Significant requirements risks include resolution of railroad agreements in Durham, higher right-of-way (ROW) condemnation rate, increased third-party scope demands, and construction concerns including unexpected soil contamination. PMOC notes that staffing capacity for ROW and third-party coordination may be low.

Importantly, the cost, schedule, and risk analyses in this report assume that no major delays occur in FTA or other approvals for D-O LRT funding (e.g. LONP, FFGA, or local funding) that would materially impact the construction progress. Such scenarios are beyond the scope of the risk modeling in this report and would be cause for re-evaluation once these types of delays are quantifiable.

The PMOC created a risk schedule by adjusting D-O LRT's schedule for mechanical consistency and ranging the project durations according to risk. Then, the PMOC used a Monte Carlo approach for analysis of the data, to develop a histogram that simulates a probability distribution curve for the D-O LRT project.

The PMOC risk analysis indicates:

- A p50 likelihood RSD of January 12, 2028;
- A p65 likelihood RSD of January 20, 2028; and
- A p80 likelihood RSD of January 31, 2028.

GoT's internal schedule risk modeling found the following projected RSD dates:

- A p50 likelihood RSD of April 24, 2028;
- A p65 likelihood RSD of May 4, 2028; and
- A p80 likelihood RSD of May 31, 2028.

GoT's current RSD is forecast at June 29, 2028, comfortably exceeding both the PMOC's and GoT's schedule risk model.

The net PMOC cost estimate adjustments total a Base Year **add** of $112.1 million (YOE $128.8 million); inflation adjustments add a total YOE $47.8 million to the unadjusted estimate. These adjustments yield a stripped, PMOC-adjusted estimate of Base Year $1,805 million (YOE $2,108 million) excluding finance charges.

The PMOC developed a top-down cost risk model, typical for FTA-funded projects. The project was modeled based on the following general levels of completion per Standard Cost Category (SCC). See Scope Review Report provided via separate document for further detail.

- SCC 10 [Guideway and Track Elements] – 60% design (Pettigrew changes to remove shared crossings at conceptual level only);

- SCC 20 [Stations, Stops, Terminals] - 60% design;
- SCC 30 [Support Facilities, Yards, Shops] - 60% design, (some value engineering inclusions less designed);
- SCC 40 [Site Work and Special Conditions] – 50% design;
- SCC 50 [Systems] - 60% design;
- SCC 60 [Right-of-way, Land, Existing Improvements] – 60%;
- SCC 70 [Vehicles] – Draft specification development ; and
- SCC 80 [Professional Services] – well-defined.

Based upon the above, the risk model factors were set for a project at the 60% design level. A Design risk factor of 0.10 was added to SCCs 10-50 to account for risk associated with the lesser degree of design for the Pettigrew changes.

Considering the PMOC estimate adjustments described above, the PMOC found the D-O LRT base estimate to be credible. In addition, the increased PMOC estimate adjustment for increased North Carolina Railroad (NCRR) lease cost is considered conservative. Accordingly, a risk model adjustment was made to SCC 60.01 [Purchase or Lease of Real Estate] – Decrease Market risk by 0.27.

The risk model results depicted in Table 1 indicate a p50 value for the D-O LRT Project is $2.578 billion (YOE), excluding finance charges, compared to GoT's current SCC estimate of $2.341 billion at the p23 level. As such, it is the PMOC's opinion that GoT's current D-O LRT Project budget is about $237 million ***below*** the modeled p50 value due to estimate calculations, inflation adjustments and increased contingency values.

Table 1 - Cost Risk Model Results

YOE Risk Assessment Detail SCC 100 Finance Charges not included	
YOE Sponsor values	**Overall**
Sponsor total estimate (SCC 10-90) (23%ile)	2,341,161
Sponsor exposed contingency	404,926
Sponsor stripped estimate (SCC 10-80)	1,936,235
YOE PMOC values	
Inflation Adjustment	42,610
Latent contingency	0
Adjustments	128,829
Adjusted estimate	2,107,674
Funding level @ (50%ile)	
Funding level (50%ile)	2,577,978
Contingency recommendation amount on adj est	470,304
Contingency %	22%
Risk analysis	
Lower report range value= (40%ile)	**2,487,619**
Median value= (50%ile)	2,577,978
Upper mid value= (65%ile)	2,734,198
Upper range reporting amount (80%ile)	**2,942,408**

Risk Review Recommendations

The PMOC recommends:

1. PMOC Recommendation 1: GoT should carefully develop plans to resolve and diligently track progress of right of way and third-party agreements, in conjunction with prudently evaluating the capacity of currently-planned staff to expedite resolution of these work items.
2. PMOC Recommendation 2: GoT should continue the process of risk identification and mitigation. Especially important are the project requirements risks noted above that should be resolved prior to grant funding.
3. PMOC Recommendation 3: It is recommended that GoT maintain its currently forecast RSD of June 29, 2028 for the D-O LRT for its planning purposes.
4. PMOC Recommendation 4: While some accommodation is made in the schedule risk model for minimal funding delay, GoT should remain aware that significant funding delays could have a material impact on its current schedule, and if such delays occur, or are forecast to occur, GoT's base schedule and estimate should be adjusted and the risk analyses should be re-run.
5. PMOC Recommendation 5: The master project schedule for the D-O LRT is adequate for this level of design, however, the level of detail and logic in the schedule needs to be expanded.
6. PMOC Recommendation 6: GoT should consider increasing the D-O LRT Project budget to $2.578 billion to ensure adequate contingency exists to protect the project at the p50 level for the finalization of design and to account for market and project complexity factors.
7. PMOC Recommendation 7: GoT should continue considering its Secondary Mitigation items for the D-O LRT Project and determine whether any such items are appropriate for inclusion as deductive alternates for bidding purposes. This action will potentially preserve these protections post-bid.
8. PMOC Recommendation 8: GoT should increase its planned frequency of risk assessments to no less frequent than quarterly during the post-bid period to provide more frequent information regarding the cost and schedule risk exposure for the project.
9. PMOC Recommendation 9: GoT should develop a standard set of risk-related reports that summarizes the risk health of the project, especially for consumption of administrative levels above the project team and the FTA.

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APPENDICIES

INTRODUCTION

In April 2018, the FTA assigned PMO Partnership JV, LLC (PMOP JV) as PMOC to the Durham-Orange Light Rail Transit (D-O LRT) Project. In Q2 2018, PMOP JV was issued work orders by the FTA to conduct the following Project reviews in preparation for application for a Full Funding Grant Agreement (FFGA) for the D-O LRT Project:

- OP 21 – Management Capacity and Capability Review,
- OP 32C – Project Scope Review,
- OP 33 – Capital Cost Estimate Review,
- OP 34 – Project Schedule Review, and
- OP 40c – Risk and Contingency (OP40c) Review (Full)

In August, September and October of 2018, the PMOC and the Project Sponsor (the Research Triangle Regional Public Transportation Authority known as GoTriangle) held a series of workshops, meetings, and teleconferences to discuss the management capacity and capability (MCC), scope, schedule and cost (SSC) issues. This report represents the PMOC's assessment of the current risk status of the report. In addition, summaries of the separately-delivered MCC, scope cost, and schedule reports are included for context.

1.1 Project Sponsor (GoTriangle)

The 1989 session of the North Carolina General Assembly enabled the creation of the Research Triangle Regional Public Transportation Authority (now known as GoTriangle, or GoT) as a regional public transportation authority serving Durham, Orange, and Wake counties. The new unit of local government was chartered by the North Carolina Secretary of State on December 1, 1989.

The transit agency was created to plan, finance, organize, and operate a public transportation system for the Research Triangle area. GoTriangle (GoT) currently provides regional bus service to the "Research Triangle Region" of North Carolina in Wake, Durham, and Orange counties.

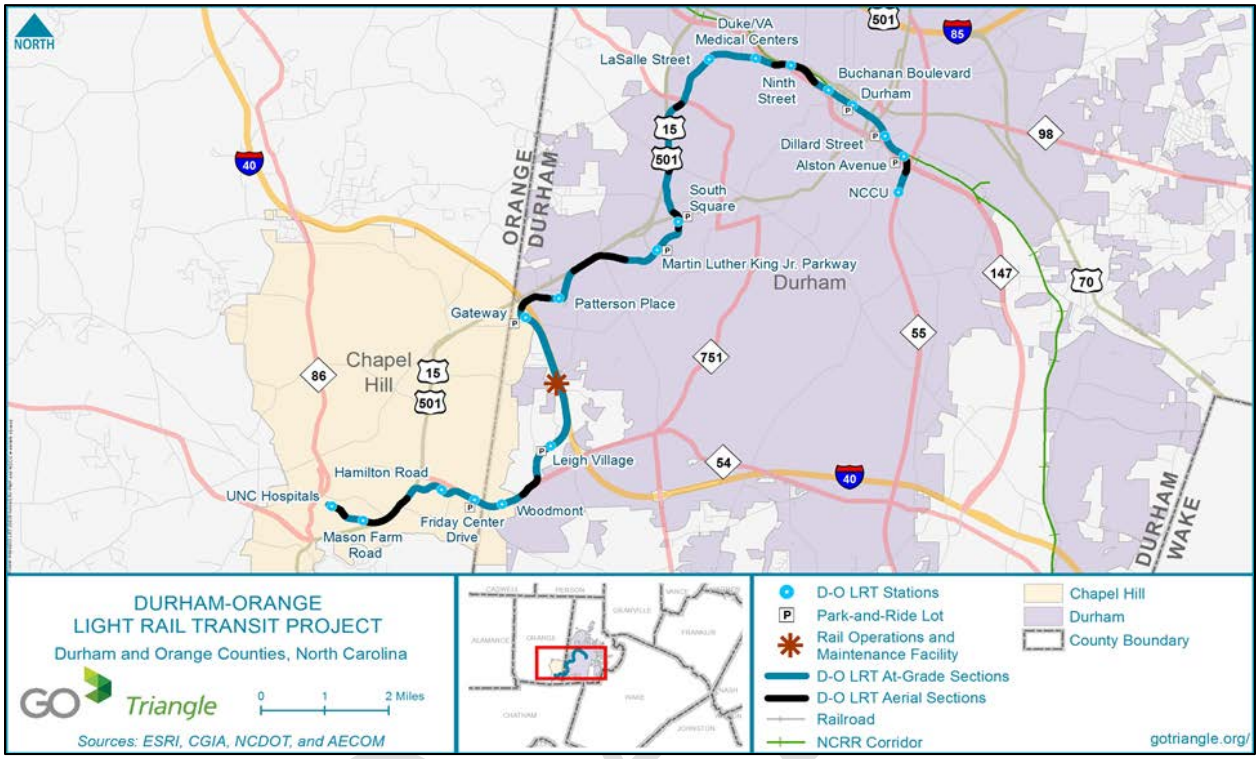
GoT is governed by a thirteen-member Board of Trustees. Ten (10) members are appointed by the region's principal municipalities and counties. The North Carolina Secretary of Transportation appoints three (3) ex office nonvoting members.

1.2 Project Description

The D-O LRT Project will implement light rail transit service, covering approximately 17.81 miles between University of North Carolina (UNC) Hospitals in Chapel Hill and North Carolina Central University (NCCU) in Durham, North Carolina, with new, dual light rail tracks: 12.84 miles at-grade and 4.89 miles on elevated structure and 0.08 miles of underground cut & cover. The Project includes a total of eighteen (18) stations: sixteen (16) at-grade and two (2) elevated. The light rail system will operate at 10-minute peak headways and 20-minute headways during off-peak hours and weekends. End-to-end travel time is estimated to be approximately 44 to 46 minutes. The double-tracked alignment would operate primarily at-grade in a dedicated right-of-way parallel with existing roadways, but with elevated sections throughout, due to local topography, avoidance

of potential traffic conflicts by grade separating, or mitigation of impacts to environmental features as required. A Project Map of the D-O LRT Project is shown in Figure 1.

Figure 1 - D-O LRT Project Alignment



1.3 Project Status

Since receiving approval from the FTA to enter the New Starts (NS) Engineering Phase on July 28, 2017, the D-O LRT Project has undergone modifications that deviate from the Project definition as approved under the Project's currently active Record of Decision (ROD). The Project Team is currently working with the FTA on a National Environmental Policy Act (NEPA) supplemental Environmental Assessment (EA) based on the deviations, and is expected to publish an Amended ROD. The project design was further modified subsequent to publication of the supplemental EA on October 29, 2018. Any design changes must be evaluated pursuant to NEPA. Once the NEPA process is complete, FTA will revise its NEPA findings as appropriate. Therefore, the NEPA process may result in additional mitigation that would not have been evaluated by this report.

The D-O LRT Project (the Project) currently has six (6) professional services contracts and is moving from the 50% to the 90% Design Stage. The Project Team has submitted a Post-50% Design Package and has updated the baseline cost estimate (BCE) and the Integrated Program Master Schedule (IPMS) based on changes from the 50% Design Package and the latest contracting strategy. GoT has decided to issue five (5) major construction contracts instead of nine (9) as previously planned.

The Project real estate efforts are currently focused on rezoning and annexing the land where the Rail Operation and Maintenance Facility (ROMF) will be located and the property donated for in-kind contribution. The third-party agreement efforts are focused on approximately thirteen (13) agreements required prior to submittal of the FFGA application in March 2019.

The Safety and Security and Fire Life Safety Review Committees have been formed and are meeting regularly.

1.4 Project Budget

The Project Budget depicted in Table 2 reflects the GoT October 1, 2018 BCE in year-of-expenditure (YOE) dollars by FTA's Standard Cost Categories (SCCs). The Budget Balance is current up to December 31, 2018.

Table 2 - Budget and Expenditures by FTA SCC

As of December 31, 2018

SCC Code	Budget	Current Month Expenses	Prior Expenses	Total Expenses to Date	Budget Balance
10-50 Construction	$1,391 M	-	-	-	$1,391 M
60 Right of Way, Land, Existing Improv.	$196 M	$0.09 M	$5.26 M	$5.3 M	$191 M
70 Vehicles	$142 M	$0.01 M	$0.05 M	$0.06 M	$142 M
80 Professional Services	$434 M	$5.21 M	$119.44 M	$124.7 M	$309 M
90 Unallocated Contingency	$179 M	-	-	-	$179 M
100 Finance Charges	$135 M	-	-	-	$135 M
Total Project Cost (10 - 100)	$2,476 M	$5.3 M	$124.8 M	$130.1 M	$2,346 M

Note: Totals include estimated accruals for unbilled expenses.

**Rounded to the nearest $1,000*

1.5 Project Schedule

Table 3 reflects the current GoT Project Milestone Schedule up to execution of the FFGA.

Table 3 - Project Milestone Schedule

FFGA Milestone	Date
Entry to Engineering - Commence 50% Design	July 28, 2017
Complete Initial Request for Federal Funding Recommendation	September 29, 2017
FFGA Application	March 2019
Execution of the FFGA	September 2019
Design Completion	**Date**
50% Design Complete	March 2018

Post 50% Design Complete	September 2018
90% Design Complete	June 2019

The Project master schedule provides a plan from the Engineering Phase to Revenue Service and undergoes progressive development with enough detail and interfaces to manage progress, forecast outcomes, and inform programmatic decisions and implications regarding time, budget and risks.

1.6 PMOC Reviews

FTA Oversight Procedures (OPs) assigned to the PMOC for the purpose of the Risk Review include:

- Separately-delivered review reports include:
  - OP 21 – Management Capacity and Capability Review,
  - OP 32C – Project Scope Review,
  - OP 33 – Capital Cost Estimate Review, and
  - OP 34 – Project Schedule Review.
- This report contains the corresponding review for:
  - OP 40c – Risk and Contingency (OP40c) Review (Full).

1.7 PMOC Risk Review Team

The PMOC Risk Review Team is presented in Appendix F.

2 MANAGEMENT CAPACITY AND CAPABILITY, SCOPE, SCHEDULE, AND COST REVIEW SUMMARY

2.1 Management Capacity and Capability (MCC) Review Summary

MCC Summary, Observations and Opinions

Overall, GoT demonstrates the Management Capacity and Capability to implement the Project if the key recommendations are successfully implemented in a timely fashion prior to receipt of an FFGA.

The D-O LRT Team has an effective organizational structure comprised of a core team of GoT Management, Engineering, Finance and Administrative Staff. This team is supplemented by a professional consulting staff for Project Management support, General Engineering and Design and Construction Management Services. Overall, the D-O LRT Team has the necessary qualifications to carry out the Project based on review of resumes, interviews and interaction with key staff to date.

In September 2018, the Project Director resigned. An interim Project Director is in place until a new Project Director is hired. As of January 2019, the interim Project Director has demonstrated the ability to be effective during the current engineering phase of the Project. GoT will hire additional staff during key phases of the Project and, most notably, for Procurement, Real-estate, Financial Controls and administrative support. The D-O LRT Team has demonstrated their ability to effectively engage and coordinate with third party stakeholders.

MCC Recommendations

1. GoT should evaluate implementing an active partnering strategy to build and sustain a more effective working relationship among key Project stakeholders where warranted.
2. GoT should develop succession plans to address the risk of losing key staff members to a very competitive construction market without the loss of program management continuity.
3. GoT should hire a Project Director as soon as possible and prior to receipt of an FFGA Award.
4. GoT should develop greater capability and experience in the procurement specialist position for FTA funded major transit construction projects at least 30 days prior to issuance of the bids.
5. Based on the comparison of staffing positions during peak staffing periods, the D-O LRT Project Team should undergo the following efforts prior to application and receipt of an FFGA:
    - Evaluate adding additional Procurement support prior to issuance of the bids.
    - Evaluate adding additional real estate support and/or increase commitment from existing staff to achieve at least double the current estimated commitment.
    - Evaluate the need for more budget and finance staffing during the Construction Phase for reporting and invoicing purposes.
    - Clarify the roles of the contract administrators and if they will also support procurement, real estate, and budget and finance functions.

6. The D-O LRT Team should update their plans (e.g. PMP, PDPP) to summarize how they will maintain project property leased, rented and purchased under the contract (e.g. computers, copy machines, etc.).
7. Chapter 15 of the PMP should be updated to more fully describe how Americans with Disabilities Act (ADA) requirements will be documented, monitored and checked during design, construction and inspection.

2.2 Scope Review Summary

Scope Summary Observations and Opinions

With the exception of the downtown Durham Area and pending design updates, overall the Project Scope is well defined including the civil, structural, track work, systems, electrical, mechanical and site work elements. Overall geotechnical investigations are completed and are summarized in the Post 50% design documentation. The design, construction and systems interfaces are well defined within each design contract package Work descriptions are included in the Technical Specifications. Value Engineering and Constructability reviews and a Market Analysis were conducted which resulted in changes in designs and the design packaging. Major and critical work details and designs are developed for the Guideway and Track, Stations, Operations and Maintenance Facility, and Systems elements.

As part of negotiations with the NCRR and NS Railroad, GoT will grade separate the alignment in the downtown Durham area long Pettigrew Street within the Railroad's corridor. This will consist of tunneling under Blackwell and Mangum Streets and an underground station and overpass bridges over Dillard and Fayetteville Streets and an aerial station. The designs are conceptual as of this Risk review As a result additional investigations will be needed in the downtown Durham area along Pettigrew including interface designs with the railroad, additional value engineering and constructability reviews and critical work details especially any necessary tunneling systems and the underground station which will be the unique within the alignment.

The Real Estate Management Plan (RAMP) is complete and consistent with the phase of the Project. Site surveys are developed sufficiently for the current design phase. The real estate information and survey information is fully coordinated with the relevant drawings. Draft vehicle technical specifications have been developed for which general vehicles descriptions, fleet size, functionalities, and performance requirements are defined. The Light Rail Vehicle design will be an industry standard design.

Scope Recommendations

1. The D-O LRT Team should include in the contract documents detailed instructions for how to bid to the single standard specification and include a master table of contents for referencing within each bid package.
2. The D-O LRT Team should develop the draft sections of the Procurement and Contracting Requirements as well as the General Conditions sections prior to submitting the application for an FFGA.

3. D-O LRT to provide sample Maintenance of Traffic (MOT) Plans for Shannon Rd. Underpass, MLK Crossing, and Duke University Segmental Bridge Construction prior to submittal of the FFGA application.
4. The D-O LRT Team should identify the potential locations of contaminated soil areas in the plans and technical documents prior to the application for the FFGA.
5. GoT should evaluate the need to conduct a full or refresh of the Value Engineering and Constructability Review in light of the recent design changes in the downtown Durham area regarding grade separation prior to submission of the 90% design plans.

2.3 Cost Review Summary

Cost Summary Observations and Opinions

The cost estimating methods and processes are in line with proven professional quantity surveying and cost estimating practices. The cost estimate is formatted differently than the current set of plans due to the repackaging of the contracts. There are variances between the cost estimate and schedule for Private Utilities and Line Civil East Packages. The PMOC is of the opinion the cost escalation of 3.1% used by the D-O should be increased to 3.6% to be in line with the National Highway Construction Cost Index. Overall the PMOC is of the opinion the estimate is mechanically correct and the SCC workbook appears to be in good order and estimating backups are well organized and detailed.

In addition, the following increases in costs are recommended based on review of the baseline cost estimate of October 1, 2018:

- Increase in indirect cost of Base Year (BY) $13.6 million,
- Increase in real estate relocation related costs of BY $5 million,
- Increase in real estate cost related to lease fees of BY $26 million,
- Increase in cost due to Durham downtown Pettigrew St. due to grade separation of BY $87.48 million plus $20 million reduction due to removal of pedestrian bridge (net increase of $67.5 million), and
- Increase in cost due to inflation by $47.8M YOE$.

These changes are reflected in the Risk Review Report.

Cost Recommendations

1. The D-O LRT Team should reconcile the SCC Workbook with the Basis of Schedule, and the year of expenditure (YOE) dollars may need to be adjusted accordingly.
2. The D-O LRT Team should revisit the labor hourly rates for ironworkers and pipefitters and adjust as warranted, especially for the Rail Operation and Maintenance Facility (ROMF) work.
3. The D-O LRT Team should re-evaluate the durations for calculating Project Management costs and adjust amounts accordingly.

4. The D-O LRT Team should re-evaluate the mobilization and equipment cost based on the Project constructability and based on industry comparison of other similar projects and adjust amounts accordingly.
5. The D-O LRT Team should re-evaluate the field office costs based on the Project constructability and based on industry comparison of other similar Projects and, as warranted, adjust amounts accordingly.
6. The D-O LRT Team should verify the roofing cost at only $1,090 for each of the three (3) aerial stations as this amount appears very low.
7. The D-O LRT Team to clarify why 2-side platform stations (e.g. UNC Hospital) cost more or less the same as the center-platform station (e.g. Mason Farm Road). For example, under LCW (Civil) the 2-side platform station is $165,000 vs $170,000 for the center platform station.
8. The D-O LRT Team should reach out to insurance companies for quotes as soon as possible to firm up this cost.
9. The D-O LRT Team to clarify if the "Procure Fare Collection Equipment & Software" Bid item should be based on a quantity of eighteen (18) stations at $225,000 for a total of $4,050,000 or whether it should be based on nineteen (19) stations.
10. The D-O LRT Team should re-evaluate references used to determine the escalation costs and re-evaluate based on the most recent industry information which is showing up to 3.8% escalation.

2.4 Schedule Review Summary

Schedule Summary Observations and Opinions

Overall the D-O LRT team has the schedule controls organizational structure, plans and procedures to manage and control the schedule. In general, the Integrated Project Management Schedule (IPMS) and the Master Schedule Methodology Report has been prepared to a sufficient level of detail for the current level of design. There are currently twelve component schedules and over 14500 activities identified in total. Initial interface milestones have been incorporated into the schedule. The schedule is consistent with the scope of work and the work breakdown structure and was found to be mechanically and fundamentally sound and reasonable. The IPMS includes key elements required for a full review.

Schedule Recommendations

1. GoT should update the Basis of Schedule document to address long lead material and equipment.

2. GoT should further evaluate the schedule sequencing and durations for the activities related to the downtown Durham area grade separation along Pettigrew Street.

3 RISK REVIEW OP40c

The PMOC performed a project risk analysis in accordance with FTA OP 40c - Risk and Contingency Review to determine the D-O LRT project's readiness for grant approval.

The PMOC evaluated GoT's process for identification of uncertainties and risks, assessed project risk, and took into consideration risk response options and alternatives including the use of schedule and cost contingencies. The PMOC relied on GoT's development of its risk and contingency processes, including its own internal risk assessment, and other elements required to develop its Risk and Contingency Management Plan (RCMP).

The schedule and cost risk analyses performed by the PMOC on the stripped and adjusted schedule and SCC Workbook, provided by GoT, are discussed in this section of the report.

3.1 Methodology

The PMOC used the methodology outlined in FTA's OP 40c (Full Risk Review) as follows:

- Study results of scope, cost, and schedule reviews;
- Review the project sponsor's RCMP;
- Conduct a workshop with project sponsor to consider results of scope, schedule, and cost reviews; and discuss GoT's process of and current risk identification in the workshop;
- Adjust GoT's schedule and cost estimate based on available project information and evaluation of likely project outcomes;
- Model schedule risk using Primavera Risk Analysis (PRA) and a Monte Carlo approach; and
- Model cost risk using FTA's top-down model.

The PMOC reviewed the following GoT risk documents prior to performing its risk analysis, in addition to other documents reviewed as noted elsewhere in this report:

- RCMP-related
  - 0111A_TBL_Secondary-Mitigation (1).xlsx
  - 0108J_SUB_RCMP_DRAFT_v2 (1).pdf
  - RiskAssessRpt_20160115.pdf
- Risk Register
  - 0111D_TBL_Risk-Register-v3-181121.xlsx

3.2 Basis of Risk Modeling / Analysis

The PMOC participated in a joint FTA/PMOC/GoT Risk Workshop for the D-O LRT Project in November 2018 and reviewed the updated D-O LRT Risk Register (January 2019) and found that GoT has been diligent in its efforts to track and revise the risk register through internal risk management processes. During the GoT Risk Workshop, key project risks were reviewed and amended as appropriate. Several key risks are noted in Table 4; an abbreviated risk register is presented in Appendix G.

Significant requirements risks include resolution of railroad agreements in Durham, higher right-of-way (ROW) condemnation rate, increased third-party scope demands, and construction concerns include unexpected soil contamination. PMOC notes that staffing capacity for ROW and third-party coordination may be low.

Importantly, the cost, schedule, and risk analyses in this report assume that no major delays occur in FTA or other approvals for D-O LRT funding (e.g. - LONP, FFGA, or local funding) that would materially impact the construction progress. Such scenarios are beyond the scope of the risk modeling in this report and would be cause for re-evaluation once these types of delays are quantifiable.

Table 4 - Key Project Risks

Type	Description
Top risks noted in D-O LRT Risk Register:	
Requirements	Design concurrence with Norfolk Southern (NS) regarding the proximity of at-grade crossings within the North Carolina Railroad (NCRR) corridor is delayed.
Requirements	Norfolk Southern Agreement may not be obtained prior to planned submittal of FFGA application.
Requirements	ROW condemnation rate higher than estimated.
Requirements	Requests from key stakeholders may require design modifications that delay the completion of design.
Market	Construction contract and front-end documents are not sufficient to mitigate contract related issues.
Additional key risks noted by PMOC from the risk workshop:	
Construction	Undiscovered contamination in assumed re-useable excavated soils (included in DOLRT Risk Register as a lower-ranked risk).
Organizational	Concern over ROW staffing capacity.
Organizational	Concern over Third Party coordination staffing capacity.

GoT has identified the above areas of requirements and construction concern and has developed measures to resolve, reduce, or provide contingency funds for the above risks.

PMOC Recommendation: GoT should carefully develop plans to resolve and diligently track progress of right of way and third-party agreements, in conjunction with prudently evaluating the capacity of currently-planned staff to expedite resolution of these work items.

PMOC Recommendation: GoT should continue the process of risk identification and mitigation. Especially important are the project requirements risks noted above which should be resolved prior to grant funding.

3.3 Schedule Risk

D-O LRT Schedule Risk Analysis

The PMOC performed a pre-risk analysis check by applying a risk distribution range across all schedule activities and reviewing the confidence level range, duration sensitivity, and criticality index.

In order to perform the schedule risk modeling, the PMOC accounted for two types of risk: 1) General risk of duration certainty across the broad spectrum of activity durations, and 2) specific schedule risk due to especially high risks noted on the risk register.

1. The PMOC assigned three durations to each remaining activity in the schedule. The three durations for each activity represent best case "minimum," most likely, and worst case "maximum." The PMOC calculated the durations by using the remaining duration to best case minimum duration, applying a 110% factor to the most likely, and assigned a 120% for the worst case or maximum duration for most of the activities.
2. The PMOC reviewed GoT's current updated risk register and applied adjusted risk factors to several activities, the risk identification, schedule activity and risk factor. The application of using specific identified risk by applying factors to specific activities is provided in Appendix E

Risk Analysis

The PMOC then used Oracle's *"Primavera Risk Analysis" (PRA)* software program, which uses a Monte Carlo approach for analysis of the data, to develop a histogram that simulates a probability distribution curve for the D-O LRT project.

The PMOC risk analysis indicates:

- A p50 likelihood RSD of January 12, 2028;
- A p65 likelihood RSD of January 20, 2028; and
- A p80 likelihood RSD of January 31, 2028.

These RSD outcomes are shown graphically in Figure 2, below. Additionally, Figure 3, below shows a schedule risk tornado diagram that indicates the risk most likely to have a significant effect on schedule delay.

GoT's internal schedule risk modeling found the following projected RSD dates:

- A p50 likelihood RSD of April 24, 2028;
- A p65 likelihood RSD of May 4, 2028; and
- A p80 likelihood RSD of May 31, 2028.

GoT's current RSD is forecast at June 29, 2028, comfortably exceeding both the PMOC's and GoT's schedule risk model.

PMOC Recommendation: D-O LRT should retain its forecast (with contingency) RSD date of June 29, 2028.

Figure 2 - Schedule Risk Model Histogram

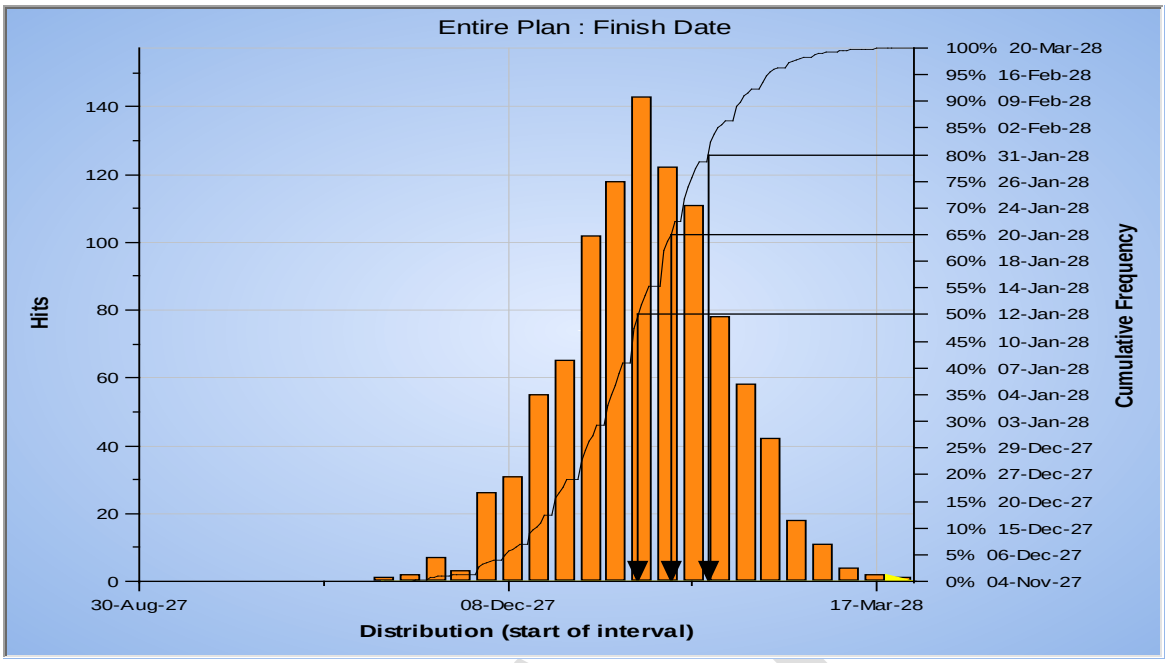


Figure 3 - Schedule Risk Tornado Diagram

Findings

GoT's target RSD, which includes contingency is June 29, 2028, comfortably conservative versus the PMOC's and GoT's internal and PMOC's schedule risk analyses. The D-O LRT stripped schedule has an RSD date of October 9, 2026. After applying modeling factors, the PMOC-

calculated a risk-based range for the D-O LRT RSD at the 50% confidence level is January 12, 2024; at the 65% confidence level the RSD is January 20, 2028; and at the 80% confidence level the RSD is January 21, 2028. The corresponding values for the internal GoT analysis is 50%: April 24, 2028; 65%: May 4, 2028; and 80% May 31, 2028.

Conclusions

The PMOC risk analysis finds that GoT's current RSD forecast of June 29, 2028 for the D-O LRT should be retained at this stage of project development. This schedule should be further developed as the design proceeds and in the process the RSD should be further confirmed.

In addition, this analysis does not contemplate material delays in funding for the D-O LRT project, which at this point are difficult to predict as regards timing.

Recommendations

- It is recommended that GoT maintain its currently forecast RSD of June 29, 2028 for the Durham-Orange LRT for its planning purposes.
- While some accommodation is made in the schedule risk model for minimal funding delay, GoT should remain aware that significant funding delays could have a material impact on its current schedule, and if such delays occur or are forecast to occur, GoT's base schedule and estimate should be adjusted and the risk analyses should be re-run.
- The master project schedule for the D-O LRT (which incorporates the LRT Extension, OMC Expansion and LRV procurement) is adequate for this level of design, however, the level of detail and logic in the schedule needs to be expanded.

3.4 Cost Risk

This section presents the results of the cost risk analysis.

SCC Estimate Adjustments

The PMOC used its professional judgment, as well as evaluation of objective data, to develop a stripped estimate based on the D-O LRT Project estimate provided. Two major categories of adjustments were made by the PMOC to GoT's SCC Project Budget. These are adjustments to the base estimate to coordinate cost with schedule and more closely reflect values determined post-risk workshop; and adjustments for inflation in expectation of higher forecast rates of inflation than that anticipated in the D-O LRT SCC workbook *Inflation* tab. No latent contingency adjustments were identified.

The following details those adjustments; further explanation is provided in the Cost Review report, separately submitted.

- PMOC adjustments (Base Year $$):
  - SCC 40.08 Increase in indirect cost of Base Year (BY) $13.6 million,
  - SCC 60.02 Increase in real estate relocation related costs of BY $5 million,
  - SCC 60.01 Increase in real estate cost related to lease fees of BY $26 million, and
  - SCCs 10-50 Increase in cost due to Durham downtown Pettigrew St. due to grade separation of BY $87.48 million plus $20 million reduction due to removal of pedestrian bridge (net increase of $67.5M).

- Inflation adjustments (does not include inflation on above adjustments; see Appendices B and C)

    - SCC 10 (distributed across the SCC)—increase to SCC 10 at Base Year of $11.7 million;
    - SCC 20 (distributed across the SCC)—increase to SCC 20 at Base Year of $1.2 million;
    - SCC 30 (distributed across the SCC)—increase to SCC 30 at Base Year of $1.7 million;
    - SCC 40 (distributed across the SCC)—increase to SCC 40 at Base Year of $8.7 million;
    - SCC 50 (distributed across the SCC)—increase to SCC 50 at Base Year of $10.0 million;
    - SCC 60 (distributed across the SCC)—increase to SCC 50 at Base Year of $2.1 million;
    - SCC 70 (distributed across the SCC)—increase to SCC 50 at Base Year of $4.9 million; and
    - SCC 80 (distributed across the SCC)—increase to SCC 50 at Base Year of $7.6 million.

The net PMOC estimate adjustments noted above total a Base Year ***add*** of $112.1 million (YOE $128.8 million); inflation adjustments ***add*** a total YOE $47.8 million to the unadjusted estimate. These adjustments yield a stripped, PMOC-adjusted estimate of Base Year $1,805 million (YOE $2,108 million) (Appendix D) excluding finance charges. The stripped and adjusted project estimate was used in the FTA cost risk model to determine adequate contingency levels.

Cost Risk and Contingency Analysis

The PMOC developed a top-down risk model, typical for FTA-funded projects. The project was modeled based on the following general levels of completion per Standard Cost Category (SCC). See Scope Review provided via separate document for further detail.

- SCC 10 [Guideway and Track Elements] – 60% design (Pettigrew changes to remove shared crossings at conceptual level only);
- SCC 20 [Stations, Stops, Terminals] - 60% design;
- SCC 30 [Support Facilities, Yards, Shops] - 60% design, (some value engineering inclusions less designed);
- SCC 40 [Site Work and Special Conditions] – 50% design;
- SCC 50 [Systems] - 60% design;
- SCC 60 [Right-of-way, Land, Existing Improvements] – 60%;
- SCC 70 [Vehicles] – well-defined; and
- SCC 80 [Professional Services] – well-defined.

Global Risk Model Adjustments

Based upon the above, the risk model factors were set for a project at the 60% design level. A global Design risk factor of 0.10 was added to SCCs 10-50 to account for risk associated with the lesser degree of design for the Pettigrew changes.

SCC Line Item Risk Adjustments

Considering the PMOC estimate adjustments described above, the PMOC found the D-O LRT base estimate to be credible. In addition, the increased PMOC estimate adjustment for increased NCRR lease cost is considered conservative. Accordingly, a risk model adjustment was made as follows:

- SCC 60.01 [Purchase or Lease of Real Estate] – Decrease Market risk by 0.27.

The results of these applied risk factors are noted below in Table 5:

Table 5 - Cost Risk Model Results

YOE Risk Assessment Detail SCC 100 Finance Charges not included	
YOE Sponsor values	**Overall**
Sponsor total estimate (SCC 10-90) (23%ile)	2,341,161
Sponsor exposed contingency	404,926
Sponsor stripped estimate (SCC 10-80)	1,936,235
YOE PMOC values	
Inflation Adjustment	42,610
Latent contingency	0
Adjustments	128,829
Adjusted estimate	2,107,674
Funding level @ (50%ile)	
Funding level (50%ile)	2,577,978
Contingency recommendation amount on adj est	470,304
Contingency %	22%
Risk analysis	
Lower report range value= (40%ile)	**2,487,619**
Median value= (50%ile)	2,577,978
Upper mid value= (65%ile)	2,734,198
Upper range reporting amount (80%ile)	**2,942,408**

The risk model results indicate a p50 value for the D-O LRT Project is $2.578 billion (YOE), excluding finance charges, compared to GoT's current SCC estimate of $2.341 billion at the p23 level. As such, it is the PMOC's opinion that GoT's current D-O LRT Project budget is about $237 million below the modeled p50 due to estimate and inflation adjustments and contingency increases.

PMOC Recommendation: GoT should consider increasing the D-O LRT Project budget to $2.578 billion to ensure that adequate contingency exists to protect the project at the p50 level for the finalization of design and to account for market and project complexity factors.

Secondary Mitigation

Secondary Mitigation (SM) is essentially potential scope reductions, design refinements or process changes designed to reduce cost without affecting the primary purpose and operational goals of the project. The purpose of developing such a list is to safeguard the project when, under conditions of realized risk, the project contingency is insufficient.

GoT provided a list of Secondary Mitigation (SM) items, as indicated in Table 6, below. The SM list totals $156 million; the decision to trigger this mitigation expires quickly post-FFGA, so these

ideas are unlikely to protect the project during bidding or construction phases unless these potential cost-cutting ideas are preserved as deductive alternates as a part of the bidding process. Further, many of the proposed SM items would involve significant policy approvals, reduction in operating capacity, and likely environmental re-assessments. As such, future cost estimates and schedules should be thoroughly vetted to determine whether an SM item should be triggered to protect the project's future health.

Table 6 - GoT Secondary Mitigation

Strategy	Estimated YOE Value (ROM)
Defer/Remove Hamilton station - 2 side platform	$4,825,000
Defer/Remove Woodmont station - center platform	$4,707,000
Defer/Remove Buchanan station - 2 sided platform	$6,472,000
Defer/Remove Dillard Street station - center platform	$5,952,000
Defer/Remove MLK station - Park and ride, center platform	$7,850,000
Defer/Remove Blackwell/Mangum Station - center platform	$5,387,000
UNC to pay for road work at UNC	$6,326,000
Shorten alignment to end at Alston	$56,681,000
Gateway infrastructure cost transfer to developer	$21,340,000
Single car trains, reduce # of LRV's	$15,000,000
Reduce bike/ped scope	$5,825,000
Contract maintenance at ROMF - reduces equip provided by GoT	$250,000
Revise Fordham Blvd structure; Maximize at-grade locations; Reduce reverse curve.	$14,193,000
Eliminate TVMs	$390,000
	$155,198,000

PMOC Recommendation: GoT should continue considering its Secondary Mitigation (SM) items for the D-O LRT Project and determine whether any such items are appropriate for inclusion as deductive alternates for bidding purposes. This action will potentially preserve these protections post-bid.

Risk and Contingency Management Plan

The PMOC reviewed GoT's Risk and Contingency Management Plan (RCMP) for the D-O LRT Project (dated August 2018); a significant update is expected after GoT's receipt of this report. The RCMP is focused on the project and written in consideration of FTA principles, including risk identification, risk assessment, risk mitigation, and risk protection through contingency funds.

The D-O LRT RCMP focuses on the mechanics of risk identification, impact analysis, and contingency establishment and tracking. Additionally, there is a definition of primary and oversight responsibilities for managing and maintaining the risk management process.

The RCMP indicates that formal risk assessments will be performed at specified milestones, those being at the key FTA Readiness milestones; and at start of, 50%, and at 90% construction. The construction-phase milestones appear to be too far apart to detect meaningful changes in the project risk levels. On a project of this magnitude, scheduling more frequent—perhaps bi-monthly or quarterly—risk assessments will provide important checks on the project's health. In between the

formal assessments, GoT is updating the status of risks on its Risk Register on a monthly basis. Other concepts discussed in the RCMP include:

- Risk Identification;
- Qualitative and Quantitative Risk Assessments; and
- Contingency Tracking (Contingency Drawdown control curves will be developed after receipt of this FTA risk report).

The above three areas are treated well in the RCMP but will need to be updated as the project advances. The method of tracking risks is professional, as are the techniques used for important tools such as contingency drawdown curves. However, the RCMP is largely a description of organizational goals and prior risk work (which is important), but does not provide a structure for how the information generated will be used or reported.

PMOC Recommendation: GoT should increase its planned frequency of risk assessments during the post-bid period to provide more frequent information regarding the cost and schedule risk exposure for the project.

PMOC Recommendation: GoT should develop a standard set of risk-related reports that summarizes the risk health of the project, especially for consumption of administrative levels above the project team and the FTA.

3.5 Conclusions

The PMOC reviewed the D-O LRT Project scope, schedule, cost estimate, risk register and supporting documentation in accordance with FTA OP 40c with a special focus on the elements of uncertainty and risk associated with GoT's project implementation.

The PMOC participated in a joint FTA/PMOC/GoT Risk Workshop for the D-O LRT Project in November 2018 and reviewed the updated D-O LRT Risk Register (January 2019) and found that GoT has been diligent in its efforts to track and revise the risk register through internal tracking processes. During the GoT Risk Workshop, key project risks were reviewed and amended as appropriate. Significant requirements risk include resolution of railroad agreements in Durham, higher right-of-way (ROW) condemnation rate, increased third-party scope needs; construction concerns include unexpected soil contamination. PMOC notes that staffing capacity for ROW and third-party coordination may be low.

Importantly, the cost, schedule, and risk analyses in this report assume that no major delays occur in FTA or other approvals for D-O LRT funding (e.g. - LONP, FFGA, or local funding) that would materially impact the construction progress. Such scenarios are beyond the scope of the risk modeling in this report and would be cause for re-evaluation once these types of delays are quantifiable.

The PMOC created a risk schedule by adjusting D-O LRT's schedule for mechanical consistency and ranging the project durations according to risk. Then, the PMOC used a Monte Carlo approach for analysis of the data, to develop a histogram that simulates a probability distribution curve for the D-O LRT project.

The PMOC risk analysis indicates:

- A p50 likelihood RSD of January 12, 2028;
- A p65 likelihood RSD of January 20, 2028; and

- A p80 likelihood RSD of January 31, 2028.

GoT's internal schedule risk modeling found the following projected RSD dates:

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- A p80 likelihood RSD of May 31, 2028.

GoT's current RSD is forecast at June 29, 2028, comfortably exceeding both the PMOC's and GoT's schedule risk model.

The net PMOC estimate adjustments total a Base Year add of $112.1 million (YOE $128.8 million); inflation adjustments add a total YOE $47.8 million to the unadjusted estimate. These adjustments yield a stripped, PMOC-adjusted estimate of Base Year $1,805 million (YOE $2,108 million) excluding finance charges.

The PMOC developed a top-down risk model, typical for FTA-funded projects. The project was modeled based on the following general levels of completion per Standard Cost Category (SCC). See Scope Review provided via separate document for further detail.

- SCC 10 [Guideway and Track Elements] – 60% design (Pettigrew changes to remove shared crossings at conceptual level only);
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- SCC 30 [Support Facilities, Yards, Shops] - 60% design, (some value engineering inclusions less designed);
- SCC 40 [Site Work and Special Conditions] – 50% design;
- SCC 50 [Systems] - 60% design;
- SCC 60 [Right-of-way, Land, Existing Improvements] – 60%;
- SCC 70 [Vehicles] – well-defined; and
- SCC 80 [Professional Services] – well-defined.
- Based upon the above, the risk model factors were set for a project at the 60% design level. A Design risk factor of 0.10 was added to SCCs 10-50 to account for risk associated with the risk associated with the lesser degree of design for the Pettigrew changes.

Considering the PMOC estimate adjustments described above, the PMOC found the D-O LRT base estimate to be credible. In addition, the increased PMOC estimate adjustment for increased NCRR lease cost is considered conservative. Accordingly, a risk model adjustment was made to SCC 60.01 [Purchase or Lease of Real Estate] – Decrease Market risk by 0.27.

The risk model results indicate a p50 value for the D-O LRT Project is $2.578 billion (YOE), excluding finance charges, compared to GoT's current SCC estimate of $2.341 billion at the p23 level. As such, it is the PMOC's opinion that GoT's current D-O LRT Project budget is about $237 million below the modeled p50 due to estimate and inflation adjustments and contingency increases.

3.6 Recommendations

The PMOC recommends:

1. ***PMOC Recommendation 1***: GoT should carefully develop plans to resolve and diligently track progress of right of way and third-party agreements, in conjunction with prudently evaluating the capacity of currently-planned staff to expedite resolution of these work items.
2. ***PMOC Recommendation 2:*** GoT should continue the process of risk identification and mitigation. Especially important are the project requirements risks noted above that should be resolved prior to grant funding.
3. ***PMOC Recommendation 3:*** It is recommended that GoT maintain its currently forecast RSD of June 29, 2028 for the D-O LRT for its planning purposes.
4. ***PMOC Recommendation 4:*** While some accommodation is made in the schedule risk model for minimal funding delay, GoT should remain aware that significant funding delays could have a material impact on its current schedule, and if such delays occur, or are forecast to occur, GoT's base schedule and estimate should be adjusted and the risk analyses should be re-run.
5. ***PMOC Recommendation 5:*** The master project schedule for the D-O LRT is adequate for this level of design, however, the level of detail and logic in the schedule needs to be expanded.
6. ***PMOC Recommendation 6:*** GoT should consider increasing the D-O LRT Project budget to $2.578 billion to ensure adequate contingency exists to protect the project at the p50 level for the finalization of design and to account for market and project complexity factors.
7. ***PMOC Recommendation 7:*** GoT should continue considering its Secondary Mitigation items for the D-O LRT Project and determine whether any such items are appropriate for inclusion as deductive alternates for bidding purposes. This action will potentially preserve these protections post-bid.
8. ***PMOC Recommendation 8:*** GoT should increase its planned frequency of risk assessments to no less frequent than quarterly during the post-bid period to provide more frequent information regarding the cost and schedule risk exposure for the project.
9. ***PMOC Recommendation 9:*** GoT should develop a standard set of risk-related reports that summarizes the risk health of the project, especially for consumption of administrative levels above the project team and the FTA.

APPENDIX A – List of Acronyms

BCE	Baseline Cost Estimate
BY	Base Year
EA	Environmental Assessment
FFGA	Full Funding Grant Agreement
FTA	Federal Transit Administration
GoT	GoTriangle
IPMS	Integration Project Master Schedule
LONP	Letter of No Prejudice
LRT	Light Rail Transit
MCC	Management Capacity and Capability
MOT	Maintenance of Traffic
NCRR	North Carolina Railroad
NCCU	North Carolina Central University
NEPA	National Environmental Protection Agency
NS	Norfolk Southern Railroad
OP	Oversight Procedure
PMOC	Project Management Oversight Contractor
PMP	Project Management Plan
PRA	Primavera Risk Analysis
RCMP	Risk Contingency Management Plan
ROD	Record of Decision
ROMF	Rail Operations Maintenance Facility
ROW	Right of Way
RSD	Revenue Service Date
SCC	Standard Cost Category
SM	Secondary Mitigation
UNC	University of North Carolina
YOE	Year of Expenditure

APPENDIX B – SCC Worksheet

MAIN WORKSHEET-BUILD ALTERNATIVE (Rev.19, June 2017)

GoTriangle — Today's Date 10/8/19

Durham-Orange Light Rail Transit Project, Durham, NC — Yr of Base Year $ 2018

Applic. for FFGA — Yr of Revenue Ops 2022

	Quantity	Base Year Dollars w/o Contingency (X000)	Base Year Dollars Allocated Contingency (X000)	Base Year Dollars TOTAL (X000)	Base Year Dollars Unit Cost (X000)	Base Year Dollars Percentage of Construction Cost	Base Year Dollars Percentage of Total Project Cost	YOE Dollars Total (X000)		Infl Adj. to 3.6% (M. Lee) per Infl Adjsts tab: Adj. Inflation Factor (BY 2018)	YOE Dollars Total (X000)	Adjustment
10 GUIDEWAY & TRACK ELEMENTS (route miles)	**17.81**	436,356	38,689	**475,045**	**$26,673**	**40%**	**22%**	**543,430**		**1.1687**	**555,174**	**11,745**
10.01 Guideway: At-grade exclusive right-of-way	12.84	20,552	1,028	21,580	$1,681			24,686	1.14		25,220	534
10.02 Guideway: At-grade semi-exclusive (allows cross-traffic)	0.00	744	37	781				893			913	19
10.03 Guideway: At-grade in mixed traffic	0.00	0	0	0				0			0	0
10.04 Guideway: Aerial structure	4.89	227,698	22,770	250,468	$51,220			280,524			292,716	9,192
10.05 Guideway: Built-up fill	0.00	0	0	0				0			0	0
10.06 Guideway: Underground cut & cover	0.00	34,046	3,405	37,450	$468,127			42,041			43,767	926
10.07 Guideway: Underground tunnel	0.00	0	0	0				0			0	0
10.08 Guideway: Retained cut or fill	0.00	75,686	7,569	83,255				95,240			97,298	2,058
10.09 Track: Direct fixation		24,394	1,220	25,614				29,301			29,934	633
10.10 Track: Embedded		5,627	281	5,909				6,759			6,906	146
10.11 Track: Ballasted		43,001	2,150	45,151				51,650			52,766	1,116
10.12 Track: Special (switches, turnouts)		4,607	230	4,838				5,534			5,654	120
10.13 Track: Vibration and noise dampening		0	0	0				0			0	0
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)	**19**	31,668	4,750	**36,419**	**$1,917**	**3%**	**2%**	**43,201**		**1.2189**	**44,390**	**1,188**
20.01 At-grade station, stop, shelter, mall, terminal, platform	16	15,683	2,352	18,035	$1,127			21,394			21,983	588
20.02 Aerial station, stop, shelter, mall, terminal, platform	3	10,257	1,538	11,795	$3,932			13,992			14,377	385
20.03 Underground station, stop, shelter, mall, terminal, platform	0	0	0	0				0			0	0
20.04 Other stations, landings, terminals: Intermodal, ferry, trolley, etc.	0	0	0	0				0			0	0
20.05 Joint development		0	0	0				0			0	0
20.06 Automobile parking multi-story structure		0	0	0				0			0	0
20.07 Elevators, escalators		5,729	859	6,588				7,815			8,030	215
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	17.81	63,253	7,590	**70,844**	**$3,978**	**6%**	**3%**	**80,696**		**1.1629**	**82,386**	**1,690**
30.01 Administration Building: Office, sales, storage, revenue counting		6,730	808	7,538				8,586			8,766	180
30.02 Light Maintenance Facility		0	0	0				0			0	0
30.03 Heavy Maintenance Facility		22,399	2,688	25,087				28,575			29,174	598
30.04 Storage or Maintenance of Way Building		3,389	407	3,796				4,323			4,414	91
30.05 Yard and Yard Track		30,736	3,688	34,424				39,211			40,032	821
40 SITEWORK & SPECIAL CONDITIONS	17.81	294,356	57,712	**352,067**	**$19,768**	**29%**	**16%**	**402,733**		**1.1687**	**411,457**	**8,724**
40.01 Demolition, Clearing, Earthwork		24,671	3,701	28,372				32,455			33,158	703
40.02 Site Utilities, Utility Relocation		72,202	21,982	94,184				107,738			110,072	2,334
40.03 Haz. matl, contam'd soil removal/mitigation, ground water treatments		6,391	3,196	9,587				10,967			11,204	238
40.04 Environmental mitigation, e.g. wetlands, historic/archeologic, parks		4,149	1,245	5,394				6,170			6,303	134
40.05 Site structures including retaining walls, sound walls		1,617	243	1,860				2,128			2,174	46
40.06 Pedestrian / bike access and accommodation, landscaping		35,316	5,297	40,614				46,458			47,465	1,006
40.07 Automobile, bus, van accessways including roads, parking lots		102,978	15,447	118,425				135,468			138,402	2,934
40.08 Temporary Facilities and other indirect costs during construction		47,030	6,602	53,632				61,350			62,679	1,329
50 SYSTEMS	17.81	226,599	38,112	**264,711**	**$14,863**	**22%**	**12%**	**320,896**		**1.2499**	**330,856**	**9,960**
50.01 Train control and signals		67,493	13,499	80,992				98,183			101,230	3,047
50.02 Traffic signals and crossing protection		14,952	2,990	17,942				21,751			22,426	675
50.03 Traction power supply: substations		38,333	5,750	44,083				53,439			55,098	1,659
50.04 Traction power distribution: catenary and third rail		62,390	9,358	71,748				86,977			89,676	2,699
50.05 Communications		25,546	3,832	29,378				35,614			36,719	1,105
50.06 Fare collection system and equipment		6,731	1,010	7,741				9,384			9,675	291
50.07 Central Control		11,153	1,673	12,826				15,549			16,031	483
Construction Subtotal (10 - 50)	17.81	1,052,232	146,854	**1,199,086**	**$67,377**	**100%**	**56%**	**1,390,956**			**1,474,763**	**33,306**
60 ROW, LAND, EXISTING IMPROVEMENTS	17.81	168,336	14,978	**183,315**	**$10,293**		**9%**	**195,937**		**1.0802**	**198,021**	**2,084**
60.01 Purchase or lease of real estate		164,813	14,978	179,792				192,172			194,215	2,044
60.02 Relocation of existing households and businesses		3,523	0	3,523				3,766			3,806	40
70 VEHICLES (number)	**18**	104,118	10,412	**114,529**	**$6,363**		**5%**	**141,719**		**1.2800**	**146,597**	**4,878**
70.01 Light Rail	18	92,483	9,248	101,731	$5,652			125,883			130,216	4,333
70.02 Heavy Rail		0	0	0				0			0	0
70.03 Commuter Rail		0	0	0				0			0	0
70.04 Bus		0	0	0				0			0	0
70.05 Other		0	0	0				0			0	0
70.06 Non-revenue vehicles		3,735	373	4,108				5,083			5,258	175
70.07 Spare parts		7,900	790	8,690				10,753			11,123	370
80 PROFESSIONAL SERVICES (applies to Cats. 10-50)	17.81	368,305	24,140	**392,445**	**$22,035**	**33%**	**18%**	**433,968**		**1.1251**	**441,547**	**7,579**
80.01 Project Development		43,606	0	43,606				48,220			49,062	842
80.02 Engineering (not applicable to Small Starts)		120,037	6,002	126,038				139,374			141,808	2,434
80.03 Project Management for Design and Construction		46,554	2,328	48,882				54,053			54,997	944
80.04 Construction Administration & Management		96,555	9,656	106,211				117,448			119,499	2,051
80.05 Professional Liability and other Non-Construction Insurance		0	0	0				0			0	0
80.06 Legal; Permits; Review Fees by other agencies, cities, etc.		19,602	1,960	21,563				23,844			24,260	416
80.07 Surveys, Testing, Investigation, Inspection		26,865	2,686	29,551				32,678			33,249	571
80.08 Start up		15,086	1,509	16,595				18,350			18,671	320
Subtotal (10 - 80)	17.81	1,692,991	196,384	**1,889,375**	**$106,085**		**88%**	**2,162,581**			**2,210,427**	**47,847**
90 UNALLOCATED CONTINGENCY				**146,995**			**7%**	**178,580**		**1.2535**	**184,252**	**5,672**
Subtotal (10 - 90)	17.81			**2,036,369**	**$114,339**		**95%**	**2,341,161**			**2,394,680**	**53,519**

APPENDIX C – Inflation Adjustment Worksheet

Original

BASE YEAR DOLLARS (	Base Yr Dollars	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
10 GUIDEWAY & TRACK	460,762	0	0	0	0	0	0	65,858	211,161	122,231	59,850	1,661	0	0	0	0	0	0
20 STATIONS, STOPS, T	35,324	0	0	0	0	0	0	984	2,333	11,550	16,040	4,415	0	0	0	0	0	0
30 SUPPORT FACILITIES	68,714	0	0	0	0	0	0	20,786	20,196	17,614	10,118	0	0	0	0	0	0	0
40 SITEWORK & SPECIA	341,481	0	0	0	0	0	23,122	63,736	86,813	97,745	67,546	2,519	0	0	0	0	0	0
50 SYSTEMS	256,751	0	0	0	0	0	0	523	0	55,850	75,998	116,121	8,082	177	0	0	0	0
60 ROW, LAND, EXISTIN	177,803	0	0	0	1,868	7,756	125,272	42,906	0	0	0	0	0	0	0	0	0	0
70 VEHICLES (number)	111,086	0	0	0	35	87	272	181	181	9,828	11,821	64,194	18,258	6,228	0	0	0	0
80 PROFESSIONAL SER	380,645	0	0	42,295	50,167	61,058	49,258	25,307	27,992	27,542	25,062	22,370	17,007	18,638	13,950	0	0	0
90 UNALLOCATED CONT	142,575	0	0	0	0	0	0	19,010	19,010	19,010	19,010	19,010	19,010	14,257	14,257	0	0	0
100 FINANCE CHARGES	102,287	0	0	0	0	753	0	398	3,005	8,618	13,487	16,332	17,572	14,992	11,811	8,409	5,082	1,829
Total Project Cost (10 - 1	2,077,427	0	0	42,295	52,071	69,654	197,923	239,690	370,691	369,988	298,933	246,623	79,928	54,292	40,019	8,409	5,082	1,829
Inflation Rate		0.020	0.000	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
Compounded Inflation Factor		1.000	1.000	1.000	1.031	1.063	1.096	1.130	1.165	1.201	1.238	1.277	1.316	1.357	1.399	1.442	1.487	1.533

YEAR OF EXPENDITURE	YOE Dollars	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Inflation factor
10 GUIDEWAY & TRACK	543,430	0	0	0	0	0	0	74,412	245,984	146,803	74,110	2,120	0	0	0	0	0	0	1.179
20 STATIONS, STOPS, T	43,201	0	0	0	0	0	0	1,112	2,718	13,872	19,862	5,637	0	0	0	0	0	0	1.223
30 SUPPORT FACILITIES	80,696	0	0	0	0	0	0	23,485	23,526	21,154	12,529	0	0	0	0	0	0	0	1.174
40 SITEWORK & SPECIA	402,733	0	0	0	0	0	25,339	72,015	101,130	117,394	83,639	3,215	0	0	0	0	0	0	1.179
50 SYSTEMS	320,896	0	0	0	0	0	0	591	0	67,078	94,105	148,246	10,637	240	0	0	0	0	1.250
60 ROW, LAND, EXISTIN	195,937	0	0	0	1,926	8,245	137,287	48,479	0	0	0	0	0	0	0	0	0	0	1.102
70 VEHICLES (number)	141,719	0	0	0	37	93	298	205	211	11,803	14,637	81,953	24,031	8,451	0	0	0	0	1.276
80 PROFESSIONAL SER	433,968	0	0	42,295	51,723	64,902	53,982	28,594	32,608	33,078	31,033	28,559	22,384	25,292	19,517	0	0	0	1.140
90 UNALLOCATED CONT	178,580	0	0	0	0	0	0	21,479	22,145	22,831	23,539	24,269	25,021	19,348	19,947	0	0	0	1.253
100 FINANCE CHARGES	135,140	0	0	0	0	800	0	450	3,500	10,350	16,700	20,850	23,129	20,344	16,525	12,130	7,558	2,804	1.321
Total Project Cost (10 - 1	2,476,301	0	0	42,295	53,685	74,040	216,907	270,823	431,823	444,364	370,155	314,850	105,203	73,675	55,990	12,130	7,558	2,804	1.192

Adjusted

BASE YEAR DOLLARS (	Base Yr Dollars	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
10 GUIDEWAY & TRACK	460,762	0	0	0	0	0	0	65,858	211,161	122,231	59,850	1,661	0	0	0	0	0	0
20 STATIONS, STOPS, T	35,324	0	0	0	0	0	0	984	2,333	11,550	16,040	4,415	0	0	0	0	0	0
30 SUPPORT FACILITIES	68,714	0	0	0	0	0	0	20,786	20,196	17,614	10,118	0	0	0	0	0	0	0
40 SITEWORK & SPECIA	341,481	0	0	0	0	0	23,122	63,736	86,813	97,745	67,546	2,519	0	0	0	0	0	0
50 SYSTEMS	256,751	0	0	0	0	0	0	523	0	55,850	75,998	116,121	8,082	177	0	0	0	0
60 ROW, LAND, EXISTIN	177,803	0	0	0	1,868	7,756	125,272	42,906	0	0	0	0	0	0	0	0	0	0
70 VEHICLES (number)	111,086	0	0	0	35	87	272	181	181	9,828	11,821	64,194	18,258	6,228	0	0	0	0
80 PROFESSIONAL SER	380,645	0	0	42,295	50,167	61,058	49,258	25,307	27,992	27,542	25,062	22,370	17,007	18,638	13,950	0	0	0
90 UNALLOCATED CONT	142,575	0	0	0	0	0	0	19,010	19,010	19,010	19,010	19,010	19,010	14,257	14,257	0	0	0
100 FINANCE CHARGES	102,287	0	0	0	0	753	0	398	3,005	8,618	13,487	16,332	17,572	14,992	11,811	8,409	5,082	1,829
Total Project Cost (10 - 1	2,077,427	0	0	42,295	52,071	69,654	197,923	239,690	370,691	369,988	298,933	246,623	79,928	54,292	40,019	8,409	5,082	1,829
Inflation Rate		0.000	0.000	0.000	0.031	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
Compounded Inflation Factor		1.000	1.000	1.000	1.031	1.068	1.107	1.146	1.188	1.230	1.275	1.321	1.368	1.417	1.468	1.521	1.576	1.633

<<Enter inflation adjustments

YEAR OF EXPENDITURE	YOE Dollars	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Inflation factor	Inflation Adjustment
10 GUIDEWAY & TRACK	555,174	0	0	0	0	0	0	75,500	250,791	150,397	76,293	2,193	0	0	0	0	0	0	1.205	0.025
20 STATIONS, STOPS, T	44,390	0	0	0	0	0	0	1,129	2,771	14,212	20,447	5,831	0	0	0	0	0	0	1.257	0.034
30 SUPPORT FACILITIES	82,386	0	0	0	0	0	0	23,829	23,986	21,672	12,898	0	0	0	0	0	0	0	1.199	0.025
40 SITEWORK & SPECIA	411,457	0	0	0	0	0	25,586	73,068	103,106	120,269	86,103	3,326	0	0	0	0	0	0	1.205	0.026
50 SYSTEMS	330,856	0	0	0	0	0	0	600	0	68,720	96,877	153,352	11,057	251	0	0	0	0	1.289	0.039
60 ROW, LAND, EXISTIN	198,021	0	0	0	1,926	8,285	138,622	49,188	0	0	0	0	0	0	0	0	0	0	1.114	0.012
70 VEHICLES (number)	146,597	0	0	0	37	93	301	208	215	12,092	15,068	84,776	24,980	8,827	0	0	0	0	1.320	0.044
80 PROFESSIONAL SER	441,547	0	0	42,295	51,723	65,217	54,507	29,012	33,245	33,888	31,947	29,543	23,268	26,418	20,485	0	0	0	1.160	0.020
90 UNALLOCATED CONT	184,252	0	0	0	0	0	0	21,793	22,578	23,390	24,233	25,105	26,009	20,209	20,936	0	0	0	1.292	0.040
100 FINANCE CHARGES	140,616	0	0	0	0	804	0	457	3,568	10,603	17,192	21,568	24,041	21,250	17,344	12,793	8,010	2,986	1.375	0.054
Total Project Cost (10 - 1	2,535,296	0	0	42,295	53,685	74,399	219,016	274,782	440,261	455,244	381,058	325,695	109,354	76,954	58,765	12,793	8,010	2,986	1.220	0.028

Note: The above is based on a calculated base year of $2017, which was derived by deflating all $2018 values by 3.1% (as shown in the SCC Main $2018 tab and as used for the risk model calculations). The purpose of this worksheet is to calculate a revised YOE value to use for the $2018 calculations.

APPENDIX D –Adjustments To D-O LRT SCC Estimate

Standard SCC codes		Base year Dollars			YOE Dollars				
SCC	Category	Estimate w/o Contingency	Plus Cost Adjustments	Stripped Adjusted Estimate	Estimate total	Plus Inflation Adjustment	Less Allocated contingency	Plus PMOC Adjustments	Stripped Adjusted estimate
SCC 10	Guideway	436,356	56,887	493,243	543,430	11,745	45,215	66,482	576,441
10.01	Guideway: At-grade exclusive right-of-way	20,552	0	20,552	24,686	534	1,201	0	24,019
10.02	Guideway: At-grade semi-exclusive (allows cross-traffic)	744	0	744	893	19	43	0	869
10.03	Guideway: At-grade in mixed traffic	0	0	0	0	0	0	0	0
10.04	Guideway: Aerial structure	227,698	69,405	297,104	286,524	6,192	26,611	81,112	347,218
10.05	Guideway: Built-up fill	0	0	0	0	0	0	0	0
10.06	Guideway: Underground cut & cover	34,046	0	34,046	42,841	926	3,979	0	39,788
10.07	Guideway: Underground tunnel	0	0	0	0	0	0	0	0
10.08	Guideway: Retained cut or fill	75,686	-7,207	68,480	95,240	2,058	8,845	-8,422	80,031
10.09	Track: Direct fixation	24,394	6,403	30,797	29,301	633	1,425	7,483	35,992
10.10	Track: Embedded	5,627	-11,749	-6,121	6,759	146	329	-13,731	-7,154
10.11	Track: Ballasted	43,001	34	43,035	51,650	1,116	2,513	40	50,294
10.12	Track: Special (switches, turnouts)	4,607	0	4,607	5,534	120	269	0	5,385
SCC 20	Stations, Stops, Terminals, Intermodals	31,668	15,881	47,549	43,201	1,188	5,790	19,357	57,956
20.01	At-grade station, stop, shelter, mall, terminal, platform	15,683	15,881	31,564	21,394	588	2,867	19,357	38,472
20.02	Aerial station, stop, shelter, mall, terminal, platform	10,257	0	10,257	13,992	385	1,875	0	12,501
20.07	Elevators, escalators	5,729	0	5,729	7,815	215	1,047	0	6,983
SCC 30	Support Facilities: Yards, Shops and Admin Bldgs	63,253	0	63,253	80,696	1,690	8,827	0	73,559
30.01	Administration Building: Office, sales, storage, revenue counting	6,730	0	6,730	8,586	180	939	0	7,826
30.02	Light Maintenance Facility	0	0	0	0	0	0	0	0
30.03	Heavy Maintenance Facility	22,399	0	22,399	28,575	598	3,126	0	26,048
30.04	Storage or Maintenance of Way Building	3,389	0	3,389	4,323	91	473	0	3,941
30.05	Yard and Yard Track	30,736	0	30,736	39,211	821	4,289	0	35,743
SCC 40	Sitework and Special Conditions	294,356	10,963	305,319	402,733	8,724	67,447	12,813	356,823
40.01	Demolition, Clearing, Earthwork	24,671	976	25,647	32,455	703	4,325	1,141	29,974
40.02	Site Utilities, Utility Relocation	72,202	8,417	80,619	107,738	2,334	25,690	9,837	94,219
40.03	Haz. mat'l, contam'd soil removal/mitigation, ground water treatments	6,391	0	6,391	10,967	238	3,735	0	7,470
40.04	Environmental mitigation, e.g. wetlands, historic/archeologic, parks	4,149	0	4,149	6,170	134	1,455	0	4,849
40.05	Site structures including retaining walls, sound walls	1,617	1,926	3,544	2,128	46	284	2,251	4,141
40.06	Pedestrian / bike access and accommodation, landscaping	35,316	-20,000	15,316	46,458	1,006	6,191	-23,374	17,900
40.07	Automobile, bus, van accessways including roads, parking lots	102,978	4,616	107,594	135,468	2,934	18,052	5,395	125,744
40.08	Temporary Facilities and other indirect costs during construction	47,030	15,028	62,058	61,350	1,329	7,715	17,563	72,527
SCC 50	Systems	226,599	-2,648	223,950	320,896	9,960	47,635	-3,310	279,911
50.01	Train control and signals	67,493	0	67,493	98,183	3,047	16,872	0	84,359
50.02	Traffic signals and crossing protection	14,952	-3,884	11,068	21,751	675	3,738	-4,854	13,834
50.03	Traction power supply: substations	38,333	0	38,333	53,439	1,659	7,187	0	47,911
50.04	Traction power distribution: catenary and third rail	62,390	1,236	63,625	86,977	2,699	11,697	1,545	79,524
50.05	Communications	25,546	0	25,546	35,614	1,105	4,789	0	31,930
50.06	Fare collection system and equipment	6,731	0	6,731	9,384	291	1,262	0	8,413
50.07	Central Control	11,153	0	11,153	15,549	483	2,091	0	13,940
SCC 60	ROW, Land and existing improvements	168,336	31,000	199,336	195,937	2,084	16,180	33,487	215,328
60.01	Purchase or lease of real estate	164,813	26,000	190,813	192,172	2,044	16,180	28,086	206,121
60.02	Relocation of existing households and businesses	3,523	5,000	8,523	3,766	40	0	5,401	9,207
SCC 70	Vehicles	104,118	0	104,118	141,719	4,878	13,327	0	133,270
70.01	Light Rail	92,483	0	92,483	125,883	4,333	11,838	0	118,378
70.06	Non-revenue vehicles	3,735	0	3,735	5,083	175	478	0	4,780
70.07	Spare parts	7,900	0	7,900	10,753	370	1,011	0	10,112
SCC 80	Professional services and Agency costs	368,305	0	368,305	433,968	7,579	27,161	0	414,386
80.01	Project Development	43,606	0	43,606	48,220	842	0	0	49,062
80.02	Engineering	120,037	0	120,037	139,374	2,434	6,753	0	135,055
80.03	Project Management for Design and Construction	46,554	0	46,554	54,053	944	2,619	0	52,379
80.04	Construction Administration & Management	96,555	0	96,555	117,448	2,051	10,864	0	108,636
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	19,602	0	19,602	23,844	416	2,205	0	22,055
80.07	Surveys, Testing, Investigation, Inspection	26,865	0	26,865	32,678	571	3,023	0	30,226
80.08	Start up	15,086	0	15,086	18,350	320	1,697	0	16,973
	SCC 10-80 total	1,692,991	112,083	1,805,074	2,162,581	47,847	231,582	128,829	2,107,674

APPENDIX E – PMOC Schedule Risk Model Adjustments

Risk Register-based Modeling

1. In reviewing the updated risk register the below duration percentages where applied to 90% design LS3 line section 3 civil activities. This includes LS3 Aerial Guideway, LS3 Station Elevated Platform, LS3 Retaining Walls, LS3 Structures. This was due to the Risk event 51 Design concurrence with NS regarding the proximity of at-grade crossings within NCRR corridor is delayed. The score rating is a 40 with a schedule probability of five (5).
    - Minimum duration is 120% of remaining duration
    - Likely duration is 130% of remaining duration
    - Maximum duration is 140% of remaining duration

2. Due to construction change in Pettigrew Street area with the cut and cover change. The below duration percentages where applied to the construction activities for Fayetteville Street Underpass and Related Walls, Duke Street Underpass and Related Walls, Blackwell-Magnum Street Underpass, Dillard Street Underpass
    - Minimum duration is 120% of remaining duration
    - Likely duration is 130% of remaining duration
    - Maximum duration is 140% of remaining duration

3. Risk 22 Requests from key Stakeholders may require design modifications that delay the completion of design. The score rating is a 32 with a schedule probability of 4. All activities for WBS section for 100%-UNC Finley Golf Course, 100%-Civil Line Section West, 100%-Civil Line Section East, 100%-Corridor Wide (Systems, Track, Stations, Landscaping, & Finishes). The following duration percentage where applied.
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration
    - Maximum duration is 130% of remaining duration

4. Due to Risk 28b Condemnation rate higher than estimated. The below duration percentages where applied to all parcel related to Civil East and Civil West package activities. The score rating is a 32 with the schedule probability of 4.
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration
    - Maximum duration is 130% of remaining duration

5. Due to Risk 99 Construction contract and front-end documents are not sufficient to mitigate contract related issues. The below duration percentages where applied to all related activities in advertise/bid/award for civil east, west and corridor wide. The score rating is a 28 with the schedule probability of 3.
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration

- Maximum duration is 130% of remaining duration

6. Due to Risk 97 Norfolk Southern Agreement may not be obtained prior to planned submittal of FFGA application. The below duration percentages where applied to all activities related to Norfolk Southern - Construction agreement and Norfolk Southern - Operations and Maintenance agreement. The score rating is a 28 with the schedule probability of five (5).
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration
    - Maximum duration is 130% of remaining duration

7. Due to Risk 39 Unknown utilities may be encountered during construction. The below duration percentages where applied to all utility related activities. The score rating is a 21 with the schedule probability of four (4).
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration
    - Maximum duration is 130% of remaining duration

8. Due to Risk 91 Contractor role in testing & commissioning not clearly defined. The below duration percentages where applied to all systems and startup related activities. The score rating is a 18 with the schedule probability of four (4).
    - Minimum duration is 110% of remaining duration
    - Likely duration is 120% of remaining duration
    - Maximum duration is 130% of remaining duration

APPENDIX F – PMOC Review Team

Name	Firm	Role
Christopher Bucknor, PE	PMO Partnership JV	Program Manager
Robert James, PE, PMP	PMO Partnership JV	Task Order Manager
Reshma Chandnani, PE	PMO Partnership JV	Civil Engineer
Joe Abbas, MSEE	PMO Partnership JV	Systems Integration Manager
Philip Adams CMQ/OE	PMO Partnership JV	QA/QC / Transit Operations Manager
Lee Hamre, SR/WA, R/W-RAC, R/W-URAC	H.C. Peck & Associates	Real Estate Manager
David Sillars, Ph.D.	Sillars Consulting	Risk Assessment Manager
Martin Lee, PE	M. Lee Corporation	Cost Estimation Manager
Bill Solomon	PMO Partnership JV	Project Scheduling Manager

APPENDIX G – Risk Register (Abbreviated)

SCC Description- (Impacted Area)	Risk Description	Cause	Impact/Effect	Pr Prob V2	Pr Cost V2	Pr Sched V2	Pr Risk Rating p*(c+s)5
Guideway: At-grade exclusive right-of-way	Design concurrence with NS regarding the proximity of at-grade crossings within NCRR corridor is delayed	The design of the at-grade roadway-light rail crossings in the NCRR Corridor (within downtown Durham) is complex and involves multiple stakeholders including NCRR, NS, NCDOT Rail Division, and FRA	Coordination requirements may be more than anticipated resulting in additional design, more costly project elements, etc.	4	5	5	40
Purchase or lease of real estate	**Condemnation rate higher than estimated.**	**ROW Acquisition does not complete on time and/or Property Owners are not cooperative**	**Higher acquisition costs.**	4	4	4	32
Temporary Facilities and other indirect costs during construction	Requests from key Stakeholders may require design modifications that delay the completion of design.	Pressure to add elements (excluding additional aesthetic requirements) to the project to maintain support of key stakeholders (NCDOT, Universities, Cities)	Design is not completed on time to advertise bid. Additional redesign costs and project costs.	4	4	4	32
Legal; Permits; Review Fees by other agencies, cities, etc.	**Norfolk Southern Agreement may not be obtained prior to planned submittal of FFGA application.**	**Lengthy and complex process**	**FTA deems not ready without the agreement**	4	2	5	28
Project Management for Design and Construction	Construction contract and front end documents are not sufficient to mitigate contract related issues.	New agency contracting documentation (new specs, policy, and procedures) need to be developed, and will be untested within industry	Cost/schedule	4	4	3	28
Site Utilities, Utility Relocation	**Unknown utilities may be encountered during construction**	**Utility company information is incomplete**	**Delay Contractor from performing work in that area.**	3	3	4	21
Site structures including retaining walls, sound walls	Precast materials are not delivered in time or to quality required delaying the scheduled installation timeline.	Insufficient Precast Manufacturer capacity to meet schedule	Not delivered on time	3	3	4	21
Unallocated Contingency	**Contractor does not have adequate labor resources to complete the contract on time.**	**Risk that contractor performance is impeded because of lack of labor resources to do the work**	**Increases bid prices to attract labor. Delay due to insufficient staffing.**	3	4	3	21

SCC Description- (Impacted Area)	Risk Description	Cause	Impact/Effect	Pr Prob V2	Pr Cost V2	Pr Sched V2	Pr Risk Rating p*(c+s)5
Legal; Permits; Review Fees by other agencies, cities, etc.	Agreement with AT&T is not obtained prior to the planned FFGA application submittal.	Utility agreements can be complex and time-consuming to negotiate	FTA deems project is not ready without the agreement	3	1	5	18
Start up	Contractor role in testing & commissioning not clearly defined.	Undefined commissioning roles and responsibilities	Delay in revenue operations	3	2	4	18
Purchase or lease of real estate	ROW acquisition appraisals may be significantly higher than the estimate.	Active real estate market along the Project corridor	ROW acquisition may cost more than anticipated	4	4		16
Site Utilities, Utility Relocation	Utility relocations may not be completed in time affecting the DOLRT Contractors critical path.	Local contractors, primarily for utility relocations, have a backlog of work with NCDOT program and therefore may not have sufficient resources for this project.	Schedule delays and resource shortages	4	1	3	16
Environmental mitigation, e.g. wetlands, historic/archeologic, parks	Removal of trees within adjacent to Duke golf course and along Erwin Road may require substantial design mitigation commitments	Removal of trees will affect the natural setting of the Al Buehler Trail and campus buffer at Duke University	Duke University may request or require substantial design commitments including screening walls to mitigate these impacts	4	4		16
Legal; Permits; Review Fees by other agencies, cities, etc.	NCRR Lease / Agreements not in place prior to planned submittal for FFGA application	Lengthy and complex process	FTA deems not ready without the agreement	3	3	2	15
Legal; Permits; Review Fees by other agencies, cities, etc.	Stakeholders (NCRR, NS, NCDOT, Universities, etc., excluding Town of Chapel Hill and Durham City) design reviews take longer than anticipated.	Stakeholders / Community (NCRR, NS, NCDOT, Universities, etc., excluding Town of Chapel Hill and Durham City) design reviews Lengthy and complex review and comment resolution process	Review may take longer than anticipated	3	1	4	15

SCC Description- (Impacted Area)	Risk Description	Cause	Impact/Effect	Pr Prob V2	Pr Cost V2	Pr Sched V2	Pr Risk Rating p*(c+s)5
Systems Allocated Contingency	Installation of system components (OCS/signals/tpss) does not meet standards or is not completed on time.	Low supply of experienced specialty trades people who know how to install system components (OCS/signals/tpss)	Schedule delay due to lack of staffing; reduction in quality; cost increases for PM/CM	3	1	4	15
Project Management for Design and Construction	**Contractors bid may differ significantly from construction cost estimate.**	**Unit prices, production, mean & methods, etc.…**	**Bids come in significantly over/under than estimated.**	3	5		15
Construction Administration & Management	Coordination between construction contract packages is poor	Interface and coordination requirements between three construction contract packages is insufficient	Poor coordination may occur, contract changes Critical path is impacted due to a delay to the contractor(s) schedule and additional project costs to GoT.	2	4	3	14
Legal; Permits; Review Fees by other agencies, cities, etc.	**Utility agreement with Duke Energy may not be completed prior to planned submittal of FFGA application submittal.**	**Utility agreements can be complex and time-consuming to negotiate**	**FTA deems project is not ready without the agreement**	2	1	5	12
Legal; Permits; Review Fees by other agencies, cities, etc.	Utility cooperative agreement with PSNC may not be completed prior to planned submittal of FFGA application submittal.	Utility agreements can be complex and time-consuming to negotiate	FTA deems not ready without the agreement	2	1	5	12
Legal; Permits; Review Fees by other agencies, cities, etc.	**Permits and agreements with Local Governments may not be completed in time**	**Local governments may not have a formal approval/ permit process in place and may not have sufficient staffing levels for a project of this size and magnitude**	**Delay in approval process**	2	1	5	12
Legal; Permits; Review Fees by other agencies, cities, etc.	A new significant redesign or scope change outside the study area requires a supplemental EA	Design progression, stakeholders. Additional design items outside of the study area.	Design changes require supplemental NEPA documentation Delay completion of design/letting of contract.	2	1	5	12