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I. PREFACE

This manual provides Project Managers and Design Consultants with information and guidelines that can be used for the implementation of project controls tools throughout the life of a project. With proper controls in place, managers are able to successfully manage project cost, schedule and risk.

Areas of Project Controls contained within this manual include Project Scheduling, Earned Value Management, Management Reports, Design Change Control, Risk Analysis, Constructability Review, Value Engineering and Estimating.

We are confident the use of this manual will ensure and enhance the quality of MBTA projects.

MBTA Project Controls Group
## II. ESTIMATING

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II. ESTIMATING

1. Introduction

An engineer’s estimate is a critical part of the project development process since it provides the following:

- Serves as a basis for probable construction cost
- Supports decision-making on project scope
- Serves as a guide to evaluate bidders’ proposals

Accurate estimating is an important component of MBTA’s cost-management process, as well as an important decision-making tool for the design team in its selection of systems and materials.

General Philosophy

All costs that a prudent and experienced contractor would incur must be included in project cost estimates. A listing of known facts, construction tasks, and supplemental judgments form the basis of the estimate at each stage of design. This provides a realistic approach to estimating, and it creates a history of project cost development.

2. Estimator Qualification and Ethics

1. Requirements

Project estimate submissions must be prepared by professional cost estimators. Certification as a cost engineer by the Association for the Advancement of Cost Engineering (AACE), or as a certified professional estimator by the American Society of Professional Estimators (ASPE), is supporting evidence of an estimator’s qualifications, although it is not required.

2. Professional Expectations

The standards of practice described in the Canons of Ethics published by the AACE and the ASPE, and available on both their Web sites, apply to all estimating services.

3. Due Diligence Expectations

The MBTA expects proper diligence in the preparation of estimates, which will grow steadily more accurate as the design progresses. While the estimator may
need to make many assumptions in preparing the concept design estimate, once the construction documents phase has begun, estimates will no longer contain major assumptions. A comparison of successive project estimates shall be performed and any discrepancies shall be reconciled. The design engineer must work closely with the estimator to coordinate the estimates with design submissions and the scope of work, to review assumptions concerning exclusions and inclusions, and generally to ensure that the estimate reflects design intent. These estimators must have a thorough understanding of the marketplace in which the project is located, research market prices, and obtain price quotes for specialty items.


1. Cost Management Principles:

   Design within Budget

   Unless otherwise specified in design-contract documents, the design engineer must design the project so that construction costs will not exceed the funding limitations established as the Basis of Fee Negotiation. FAR 36.609-1 requires that the engineer redesign the project at the firm's own expense to ensure that a responsive construction bid amount will be within funding limitations.

   Construction Services

   Construction bids may be solicited only if the Estimated Cost of Construction at Award (ECCA) amount at final construction documents is within MBTA authorized budget limits.

   Itemized Cost Management

   When project funds are secured from different agencies, funding sources or are provided as a dedicated allowance for a specific program goal, estimates must be made for each, allowing separate tracking of expenditures. Funding allocated for such projects is tracked to confirm that expenditures are apportioned according to amounts authorized by each agency, so as not to exceed the dedicated allowance.

   Independent Cost Estimates

   For projects that are determined by the Assistant General Manager for Design and Construction to require an Independent Engineer's Construction Cost Estimate to be performed, generate a task order with one of the MBTA cost consultants through MBTA Project Controls. This independent estimate determination will be made at the 100% Estimate/Schedule review meeting.
Projects over $50 million must have an independent cost estimate. For projects below this threshold, the Assistant General Manager of Design & Construction will make the determination of whether an independent cost estimate will be performed.

The consultant may be required to perform any of the following services associated with projects during the design and construction phases:

1. Review Requests for Proposals in order to develop an independent estimate of design and construction costs.
2. Develop and compare independent cost estimate with design consultant estimate.
3. Highlight and/or dispute variances between design consultant and independent estimates. Verify unit prices, escalation costs and allowances for overhead and profit.
4. Prepare an itemized engineer’s construction cost estimate (CSI format) at the design milestones at project intervals requested by the MBTA.

4. Estimating Requirements

1. General

The MBTA requires cost estimates for, at a minimum, the following phases of design:

- Initial Project Estimate
- Pre-Conceptual Project Estimate
- 15% Conceptual Construction Estimate
- 30% and 60% Design Development Construction Estimate
- 100% Construction Documents Construction Estimate

The estimate must include all elements of the proposed project work (including all design contract modifications), regardless of the design phase. Where costs are included for details not indicated on the drawings and specifications, the estimator must include design assumptions to complete the scope. The estimator must check all cost-estimate calculations for accuracy and completeness, including assessing whether estimates completely and accurately represent design features and quantities.

*Lump-sum pricing is not acceptable without description and quantification.

During Construction Phase Services, estimates pertaining to Change Orders and claims must follow format described in the MBTA’s Construction Contract Change Order Guidelines.
2. Estimating Formats:

Using standard estimating formats for cost estimating and cost management:

- Ensures a uniform cost-control framework throughout the various stages of project development.
- Defines a proper level of detail to set expectations for the estimating effort.
- Serves as a checklist to ensure complete coverage of project scope.
- Provides for a standardized historical database or library.

**MasterFormat Estimates**

MasterFormat, a product of the Construction Specifications Institute (CSI), is the most widely used standard for organizing project specifications and detailed cost estimating data in the U.S. This CSI method is typically aligned with a general contractor’s approach to preparing a bid.

*MasterFormat is required when the design engineer’s estimator is providing construction estimates.*

If a consultant wishes to provide the MBTA with another format, a submittal for approval will be required.

Each individual row, within the cost estimate, shall contain the following:

A. Line #
B. CSI #
C. MBTA Pay Item
D. Description
E. Quantity
F. Unit
G. Hrs.
H. Crew
I. Labor
J. Materials
K. Equipment
L. Unit Cost
M. Total Cost

The following shall be shown as separate line items:

A. General Conditions
B. Overhead
C. Profit
D. Bond
E. Design Contingency
F. Construction Contingency
G. Escalation

CMG Format

Project Managers must provide project estimates in Capital Management Group (CMG) format. The format must include, but is not limited to, these following items:

Design and Engineering
Construction Contracts
Other Construction
Construction Contingency
Material Procurement
Escalation
Project Contingency

See Figure 1.

---

**Monthly Project Status Report**

**May 2011**

<table>
<thead>
<tr>
<th>Task Budgets</th>
<th>Original Authorized Budget</th>
<th>Current Authorized Budget</th>
<th>Forecast-to-Complete</th>
<th>Expenditures through 4/26/2011</th>
<th>Remaining Budget</th>
<th>Cost-to-Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Engineering</td>
<td>$0</td>
<td>$14,980,165</td>
<td>$10,973,000</td>
<td>$7,866,012</td>
<td>$7,114,153</td>
<td>$3,106,988</td>
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<tr>
<td>Construction Contract(s)</td>
<td>$0</td>
<td>$34,604,527</td>
<td>$63,082,000</td>
<td>$14,102,758</td>
<td>$20,501,769</td>
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<td>Other Construction</td>
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<td>$63,250</td>
<td>$0</td>
<td>$29,742</td>
<td>$33,508</td>
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<td>$0</td>
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<td>Material Procurement</td>
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<td>$0</td>
<td>$0</td>
<td>$0</td>
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</tr>
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<td>Land Acquisition</td>
<td>$0</td>
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<td>$1,000,000</td>
<td>$0</td>
<td>$0</td>
<td>$1,000,000</td>
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<td>Flagging/Force Account</td>
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<td>$1,763</td>
<td>$580</td>
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<td>Inspection</td>
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<td>$3,096,617</td>
<td>$1,129,050</td>
<td>$1,162,322</td>
<td>$1,967,561</td>
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<tr>
<td>Project Administration</td>
<td>$0</td>
<td>$4,559,815</td>
<td>$1,286,562</td>
<td>$1,223,354</td>
<td>$3,336,461</td>
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<td>Indirect Costs</td>
<td>$0</td>
<td>$2,373,345</td>
<td>$2,706,305</td>
<td>$961,930</td>
<td>$1,411,415</td>
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<td>Credit</td>
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<td>$0</td>
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</tr>
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<td>Escalation</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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<td>Project Subtotal</td>
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<td>$90,201,426</td>
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<td>Project Contingency</td>
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<td>$2,082,543</td>
<td>$0</td>
<td>$0</td>
<td>$2,082,543</td>
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<tr>
<td>Total</td>
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<td>$92,289,969</td>
<td>$25,893,325</td>
<td>$121,106,675</td>
<td>$66,396,644</td>
</tr>
</tbody>
</table>

**Figure 1**
3. Contents and Degree of Detail

Unit Pricing

Unit-price cost estimates are based on detailed design documents and developed by adding up the direct costs of materials and supplies, labor, and construction equipment for each individual task of construction work. The basis for these unit costs must be well documented and included in the supporting data of the estimate. To these, direct costs are added applicable indirect costs, such as overhead and profit at a subcontractor level, to reflect the in-place construction cost per unit of work required.

For conceptual design construction estimates, it is acceptable to use unit prices combining labor, materials, and equipment costs in a single figure. For estimates prepared at the design development and construction documents phases, MBTA requires separate labor, material, and equipment unit pricing.

Documentation of unit-price data for smaller items could include price quotes, audits, catalog cuts, and historical costs to clarify price bases and assumptions made when other information is not available.

General Conditions and Profit

1. 30% Design Development – An overall percentage allowance for the General Contractor’s general conditions, bonds, insurance, and corporate overhead and profit–is appropriate if the project involves no unusual coordination, site preparation, or specialized support services.

2. 60% and 100% Design Development and Construction Document - It is appropriate to estimate these costs with breakdowns:
   - General Conditions: Comprised of itemized general requirements and job-site supervision.
   - Mark-Ups: Comprised of general and administrative costs, profit, bonds, and insurance.

Design Contingencies

Contingencies are an integral part of the total estimated costs of a project and cover costs that may result from incomplete design, unforeseen and unpredictable conditions or uncertainties concerning project scope. The amount of the contingency will depend on the status of design, procurement, and construction, as well as the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate
assessment of expected cost. MBTA may choose to set aside separate
contingencies for major schedule changes, unknown design factors,
unanticipated regulatory standards or changes, additions to project scope or
force majeure situations. Contingencies must always be separately identified so
that the magnitude of a contingency’s impact is clear. For example, the estimator
may never add contingency by concealing it within unit pricing or quantity
estimates or takeoffs. Design contingencies start at 50% during initial stages and
are reduced to zero as the design is completed. Figure 2 shows contingency
allowances.

### Recommended Design Contingency Allowances
(Expressed as a percentage of estimated cost)

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Project Contingency</th>
<th>Design Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>50%</td>
<td>0</td>
</tr>
<tr>
<td>Pre-conceptual</td>
<td>40%</td>
<td>0+</td>
</tr>
<tr>
<td>Conceptual</td>
<td>35%</td>
<td>15%</td>
</tr>
<tr>
<td>Design Dev.</td>
<td>25%</td>
<td>30-60%</td>
</tr>
<tr>
<td>Construction Documents</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 2

### Construction Contingency

The construction contingency is an allowance for cost growth that may occur
during construction as a result of unexpected circumstances or incomplete
design documents. The MBTA currently recommends 10% for construction
projects, but may direct the use of different figures on a project-by-project basis.
MBTA Project Controls should be contacted and will assist in determining an
appropriate contingency using risk modeling, trend analysis and historical data.

### Escalation

Escalation is the anticipated increase in the project’s cost due to inflation
between the time the estimate is prepared and when the project is finished,
since inflation continues during project construction. For simplicity, the
estimator must assume that half of the work will occur before the midpoint of
construction and half after. Therefore, the estimate is escalated to the midpoint
of construction to reflect the contractor’s provision for inflation in its bid.

### Applying Markups, Contingency and Escalation
Demonstrate how mark-ups, contingencies, and escalation should be calculated and applied to projects.

**Reviewing and Reconciling Estimates**

An engineer’s estimate will be prepared at the 15%, 30%, 60% and 100% design stage and at 30% - 100%, the estimate will be reviewed by a Senior Management review team. The design consultant and its estimator are required to prepare a standardized review package for Project Controls which will be issued three (3) weeks prior to the review meeting. The review package shall consist of: the estimate in the appropriate format as described in this section along with a Cost Growth Report, project scope description, estimate basis and assumptions, pricing basis, allowances and back-up, exclusions, exceptions and recommended Add Alternates. The estimator will present the full basis for the estimate in conjunction with the design consultants.

The estimate review meeting is held in conjunction with in-depth schedule review and risk analysis. Please contact Project Controls prior to coordinating this meeting.

On projects for which MBTA requires the preparation of an Independent Cost Estimate (ICE), the design engineer is responsible for designating a member of its team to reconcile the ICE with its own estimate in an orderly and comprehensive manner.

5. **Cost-Estimating Systems**

MBTA encourages but does not require the use of computer-based cost-estimating programs to mitigate manual calculation errors and facilitate changes. The requirements defined in this document can be easily met by using various commercially available computer software programs and spreadsheets. Generic spreadsheets allow user adaptation and offer flexibility in applying different cost databases.


Any design-submission may include, but are not limited to:

- cost estimates and reports
- market survey
- cost growth reports
- space-type cost analysis
- life-cycle cost analysis
- value engineering studies
- independent estimate reviews
• budget analysis
• construction award bid analysis
• database information preparation
• construction modifications & claims analysis
• value engineering change proposals analysis (VECPS)
• risk analysis reports

The purpose is to establish a cost management system that tracks budgets established based on the prospectus in a MasterFormat, comparing cost growth and cost modifications for all MasterFormat elements through design, procurement, construction and project completion.

As a general rule, all estimates being provided by the design engineer’s estimator shall be in CSI MasterFormat. A Cost Growth Report is required at all submissions, and a Life-Cycle Cost Analysis is required through design development and potentially during construction documents phases for significant items.

An independent third party hired by the MBTA conducts a value engineering (VE) workshop. Value Engineering is required at the completion of 30% design. MBTA may elect to conduct an additional VE study at the construction documents phase on a project-by-project basis. After the MBTA completes an internal review and selects particular VE options, an estimate that incorporates the VE shall be provided.

1. Cost Estimates and Summaries

Initial Project Estimate

The PM develops an initial estimate of what the total project budget will be and determines individual costs. Below is a sample of what should be included:

Total Project Budget of $XXXXX, Construction $XXXXX, Design $XXXXX, Real Estate $XXXXX, Force Account $XXXXX, Project Administration Inspection $XXXXX, Indirect Costs $XXXXX.

Pre-Conceptual Project Estimate

After a designer is selected, the PM reviews and revisits the initial project estimate and refines the cost, if necessary.

15% Conceptual Construction Estimate

These estimating requirements apply to any concept-level estimate submitted by the design consultant and its estimator. If a project's design requires multiple concept submissions, each concept submission must be supported by the estimates described here.
Conceptual estimating may require the preparation of estimates on three competing basic schemes/concepts, allowing MBTA to select its preferred scheme. For each scheme, the design engineer's estimator prepares separate estimates for phased work, multi-structures, and/or bid alternates/options. The design engineer also submits estimates for concept design analysis/studies as specified in design-programming directives and/or design criteria references, and a comparison sheet for multiple concepts/schemes.

Estimators must calculate quantities for appropriate systems or apply parameters to appropriate building/transit areas. Applied unit costs may be based on combined material and labor costs. Concept estimates must match the estimate format of the budget estimate to facilitate cost-breakdown comparisons.

Backup worksheets must support detailed estimates, covering all cost-sensitive project data and defining all major assumptions made. Backup estimating data and quantity-survey information may be in any format, grouped under appropriate format classification headings.

The design engineer is required to provide the estimator advance copies of all concept plans and documentation early enough to allow for the preparation of required estimates as part of the concept design submission. Advance documents must include, but not limited to, floor plans, elevations, sections, and perspective views in sufficient detail to allow a realistic parametric cost assessment. In addition, the engineer provides:

- A statement on the conceptual approach and general features for each major building system, including an itemized listing of anticipated types and approximate capacities/sizes. Block loads for structural, mechanical, and electrical systems.

- Quality levels of major materials and systems to be used, including any special design programming or code requirements relating to fire protection, HVAC, plumbing, electrical, and structural components.

- A copy of the design program to ensure that the estimator understands goals, objectives, and design directives that may not yet be reflected in concept design submission documents.

To ensure that the project is developing on-budget, the engineer's estimator must also submit a list of cost-saving items that collectively would reduce the project's cost to approximately 10 percent below budget.

The PM must take each current estimate (given in CSI Format) and confirm and/or refine previous estimated costs, associated with the project.
30% and 60% Design Development Construction Estimate

The design engineer and its estimator shall develop a construction estimate of the selected design scheme. As a separate cost-saving task, the engineer’s estimator and design consultant must also submit a list of cost-saving items that collectively would reduce the project’s cost to at least 10 percent below budget.

Backup worksheets are required to support the detailed estimates, which represent all cost-sensitive project data. Define all major assumptions. Backup estimating data and quantity-survey information may be in any format, but must be grouped under appropriate format classification headings.

The PM must take each current estimate (given in CSI Format) and confirm and/or refine that previous estimated costs, associated with the project, are within budget.

100% Construction Documents Construction Estimate

The design engineer and its estimator must provide a detailed construction estimate. If the overall project’s construction estimate exceeds the budget, the estimator is again required to propose cost-saving measures to bring the project within budget, at its own expense. To avoid over-budget construction bids, the estimator must identify at least five construction cost-saving items, formulated as bid alternates, to bring the project’s estimate at least 10 percent below budget.

The PM must take each current estimate (given in CSI Format) and confirm and/or refine previous estimated costs to ensure the project is within budget.

2. Cost Growth Report

A Cost Growth Report consists of a table that details and explains the items that contributed to cost growth.

A Cost Growth Report (CGR) is to be provided to the MBTA with every construction estimated submittal in order to track cost growth at each design phase by comparison with the project budget.

3. Requirements for Bid Submission

The Contract Administration Department ensures that the bid packages include a lump-sum bid requirement for each bid option, alternate, and unit-pricing item.

4. Construction-Award Bid Analysis
Bids are opened publically, read aloud and the apparent low bidder is determined as the lowest responsive bidder according to MGL Chapter 30 and 39 M. After the apparent low bidder is identified, an analysis of the bids is performed by Contract Administration and the MBTA's designer engineer.

After the construction contract is awarded, the estimator analyzes the bid cost, using all available cost data, including the contractor's breakdown of costs submitted as the payment schedule for monthly progress payments for each trade or subcontract.

MBTA will provide the engineer and the estimator the following data:

- The abstract of bids received for the procurement with an indication of the award amount and the bids offered by all contractors.
- Any breakdown or verification of contractor or subcontractor prices in the course of contract award.

5. Cost Database

MBTA uses cost data collected for all construction projects to develop space-type cost benchmark tools to improve budget development for future projects. The estimator is required to look at Scope of Work, identify existing pay items and provide unit prices.

6. Construction Modifications and Claims Analysis

Please refer to Construction Contract Change Order Guideline. The Guideline provides information, procedures, and guidance for estimating and processing construction contract modifications. Contract modifications include change orders, contractor claims, formal resolution of constructive changes, the impact on unchanged work, suspension of work, and time extension.

7. Delivery Methods and Deliverables

1. Requirements for Estimates

The following deliverables shall be provided by the estimator, which will help ensure more accurate construction cost estimates:

- Project Scope Description
  - This section of the estimate basis should be organized to correspond with the project’s work breakdown structure. A semi-detailed description of the scope of work should be provided for each major segment of the project. Identify any major pieces of equipment or components. It's also
good practice to indicate the primary trades that will be involved with the project.

If material take-offs (MTO’s) are provided to the estimator, identify specifically who developed the MTO’s and the methodology used;

• General estimate basis and assumptions
  o Estimate basis and assumptions include, but are not limited to, constructability, use of specialized construction equipment, etc.
  o A schedule should be developed as a key basis for cost estimate. The schedule shall coincide with the estimate. Development of the schedule and cost estimate is a highly iterative and interrelated process; therefore, a statement confirming the estimate and schedule are in unison with each other shall be provided with the estimate.

• Pricing basis
  o Pricing sources for all major equipment (vendor quotes, historical data, etc.).
  o The pricing source for all labor hours, and all labor productivity adjustments. Provide appropriate detail if productivities vary by trade and/or location within the project (station, etc.).
  o All wage rates used (including crew/craft rates, craft mix, etc.). Pricing source and methodology for all home office costs (project management, engineering, design, etc.). Document the basis for any contractor fee costs.
  o Pricing source and methodology for costs such as freight, taxes, duties, etc.
  o Escalation indices used, and the method of calculation (including duration).
  o Location factors used and the basis for these factors.
  o Influence of local market conditions.
  o Any other pricing factors or external influences that may have a significant impact on project cost should be identified.
  o Estimate line items to be stripped of contingency.

• Allowances
  o Identify the level and types of allowances used in the estimate. Describe the basis for the common estimating allowances such as material take-off allowances, design allowances for engineered equipment, congestion allowances, working height allowances, etc.
  o This section should also describe any other costs, and appropriate back-up, that have not been detailed in the body of the estimate, such as lump-
sum allowances for specific areas of scope or any other factored costs not described elsewhere in the estimate basis.

- **Assumptions**
  - Any other assumptions made by the estimator but not documented elsewhere in the estimate basis should be included in this section. This may include assumptions such as an adequate labor supply being available, adequate funding available, site conditions, etc.

- **Exclusions**
  - In this section, the estimator should document all potential items of cost which a reviewer might associate with the project, but for which no costs have been included in the estimate. MBTA Force Account and land acquisition are examples of potential items that may need to be identified.

- **Exceptions**
  - The estimator should identify any anomalies or variances to MBTA’s standard estimating practices. This section should document any significant deviations from the project and/or engineering deliverables normally required for the applicable class of estimate. A good practice is to provide a checklist as an attachment to the BOE that will document any exceptions that are identified. This checklist should correspond to the company’s standard estimating practices.

- **Estimate comparisons**
  - Include MBTA historical cost items.

- **Cost Growth Report**

- **Risks and Opportunities**
  - Any areas of the estimate containing significant risk or opportunity should be identified.

- **Estimating Team**
  - All members of the estimating team should be identified, including roles, responsibilities and qualifications.
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1.3 Construction Schedule Requirements

1.4 Use of Float

1.5 Activity Requirements

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1.7 Construction Schedule Revision 0 Submittal

1.8 Progress Schedule

1.9 Payment

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III. PROJECT SCHEDULE

Project Managers (PM) are responsible for managing design and construction schedule associated with their projects. It is the PM’s role to act as the coordinator and catalyst for the activities of the design contractor and other team members and to assist the team in establishing and meeting the time management goals of the project.

Project Managers must be skilled in anticipating and analyzing problems, resolving or facilitating the resolution of problems in a timely manner and monitoring the implementation of the resolution to avoid adverse time impacts. Schedules are to be used for managing all the project phases.

Once a designer has been selected, the PM works closely with the design engineer to develop a design schedule within the time frame described in the project RFP. The Design Engineer is responsible for developing and updating the Project Design Schedule.

A. Project Design Schedule Submittal

1. Scheduling Representative

Prior to the submission of the Project Design Schedule, the Design Engineer shall designate a scheduling representative during the design phase for the project. The scheduling representative is the person primarily responsible for development and maintenance of the Project Design Schedule, the Design Engineer’s representative in all matters regarding the Project Design Schedule, and the designated attendee for all schedule related meetings. The Design Engineer shall notify the Authority of any changes to the person(s) designated as the scheduling representative.

The Engineer shall submit the qualifications of the scheduling representative to the Authority for approval. This approval is required before the Project Design Schedule will be accepted. The scheduling representative shall have experience in project controls, specifically cost and resource loading schedules along with performing an earned value analysis on projects using Oracle Primavera Scheduling Software® or equivalent Critical Path Method (CPM) schedule software.

2. General Requirements

Within thirty (30) calendar-days after the start date specified in the Notice to Proceed, the Engineer shall submit a detailed Project Design Schedule (PDS) to the Authority for review and acceptance. The PDS shall detail the activities required to complete Design Phase
Services within the time period specified in the Contract. The PDS shall be a computerized **cost loaded** CPM Schedule showing the estimated cost and duration of each activity for all phases of the design work. The Engineer shall cost-load the PDS by developing cost accounts for specific design scope items and assigning a cost value to each activity in the PDS. The cost value assigned to the activity shall be designated as the “Budget-At-Completion” (BAC). The BAC for each activity shall represent an allocation of the total project budget for the Design and Engineering Phase. The Engineer shall base the BAC on the labor rates and hours to complete each activity as determined by the Engineer or negotiated with the Authority. The Engineer shall submit a *Cost Accounting Standard Disclosure Statement* that details the procedures used to ensure the budget for each cost account is consistent and properly recorded in the Engineer’s general cost accounting system for the design work planned to be performed by the Engineer and its sub-consultants.

The Design Engineer shall use Oracle Primavera Scheduling Software® or equivalent CPM schedule software to develop the PDS. The schedule software shall have the capability to identify the critical activities along longest path of work through the schedule network for the project. The schedule software shall run on PC compatible equipment and be compatible with Microsoft Windows© based software. The software shall be capable of processing and plotting the progress of the work, determining the earned value of the work performed by the Design Engineer on a monthly basis, and comparing the progress and earned value of the work shown in multiple updates submitted by the Design Engineer.

The PDS submittal shall include an electronic computer disk with the schedule data files for the PDS and the following documents:

a. Time scaled diagram with a scale and format that is acceptable to the Authority;
b. Budgeted Cost Curve;
c. Work Breakdown Structure;
d. Schedule Tabular Reports and Cost Control Reports with at a minimum the following reports sorted by:
   1. Predecessor/successor,
   2. Early Start/Total Float,
   3. Total Float/Early Start,
   4. Critical Path of Work, and
   5. Summary by Cost Account sort report.
e. Written Narrative (WN) shall explain the sequence of design work, the critical or longest path of work, interim completion dates and phasing, significant dates that require actions by the MBTA or others, critical action items, and adequacy of the design budget. The narrative shall also describe how the PDS provides for permit requirements, environmental requirements, coordination with other public agencies, third parties, i.e. businesses, community, property owners, milestone dates
(for the design phases or other related work significant to the design), and coordination with all utility companies. Explain the specific scope of each design phase and the basis used to determine the original duration of each phase. The WN shall provide a description of the design alternatives included in the design or presented separately for the Authority for review.

f. The method used to determine the percent complete for each milestone deliverable based on earned value (Note: The method the Design Engineer uses to determine the percent complete shall be based on the physical progress of the work not the actual costs incurred as compared to the planned budget for an activity),

g. Printed Calendars with a listing, description, and calendar form tabulation of all calendars used. Include the total number of anticipated work days required to complete the design work.

The Design Engineer shall submit to the Authority four hard copies of items a through g. The Design Engineer may submit electronic copies of items a, through g, in a PDF format, if acceptable to the Authority.

Upon acceptance of the PDS by the Authority, the PDS shall become the Baseline Project Design Schedule of Record (PDS Baseline). The PDS Baseline shall be used to assess the Design Engineer’s reported progress in the PDS updates, as described in Section B.

3. Activity, Milestone, Work Breakdown Structure Requirements

In the PDS, the Design Engineer shall develop and layout project-specific activities, Milestones, durations, and phasing to meet the scope and earn value requirements of a project. An example of the layout for the PDS is shown in Figure 3. The Authority shall review the PDS Baseline and may require the Design Engineer to revise the PDS to add activities or Milestones, change activity descriptions, and modify activity relationships and logic to reflect the scope requirements and expected work sequencing.

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Figure 3 – Layout for Project Design Schedule

A. Activity

The PDS shall include the budgeted cost and duration to complete each activity along with the sequence and logic for each activity from Notice to Proceed to the start of Construction.
Phase Services. The Design Engineer shall refer to the description of each task in the Request for Proposals Design Services (RFP), Scope of Services section to develop the appropriate activities for each phase of the design work.

B. Milestones

The Design Engineer shall include a Milestone for each Phase of the design work. The Design Engineer shall refer to the description of each phase in the Request for Proposals Design Services (RFP), Scope of Services section to develop the appropriate milestones for design work. The Design Engineer may include the following Phases:

1. Phase 1 - Conceptual Engineering Plan (0-15%)
   a. Phase 1A – Community Participation and Interagency Coordination
   b. Phase 1B – Conceptual Design
   c. Phase 1C – Schematic Design
2. Phase 2 – Preliminary Design (15-30%)
3. Phase 3 – Design (30-60%)
4. Phase 4 – Design (60-90%)
5. Phase 5 – Final Design (90-100%)
6. Phase 6 – Bid and Award (End of Design Phase Services)

C. Work Breakdown Structure

A multi-level hierarchal Work Breakdown Structure (WBS) shall be incorporated into the PDS. An example of a WBS multi-level hierarchy is shown in Figure 4.

![Figure 4 – WBS Multi-Level Hierarchy](image-url)
The WBS is a deliverable-oriented grouping of the work elements, which organizes and defines the total scope of the design. The WBS includes descending levels of the work, which represents an increasingly detailed definition of the design components. The levels shall include, but not be limited to:

Level 1: Project design;
Level 2: Three categories: Administrative activities, Design Development activities, and Bid and Award activities;
Level 3:
  1. Design Development Milestones with five categories, Conceptual Design activities, 30% Design activities, 60% Design activities, 90% Design activities, and 100% Design activities;
  2. Bid and Award categories for Bidding preparation activities and post-Bid and Award activities

Level 4: Specific types of design work categories that may include Site, Civil, Structural, Mechanical, Electrical, Plumbing, and Rapid Transit Construction for the Level 3 categories.

The Authority may require the Design Engineer to add levels to the WBS to reflect specific item of design work for the project.

B. Project Design Schedule Updates

1. Requirements for PDS Update

Upon acceptance of the Baseline PDS, the Design Engineer shall submit monthly schedule updates identified as the Project Design Schedule Update (PDS Update). The submission of the PDS Update is a prerequisite to processing the Partial Payment Request. The PDS Update shall reflect the Design Engineer's progress of work on the data date. Each PDS Update shall include an electronic computer disk with the Design Engineer's schedule data files (including activity data, logic, WBS coding, and cost data) and a Progress Monitoring Report prepared in accordance with Section B.4. The Authority shall review, provide comments and return the PDS Update to the Design Engineer as “accepted,” accepted as noted,” or “revise and resubmit.” If necessary, the Authority and Design Engineer shall meet to discuss the progress of work as of the data date prior to the submission or resubmission of the PDS Update. Upon acceptance by the Authority, the PDS Update shall become the Progress Schedule of Record for the period between its data date and the data date of the next approved update or revision.

If the PDS Update submittals are returned to the Design Engineer for corrections or revisions, the Design Engineer shall revise and resubmit the PDS Update submittal to the Authority for review within ten (10) business days from the date returned by the Authority.
2. Progress of the Design Work

The Design Engineer shall provide for the Authority’s review and acceptance the proposed deliverables and method it plans to use to measure the percent complete for each activity in the PDS. The Design Engineer shall refer to the description of each phase and task in the RFP’s Scope of Services section to develop the appropriate method for measuring and quantifying the progress of the design work. The actual percent complete shall be based on the physical progress of the work completed by the data date, not the actual cost incurred.

The Design Engineer shall submit the PDS Update with its request for partial payment application.

C. Revisions to the Project Design Schedules

A revision to the Design Engineer’s scope of work due to a change in accordance with Contract Article II, Subsection 9, Revisions in the Scope of Work, Subsection 13, Changes, Subsection 14, Excusable Delays, shall be incorporated into the PDS and in accordance to the MBTA’s Design Change Control Guidelines and as shown below.

1. Project Design Schedule

The Design Engineer shall incorporate the proposed change(s) into the appropriate PDS Update as a fragnet(s). The fragnet shall include the following data:

   a. Start Date
   b. Finish Date
   c. Duration
   d. Linked to the appropriate predecessor activity.
   e. Linked to the appropriate successor activity.
   f. Description of the added work.
   g. An Activity identified as the Authority review of the proposed change.

The Design Engineer shall incorporate the fragnet into the proposed PDS Update identified by the Design Engineer. The PDS Update with the fragnet shall be identified as the Project Design Schedule with Proposed Revisions (PDSRV). The Design Engineer shall submit the PDSRV with a detailed report to the Authority for review and acceptance. The detailed report shall discuss the effects of the fragnet on the progress of the design work. The effect of the change to the project’s Critical Path shall be stated. Extra work or additional work that does not affect the critical path work will not be considered as the basis for a time extension. If a revision to the scope of work, change, or an excusable delay increases or decreases the contract duration then the Design Engineer shall notify the Authority in accordance with Contract Article II, Subsection 9, Revisions in the Scope of Work, Subsection 13, Changes, Subsection 14, Excusable Delays. Upon acceptance and issuance of an amendment for the change, the Design Engineer shall incorporate the fragnet into the PDS
Update, which correspond to the date the Authority approved the change. The PDS Update with the accepted fragnet shall become the Revised Progress Schedule of Record. Design changes shall be in accordance with the Design Change Control process described in Section VIII. Modifications to earned value shall be in accordance with Section IV - Earned Value Management During Design.

Project Managers are required to keep all project design schedules on file. A copy of all design schedules should always be sent to MBTA Project Controls.

D. Anticipated Construction Schedule

Per a Design and Construction Directive issued on November 17, 2010:

“A Construction Schedule will be prepared by the Design Engineer at the 30%, 60% and 100% design stage, which will receive an expanded review by a Senior Management review team. The scheduler is required to prepare a standardized review package which will be issued three (3) weeks prior to the review meeting. The scheduler will present the full basis for the construction schedule in conjunction with the design consultant. The topics to be included in the review package are as follows:

- Full CPM Schedule;
- Schedule showing longest/critical path;
- Near Critical Path;
- Schedule showing work associated with each milestone;
- Work shifts (days, nights, non-revenue) shutdowns; and
- Assumed construction approach.

Companies performing MBTA construction scheduling services will be required to submit a statement of qualifications for review that includes:

- Resumes of personnel performing construction schedule.
- A five (5) year summary of the company’s and individual’s construction scheduling history.
- Five (5) years experience developing construction schedules for projects of similar scope and complexity.”

CONSTRUCTION PHASE SERVICES

During Construction Phases Services the Design Engineer is responsible for reviewing all contractor issued schedule submittals to determine if the schedules are in compliance with the Project Schedule Specification. The Project Manager is responsible for ensuring that the Design Engineer is performing schedule reviews in accordance with the specifications and requirements shown below.
The requirements of review are as follows:

a. **Baseline Schedule Review** – *(Initial Construction Schedule Review)* Define and identify layouts and reports for routine reviews of contractor schedule submittals. Independently assess the project scope to establish compliance of “preliminary” As-Planned Construction Schedule. Compare Schedule and Scope against Contract Times. Review schedule for contract required sequencing, phasing and time allowances for submittal reviews and other owner responsibilities. Review schedule logic for completeness, feasibility and proper predecessor and successor relationships to submittals, procurement, permitting and ties to proper access restraints, milestones and interfaces. Ensure that all interfaces are practical and confirmed by appropriate agencies, parties and subcontractors. Review Contract accesses and milestones to ensure proper constraints are reflected. Identify preferential logic that could be removed if necessary. Review durations for reasonableness and identify if greater than 30 days. Review cost/resource loadings for reasonableness. Review schedule for reasonableness of critical path, float management and float utilization. Confirm submittals meet contract technical requirements. Confirm that reasonable allowances are included for uncertain events such a repeat submittals and normal weather effects on weather sensitive work. Confirm that schedule allows for actual project conditions. Prepare schedule review report along with recommendation.

b. **Update Schedule Review** – *(Regular Monthly Schedule Updates)* Validate progress with MBTA team Project Manager and confirm compliance to contract times. Identify changes between updates and compare to the baseline. Identify/review critical path logic changes and out-of-sequence progress. Determine that change orders have been incorporated and delay issues are fair and reasonable. Summarize and review the critical and near critical paths. Prepare progress analysis and trend charts (manpower/cost). Consider overall implication of the information in the schedule submittal. Assist MBTA in preparing written responses to the Contractor and attend monthly progress meeting. Minor schedule changes and minimal time impacts will be reviewed as part of the typical update process.

c. **Time Impact Analysis Review** - (TIA) Review substantial schedule impacts, delays or changes to the Contract submitted by contractor. Provide detailed analysis to determine time entitlement. Review contractors schedule fragment, associated resources, cost loading and supporting documentation. Recommend approval or disapproval of TIA.

In some instances, the PM utilizes the services of an independent schedule consultant to review construction schedules submitted by contractors. The services of an independent schedule consultant are arranged through MBTA Project Controls. A task order will be issued to provide these services.
During construction, the Contractor is responsible for providing schedules in accordance with the Construction Schedule Specification 01321. The content of Specification 01321 is provided below.
1.1 DESCRIPTION

A. This Section specifies the general requirements and procedures for preparing and submitting Contract Schedules to the Authority for review and acceptance.

1.2 SCHEDULE GLOSSARY

A. The following terms used in this Section or elsewhere in the Contract Documents shall have these meanings:

1. **Activity** - An element in the Progress Schedule highlighting or depicting a part of the Work and establishing the time and resources required, for completing that part of the Work.

2. **As-Planned Schedule** - Construction Schedule Revision 0 (Rev. 0) Submittal returned by the Authority to the Contractor as “Resubmittal Not Required,” with or without comments or objections noted, showing the Contractor’s plan to complete the work within the Contract Time.

3. **Business Day** - Any day except Saturdays, Sundays and legal holidays observed by the Authority. Also termed Work Days.

4. **Days** - Refer to Section 00700, Article 1 of the General Conditions.

5. **Contract Float** - Number of Business Days between the Contractor’s anticipated date for early completion of all or part of the work and the corresponding Contract Time or Contract Milestone(s). Contract Float is further defined as the amount of time any given activity or path of activities may be delayed before it will affect the Contract Time.

6. **Cost Loaded Schedule** - A CPM schedule which includes the accurate allocation of the cost of the Work to all schedule activities. Costs allocated to each Activity are to be proportional to the scope of the Work of the Activity and consistent with the Contractor's detailed bid. The Authority reserves the right to use the cost-Loading as a secondary means to resolve changes and/or claims. ‘Front-loading’ or other unbalancing of the cost distribution will not be permitted. The sum of the cost of all schedule Activities is equal to the total Contract Price. If the cost distribution appears to be unbalanced, the Authority will require justification.
7. **Critical Path** - Any continuous sequence of Activities in the Progress Schedule that control achievement of a corresponding Contract Time or Milestone(s).

8. **CPM** - The Critical Path Method of planning and scheduling. References to the Critical Path Method (CPM) shall be to CPM construction industry standards that are consistent with this Section 01321.

9. **Construction Schedule** - Schedule which shows the Contractor’s approach to planning, scheduling, and execution of the work. Includes the Revision 0 and monthly Progress Schedule Submittal(s).

10. **Date for Commencement of Contract Time** - The date when the Contract Time starts as defined by Article 6.02 A.

11. **Delays** - Slippage of the Early Dates in any Progress Schedule Submittal which forecast any slippage or overrun of Milestone(s) or Contract Times.

12. **Early Completion Schedule** - A CPM schedule showing completion of the Work ahead of the Contract Time specified in article 6.02, Prosecution of Work.

13. **Early and Late Dates** - Early times and late times of performance for the Activities as defined by CPM techniques and as further limited by the requirements of the General Conditions.

14. **Job Progress Meeting** - A bi-weekly Schedule meeting to review the progress on the Schedule including but not limited to the actual percentage of completion, the actual quantity of resources and number of personnel used, comparing actual dates with the early dates; and the resources/personnel intended to be used for the Look-Ahead Schedule and Recovery Plans as necessary.

15. **Milestone** - A key point of progress (zero duration) established in the Construction Schedule and as specified in the Contract Documents under Article 6.02.

16. **Progress Schedule Submittal** - A monthly status report of the As-Planned Schedule (Rev. 0) intended to aid in and facilitate the evaluation of a Partial Payment. Submittal to reflect Delays, schedule recovery plans and all other Contractor-initiated schedule revisions, subject to the acceptance by the Authority.
17. **Resource Loaded Schedule** - A CPM schedule which includes the accurate allocation of the resources to perform the Work, for all schedule activities. Resources allocated to each Activity are to be proportional to the scope of the Work of the Activity and consistent with the Contractor's detailed bid. The Authority reserves the right to use the Resource Loading as a means to resolve changes and/or claims. Indicating the manhours per day, by craft, and equipment hours/day will be acceptable. In addition, all change orders will be required to be resource loaded to validate and monitor the duration of the Work to be performed.

B. Other terms used in this Section shall have the meanings assigned to them elsewhere in the Contract Documents, and if not assigned and where the context will permit, as used or defined in Massachusetts General Laws (M.G.L.).

1.3 **CONSTRUCTION SCHEDULE REQUIREMENTS**

A. The Contractor's approach to prosecution of the Work shall be disclosed to the Authority by submission of the computerized; **cost/resource loaded** Construction Schedule required in this Section. These requirements are in addition to, and not in limitation of, requirements imposed in other sections.

B. The project requires an integrated cost/schedule controls program that the Contractor shall comply with, from Contract award, until final completion of all Work. The Contractor is advised that its schedules and reports, as specified herein, will be an integral part of the Authority's management program. The Contractor's schedules will be used by the Authority to monitor project progress, plan the level-of-effort by its own workforces and consultants, and as a critical decision making tool. Accordingly, the Contractor shall ensure that it complies fully with the requirements specified herein and that its schedules are both timely and accurate throughout the life of the project. The Contractor's Schedules shall be used by the Authority and Contractor for the following purposes as well as any other purpose where the issue of Time is relevant, the Contractor must prepare and plan the CPM with the following considerations:

1. To communicate to the Authority the Contractor's current plan for performing and completing the Work;
2. To identify Work items and paths that are critical to the timely completion of the Work;
3. To identify upcoming activities on the critical path(s);
4. To evaluate the best course of action for recovering schedule delays;
5. As the basis of progress payments to the Contractor;
6. As the basis for analyzing the Time; impact of changes in the Work;
7. To identify when submittals will be submitted by the Contractor for the Authority's review.
8. To aid in prioritizing the Authority's review of submittals;
9. To document the actual progress of the Work;
10. To evaluate resource requirements of the Contractor and the Authority;
11. To aid in integrating the Work with the operational requirements of the Authority;
12. To facilitate efforts to complete the Work in a timely manner.
13. Assignment of responsibility for performing specific activities;
14. Access to and availability of work areas;
15. Identification of interfaces and dependencies with proceeding, concurrent, and follow-on contractors;
16. Actual tests, submission of test reports, and approval of test results;
17. Planning for phased or total takeover by Authority.

C. Within 5 days after Contract award, and prior to submission of the initial Construction Schedule Revision 0, the Contractor shall host and conduct a schedule planning session. This session will be attended by the Authority and its consultants. During this session, the Contractor shall present its planned approach to the project (including the Work to be performed by the Contractor and its subcontractors) including, but not limited to: the planned construction sequence and phasing; planned crew sizes; summary of equipment types, sizes, and numbers to be used for each work activity; estimated durations of major work activities; the anticipated critical path of the project and a summary of the activities on that critical path; a summary of the most difficult schedule challenges the Contractor is anticipating and how it plans to manage and control those challenges; and a summary of the anticipated quarterly cash flow over the life of the project. This will be an interactive session, and the Contractor shall answer all questions that the Authority and its Consultants may have. The Contractor shall provide 5 copies of a written summary of the information presented and discussed during the session to the Authority. The Contractor's initial Construction Schedule Revision 0 and accompanying schedule narrative shall incorporate the information discussed at this schedule planning session.

D. The Construction Schedule shall consist of (a) the Construction Schedule Revision 0 (Rev. 0) Submittal (As-Planned Schedule), and (b) monthly Progress Schedule Submittals. The Construction Schedule shall clearly define the prosecution of the Work from the Date of Commencement of Contract Time to substantial completion by using separate CPM activities for, but not limited to: construction; testing; permitting; submittal preparation, reviews, resubmissions and approval; material and equipment deliveries; Authority furnished items; interfaces with other contractors, Public Utilities, etc.; Final Inspection; Punchlist; Milestones and Substantial Completion; Authority
training; and move-in. CPM Activities and logic ties shall be detailed as necessary to show the Contractor's Work sequencing and separately define all requisite Authority tasks.

E. In preparing the Construction Schedule Submittals, the Contractor has the responsibility to request clarification from the Authority on any areas of the schedule which reflect the Contractor's interpretations of, or variations from, the requirements of the Contract Documents. The Contractor also has the responsibility to incorporate the Subcontractors and Suppliers input into the schedule for Activities, logic ties, restraint dates, etc. involving their Work.

F. Acceptance of the Construction Schedule by the Authority shall not relieve the Contractor from compliance with the requirements of the Contract Documents, or result in the approval of any variation from the Contract Documents.

G. Primavera CPM Scheduling or equivalent schedule software shall be used for the Construction Schedule and one license is to be provided to the MBTA Project Office. The schedule software shall run on IBM PC compatible equipment, capable of processing and plotting the Progress Schedule information required in this Section, and create data base files accessible by Windows based software.

The software must also have a demonstrated ability to compare multiple updates (equivalent to Primavera 'target' and claim digger). The Contractor shall inform the Authority of the Construction Schedule software the Contractor will use to comply with the requirements of this Section. Provide the Authority with certified software training, pay all costs associated with maintenance fees and furnish to the Authority all upgrades and updates acquired from the software vendor during the period allowed for completion of the Work.

H. The Contractor will submit as part of the Rev. 0 and monthly Progress Schedule Submittal(s) a compact diskette containing the complete Construction Schedule data, files in compliance with the requirements of this Section. Submit electronic files in XER/PRX format. Provide the appropriate amount of schedule submittals to the project and one copy to:

Sr. Project Manager, Construction Project Controls,
MBTA
500 Arborway,
Jamaica Plain MA 02130
617-222-5910
*Project Controls reviews all schedules as a secondary reviewer and coordinates all review comments with the Design Engineer.

I. Contractor agrees to and guarantees that the Contractor will not:

1. Misrepresent to the Authority it’s scheduling or execution of the Work.

2. Utilize schedules substantially different from those submitted to the Authority or any Subcontractor for performance or coordination of the Work, or are not practical.

3. Submit schedules that do not accurately reflect the intent or reasonable expectations of the Contractor and its Subcontractors.

J. Contractor’s failure to substantially comply with this agreement shall be a substantial and material breach of contract. In the event the Contractor fails, refuses or neglects to comply to a significant extent with the requirements of this Section 01321, the Authority may elect any of the following: (a) nullify any mobilization payments previously made, (b) stop payments under the monthly Partial Payment Request, (c) prepare alternate progress schedules, as may be suitable under the circumstances, and deduct from the Contract Price all related costs by Change Order, (d) entitle the Authority to the damages afforded for misrepresentation or fraud by these Contract Documents or applicable law. Continued failure of the Contractor to perform in accordance with the requirements of this Section 01321 will be reason to place the Contractor in default of his obligation there under and terminate the Contract.

K. The Contractor is required to provide a Cost/Resource Loaded Schedule. These project controls tools are to include the accurate allocation of the costs and resources to complete the Work for all schedule activities. Costs allocated to each Activity are to be proportional to the scope of the Work of the Activity and consistent with the Contractor’s detailed bid. The Authority reserves the right to use the Cost-Loading as a means to resolve changes and/or claims. Front-loading or other unbalancing of the cost distribution will not be permitted. The sum of the cost of all schedule Activities is equal to the total Contract Price. If the cost distribution appears to be unbalanced, the Authority will require justification.

L. Default progress data is not allowed. Actual start and finish dates shall not be automatically updated by default mechanisms that may be included in the CPM scheduling software systems. Actual start and finish dates and remaining duration on the CPM schedule shall match those dates provided from the Contractor back up paperwork (i.e. daily reports, delivery slips, etc...).
M. ‘Out-of-sequence progress’ - Activities that have posted progress without predecessors being completed, is not allowed without the written approval of the Authority. The contractor shall not utilize "Progress Override" (schedule calculation) unless written approval is provided by Authority.

N. The contractor shall not artificially improve its progress by revising schedule logic restraints or shortening planned activity durations. The contractor may improve its progress by performing sequential activities concurrently or by performing activities more quickly than plan, but such improvement shall not be recorded on the schedule until they have actually been achieved by the contractor.

1.4 USE OF FLOAT

A. Contract Float is not for the exclusive use or benefit of either the Authority or the Contractor, but must be used in the best interest of completing the project within the Contract Time. If the Early Dates in any Progress Schedule Submittal forecast any slippage or overrun of the Contract Times, the Contractor shall indicate such slippage or overrun by reporting negative Contract Float.

B. The Contractor shall not utilize (1) float suppression techniques in the Construction Schedule, including but not limited to interim dates imposed by the Contractor other than Contract Time(s) and Contract Milestone(s), or (2) the inclusion of activities or constraints in a path or chain leading to a Contract Milestone which are unrelated to the Work as stated and specified in the Contract Documents, or (3) activity durations or sequences deemed by the Authority to be unreasonable in whole or in part.

C. All Contract Time(s) and Milestones shall be imposed, coded and separately identified in all Progress Schedule Submittals in conformance with the Milestone(s) and Contract Time(s) set forth in the Contract Documents. The Contractor shall impose no other date restraints in the Construction Schedule, unless an explanation of their bases is provided and is acceptable to the Authority. Contract Completion and Milestones incorporated in the Contractor’s Construction Schedule shall be assigned duration of zero (0) days.

D. Contract Float in an early completion Revision 0 Submittal or Progress Schedule Submittal shall be calculated based on the definitions given in the Contract, regardless of the float values shown in any Construction Schedule Revision Submittal or Progress Schedule Submittal.

E. Extensions of time for performance of the Work required under the General Conditions pertaining to equitable time adjustment will be granted only to the extent that the equitable time adjustment for activities affected by any
condition or event which entitles the Contractor to a time extension, exceed
the Contract Float along the path of the activities affected at the time of
Notice to Proceed of a Contract Modification or commencement of any delay
or condition for which an adjustment is warranted under the Contract
Documents.

F. If the Contractor is delayed in performing the Work, the Contractor shall
absorb any related delay, disruption, interference, hindrance, extension or
acceleration costs, however caused, until all Contract Float, if any, is
consumed and performance or completion of the Work, or specified part,
necessarily extends beyond the corresponding Contract Times. The
Contractor shall work cooperatively with the Authority, adjacent contractors,
and third parties, to identify and implement to the maximum extent possible,
no-cost measures to recover all schedule delays, regardless of the cause of
the delays. One example of such measures is no-cost re-sequencing of Work
activities.

1.5 ACTIVITY REQUIREMENTS

A. Activity durations shall equate to the Business Days required to complete the
Work included in each Activity. Activities shall be in sufficient detail to
separate items of Unit Price Work from lump sum Work, breakout distinct
classes of Work (e.g., CSI Divisions/Sections or equivalent) and Work in
separate areas or locations, as specified by the Authority. Work being
performed by DBE firms shall be identified as separate CPM activities.

B. In general, Activities shall be detailed in a manner that utilizes planned
durations from ten (10) to thirty (30) Calendar Days, unless shorter
durations result from the rules in paragraph 1.5.A, and have a value not
exceeding $50,000. Activity durations, greater than 30 calendar days shall be
kept to a minimum, and must be approved by the Authority, except in the
case of nonconstruction activities such as procurement of materials, delivery
of equipment, and concrete curing. Submittal Review Activities shall be
thirty (30) Calendar Days, unless different review times are specified in other
sections of the Contract Documents.

C. Activities shall be assigned consistent descriptions, identification codes and
sort codes. Sort code schemes shall: (a) be subject to the Authority’s prior
consent; (b) group Activities using meaningful schemes defined by
Contractor and the Authority; and (c) designate lead responsibility for each
Activity. The Contractor shall include specific schedule activity identification
codes in its daily field reports when describing the items of Work performed
each day.
D. The total Contract Price shall be allocated to the CPM activities. The cost coded schedule shall be directly related to the Bid Form, Schedule of Bid Prices (Section 01150). Other data such as the proposed number of business (working) days per week, manpower allocation by crew size and type, the planned number of shifts per day and the number of hours per shift, shall all be included in the computerized Construction Schedule.

E. Work Breakdown Structure – The first code field shall designate the bid item. The second field shall identify the type of activity. (Types of activities shall be defined as “submittal”, “review/approval”, “procurement/fabrication”, “delivery”, “construction/installation” or “change order”.) The third code field shall identify which specification section the activity shall be paid under. The forth code field shall identify who is responsible to perform the activity (i.e., contractor, subcontractor(s) by trade, supplier, etc). The fifth code field shall identify the different areas being worked in if appropriate. The sixth code field shall identify the construction phase and associated milestone. All change orders and notices of non-conformance shall be included as separate code fields.

1.6 SCHEDULES; REPORTS; PLOTS; NARRATIVES

A. **Activity Reports** shall include Activity identification code, description, duration, calendar, Early Dates and Late Dates, Total Float and sort codes as specified by the Authority. The Late Finish Date of any Activity representing a Milestone shall equal the corresponding Contract Time. In addition, Activity reports shall show, for each Activity, all preceding and succeeding logic ties (lead/lag and lead times) or attach a separate report combining such Activity and logic tie data.

B. **Time Scaled Logic Diagrams** shall be arrow or precedence and shall be plotted on MBTA Standard Size 22"x 34" sheets with a calendar heading acceptable to the Authority. Logic diagrams shall identify the Contract Time(s) and Critical and sub-Critical Path(s). Activities shall show the Early Dates, Remaining durations and Total Floats. Logic connectors will be shown for all predecessors and successors.

C. Resources - The Contractor shall manpower load all Schedules. The Contractor shall manpower load each individual Activity. The activities included in the Schedule shall be analyzed, in detail, to determine activity durations in units of project working days. Durations shall be based on the planned production rates, based on the labor (crafts), equipment, and materials required to perform each activity on a normal work-day basis, in accordance with the Contractor’s bid. All durations shall be the result of definite manpower and resource planning by the contractor to perform the work in consideration of contractually defined on-site work conditions. The
manpower to be assigned, by craft definition, shall be shown on each construction activity of the Schedule. All of these Activities shall remain manpower loaded, and updated, until final Contract completion. The Contractor shall provide weekly, monthly, and cumulative manpower curves for its own forces and Sub-contractors, as designated by the Authority, with all Schedule submissions. Curves shall be based on current Early Dates and Late Dates and, when requested by the Authority, shall compare As-Planned Early Dates and current Early Dates. The Contractor shall also resource load its planned equipment for all activities. At all times throughout the duration of the Project, the manpower loaded Schedules, manpower curves, and list of equipment shall be kept current and shall accurately represent the Contractor's current actual plan for performing the Work.

The Contractor shall prepare a manpower analysis in the form of a series of graphic displays depicting manpower by principal trades in the aggregate, and in accordance with the Schedule. The graphs shall display the number of man-days of effort, for each month, over the life of the project. This submission shall be computerized and shall correlate with the manpower data, exported from the Scheduling software. The Manpower requirements forecast shall be updated monthly and shall include the manpower actually expended, by trade, as of the current report period and the manpower required to complete all remaining contract work.

D. **Cash Flow** - Using the cost assigned to each activity of the Schedule, the Contractor shall develop a cash flow projection, illustrated by exporting the scheduling data in graphic display or tabular form. Both shall demonstrate the estimated cash drawdown in the aggregate, by month, over the life of the project. Additionally, the data shall be organized/sort able by bid-item. The cash flow projection shall be updated each month to show actual cash drawdown and a forecast of remaining payment to be made over the remaining life of the project.

E. Each Look-back and Look-Ahead Schedule shall display the activities planned at the closing (i.e., data, cut-off) date that cover the previous two (2) weeks and the next four (4) weeks.

F. **Monthly Schedule Narrative** - Each narrative shall list the Activities on each Critical Path and compare Early Dates and Late Dates for Activities designating Contract Times.

1. Rev. 0 narrative shall be included which details (a) the Contractor's site management plan (e.g., lay down, staging, traffic, parking, etc.), (b) the use of construction equipment and resources, (c) basis and assumptions for critical activity durations and logic, (d) compliance
with winter weather requirements, and (e) any shifts, non-Business Days and multiple calendars applied to the Activities.

2. For each Progress Schedule Submittal, the narrative also shall recap progress and days gained or lost versus the previous Progress Schedule, describe changes in resources to be used on remaining Work and identify Delays, their extent and causes. For Progress Schedule Submittals, each narrative also shall itemize changes in Activities and logic ties caused by each Change Order, schedule recovery plans and grouping of related Contractor-initiated revisions.

3. The Schedule Narrative shall include the following components, to communicate to the Authority the Contractor’s current plan for performing and completing the Work. A statement:

- to identify Work items and paths that are critical to the timely completion of the Work;
- of upcoming activities that the Authority needs to be aware of;
- of the proposed course of action for recovering any schedule delays;
- of critical submittals by the Contractor, for the Authority’s review;
- of any significant changes to resource for future or past work;
- of any upcoming information that is important to the operational requirements of the Authority;
- that alerts the Authority of any potential/future/pending changes in access to or availability of work areas;
- that highlights future tests, submission of test reports, and approval of test results;
- that addresses and upcoming phased or total takeover by Authority. Overview of Progress and Changes Since the Last Submittal and Discussion of Potential and Actual Delays
- that describes the plan and approach to sequencing of the Work
- that highlights and describes any Change Orders that have been included or are pending for approval.
- that provides a Glossary of Terms, Schedule Coding, and Abbreviations used in the Contract Schedule
G. Each narrative shall certify that the Contractor has not been delayed, as of the closing date, by any act, error or omission of the Authority, except as otherwise specifically stated in the narrative or identified in a claim submitted in accordance with the General Conditions of the Contract. Any determination by the Authority will be binding on the Contractor if the Contractor fails to do.

H. Additional Scheduling Update Requirements – The initial updating shall take place during the first week after the approval of the Contractor’s schedule. Subsequent updates shall be scheduled at the end of each month thereafter for the duration of the contract. The Schedule and computer tabulations shall be reviewed jointly at a meeting, with the Authority, for the purpose of verifying:

a. Actual start dates;

b. Actual completion dates;

c. Cost value of work reported in place;

d. Activity percent completion;

e. Revised logic (as-built and projected) and changes in activity durations, costs, and manpower assigned;

f. Influence of change orders;

g. Revisions due to unauthorized modifications;

If any of the required schedule submissions, in this Section, are returned to the Contractor for corrections or revisions, they shall be resubmitted, along with a new computer disk, for approval within ten (10) calendar days after the return.

1.7 CONSTRUCTION SCHEDULE REVISION 0 SUBMITTAL

A. The initial 90 Day Submittal shall be due within ten (10) Days after receipt of the Commencement of Contract Time, and shall include the Contractor’s detailed plan, with all schedule requirements contained in this Section with at least the first three (3) months of the forthcoming complete Rev. 0 Submittal.

B. The complete Rev. 0 Submittal (i.e. the full cost and resource loaded Baseline Schedule Submission) shall be due with the first partial payment. The Construction Schedule Rev. 0 Submittal shall reflect the Work as awarded and shall purposely exclude any Delays, Change Orders, "or equal" materials and equipment and substitutions of any kind. Additionally, the Contractor is to ensure that the schedule submission is complete conformance with the intent of the Contract Documents; no proposed alternates will be accepted.
until presented to the Authority after the full Baseline Schedule has been accepted.

C. Each Revision 0 Submittal shall include an electronic computer disk with the Contractor's schedule data files (including activity data, logic, coding, resource and cost data), a narrative and four (4) copies of the specified Activity Reports, Time Scaled Logic Diagrams, Cash Flow Plots, Resource Plots, Look Ahead Schedule and Cost Distribution as defined in paragraph 1.05, all in formats, sorts and sequences acceptable to the Authority.

D. Once the Rev. 0 Submittal (initial and full baseline) (or Rev. 0A, or Rev. 0B, etc. for a resubmission) is returned to the Contractor as "Resubmittal Not Required," with or without comments or objections noted, it shall become the As-Planned Schedule of record. Once established, the As-Planned Schedule shall be used as the basis for Progress Schedule Submittals (i.e. Monthly Schedule Updates).

E. The first partial payment shall be not be made until the Authority returns to the Contractor the Initial Rev. 0 Submittal as "Resubmittal Not Required." The second partial payment shall not be made until the Authority returns to the Contractor the complete Rev. 0 Submittal as "Resubmittal Not Required".

F. In the event the Authority is unable to accept the complete Rev. 0 Submittal and the As-Planned Schedule is not established, the Contractor shall submit unapproved Progress Schedule Submittals as specified by the Authority, each reflecting the Contractor's approach to completion of Work remaining, progress of the Work and schedule issues in dispute.

G. The Construction Schedule shall incorporate the Contractor's best estimate of the Activities and logic ties required to perform items covered by allowances within the limits of the Contract Times.

1.8 PROGRESS SCHEDULE

A. PROGRESS SCHEDULE SUBMITTAL

1. Schedule Meeting Prior to: the first week of each month, the Contractor shall submit a DRAFT Progress Schedule (4 prints and e-disk) to the Authority and the Consultant. This DRAFT schedule shall include information described in the Section 01321.1.8.A.4 for the previous month. After the Authority's review of this DRAFT schedule, a schedule meeting with the Contractor will be held in the second week of the month to validate the as-built data and discuss at a minimum: the delays, recovery plan, change order schedules
(subnets), plan vs. performance, manpower, etc. The Contractor shall incorporate the information discussed at this schedule meeting and finally submit Progress Schedule Submittal in the third week of the month.

2. Progress Schedule Submittals statusing the *As-Planned* Schedule Submittal shall be due with each partial payment request, starting with the third request and with each subsequent monthly partial payment request. The Progress Schedule Submittal is a prerequisite to processing the Partial Payment Request.

3. Each required Progress Schedule Submittal shall include an electronic computer disk with the Contractor's schedule data files (including activity data, logic, coding, resource and cost data), a narrative and four (4) copies of the reports, schedules and plots, defined in paragraph 1.06, all in formats, sorts and sequences acceptable to the Authority.

4. The Contractor shall uniquely identify each Progress Schedule Submittal by using a numbering convention similar to that used on technical Submittals. Resubmissions shall be assigned the corresponding Submittal number and the letter A, or B, or C, etc., and shall fully address all the Authority's review comments and objections on the previous Submittal. If the Contractor fails to fully address all the Authority's review comments and objections in the next Schedule Submission, the Authority may withhold all progress payments until the Contractor addresses all such comments and objections to the satisfaction of the Authority.

5. Progress Schedules Submittals shall reflect progress up to the closing (i.e., data, cut-off) date, forecasted finish for in-progress Activities and re-forecasted Early Dates for Activities planned in the next update period. The current Progress Schedule Submittal should incorporate all proposed Activity, logic and restraint date revisions required to (a) implement changes in the Work, (b) detail all impacts on pre-existing Activities, sequences and restraint dates, (c) recover schedule, (d) reflect the Contractor's current approach for Work remaining, (e) incorporate any Delays that are being negotiated between the Authority and Contractor, and (f) reflect "or equal" or substitution proposals. Progress up to the closing date shall be limited to changes in as-built dates for completed and in-progress Activities. As-built data shall include actual start dates (excluding premature starts), remaining durations, actual finish dates (when dependent Work could/did proceed), Delays and other events significant to the
Progress Schedule that occurred since the previous Progress Schedule Submittal.
Any revisions for the Contractor’s convenience shall be excluded when reconciling an extension to a Milestone or Contract Time.

6. The Authority and Contractor shall employ the accepted Progress Schedule, subject to the Contractor’s position on the Authority objections to outstanding schedule issues, to monitor progress against the Contract Time(s), evaluate the effect of Delays on Contract Time and Contract Price and support the justification for any assessment of liquidated damages.

7. In the event the evolution of the Progress Schedule is interrupted, paragraph 1.8 B.3 provides Delay evaluation and Progress Schedule update procedures which shall be binding on both the Authority and Contractor.

8. When change orders or delays are experienced by the Contractor and the Contractor requests an Extension of Time, the Contractor shall submit to the Authority a written Time Impact Analysis illustrating the influence of each change or delay on the current Completion Milestones. Each Time Impact Analysis shall include a ‘fragnet’ demonstrating how the Contractor proposes to incorporate the change order or delay into the next Progress Schedule Update. A fragnet is defined as a sequence of new activities and/or activity revisions that are proposed to be added to the existing schedule to demonstrate the influence of delay and the method for incorporating delays and impacts into the schedule as they are encountered. This fragnet shall be presented with resource and cost loading as well.

B. DELAY PROVISIONS

1. The Contractor shall review the schedule information presented in this Section, and the progress of Work, bi-weekly at the Job Progress Meeting. Unless otherwise directed in writing, by the Authority, whenever this review, as determined by the Authority indicates a late completion of the Work, or should activities shown on the Progress Schedule Submittal slip by ten (10) or more Days beyond any Contract Time or Milestones. The Contractor shall work cooperatively with the Authority, adjacent contractors, and third parties, to identify and implement to the maximum extent possible, no-cost measures to recover all schedule delays, regardless of the cause of the delays. One example of such measures is no-cost re-sequencing of Work activities.
The Contractor shall be required to, at no extra cost to the Authority, prepare and submit a recovery schedule which displays how the Contractor intends to reschedule those activities, in order to regain compliance with the Contract Time or Milestones. The Contractor will also submit a narrative, which shall describe the cause of schedule slippage and actions taken to recover schedule within the shortest reasonable time (e.g., re-sequencing of Work activities, hiring of additional labor, use of additional construction equipment, expediting of deliveries, etc.).

2. Schedule recovery will be excused if the Contractor requests and demonstrates entitlement to an extension in Contract Time, in writing, due to delay(s) not within the control of the Contractor, and the Authority concurs schedule recovery is not required at that time. Any Contractor request for adjustment in Contract Time and Contract Price will not be evaluated unless (a) the Contractor, using the procedures in this Section and the Contract, shows that conditions justifying adjustments in Contract Time and/or Contract Price have arisen, and (b) the Contractor's analysis is verifiable through an independent review by the Authority of the electronic disk files for the Progress Schedule Submittal provided by the Contractor.

3. In the event the Authority is unable to return any Progress Schedule Submittal as "Re-submittal Not Required," and the effect of Delays on Contract Time and Contract Price need evaluation, both the Authority and Contractor shall employ the As-Planned Schedule and not any unapproved Progress Schedule Submittal for such evaluations. The procedure for updating the As-Planned Schedule and including Activity, logic tie and restraint date revisions is specified in paragraphs 1.08 B.3.A and 1.08 B.3.B, respectively.

a. The Contractor shall include a subnet demonstrating how the Contractor proposes to incorporate each Change Order into the most recently accepted Schedule. A subnet is defined as a sequence of new or revised activities that are proposed to be added to the Schedule.

b. The extension of Contract Time shall be considered only if the Contractor demonstrates via the timely submittal of a detailed schedule analysis by using the contemporaneous window Analysis methodology or other similar methodology acceptable to the Authority. The analysis shall include: a) a detailed narrative which clearly describes the events causing the delay and the resulting impacts to the project schedule; b) documentation substantiating and supporting the delay; c)
detailed CPM schedules (both electronic and hard copies) clearly delineating the delay; d) a matrix showing delays caused by any third party and any force majeure delays; e) any additional information reasonably requested by the Authority, in order to enable the Authority to perform a timely and informed analysis of the request for extension of Contract Time.

4. Determination and extension of Contract Time will be in accordance with Article 6.8 and this Section 01321 CONSTRUCTION SCHEDULE. Contractor acknowledges and agrees that the actual delays in activities which, according to the most recent Progress Schedule Submittal accepted by the Authority, do not have any effect on the Contract Time or Milestone shown by the critical path in the network, do not have any effect on the Contract Time or Milestone and therefore will not be the basis for a change therein.

5. The Contractor's failure, refusal or neglect to comply with the requirements specified in Section 01321 Article 1.8 B.I shall be reasonable evidence that the Contractor is not prosecuting the Work with due diligence. If faced with such situation, the Authority may (a) demand adequate, written assurance of due performance, as required in Section 00700 Article 6.10 Termination of the Contract (b) direct alternate schedule recovery actions. If in the judgment of the Authority it appears that the Contractor cannot complete his Work within the scheduled time, then the Contractor shall work overtime, additional shifts or adopt such other procedures as may be necessary to restore adherence to the schedule. The full cost of any such recovery work efforts shall be borne by the Contractor, and/or (c) withhold liquidated damages, as provided in Article 6.9.

C. The Contractor will provide a separate electronic disk file of the As-Planned Schedule statused for all activities in progress or completed through the time periods for each delay issue or significant project events. Each updated schedule will be compared and analyzed, identifying any slippage between the actual dates for any impacted or delayed activities and the As-Planned Schedule. This schedule slippage can then be correlated to the Delay Issues that occurred between two (2) schedule update periods.

D. For each update window schedule submitted, revisions in Activities, logic ties and restraint dates affecting Work after that update window shall be included only if they are identified and jointly agreed to be incorporated by the Contractor and the Authority.
1. Determination and extension of Contract Time will be in accordance with Article 6.08. Contractor acknowledges and agrees that the actual delays in activities which, according to the Progress Schedule Submittal, do not affect any Contract Time or Milestone shown by the critical path in the network do not have any effect on the Contract Time or Milestone and therefore will not be the basis for a change therein.

2. The Contractor's failure, refusal or neglect to comply with the requirements specified in Section 01321 Article 1.08 B.1 shall be reasonable evidence that the Contractor is not prosecuting the Work with due diligence. If faced with such situation, the Authority may (a) demand adequate, written assurance of due performance, as required in Section 00700 Article 6.09 (b) direct alternate schedule recovery actions. If in the judgment of the Authority it appears that the Contractor cannot complete his Work within the scheduled time, then the Contractor shall work overtime, additional shifts or adopt such other procedures as may be necessary to restore adherence to the schedule. The full cost of any such recovery work efforts shall be borne by the Contractor, and/or (c) withhold liquidated damages, as provided in Article 6.09.

1.9 PAYMENT

1. Fifteen percent (15%) of the fixed price for CPM Scheduling will be made upon return to the Contractor of the complete cost and resource loaded CPM Construction schedule Rev.0 Submittal as “Resubmittal Not Required” (As-Planned Schedule).

2. The remaining (85%) will be pro-rated in equal amounts on each subsequent application for payment upon the Authority’s receipt and approval of the monthly CPM updates. The number of months to be used for the pro-rating will be the number of months estimated to complete the work as defined under Article 6.02 - Prosecution of Work. The final month pro-rated amount will not be made until the final application for payment.

3. All payments are subject to retainage.
SCHEDULE REVIEW LOG

Project Managers are required to maintain a Construction Schedule Review Log throughout the duration of the construction project. PM’s are expected to update this log every month, with requests for progress payments.

<table>
<thead>
<tr>
<th>MBTA Project #</th>
<th>Project Name</th>
<th>Project Manager</th>
<th>Resident Engineer</th>
<th>Designer Firm</th>
<th>Notice To Proceed</th>
<th>Due Date by Contract</th>
<th>Submitted</th>
<th>Returned</th>
<th>Submitted</th>
<th>Returned</th>
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Baseline Schedule:

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<th>Monthly Schedule Updates</th>
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<th>Reviewed</th>
<th>Returned</th>
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CONSTRUCTION SCHEDULE REVIEW LOG

Report Date: 6/22/2011
IV. EARNED VALUE MANAGEMENT DURING DESIGN

Earned Value Analysis 46

Progress Monitoring Report 49

Revisions to Project Design Schedules that Impact Earned Value Analysis 50
IV. EARNED VALUE MANAGEMENT DURING DESIGN

Earned Value Management (EVM) is a project management technique for measuring project performance and progress in an objective manner. EVM has the ability to combine measurements of scope, schedule, and cost in a single integrated system. Earned Value Management is notable for its ability to provide accurate forecasts of project performance problems. Early EVM research shows that the areas of planning and control are significantly impacted by its use; and similarly, using the methodology improves both scope definition as well as the analysis of overall project performance. More recent research studies have shown that the principles of EVM are positive predictors of project success.

Earned Value (EV) shall be incorporated into all projects during design phase services. In design-bid-build projects EV will be utilized from concept to the delivery of 100% construction documents. For Design-Build projects, EV will be utilized from concept to the delivery of design-build packages. For projects involving CM@ Risk, EV will be utilized from concept to the point at which a GMP is achieved and the CM is chosen and provided the design.

1. Earned Value Analysis

Each month, the Engineer shall perform an Earned Value Analysis (EVA) using the cost and schedule software specified in Section III of this manual. The Engineer shall include the results of the EVA in the Progress Monitoring Report as described later in this section.

The EVA shall be based on the following data in the Project Design Schedule (PDS) at the data date:

1. Actual start and finish for each activity as of the data date.
2. The progress of the activities that started, but are not finished on the data date.
3. Percent complete of the work for each activity from the start date to the data date.
4. Actual cost expended for each activity as of the data date.

The Engineer’s Cost Accounting Standard Disclosure Statement shall include the procedures used to ensure the actual value of each cost account in the PDS Update was properly represented and timely recorded in the Engineer’s general cost accounting system for the design work completed by the Engineer and its sub-consultants. If the sub-consultant actual cost data is not available prior to the submission of the PDS Update, the Engineer shall estimate the sub-consultant’s actual cost as of the data date for PDS Update. The Engineer shall confirm the actual cost from the sub-consultants prior to the submission of the next PDS Update.
The Engineer shall use the cost accounts and scheduling data in the PDS Update to calculate and show the results of each data item in Table No. 1.

<table>
<thead>
<tr>
<th>Table No. 1 – Data Item for Earned Value Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Item</strong></td>
</tr>
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</table>
| Budgeted Cost of Work Scheduled (BCWS) | The budgeted cost of work scheduled for completion at the data date.  
(BCWS = Budget Cost x Target Percent Complete) |
| Budgeted Cost of Work Performed (BCWP) | The value of completed work expressed in terms of the budget assigned to that work.  
BCWP is also known as the “earned value” of the work completed to date.  
(BCWP = Budget Cost x Percent Complete of the Work) |
| Actual Cost of Work Performed (ACWP) | The actual cost-to-date for work performed during a specific time period or duration.  
[The actual cost incurred shall correspond to the cumulative amount shown in payment application for the month.] |
| Schedule Variance (SV) | The Schedule Variance indicates if the project is ahead or behind schedule.  
(SV = BCWP – BCWS) |
| Cost Variance (CV) | The Cost Variance indicates if the project is over or under budget.  
(CV = BCWP – ACWP) |
| Estimate To Complete (ETC) | The Engineer’s estimated cost to complete the design work from the data date to the forecast completion date. |
| Estimate At Completion (EAC) | The Engineer’s projected final cost of the design work at the data date.  
(EAC = ACWPcumulative + ETC) |

The Engineer shall determine and record the progress of work based on the results of the Schedule Performance Index and Cost Performance Index shown in Table No. 2.

<table>
<thead>
<tr>
<th>Table No. 2 – Earn Value Indexes</th>
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<tr>
<td><strong>Description</strong></td>
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</table>
| Schedule Performance Index (SPI) | BCWP / BCWS | A SPI greater than 1.0 indicates no delays to the PDS.  
A SPI less than 1.0 indicates that there are delays to the PDS. |
| Cost Performance Index (CPI) | BCWP / ACWP | A CPI greater than 1.0 indicates the project design is within design budget.  
A CPI less than 1.0 indicates that the project design budget is over budget. |
| Variance At Completion (VAC) | BAC- EAC | Projected final cost over/under the total budgeted cost based on the difference between the value of the Budget at Completion (BAC) and the Estimate at Completion (EAC). |
The Engineer shall use Microsoft or equivalent software to provide and summarize the total values for earned valued data shown in Tables No. 1 and Table No. 2 for all activities in the PDS Update.

The Engineer shall provide a cost curve graphic based on the cumulative total values of the BCWS, BCWP, ACWP, BAC, EAC and VAC for each PDS Update. The Engineer shall also show the planned BCWS from each update period to the forecast completion date. See Figure 5 for example of a summary cost curve.

![Figure 5 – EVA Summary Cost Curve Graph](image)

<table>
<thead>
<tr>
<th>Update No.</th>
<th>1</th>
<th>2</th>
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<td>VAC</td>
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The Engineer shall prepare a project analysis report along with a summary of each update period that compares the earned value data on the data date to the cumulative total values for the EVA categories shown in Figure 6 and Figure 7.
2. Progress Monitoring Report

In accordance with Article II, Subsection 12, the Engineer shall submit each month a Progress Monitoring Report (PMR) for the Authority’s review and approval. The PMR shall contain the following information regarding the progress of work performed by the Engineer along with the earned value data specified in Section 1.

a. Schedule Tabular Reports and Cost Control Reports, which at a minimum shall include the following:

i. Predecessor/successor report sorted by Activity ID.
ii. Early Start/Total Float sort report.
iii. Total Float/Early Start sort report.
iv. Critical Path of Work sort report.
v. Summary by Cost Account sort report
b. A description of the design work completed during the reporting period;
c. Work items and paths that are critical to the timely completion of the design phase;
d. Anticipated work to start and finish during the next reporting phase;
e. Additional design scope items;
f. Explanations of schedule delays;
g. Anticipated problems and recommended possible solutions;
h. Critical action items (listing person/agency/company responsible and date needed);
i. Explanation of the SPI and CPI results in the PDS Update submitted by the Engineer;
j. Explanation of the variances between the previous PDS Update’s SPI and CPI results to the current results (See Sample Variance Analysis Report, Figure 8);
k. Statement of the adequacy of the remaining design budget and time;
l. EVA cost curve graph (Similar to Figure 5); summary analysis as shown in Figure 6; and
m. Project analysis report for WBS Level 4 categories (Figure 6); and
n. EVA summary analysis as shown in Figure 7.

The PMR shall also include a summary that explains the Basis of Design for each phase of the design. Basis of Design shall consist of a well-defined explanation that forms the basis of the Engineer’s inspection, test acceptance criteria, expected performance, and the operational requirements designed for the project and its systems.

After reviewing the PMR and the PDS Update with the project manager, the engineer shall submit both reports with its request for partial payment application.

3. Revisions to Project Design Schedules that Impact Earned Value Analysis

Earned Value Analysis

The Engineer shall incorporate the cost of the proposed change(s) into the EVA, which corresponds to the proposed PDS with the fragment. The EVA with the cost of the proposed changes shall be identified as the revised EVA for the PDSRV. The Engineer shall perform the revised EVA in accordance with Section 1. The Engineer shall submit a detailed report to the Authority for review. The detailed report shall include the results of the EVA, the cost curve graph, and discuss the effects of the proposed change on the Engineer’s Estimate-To-Complete (ETC) and Estimate-At-Completion (EAC) along with the earned value indexes shown in Figure 6. Upon issuance of an amendment for the change, the EVA that includes the cost for approved change(s) shall become the EVA for Revised Progress Design Schedule of Record. Design changes shall be in accordance with the Design Change Control process described in Section VIII. All design schedule changes shall be in accordance with Section III - Project Schedule.
In order for an EV system to operate properly, it must, at a minimum, meet the following 10 criteria:

**EVMS Criterion 1 - ANSI/EIA-748-B, 2.1(a) Organization:**

Define authorized work elements for the program. A work breakdown structure (WBS), tailored for effective internal management control, is commonly used in this process.

**EVMS Criterion 2 - ANSI/EIA-748-B, 2.1(b) Organization:**

Identify the program organizational structure, including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled.

**EVMS Criterion 3 - ANSI/EIA-748-B, 2.1(c) Organization:**

Provide for integration of the company’s planning, scheduling, budgeting, work authorization and cost accumulation processes and, as appropriate, the program WBS and organizational structure.

**EVMS Criterion 4 - ANSI/EIA-748-B, 2.2(a) Planning, Scheduling and Budgeting:**

Schedule the authorized work in a manner that describes the sequence of work and identifies the significant task interdependencies required to meet the requirements of the program.

**EVMS Criterion 5 - ANSI/EIA-748-B, 2.2(b) Planning, Scheduling and Budgeting:**

Identify physical products, milestones, technical performance goals or other indicators used to measure progress.

**EVMS Criterion 6 - ANSI/EIA-748-B, 2.2(c) Planning, Scheduling and Budgeting:**

Establish and maintain a time-phased budget baseline at the control account level against which program performance can be measured. Initial budgets established for performance measurement will be based on either internal management goals or the external customer-negotiated target cost, including estimates for authorized (but incomplete) work. Budget for long-term efforts may be held in higher level
accounts until it is appropriate for allocation at the control account level.

**EVMS Criterion 7 - ANSI/EIA-748-B 2.3(a) Accounting Considerations:**

Record direct costs consistently with the budgets in a formal system controlled by the general books of account.

**EVMS Criterion 8 - ANSI/EIA-748-B, 2.4(a) Analysis and Management Reports:**

At least monthly, generate the following information at the control account and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system:

1. Comparison of the amount of planned budget and the budget earned for work accomplished. This comparison provides the schedule variance.

2. Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.

**EVMS Criterion 9 - ANSI/EIA-748-B, 2.4(f) Analysis and Management Reports:**

Develop revised cost estimates at completion based on performance to date, commitment values for material and estimates of future conditions. Compare this information with the performance measurement baseline to identify variances at completion important to company management and any applicable customer reporting requirements, including statements of funding requirements.

**EVMS Criterion 10 - ANSI/EIA-748-B, 2.5(a) Revisions and Data Maintenance:**

Incorporate authorized changes in a timely manner, recording the effects in budgets and schedules. Base changes on the amount estimated and budgeted to the program organizations.
VARIANCE ANALYSIS REPORT

COMPANY:
PROJECT NAME:
PDS UPDATE NO.:
WBS LEVEL 4 DESIGN WORK:

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<th>COST VARIANCE RED FLAG</th>
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<td>(B)</td>
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<td>PLANNED VALUE</td>
<td>EARNED VALUE</td>
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<td>DATA DATE OF PDS</td>
<td>BCWS</td>
<td>BCWP</td>
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<td>CUMULATIVE</td>
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(1) CAUSE OF SCHEDULE VARIANCE:

(2) CAUSE OF COST VARIANCE:

(3) PROPOSED SOLUTION/CORRECTIVE ACTION:

(4) IMPACT ON PROJECT SCHEDULE / COST:

(5) COMMENT:

DESIGN CONSULTANT PROJECT MANAGER: ___________________________ DATE: ___________________________

PAGE ___ OF ___
V. GENERAL MANAGER REPORTS

General Manager Report Requirements 55

Sample 1 - Report 56
V. GENERAL MANAGER REPORT REQUIREMENTS

Every quarter, each Project Manager is required to prepare a project briefing report for the General Manager on all of their respective projects. These briefings should be limited to one page, using a second page only if absolutely necessary. Electronic files of completed reports shall be forwarded to Project Controls.

The briefing should indicate the stage the project is in: “Construction,” “Entering Construction this Calendar Year,” “Design,” “Development/Conceptual Design,” “On Hold,” or “Transit Oriented Development (TOD).”

For projects in “Construction,” the briefings shall be in narrative form. Provide the project name, location and contract number. Also provide a description of the scope of work. The narrative should identify the contractor, the contract award dollar value and the date the NTP was issued. Indicate the duration of the construction contract and its current anticipated completion date. A brief description of any recent progress, along with recent photos, should be included.

Projects “Entering Construction this Calendar Year,” “Design,” “Development/Conceptual Design,” and “On Hold,” the briefing shall also be in narrative form. The name of the project, a contract number, if applicable, the project location, a brief description of the scope of work, the designer and the design award date is required and should be provided. Also indicate when the 100% design submittal is due or was provided. Provide anticipated construction duration, completion date and estimated construction value. If applicable, any significant challenges facing the project should be mentioned, along with a photo or rendering.

For TOD projects, project name, developer, location, description of scope of work, anticipated construction start and finish and construction duration should be provided, along with a rendering or photo.

A sample report is provided (Sample 1).
The MBTA is currently executing Phase II of the Fairmount Corridor Improvements Program. As part of this program, four new commuter rail stations will be constructed to significantly increase ridership, and provide residents with a direct and convenient mode of public transportation; the first of these new stations is located in the vicinity of the Four Corners section of Dorchester, MA.

The Station is located between Washington Street and Geneva Avenue, approximately three and one-half miles from South Station. The station is below grade at the Washington Street end, and above grade at the Geneva Avenue end. The Station will be fully accessible with ADA compliant pedestrian connections to the proposed station platforms from both roadways. The accessible routes will consist of both sloped walkways and covered ramps. Benches will be installed every 200 feet or less along these routes.

The Station will consist of new 800-foot long high-level platforms, set four feet above the tracks allowing direct passenger boardings from platforms to train coaches. The platforms will include detectable warning strips, new steel canopies, benches, passenger shelters, a train approach warning system, variable message signs, and lighting. The Station will also be equipped with closed circuit television (CCTV) video cameras, police call back assistance system, and public telephones.

The project is approximately 73% physically complete. Major work elements completed this month excavation, lagging and crushed stone placement at Geneva Avenue Outbound Ramp Structure; completed installation of walers and struts at the Geneva Avenue Outbound Ramp Structure; completed installation of formwork, rebar and concrete placement at Retaining Wall B; installation of structural steel for inbound north end canopy and installation of twenty-two (22) precast platform panels.
<table>
<thead>
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<th>VI. ASSISTANT GENERAL MANAGER DESIGN REPORTS</th>
<th>Page No.</th>
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</thead>
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<tr>
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<tr>
<td>Design Report Template</td>
<td>59</td>
</tr>
<tr>
<td>Design Report Submittal Checklist</td>
<td>64</td>
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</table>
VI. ASSISTANT GENERAL MANAGER DESIGN REPORT REQUIREMENTS

AGM Design Reports are due to the AGM for Design and Construction on the first day of every new month. Project Managers are responsible to complete the reports and forward the reports to their respective Deputy Director for review. Upon their review of the report the Deputy Director shall forward the completed submitted report to the Executive Assistant of the AGM for Design & Construction.

Prior to submission, Project Managers are to ensure the following:

A. Current financial data is obtained from a Budget Analyst.
B. Use electronic Excel template for each Project. All fields are required to be filled in.

Note: The template contains some fields that have been preformatted. Do not add or delete any existing fields, but rows may be expanded as needed.

C. Create a Project Report folder and identify each project as a subfolder. Within the submission of a new report shall be the creation of a separate monthly tab.

Exhibit 1 is a copy the AGM Design Report template.

Exhibit 2 is a checklist used to determine which reports have been submitted. Late and outstanding reports are highlighted for tracking purposes.
AGM DESIGN REPORT
FOR PERIOD ENDING xxxxx

Contract Title:

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<th>Contract Number</th>
<th>Prime Designer</th>
<th>MBTA Project Manager:</th>
<th>Deputy Director</th>
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Contract Scope Summary Description

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<th>Design Substantial Completion Date at NTP</th>
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Milestone behind Schedule

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Schedule Exposure

Recovery Action

Describe Major Work in Progress

Issues/Action

% DBE Paid through Last
**AGM DESIGN REPORT**

**FOR PERIOD ENDING xxxx**

**Contract Title:**


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<th>Original Authorized Budget</th>
<th>Current Authorized Budget</th>
<th>Forecast-to-Complete</th>
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### Executed Change Orders/CQV's in CMS
- $\text{____}$

### Pending Change Orders/CQV's in CMS
- $\text{____}$

### Total with executed & Pending Change Orders/CQV's in CMS
- $\text{____}$

#### Pending Amendments not in CMS (list separately)

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**PENDING AMENDMENTS TOTAL VALUE**
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#### Pending Claims not in CMS

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**PENDING CLAIM TOTAL VALUE**
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**SUBTOTAL OF PENDING AMENDMENTS /CLAIMS NOT IN CMS**
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**Forecast Cost to Complete Total**
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**DESIGN SCHEDULE LOG**

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**Baseline Schedule:**

- Recovery

**Monthly Schedule Updates:**

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* Highlight Months for Project Report Submitted Late
VII. ASSISTANT GENERAL MANAGER
CONSTRUCTION REPORTS

Assistant General Manager Construction Report Requirements  66

Construction Report Template  67

Construction Report Submittal Checklist  73
VII. ASSISTANT GENERAL MANAGER CONSTRUCTION REPORT REQUIREMENTS

AGM Design Reports are due to the AGM for Design and Construction on the first day of every new month. Project Managers are responsible to complete the reports and forward the reports to their respective Deputy Director for review. Upon their review of the report the Deputy Director shall forward the completed submitted report to the Executive Assistant of the AGM for Design & Construction.

Prior to submission, Project Managers are to ensure the following:

A. Current financial data is obtained from a Budget Analyst.
B. Use electronic Excel template for each Project. All fields are required to be filled in.

Note: The template contains some fields that have been preformatted. Do not add or delete any existing fields, but rows may be expanded as needed.

C. Create a Project Report folder and identify each project as a subfolder. Within the submission of a new report shall be the creation of a separate monthly tab.

Exhibit 3 is a copy the AGM Construction Report template.

Exhibit 4 is a copy of AGM Construction Report submittal checklist. The checklist is used to determine which reports have been submitted. Late and outstanding reports are highlighted for tracking purposes.
AGM CONSTRUCTION REPORT
FOR PERIOD ENDING xxxxx

Contract Title: 

<table>
<thead>
<tr>
<th>Contract Number</th>
<th>Contractor</th>
<th>Deputy Director</th>
<th>MBTA Project Manager:</th>
<th>Design Consultant (if applic.):</th>
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<table>
<thead>
<tr>
<th>Contract Scope Summary Description</th>
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<table>
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<tr>
<th>NTP Actual Date</th>
<th>Substantial Completion Date at NTP (Base)</th>
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<table>
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<th>Original Contract Duration</th>
<th>Substantial Completion Date Forecast</th>
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<thead>
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<th>Actual % Complete</th>
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Exhibit 3
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<tr>
<th><strong>Schedule Exposure</strong></th>
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<th><strong>Recovery Action</strong></th>
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<th><strong>Describe Major Work in Progress</strong></th>
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<th><strong>Issues/Action</strong></th>
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<th><strong>Safety Issues or Incident that Occurred within Reporting Period</strong></th>
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<tr>
<th><strong>Outstanding Non Conformance Report</strong></th>
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<tr>
<th><strong>% DBE Paid through Last</strong></th>
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AGM CONSTRUCTION REPORT  
FOR PERIOD ENDING xxxxx

Contract Title: 

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### BUDGET SUMMARY

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### CONSTRUCTION COST TO COMPLETE BUDGET WORKSHEET

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#### Pending Change Orders not in CMS (list separately)

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**PENDING CHANGE ORDERS TOTAL VALUE** $0.00

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**PENDING CLAIM TOTAL VALUE** $0.00

**SUBTOTAL OF PENDING CHANGE ORDERS & CLAIMS NOT IN CMS** $0.00

**Forecast Cost to Complete Total** $0.00
## DESIGN COST TO COMPLETE BUDGET WORKSHEET

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**PENDING AMENDMENTS TOTAL VALUE** $0.00

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**PENDING CLAIM TOTAL VALUE** $0.00

**SUBTOTAL OF PENDING AMENDMENTS /CLAIMS NOT IN CMS** $0.00

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**$0.00**
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**CONSTRUCTION SCHEDULE REVIEW LOG**

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* Highlight Months for Project Report Submitted Late
### VIII. DESIGN CHANGE CONTROL

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<td>Change Request Log</td>
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VIII. DESIGN CHANGE CONTROL

1. Change Control

A. The Change Control process delineated in this section is to be used for requesting, reviewing, and documenting changes to the approved project baseline for design projects. Baseline changes may occur as a result of contractual modifications, application of undistributed budget, re-planning, or formal reprogramming. Managing change to the project baseline is crucial to ensure the project's work scope, schedule, and cost do not spiral out of control. Changes to baseline documents should be minimized and are normally approved only in the interest of work scope changes, design adequacy, reliability, performance, cost reduction, or safety/environmental considerations.

Actions pertaining to change control may affect earned value and schedule. Refer to Sections III and IV to determine incorporated requirements.

B. The purpose of the Change Control process is to ensure that:

- The cost, schedule, and technical impacts of the proposed changes are developed and considered by all affected parties.
- The collected evaluations are considered in the approval or rejection of the proposed changes.
- All affected parties are informed of proposed changes and their dispositions.
- Baseline documentation is controlled and updated as appropriate to reflect approved changes.
- Action on proposed changes occurs deliberately, but without undue delay and without interfering disproportionately with project progress.

C. The stated goals of the Change Control process are:

- To anticipate, recognize, and predict changes to the approved design project baseline
- To prevent unauthorized or unintended deviations from the approved project design baseline
- To evaluate and understand the technical, schedule, cost and safety/quality impacts of each change to the approved project design baseline
- To identify, understand, and control the consequences of changes to the approved project design baseline
- To ensure each change is evaluated, reviewed, and dispositioned at the proper authority level

2. Change Control Process
A. The Change Control process allows the project team to identify, evaluate, approve, and document proposed changes to the project baseline. The process is initiated with the generation of a Change Request. The Change Request is the formal mechanism for proposing and assessing a change, waiver, or deviation to the project. After an evaluation of the Change Request, an approval is granted at an appropriate level and the Change Request becomes an Amendment for implementation. The Amendment is expeditiously communicated to affected parties and incorporated in the project baseline documentation in an auditable manner. The Change Control process is accomplished in three phases: the Request Phase, the Review Phase, and the Documentation Phase. The Request Phase is where the Change Request originates and appropriate classification is determined. For the Review Phase, an assessment of the proposed Change Request is accomplished and approval is obtained from the appropriate authority level. Approved changes are implemented and integrated project baseline documents are revised in the Documentation Phase.

B. During the course of project execution, errors in accounting and cost/schedule databases can occur. Integrity of the Performance Measurement Baseline is vital to a clear understanding of project status. Retroactive changes to the performance measurement data are to be avoided. Action should be taken promptly when errors are identified. Adjustments can be made to correct accounting and data entry errors and do not require instituting the formal change request process. These adjustments will not be made to historical project data, only the current and future accounting periods.

3. Request Phase

A. The Change Control process begins with the generation of a Change Request form typically the MBTA PM will initiate the Change Request form. Some changes are considered design refinement within the designer’s original scope. The change management procedure only applies to changes that modify scope/program. Therefore, the PM needs to determine what kind of change is being requested in order to decide if a Design Extra Work Request Form should be submitted and this procedure followed. The Change Request is then submitted to the Director of Design. Upon concurrence, the Director signs the Change Request and forwards it through to the appropriate authorization level. The Change Impact Assessment section records the potential impacts of the proposed change to the project baseline and addresses safety/quality concerns. The assessment is to be all-inclusive and thorough, to ensure the consequences of implementing (or not implementing) the proposed change is fully understood.

B. Change Requests are numbered sequentially (scheme: FY - sequence #, e.g., 08-001) in order of receipt for tracking purposes. The Change Request Log is updated each time there is a change to the status of a Change Request.
4. Review Phase

A. The Review Phase is dictated by the Classification level of the Change Request. Changes are classified according to the extent that they impact the project baseline. The Budget Classification is determined by authorization levels.

B. During the review process, any rejected Change Request is sent back to the MBTA Project Manager who will determine further action.

5. Documentation Phase

A. The Documentation Phase is where the project baseline is revised and the approved change is implemented. Once the Change Request documents have been signed by the proper level of authority, a budget reallocation or amendment should be processed. The MBTA Project Manager is responsible for coordinating with the design consultants for the purpose of revising cost/schedule baseline documents for changes impacting these project baselines. When appropriate, a new project baseline will be generated for each approved Change Request. This action will improve traceability between the Change Request and the Schedule and Cost Management Systems.

B. Once the baseline documents are revised, the Project Manager updates the Change Request Log and implements the Amendment within his/her work scope.

6. Exhibits

1. Exhibit A - Change Request Form
2. Exhibit B - Change Request Log
Instructions for Change Request Form

Project Name: Self-explanatory.

Change Request #: This number will be filled in by PM. The forms will be numbered consecutively as they are received and will be entered into the Change Request Log.

Title: A brief descriptive title.

WBS #: Work Breakdown Structure Number(s) affected by the change.

Date: Originator enters the date for the submission of the Change Request.

Date Required: Originator enters the estimated date approval is needed to avoid adverse impacts on technical performance, schedule, cost or quality/safety.

Originator Name: Name of individual submitting the Change Request.

Item Name: Enter name of item or procedure (component, subassembly, assembly, system, test, etc.) to be changed.

Change Request Status: This field in the form lists the current status of the Change Request: New / Open / Deferred / Duplicate / Approved / Disapproved / Withdrawn

Description of Proposed Change: Describe the change requested. Use the continuation page, as required.

Justification for Proposed Change: Justify the proposed change. Describe the problem or defect that will be corrected by the proposed change. Indicate the experience that dictates the need for the change. Summarize the capability to make the change. Include the impact if the change is not approved. Use the continuation page, as required.

Change Impact Assessment: Provide a statement of impact to technical performance, schedule, cost, and quality/safety. Use the continuation page, as required.

Amendment: Change to a contract.

Transfer Amendment: Transfer funds between one or more contract actions, new scope.

Budget Reallocation: Reallocates funds within one contract action; does not involve new scope.

Classification Level: Authorization Level.

Recommendation and Disposition: Recommendations and decisions concerning the Change Request are documented in this section. Use the continuation page, as required.

Final Approval: Based on the Change Request classification, the project customer or appropriate project member will sign in the designated signature block.
MBTA

DESIGN EXTRA WORK REQUEST FORM

PROJECT NAME:________________________  CONTRACT #:______________________

CHANGE REQUEST #:_____________  TITLE:____________________________________

WBS #:_____________  DATE:_____________  DATE REQUIRED______________

ITEM NAME:_______________  CHANGE REQUEST STATUS____________________

1. DESCRIPTION OF PROPOSED CHANGE:

2. BASIS OF ORIGINAL DESIGN:

3. WHY WAS CHANGE NOT ANTICIPATED?

4. JUSTIFICATION OF PROPOSED CHANGE:
5. TECHNICAL/OPERATIONS IMPACT:

6. IMPACT IF CHANGE REQUEST NOT APPROVED:

7. SCHEDULE IMPACT:
   a) DESIGN:
   
   b) CONSTRUCTION:

8. COST IMPACT:
   a) DESIGN:
   
   b) CONSTRUCTION:

9. THIS CHANGE WILL REQUIRE?
   - [ ] AMENDMENT
   - [ ] BUDGET REALLOCATION
   - [ ] TRANSFER AMENDMENT
10. CLASSIFICATION LEVEL:

☐ DIRECTOR <$25,000
☐ AGM <$250,000
☐ GM <$1M

11. RECOMMENDATION AND DISPOSITION:

SUBMITTED BY: _________________________________  DATE: ________________

TITLE: _________________________________
CONCURRENCE: ____________________________________________

DIRECTOR OF DESIGN

APPROVED: ________________________________________________

AREA DIRECTOR

APPROVED: ________________________________________________

AGM OF DESIGN & CONSTRUCTION

ATTACHMENTS (CHECK IF ATTACHED):

_____ DESIGN EXTRA WORK ORDER REQUEST LETTER (FOR SIGNATURE)

_____ CMS REPORT CMS-PS-020 - ACTION LIMIT SUMMARY

_____ SUPPLEMENTAL AGREEMENT (SA) LIST BY CONTRACT

_____ REALLOCATION HISTORY

_____ LETTER FROM CONSULTANT (ADDRESSING ITEMS 1-9)
### Exhibit B

**Design Change Request Log**

Project Name: ____________________________________________________________

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# IX. RISK ANALYSIS

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<td>Risk Identification and Qualification</td>
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<td>Risk Management</td>
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<td>Implementation and Monitoring</td>
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IX. RISK ANALYSIS

Risk Analysis Process

Risk Analysis is the systematic evaluation of uncertainty about the scope, cost, and duration of an MBTA project. This uncertainty is in the form of risks that the project may encounter during the course of various design development and construction phases. It also can be in the form of unknown opportunities for improving the cost and schedule prospects for a project.

Risk Analysis offers a systematic, cost-effective approach for the MBTA to evaluate project uncertainty. This process provides valuable data about the project. The results from a Risk Analysis are an important management tool for the MBTA to manage and reduce project uncertainty through the mitigation of significant risks. The following are necessary components for an effective risk analysis:

- Validation of Base Conditions
- Risk Identification & Quantification
- Assessment (Modeling)
- Discussion/Review
- Risk Mitigation Planning (RMP)
- Implementation/Modeling

These six steps are divided into two parts. The first four steps comprise the Risk Assessment and the last two steps cover Risk Management.

1. Validation of Base Conditions

A risk analysis will be performed when projects reach 30% and 100% design. PM’s should notify MBTA Project Controls and request a Risk Workshop at 30% and 100% design. Project Controls will then assign a Risk Officer (RO) to manage the workshop in-house or require the design consultant to perform the service.

A minimum of three (3) weeks prior to the risk workshop, the design consultant shall provide MBTA Project Controls with the following documents in order to review the project and validate the base conditions.

1. Plans (no CD’s)
2. Specifications (no CD’s)
3. Estimate as required in Estimate section of Project Controls Manual
   a) CSI Format
b) Line #, CSI, MBTA Bid Item, Description, Labor, Materials, Equipment, Quantity, Unit, Hours, Crew, Unit Cost, Total Cost

c) Separate line items for General Conditions, Profit, Overhead, Bond, Design Contingency, Construction Contingency and Escalation.

d) Basis of Estimate, Exclusions and Assumptions

4. An anticipated Construction Schedule, as required in Section III.

   a) Full Schedule
   b) Critical Path
   c) Near Critical Path
   d) Milestones
   e) Work shifts (days, nights, non-revenue, shutdowns, etc...)

5. Design Schedule

6. List of potential risks

7. Project Budget

   a) Design
   b) Construction
   c) Force Account

2. Risk Identification and Quantification

The second step in risk assessment is identifying the risks that could affect the base scope, cost, and schedule.

Once the RO is selected, the PM and RO shall convene a group of individuals that have specific expertise and knowledge about the project. This group is known as the Risk Analysis Team for the project. The Risk Analysis Team shall include individuals involved in project design and planning, such as the design consultant, project scheduler and cost estimator.

After each member of the Risk Analysis Team evaluates and identifies the risks or opportunities associated with project, the Risk Officer shall schedule a workshop, known as the Risk Analysis Workshop. The duration of the workshop will depend on project size and complexity. A typical workshop will take one to two days.

Each member of the Risk Analysis Team along with key subject experts shall attend this workshop. The attendees shall discuss, assess, and quantify the risks identified by the team members. During the workshop, the RO shall define the workshop objectives, elicit comments, and summarize the conclusions of the Risk Analysis Team.
Using the information obtained from project scope validation and a risk checklist, the Risk Analysis Team develops a list of risks that are likely to affect the project under consideration. The risks identified by individual team members will then be discussed and augmented during the risk analysis workshop. After identifying the risk factors, the RO and Risk Analysis Team must document and record the risks for review and evaluation. The risks identified by the Risk Analysis Team are recorded in the risk register; a sample is provided (Sample 2).

In order to quantify the effect of risk, the Risk Analysis Team needs to consider the probability of occurrence of each risk event and the range of cost or schedule impact if the event occurs.

After the probability of occurrence of each risk event and the impact is determined, the risks shall be modeled using Monte Carlo simulation.

3. Risk Management

The RO shall provide the project with a report that includes:

- List of project risks ranked according to their significance.
- A quantified risk register and the histogram of possible project costs (and/or schedule delay) accompanied with a contingency analysis.

Each member of the risk team will review the report and provide feedback to the RO. When all feedback has been received, the task team will once again meet to begin developing strategies to mitigate the potential cost and schedule impacts of the risks. The risk team will determine which risks contribute to significant variance in total project cost and schedule and appropriately target risk mitigation measures.

Risk mitigation planning involves:

- Identifying unacceptable risks
- Identifying potential causes (risk drivers)
- Establishing implementation requirements (time, costs)
- Prioritizing risk mitigation strategies
- Assigning mitigation responsibility
- Allocating risks to owner, contractor, other parties

The Risk Mitigation Plan assists the Project Manager and Risk Analysis Team in making decisions to influence risks and taking cost-effective actions to reduce adverse risks and to realize opportunities. The process involves preparing an action plan that prioritizes risks, identifies the underlying causes of risk events, describe the likelihood of the risk events occurring, and develop strategies that can mitigate the potential impact of the risks to the
The Risk Mitigation Plan is the action plan with the most important tangible result of the overall risk analysis process. The summary outcome of the mitigation strategies are listed in a Risk Mitigation Register.

The mitigation register should only contain risks that can be mitigated. The register should include:

- Cost of mitigation strategy
- Probability of success of mitigation
- Party responsible for mitigation

Performing risk analysis allows the project management team to determine an appropriate monetary contingency for the project. The risk analysis will also determine the appropriate project duration.

4. Implementation and Monitoring
After risk mitigation measures are established and assigned to responsible parties, MBTA management must give final approval to implement the recommended measures. Approvals and decisions on the implementation process should be initiated as early as possible to minimize the cost of implementation, which is likely to increase as the project advances. The risk review is requested again when the project reaches 100% Construction Documents.

Throughout the life of the project, PM’s are required to monitor and manage risks.
### Risk Identification

<table>
<thead>
<tr>
<th>Risk #</th>
<th>Phase</th>
<th>Risk Desc.</th>
<th>Risk Outcome</th>
<th>Quantitative Analysis</th>
<th>Impact Effect</th>
<th>Mitigation Response Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>CN</td>
<td>Different Site Condition</td>
<td>DN,P,CN</td>
<td>Cost</td>
<td>Time</td>
<td>H</td>
</tr>
<tr>
<td>38</td>
<td>CN</td>
<td>Hazmat</td>
<td>Hazardous material inside vault; trace of PCB</td>
<td>Cost</td>
<td>Time</td>
<td>L</td>
</tr>
<tr>
<td>39</td>
<td>CN</td>
<td>Relocating CCTV equipment doesn't work when relocated; contractor blames MBTA</td>
<td>Cost</td>
<td>Time</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>

### Sample 2

**HINGHAM INTERMODAL RISK REGISTER**

<table>
<thead>
<tr>
<th>Risk #</th>
<th>Phase</th>
<th>Risk Desc.</th>
<th>Risk Outcome</th>
<th>Quantitative Analysis</th>
<th>Impact Effect</th>
<th>Mitigation Response Action</th>
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<tbody>
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</table>

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**Risk Identification**

- **Risk #**: Identifies each risk with a unique number.
- **Phase**: Indicates the phase of the project where the risk is identified.
- **Risk Desc.**: Describes the nature of the risk.
- **Risk Outcome**: Outcomes associated with the risk.
- **Quantitative Analysis**: Analysis of cost and time impact.
- **Impact Effect**: The effect of the risk on the project.
- **Mitigation Response Action**: Actions to mitigate the risk and achieve the desired outcome.
X. CONSTRUCTABILITY REVIEW

Guideline for Constructability Review 93

Constructability Review Waiver Form 97
X. CONSTRUCTABILITY REVIEW

The MBTA recognizes the need for contract documents that will ensure rational bids and minimize problems during construction. The Constructability Review Process (CRP) establishes a formal, as well as a routine plan review. These reviews have the potential to minimize the number and magnitude of changes, disputes, cost overruns, and delays during construction. They are conducted to determine that the design is constructible with conventional construction techniques, without undue difficulty or expense, or, if the design is unusual, that a construction methodology exists or is developed prior to release of the design. It is also a form of QA/QC to ensure that major elements of the project have received a thorough review prior to the completion of the 100% PS&E package.

The CRP must be flexible enough to be applied to all types of projects handled by the Authority. Furthermore, the process must address the critical issues impacting today's transportation construction projects such as, ease of construction, environmental factors, construction phasing and scheduling, and project safety.

To obtain maximum benefit from a constructability review, PM must assure that it is initiated early enough to give the reviewers and others sufficient time to review the project, and then sufficient time to allow the designers to incorporate the recommended revisions. Therefore, when designs reach 60% completion each MBTA project shall undergo a constructability review. The 60% design phase provides reviewers a nearly complete detailed plan to allow a constructability review. However, for large projects, the Assistant General Manager of Design and Construction may want to consider doing reviews during earlier phases of the design.

The CRP must be flexible in order to adapt it to specific project characteristics and requirements. A key factor in determining the scope or type of the CRP is project complexity. Typically, total project cost and total work-hour effort reflects a level of complexity. Projects located in an urban setting and those involving reconstruction or grade separation are often more complex. Projects that involve many interfaces with other government agencies, utilities, the public, local officials etc. may indicate a higher level of complexity.

Typically, the Design Engineer is required to have an independent consultant perform a review of the 60% design. An independent constructability review is a formal review of all project data and documents by a specially selected independent team. On occasion, the Authority may elect to have one of its Constructability Consultants perform the review through a task order prepared by Project Controls.

Constructability Consultants shall preclude themselves from bidding the work they perform constructability reviews for. Project Managers shall obtain from the selected Constructability Consultant a signed and dated statement precluding themselves bidding said work if they are performing the constructability review.
The constructability review team will be comprised of individuals with experience in the various aspects of design and construction required for the project at hand. The size of the team will depend on the complexity, regional significance and the number of experts from other program areas needed to conduct an effective and timely review.

The PM shall notify Project Controls a minimum of three (3) weeks in advance prior to initiating constructability reviews and also provide all the documents associated for this review. Project Controls will participate in all Constructability Reviews.

The Constructability Consultant selected to perform the constructability review will receive a thorough briefing of the project by the project designer and examine the project site (if appropriate). The Constructability Review shall receive all available pertinent reference materials, including but not limited to, the design document, advanced detail plans, cost estimate, environmental studies, traffic maintenance and traffic management plan, right of way, construction phasing, site investigation, any special specifications or special notes, the construction schedule, baseline data, utility & railroad agreements if available. The reviewer(s) will address as a minimum, each of the items listed in the “GUIDELINE FOR CONSTRUCTABILITY REVIEW” that applies to the project (Exhibit C).

At the completion of the review, the Constructability Reviewer shall prepare a report addressing, at a minimum the topics outlined in this guideline. The completed report shall be submitted to the PM and Project Controls. After review and consideration of the recommendations contained in the report, the Design Engineer must document the reasons for their course of action concerning each recommendation and provide a copy to the Constructability Review team, Project Manager, and Project Controls.

Constructability reviews, as currently conducted, should reduce the number of change orders, delays and disputes during construction, resulting in a net savings for the Authority.

Project managers can request a waiver from the above requirement by providing justification and submitting a Waiver Request form as shown in Exhibit D. Provide MBTA Project Controls with a copy of all Constructability Waivers.
### GUIDELINE FOR CONSTRUCTABILITY REVIEW

<table>
<thead>
<tr>
<th>Description</th>
<th>YES</th>
<th>NO</th>
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<th>MORE INFO NEEDED</th>
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<tbody>
<tr>
<td><strong>A. BIDDABILITY</strong></td>
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<tr>
<td><em>The clarity of the final plan and proposal to the bidders so that they may submit a fair and accurate bid.</em></td>
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<td>1. Are bidders unnecessarily restricted in their bids, or has the appropriate degree of flexibility been included in the bidding documents?</td>
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<td>2. Information sufficient to avoid major field changes?</td>
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<td>3. Coordination and agreements with appropriate agencies/parties?</td>
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<td>4. Permits been identified and sufficient time allowed to secure?</td>
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<td>5. TMP adequate and complete?</td>
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<td>6. TMP too restrictive?</td>
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<td>7. Items appropriate?</td>
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<td>8. Items omitted?</td>
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<td>9. Cross referencing between various contract documents consistent?</td>
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<td><strong>B. BUILDABILITY</strong></td>
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<tr>
<td><em>The accuracy and completeness of the contract plans so that the design as shown on the final plans can be built</em></td>
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<tr>
<td><strong>A. Site Investigation</strong></td>
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<tr>
<td>1. Sufficient field investigation been done to ascertain that contract work can be performed as shown on plans?</td>
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<td>2. Current site survey (horizontal &amp; vertical controls)?</td>
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<td>3. Subsurface exploration?</td>
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<td>4. Utility investigation?</td>
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<td>5. Current traffic counts?</td>
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<td>6. Structural inspection?</td>
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<td>7. Emergency/interim structural repairs been considered?</td>
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<td>Description</td>
<td>YES</td>
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<td>MORE INFO NEEDED</td>
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<tr>
<td><strong>B. Right of Way</strong></td>
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<tr>
<td>1 Sufficient R.O.W. available for all operations</td>
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<td>2 Equipment, material and hazardous waste storage?</td>
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<td>3 Staging?</td>
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<td>4 Field Office?</td>
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<tr>
<td>5 Access requirements?</td>
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<tr>
<td>6 Access to work areas?</td>
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<tr>
<td><strong>C. Construction Staging</strong></td>
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<tr>
<td>1 Phased to provide minimum number of stages and reasonable work areas and access?</td>
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<td>2 Are there areas with restricted access?</td>
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<td>3 Are widths of work zones and travel lanes adequate?</td>
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<tr>
<td>4 Does staging cause special conditions (i.e., structural adequacy/stability)?</td>
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<td>5 Proposed adjacent contracts, restrictions, constraints identified and accounted for?</td>
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<tr>
<td>6 Can the details as shown on the plans be constructed using standard industry practices, operations and equipment?</td>
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<tr>
<td><strong>D. TMP/Traffic Control</strong></td>
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<tr>
<td>1 TMP requirements realistic for site conditions?</td>
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<tr>
<td>2 Are lane closures reasonable for traffic volumes?</td>
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<tr>
<td>3 Adequate provisions for access for pedestrians and abutting properties?</td>
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<tr>
<td>4 Signing and traffic control adequate?</td>
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<tr>
<td>5 Can construction operations be carried out safely under TMP and staging?</td>
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<tr>
<td>6 Design adequate for averting delays /congestion?</td>
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<tr>
<td>7 Is a detour necessary for averting delays /congestion?</td>
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</tbody>
</table>
### E. Schedule

1. Length of time and production rates for work reasonable?  
2. Is sequence of construction reasonable?  
3. Seasonal limits on construction operations?  
4. Utility relocation schedule reasonable?  
5. Regulatory permit restrictions?  
6. Processing of shop drawings and related approvals?  
7. Materials ordering, fabrication and delivery requirements  
8. Restricted hours impact on production?  
9. All necessary construction operations identified?  
10. Relationship with adjacent contracts?  
11. Impact of additional work (emergency structural repairs, additional quantities of concrete/steel repair)?  
12. Time related specs - completion / milestone realistic?  
13. Night and weekend work proposed, and impacts considered?

### F. Special Materials / Conditions

1. Pertinent provisions and restrictions clearly indicated?  
2. Any special (unique / proprietary) materials, methods of technologies required for contract?  
3. Special coordination required, RR, Permits, Regulatory  
4. Presence of asbestos, hazardous waste or toxic materials?  
5. Safety requirements, fall protection, electric lines, and other utilities, RR requirements  
6. Winter concreting and the schedule for delivery of concrete?
<table>
<thead>
<tr>
<th>Description</th>
<th>YES</th>
<th>NO</th>
<th>NA</th>
<th>MORE INFO NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>C General</td>
<td></td>
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<tr>
<td>1 Ensure MBTA Operation/Operation Support understands how and when construction will take place.</td>
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<tr>
<td>2 Is Value Engineering performed on the project?</td>
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<tr>
<td>3 Ensure Value Engineering incorporated if it was performed?</td>
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<tr>
<td>4 Review the economic viability of selected materials and products.</td>
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<tr>
<td>5 Check that selected materials are available and appropriate for the anticipated work conditions.</td>
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<tr>
<td>6 Review unique conditions and material transitions to insure clear and detailed delineation.</td>
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<tr>
<td>7 Review all project drawings and specifications for clarity, completeness, coordination, economic feasibility, and schedule impact. The review shall provide assurance that plans and spec are consistent and do not contradict themselves and that vague or incomplete requirements are avoided.</td>
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<tr>
<td>8 Make certain adequate provisions are provided for access, staging, and storage of waste and supplies; parking for worker and construction vehicle, and mitigation of environmental impacts during construction.</td>
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<tr>
<td>9 Pay attention to the requirements of the public including adjacent land use functions, existing transit patrons, and persons with disabilities.</td>
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<tr>
<td>10 Determine requirements for Authority-provided services, and utility connections.</td>
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<tr>
<td>11 Clearly define procedures for scheduling outages and the reasonableness of utility relocation efforts.</td>
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<tr>
<td>12 Verify requirements for QA/QC during construction.</td>
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<tr>
<td>13 Verify accurate depictions of site conditions with regard to access, utilities, ROW, soils, and general configuration</td>
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<tr>
<td>14 Maximize constructability, recognizing the availability and suitability of materials and the standards of practice of the construction resources.</td>
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<tr>
<td>15 Eliminate construction requirements that are impossible or impractical to build.</td>
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</tbody>
</table>
Constructability Review Waiver

Contract #:__________________________________________________________

Description:________________________________________________________

Project Manager:______________________________________________________

Date:_______________________________________________________________

All projects are required to undergo the process of a constructability review when they reach the 60% design stage, unless a waiver is requested. The project is formally requesting a waiver from the constructability requirement shown above. Please provide a reason for the waiver request in the allotted space below:

____________________________________________________________________
____________________________________________________________________
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____________________________________________________________________
____________________________________________________________________

Print Name:________________________________________________________

Signature:___________________________________________________________ Date:_____________________

[ ] Approved  [ ] Denied

___________________________________________________________ Date:_____________________

AGM for Design and Construction
XI. VALUE ENGINEERING

Cost Threshold 99

Scheduling and Team Selection 99

Value Engineering Waiver 102
XI. VALUE ENGINEERING

The Federal Transit Administration (FTA) encourages agencies to utilize Value Engineering techniques on all construction projects. Value Engineering (VE) is a systematic, multi-discipline approach designed to optimize the value of each dollar spent on a project. To accomplish this goal, an independent team of architects/engineers identifies, analyzes and establishes a value for a function at the lowest total cost (capital, operating, and maintenance) over the life of a project consistent with the requirements of performance, reliability, maintainability, safety and esthetics.

Project Managers are responsible for complying with the VE Program requirements as outline in this section. Project Design Engineers are responsible to provide study materials and address study recommendations by implementing accepted recommendations and providing justification for unaccepted recommendations.

Project Controls is responsible for coordinating the VE workshops, serving as a liaison between the project and VE Consultants and developing and processing Task Orders associated with the VE effort.

1. Cost Threshold

Projects with construction costs over $2M require a VE study. A waiver from the VE requirement may be requested by filling out the attached VE Waiver form and submitting it to the AGM for Design and Construction for approval (Exhibit E). Provide MBTA Project Controls with a copy of all VE Waivers.

2. Scheduling & Team Selection

Scheduling:

The highest return on the VE effort can be expected when a VE workshop (or study) is performed early in the design process before major decisions have been completely incorporated into the design. Value Engineering should occur when design reaches 30%. Value Engineering may occur earlier in the design stage for some large, complex projects that the FTA defines as a major capital project typically involving design of a new fixed guideway at a cost in excess of $100M. In that case, two (2) VE workshops will be held. The first VE workshop should be conducted at the 10% level and the second at the 30% design level. Contact Project Controls to arrange a VE study.

Team Selection:

Project Controls will select a consultant to perform the VE study. After receipt of a task order, the VE Consultant will propose a VE Team, which should consist of
the Team Leader and technical experts. The technical experts shall have the expertise to evaluate the major areas of design included in the project scope. The VE Consultant Team Leader shall be a Certified Value Specialist (CVS) with experience in managing the VE process for transportation system facilities.

A. Value Engineering Study

All VE studies shall be conducted in accordance with the following methodology as prescribed by AASHTO VE Guidelines and SAVE International. Each study will have three distinct parts:

- **Pre-Study Activities** - Gather information, select Team, develop cost model, finalize logistics and agenda, review all project documents, conduct site visit, and coordinate with the designer who shall present a project overview to the VE Team.

- **VE Study** - Typically a 5-day workshop, but could be less for smaller projects.

- **Post-Study Activities** - Prepare Preliminary Report, conduct Implementation meeting and prepare Final Report.

B. Required Study Elements

The following items shall be required of the VE Team:

1. Define the original project objective.
2. Identify the design criteria for the project.
3. Verify all valid project constraints.
4. Identify specifically the components and elements of high cost.
5. Determine basic and secondary functions.
6. Evaluate the alternatives by comparison.
7. Consider life cycle cost of alternatives.
8. Determine high risk factors (cost and/or schedule).
9. Develop a detailed implementation plan.
10. Define which VE alternatives can be implemented and which stand alone. The VE Team shall select which combination of developed solutions is being specifically recommended.
11. VE studies for design build projects shall review the proposed RFP.
12. VE studies for bridge projects shall consider bridge substructure requirements based on construction materials, evaluation using life cycle costs and construction duration, and evaluation of acceptable bridge design based on sound engineering and economic considerations.

C. VE Study Report
The VE report shall be organized in sections by areas of focus consistent with the VE job plan. The format of any report should contain at a minimum the following:

1. Executive summary
2. Participant list
3. Research sources
4. Project history (including project criteria, commitments and constraints)
5. Potential Study Areas
6. Existing design description
7. Performance Criteria
8. Evidence that a function analysis was performed
9. Cost Model
10. Life cycle cost estimate
11. VE Alternative Description
12. VE Alternative Cost calculation
13. Risk register
14. Evaluation by comparison
15. Proposed design
16. Detailed findings or analysis
17. Specific recommendations and costs
18. Design suggestions
19. Implementation Plan
20. Final report to include a summary section that includes the study findings

D. Post Workshop

The VE Consultant forwards a VE report to MBTA Project Controls for review. The report will then be forwarded to the PM and Design Consultant. The Design Consultant reviews the report.

After the review, the Design Consultant prepares a document that details which VE options were chosen, the cost to implement the VE options and what cost savings were achieved. This document is also forwarded to MBTA Project Controls.
Exhibit E

Value Engineering Waiver

Contract #:__________________________________________________________

Description:________________________________________________________

Project Manager:_____________________________________________________

Date:_______________________________________________________________

All projects over $2 Million are required to undergo the process of value engineering when they reach the 30% design stage*. The project is formally requesting a waiver from value engineering requirements shown above. Please provide a reason for the waiver request in the allotted space below:

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______________________________________________________________

Print Name:_________________________________________________________

Signature:___________________________________________________________ Date: ________________

☐ Approved                             ☐ Denied

______________________________________________________________ Date: ________________
AGM for Design and Construction

*Major capital projects are encouraged to undergo the process of value engineering at the 10% design stage.
XII. LESSONS LEARNED

Lessons Learned Overview 104
Lessons Learned Form 106
XII. LESSONS LEARNED

OVERVIEW

In accordance with FTA requirements of sharing experiences gained in the planning, design, construction and revenue operations of major capital transit projects, the Design and Construction Department has mandated the incorporation of Lessons Learned on every MBTA project.

Lessons Learned can potentially produce higher quality projects while saving time and cost and help the project team share knowledge gained from experience so that the entire organization may benefit. A successful Lessons Learned program will help project teams:

- Repeat desirable outcomes
- Avoid undesirable outcomes

Project Managers are required to record Lessons Learned throughout the life cycle of each project. The form, Exhibit F, should be submitted quarterly - an exception of this would be when there is a safety incident, in which case, the form will need to be filled out immediately. A minimum of one (1) Lessons Learned, for each project, from each PM, is due at the end of each quarter. The data that is compiled will be available for PM’s and design consultants to review as they are assigned new projects or as projects enter new phases. Completed Lessons Learned should be sent to Project Controls.

During project close-out, PM’s are required to archive Lessons Learned with project records.
Instructions for Lessons Learned Form

Limit one (1) form per Lesson Learned.

Project Managers are encouraged to document as many lessons learned as possible in an effort to share their experiences with others.

Lessons Learned are submitted quarterly to Design & Construction Project Controls. Only new lessons learned, created within the corresponding quarter are submitted.

QTR: Provide year and appropriate quarter.

Project Title: Self-explanatory.

Contract #: If project is in design, provide design contract number. If project is in construction, provide construction contract number.

Lessons Learned #: For the duration of design, each lesson learned shall have a unique designated number. Numbering shall be sequential. The same applies to projects in construction.

Date: Indicate date Lessons Learned is recorded.

Project Delivery Method: Self-explanatory.

Phase: Choose one phase Lessons Learned applies to.

Project Classification: Choose appropriate project classification.

Lessons Learned Category: Determine which category the Lessons Learned issue applies to. What was the root cause of the issue? Choose one.

Title of Lesson Learned: The project lessons should be descriptively titled to allow the reader to understand the lesson content through the title alone.

Lessons Learned: Describe the issue surrounding the lesson. This should include just enough information to facilitate understanding the lesson.

Background: Briefly describe product. What happened during the execution of the project that brought to light the deficiency or need to create or modify a process, procedure, plan and/or specification?

Lessons Learned Recommendation: How would you improve or avoid the situation? What would you do differently?

Applicability: When or where can this particular Lessons Learned be used?

Submitted By: Individual completing the Lessons Learned form.

Telephone # & Email: Self-explanatory.
## Lessons Learned Form

**QTR. 20____**

<p>| | | | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>1.</td>
<td>Project Title: ____________________________</td>
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<td>2.</td>
<td>Contract #: ________________________________</td>
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<td>3.</td>
<td>Lessons Learned #: __________________________</td>
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<td>4.</td>
<td>Date: __________</td>
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<td>Design - Bid - Build</td>
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<td>Design Build</td>
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<td>CM @ Risk</td>
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<td>6.</td>
<td>Phase:</td>
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<td></td>
<td>Conceptual Design of 15%</td>
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<td></td>
<td>Preliminary Design 15% - 60%</td>
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<td>Final Design 60% - 100%</td>
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<td>Procurement</td>
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<td>Construction</td>
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<td>7.</td>
<td>Project Classification:</td>
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<td></td>
<td>System Improvement</td>
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<td>Maintenance Facility Improvement</td>
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<td></td>
<td>Parking Lot</td>
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<td>New Elevator</td>
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<td>Roadway</td>
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<td>Replacement Elevator</td>
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<td></td>
<td>Commuter Rail</td>
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<td>Light Rail Right-of-Way</td>
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<td>Noise Wall</td>
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<td>Heavy Civil</td>
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<td></td>
<td>Building Demo</td>
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<td>Signal/Comm./Power</td>
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<td>Lessons Learned Affected Category:</td>
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<td>Management</td>
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<td>9.</td>
<td>Is this a safety related lesson?</td>
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<td>Yes</td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

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10. Title of Lessons Learned: 

11. Background:

12. Lessons Learned Challenges (what needs improvement or what went well?):

13. Lessons Learned Recommendations (how would you improve or avoid or why do you think it went so well?):

14. Applicability:

Submitted by: 

Telephone #: Email:
XIII. **PROJECT MANAGER FILING SYSTEM**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
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<tbody>
<tr>
<td>Project Manager Filing System Overview</td>
<td>109</td>
</tr>
<tr>
<td>Project Manager Flow Charts</td>
<td>110</td>
</tr>
</tbody>
</table>
XIII. PROJECT MANAGER FILING SYSTEM

OVERVIEW

In order to maintain proper documentation and proper archiving throughout a project life cycle, the following standard format shall be followed.

The filing system for projects shall be divided into two phases: Design phase and Construction phase.

The Design phase of the project shall then be subdivided into 2 categories; Pre-design (PDN) and Design (DN).

The Construction phase shall be subdivided into two categories: Pre-construction (PCN) and Construction (CN).

See Figure 9, 10 and 11 for more details. The first 2 letters shall represent the project name abbreviation, i.e. SL (Shoreline Bridge), followed by the phase of the contract (PDN, CN etc...) and the sequential number for each document.

![Project Manager Filing System Diagram]

**Figure 9**
Project Manager Filing System

Design Phase

Contract No. "xx"

Pre-Design (PDN)

XX.PDN-001 LOI
XX.PDN-002 RFP
XX.PDN-003 RFQ
XX.PDN-004 Budget Concurrence Memo
XX.PDN-005 Public Announcement
XX.PDN-006 Authorization Cover Memo
XX.PDN-007 Selection Committee
XX.PDN-008 Proposal Evaluation Sheet & Scoring
XX.PDN-009 Letter to Selected Firm

XX.DN-001 Award Documents
XX.DN-002 Amendments
XX.DN-003 Reallocations
XX.DN-004 PDG Meetings
XX.DN-005 Design Reports (EVM)
XX.DN-006 Project Design Schedules and Updates
XX.DN-007A 0-15% Plans/Specs/Review Comments
XX.DN-007B 15-30% Plans/Specs/Review Comments
XX.DN-007C 30-60% Plans/Specs/Review Comments
XX.DN-007D 60-90% Plans/Specs/Review Comments
XX.DN-007E 90-100% Plans/Specs/Review Comments
XX.DN-010 Contract Document/Plan/Spec/Addendum
XX.DN-011 Conformed Documents
XX.DN-012 VE Reports
XX.DN-013 IA Agreements
XX.DN-014 P.I. Agreements
XX.DN-015 Utility F.A. Agreements
XX.DN-016 MBTA F.A. Agreements (TRS)
XX.DN-017 Letter from Design Consultant
XX.DN-018 Letter to Design Consultant
XX.DN-019 Design Meeting
XX.DN-020 Real Estate Acquisition
XX.DN-021 Peer Reviews
XX.DN-022 DPS, Fire Approvals
XX.DN-023 Variances
XX.DN-024 Pre-bid Control Sheets w/back-up
XX.DN-025 Anticipated Construction Schedule from Designer
XX.DN-026 Change Management Document and Log
XX.DN-027 Bid Escrow Task Order
XX.DN-028 Misc. Files:
  - AGM Report (Design)
  - Budget Documents
  - Consultant Evaluation
  - Errors & Omissions
XX.DN-029 Invoices
XX.DN-030 Lessons Learned

Design (DN)

Figure 10

Construction Phase

Contract No. "xx"

Pre-Construction (PCN)

XX.PCN-001 Prebid
XX.PCN-002 Notice of Award
XX.PCN-003 Pre-Award Meetings
XX.PCN-004 Preconstruction
XX.PCN-005 NTP

XX-CN-006 Construction Baseline Schedule and Updates
XX-CN-007 Schedule Workshop Meeting
XX-CN-008 Progress Meeting Minutes
XX-CN-009 Letters from Contractor
XX-CN-010 Letters to Contractor
XX-CN-011 Memo to File
XX-CN-012 Subcontractor Approval
XX-CN-013 Submittal Log
XX-CN-014 RFILog
XX-CN-015 RFIS
XX-CN-016 Shop Dwg Log
XX-CN-017FCN/Construction Change Directives (Modifications)
XX-CN-018 FCN Log
XX-CN-019 Misc. Correspondence (external stakeholder) to MBTA
XX-CN-020 Misc. Correspondence (external stakeholder) from MBTA
XX-CN-021 Change Order
XX-CN-022 EWOL
XX-CN-023 Claims
XX-CN-024 Photos/Videos
XX-CN-025 Contractor Schedule of Values
XX-CN-026 Meeting (misc.)
XX-CN-027 Misc. Files:
  - AGM Report (Construction)
  - Budget Documents
  - Contractor Evaluation
  - Errors and Omissions
XX-CN-028 Lessons Learned
XX-CN-029 Form 6, 7, 8 & 9
XX-CN-030 Contract Closeout Documents
XX-CN-031 As-built
XX-CN-032 Q and M Manuals
XX-CN-033 Certifications
XX-CN-034 Pay Requisitions
XX-CN-035 MBTA Contracts
XX-CN-036 MBTA Agreements

Construction (CN)

Figure 11
XIV. REFERENCES

2. Association for the Advancement of Cost Engineering International - Cost Estimating & Budgeting; Basis of Estimate Recommended Practice #34R-05
6. Department of Health and Human Services Policy for Earned Value Management (June 11, 2007)
7. Massachusetts Highway Department’s Value Engineering S.O.P No. HED-09-09-1-000 (2009)

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