QUALITY MANAGEMENT SYSTEM GUIDELINES

FTA

Federal Transit Administration

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Individual	Case Study
Winifredo M. Alfelor	Case Study 1: Cost of Quality
Kevin Diviness	Case Study 4: Denver FasTracks
Debra Hebisen	Case Study 5: DART Light Rail Project

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List of Acronyms

AA	Alternatives Analysis
A2LA	American Association for Laboratory Accreditation
ACI	American Concrete Institute
ANSI	American National Standards Institute
AQL	Acceptable Quality Level
ASQ	American Society for Quality
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BRT	Bus Rapid Transit
CATS	Charlotte Area Transit System
CLRL	Central Light Rail Line
CM	Construction Manager
CM/GC	Construction Manager/General Contractor
CMC	Construction Management Consultant
CNYRTA	Central New York Regional Transportation Authority
CQCS	Contractor Quality Control System
CQE	Certified Quality Engineer
CTA	Chicago Transit Authority
DART	Dallas Area Rapid Transit
DB	Design-Build
DBOM	Design-Build-Operate-Maintain
DCD	Design and Construction Division
DOD	Department of Defense
DTCG	Denver Transit Construction Group
ESA	East Side Access
FFGA	Full Funding Grant Agreement

FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FTC	Franklin Transportation Center
GEC	General Engineering Consultant
ILAC	International Laboratory Accreditation Cooperation
IFB	Invitation For Bid
IPS	Integrated Project Schedule
ISO	International Organization for Standardization
LAP	Laboratory Accreditation Program
LRT	Light Rail Transit
MCP	Major Capital Project
MDMTA	Maryland Mass Transit Administration
MDT	Miami-Dade Transit
MTA	Maryland Transit Administration
MTACC	Metropolitan Transportation Authority Capital Construction
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology
NVLAP	National Voluntary Laboratory Accreditation Program
NYCT	New York City Transit
OEM	Original Equipment Manufacturer
OP	Oversight Procedure
PE	Preliminary Engineering
PCGA	Project Construction Grant Agreement
PMO	Project Management Oversight
PMOC	Project Management Oversight Contractor
PMC	Project Management Consultant
PMP	Project Management Plan
PM	Project Manager (or Program Manager)
QA	Quality Assurance

QC	Quality Control
QMS	Quality Management System
REE	Rail Equipment Engineering
RFP	Request For Proposals
RTD	Regional Transportation District of Denver
SAS	Second Avenue Subway
SEPTA	Southeastern Pennsylvania Transportation Authority
SFRTA	South Florida Regional Transportation Authority
SPC	Statistical Process Control
SQA	Software Quality Assurance
SSMP	Safety and Security Management Plan
TCRC	Tri-County Commuter Rail
TRIMET	Tri-County Metropolitan Transportation District of Oregon
UPRR	Union Pacific Railroad
VQS	Vendor's Quality System
VSDP	Vendor's Software Development Process
WMATA	Washington Metropolitan Area Transit Authority

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EXECUTIVE SUMMARY

The *Quality Management System Guidelines* were first published in 1992, and subsequently updated in 2002, as the *Quality Assurance and Quality Control Guidelines*. This constitutes the second update to the original document. These *Quality Management System Guidelines* are for Federal Transit Administration (FTA) grantees that are undertaking design, construction, or equipment acquisition programs. They may also be used as a guideline for grantees in establishing a Quality Management System (QMS) related to their Operations and Maintenance (O&M) programs.

FTA requires grantees undertaking major capital programs to prepare a Project Management Plan (PMP), which includes a Quality Plan. The Quality Plan should be developed in concert with the PMP. Even for smaller projects, a Quality Plan can be a useful management tool for developing and specifying activities to ensure project quality.

For grantees undertaking multiple projects, the development of a Project Quality Plan should be an outgrowth of a functioning QMS. A comprehensive QMS is comprised of a written quality policy, quality plan, written procedures, and support from both management personnel and other staff.

Chapter 1 provides an introduction to quality including relating these *Guidelines* to ISO 9001 standards, guideline objectives, definitions, and an overview of various other quality topics as they may relate to transit projects. Chapter 1 also includes a brief historical overview of quality, a description of quality as it relates to the project lifecycle, a description of quality costs and quality tools, and possible barriers to the successful implementation of a quality program.

A description of FTA's 15 essential elements of a QMS is given in **Chapter 2**. The elements should be taken into consideration when developing a Quality Plan, Manual, or any related procedure. The 15 elements, originally derived from the 20 elements of the ISO 9001:1987 standard, are as follows:

1. Management Responsibility
2. Documented Quality Management System
3. Design Control
4. Document Control
5. Purchasing
6. Product Identification and Traceability
7. Process Control
8. Inspection and Testing
9. Inspection, Measuring, and Test Equipment
10. Inspection and Test Status
11. Nonconformance
12. Corrective Action
13. Quality Records
14. Quality Audits
15. Training

This update to the 2002 *Guidelines* has placed additional focus on the establishment of quality objectives (or goals), increased the scope of document control, and stressed the importance of continual improvement, in addition to corrective and preventive action. It is important to note that the exact numbers and names of the 15 elements have been retained in this revision since many grantees and contractors have developed their Quality Plans that contain 15 chapters with the same titles as the 15 elements.

Although it may be helpful to structure the quality manual or procedures in accordance with these elements as many grantees and contractors have done, organization of the quality functions for the organization or project should be tailored to the organizational needs and management structure of the grantee. It is not mandatory that a Quality Plan be structured corresponding to the 15 elements, only that the Quality Plan incorporate the concepts of the 15 elements.

Chapter 3 discusses alternative approaches to organizational structures for different types of projects. No matter what organizational structure is utilized on a project, or what consultants or contractors may be involved, the grantee has overall responsibility for the QMS and must maintain oversight and/or a Quality Assurance (QA) function on the project. It is important that quality personnel remain objective and independent from other project functions. Chapter 3 also includes an overview of the use of Independent Assurance Programs and sections on Test Lab Accreditation and Software Quality Assurance.

The development of a Project Quality Plan is the focus of **Chapter 4**. Initially developed along with the PMP during the project planning phase, the Project Quality Plan is a living document, which evolves over the project lifecycle, going into appropriate levels of detail at each stage. Chapter 4 includes specific information on what the Project Quality Plan should cover during each of the following phases of the project lifecycle:

- Project Planning
- Preliminary Engineering and Final Design

- Construction and Equipment Procurement
- Testing and Start-up

When developing project-specific forms, procedures, or plans, it should be noted that existing grantee quality documents can be tailored to fit the needs of the project through minor changes. This approach is often quicker than starting from scratch, and can also be more advantageous as it provides a better uniformity and more traceability to other organizational documents.

Several appendices provide more information that may be of help to grantees. **Appendix A** provides examples of FTA's 15 essential QMS elements as contained in various grantee quality manuals and/or procedures. These examples accompany text explaining why they were included. Each of the 15 examples is provided to illustrate how various grantees relate their quality documentation to the FTA elements. Sometimes, the text from these examples may not cover all aspects of that element as written in Chapter 2 of these *Guidelines*. However, they still meet the basic intent of that element. **Appendix B** is new to this update of the *Guidelines* and outlines the 15 elements as they may apply to a grantee's Operations and Maintenance programs. **Appendix C** provides several case studies which stress the importance of quality in transit projects and can also serve as lessons learned for future projects.

It is important to remember that quality improvement need not stem from action taken to correct issues as they arise. Using the quality tools outlined in these *Guidelines*, grantees can work to continually improve their capital projects throughout the project lifecycle.

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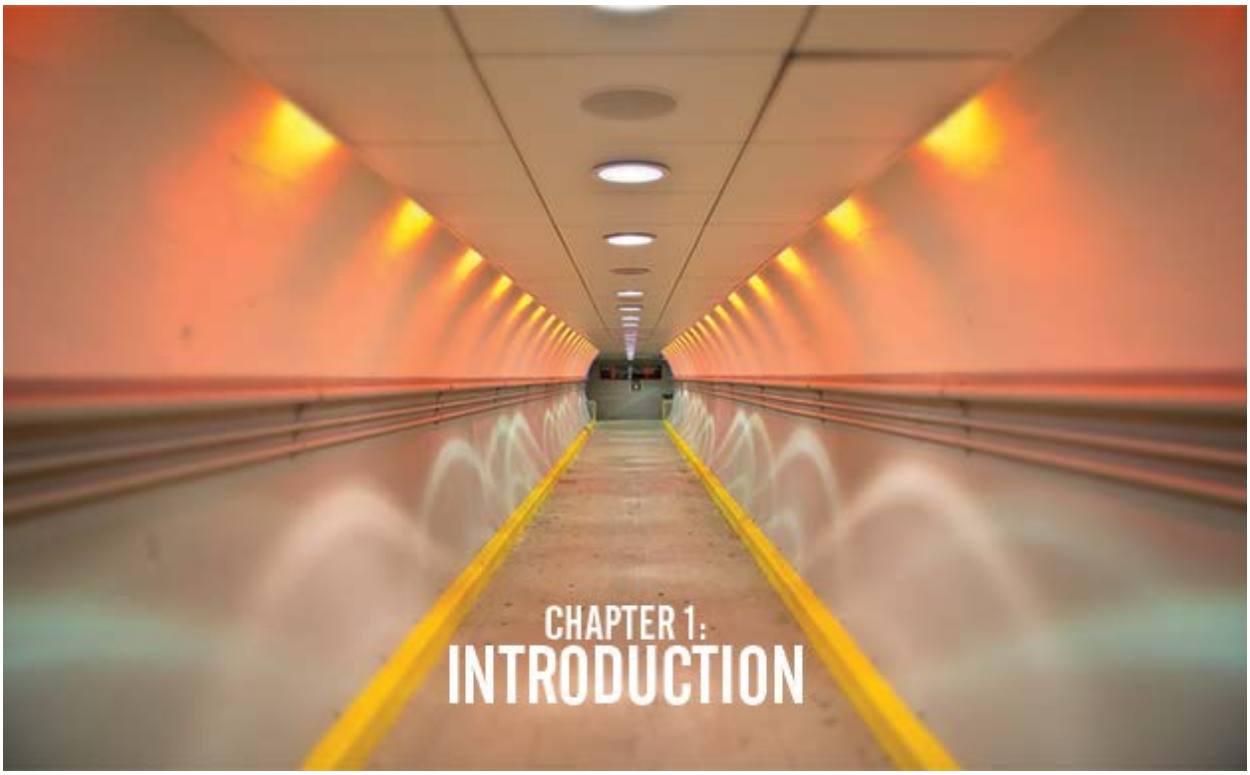


1.1 Objectives and Background

These *Guidelines* were originally developed in 1992 and updated in 2002 (then called the *Quality Assurance and Quality Control Guidelines*) under the Federal Transit Administration (FTA) sponsorship to assist each transit agency in developing its Quality Management System (QMS) and plans for its FTA-funded transit capital improvement projects. For this reason, these *Guidelines* are focused on quality management as it applies to capital projects, though it does cover many other aspects of quality in transit agencies. FTA regulations require each FTA funded major capital program to submit a Program Management Plan (PMP) for FTA approval. These regulations also stipulate that a Quality Plan must be referenced or included as part of the PMP.

FTA maintains oversight for the grants that it awards, but assigns the grant administration and management responsibility to the grantees. FTA's Office of Program Management delegates the responsibility for oversight of nearly all capital grants to the appropriate FTA Regional Office.

The *Quality Management System Guidelines* is one of several initiatives undertaken by FTA to enhance the management of the projects that it funds. The initiatives have included guidance to grantees on topics such as insurance and risk management; the continued development of the *Construction and Project Management Guidelines*, and assignment of Project Management Oversight Contractors (PMOC) to perform oversight and provide input to FTA. Project Management Oversight means the monitoring of a major capital project's progress to determine whether a project is on time, within budget, in conformance with design criteria, constructed to approved plans and specifications and is efficiently and effectively implemented. The roles and

responsibilities of the PMOC are defined in the FTA's Project Management Oversight Procedures (OPs).

The *Construction and Project Management Guidelines* and the *Construction Project Management Handbook* each include a brief description of Quality Assurance (QA) and Quality Control (QC) as a part of a management control system. They describe some aspects of both QA and QC as they apply to a Quality Program in Preliminary Engineering (PE), final design, construction, testing, and start-up, as well as some of the management responsibilities that will be assumed by quality personnel.

This *Quality Management System Guidelines* document expands upon the Quality Program guidance contained in other documents. Its major purpose is to promote the development of a grantee's QMS consistent with contemporary FTA practices, to affect successful implementation of projects.

Before undertaking the original 1992 effort, information was gathered through the PMOCs to determine the state of Quality Programs for FTA funded capital improvement projects. As of 2012, all of the larger grantees have mature Quality Programs and staffs both dedicated to and familiar with quality requirements and activities. In 2012, the title of the *Guidelines* was changed to refer to the QMS rather than QA and QC, because guidance is not only offered for these activities, but for the system as a whole, including how it is integrated with the management of the project itself in capital projects.

This chapter defines a number of quality concepts, gives a historic overview of their development and their relationship, and discusses quality in the context of project and construction management. This chapter also includes a description of what makes up an effective QMS; perspectives on quality from the standpoint of the service provider and user; a description of the inter-relationships and balances among quality, cost, and schedule; an overview of the barriers to quality and suggested resolutions; and directions for using these *Guidelines*.

1.2 Quality Definitions

Following are definitions of various terms used in the quality field:

Table 1-1: Quality Term Definitions

Quality Policy	The overall quality intentions and direction of an organization with regard to quality, determined by top management. The ISO 9001:2008 quality standard specifies that a Quality Policy will be appropriate to the purpose of the organization, provide a framework for establishing quality objectives, and be communicated and understood within the organization.
Quality Objectives	Objectives or goals, related to quality. ISO 9001:2008 specifies that objectives should be measureable and consistent with the Quality Policy.
Quality Management System (QMS)	The American Society for Quality (ASQ) defines the QMS as "A formalized system that documents the structure, responsibilities and procedures required to achieve effective quality management."

Quality Management	ASQ defines Quality Management as "The application of a quality management system in managing a process to achieve maximum customer satisfaction at the lowest overall cost to the organization while continuing to improve the process."
Quality Procedures	Written instructions for implementing various components of the QMS. Procedures should identify what is to be done; who should do it; and how, where, and when it should be done.
Quality Plan	The typical form of the main document used in developing and implementing a QMS. The Quality Plan should contain the Quality Policy, objectives, and written procedures. In larger properties, there can be more than one Quality Plan. For example, there could be a corporate quality plan, divisional quality plans, and specialized quality plans for design, procurement, construction, operations, and maintenance activities, with each prepared by those responsible for the work.
Quality Program	The coordinated execution of applicable Quality Plans and activities for a project.
Quality Control (QC)	Techniques that are used to assure that a **product or service** meets requirements and that the work meets the product or service goals. Generally, QC refers to the act of taking measurements, testing, and inspecting a process or product to assure that it meets specification. It also includes actions by those performing the work to control the quality of the work. Products may be design drawings/calculations or specifications, manufactured equipment, or constructed items. QC also refers to the process of witnessing or attesting to, and documenting such actions.
Quality Assurance (QA)	QA emphasizes actions **at a management level** that directly improve the chances that QC actions will result in a product or service that meets requirements. QA includes ensuring the project requirements are developed to meet the needs of all relevant internal and external agencies, planning the processes needed to assure quality of the project, ensuring that equipment and staffing is capable of performing tasks related to project quality, ensuring that contractors are capable of meeting and carrying out quality requirements, and documenting the quality efforts.
Quality Oversight (or Quality Surveillance)	Oversight can be defined as watchful care or general supervision. Quality oversight can range from an informal process of keeping in touch with the QA organization to a second layer of QA activities, depending upon the circumstances. Quality oversight verifies the execution of the Quality Program. Quality surveillance generally refers to the same actions included in quality oversight.

Major Capital Project	A Project that: 1 Involves the construction of a new fixed guideway or extension of an existing fixed guideway; 2 Involves the rehabilitation or modernization of an existing fixed guideway with a total project cost in excess of $100 million; or 3 The Administrator determines what is a major capital project because the project management oversight program will specifically benefit the agency or the recipient. Typically, this means a project that: i. Generally is expected to have a total project cost in excess of $100 million or more to construct; ii. Is not exclusively for the routine acquisition, maintenance, or rehabilitation of vehicles or other rolling stock; iii. Involves new technology; iv. Is of a unique nature for the recipient; or v. Involves a recipient whose past experience indicates to the agency the appropriateness of the extension of this program.

1.3 A Historical Overview of Quality

Dating back to the early crafts, product quality was a very personal product characteristic. Craftsmen earned their reputation by producing quality goods for each customer. With the industrial revolution and mass production, the one-to-one relationship between craftsmen and customer was gone. Specifications or standards for how to produce a product became the substitute for the craftsman's personal touch. QC was the function of inspecting the end product to determine if it met the specification or standard.

Standards became important not just to ensure that pieces fit together, but also to ensure the safety of the final product. As early as 1914, the American Society of Mechanical Engineers (ASME) developed codes for boilers and pressure vessels. Use of these standards for boilers resulted in fewer failures, even as performance improved.

Quality standards began to be applied to the nuclear industry in the late 1940's, and in 1954, the ASME published ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*. This publication listed eighteen criteria for a QA program. In the nuclear industry, QA refers to the entire quality process.

In the 1950's, the Japanese adapted the statistical QC procedures promoted by W. Edwards Deming, and the managerial performance approach advocated by Joseph M. Juran. These concepts combined with a highly educated Japanese work force, and with the Japanese approach to continual quality improvement, led to Japan establishing itself as the leader in quality in the electronics and automobile industries. The real push for Quality Programs in the United States came in the 1960's, when Secretary of Defense Robert McNamara introduced the concept in the Department of Defense (DOD). The idea eventually spread to the construction sector of DOD and the Corps of Engineers instituted its own program in the late 1960's.

The Japanese went beyond concepts of QC and reliance on inspection and testing, to the point where high quality work is expected from the start. Japanese corporations expect an extremely high level of quality from their suppliers, and long-term relationships are built with those suppliers

that can meet quality expectations. The Japanese use management techniques to involve the entire work force in quality improvement efforts. They make a continuing effort to understand the desires of the customers to ensure that they are “building the right thing as well as building it right”. The Japanese now have a program that encompasses a total QMS.

Since 2000, many large companies have implemented other quality approaches, such as ISO 9000 and Six Sigma, a more statistical-based approach, which has additional focus on controlling quality through continual improvement. The FTA and these *Guidelines* refer to quality as an overarching system which includes aspects of both QA and QC, along with management focus on achieving objectives through continual improvement of its systems.

1.4 Quality in the Context of Project and Construction Management

The function of project and construction management is to assure acceptable quality while executing the project on time and on budget. For an FTA grantee, acceptable quality has a several definitions, one of which is meeting the needs of the FTA, other stakeholders, and the public, as well as satisfying all of the regulatory and operational requirements outside and within the grantee’s agency.

The major reason for emphasizing the need for a Quality Plan/Objectives, in addition to the PMP requirement, is to explicitly recognize the importance of quality, while keeping it both objective and separate from (while still integral to) other project management functions. The job of project management is to manage scope, schedule, budget, and quality of a project. However, since quality measures are often best made from a separate, objective viewpoint, it helps to have a management structure that retains this objectivity. Some examples of management structures for various project types are shown in Chapter 3.

1.5 Quality Management System (QMS)

Transit projects can involve many processes that vary in nature: planning, engineering design, systems design, software development, construction, and manufacturing. The manufacturing industry, which generally utilizes processes that are repetitive in nature, can more easily make use of quality programs that are based on statistical QC techniques. The statistical nature of these types of quality programs facilitates process improvements through continual efforts.

Planning, engineering design, and construction, on the other hand, often involve "one of a kind" projects where a QMS that emphasizes effective management practices is more appropriate. Similarly, software development and systems design are related processes that each requires their own unique QMS and specialized quality tools and procedures.

1.5.1 Characteristics of a QMS

An effective QMS is not just one where good products and services are delivered. Rather, it is one that continuously seeks to improve the products and services being delivered and the corresponding delivery processes used by the organization. In order to establish an effective QMS, the following characteristics are required:

- **Leadership –** Adopting a Quality Policy, instilling a culture that values quality, involving all levels of management in quality initiatives, identifying a senior Quality Manager (QM), providing resources and personnel to accomplish quality objectives, delivering products and services that always meet customer expectations.
- **Design Quality and Prevention –** Developing products and services that meet customer expectations and reduce life cycle cost.
- **Strategic Quality Planning –** Establishing a vision for the future of where and what the organization wants to be and developing a Plan to arrive at that destination.
- **Focus on Customer Satisfaction –** Clearly identifying internal and external customers, their requirements, and making decisions that support the commitment to meet those requirements.
- **Continual Improvement –** Identifying key areas for improvement, whether they are products and services or processes.
- **Teamwork and Employee Participation –** All employees participate to the best of their ability and within the bounds of their areas of expertise to deliver products and services that meet requirements for performance, cost, and schedule.
- **Training and Development –** All persons at all levels within the organization receive basic and advanced quality training relative to their functional and managerial responsibilities within the organization.

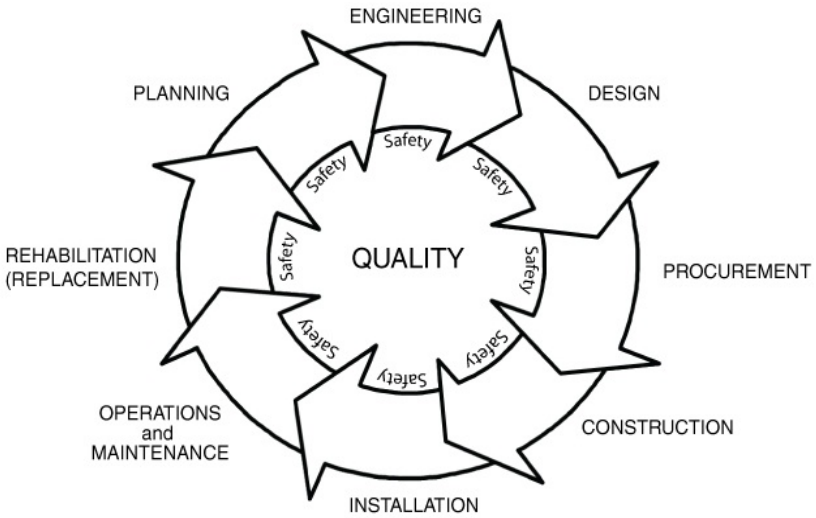


Figure 1-1: Quality and the Project Lifecycle

Quality should be involved in all stages of project design and implementation, including being an integral member of the grantee's management organization, separate from projects themselves. It is important to note that individual elements of the grantee's QMS are introduced into projects at different stages, so quality does not start nor does it stop with the projects themselves.

Figure 1-1 illustrates the project lifecycle. Quality, along with safety, remains at the core of any project phase during the lifecycle. Quality does not start/stop before and after design and construction. It is a constant.

1.5.2 Involvement

The goal of a QMS is to be pervasive throughout the transit agency. As a result, every person within the organization must participate to the extent that his or her job responsibilities dictate. This includes members of grantee senior management, functional management, and project management; functional and office staff; and shop and field personnel. In addition, all consultants, contractors, and suppliers must adhere to the QMS. Some, such as testing labs, may have their own Quality Plan or certification, which must conform to that of the grantee organization. Others may choose to adopt the grantee's Quality Plan in some respects, or submit their own quality system to conform. In all of these cases, the consultant/contractor/supplier becomes an extension of the grantee's QMS.

1.5.3 Implementation Process

In order to implement an effective QMS, the following general steps should be followed:

- Senior management must commit to the development of a QMS. All personnel should receive introductory and advanced training, as applicable, on general and specific quality topics.
- Organizational objectives must be defined and followed.
- Customer expectations and requirements must be defined.
- Data related to the products, services, and the delivery processes must be gathered and analyzed. The results of the analyses must be used to improve services.
- Feedback must be provided to the responsible managerial and functional areas for further process improvement.

1.5.4 Tools

There are many tools available to Project Managers (PMs), also referred to as Program Managers, and project and quality personnel to solve problems, control processes, improve products and services, and assure project success. A summary of those tools may be grouped into two broad categories:

- Statistical Quality and Process Control Tools
    - Process Analysis/Flow Diagrams
    - Check Sheets
    - Pareto Analyses/Charts
    - Histograms
    - Cause and Effect Diagrams, also known as Fishbone or Ishikawa Diagrams

    - Run Charts
    - Scatter Diagrams
    - Control Charts
    - Acceptance Sampling

- Project-related Tools
    - Pre-Activity and Coordination Meetings
    - Progress Meetings
    - Quality Meetings
    - Partnering
    - Constructability Reviews
    - Design Reviews
    - Value Engineering
    - Risk Assessment
    - Status Reports
    - Action Item Lists
    - Inspections
    - Nonconformance Reports
    - Corrective and Preventive Actions
    - Brainstorming
    - Benchmarking
    - Peer Review
    - Quality Audits/Oversights

1.5.5 Root Cause Analysis

The tools identified in Section 1.5.4 will assist the PM or quality staff in identifying quality and other problems. Once a problem is identified, it is necessary to determine the cause of that problem. Sometimes the cause is not so obvious and the PM or quality staff must look further to determine the actual cause. It is important to note that there are often cases where a direct "cause" is apparent, but the actual cause is an issue that stems from the same root cause. For that reason, this process is known as Root Cause Analysis.

Root Cause Analysis is the concept of analyzing a problem beyond the obvious symptoms manifested by the problem, and identifying the actual cause of the problem. A piece of equipment that is not able to produce product to the specified tolerance, at first glance, may appear to require adjusting, or replacement. However, the root cause of the problem could very well be operator error, incorrect drawings, unrealistic requirement, incorrect material, factory conditions, or some combination of all of these (sometimes there may be more than one root cause). Fixing the most obvious condition may not solve the problem and could result in further complications or delays. Consequently, all possible conditions and combinations must be explored before a problem can truly be eliminated. Note that this is true whether the problem involves a piece of equipment, a process, or an individual.

One useful technique for determining root cause is the "5 Whys", used in many organizations and originally developed by Japanese industrialist Sakichi Toyoda. This technique suggests that one should continue to ask "why" in order to properly identify an issue's root cause. Although the technique suggests that one should ask this question five times to determine root cause, the question may be asked more or fewer times in practice, depending on the issue. The point of the

technique is to remind the user of the depth that cause-effect relationships can have, and how that depth may not always be apparent. The actual root cause, when discovered, will often point towards a process or system issue.

Other techniques used in root cause analysis include the Cause and Effect Diagram (also known as the Fishbone or Ishikawa Diagram)

1.6 Quality from Service Provider and User Perspectives

It is important to take into account differing perspectives with regard to quality in the transit industry, specifically that of the service provider (see Section 1.6.3) and the user (see Section 1.6.4). Depending on what a person sees or values in a product, or process, or project, the definition of quality can vary vastly. It is virtually impossible for all parties to agree on one definition that satisfies everyone, due to their different places in the organization and their focus in the project. Given the inherent "subjective" nature of the definition of quality, it is often important to identify specifications for acceptance, or Acceptable Quality Levels (AQLs).

Quality objectives are more often met (or exceeded) when agencies employ performance specifications in their procurement documents. By focusing on the functional elements of the end product, rather than the detailed characteristics of each subcomponent, the owner agency provides the contractor/manufacturer with the needed flexibility to utilize its expertise in delivering a quality product that will not only meet the owner agency's expectations, but do so in a cost effective manner.

1.6.1 Product Characteristics

Each grantee project will have its own unique objectives and product characteristics or design features, even in those cases where the project involves similar product deliveries, such as buses or rail vehicles. A quality project or product is one that delivers to the grantee all of these features in a timely, cost effective manner. Not only must the product contain the requisite features, but also these features must effectively integrate and operate within the surrounding infrastructure in which the product will be used. As a result, the quality of the system or product should be evaluated, not as a stand-alone unit, but as an integrated system. Additionally, the delivered project or product should be evaluated in light of its associated support materials, such as documentation, training, test equipment, and spare parts. Although the user and service provider will view most of the product characteristics similarly on the surface, the underlying product characteristics and support material will not be viewed at all by the user. Individual product characteristics are too numerous to list, but may be broadly described as features related to the product's design and its associated support materials.

1.6.2 Service Characteristics

In addition to product characteristics, each grantee project will require its own unique service characteristics. These service characteristics, when viewed by the service provider, will differ from those that will be expected by the user of the system. They differ in the sense that they represent the service delivered by the consultants, contractors, suppliers, etc. on the project. The user, on the other hand, views service characteristics by how well the service provider performs.

Although some of the language that describes quality may be the same, e.g., on-time performance, the deliverer of the service will differ. Essentially, in one case the grantee is the recipient of the service and in the other case the grantee is the deliverer of the service. Some of the service characteristics are:

- Reliability
- Dependability
- Availability
- Responsiveness
- Competence
- Courtesy
- Credibility
- Security
- Accessibility

1.6.3 The Service Provider

The service provider is generally the transit agency or port authority that provides transit services to the public. The grantee and transit agency are generally one and the same. However, within the transit agency is a broad range of functional and administrative departments, all of which are typically customers and service providers to one another. For example, the construction management and engineering departments are typically involved in the procurement of systems and equipment that will be used by the operations department to deliver service to the riding public. Thus, the construction management and engineering departments are providing a service to the operations department that is providing a service to the public. Reversing the process, the operations department must provide their operating requirements to the construction management and engineering departments so that they can be translated into contract specifications.

At the opposite end of this cycle is the maintenance department that also provides a service to the operations department. Each of these departments, along with all those departments not explicitly mentioned, report to or provide a service to the administration of the transit agency. Thus, it is safe to assume that every individual in the transit agency is a “service provider” in some capacity – operations, engineering, construction, maintenance, procurement, etc. A department that receives a service from another department is an internal customer.

1.6.4 The User

The user of the system is the public. In most cases, the public has the option to use or not use the services offered by the transit agency. Thus, the transit agency is competing for the dollars that will be spent by the public on transportation. These dollars are vital to the long-term success of the transit agency and thus, the user is a necessary component to that success. The public is one of several external customers.

1.6.5 Benefits to the Service Provider

When transit projects are successfully accomplished in a quality fashion, they offer the following benefits to the service provider:

- Successful, within-budget, on-time projects
- Reliable, safe, dependable equipment
- Effective, easy-to-use support materials
- Lower life cycle costs for materials, maintenance, etc.
- Involved, interested, satisfied work force
- Increased ridership
- Opportunities for growth
- Increased funding
- Improved image
- Transit-supporting public

1.6.6 Benefits to the User

When transit projects are successfully accomplished, they offer the following benefits to the user:

- Transportation that is accessible, easy-to-use, reasonably priced, reliable, safe, and dependable
- Transit alternatives that offer less stress and more peace of mind

1.7 Inter-relationships and Balances among Quality, Cost, and Schedule

1.7.1 Quality Attributes or Dimensions

As noted in Section 1.6 above, the definition of quality varies depending on who is doing the defining, be it grantee, customer, consultant, contractor, or supplier. Nevertheless, it is imperative that the grantee clearly identify the "attributes or dimensions of quality" in its contract specification and purchase orders. By so doing, the grantee can make clear to its consultant, contractor, or supplier its quality expectations and it will maximize the probability that the product or project that it is procuring will satisfy its needs. Examples of quality attributes that can and should be specified include:

- **Performance** – A project's main operating or functional characteristics
- **Conformance** – How the project will be measured as meeting the contract specification
- **Reliability** – The mean time or distance between failures
- **Maintainability** – The mean time to repair
- **Availability** – The percent of time the system is available for service
- **Aesthetics** – Appearance, color, etc.
- **Features** – Functionality, beyond the main operating or functional characteristics
- **Durability** – Ability to adapt to ambient conditions
- **Safety** – Freedom from hazards
- **Warranty** – Guarantee of freedom from defects for a specified period of time
- **Service Life** – Expected time prior to major overhaul of the system

In addition to specifying these quality attributes, it is imperative to specify the support materials that will allow the service provider to cost effectively maintain the system in a manner that will assure continued delivery of quality service to the user of the system. Examples include:

- **Documentation** – Drawings, maintenance and operator manuals
- **Training** – Maintenance (primary and secondary) and operator
- **Test equipment** – Primary and secondary
- **Recommended** staffing levels
- **Spare parts**

1.7.2 Quality Costs

Quality costs fall into two broad categories, the price of conformance and the price of non-conformance. The price of conformance is also known as the cost of detection and can be further divided into prevention costs and appraisal costs. The price of nonconformance is also known as the cost of lesser quality and can be further divided into internal failure costs and external failure costs. Table 1-2 and Table 1-3 identify examples of each of these categories.

As shown in Tables 1-2 and 1-3, quality costs cover a wide spectrum and occur during all phases of the project. Although most nonconformance costs are borne by the contractor, the grantee may also experience unwanted costs as a result of nonconformance, such as loss of revenue, project personnel cost increases due to longer project duration, and extra costs associated with work performed by the grantee's own personnel (force account) supporting the contractor. In addition, overall life cycle costs for such items as maintenance and spares will typically be higher for the grantee as a result of nonconformance issues that could not be resolved.

Grantee costs associated with conformance quality activities include design, process and document control, inspection and testing, and audits and training.

Table 1-2: Quality Costs - Price of Conformance/Cost of Detection

Prevention Costs (Associated with assuring the product or project meets requirements)	Design analysis & reviews Constructability reviews Training Prototyping Systems analysis Planning activities Value Engineering Preparation of: ▪ Project Management Plan (PMP) ▪ Quality Plan ▪ Risk and Contingency Management Plan ▪ Safety and Security Management Plan (SSMP) ▪ Real Estate Acquisition Management Plan

Appraisal Costs (Associated with determining the degree of product or project conformance)	Audits Design checking Supplier inspection Incoming inspection In-Process Inspection Final Inspection Field inspection Testing Reliability/maintainability/safety analysis & testing

Table 1 -3: Quality Costs - Price of Nonconformance/Cost of Lesser Quality

Internal Cost of Defects or Failures (Associated with problems discovered prior to product or project delivery)	Assessment costs Scrap Repair Rework Downtime Schedule delays Cost of extended financing
External Cost of Defects or Failures (Associated with problems discovered after product or project delivery)	Warranty repair costs Product Recalls Customer complaints Product liability costs Transportation costs Labor, equipment, and materials Decrease in ridership

1.7.3 Balancing Quality, Costs, and Schedules

It is evident from Table 1-2 that the conformance activities are not just related to quality, but also fall into the category of good project management practices. Thus, it is difficult to clearly define how much is being spent on quality activities. Nevertheless, industry studies have shown that preventing defects avoids or reduces unwanted project costs and improves delivery performance. One rule of thumb is that every dollar spent on prevention saves ten dollars in appraisal and failure costs. Further, quality expert Philip Crosby, in his 1979 landmark book, *Quality is Free*, espoused the philosophy that the cost of poor quality is greater than the cost of preventing it. Thus, he concluded that quality improvement efforts will more than pay for themselves.

Grantees are generally both consumers and providers of products and services. If the grantee accepts a poor design or approves nonconforming workmanship that does not satisfy its own requirements, it can be certain that the resulting product or service will not meet the requirements of its customers, the public. This can have serious consequences resulting in the loss of ridership, the potential for liability, the loss of productivity, and an increase in life cycle costs.

Quality-related efforts are beneficial to the success, overall cost, and delivery performance of the project; therefore, PMs must demonstrate diligence when making decisions that affect the quality-related efforts outlined in the 15 quality elements.

1.8 Barriers to Quality and Suggested Resolutions

1.8.1 Management Awareness

Managers have the responsibility for guiding the organization. They set the direction for the organization, establish the goals, and inspire the attitudes that drive their individual teams toward accomplishing the organization's mission. Most employees will focus on issues that they believe are of primary concern to their managers. This attitude moves up and down the chain of command. There is no doubt that management is interested in providing quality products and services to their clients; however, the degree of interest is directly proportional to the actions of management. Simply put, actions speak louder than words and merely saying that a manager is interested in quality is not enough. Rather, grantee managers must:

- Establish a Quality Policy, quality objectives, Quality Plans and quality procedures/work instructions
- Provide leadership of, and actively participate in, business/quality initiatives
- Provide the necessary resources to accomplish project/quality objectives
- Install an infrastructure that assures contractual/quality requirements are accomplished
- Make decisions that support an emphasis on quality and long-term goals

1.8.2 Cost and Schedule Concerns

At the project level, PMs are still faced with day-to-day decisions that must balance their short-term requirements with the agency's long-term goals. Furthermore, although Section 1.7 purports that the long-term benefits of quality far exceed the short-term costs, PMs are generally evaluated annually on their short-term performance. This may tend to impact their decision-making. The following **suggestions** may help to mitigate this concern:

- Senior management should be educated as to the wisdom of focusing on quality and the need to keep encouraging it
- Life cycle costing should be used to evaluate decisions in lieu of simply using project costs
- Senior management should support decisions that favor long-term cost considerations rather than short-term project costs
- PMs should be evaluated on the long-term implications of their decision-making
- Project quality management should be organized so that decision-making is reported to, and can be supported by, transit agency quality management
- Project objectives should be clearly established, and decision-making, when possible, should be directed toward meeting these overarching objectives

1.8.3 Resistance to Change

Many people and organizations are apprehensive of change and consequently are slow to change. It is usually when the negative consequences of not changing outweigh the consequences of changing that change takes place. In fact, it was only after the Japanese auto industry successfully applied quality improvement concepts and posed serious competition to the American auto industry that quality began to make serious strides in the United States. Thirty years later the FTA required grantees to incorporate quality concepts in their projects and the

result has been the successful application of these concepts and improved project performance. Thus, we can see how slowly change can take place.

Even though significant strides have occurred, there is still room for improvement in the transit industry. Some of the rules suggested by quality guru Joseph Juran to avoid resistance to change include:

- Select the right time to start
- Work with the recognized cultural leadership
- Start with small quality-related initiatives
- Provide participation in quality-related activities at all levels within the organization
- Provide enough time for change to take affect
- Avoid surprises that can negatively affect the outcome
- Treat people with respect and dignity
- Deal directly with the resistance

1.8.4 Lack of Training

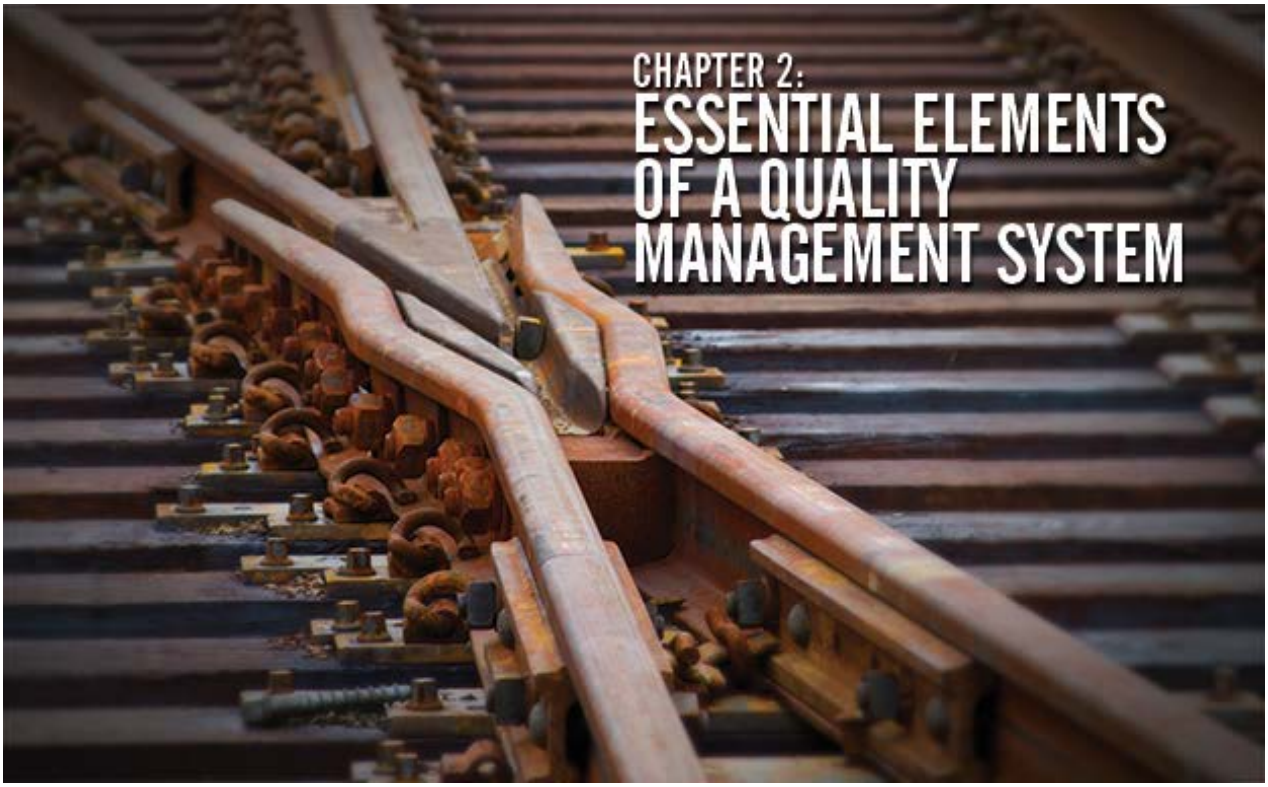
As noted in Section 1.5.1, an effective QMS involves all personnel at all levels within the organization and even personnel outside the organization, especially those entities that supply funding. It was further noted that everyone within the organization should be trained in order to know what role he or she plays in implementing an effective system. Training should start with senior management and work its way down into the organization. The quality department should receive parallel training in order to be in a position to help implement initiatives and provide additional levels of leadership and further training within the organization. At the project level, the entire project team should be trained regarding the unique quality requirements of the project. As the project evolves, training should be expanded to include consultants, contractors, and suppliers, as required. Inspectors and other personnel may require specialty training or certification when performing critical functions, such as welding or inspecting pressure containers, etc. Finally, training is not a one-time event. Rather, it is an on-going process that helps to assure that all members of the organization, in general, and the project team, in particular, can successfully implement and assure the success of the organization's or project's quality goals and requirements.

1.9 How to Use These Guidelines

Grantees should use these *Guidelines* to develop their Quality Plans. In order to develop an effective Quality Plan, the grantee should:

1. Read the *Guidelines* in order to understand what constitutes a Quality Plan.
2. Seek advice and counsel from the regional FTA representative and personnel from other agencies about the development of a Quality Plan.
3. Collect source material that may be useful and applicable.
4. Determine which of the fifteen elements apply to the grantee's project(s).
5. Review the examples provided in the Appendices.
6. Begin to establish the Quality Plan following the direction of these *Guidelines* and the applicable elements.

Grantees should develop unique Quality Plans and quality procedures that satisfy their individual needs. The FTA recommends seeking the advice and counsel of other grantees who have developed successful Quality Plans in order to learn from their experiences. However, it is important to note that the examples in these *Guidelines* and other sources should only be used as reference material and should not be copied by grantees.



This chapter discusses the fifteen elements that are the basis for FTA's guidance regarding Quality involving design, procurement, manufacturing, and construction. In addition, this chapter provides some guidance in determining which elements are appropriate for different projects. Note that each project is unique in scope and size and not all elements are applicable to all projects. An analysis of the project is recommended in order to determine which elements are applicable and warrant procedures.

FTA's guidance regarding Quality involving operations and maintenance is covered in Appendix B of these *Guidelines*.

Section 2.1, Background, describes the origin of the fifteen elements, other efforts to develop construction-oriented Quality standards, the justification for FTA adaptation of the fifteen elements, and organizational definitions required to understand the fifteen elements.

The fifteen quality elements are as follows and should be considered in the development of a Quality Plan and detailed quality procedures:

1. Management Responsibility
2. Documented Quality Management System
3. Design Control
4. Document Control
5. Purchasing
6. Product Identification and Traceability
7. Process Control

8. Inspection and Testing
9. Inspection, Measuring, and Test Equipment
10. Inspection and Test Status
11. Nonconformance
12. Corrective Action
13. Quality Records
14. Quality Audits
15. Training

The description of each element begins with text describing the core principles of that element in **bold**. Additional requirements for the element follow the bold text. The element description ends with an **example**, which presents a successful implementation of either some or all of the requirements in that element.

2.1 Background

The fifteen elements were originally adapted from the 1987 version of the American National Standards Institute Guidelines (ANSI/ASQC Q90 through Q94). The International Organization for Standardization's standards (ISO 9000 through 9004) were almost identical to the ANSI standards. Both sets of standards have been subsequently updated, but they still contain the fundamental information upon which these *Guidelines* are based.

The **ISO 9000:1987** standard, which contained the twenty elements from which the FTA's fifteen quality elements are derived, has gone through three revisions:

- **ISO 9000:1994** emphasized quality assurance via preventive actions, instead of just checking final product, and continued to require evidence of compliance with documented procedures.
- **ISO 9001:2000** combined the three standards (9001, 9002, and 9003) into one, and was named ISO 9001:2000. Design and development procedures were required only if a company engaged in the creation of new products. The 2000 version sought to make a radical change in thinking by emphasizing the concept of process management. The Year 2000 version also demanded involvement by upper management, in order to integrate quality into the business system. This update also involved focus on continual improvement and data analysis and changed the numbering system from the 1987 and 1994 versions.
- **ISO 9001:2008** uses the same numbering system as ISO 9001:2000 to organize the standard. As a result, the new ISO 9001:2008 standard looks very much like the ISO 9001:2000 standard. No new requirements have been added. However, some important clarifications and modifications have been made. More emphasis was put on purchasing and documentation.

Table 2-1 shows the relationship of ISO 9001:1994 and the updated 2000/2008 versions to the FTA's 15 elements. This table is an ideal cross-reference for the FTA, grantee, and companies who use the latest ISO standard's documentation format. They can be used as an aid in indicating that all of the required elements of these *Guidelines* have been properly addressed.

ANSI and ISO Standards represent sound quality management practice. Evidence of the acceptance of these standards by industry is the proliferation of companies that have become ISO certified over the past ten years. At the end of 2000, fewer than one-half million companies were certified to ISO 9000. By the end of 2009, more than one million companies from over 175 countries were certified to ISO 9001:2008.

The update to these *Quality Management System Guidelines* incorporates improvements from the revisions to the ISO standard since 1987, while retaining the elemental structure of the initial 1987 and 1994 revisions.

The fifteen quality elements are seen as good management practice to ensure quality of design, manufacturing, and construction services, as well as other transit agency functions such as operations and maintenance. They are applicable not only for quality programs of FTA grantees, but also for organizations providing goods and services to grantees. In fact, many consultants and construction contractors have developed their Quality Plans based on the fifteen quality elements. The Second Avenue Subway (SAS) Project in New York City requires each of their construction contractors to prepare their Quality Plan based on the fifteen quality elements. This provides a benefit of maintaining a consistent Quality Management System for a multi-billion dollar project.

Table 2-1: Comparison of FTA 15 Elements with ISO 9000

FTA ELEMENT NUMBER	TITLE	ISO 9001: 1994 Para. No.	ISO 9001: 2000/2008 Para. No.
1.	MANAGEMENT RESPONSIBILITY	4.1	5
2.	DOCUMENTED QUALITY MANAGEMENT SYSTEM	4.2	4
3.	DESIGN CONTROL	4.4	7.3
4.	DOCUMENT CONTROL	4.5	4.2.3
5.	PURCHASING	4.6	7.4
6.	PRODUCT IDENTIFICATION AND TRACEABILITY	4.8	7.5.3
7.	PROCESS CONTROL	4.9	7.5.1, 7.5.2
8.	INSPECTION AND TESTING	4.10	8.2.4
9.	INSPECTION, MEASURING, AND TEST EQUIPMENT	4.11	7.6
10.	INSPECTION AND TEST STATUS	4.12	7.5.3
11.	NONCONFORMANCE	4.13	8.3
12.	CORRECTIVE ACTION	4.14	8.5.2, 8.5.3
13.	QUALITY RECORDS	4.16	4.2.4
14.	QUALITY AUDITS	4.17	8.2.2
15.	TRAINING	4.18	6.2.2

The American Society for Quality (ASQ) has been a leader in emphasizing quality throughout the design and construction community. ASQ's Construction Technical Committee, which was established in 1982, evolved into the Engineering, Architectural, and Construction Division in the early 1990's and then into the Design and Construction Division (DCD) in the mid-1990's. Currently, DCD membership includes many quality professionals from grantee, consultant, and contractor organizations throughout the United States.

Each of the fifteen elements may refer to QA or QC activities. QA activities include planning for quality events and verifying that those events were carried out. QC activities include the actual implementation of quality events and the documentation thereof.

The elements sometimes refer to generic organizational entities that could be the transit agency/grantee, the consultant, or the construction contractor. The following table, Table 2-2, lists some of the generic organizational entities referenced in the quality elements:

Table 2-2: Organizational Entities in a QMS

Management	The grantee's organization responsible for managing the project. Also, the management group of any consultant or contractor to the grantee.
Designer	The organization responsible for design. This could be the grantee itself, and/or a contractor providing architectural/engineering services.
Purchaser	The grantee or other organization responsible for specifying, contracting, and accepting requirements for goods or services.
Supplier or Vendor	Any organization providing services, products, or materials for grantee capital projects. The supplier could be a product manufacturer, or a provider of raw materials.
Contractor or Consultant	Any organization providing services or products to a transit agency under direct contractual agreement. The contractor could be part of the grantee organization in the case of force account work. For large contracts, the contractor/consultant will often consist of a joint venture with two or more contractors/consultants.
Subcontractor or Subconsultant	Any organization supplying services or products under contract to a contractor or consultant. The subcontractor/subconsultant would not contract directly with the transit agency, but with a contractor/consultant or another subcontractor/subconsultant.

2.2 The Fifteen Elements of a Quality Program

2.2.1 Element 1: Management Responsibility

The grantee should define and document a Quality Policy that includes objectives for each specific project and should communicate, implement, and maintain that Policy at all levels of its organization. Management should designate a representative who will have defined authority and responsibility for ensuring that the Quality Policy is implemented, maintained, and continually being evaluated and improved. Management should also identify those persons responsible for the quality assurance function and should define in writing the responsibility, authority, and interrelation of those persons. There should be an established Quality Plan.

The responsibility for and commitment to the Quality Policy belongs to the highest level of management. Management should, therefore, declare and document its commitment to quality. Management should ensure that the Quality Policy is understood, implemented, and maintained throughout the organization, and that it includes continual improvement. Note: If the Quality

Program remains constant, it may stagnate. However, when continual improvement is part of the culture, quality remains an active part of the project.

A management person should be designated, who has the responsibility and authority to ensure that management's Quality Policy is implemented and maintained. This position should report to the highest position on the project organization chart to assure that quality is implemented properly and independently. Maintenance includes documented review of the Policy at regular intervals to ensure that it remains suitable and effective. For individual projects, periodic meetings with the project's management team are recommended.

The Quality Plan should set objectives, based on the grantee's Quality Policy, which will be reviewed by grantee management and evaluated based upon available data and records. Some projects may require a project-specific Quality Plan. This Plan should also include project-specific objectives, and document the FTA's expectations for the project.

Project personnel who have responsibility for ensuring or controlling quality should be identified and their interrelationships with project management defined. These relationships should be shown on an organization chart. In particular, the chart should identify the personnel, who have responsibility to initiate action to prevent quality problems, to identify and record quality problems, to initiate solutions through appropriate channels, and to verify implementation of solutions to quality problems. Those personnel responsible for assuring quality must be independent of those having direct responsibility for the work being performed. This can best be accomplished when those ensuring or controlling quality report to the highest level of management.

Each organization involved in a transit capital project should be responsible for its own quality. While consultants or contractors to the grantee can assume some responsibility for QA, this responsibility must not be completely delegated. The grantee should maintain a QA oversight capability to ensure that quality programs are working at the agency itself and within the supplier and contractor organizations.

Example:

In some quality programs that are considered a successful model for construction projects, the grantee maintains the independence of the contractors' quality processes as much as possible. The contractors maintain primary QC responsibility, as well as a QA responsibility of their own, as part of their Quality Management System (QMS), but the grantee provides an independent oversight of the entire process, making them primarily responsible for QA.

2.2.2 Element 2: Documented Quality Management System

The grantee should establish and maintain a documented QMS to ensure project quality objectives are satisfied. The QMS requirements should extend to the grantee's consultants, contractors, and suppliers as appropriate.

Written procedures and instructions should be developed and regularly reviewed/updated for activities affecting quality in design, procurement, manufacturing, and construction as applicable to the work performed. Procedures and instructions should also be developed for control of processes including inspection; testing; nondestructive examination; inspection, measuring, and

test equipment; disposition of nonconforming product; corrective action; maintenance of quality records; quality audits; and training.

The procedures and instructions should contain a statement of their purpose and scope, and should contain any references to appropriate codes, standards, or specifications. In developing the quality procedures and instructions, consideration should be given to identifying and acquiring any inspection equipment, skills, or special quality processes needed to ensure quality performance. Inspection and testing techniques should be kept up-to-date.

Where new techniques are being used for construction or manufacturing, adequate time should be allowed to develop appropriate quality procedures and instructions for the new techniques and to train the personnel who will be using these new techniques. The procedures and instructions should contain formats for the quality records needed to ensure that the procedures and instructions are followed and documentation requirements are understood.

Example:

Many successful projects have a top-tier Quality Plan which ties together the various elements, processes, and forms. This Plan is then updated over time to tailor the Quality Plan to the design, procurement, manufacturing, and construction aspects of the transit capital construction project as it progresses. Each transit agency determines which procedures and instructions are applicable to its specific capital project(s) at any given time, and this is a helpful way to facilitate this determination throughout the lifecycle of the project(s).

2.2.3 Element 3: Design Control

During the development of the project's design criteria and/or Design Quality Plan, the designer should insert quality control provisions and references to the project's Quality Plan within the Design Quality Plan. Furthermore, the designer should establish and maintain procedures in the Project's Quality Plan to control and verify the design of the project in order to ensure that the design criteria, other specified requirements, and requirements of the relevant regulatory agencies are met. Design Control includes ensuring that the design requirements are understood, planning and scheduling the design interfaces and the design verification activities, executing the design verification activities, and controlling design changes through project completion.

Each group (e.g., discipline, consultant, etc) responsible for the design of a defined element of the project scope should provide its own written quality control procedures. These should include the checking of drawings, calculations, and specifications, the peer review of drawings, and the documentation of such activities. Quality activities are performed to verify compliance with established procedures and to determine the effectiveness of the procedures in meeting quality objectives.

The designer should prepare a Design Quality Plan and schedule for design activities. This schedule should be inserted into an Integrated Project Schedule (IPS). The Design Quality Plan should identify who has professional responsibility for the different design elements, and who has the QC responsibility for each design element, including those individuals who are responsible for the review, verification, and approval of design documents and changes. The Design Quality Plan should also identify the various organizational interfaces required among different groups producing and commenting on the design. It should specify the information to

be documented, transmitted, and regularly reviewed. The Design Quality Plan should specify how the operating and maintenance departments of the transit agency will interface with those producing the design. The development of this Design Quality Plan and the IPS are both quality functions which are carried out by the designer, and are further described by the FTA in other documents. However, both the Design Quality Plan and IPS are to be developed and reviewed/updated in such a manner that ensures proper integration, and should be subject to review by quality staff.

The Design Quality Plan should also include checks of the integration of various elements of the design performed by subconsultants. Too often, the prime design consultant performs quality checks of its own work and requires its subconsultants, including Disadvantaged Business Enterprise consultants, to perform their own quality checks, but no one checks the integration of all the design elements into a complete design package. Integration quality checks, completed before each submittal, should be specified in the Design Quality Plan, with a requirement for record documentation indicating that integration coordination review has been completed for interdiscipline design, external stakeholders' requirements, and existing conditions.

The Design Quality Plan should include or reference important design milestones that impact the overall project schedule. The milestones should be established with project objectives and FTA expectations having been taken into consideration.

Design input requirements should be identified, documented, and reviewed by the designer. Any ambiguity in the design input requirements should be resolved between the designer and those responsible for developing the requirements.

Design output should be documented. It should meet the input design requirements, include acceptance criteria, conform to appropriate regulatory requirements whether or not these have been stated in the design input requirements, and identify those aspects of the design that are crucial to the safe and proper functioning of the final product or system.

The Designer should assign sufficient competent personnel to verify the type and number of activities required to attain the quality of the design. These are called quality control activities. Design quality control activities should include the carrying out of independent checks of design calculations, specifications, drawings, and contract documents; conducting and documenting design reviews; undertaking qualification tests and demonstrations; and comparing the design with a similar proven design, if available. Design reviews include reviews for bidability, constructability, operability, and maintainability. Design audits should be undertaken to verify that the personnel assigned to perform design quality control activities are implementing the QC activities properly.

Appropriate procedures should be established for the identification, documentation, review, and approval of all changes and modifications to the design. Additionally, procedures should be established to incorporate construction phase generated as-built information into the end-of-project design documentation.

Example:

The 2003 update of the *Project and Construction Management Guidelines* uses the term "controlling project configuration and changes" to refer to control of design changes, and the related document control (see below). The following detail about configuration control was taken from the *Project and Construction Management Guidelines:*

> *Configuration management consists of the evaluation, coordination, and approval or disapproval of changes in the configuration of a component, system, or process after its baseline has been defined.*

The project is typically baselined at the completion of the Preliminary Engineering (PE) Phase to allow accurate and comprehensive monitoring of any and all changes that follow and to establish the basis on which the project cost estimate is determined. In the case of Major Capital Projects (MCPs), the baseline for the project definition will be established during the initial Final Design phase activities but prior to FTA considering a Full Funding Grant Agreement (FFGA), as it is those details (in drawings, specifications, contract packaging and scheduling) that must be carried forward and implemented. A similar approach is taken by FTA with regard to Project Construction Grant Agreements (PCGAs) for non-MCP projects. The *Project and Construction Management Guidelines* go on to state the following:

> *In an effective configuration management program, drawings are uniquely numbered and otherwise identified. Specifications follow a standard format and each [section, subsection and] paragraph is identified. Complete drawing lists are established and the total number of drawings, the titles of the drawings, the revision status, and the dates on which the drawings were approved are recorded. Procedures are established and changes to approved drawings or specifications should only be made in accordance with [these approved procedures]. Permanent files are maintained of all contract documents that include historical information relating to all project changes. As the project is implemented, configuration management evolves to include the documentation of the completed improvement in terms of as-built drawings. Configuration management ensures that the correct, approved status of the evolving design is known or is available to all project personnel using that information. If done properly, configuration management ensures that replacement equipment or components capable of meeting the original equipment requirements can be procured at a later date.*

2.2.4 Element 4: Document Control

Procedures for control of project documents should be established and maintained. The document control measures should ensure that all relevant documents are current and readily available to all users who require them. Electronic document distribution and

management should be managed in the same manner as hard copy distribution and management.

Document Control is more than maintaining a project's files. It includes controlling a Master Set of the latest project documents by a management group. Once a baseline set of documents is established by project management, any change to the baseline set is reviewed and accepted/rejected by the group and the documents are changed under the group's control. Controlled sets of documents are distributed to the members of the project that require them and a list of those holding the documents is maintained. The distribution, storage and retrieval of these documents, the elimination of obsolete documents, and control of changes to the documents is the function of this group.

Copies of the documents should be distributed so that they will be available at all locations that need them for effective functioning of the QMS. Distribution should be controlled in a way that approved documents are accessible in a timely manner, noting their revision and/or date information. Obsolete documents should be promptly eliminated from each work location or prominently identified that they are obsolete or have been superseded. All document changes should be reviewed and revised by the responsible parties. The grantee should verify that the change has been made.

When possible, the same authorized personnel who reviewed and approved the original documents should review changes to the documents and data, unless the control procedures specifically allow otherwise. Changes should be promptly distributed to all locations, along with a master list enumerating the current revision of each document. Often the master list is updated and maintained electronically on a server with "read only" permission provided to authorized individuals.

Following are examples of the types of documents requiring control:

- Drawings
- Specifications
- Inspection procedures
- Test procedures
- Special work instructions
- Operational procedures
- Project Management Plans
- Risk and Contingency Management Plans
- Real Estate Acquisition Management Plans
- Quality Assurance Plans
- Rail and Bus Fleet Management Plans
- Safety and Security Management Plans

Example:

A useful tool for keeping track of project documents is the Design Output Index that lists every document developed for the execution of the project. The Design Output Index contains a listing of the latest revisions of the following:

- Drawings
- Technical specifications
- Special processes
- Test specifications
- Engineering change notices

2.2.5 Element 5: Purchasing

The purchaser should ensure that the purchased service or product conforms to the purchaser's specified requirements. The purchaser should require supplier quality programs appropriate to the work being performed and in accordance with these Guidelines.

The purchaser should establish a documented list of acceptable suppliers, consultants, and contractors for the desired service or product. The list should be consistent with applicable procurement requirements and conscious of any applicable Suspension or Debarment lists. The purchaser should select suppliers, consultants, or contractors based on their ability to meet contract requirements, including quality and timeliness requirements. As such, the purchaser should have a systematic process in place to review the suppliers', consultants', or contractors' ability to meet these requirements (e.g., due diligence by the purchaser) either prior to, or immediately after the completion of the solicitation, but always prior to awarding a purchase order or contract. The quality requirements placed on the supplier, consultant, or contractor will depend upon the nature of the service or product.

The contract or purchasing requirements should clearly specify the requirements and expectations of the purchaser, including relevant standards, drawings, specifications, milestones, processes, procedures, tests, inspections, documentation, and approval criteria for all deliverables. The purchasing documents should be reviewed and approved by an independent and qualified authority for adequacy and consistency of specified requirements prior to the release of a solicitation. The purchaser of services or products should ensure that the selected supplier/consultant/contractor fully understands and agrees to the contract terms and conditions and has the capacity to perform as required. For after-market purchases from an Original Equipment Manufacturer (OEM) where proprietary parts or systems are required, or in the case of sole source requirements, the purchaser should determine and define the salient characteristics of the product and make sure that the supplier/consultant/contractor has quality standards and systems in place to meet these characteristics. Furthermore, the purchaser should determine internal means for periodically testing proprietary products for compliance with the defined salient characteristics.

Where a construction or equipment procurement is involved, the contract between the purchaser and the supplier or contractor should specify the right of the purchaser or other authorized representatives to carry out inspection and testing at the site or source and prior to conditional acceptance and/or upon receipt of deliverables to verify that the work or product meets specifications. Such provision should not absolve the supplier or contractor of the responsibility to provide acceptable work or product, nor should it preclude subsequent rejection by the purchaser.

Where equipment procurement is involved, the purchaser should define, as appropriate, the means and methods for handling, storage, packaging, and delivery of the equipment and any timelines associated with such. The purchaser should establish procedures to receive, inspect,

accept, store, and maintain equipment procured. All equipment that is damaged or is otherwise deemed unsuited for use prior to acceptance by the purchaser, should be documented and reported to the supplier or contractor immediately upon discovery. Similar quality standards should be placed on the purchase of small parts from catalogue suppliers or distributors, with the responsibility for compliance and periodic testing shared by both the supplier and purchaser.

Purchasing requirements apply to all contractors, consultants, and suppliers, including construction contractors, and manufacturers. The purpose of this element is to ensure that purchasing requirements are clear and complete, that the contractor, consultant, or supplier understands them, and that appropriate quality elements are made part of the contract. Additional requirements, such as on-site inspection and handling and receiving procedures, may be required for construction or equipment procurement contracts.

The level of Quality Program specified in the contract will depend upon the complexity and importance of the service or product. For some projects, all fifteen elements of these *Quality Management System Guidelines* might be specified. In other cases, the contractor, consultant, or supplier may be required to use only its existing quality programs or standards or other quality standards if specified by the grantee or any stakeholders. In addition, FTA Circular 4220.1F, *Third Party Contracting Guidance*, provides contracting guidance to assist grantees in procuring third-party services on capital projects receiving federal funding.

Example:

One example of an outstanding purchasing system has the agency's Procurement Department keeping an ongoing index of all suppliers', contractors', and consultants' compliance with the terms, conditions, and delivery of quality products or services, consistent with the requirements of awarded contracts or purchase orders.

All deviations or poor performance is recorded and maintained and becomes the basis for responsibility checks and requests for remedial action of the contractor, consultant, or supplier in future procurements. Further, for large capital construction and manufacturing procurements, the agency regularly conducts industry forums several months prior to advertising procurements, in order to go over contractual terms and conditions, and technical elements that might present problems to the contracting community and that may dissuade competition for or interest in the procurement. During these sessions, the agency lets the contracting community know how it plans to procure and manage the project, so that there are no surprises and all rules and expectations are clearly understood.

By taking proactive measures such as recording deviations and poor performance, the agency is able to continually review and update its policies, procedures, and template purchasing documents in order to maximize competition and foster collaborative relationships with the contracting community, which leads to better pricing, timely performance, and quality deliverables.

2.2.6 Element 6: Product Identification and Traceability

Measures should be established and maintained for identifying and controlling items of production (batch, materials, parts, and components) to prevent the use of incorrect or defective items and to ensure that only correct and acceptable items are used or installed.

Physical identification and control should be used to the greatest extent possible. Where physical identification is impractical, physical separation, procedural control, or other appropriate means may be employed. Items that fail to possess identification, items for which record traceability has been lost, or items that do not conform to requirements should be segregated to prevent use or installation. All items will be marked for identification. If an item is not to be immediately utilized, it needs to be appropriately marked and stored in a separate location, with necessary safeguards, for later use.

Example:

Product identification and traceability are best implemented when they take place during all the various production phases - from receipt of raw materials, components, or subassemblies through the manufacturing process, to delivery of final products or systems.

Traceability means traceable to a particular project, specific warranty, test report, supplier, point in time, purchase order, or through production.

Raw materials should be traceable back to a particular batch number, shipment number, packing slip, or invoice and should be accompanied by applicable test data sheets and material certifications.

Storeroom or inventory tracking procedures should allow for items to be traceable back to a particular order number, batch number, date received, test lot, or other pertinent source.

Assemblies in production should be traceable to particular projects through the use of routing documentation. Routing documentation should contain sufficient manufacturing information, including work instructions, manufacturing standards, tooling, etc.

Final assemblies should be clearly marked with project numbers, model numbers, serial numbers, bar codes, and similar information so that all pertinent information regarding that assembly may be retrieved.

The number of separate parts or assemblies that are required by a transit facility is in the thousands, and each one needs to be appropriately marked not only for the initial installation but also to be retrievable from storage as spare parts. The identification system is critical, since time to retrieve needs to be minimal. Otherwise, workers are delayed from getting their tasks completed. Furthermore, a good system will allow for expedited reordering, since the part or assembly is identified in the system. Good practice includes having the agency's specification tied electronically to the part. Also, in the event a problem develops with a part or assembly, the agency needs to know where the rest of a production run is located so it can be checked for similar problems and/or replaced.

2.2.7 Element 7: Process Control

Suppliers and contractors should identify and plan the production and installation processes that directly affect quality and should ensure these processes are performed under controlled conditions. Special processes, the results of which cannot be verified by subsequent inspection and testing of the product, should be continuously monitored. The grantee should also ensure that any activities related to the expectations of the FTA or other involved agencies are carefully monitored and controlled by identifying any necessary specifications and determining a method to verify that they are met.

To achieve accuracy and consistency in production and installation processes, the Quality Program should provide for:

- Documented work instructions where such are needed to ensure quality, use of suitable production and installation equipment, a suitable working environment, personnel qualifications/certifications, and conformance with referenced standards/codes and Quality Plans
- Monitoring and controlling of processes and product characteristics during production and installation.

Continuous monitoring and/or conformance with documented procedures is required during special processes, such as welding, nondestructive testing, and heat treatment, where the results of the processes will affect quality of the final product.

Example:

A major issue in process control is to ensure that work is performed in the proper sequence. Documented work instructions can help with sequence control where there is complex work or when there are multi-disciplined interfaces.

Documented work instructions, for example, can be utilized in the control of the epoxy grouting of rebar into a concrete deck. The rebar would be used to hold poured concrete plinths upon which track is affixed. Two other related examples are the process of epoxy coating rebar at the fabricator's shop, usually before bending and the repair in the shop before shipment to any damage to the coating that occurred during the bending process. A related example is the process of epoxy coating in the field to rebar damaged in transit or during field bending or installation. For the epoxy coating to be effective, the application processes need to be monitored and performed in strict accordance with manufacturer's procedures.

2.2.8 Element 8: Inspection and Testing

Inspection and testing procedures should be planned and executed as necessary to verify quality. Procedures should be specified, implemented, and the results documented for receiving incoming products, and for final inspection and testing. Testing should be included, where appropriate, in the specifications, including references to testing procedures, frequency and location, requirements for witnessing of tests, and where factory inspection and/or testing is recommended prior to shipping.

When products are delivered to the purchaser, it is the responsibility of the purchaser to verify that the products are in conformance with requirements. Verification should be in accordance with the Quality Plan or documented procedures. The extent of receiving inspection can vary with the amount of inspection at the source, the safety criticality of the product, and the confidence in the quality history of the supplier.

In-process testing and inspection of the work to verify conformance of an item or work activity to specified requirements should be in accordance with the construction documents, Quality Plan, documented procedures, or referenced industry standard procedures. Both inspection and process monitoring methods should be performed, as necessary, to ensure that the specified requirements for the control of work processes and the quality of the item are being achieved throughout the duration of the work.

Final inspection and testing should ensure that all specified inspections and tests, including those specified for receipt of product or in-process work, have been carried out and the resulting data meet specifications. Final inspection and testing should be carried out and properly documented to ensure conformance of the finished product to the specifications.

Records of the various inspections and tests must be maintained to provide evidence that the product has passed inspection and/or test with defined acceptance criteria.

Example:

Given that everything cannot be inspected, the following criteria are offered as guidance for what to emphasize in an effective inspection and testing program:

- Items or work affecting safety
- Items that affect system reliability
- Items that affect service life
- Long lead time items or custom manufactured items
- High visibility areas
- ADA compliance items

2.2.9 Element 9: Inspection, Measuring, and Test Equipment

Inspection, measuring, and test equipment required to carry out inspection and testing should be identified, controlled, calibrated, and maintained in order to demonstrate the conformance of work to the specified requirements. Provisions should be made for recalibration of such equipment in a timely manner and documented in the Quality Plan or other project documentation. A schedule of testing equipment that needs periodic and regularly scheduled recalibration should be required of the contractor(s) and be checked by the grantee's QA personnel. Requests for Proposal (RFPs) and Invitations For Bid (IFB) should require that all contractors' testing equipment be calibrated prior to its use on the project.

Inspection, measuring, and test equipment used should meet the standards of accuracy for the measurements that are required. The equipment should be calibrated according to national standards where available, and to documented standards where no national standards exist. The equipment should be recalibrated at regular intervals, and the recalibration properly

documented. A record of the equipment calibration status should be maintained, including calibration date and due date. When feasible, a sticker should be secured to the equipment identifying calibration status.

The equipment should be properly maintained to ensure its fitness for use. When in use, the user should ensure that the environmental conditions are suitable for the use of the equipment. When inspection, measuring, or test equipment is found to be out of calibration, the validity of previous inspection and test results should be assessed and documented.

Example:

ISO 10012:2003, *Measurement Management Systems - Requirements for measurement processes and measuring equipment*, is the ISO standard that specifies generic requirements and provides guidance for the management of measurement processes and metrological confirmation of measuring equipment used to support and demonstrate compliance with metrological requirements.

Some examples of construction test equipment that require regular calibration follow:

- Devices that test for the tightness of structural bolts
- Concrete entrained air and slump measuring devices
- Soil density and plasticity, and gradation measuring devices
- Loading frames for soils, aggregates, and bituminous testing
- Coating thickness measuring devices
- Meggering devices that test resistivity to ground
- Ohm meters for testing resistivity
- Distance measuring equipment for surveying
- Pressure testing gauges for testing pressure capacity of piping systems

2.2.10 Element 10: Inspection and Test Status

A means should be provided for identifying the inspection and test status of work during production and installation. The purpose of this is to ensure that only work that has passed the required inspections and tests is accepted.

The test and inspection status should be identified by means of markings, stamps, tags, labels, routing cards, inspection records, test software, physical location, or other suitable means. The status identification indicates the conformance or nonconformance with regard to inspections and tests performed.

The inspection and test status of planning and design documents should be identified by suitable means that indicate the conformance or nonconformance of product with regard to checking and reviews performed.

The status of completed, tested and inspected construction should be kept as an ongoing record in the daily inspection reports. Nonconforming materials or construction should be recorded with location noted on inspection reports or nonconformance reports as applicable. Photographic records of nonconformances can be useful.

Example:

While some operations may be easily tagged in the field as to their inspection status, it is good practice to keep a record set of drawings in the construction manager's or resident engineer's office with traceability through daily inspection reports, status reports and payment documents. On MCPs, the quality organization should keep test records to include conformances and nonconformances. It can be beneficial to maintain these records in a database for analysis and trending to help identify the root cause of nonconformances.

2.2.11 Element 11: Nonconformance

Procedures should be established and maintained for the immediate control of nonconforming work, in order to ensure that such work is not inadvertently used or installed. Nonconforming work should be identified, documented, and evaluated to determine appropriate disposition.

Where practicable, nonconforming items should be segregated. When segregation is not possible, nonconforming items should be clearly identified as such. Those activities affected by the nonconforming work should be notified. The responsibility for review and authority for the disposition of nonconforming work should be defined in documented procedures.

Disposition of nonconforming work can include reworking it to meet requirements, accepting it with or without repair, using it for alternative applications, or scrapping it. A determination to accept nonconforming work, as is or with repair, should have the concurrence of the engineer of record. It may be advantageous to the owner to negotiate some form of compensation for accepting nonconforming work, e.g., additional spare parts or extended warranty. Disposition of nonconforming work should be determined by appropriate personnel and documented for the record. Reworked or repaired work should be re-inspected in accordance with the original documented procedures.

Nonconforming conditions should be documented on nonconformance forms, in reports, letters, memos, corrective action lists, audit findings, etc. It is imperative that all nonconformances be resolved in cooperation with project management and quality personnel.

Example:

The grantee should require the contractor to keep a log of nonconformance items, with traceability to the original findings, disposition, and corrective/containment actions to which they are tied. Assigning items with due dates to specific personnel can help to expedite their resolution. Grantee quality management can use this tool to work through issues with the contractor and monitor progress. Nonconformance logs can assist with analysis and trending to help identify root causes similar to test data captured in Element 10, *Inspection and Test Status*.

2.2.12 Element 12: Corrective Action

Corrective action procedures should be established, documented, and maintained. These include procedures for investigation of the root cause of nonconforming work and the corrective action needed to prevent recurrence, and procedures for analysis to detect and eliminate potential causes of nonconforming work. QA personnel should verify that the

corrective action has been accomplished. The grantee should also determine preventive action to eliminate the causes of potential nonconformances in order to prevent their occurrence. This element also includes implementing and recording changes in procedures resulting from preventive action, corrective action, and continual improvement initiatives.

Corrective action procedures should be established for:

- Investigating the root cause of nonconforming product and taking the corrective actions needed to resolve nonconformance and/or prevent recurrence
- Ensuring that corrective actions are taken and that they are effective
- Initiating preventative actions to deal with problems to a level corresponding to the risks encountered
- Implementing and recording changes in procedures resulting from corrective action

Preventive action procedures should be established for:

- Determining potential nonconformances and their causes
- Evaluating the need for action to prevent occurrence of nonconformances
- Analyzing processes to detect and eliminate potential causes of nonconforming product
- Ensuring that preventive actions are taken and that they are effective
- Implementing and recording changes in procedures resulting from preventive action

Corrective action should be taken with respect to nonconforming work in order to eliminate potential problems related to a dispositioned nonconformance. Where the nonconformance involves work common to most projects, the corrective action should be memorialized in a Lessons Learned format and disseminated throughout the grantee's organization.

Potential risks and/or areas of improvement should be identified early and continually throughout the life of a project. The need for action should be evaluated. If actions are taken, the results of these actions should likewise be recorded.

Example:

It is good practice for the grantee to receive a copy of the contractor's log of open issues and to continually review the status of these issues. When evaluating the resolution of an issue, one should determine corrective actions to prevent recurrence. The corrective action to prevent recurrence is usually an action at a management level that fixes the practice that led to the field issue and could lead to further issues.

2.2.13 Element 13: Quality Records

Procedures should be established and maintained for quality records. These procedures should identify which records should be kept, responsibility for production and collection, and responsibility for indexing, filing, storage, maintenance, and disposition of quality records.

Quality records should be maintained to show achievement of quality objectives and appropriate functioning of the QMS. Supplier, consultant, contractor, and subcontractor quality records should be included when pertinent. There should be a controlled version of each quality record. Different versions of quality records should be identifiable and traceable, so there is no confusion when referencing these records.

Quality records should be legible and should specify the work involved. They should be kept in an environment to minimize deterioration and damage. Retention times and final disposition should be established and recorded. Wherever possible, testing results, delivery slips, and certifications for material should be kept together to show test results for specific material.

Additionally, any electronic data should be regularly backed up, and backups should be stored offsite in a manner to ensure their safety from deterioration and/or damage.

FTA has specific requirements for maintenance of project records beyond the successful completion of the project. For example, all project documents related to issues in litigation must be available until the litigation is settled. Safety related documents must be maintained for the operational life of the transit system. Therefore, it is in an agency's best interest to provide continuity in the maintenance of the files for a project by having the agency's personnel take possession of the files prior to the departure of the design and construction consultants/contractors. The ability to readily retrieve documents for review and use by the project is also critical; this function should be tested periodically.

Where specified by contract, quality records should be made available to the purchaser or purchaser's representative.

Following are examples of the types of quality records requiring control:

- Inspection reports
- Test data
- Qualification records
- Calibration records
- Nonconformance reports
- Corrective actions
- Audit reports
- Training records

Example:

A useful tool for keeping track of quality records is a Quality Records List. This is a list of every document generated as a result of implementing the Quality Program. Note that all applicable records should be tracked and controlled, including those of suppliers, consultants, contractors and subcontractors. Similarly, applicable contract documents should be tracked and controlled in accordance with grantee retention policies.

2.2.14 Element 14: Quality Audits

Quality audits are not the same as financial audits. A quality audit program should be established to ensure that the elements of the QMS are functioning as intended.

Each internal and external audit should be scheduled, or identified in advance on a schedule of audits. A checklist or other indicator of scope should be prepared in advance of the audit and shared with the auditee prior to the audit. The frequency should depend upon the status and importance of the activity being audited. The audits and follow-up actions should be documented and conducted in accordance with documented procedures. The results of the audits should be presented to the personnel having responsibility for the area being audited. These documents should be maintained as quality records. Responsible management personnel should take timely action to respond to audit findings. A follow-up audit to verify the corrections were made or are in process is recommended in some cases.

Audit findings can be deficiencies, which require corrective action, or recommendations, which suggest action be taken to make improvements. Findings may be further classified as minor or major deficiencies to specify the severity of the issue, observations of items that may develop into deficiencies if no action is taken, or recommendations for improvement without any danger of deficiency if no action is taken. Recommendations can be a source for continual improvement in an organization or project, while observations can be a form of preventive action, as discussed in Element 12, *Corrective Action*. Continual improvement can also be facilitated via audit findings through the documentation of noteworthy efforts, which are practices observed during the audit which may have positive impact if applied to other projects or areas.

Quality audits should be independent, scheduled, and performed to standards and/or checklists. Qualified quality personnel should conduct the quality audit in order to ensure that it provides substantive results. As part of the audit, an entrance meeting and an exit meeting should be held. A final report that identifies the results of the audit should be generated, distributed, and tracked for completion of actions.

Example:

Successful grantee quality programs usually audit in a systematic manner which ensures each element is audited at least once a year, with several elements being audited each quarter. Audit frequency may also coincide with any incentive programs established for the project or significant project milestones. Regardless of approach, the Document Control function should be visited frequently, as this area can breakdown in a short time if not rigidly maintained. Auditing all elements at once can become time consuming, so auditing several elements each quarter allows for more frequent, shorter audits of contractor activities.

2.2.15 Element 15: Training

The grantee should establish and maintain procedures for identifying the training needs of and provide for the training of all personnel performing activities affecting quality.

All personnel performing activities affecting quality should be qualified on the basis of appropriate education, training, and/or experience, as required. Appropriate training and qualification records should be maintained.

Training needs should be identified for grantee and project staff. It is also encouraged that effectiveness of training be evaluated. Records of the training and evaluation should be maintained.

Example:

A training matrix can be used as an effective tool for determining which personnel require what training. The training matrix lists the relevant personnel within the agency or within project consultants and contractors versus various quality related procedures. Table 2-3, below, is an example of a training matrix, and the information that should be contained in one.

Table 2-3: Example of a Training Matrix

	Procedure Number							
	1	2	3	4	5	6	7	8
CEO	CR		RA					
Project Manager	CR	RA	RA	RA	RA	RA	CR	RA
Project Engineer	CR	RA	RA	RA	RA	RA	CR	
Staff Engineers		RA	RA					
Purchasing Manager	CR	RA	RA			RA	CR	RA
Resident Engineer	CR	CR	RA	RA				
Inspectors		CR		RA	RA			RA
Safety Manager	CR	RA	RA				CR	RA
QA Personnel	RA	RA	CR	RA	RA	RA	RA	RA

Key
CR: Classroom
RA: Read and Acknowledge

FTA grantees use many different organizational structures for carrying out capital projects. All work, including design, procurement, construction management, construction, and start-up and testing may be done in-house or by outside suppliers, consultants, or contractors. All of the applicable Quality Management System (QMS) elements should be incorporated into the activities of the organizational entities involved in the project, regardless of its structure. The implementation of quality management activities should mitigate the disruption to continuing grantee operations, while remaining both separate/objective and integral to those operations.

3.1 General Principles

In Chapter 2, the quality element *Management Responsibility* states that a person should be designated as a representative of management who has the responsibility and authority to assure that the management's Quality Policy is implemented and maintained. Those responsible for verifying that quality activities are performed in accordance with established requirements and procedures should be independent of those directly responsible for the work. For example, the Quality Manager (QM) on a construction project should report to the grantee's management at a level above the Project Manager (PM).

The fulfillment of management's responsibility for quality requires that:

- A Quality Policy be adopted by the grantee's senior manager (e.g., General Manager or CEO) and accepted by all members of management.
- Quality Objectives be established, based on this Quality Policy, and progress toward these objectives be tracked.
- There be a prevailing attitude that all members of the organization are responsible for the fulfillment of the Quality Policy and achievement of these objectives, and that management examines all elements of the organization for assurance that quality is being attended to.
- There be a person designated by and reporting to the senior manager to oversee the established QMS and advise the manager of the effectiveness in meeting project quality objectives.
- Those responsible for ensuring quality report at least one level higher than the activity for which they have oversight responsibility.

It is important to distinguish between responsibility for Quality Policy/Objectives and responsibility for quality of a project or activity. Each person responsible for a project or an activity is also responsible for the quality of that project or activity. On the other hand, the Quality Assurance (QA) staff is responsible for participating in the quality processes to ensure that these processes are working. If the processes are working properly within a project, there is more certainty that the project quality objectives will be achieved.

The QA staff should be seen by the PM as part of the team. The QA staff and the Quality Control (QC) activities should be seen as helpful in preventing errors which could lead to significant problems and increased cost. The PM and his/her organizational structure should reinforce the concept that the QA staff is part of the project team.

An appropriate approach to carrying out the *Management Responsibility* element is for the grantee to have a Director of Quality reporting to senior management. Where the QA role is focused on capital projects, the Director of Quality should report to the manager responsible for the implementation of all capital projects or to another senior member of the grantee. The advantages of such a structure are:

- The responsible management for the grantee can be confident that appropriate attention is being paid to quality and that FTA and other funds are being used wisely.
- Quality is highly visible within capital projects of the grantee.
- QA activities are coordinated so that duplicate planning, training, and oversight activities are eliminated.

The Director of Quality should be responsible for verifying the implementation and maintenance of the grantee's Quality Policy and detailed Quality Procedures. The Director of Quality should provide oversight of all quality activities, assistance to the PMs in the development of Project Quality Plans, prevention and resolution of quality problems, oversight of contractor quality programs, QA training programs, QA oversight, and QA audits.

As stated previously, FTA requires that major capital projects have a Project Management Plan (PMP) that includes or references a Quality Plan for the project. Responsibility for quality within a capital project and for the Quality Plan should rest with the PM for that project. Although the Director of Quality should report independently to a senior manager, inspectors on a project who are performing QC activities generally report to the PM or resident engineer. The PM should

have access to quality personnel to assist with project quality activities. A concerted effort to comply with quality requirements by those performing the work can further prevent errors which could lead to significant problems and increased cost.

The matrix organization for project management provides a mechanism for the PM to have access to QA staff assistance, and for quality oversight to be provided at management level higher than the PM. The QA personnel work in partnership with representatives of engineering, procurement, construction, and start-up and testing on various projects. This structure allows the QA representatives to be partners in the QMS, rather than outsiders who are there to find fault.

Some grantees divide the QA responsibilities and assign them to functional areas such as engineering, procurement, construction, and start-up and testing. This approach recognizes the specialty skills that are appropriate for QA in these various areas. Indeed, in larger grantee organizations, it makes sense to have functionally specific Quality Plans. However, it is less desirable to split the QA organization because it results in multiple Quality Programs and procedures within the agency and a less visible program overall. However, such a program can still provide adequate quality at the project level.

There are situations where a grantee may not have a permanent QA staff. One example is where a grantee undertakes a one-time capital project where the quality function is a discrete activity developed solely as a part of the project. In general, lack of dedicated QA staff can cause a problem if the project faces budget or time pressures. Lack of a dedicated QA staff has often resulted in weakened Quality Programs.

3.2 Project Management Plan

FTA requires its grantees undertaking a major capital project to submit a PMP for FTA's review and approval, both initially and as changes are made throughout the project. Although FTA has some discretion in determining which capital projects are considered major, they generally include projects like construction of a new fixed guideway segment, extension of an existing fixed guideway, or modernization of an existing fixed guideway pursuant to a full funding grant agreement. As part of the PMP, FTA requires that the grantee include a Quality Plan and define quality responsibility for design, construction, procurement, system installation, and integration of system components.

While PMPs are required only for major capital projects, they are encouraged for all projects because they are a very useful project management tool. Similarly, significant benefits can be derived from a Quality Plan even where the project is not considered major and a Quality Plan is not required.

The PMP should be produced during the Project Planning phase of the project. The timing is essential for the Quality Plan as well, since the requirements for quality in design should be specified at the time of the design procurement. The PM's expectations for a project QMS must be made known in the procurement documents. These requirements should be a detailed extension of the PMP’s established quality requirements.

The PMP should be updated as the project progresses through final design, procurement, construction, testing, and start-up. Likewise, the Quality Plan and Objectives should be adjusted to reflect the organization and particular requirements to be instituted at each of these phases. Chapter 4 of these *Guidelines* discusses the development of the Quality Plan for a project.

When a grantee has an existing Quality Plan, Quality Policy, and/or written procedures, a project Specific Quality Plan can adopt any of those elements that are appropriate for the specific project or project phase under consideration. Responsibility for preparing the Specific Quality Plan could rest with the Director of Quality or with quality staff assigned to the project. The PM must approve the Specific Quality Plan because the PM is ultimately responsible for the quality of the project.

3.3 Alternative Organizational Structures

Following is a discussion of alternative ways of organizing a QMS given different project organizations and objectives:

3.3.1 Quality Program for Construction with a Project/Construction Management Consultant

One alternative for organizing a major capital project is to use a Project or Construction Management Consultant (PMC or CMC) to manage outside construction contractors. This type of project management organization is one of several that have been successful in implementing quality programs.

There may be a number of reasons for the success of this approach. First, a project can be a discrete activity organized to minimize disruption to the grantee's established internal relationships. Second, many experienced PMCs and CMCs have adopted QA programs and have considerable experience in applying such programs for design and construction projects. It is important that a PMC or CMC tailor their Quality Program to the project that they are managing.

When a grantee uses a PMC/CMC to undertake the QA role for a project, the grantee still needs assurance that the project quality objectives are satisfied. The grantee cannot delegate this responsibility. Therefore, the grantee oversight of the quality process must be maintained to assure that it functions effectively.

Figure 3-1 shows an organization chart for the project management and the quality organization for a project with a PMC/CMC. As can be seen from this figure, the construction contractor is responsible for QC. The PMC/CMC provides the QA, and in this scenario, the grantee provides QA oversight for the project.

In order for the structure shown in Figure 3-1 to be successful, all parties must understand their responsibilities and Quality Plan requirements from the beginning. The contract documents for the construction contractors must specify the role of the PMC/CMC in providing QA for the project as well as the contractor’s responsibility for QC, including the development of Quality Program Plans. Contract documents must specify that the construction contractor must provide

the PMC/CMC with appropriate access for observation and inspection, as well as access to quality records. In most cases, grantees have found it difficult to achieve effective contractor Quality Programs when the PMC's/CMC's QA role has not been adequately defined in the contract documents.

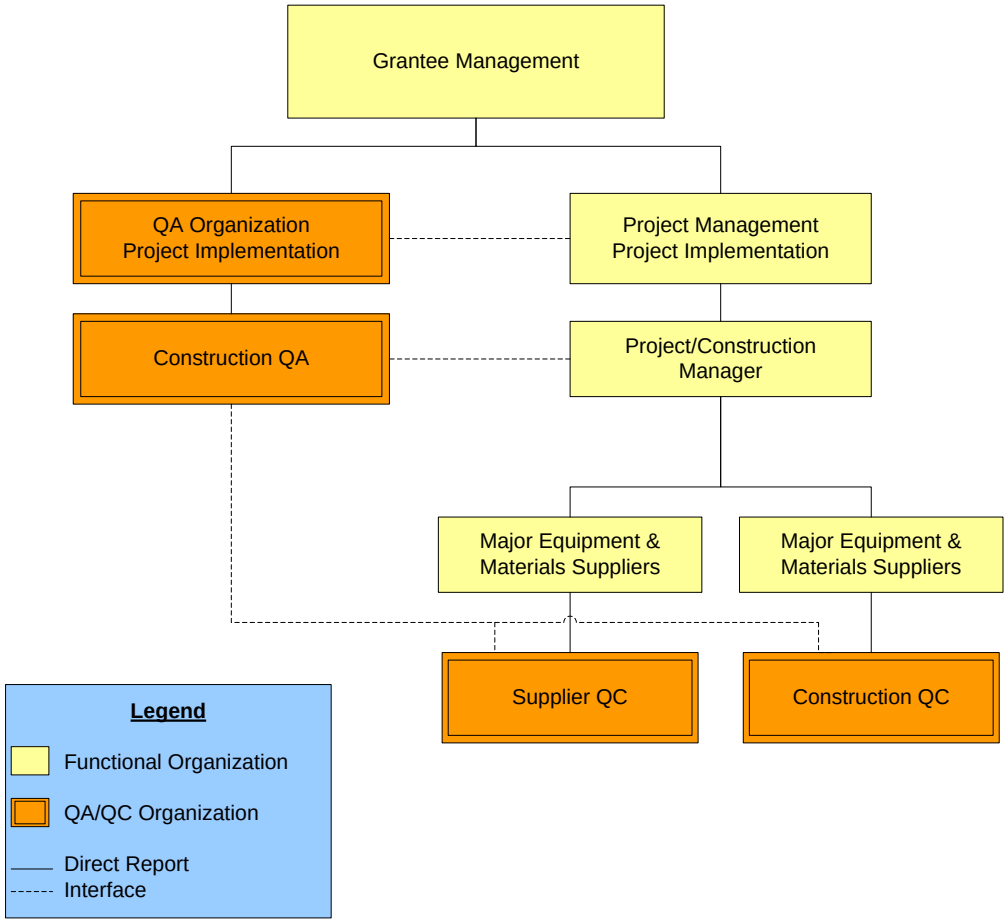


Figure 3-1: Example of a Project Quality Organization with a PMC/CMC

Likewise, the PMC/CMC must understand the grantee's role in quality oversight of the project. That role needs to be spelled out in the request for qualifications and the contract documents with the PMC/CMC to clearly indicate the approach the grantee will take to assure that the PMC's/CMC's QMS requirements are satisfied.

3.3.2 Quality Program with In-house Construction Management

Another alternative for organizing a large capital construction project is to use internal staff for construction management. Construction is done either by outside construction contractors or by inside force account staff. Often this option follows the use of PMCs/CMCs on long, multi-stage projects. Agency staff assumes more and more of the responsibilities of the PMC/CMC, and finally takes over all construction management functions.

The grantee construction management team should be responsible for QA for the project and should have appropriate staff available for undertaking the QA role. The person designated to provide QA oversight for the project should verify to the grantee's senior manager that the established QMS is being appropriately implemented and followed. This oversight activity is especially important where the project scope does not justify a separate QA staff for the project, and where the PM/PMC/CMC staff assumes QA responsibilities. Without oversight, this latter arrangement often leads to a weakened QA program.

Typically, where there is an outside construction contractor; that contractor is responsible for the QC system to be applied to the work performed. Often the construction contractor has its own Quality Program that can be utilized when acceptable to the grantee. An exception in transit construction projects occurs where the grantee or a third party takes responsibility for materials testing, thus assuming a QC activity. Contract documents must clearly specify the responsibilities of each organization.

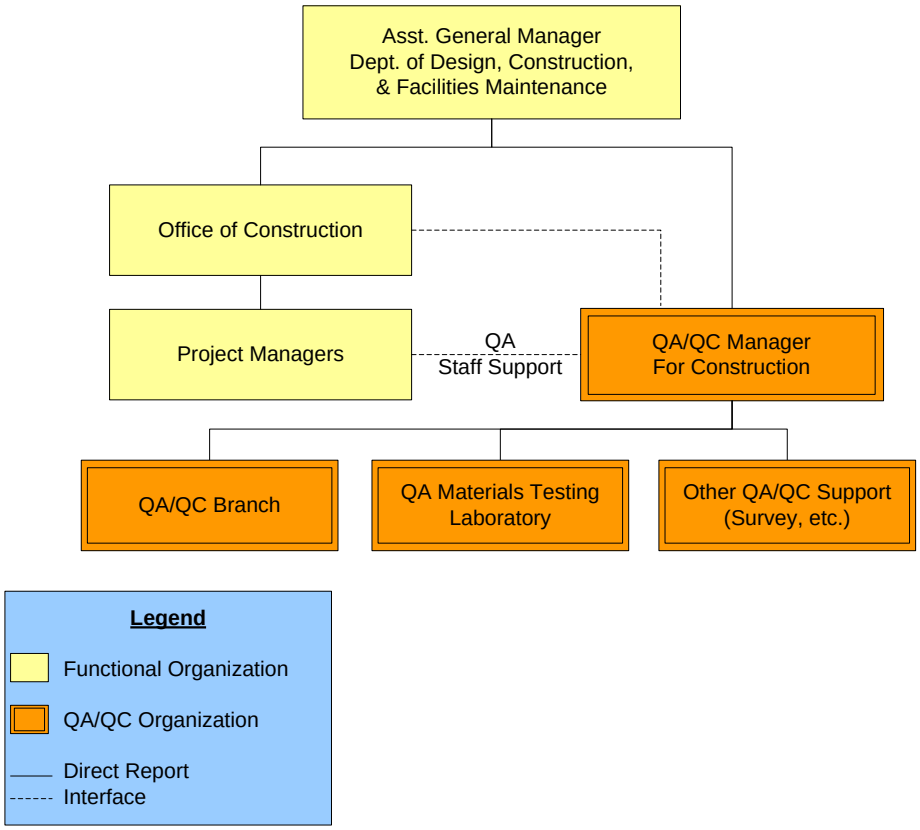


Figure 3-2: Example of a Quality Program with In-house Construction Management

A similar approach for quality should be followed where construction is performed by force account staff. The internal construction manager should be responsible for undertaking the QA role, while the force account staff should be responsible for QC. There should also be an independent person from the grantee's staff designated to provide QA oversight to verify to the grantee senior manager that the established QMS is being appropriately applied. This latter role is important, especially if the construction manager is not familiar with QA responsibilities and the QMS.

Some grantees have evolved from using a CMC to doing their own construction management, employing outside construction contractors. Such organizations should have a QM for transit development activities. The QM may require staff for providing quality support to the PMs, depending on the scope of the department/organization and its projects. It may also have a materials testing laboratory or additional QC resources to provide some QC for contractor work. Construction contractors are still responsible for the QC, so the grantee should develop minimum specifications for the contractor's QC program. It is extremely important that contract documents clearly specify responsibilities of each organization. Figure 3-2 shows an organization for a Quality Program with in-house Construction Management.

3.3.3 Quality in Design

As with construction, there are many different ways for a grantee to organize its design activities. The grantee may use a General Engineering Consultant (GEC) for design and outside A&E firms to produce the design. The grantee may handle design management in-house and contract the design to an A&E firm. The grantee could handle both management and design in-house.

Quality Programs in design can vary to accommodate the management organization for design. Typically, the organization doing the design is responsible for QC of design.

The organization providing design management should be responsible for providing QA for design. Where an outside consultant is responsible for design management, all QA responsibilities should be contractually specified early in the relationship between the grantee and the design management consultant. Likewise, the QA role of the design management consultant should be specified in the contract of the organization responsible for doing the design. The grantee needs to maintain an oversight role to acquire confidence that the QMS for design is achieving the project quality objectives when an outside consultant is responsible for design management. Figure 3-2 illustrates an organizational structure for QA in design using an outside design management consultant.

Where the grantee retains responsibility for design management, the grantee's PM should be responsible for establishing a design QA system.

Where the design effort remains entirely in-house, a two-tier organization for Quality is warranted. Those producing the design should be responsible for QC activities. Those functioning as design management should be responsible for establishing a design QA activity for oversight of the design process. In this case, an independent QA audit might be conducted to assure design management compliance with design procedures.

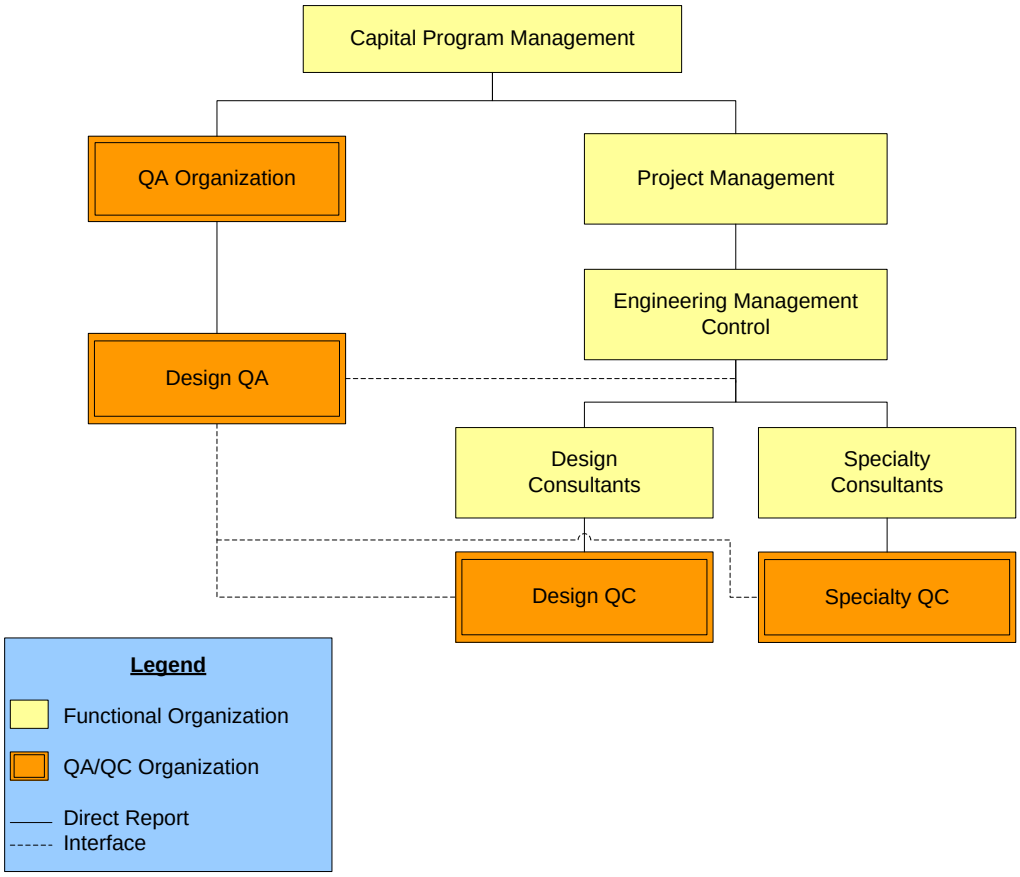


Figure 3-3: Quality Organization for Design with a Design Management Consultant

3.3.4 Quality for Small Projects

Smaller grantees may not be able to justify a special Quality Staff for a one-time project. Also, grantees may not be able to justify Quality Staff for smaller projects such as bus storage and maintenance facilities. Nevertheless, each grantee still has the responsibility to assure that FTA capital funds are spent wisely. The PM of a small project should develop a QMS for the project by determining which of the fifteen elements of a Quality Program are applicable to the work being performed. Where the project is simple, where design and construction methods are standard, and where the risk of failure is low, the QMS might be focused on final inspection and testing activities. Even so, many of the fifteen elements may be required to get to the final inspection and testing stage.

One approach for handling quality activities on projects of limited scope is to make the construction contractor responsible for some QA and QC activities and the grantee's project management responsible for QA oversight activities. For example, the construction contractor could perform inspection and testing and provide the documentation thereof, document all design changes, inspect and track all purchased products, and document all nonconformances and corrective actions. For a small project, the project management staff should undertake QA oversight activities such as witnessing testing, reviewing contractor documentation, and monitoring contractor compliance with its Quality Program and other contract requirements. An option for providing QA oversight of both the project management and the construction

contractor activities is to use an outside firm for this purpose. Contract documents must clearly specify the role of each organization. Following is a Case History for a Small Project:

Case History of a Small Project

A small rehabilitation project had many inter-disciplinary interfaces, and the project had to be performed while existing services were maintained. The grantee knew the difficulties that the project would present and started thinking about ways to control cost, schedule, and quality during the planning phase of the project. Resources, including funding and manpower, were limited. The following actions were taken:

- *The grantee required the contractor to provide a Quality Plan to cover the scope of the work.*
- *The grantee required that the contractor provide personnel to perform quality activities.*
- *The grantee required that all the project work be identified on checklists that could:*
  - *Be signed off by the contractor*
  - *Provide grantee hold and witness points*
  - *Be signed off by quality personnel*
- *The grantee identified what records would be required to be turned over as a result of implementing the Project Quality Plan.*

Of the fifteen quality elements, parts of each (except for Quality Audits) were contained in the contractor's Quality Program. The benefits that were realized as a result of these actions were:

- *The contractor supplied the needed human resources*
- *Every interface that the grantee needed was retained*
- *Every document that the grantee needed was retained*
- *A system to identify and rectify potential problems was established prior to the first problem becoming an issue.*

3.3.5 Quality in Equipment Procurement

The purchase of major capital equipment by a grantee is another process where the application of the fifteen quality elements is appropriate. The grantee's QMS should include procedures for purchasing. The PM or project engineer in charge of the purchasing effort would be responsible for determining which quality elements and procedures should be applied to the equipment procurement on their project. If the grantee has a quality function, a member of the quality staff should help determine which quality elements and procedures should be applied.

Alternatives for purchasing vary from requirements for the supplier to have a complete fifteen-element Quality Program to requirements for a program limited to final inspection and testing. In

either case, the grantee will have to provide QA oversight to assure that the supplier programs are consistent with the project quality objectives and effective in meeting grantee expectations.

An adequate supplier Quality Program and the responsibility for QA oversight are both critical. The role of QA oversight on complex procurement projects requires highly knowledgeable staff. Where such staff is not available, a grantee should consider hiring a consultant to assist with the QA oversight activities.

3.3.6 Quality in Design-Build Projects

Unlike conventional project delivery methods (i.e., Design-Bid-Build), the Design-Build (DB) project development approach combines both responsibilities of design and construction under the auspices of a single entity, the DB Contractor. With such an arrangement comes modification to the roles and responsibilities of the parties involved, which will undoubtedly affect many aspects of the project. The DB concept utilizes the combined expertise of both the design and construction industry to promote innovative designs, speed project delivery, and reduce cost. The grantee is often required to relinquish detailed oversight to obtain complete benefit of this project delivery system. Naturally, this transfer of responsibility generates great concern over whether the DB team will adequately address quality. This section focuses on how quality is addressed under the DB approach.

DB project delivery has many unique characteristics. Several of these are listed below:

- Includes variation to virtually all project development tasks
- Combines many task contracts into more limited number of contracts
- Combines design, construction and installation functions
- Increases emphasis on procurement documents
- Redefines relationships among all contracting parties
- Reallocates risk among project development organizations
- There are several variations of DB project delivery. Some of which are outlined below:

    - Super Turnkey: Combines all the elements of DB (Civil, Systems), and includes financing mechanisms. This variation can also allow for ownership of completed project.
    - DBOM (Design-Build-Operate-Maintain): Under this type, the DB contractor is also responsible for operating and maintaining the system after its completion. The period of operation and maintenance is stipulated in the contract agreement, after which this responsibility is transferred to the grantee.

In order to assure the success of Quality Programs in DB project delivery, grantee agencies need to consider several key practices:

- Clearly define roles and responsibilities of parties involved early in the bid documents.
- Clearly define requirements of the Quality Program in the contract documents.
- Commit to a higher level of grantee oversight activities in order to assure effectiveness of the Quality Program. Where agency in-house expertise is limited,

the use of independent specialized consultants can prove beneficial to the effectiveness of the program.

- Require additional levels of reporting and/or detail by the DB contractor team.
- Maintain a proactive and systematic Quality Program that encompasses all of the project lifecycle stages.

Quality Program effectiveness hinges on clear allocation of roles and responsibilities to the involved parties. Ideally, the best results are achieved when quality roles and responsibilities are clearly defined in the contract documents and, more importantly, are agreed upon by the parties at the outset. Under DB project delivery, the grantee may elect to shift some of the quality roles and responsibilities to the DB contractor. In such cases, it is recommended that the grantee conduct audits and testing at every stage of the quality process, and retain ownership of the resident database. In less ideal cases, grantee agencies have elected to retain the QA role only, with the DB contractor performing the QC activities. Crucial to the success of this arrangement is the DB contractor's level of experience and the grantee's in-house oversight capabilities. Typically, DB projects provide DB contractors with added responsibility for program implementation. There are some perceived disadvantages to the shift in responsibilities from the grantee's perspective. As was previously stated, a major concern in the DB environment has been the potential for an agency conflict of interest when the DB contractor performs its own quality oversight of the project. Although this is a legitimate concern, it can be adequately addressed through careful stipulations and requirements delineated in the contract documents. As indicated earlier, the grantee could place more quality responsibility on the DB contractor while retaining a more stringent oversight role.

One example of a grantee maintaining a stringent quality oversight or QA role over a DB contractor can be seen in Case Study #3 contained in Appendix C of these *Guidelines*. This example deals with the Maryland Mass Transit Administration (MDMTA), now the Maryland Transit Administration (MTA), and their role in the Baltimore Central Light Rail Line (CLRL) Phase II Extensions project, which was a DB project. The organizational structure utilized on this project is illustrated in Figure 3-4. The figure shows that although the DB contractor utilized its own QM, the grantee quality organization maintained direct QA oversight of their work.

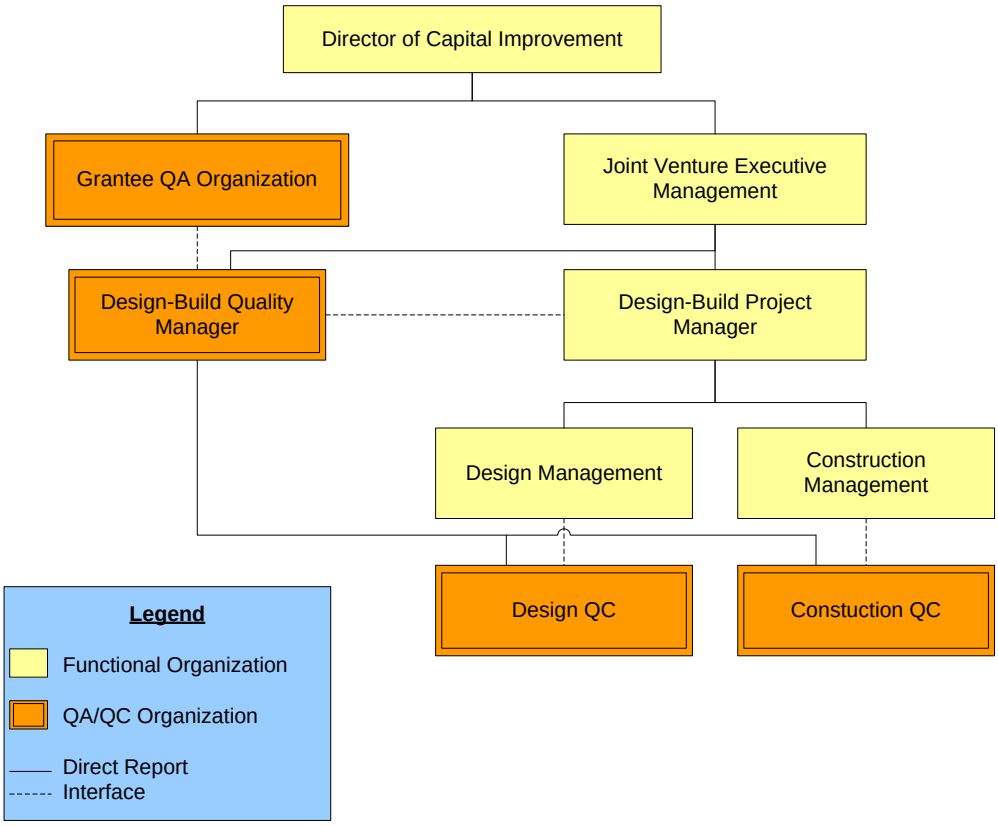


Figure 3-4: Quality Organization for a Design-Build Project

Responsibility for quality under the DB method requires clear definition of roles for both the grantee and DB contractor. The grantee and DB contractor must carefully define the Quality Program, including roles and responsibilities within the bid documents so that the participants' requirements are clear. As with other areas of project management control, it is necessary for grantees to monitor the Quality Program. The grantee may have to provide more monitoring than would be anticipated in the DB contract to ensure that the contractor has a full understanding of requirements for quality management and corrective actions.

3.4 Independent Assurance Program

3.4.1 Description

Another alternative to the project QMS is to have an independent contractor responsible for the Quality Program. This alternative was proposed in Section 3.3.4, *Quality for Small Projects*. It is also useful when the grantee undertakes multiple projects simultaneously, such that the grantee's quality staff is unable to adequately cover all of the project quality oversight requirements. It is also useful, when the construction management consultant does not possess a sufficiently experienced quality team.

In the case where there is a project/construction management consultant or there is a DBOM contractor, the responsibility for hiring the independent quality firm may rest with them.

When there is in-house construction management, the responsibility for hiring the independent outside firm should rest with the grantee's existing Quality function, or with the PM when no quality function exists. When the quality function performs the hiring, the outside firm should report directly to the grantee's quality function, with dotted line or matrix responsibility to the PM. When the PM performs the hiring, the outside firm should report to the PM, but provide written reports to grantee senior management.

It is important to note, that in either case, responsibility for project quality still rests with grantee senior management, quality management, or project management. The grantee cannot abdicate responsibility for satisfying all the project quality requirements.

3.4.2 Advantages and Disadvantages of an Independent Assurance Program

Advantages of an Independent Assurance Program include:

- Additional resources will allow the existing grantee quality function to cover all of their projects without spreading their resources so thin as to become ineffective.
- With additional resources, the existing grantee quality function can effectively play a leadership role on all projects, while still accomplishing its day-to-day quality activities.
- An independent outside firm can immediately provide experienced, professional personnel without having to undergo a learning curve. The grantee can review and accept or refuse these personnel on an individual-by-individual basis.
- The outside firm personnel can provide resources that can be dedicated to one or more specific projects.
- The outside firm provides an independent approach to quality.

Disadvantages and associated mitigation of an Independent Assurance Program include:

- There will be some learning at the start of the project by the outside firm; so it is advisable to bring it into the project in the planning stage or as early as possible.
- Depending on the program management structure, allegiance on the part of the outside firm may become an issue, depending on who directly pays the salaries of the outside firm's personnel. Roles, responsibilities, reporting, and allegiance must be clearly defined prior to hiring the outside firm and included in the firm's contract.
- Depending on whether the hired firm is local or distant, on-site availability may become an issue; but at a minimum, dedicated on-site support should be negotiated with the outside firm.

3.4.3 Methods of Control

As was stated earlier, the grantee cannot abdicate responsibility for satisfying the project quality requirements. Therefore, it is necessary to implement methods of control to assure that the requirements are being met. Recommended methods include:

- Development and approval of mutually agreeable, well defined contract requirements that include clearly defined roles, responsibilities, and reporting.
- Frequent status reports and review meetings with the outside firm.

- Contract language clearly indicating that the outside firm must act in an independent professional manner and additional contract language that provides for an immediate termination option by the grantee in the event of an irresolvable conflict.

3.5 Test Lab Accreditation and Quality Personnel Qualifications

3.5.1 Test Lab Accreditation

Depending on the type of project, test labs may be used for several types of testing, such as:

- Soil testing
- Aggregate testing
- Concrete testing
- Structural bolting testing
- Electrical testing
- Mechanical and welding testing
- Nondestructive examination operations
- Calibration of measuring and test equipment

When test labs are required, projects should only use accredited laboratories. These accredited labs may be local, national or international. In any case, the accreditation of the labs that perform various types of tests is the formal recognition that a laboratory is competent to carry out specific tests or types of tests or calibrations.

Accreditation is different from certification. Accreditation is the procedure by which an authorizing body gives formal recognition that a given entity has written procedures in place in accordance with standards and technical regulations and is competent to carry out specific tasks such as testing, calibration, certification, and inspection. Certification is the action of an independent third party/authorizing body who verifies that an end product, process or service fulfills all the specified requirements of relevant standards or technical regulations.

The difference between accreditation and certification lies in the fact that accreditation is the formal recognition of competence and is based on proven technical knowledge and therefore requires the consultation of a technical expert for the entity to be accredited. Certification primarily involves ensuring/verifying conformity with a given norm, e.g., a management system or a product.

3.5.2 Accreditation Agencies

The International Laboratory Accreditation Cooperation (ILAC) is an international cooperation of laboratory and inspection accreditation bodies formed in 1977 to help remove technical barriers to trade. Accreditation is the independent evaluation of conformity assessment bodies against recognized standards to carry out specific activities to ensure their impartiality and competence. Through the application of national and international standards, government, procurers, and consumers can have confidence in the calibration and test results, inspection reports and certifications provided by an Accredited Agency. Accreditation bodies are established in many countries with the primary purpose of ensuring that conformity assessment bodies are subject to

oversight by an authoritative body. Two of the original signatories from the United States to the ILAC Mutual Recognition Arrangement for both testing and calibration are:

1. The American Association for Laboratory Accreditation (A2LA)
2. The National Voluntary Laboratory Accreditation Program (NVLAP)

The ILAC and its associated members enter into mutual recognition arrangements with national and international accreditation associations so as to eliminate unnecessary duplication in the development and promulgation of accreditation efforts. As a result, once a facility is accredited by one agency, its accreditation is recognized by all national and international agencies with which agreements have been made. Grantees can consequently be assured that labs, which have been accredited by agencies recognized by ILAC, have all met the same rigid standards and are competent to carry out the tests in the areas for which they have received accreditation.

3.5.2.1 American Association for Laboratory Accreditation (A2LA)

The American Association for Laboratory Accreditation (A2LA) is a nonprofit, non-governmental, public service, membership society. A2LA's mission is to provide world-class accreditation and training services for testing and calibration laboratories, inspection bodies, proficiency testing providers, reference material producers and product certifiers.

A2LA provides comprehensive services in laboratory accreditation and laboratory-related training. Services are available to any type of organization, be it private or government. Laboratory accreditation is based on internationally accepted criteria for competence (ISO/IEC 17025:2005). A2LA also offers programs for accreditation of inspection bodies, proficiency testing providers, reference material producers, and product certification bodies.

3.5.2.2 National Voluntary Laboratory Accreditation Program (NVLAP)

The National Institute of Standards and Technology (NIST) is an organization within the US Department of Commerce and is headquartered in Gaithersburg, Maryland. NIST administers the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP's mission is to facilitate cross-border trade through the establishment and maintenance of international MRAs; to promote confidence in the technical competence of NVLAP-accredited laboratories and the reliability of their results; to communicate frequently with customers and stakeholders to determine their accreditation needs and requirements; to develop accreditation programs, using balanced input from technical experts, industry, and interested parties; to meet the highest professional standards for integrity, impartiality, and ethical conduct; to manage resources in a manner that maximizes delivered value to customers; and to afford employees the opportunity to develop their full potential in a working environment that recognizes individual and group quality achievements and encourages excellence.

NVLAP provides accreditation services through various Laboratory Accreditation Programs (LAPs), which are established on the basis of requests and demonstrated need. Each LAP includes specific tests or calibration standards and related methods and protocols assembled to satisfy the unique needs for accreditation in a field of testing or calibration. NVLAP accredits public and private laboratories based on evaluation of their technical qualifications and competence to carry out specific calibrations or tests. NVLAP provides third-party accreditation to testing and calibration laboratories. NVLAP's accreditation programs are established in

response to Congressional mandates, administrative actions by the Federal Government, and requests from private-sector organizations and government agencies.

3.5.3 Quality Personnel Qualifications

Section 3.3 of these *Guidelines* provided various organizational suggestions that can be utilized on grantee projects. These alternative organizational structures identify the quality organization, quality management, and lines of communication. Personnel filling these positions should have the requisite education and experience required to accomplish a successful project Quality Program. It would be unrealistic to identify one set of requirements that would satisfy all of the needs of every organization or project. However, the following suggestions are recommended:

- **Management/Supervisors** should possess understanding of the general concepts and objectives established in these *Guidelines* to assure that they are considered in major capital projects.
- **Quality Management/Supervisors** should possess experience managing professional personnel in similar circumstances or on similar projects. They should have experience with matrix organizations and managing multiple projects. They should have excellent communication skills and a working knowledge of quality and quality management. They should possess certification as quality professionals from ASQ (Certified Manager of Quality/Organizational Excellence (CMQ/OE), preferably) or other appropriate certifying bodies or have successfully completed training courses in the quality discipline.
- **Quality Engineers** should have a Bachelors or Masters degree in the necessary fields of study (Civil, Electrical, Mechanical Engineering, etc., as appropriate) for the project; experience commensurate with the type of project and size of the quality department; and, depending on the project, one or more engineers should be a licensed Professional Engineer in the state where the project is taking place. Certification as a quality professional, e.g. a Certified Quality Engineer (CQE), Certified Quality Auditor (CQA), or other certification from ASQ, is desirable.
- **Inspectors** should have the appropriate education or experience commensurate with the job responsibilities. They should possess the necessary certifications required for assignments (e.g., American Welding Society (AWS), American Society for Testing and Materials (ASTM), American Concrete Institute (ACI), etc.). While certification from ASQ may also be beneficial to inspectors, this should be considered a bonus, as it is more critical for inspectors to focus on certifications which directly affect their work.

3.6 Software Quality Assurance (SQA)

Software plays an increasingly important role in every product and organization. Of the number of mission critical applications, those with a high cost of failure (e.g., Automatic Train Supervision and Automatic Train Protection software), or high cost to fix (e.g., communication equipment and other consumer products), have increased exponentially in recent years. Software for embedded systems more often than not fits a mission-critical profile, and with the forecast for embedded systems continuing to accelerate, the need for proactive quality assurance is higher than ever before.

The software developer or vendor should understand the value of having a formal software QMS and should be committed to utilizing the best available standards, methods, practices, and dedicated resources to ensure all software meets a well-defined quality objective. SQA encompasses the entire software development process, which includes processes such as requirements definition, software design, coding, source code control, code reviews, change management, configuration management, testing, release management, and product integration. SQA is organized into goals, commitments, abilities, activities, measurements, and verifications.

There are two key elements that make up a sound software QMS: the Vendor's Quality System (VQS) and the Vendor's Software Development Process (VSDP).

The VQS consists of procedures assuring that quality is addressed and implemented in all aspects of project management and product development. These procedures should be developed in accordance with ISO 9000 or the requirements of another applicable Quality Standard. In addition, the VQS defines the QMS requirements, the policy stating the vendor's belief in the requirement, the resources responsible for implementing the policy, and the standard operating procedures that describe how the vendor conforms to the software QMS requirements.

The VSDP describes the detailed and comprehensive development process that translates the software QMS requirements defined in the VQS. The VSDP includes project planning; project execution; product creation, verification, and validation; and installation and support functions. The VSDP identifies and defines the roles and responsibilities of project team members; project deliverables; and a monitoring mechanism based on measurements, analysis, and continuous improvement. Key audits and reviews are performed in order to track status and progress and to ensure that the project meets its requirements and milestones. The VSDP should be developed in accordance with Element 2 of these *Guidelines*, *Documented Quality Management System*.

The QA department within the vendor's organization performs configuration management, verification and validation, and quality assurance activities to ensure that the VQS is adhered to throughout the project development lifecycle. The VSDP ensures that the grantee's/client's needs are fully understood and captured, and that project planning, development, and testing activities are documented prior to product creation. The VSDP should be flexible to allow tailoring to meet any solution that grantees/clients require.

A Software QMS process needs to set expectations for the grantee/client, project team members, and the vendor's organization and should support these expectations through the VQS and VSDP. The most important characteristic of the software QMS is predictability; the vendor should be able to predict the budget, the schedule, and the quality of deliverables. This translates to grantee/client satisfaction since the project will be delivered on time, within budget, and with the best quality.

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4.1 Goals and Objectives

The goal of a Quality Plan is to explicitly plan for and describe the quality related activities needed to ensure that the project meets the requirements of the grantee and complies with regulatory requirements. The Quality Plan should be developed hand-in-hand with the PMP for the project. It is a living document in that it will probably have to be revised as the project progresses from the Project Planning Phase through Preliminary Engineering (PE), Final Design, Construction/Procurement, and Testing and Start-up.

4.2 Responsibilities

The Project Manager (PM) is ultimately responsible for the Quality Plan. Ultimately, the PM must determine which procedures should be applied to the project. Where there is a Quality Manager (QM), Director of Quality, or equivalent position, that person should also approve the plan.

4.3 Approach

Where a grantee has detailed procedures for carrying out the elements of the Quality Policy, the development of a Quality Plan for a project is straightforward. The PM can adopt particular

procedures as appropriate during the different project phases of Project Planning, PE and Final Design, Procurement/Construction, and Testing and Start-up, or tailor existing procedures to the needs of the project through minor changes. The Quality Plan should provide an overview of the entire Quality Program for the project and should provide enough detail, either through incorporation of or reference to written procedures. It should also cite project objectives based on the grantee's Quality Policy and the expectations of the FTA and/or other project stakeholders.

Where written procedures have not been adopted by the grantee, they will have to be developed specifically for the Quality Plan. Thus, if a grantee expects to be involved in multiple capital projects using FTA funding, the grantee should consider the formal development of written procedures.

The Quality Plan should be written to provide project management with easy access to the quality requirements. When the Plan references procedures or standards, those items should be readily available.

4.4 Technical Requirements During Each Project Phase

While it is possible that one Quality Plan, applicable throughout the project, could be written at the end of the Planning Phase, the more likely situation is one where the Quality Plan evolves as the project progresses. This is so because the organizations may change and the level of quality assistance required by contractors can vary. Also the procedures, forms, reports, etc., initially proposed for a Quality Program may be changed during the course of the project or not used at all. Changes should be reflected in the Quality Plan if they improve the final documentation and quality of the work.

There are exceptions to the traditional phased approach to a project. In design-build situations, one contractor could be responsible for several project phases. Therefore, the Quality Program requirements should be completely specified at the time of the project bid and design-build contractor selection. The grantee may choose to require that a Project Quality Plan or an outline be submitted with each proposal/bid, to aid in the selection process.

The following sections describe the type of detail that is desirable in a Quality Plan during the relevant project phases. The description is for the desired detail for a complex project where all of the quality system elements should be included at some time during the project. Less detail may be appropriate for simpler projects.

4.4.1 Project Planning

Project Planning can include the bus maintenance facility planning process, rail modernization planning, and the Alternatives Analysis (AA) process for major capital investments for which FTA has established detailed procedures. Responsibility for bus maintenance facility planning and rail modernization planning typically rests with the operating agency. For AA planning, the responsibility may be spread among several agencies. The lead agency need only have the charter, authority, and capability to perform the planning and receive the grants required to accomplish the AA.

For major capital projects, a PMP should be initiated during the Project Planning Phase and completed and approved before entering into Final Design. The grantee should develop the PMP, which may be different from the organization implementing the Project Plan. Generally, the PMP must be submitted during the project grant review process and as part of FTA's grant application review. A Quality Plan is required as part of the PMP and is usually prepared as a stand-alone document.

At this early phase, much is still unknown about the project. All of the participants may not be known, so that the Quality Plan cannot name organizations and persons. Schedules, budgets, construction techniques, and so forth have yet to be decided. Initially, therefore, the Quality Plan should consist of a general description of the fifteen basic quality elements as applicable to the grantee, and how they relate to the project. The Quality Policy and appropriate existing procedures should be included in the Quality Plan.

Development of the Quality Plan is important at this phase to set an overall expectation, objectives, and direction for quality for the project, and to clearly spell out quality requirements for procurement of the design consultants. Table 4-1 indicates the quality system elements for which design-related detail might be appropriate at this initial phase. The Table then displays requirements for each element as the project progresses through Testing/Start-Up.

There may not be a quality requirement for submittal of a Quality Plan for projects which are not major, and which do not have a PMP requirement. However, the development of a Quality Plan can be beneficial for project management and project control purposes on any project. Again, at this phase, the major planning effort should be focused on the quality requirements for the design activity.

4.4.2 Preliminary Engineering and Final Design

The Preliminary Engineering Phase is initiated at the conclusion of Project Planning. In PE, the design is developed enough to provide a more accurate estimate of project costs and impacts. The resultant technical and financial information forms the basis for subsequent funding and implementation decisions. During PE, the merits of all sound configurations and designs are investigated.

The Final Design Phase is the last project development phase prior to construction. During this phase, the design consultant and/or in-house design staff prepares the plans, specifications, and bid documents required for awarding the individual facility construction and equipment fabrication/installation contracts.

Management of PE and Final Design is the responsibility of the grantee, which must ensure that knowledgeable personnel are available to perform the required services.

Two basic alternatives exist for organizing the PE effort. The chosen alternative may be continued into Final Design or a different alternative can be established at that point. The two alternatives are: 1) the grantee staff performs all design, or 2) consultants have the primary responsibility for design. There are also organizational alternatives to these extremes that mix the use of grantee staff and consultant staff. For larger projects, either the grantee or a general design/engineering consultant can supervise and manage the work of firms retained to design sections of the project.

As design consultants are chosen and the design management organization is put into place, the PMP should be updated to reflect these actions. The Quality Plan should be updated to reflect each new organization of quality activity, and it should be updated to reflect more closely the planned quality activities during the Final Design Phase. The Plan should begin to answer more specifically the questions of who is responsible and when in time actions should occur.

More important, the Quality Plan should be updated to reflect the quality requirements for the next phase in the process. Since an important product of the design phase is construction contract documents for construction contractors, decisions about quality requirements for construction and manufacturing need to be planned and included in the contract documents. Table 4-1 indicates the detailed descriptions that might be appropriate at this phase in the Project Quality Plan.

4.4.3 Construction and Equipment Procurement

During the Construction and Equipment Procurement Phase, suppliers, contractors, and/or agency force account employees construct the fixed facilities, fabricate/install equipment, and integrate them into a functioning system. During this phase, the Quality Plan should be updated in sufficient detail to guide the grantee in appropriate QA, QC, and quality oversight procedures.

During this phase, the first task is to procure the required contractors. These include the Project or Construction Management Consultant (PMC or CMC), the construction contractors, and/or the equipment manufacturers. Where procurement regulations allow, contractors should be prequalified. Evidence of an acceptable Quality Program should be part of the prequalification process.

Where the specifications for the various contracted project tasks require the contractor to assume responsibilities for specific quality activities, the contractor should prepare written documentation of its Quality Program. This program should be reviewed and approved for adequacy by the grantee's PM and the QM, or equivalent position.

Key quality elements that need to be specified in detail in the Quality Plan and, where appropriate, in contract documents, are procedures for nonconformance and corrective action during manufacturing and/or construction. In particular, the process for stopping work should be spelled out. Persons authorized to issue stop-work orders, procedures for doing so, approvals required, and restrictions need to be clearly understood by the contractors as well as the grantee. The grantee's role in providing quality oversight for the project should be described, and any audit activities should be planned. Table 4-1 indicates the type of information that would be useful during this phase.

4.4.4 Testing and Start-up

The Testing and Start-up Phase is the bridge between the Construction and Equipment Procurement Phase and the beginning of revenue service. The purpose of this phase is to accept the newly constructed or modernized facility, and/or the newly procured equipment. This phase also includes integration testing of the operating system prior to beginning or resuming revenue service. This phase overlaps with the Construction and Equipment Procurement Phase, since some testing is performed in accordance with contract requirements during the earlier phase.

The Quality Plan should be modified prior to the beginning of the Testing and Start-up Phase to include detailed procedures for those tests required for the transfer of facilities and equipment from the constructing organization to the operating organization. Although contractually required testing will have been done as part of Construction and Equipment Procurement, other testing may be required by the grantee to accept the facilities and equipment. Acceptance criteria, however, must be specified at the end of the Final Design Phase and included in the construction contract documents.

Assurance of the testing program at this point is the responsibility of the grantee. A test management team, as part of the project staff, should manage testing. A test engineer should manage the program with assistance from consultants and grantee staff, as appropriate.

An exception to this situation would be when the contractor constructing the new system will also be responsible for operating the system for a period of time. In this case, all system integration testing would be performed as part of the contract with the constructing/operating organization. The tests must therefore be detailed in the Final Design Phase.

Preparation for revenue service start-up also includes the training of personnel to operate and maintain the facilities. Prior to service start-up the grantee should simulate service to test whether all system elements are functional and perform as designed. Start-up operations should verify the competence of the personnel and ensure a smooth and safe transition into operations.

The Quality Plan for the project should also reflect the need for ongoing maintenance contracts, as well as grantee/operator actions required to keep the contractual warranties in force. Table 4-1 shows the details to be included in the Quality Plan at the beginning of the Testing and Start-up Phase.

Given the existence of a detailed Project Quality Plan and given that the Plan is carefully executed, each of the project phases from Project Planning through Testing and Start-up should meet the quality specifications of the grantee and provide excellent service. This, ultimately, is the objective of the Quality Program.

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Table 4-1: Details of the Project Quality Plan at Various Project Phases

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
1. Management Responsibility	Describe the quality responsibilities of the project team and the organization responsible for quality for the grantee. Identify policy and objectives. Identify specific positions where possible.	Describe the quality responsibilities of the project team and the organization responsible for quality for the grantee and for the design consultant. Identify policy and objectives. Identify specific positions where possible.	Describe the quality responsibilities of the grantee project team and the organization responsible for quality for the grantee and for construction management consultants, construction contractors, and equipment manufacturing contractors. Identify policy and objectives. Identify specific positions where possible. Identify grantee functions responsible for quality oversight activities.	Describe the quality responsibilities of the project team and the organization responsible for quality for the grantee and for construction management consultants, construction contractors, and equipment manufacturing contractors. Identify policy and objectives. Identify specific positions responsible for acceptance, demonstration, and integration testing. Identify grantee functions responsible for the testing program.
2. Documented Quality Management System	Incorporate by reference any written quality procedures applicable to the project. Applicable existing procedures can be referenced for any of the Quality Program elements.	Incorporate by reference any written procedures for quality applicable to the project. Construction and/or equipment manufacturing related procedures are particularly relevant.	Incorporate by reference any written procedures for the Quality Plan applicable to the project. Construction and/or equipment manufacturing related procedures are particularly relevant.	Incorporate by reference any written procedures for the Quality Plan applicable to the project. Testing related procedures are particularly relevant.

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
3. Design Control	Specify requirements for review & sign-off for design from departments, such as Construction and Operations, and other relevant agencies. Specify required design reviews during the PE and Final Design Phase. Specify any contract quality requirements for PE or Final Design consultants. Describe the procedures to be followed for design changes, including sign-off and documentation.	Describe the procedures to be followed for design or specification changes or waivers of requirements during construction. Sign-off of the responsible design consultant is desirable as well as sign-off by those originally responsible for the design approvals. Requirements for "as-built" documents should be stated.	Describe the procedures to be followed for design or specification changes or waivers of requirements during construction. Sign-off of the responsible design consultant is desirable as well as sign-off by those originally responsible for the design approvals. Requirements for "as-built" documents should be stated. Construction Phase Services procedures should be defined,	Describe the procedures to be followed for fixing problems that are uncovered during final testing. Configuration management practices should be identified and followed.
4. Document Control	Describe procedures for the control of project documents. These procedures may be modified as contractors and consultants join the project.	Describe procedures for the control of project documents incorporating the design consultants for the project. These procedures may be modified as construction contractors and construction management consultants join the project.	Describe procedures for the control of project documents as relates to the various construction contractors and consultants for the project. Contractor obligations should be specified and should be included in the contract documents.	Describe procedures for the control of documentation from the testing program.

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
5. Purchasing	Describe procedures to obtain a list of qualified contractors/consultants for the design service. Provide a statement of general requirements, including quality requirements, and any past demonstrated capability and performance requirements. Describe the process to ensure that purchasing documents are reviewed and approved by a designated authority prior to release.	Describe procedures to obtain a list of qualified contractors for the desired service. Provide a statement of general requirements, including quality requirements, and any past demonstrated capability and performance requirements. Describe the process to ensure that purchasing documents are reviewed and approved by a designated authority prior to release.	Describe requirements for purchasing control to be placed upon construction contractors or equipment manufacturing contractors for the project. Describe purchasing and receiving control procedures to be followed by the grantee.	In addition to the requirements for testing of materials defined in the purchasing contract documents, specify in the Quality Plan random testing by the grantee of products for which fabricators submit material certificates or certificates of compliance. Testing should also be conducted when the validity of the materials/products or documentation are questionable.
6. Product Identification and Traceability	N/A	Describe requirements for product identification and traceability to be placed in contract documents, where appropriate, for equipment manufacturers or others supplying products for the project. Describe where these requirements are appropriate.	Describe requirements for product identification and traceability that should be included, where appropriate, in contract documents.	Describe the requirements for product identification and traceability for products and materials turned over to the grantee at the project conclusion.

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
7. Process Control	N/A	Describe requirements for process control and procedures for special processes to be placed in contract documents, where appropriate, for contractors. Describe where these requirements are appropriate.	Describe requirements for process control and procedures for special processes, which should be included, where appropriate, in contract documents. These procedures should specify any sequencing of work requirements.	Describe plans for maintenance of the facility and equipment, especially as required for warranty purposes.
8. Inspection & Testing	N/A	Describe requirements for inspection and testing to be placed in contract documents, where appropriate, for contractors. Inspection and testing can include source inspection, receiving inspection, in-process inspection and testing, and final inspection and testing. Specifications should indicate the types of tests required and the standards to be met. Describe where these requirements are appropriate.	Describe requirements for inspection and testing for each contract, as appropriate. Inspection and testing can include source inspection, receiving inspection, in-process inspection and testing, and final inspection and testing. State the types of tests required and the standards/specifications to be met.	Describe plans for acceptance testing, demonstration testing, and integration testing of the system and equipment. Acceptance tests verify that performance of all delivered equipment is in conformance with specifications. Demonstration tests demonstrate the reliability of the system equipment. System integration testing demonstrates the ability of various subsystems and facilities to work together as a system and for the new or modernized system to function with an existing system. Tests that affect system safety should be reviewed independently in a safety review to ensure that potential hazards are identified and fixed.

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
9. Inspection, Measuring & Test Equipment	N/A	Describe requirements for calibration and maintenance of inspection, measuring, and test equipment to be placed in contract documents, where appropriate, for contractors. Describe where these requirements are appropriate.	Describe requirements, as appropriate, for calibration and maintenance of inspection, measuring, and test equipment for each contract.	Describe requirements, as appropriate, for calibration and maintenance of inspection, measuring, and test equipment as required for final testing.
10. Inspection & Test Status	N/A	Describe requirements to be placed in contract documents, where appropriate, for contractors to identify the inspection and test status of work during production and installation. Describe where these requirements are appropriate.	Describe requirements, as appropriate, for contractors to identify the inspection and test status of work during production and installation.	Describe requirements, as appropriate, to identify the inspection and test status of work during final testing.
11. Non-conformance	Describe procedures for managing nonconforming work. Potential design consultants/contractors should be made aware of these procedures.	Describe grantee procedures for managing nonconforming work. These procedures should be included in contract documents to clarify future expectations.	Specify grantee procedures for managing nonconforming work in detail. All contractors should be made aware of the procedures. Procedures include defining responsibilities, stating conditions that would cause work to stop, and providing documentation. Specify the requirements for the contractor to have their own procedures.	Describe procedures for managing nonconforming work. These procedures should be maintained during final testing.

Quality Program Element	Project Phase			
	Project Planning	**Preliminary Engineering/ Final Design**	**Construction/Procurement**	**Testing/ Start-Up**
12. Corrective Action	Describe procedures for managing corrective action. Potential design consultants/contractors should be made aware of these procedures.	Describe grantee procedures for corrective action and include these procedures in contract documents to clarify future expectations.	Describe procedures for taking corrective action in detail. Each contractor should be made aware of the procedures. Specify any requirements for the contractor to have their own procedures.	Describe procedures for taking corrective action. These procedures should be maintained during final testing.
13. Quality Records	Specify procedures for establishing and maintaining quality records. Requirements for consultants and/or contractors should be specified and made part of bid contracts and specifications.	Specify procedures for establishing and maintaining quality records. Requirements for contractors should be specified, and made part of contract documents.	Specify procedures for establishing and maintaining quality records. Requirements for contractors should be specified, and made part of the contract documents.	Specify procedures for maintaining quality records for a specified period after project completion.
14. Quality Audits	Describe an audit program with the initial focus on the design process at this phase in the project.	Plan and implement a quality audit system for the design activities during PE/Final Design. Requirements for consultants/contractors to cooperate with quality audits should be stated, and included where appropriate, in contract documents.	Plan and implement an audit program for the construction and equipment manufacturing activities.	A final audit should be planned to ensure that project quality records are complete and in satisfactory condition.
15. Training	Identify specific training required for personnel.	Identify specific training required for grantee and consultant/contractor personnel.	Identify specific training required for grantee and contractor personnel.	Identify specific training required for grantee operating and maintenance personnel to ensure a smooth transition to operations.

Appendix A: Examples from Transit Quality Programs

The 15 Elements as Covered by Various Agencies

The following examples are procedures and excerpts from quality plans which illustrate how a number of grantees have implemented different aspects of the 15 elements provided in the Guidelines. Each example follows a description of why it has been included and which aspects of the revised Guidelines it may or may not cover.

- **Element 1:** Management Responsibility provided by Maryland's MTA
- **Element 2:** Documented Quality Management System provided by Maryland's MTA
- **Element 3:** Design Control provided by New York's MTACC East Side Access project
- **Element 4:** Document Control provided by North Carolina's CATS
- **Element 5:** Purchasing provided by North Carolina's CATS
- **Element 6:** Product Identification and Traceability provided by Washington's Sound Transit
- **Element 7:** Process Control provided by Washington's Sound Transit
- **Element 8:** Inspection and Testing provided by Pennsylvania's SEPTA
- **Element 9:** Inspection, Measuring, and Test Equipment provided by Washington's Sound Transit
- **Element 10:** Inspection and Test Status provided by Washington's Sound Transit
- **Element 11:** Nonconformance provided by Maryland's MTA
- **Element 12:** Corrective Action provided by Colorado's RTD
- **Element 13:** Quality Records provided by Maryland's MTA
- **Element 14:** Quality Audits provided by Washington's Sound Transit
- **Element 15:** Training provided by Colorado's RTD

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Element 1:
Management Responsibility

The following is Section 01 of Revision 0 (August 2007) of the Maryland Transit Administration (MTA) Quality Assurance Program Plan, which has been generously provided by MTA - Baltimore, MD.

This example has been provided because it specifies that an effective Quality Management System (QMS) have defined goals and objectives. Defined quality objectives are a new addition to the FTA *Quality Management System Guidelines* as of this update, and are primarily covered under Element 1. Objectives should be referenced in manuals and/or procedures which relate to Element 1 as they are here. Organizational Charts have been grayed out.

1. MANAGEMENT RESPONSIBILITY AND ORGANIZATION

1.1 Purpose

To describe the Office of Engineering and Construction's management responsibilities and organizational requirements for quality-related activities for the Maryland Transit Administration (MTA) engineering projects and all other projects undertaken by the Office of Engineering and Construction.

1.2 Scope

These requirements apply to all Office of Engineering and Construction staff, consultants and contractors who perform activities that affect quality on MTA engineering projects and on all other projects undertaken by the Office of Engineering and Construction.

1.3 Policy

It is the Policy of the MTA that all engineering projects be planned and implemented with the highest regard for quality. Implementation should be based on an effective Quality Management System (QMS) with defined quality goals and objectives, specified quality-related activities and indicators, and assigned responsibilities for ensuring that the activities are conducted and that the objectives are met.

1.4 Requirements

1.4.1 The Office of Engineering and Construction and its consultants and contractors shall be organized in such a manner that:

- Quality is achieved and maintained by those who have responsibility for performance of the work.

- Quality achievement is verified by persons or organizations not directly responsible for the performance of the work.

1.4.2 The QA/QC Manager or designated individuals, e.g., Assistant QA/QC Manager(s), Resident Engineers, and assigned Inspectors, shall be responsible for verifying compliance with this QAPP.

1.4.3 The composition of the management structure for each consultant and contractor performing work for the Office of Engineering and Construction shall be the responsibility of that organization and is subject to approval by the Office of Engineering and Construction. The management structure shall be task-specific and comply with MTA requirements, as described herein.

1.4.4 Consultants and Contractors shall prepare project- or task-specific plans to achieve the measure of quality demanded by the Office of Engineering and Construction. A&E design consultants' plan shall comply with the MTA's *Quality Management Plan for A/E Design Consultants*. Contractors shall prepare a project-specific Contract Quality Control (CQC) Plan, which shall comply with Special Provision Section 01450, *Quality Assurance and Quality Control*.

1.4.5 The organization responsible to the MTA for quality shall have sufficient authority, access to work areas, and organizational freedom to identify quality problems and implement solutions acceptable to the MTA's Quality Assurance and Quality Control Manager (QA/QCM). The organization shall assure that further processing, delivery and installation continues to be controlled until proper disposition of deficient and/or nonconforming work has occurred, or until a satisfactory resolution of the problem has been achieved.

1.4.6 Quality staff performing verification functions shall report to a level of management that provides sufficient authority and organizational freedom to assure that appropriate action is taken to resolve conditions that may adversely affect quality.

1.4.7 For construction contracts in amounts of five million dollars and above, a Contract Quality Control (CQC) Plan Manager shall be at the project site on a full-time basis throughout the duration of the contract and shall have no responsibilities other than those required by Special Provision Section 01450, *Quality Assurance and Quality Control*. Depending on the nature and complexity of the work to be performed under the contract and/or for instances of nonconforming work, the MTA's Resident Engineer may require the CQC Plan Manager to be at the project site on a full-time basis for contracts in amounts less than five million dollars.

1.4.8 The adequacy and effectiveness of quality assurance and quality control programs shall be regularly and formally assessed by the management of the organizations implementing the quality assurance and quality control programs and by MTA.

1.5 Responsibilities

1.5.1 The MTA Administrator Organizational Chart (see Figure 1-1) shows the reporting relationships of MTA staff members.

1.5.2 The Office of Engineering and Construction Organizational Chart (see Figure 1-2) shows the reporting relationships of Office of Engineering and Construction staff members. The responsibilities for quality and interrelationships of the staff are delineated in each section of this QAPP. Each MTA staff member has responsibility for overseeing the quality of consultant's and contractor's work, as applicable, and managing the quality of his/her own work in accordance with this QAPP and other MTA Plans and Procedures specific to his/her division.

1.5.3 The Chief Engineer, Office of Engineering and Construction, is responsible for the development, establishment, implementation, maintenance, evaluation, and communication of the overall quality program for all of the MTA engineering projects.

1.5.4 MTA's QA/QCM, reporting to the Chief Engineer, Office of Engineering and Construction, is designated as the representative who shall have authority and responsibility for ensuring that the quality policy is implemented and maintained in all divisions within the Office of Engineering and Construction. The QA/QCM is responsible for administration of the Office of Engineering and Construction's QAPP. These activities shall include, but are not limited to:

- Assuring that the Office of Engineering and Construction's QAPP is established, implemented, maintained, and promulgated.

- Providing QAPP training to appropriate MTA staff, consultants and contractors who perform activities that affect quality on MTA engineering projects.

- Providing QA/QC consultation and direction to design, construction management, and contractor organizations in implementing quality procedures.

- Monitoring and evaluating quality program implementation, adequacy, and effectiveness through quality surveillance and quality compliance reviews.

- Recommending staffing for the QA/QC organization.

1.6 Procedure

Each bid/proposal document and contract for engineering design, construction management, or other quality/engineering services shall be reviewed by the QA/QCM to determine the specific elements of this QAPP that shall be implemented for the project. The applicability of each element shall be based on the project's size, complexity, uniqueness, and impact on the safe and efficient operation of the transit system.

This QAPP provides for the implementation of administrative and control measures during planning, design, procurement, construction, installation, testing, and start-up of MTA engineering projects.

Maryland Transit Administration

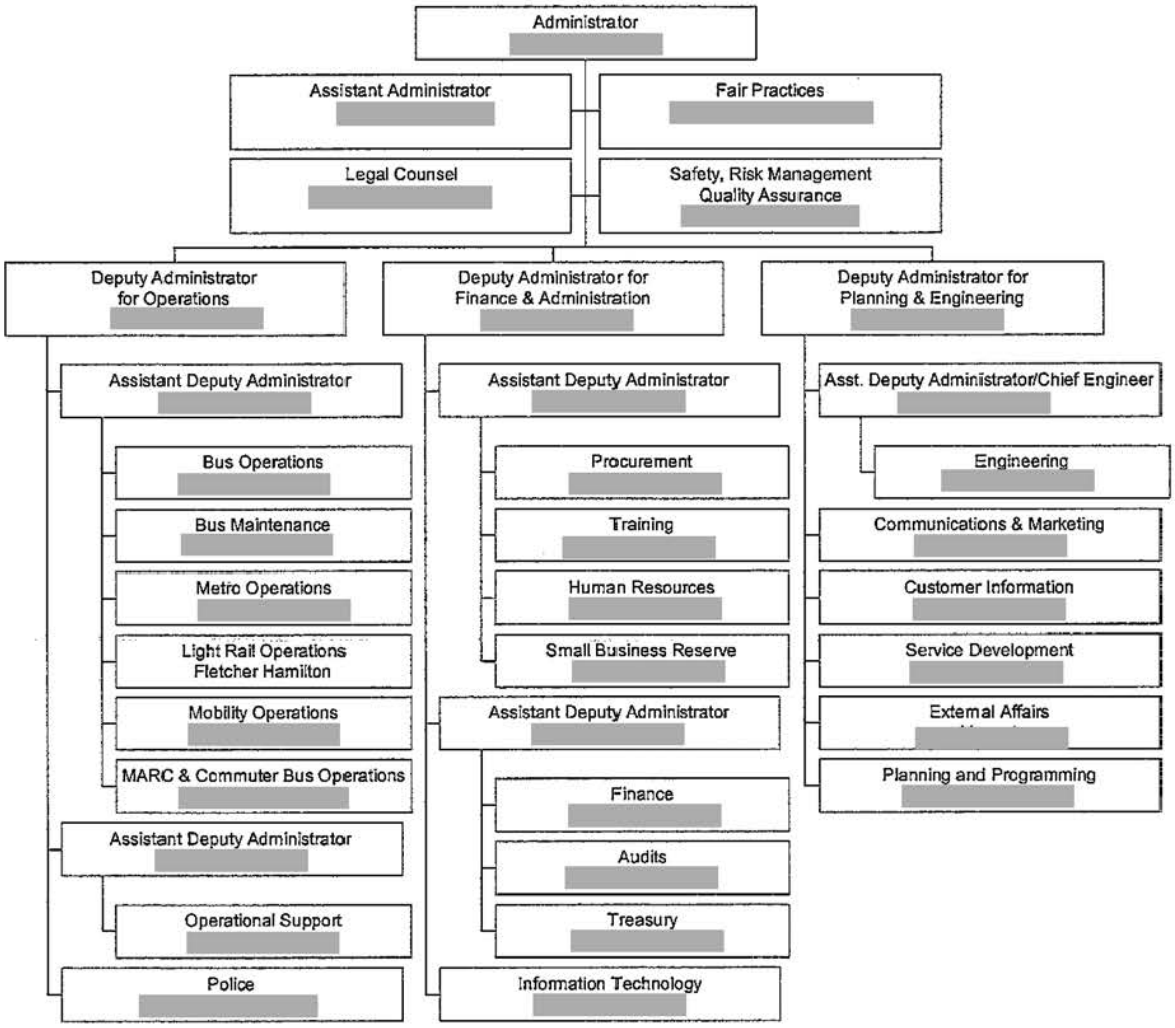

Figure 1-1

Office of Engineering and Construction
Organizational Chart

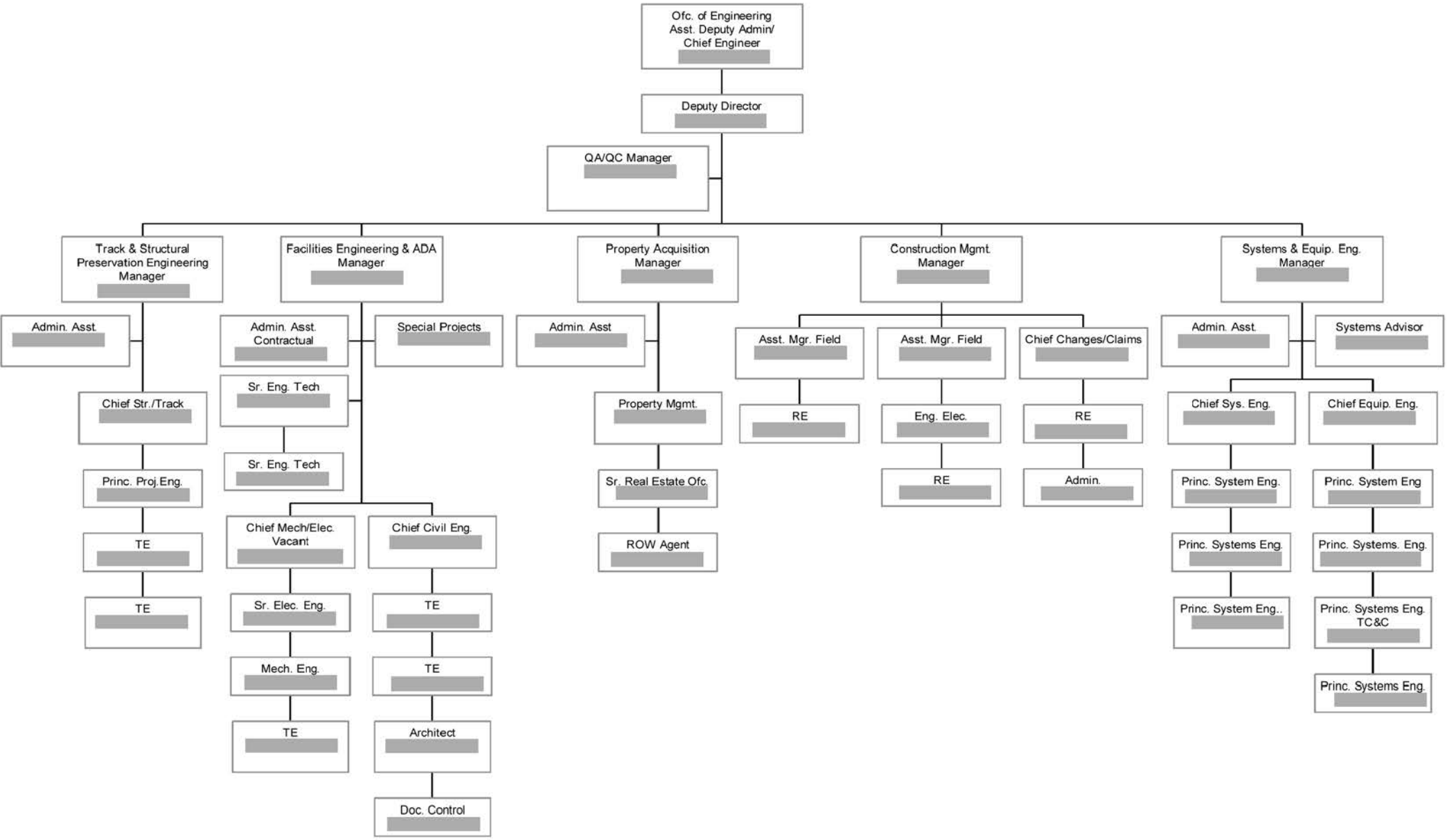

Figure 1-2

Element 2:
Documented Quality Management System

The following is Section 02 of Revision 0 (August 2007) of the Maryland Transit Administration (MTA) Quality Assurance Program Plan, which has been generously provided by MTA – Baltimore, MD.

This example has been provided because it stipulates that quality plans should be updated as required. The *Guidelines* state that QMS documents need to be regularly reviewed and updated. The frequency of these reviews should be determined by the specific needs of the grantee or capital project involved, and are not required to be referenced in the grantee quality manual, though they may be.

2. DOCUMENTED QUALITY MANAGEMENT SYSTEM

2.1 Purpose

To describe the Quality Assurance program requirements for MTA engineering projects and to assign responsibility for developing, approving and implementing Quality Assurance Procedures for the program.

2.2 Scope

These Quality Management System requirements apply to all Office of Engineering and Construction staff, consultants and contractors who perform activities that affect quality on MTA engineering projects and on all other projects undertaken by the Office of Engineering and Construction.

2.3 Policy

2.3.1 This Office of Engineering and Construction QAPP establishes elements pursuant to a documented Quality Management System that ensures MTA engineering project quality objectives are satisfied. The requirements of the MTA's Quality Management System shall be extended to consultants and contractors as appropriate.

2.3.2 This Office of Engineering and Construction QAPP defines the requirements contributing to the attainment of a safe, convenient, reliable, and economical transportation system. The MTA QA/QCM shall be responsible for the administration of this program.

2.3.3 Each MTA engineering project contract shall be reviewed to determine the elements of this Office of Engineering and Construction QAPP that shall be implemented. Consultants and contractors shall be required to develop, implement, and maintain a Quality Management System that is consistent with the quality requirements stated in the contract documents applicable to its Scope of Work.

2.3.4 Each consultant and contractor, as required by contract, shall be responsible for documenting and publishing a Quality Management Plan/Contract Quality Control Plan in response to the MTA's pursuit of consultant and contractor services. In the event that a consultant or contractor subcontracts any portion of the contracted work, the accountability for the quality program shall remain with the primary consultant or contractor. The subcontractor may be required to prepare a quality plan.

2.3.5 All personnel who manage or perform activities affecting quality shall be qualified on the basis of appropriate education, training, and/or experience and are subject to approval by the MTA. See Section 15, "Training", of this QAPP.

2.4 Requirements

This QAPP identifies requirements for the development, implementation, maintenance, auditing, compliance review, and reporting of quality assurance activities.

All Invitations for Bids (IFBs), Request for Proposals (RFPs) and Purchase Orders (POs) shall include a requirement/specification for quality assurance/quality control considerations.

All bids and proposals shall include the quality assurance/quality control effort as defined in the program.

All consultants, as required by contract, shall prepare, publish, maintain, and utilize a Quality Management Plan addressing the work they are performing. The Plan shall be submitted to MTA and approved prior to the Notice to Proceed (NTP).

All contractors, as required by Special Provision Section 01450, shall publish, maintain, and utilize Contract Quality Control Plans specific to the projects bid. The Plans shall be submitted to the MTA within time periods specified in Section 01450.

This QAPP and consultants and contractors Quality Plans shall be reviewed and updated as necessary to remain current.

All consultants and contractors shall be required to maintain quality records, and quality records must be available for Quality Assurance Surveillance and audits. Quality Records shall be transmitted to the MTA's Project Manager in accordance with contractual requirements.

2.5 Responsibilities

2.5.1 The MTA Project Manager shall be responsible for ensuring that appropriate quality assurance requirements are included in specifications, drawings, statements of work and bid packages.

2.5.2 The Procurement organization shall be responsible for assuring that quality assurance requirements are included in every procurement package.

2.5.3 The QA/QCM has responsibility and commensurate authority for:

- Implementation and administration of this QAPP
- Verifying the effectiveness of this QAPP

2.5.4 The assigned Office of Engineering and Construction Staff Member shall be given responsibility and commensurate authority for:

- Review of all applicable IFBs, RFPs, POs and contracts prior to issuance for bid to determine and designate the specific quality provisions to be implemented.

- Review of all proposals for concurrence with the proposed quality provisions.

- Approval of consultant and contractor quality plans.

- Approval of consultant and contractor quality personnel.

2.5.5 Consultant and contractor Quality Assurance Managers shall be responsible for:

- Preparation, implementation, and maintenance of their organization's quality plans.

- Quality assurance of their subcontractors, suppliers, and vendors, as applicable.

- Verifying the effectiveness of its organization's quality plan.

- Maintaining verification of records and providing access to these records upon request.

2.6 Procedure

2.6.1 Contract documents to consultants and contractors shall include a stipulation that they develop and implement effective quality programs for their assigned task orders that meets MTA's QA requirements.

2.6.2 Quality Assurance Program Plan requirements shall be outlined at pre-proposal and pre-bid conferences, and project "kick-off" meetings. Consultants and contractors shall be formally notified of the quality assurance requirements and shall be required to acknowledge their understanding of, and ability to adhere to these requirements.

2.6.3 Each consultant and contractor performing work on MTA engineering projects shall prepare a Quality Management Plan or Contract Quality Control Plan, as applicable, for its assigned task order. Consultant plans shall be submitted to the MTA's QA/QCM for review and approval. Contractor plans shall be submitted to the Resident Engineer for review and approval.

2.6.4 The QA/QCM or assigned Project Manager/Resident Engineer shall conduct a compliance review of each consultant's and contractor's quality plan to assure its adequacy, assess its effectiveness, and confirm that it is consistent with MTA's specifications and contractual requirements. Each plan shall be updated as necessary to remain current.

Element 3:
Design Control

The following is Section 03 of Revision 6 (February 2009) of the East Side Access (ESA) Project Quality Manual for MTA Capital Construction (MTACC) in New York, which has been generously provided by MTACC and ESA – New York, NY.

This example has been provided for reference, although it does not include all aspects of Element 3 in its text. As suggested in Chapter 2 of the *Guidelines*, this project does include planned design activities in an overall Integrated Project Schedule (IPS); however, many requirements for design control (like the IPS) are stipulated in the contract documents. The ESA Project Quality Manual, rather than duplicating those requirements, references the contract documents in section 3.3 of the manual.

3.1 Purpose

To define the requirements for the control, verification, and documentation of the quality of design activities associated with the ESA Project.

3.2 Scope

These design control requirements apply to the design of facilities, systems, and equipment for the ESA Project.

3.3 Policy

The General Engineering Consultant (GEC) is required to develop and maintain a Design Quality Management System (DQMS) that describes their design processes and design quality assurance/control processes. The Design Project Quality Manual component of the DQMS is to be submitted to the ESA Project Quality Assurance Manager for review and approval prior to the start of work. The design consultant's Design Project Quality Manual will define a comprehensive Quality Assurance Program to be implemented by the design consultant, as well as a design quality control program to be implemented as applicable by the design consultant and their subconsultants. Implementation of all aspects of the each design consultant's DQMS will be subject to Audit/Surveillance by the ESA Project Quality Assurance Manager or designee.

Design activities will be controlled in accordance with applicable requirements of the Contract Documents, as described in the DQMS. Quality standards and appropriate quality criteria will be specified in the design documents including, but not limited to:

- Design Basis
- Scope of work/services
- Technical requirements/specifications
- Drawings
- Codes and Standards
- Design and Performance Criteria

Quality standards will be established that are consistent with the criticality of the facility, system, or subsystem element regarding safety, reliability, maintainability, and performance. Special control will be applied to the development of software requirements.

Design documents, specifications, test/analysis reports, or other documents used to specify the design will be identified using an approved Project Numbering System prepared in accordance with applicable standards or practices and accounted for in a log or register as specified in the document control implementation procedures. Design documents will be subject to a review/check process, and coordinated with interfacing design disciplines or groups, as described in the design consultant's DQMS.

Change to design documents shall receive the same review and approval process as the original document.

Design documents are to be controlled in accordance with the design consultant's Configuration Management and Document Control IPs to ensure the use of approved

documents. They are to be maintained and distributed in accordance with the MTACC, design consultant, and contractor's IPs.

Design documents shall provide for identification of items important to quality and safety by providing traceability of the item through part numbers, heat/log numbers, serial numbers, or other means in accordance with applicable codes and standards. Design documents shall provide identification of design criteria.

Design reviews shall be performed to determine that the design bases have been accurately expressed, and to verify the constructability of the design.

- They determine if appropriate quality standards have been specified for the intended use, and that parts, materials, equipment, and processes specified are appropriate to the application
- They include appropriate means of verifying design such as modeling, independent design analysis, qualification testing, evaluation of historical data, and simulation
- Design reviews, checking, calculations, alternate calculations, performance tests, peer reviews, or other means used to verify the design prior to issue will be performed by personnel other than those who originated the design, but with qualifications at least equal to those of the originator. Review personnel may be supervisors who were not actually involved in the design

Design changes (revisions) will be subject to checking, coordination, and design review to the same level as the original design. Design change documents must be approved and processed in accordance with ESA Project configuration management procedures. Superseded design documents will be marked as such, and retained for information only. Design changes shall be controlled using an alphanumeric system or other approved method.

- Design changes shall be issued according to a standard distribution list; changes, including field changes, shall be promptly incorporated into design documents
- A Design Change Notice procedure shall be a part of the Design Project Quality Manual. To expedite design changes, parties affected by changes shall be promptly notified. Design changes should be incorporated into a drawing revision within 90 days of issue, and no more than five changes should be allowed against a drawing without revising and reissuing the drawing

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Element 4:
Document Control

The following is Section 04 of Revision 9 (June 2010) of the Charlotte Area Transit System (CATS) Project Quality Plan, which has been generously provided by CATS – Charlotte, NC.

This example has been provided because it includes stipulations for document retention and refer to the control, storage, and retention of electronic documents. It also stipulates that distribution be controlled in an appropriate manner to ensure quality. These concepts were added to the *FTA Quality Management System Guidelines* as of this update.

4 DOCUMENT CONTROL

4.1 Purpose

To establish requirements for control of documents including:

- Describe the requirements for a systematic control of documents
- Identify and maintain all available information relevant to the project.
- Identify and maintain the current project documents.
- Ensure the proper & timely distribution of all project documents.
- Ensure that project documents are archived for later retrieval.
- Implement a disaster recovery plan for project documents.

4.2 Scope

These requirements for document control apply to the controlled release, reproduction, distribution, maintenance, retention, and disposition of project documents. Many documents are subject to controlled distribution to ensure that changes and updates to key documents are made in a controlled and systematic manner and that all parties are working to the latest version of the document.

Management documents approved by CATS senior management for use on the project are also subject to formal document control (see CATS QA02 *Control and Distribution of Plans, Manuals, Policies and Procedures*). These include the *Project Management Plan*, *Design Criteria Manual*, change control procedures, *Procedures Manual for Procurement*, and others that are developed as the project advances. Controlled distribution of these documents is necessary to ensure that key project participants and organizations receive and work from the latest version of each document.

4.3 Responsibility

All CATS project participants are responsible for document control within their work scopes.

4.4 Procedure

All contract records and method of record maintenance will be subject to inspection by CATS QA Section at any time.

CATS requires its contractors to have control procedures assuring the following:

- Distribution to appropriate personnel.
- Review by appropriate personnel.
- Establishment of filing indices, register, etc.
- Safely secured storage and reliable retrieval.
- Elimination of obsolete documents.
- Control of document changes.
- Proper reproduction of controlled documents.
- Disaster recovery plan.

As-built drawings will be maintained by the Contractor and submitted to CATS at the completion of the contract.

The Resident Engineer (RE) or Project Manager will review the contractor record drawings and other documents on a regular basis, as described in the CM Manual, to ensure that the records are being properly maintained with as-built conditions correctly and completely documented and Change Notices and RFI information are posted.

CATS has procedures for control of all project documents including submittals, procedures, forms, and drawings. These procedures are available in CATS *Policy and Procedure Manual* and *Construction Management Manual*. Project specific detail may be found in PMP Section 5 entitled Quality Assurance Management and Control.

Documents shall be protected from damage or loss. The document control process shall provide positive version control, record of change authorization, archives of each revision, change control logs, document holder logs, and associated reports in an integrated hard copy and electronic media.

4.5 CATS Disaster Recovery Program

Electronically stored documents (other then e-mails) are backed up daily. Tapes are maintained for a period of one year. Backup tapes are stored off-site for protection in case of fire. Backup e-mails are maintained by the City of Charlotte's IT Department for two weeks.

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Element 5:
Purchasing

The following is Section 05 of Revision 9 (June 2010) of the Charlotte Area Transit System (CATS) Project Quality Plan, which has been generously provided by CATS – Charlotte, NC.

This example has been provided because in section 5.4.1 of the Project Quality Plan it extends purchasing requirements to all contractors and suppliers, including consultants. It is important to note, somewhere in a grantee's quality and/or contract documentation, that these requirements are extended to third parties, as many will be procuring services, materials, etc. as a part of their contract performance.

5 PROCUREMENT CONTROL

5.1 Purpose

To outline the requirements of quality assurance/quality control measures to be incorporated into procurement documents.

5.2 Scope

The requirements of this procedure apply to all procurements for FTA funded projects.

5.3 Responsibility

As identified in CATS *Project Management Plan*, CATS Chief Procurement Officer has primary responsibility for procurement and contract administration.

CATS Chief Executive Officer, Chief Development Officer, Assistant Director of Transit Support Services, Project Manager, and other key personnel have contributor/support responsibilities as identified in the PMP and as appropriate based on the scope of the contract.

CATS Quality Assurance, working with CATS Procurement and Contract Management (P&CM) Section, shall identify the quality assurance requirements to be included in the contract documents.

5.4 Procedures

CATS Procurement and Contract Management Section has developed the *Procedures Manual for Procurement,* which details the requirements for all important activities, such as preparation of purchase orders, contracts for services, bid lists and vendor quality requirements.

The *Procedures Manual for Procurement* identifies the legal requirements for purchasing for local governments and the level of authority guidelines for contracting actions including change orders and amendments.

Contracts for procurement involving federal financial assistance are made in accordance with and include the appropriate contract clauses from FTA Circular 4220.1F, the FTA Master Agreement and all other provisions required as a condition of federal financial assistance.

Pre-Award Surveys may be necessary to determine the contractor's technical performance capability under the terms of the proposed contract. Pre-Award Surveys may include a qualification hearing, verification of a bidder's financial capability, labor resources, skills and/or an on-site inspection of plant and facilities.

Documents which are used to procure materials are to be reviewed by CATS staff to verify that data necessary to assure quality is included or referenced in such documents. Revisions to these documents are subject to the same review as the original.

5.4.1 Sub Consultants, Contractors, and Suppliers

Consultants are responsible for review and acceptance of their sub-consultant Quality Programs.

Contractors and suppliers are responsible for the quality of work under their contract, including their subcontractors, and for providing QA/QC in accordance with contract documents and their approved quality control plan.

5.4.2 Audits

Contractors and suppliers are responsible for performing audits as required by their contract and according to their approved quality plans.

As specified in the contract document, CATS has the right of access to the contractor and/or subcontractor facility to inspect, audit or otherwise verify the specified purchasing requirements are being fulfilled.

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Element 6:
Product Identification and Traceability

The following is Section 06 of Revision 0 (May 2010) of the Sound Transit Quality Assurance Program Plan, which has been generously provided by Sound Transit – Seattle, WA.

This example illustrates the importance of establishing requirements for traceability for the grantee agency or project. These requirements should ideally specify that materials be traceable both to their source or production batch and to where/how they were incorporated into the work.

6.0 MATERIAL CONTROL AND PRODUCT IDENTIFICATION

6.1 OBJECTIVE

The objective is to establish the control process to identify parts and services with correct configurations based on approved drawings and specifications, inspections and approved criteria.

6.2 SCOPE

The scope of the objective is to apply to all materials, parts, components, equipment, and products, including partially fabricated or assembled components, produced for incorporation into Sounder projects.

6.3 POLICY

A. Sounder contract documents and procurement specifications will, as applicable, contain requirements for control of materials. Contractors, suppliers, and procurement organizations will establish quality control procedures to ensure control, identification, and traceability of items.

B. Contractors or suppliers procedures for control of materials, identification, and traceability will be established and maintained to assure that only correct and acceptable items are used and to prevent the use of incorrect or defective items. Procedures will cover such activities as receipt of materials, storage of materials, and incorporation of materials into the work.

C. Inspection personnel will verify and document that items are identified properly. Documentation of identification and traceability activities is to be retained as a quality record.

6.4 PROCEDURES

The contractor or supplier will establish procedures for control of materials, parts, components, equipment and products, including partially fabricated or assembled components, and will provide for identification and traceability of those materials. Procedures will provide for such activities as receipt of materials, storage of materials and incorporation of materials into the work.

6.5 RESPONSIBILITIES

A. ST Quality Assurance is responsible for ensuring that requirements for control, identification, and traceability, are contained in contract documents and procurement specifications and for monitoring contractor's or suppliers' procedures.

B. Contractors, suppliers, or procurement organizations will be responsible for assuring control of materials, identification, and traceability.

6.6 IDENTIFICATION AND TRACEABILITY

A. Procedures for product identification and traceability will be established to aid in the control of materials, to assure that only correct and acceptable items are used and to prevent the use of incorrect or defective items. Physical identification and control of individual elements will be used to the extent possible. Where physical identification is impossible, other appropriate means, such as physical separation into lots will be used. Inspection personnel will verify and document that items are identified properly and documentation of identification and traceability activities is to be retained.

B. Identification will be provided by such means as the following:

1. Item description or number
2. Serial number
3. Reference to applicable contract section
4. Supplier name and contact information

6.7 SHIPPING

A. Procedures for shipping of materials will be established to ensure that materials shipped are identified and traceable in accordance with acceptance criteria. The shipping procedures will include documentation of such items as:

1. Item description or number
2. Serial number
3. Date shipped
4. Quantity shipped
5. Shipper name

6.8 RECEIPT

A. Procedures for receipt of materials will be established to ensure that materials received are identified and traceable in accordance with acceptance criteria. The receipt procedures will include documentation of such items as:

1. Identification as provided in 6.6 above
2. Date received
3. Quantity
4. Verification of receipt of supporting documentation, such as a Certificate of Material Test Report or a Certificate of Compliance
5. Material Safety Data Sheet, if applicable
6. Visual inspection for damage

6.9 STORAGE

A. Procedures will be established for storing and handling materials. The storage and handling procedures will include the following:

1. Protection from damage, deterioration, and loss
2. Inspection and maintenance during storage and handling
3. Utilization of special storage and handling facilities as required
4. Labeling with expiration dates for perishable items, or “Use By” dates

6.10 INCORPORATION INTO THE WORK

Procedures will be established for preparation and maintenance of material records to document the identification of materials and traceability to the location where the materials are incorporated into the work.

6.11 AGENCY - FURNISHED MATERIALS

Agency-furnished materials, if any, will be listed or described in the Contract Documents. Procedures for unloading, transporting from the designated delivery point, handling, storing, and protecting such Agency-furnished materials will be included in the contractor’s Quality Plan or in a separate Material Handling and Storage Plan or Procedure.

Element 7:
Process Control

The following is Section 07 of Revision 0 (May 2010) of the Sound Transit Quality Assurance Program Plan, which has been generously provided by Sound Transit – Seattle, WA.

This example illustrates the flow of grantee quality requirements through the consultants and subcontractors regarding process control. Though it is not shown here, the requirements and goals of the FTA and other project stakeholders should also be taken into account when developing process control plans and procedures that include activities involving those parties.

7.0 PROCESS CONTROL

7.1 OBJECTIVE

The objective is to establish the requirements for the control of special processes, as identified herein. The objective of special process control is to define and/or identify proper sequence of work flow utilizing properly maintained equipment operated by qualified operators producing parts conforming to all applicable quality standards/engineering codes based on the approved drawings and process requirements verifiable by inspection criteria.

7.2 SCOPE

These requirements apply to all special processes, including, but not limited to, welding, soldering, heat treatment, cleaning, plating, non-destructive examination and testing. The scope of process control will apply to all materials, parts, components, equipment, and products, including partially fabricated or assembled components, produced for incorporation into Sounder's projects by qualified personnel in the fields.

7.3 POLICY

The policy controlling the special process control will apply to all-producing parts, components, equipment and/or services in the approved contract documents and will be implemented to ensure that special process control requirements are defined with appropriate engineering standards and codes established in the approved drawings, plans and contract documents.

7.4 REQUIREMENTS

A. Special processes required in fabrication, production, or installation that cannot be verified by subsequent inspection, will be performed under controlled conditions.

B. Contractors and suppliers will submit a Quality Plan acceptable to Sound Transit Quality Assurance, which addresses the following:

   1. Identification of special processes.
   2. Special process production procedures and instructions in accordance with applicable codes, standards, specifications, and drawings.
   3. Testing procedures and acceptance values
   4. A work plan for special process productions or installation that provides for an appropriate work sequence, suitable working environment, and appropriate equipment.
   5. Appropriate certifications for special process production procedures.
   6. Appropriate qualifications and certifications for personnel performing or inspecting special processes.

7. Equipment warranty requirements.

P. The Construction Management Consultants and contractors will impose on their subcontractors and suppliers the same QA/QC requirements imposed on them by the Agency, as set forth in this plan. Records of special process operations and operator qualifications will be prepared and maintained in the project files in accordance with Agency document control procedures.

7.5 PROCEDURES

Special processes will be controlled and accomplished by qualified personnel using approved procedures and/or instructions in accordance with applicable codes, standards, or specifications, and as specified by contract. Records of procedure qualification as well as personnel qualification and certification are to be maintained in project files in accordance with Agency document control procedures. Operations and maintenance procedures for equipment will be required as a deliverable in each system's procurement contract. Special process work plan and personnel certifications must be approved prior to start of any work relative to that process. Source Inspectors will document and submit a Process Control Inspection Report to the ST QA Manager (See Exhibit 7-1 herein)

7.6 RESPONSIBILITIES

A. Contractors and suppliers are responsible for performing special processes and special inspections in accordance with their contract documents and their Quality Control Plans.

B. ST Quality Assurance will review and approve the special process control plans provided by the contractors and suppliers.

EXHIBIT 7-1
PROCUREMENT PROCESS CONTROL INSPECTION REPORT

Procurement Components – Structural Steel Daily Inspection Report	
Contract:	Inspector:
Unit Description:	
The following inspection checklist are attached: _____ Materials _____ Burning _____ Welding _____ Bolted Connections _____ Misc.	 _____ Sandblasting & Painting _____ Radiographic Test _____ Ultrasonic Test _____ Magnetic Particle Test _____ Soldering
Summary of shop activities witnessed:	
Summary of inspection activities performed:	
Problems identified and/or resolved:	
Witnessed by:_____ Date_____ Page __ of __	

Element 8:
Inspection and Testing

The following is Revision 0 (June 2008) of a Rail Equipment Engineering (REE) Procedure, which has been generously provided by the Southeastern Pennsylvania Transportation Authority (SEPTA) – Philadelphia, PA.

This example is an actual inspection procedure, rather than an excerpt from a Quality Manual. It does not include all aspects of Element 8 as shown in Chapter 2 of the *Guidelines*, but it does include stipulations on the frequency for these types of inspections. The establishment of inspection/testing frequency has been stressed in this update to the *Guidelines*, though the frequency specification will vary for differing types of inspections/tests. *The Rail Quality Assurance Materials Inspection Guidelines* here only state that inspections be performed "as timely as practicable". Some inspections/tests may have a set schedule or frequency. This example also includes a process flow chart. Similar charts and/or work instructions can be useful inclusions for QMS documentation related to Element 8.

RAIL EQUIPMENT ENGINEERING PROCEDURES REE 13.0

TITLE: Rail Quality Assurance Materials Inspection Guidelines	REVISION: 0 DATE: 06/23/08 PAGE 1 OF 4
APPLICABILITY: Regional Rail, Heavy Rail and Light Rail Fleets and Locations	**SUPERCEDES:** Rail QA Inspection Process Summary guidelines
CHANGE: Reformatted QA Inspection Process Summary guidelines into standard REE Procedure format.	**APPROVAL:** **ORIGINAL SIGNED BY STEPHEN H PETTERSEN** Assistant Chief Mechanical Officer, REE

1.0 PURPOSE AND SCOPE:

To establish and define the scope and guidelines for the Materials Inspections performed by Quality Assurance (QA) personnel. The QA group is responsible for performing receipt inspections on Purchased Materials upon their delivery to SEPTA's various rail storerooms and material warehouse storage locations.

2.0 MATERIALS RECEIPT INSPECTIONS

2.1 *Material inspection process objective*:

To eliminate defective parts and materials from entering the SEPTA materials inventory system by performing material receipt inspections.

2.2 *Process:*

The material inspection process works in conjunction with the Procurement and Contracts Department's "Accelerated Supply and Procurement (ASAP)" material management program. Attached is a copy of the QA Material Inspection Process Flow Chart used to perform material inspections.

This process relies upon the Storerooms' utilization of the ASAP system to automatically notify QA personnel that inspections are required upon material arrivals. QA personnel are to confirm the correct specification and/or drawing to be used for inspection. If necessary, an updated specification and/or drawing is/are to be secured through the main body of the engineering technical documents or through the Quality Manager. When Pre-production samples are required by the purchase order, the inspector will perform a complete inspection on the samples received. Larger quantity production runs, marked for incoming inspection, are to be inspected based on a sampling plan. The QA sampling plan is based on a modified Mil. Specification (105(e)) or a custom QA sampling plan.

Inspections are to be performed as timely as practicable. The material inspection process establishes a goal of three working days to complete an inspection after notification. Material inspection priorities are based on the following situations or conditions: First priority is given to material that is holding a car or cars out of service. Second priority is given to SEPTA's support shops and their need to fulfill their production requirements. Third priority is given to Pre-Production samples holding the contracted manufacturer's production line from producing material, and Forth priority is given to routine inspections. Inspected material is to be identified in the ASAP material management system as either "accepted" or "rejected". Accepted material is to be electronically marked by the storekeeper and put into stock. If material is determined to be nonconforming, QA personnel are to document the nonconformance on a Nonconforming Material Notice (NCMN) form and advise the appropriate personnel.

2.3 Local Material Review Board (LMRB):

Under certain conditions an internal Local Material Review Board (LMRB) may be convened to re-disposition the material status. A Local Material Review Board (LMRB) can be called together if the rejected material holds, or continues to hold, a car out of service or has an adverse impact on production. The Local Material Review Board (LMRB) at a minimum is to consist of the Inspector and an Engineering representative, but could also include the Shop representative and a Purchasing representative. Ultimate acceptance of the nonconforming material will be solely based on engineering's evaluation. The LMRB members are to evaluate the specific situation or condition and discuss possible alternatives to the return of the nonconforming material. When the LMRB determines that nonconforming material shall be used "as is" or "reworked," the Engineering representative is to approve the NCMN report with his/her signature and date. Reworking the material will require the engineer to issue instructions on how the rework is to be accomplished. The Vendor of the nonconforming material is to be contacted and advised of the LMRB decision. Storeroom personnel are to be notified of the results of LMRB and the data input into the ASAP system.

2.4 *Forms:*

The forms that are to be used in the material inspection process include:

2.4.1 *VEM Material Inspection Report (MIR)*

This document is to be used to record all measurements, and observations for each material inspection. When required, certifications are attached to this form.

2.4.2 *VEM Pre-Production Evaluation (PPE)* form

This form is to be used to notify Vendor(s) of the acceptance or rejection of pre-production samples that they submitted.

2.4.3 *VEM Nonconforming Material Notice (NCMN)* form

This form is to be used to notify the Vendor, Chief Inventory Coordinator, Storeroom Operations, the Purchasing Agent, affected Shop Director and the Quality Manager of nonconforming material. Information on the form is to include a detailed description of the discrepancy of the nonconforming material and if convened, the final disposition determined by the Location Material Review Board.

2.5 *Purchasing inspection coding:*

Documented inspections provide SEPTA's Rail Equipment Engineering and Maintenance Department with a database for identifying specific Class & Lot (C/L) material and/or vendors that require greater or lesser QA support and attention. While the expanding process has proven to be of value in controlling defective incoming material, it has also expanded the inspection activity to the limit of our resources ensuring all designated material receives the necessary inspection. This situation has been further exacerbated by the adopted procedure for expanding and expediting approval of alternate manufacturer's parts along with new material being defined by specification and drawing for procurement.

To maintain a continuous improvement process, and to achieve quality group objectives, a QA procedure to enhance the inspection coding criteria was developed. This QA procedure is designed to more efficiently utilize QA resources and to help assure that all material receives the necessary inspection(s):

2.5.1 Purchase Orders requiring inspection:

2.5.1.1 Procurement & Contracts is to place the standard "Y" (inspection required) coding on all purchase orders requiring material to be made to a specification/drawing.

2.5.1.2 Material descriptions that make reference to any type of "inspection" or are designated as "Safety Critical" are to have the P.O. coded with the standard "Y" (inspection required). On a case-by-case basis QA and Engineering will review and standardize the material descriptions.

2.5.1.3 Purchase orders issued to alternate manufacturers that are not approved sources are to be coded with the standard "Y" (inspection required)

2.5.2 Purchase Orders requiring pre-production samples:
Procurement & Contracts are to place the standard "SP" pre-production language on all purchase orders requiring material to be made to a specification and/or drawing. At the same time the ASAP System purchase order is to be coded in the inspection code field with "Y" to route the incoming material covered by the P.O. to QA for inspection until the P.O. is fulfilled or QA advises the IMG, by way of Pre-production Evaluation Form (PPE), that the "Y" inspection requirement be discontinued for the balance of the purchase order. This is to ensure that all material purchased to a specification and/or drawing will have pre-production or "first article" parts routed to QA for inspection and to permit QA to elect to inspect the balance of a purchase order shipment, or to discontinue the incoming inspection of the C/L item, for the remaining pieces of the order.

2.5.3 Waiving Pre-Production Samples: The standard language for "SP' marking includes the vendor's option to request a waiver in writing for supplying pre-production samples. The request is directed to the Quality Assurance Manager, who reviews and determines eligibility. Written disposition is then sent to the vendor.

2.5.4 Approved Alternate Manufacturers
Material purchased to an OEM (or an "approved "alternate manufacturer's) part number need not to be endorsed on the purchase order as requiring pre-production samples nor is it to be endorsed to require incoming inspection, unless special circumstances exist.

2.6 Alternate Manufacturer Part Process:

2.6.1 Approved Alternate Manufacturer
Procurement &Contracts are to only purchase manufacturers' parts designated in the ASAP System description and/or Manufacturer's Part Number Cross Reference "screen" (MM/PQ). Parts by other manufacturers shall not be considered as approved for purchase without specific Rail Equipment Engineering approval. Previous supplier history for other than the specified part shall not be considered as an implied approval.

2.6.2 Alternate Manufacturer with History - Not Approved
When an OEM part number is specified in the C/L description, and the purchase order history includes a successful history of an after market supplier but the vendor is not approved in the ASAP system Procurement & Contracts is to issue the P.O. with the "standard pre-production language," directing that the vendor provide samples. At the same time the ASAP System purchase order is to be coded in the inspection code field with "Y" to route the incoming material covered by the P.O. to QA for engineering notification and final engineering evaluation. Disposition is to be processed by way of the QA Pre-production Evaluation Form (PPE). Additionally; the P.O. is to require the vendor to mark the part with the vendor's name/logo and part number.

2.6.3 Alternate Manufacturer Approval Request

When an OEM part number is specified in the C/L description and an alternative manufacturer is desired and/or identified: Procurement & Contracts is to forward a request for quote form to the Engineering Manager responsible for the vehicle fleet. (e.g., RRD, M4 and NHSL fleets for S. K. Kakkar; LRV, MSHL and N5 fleets for J. MacEwen). The form is to identify the recommended manufacturer and the C/L of the part to be supplied. Engineering is to review the manufacturer's history and capabilities to produce the part and advise Procurement & Contracts of its decision via the request form within ten days of the request. If the manufacturer has been approved by Engineering, Procurement & Contracts are to endorse the purchase order with the "standard pre-production language," directing that the vendor provide the samples. At the same time the ASAP System purchase order is to be coded in the inspection code field with "Y" to route the incoming material covered by the P.O. to QA for engineering notification and final engineering evaluation.

Upon receipt of the pre-production samples at the location storeroom, QA is to notify Engineering that the pre-production samples have been received by the storeroom and are available for evaluation. Upon Engineering's approval/disapproval, QA will prepare and distribute the Manufacturer's Part Preproduction Evaluation (MPPPE) form (attached) with a copy to the vendor, engineering and purchasing. If approved, the approving Engineer is to prepare a file maintenance request form authorizing the "new" manufacturer's part number and date of approval. The manufacturer's part number and date of approval are then to be placed in the ASAP System manufacturer's Part Number Cross-Reference "screen."

2.6.4 Alternate Manufacturers Superseded By SEPTA Specification and Drawing

When a C/L manufacturer's part number is superseded by an Engineering specification and drawing, a file maintenance form is to be submitted by Engineering to Procurement & Contracts specifying the change in the description and manufacturer part number. The superseded manufacturer(s) part number(s) are to be retained in the ASAP System cross-reference for "reference and historical purposes only" and indicated as such. A manufacturer's part number that is identified for reference only will not be quoted, nor will it be placed on a purchase order.

2.6.5 Specification and Drawing Issued **and** OEM part number **still** acceptable

When an OEM part has been "reversed engineered" to SEPTA's specification and drawing and no change has been made from the OEM part, and both are approved, a file maintenance form will be submitted by Engineering to Procurement & Contracts specifying the change in the description to specification and drawing. The manufacturer(s) part number(s) shall be retained in the ASAP System cross-reference and the Engineering approval date is to be added with the OEM part number.

2.6.6 Specification and Drawing Issued **and** OEM part number **not** acceptable
When the occasion develops that a vendor's part does not meet, or no longer meets, Engineering's standards and it is required that the part number be discontinued, Engineering is to prepare a file maintenance request form authorizing the manufacturer's part number be marked as "reference only" with the effective date listed. The manufacturer's part number and date of change are then to be placed in the ASAP System manufacturer's Part Number Cross-Reference "screen." The OEM part number that is identified for reference only is not to be quoted or placed on a purchase order.

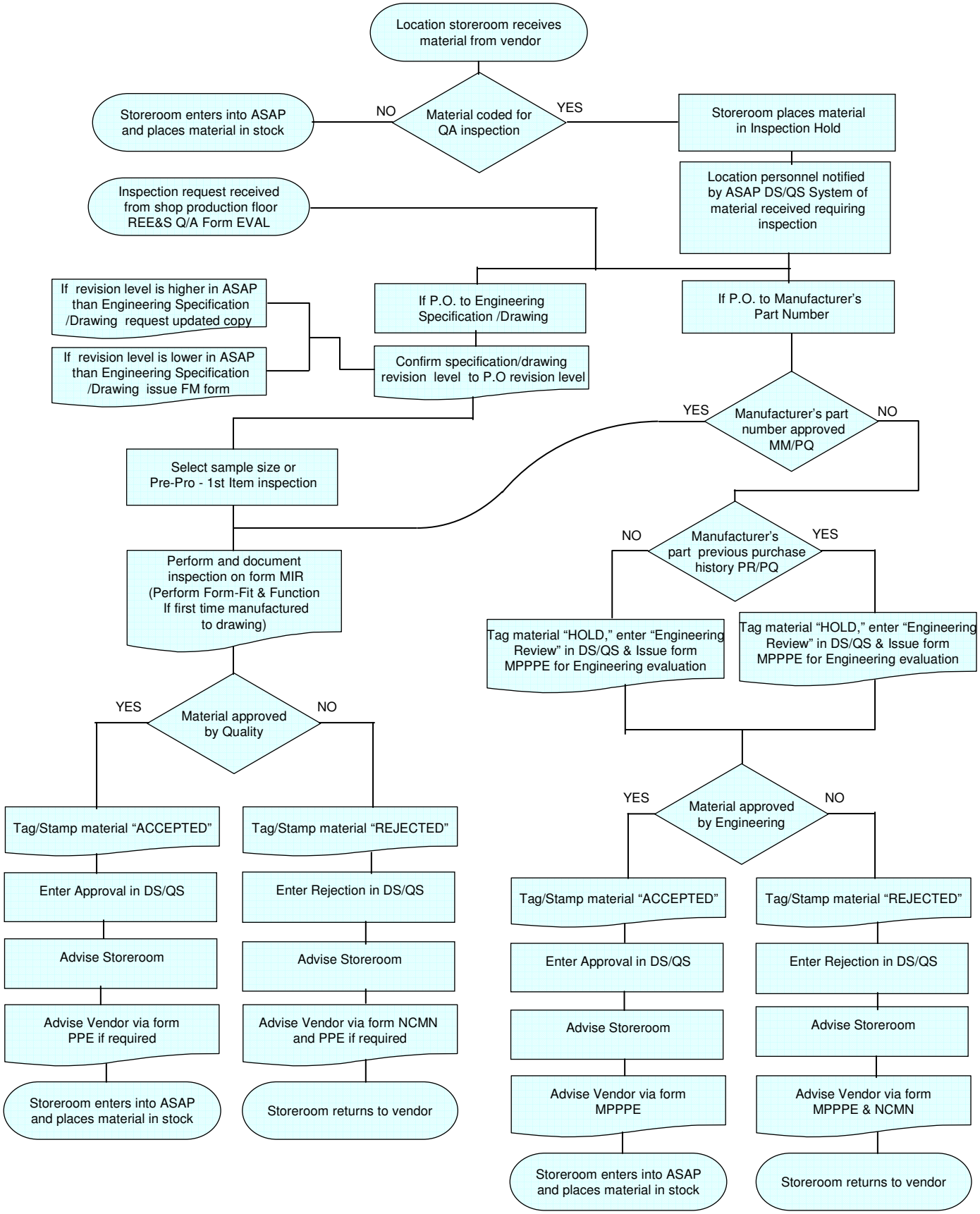
2.7 Process Flow Charts

The flow charts listed below further describe and depict the inspection processes.

2.7.1 QA Material Inspection Process Flow Chart (attached)

2.7.2 C/L Purchase Order Flow Chart (attached)

QA MATERIAL INSPECTION PROCESS FLOW CHART



Rev. 6/08

Element 9:
Inspection, Measuring, and Test Equipment

The following is Section 09 of Revision 0 (May 2010) of the Sound Transit Quality Assurance Program Plan, which has been generously provided by Sound Transit – Seattle, WA.

This example stipulates, in section 9.4, that "supplier's procedures for control of inspection, measuring, and testing equipment will be submitted… for review and approval prior to the start of work". This requirement reflects changes to Element 9 of the *Guidelines* in this update which place additional emphasis on planning for and properly setting up equipment to be used on the job, including the establishment of a calibration schedule and the inclusion of control procedures in the Quality Plan.

9.0 INSPECTION, MEASURING, AND TESTING EQUIPMENT

9.1 OBJECTIVE

The objective is to establish a process that defines, develops and implements proper requirements for controlling equipment used in inspection, measuring, and test equipment to demonstrate the conformance of components/parts and works according to specifications established by contract documents.

9.2 SCOPE

The scope of requirements applies to all inspection, sampling, measuring, and testing equipment used through final testing for determining the quality of materials, parts, components, equipment, products, and constructed works.

9.3 POLICY

A. All equipment used in quality control work will be identified, calibrated, and maintained in proper working order. Provisions will be made for periodic recalibration. Such equipment will be controlled and consistent with National Institute of Standards and Technology (NIST) requirements.

B. Equipment will be calibrated according to and traceable to national standards, when applicable or to documented standards when no national standards exist. If inspection, sampling, measuring, or testing equipment is found to be out of calibration, the validity of previous inspection and test results will be re-evaluated for acceptability.

C. Contractors and suppliers will be required to submit a written procedure for control of inspection, sampling, measuring and testing equipment under their control which includes the following:

   1. Unique identification of equipment
   2. Records of equipment maintenance, calibration dates and results
   3. Intervals of scheduled recalibration

Q. Calibration records and Instrumentation status will be documented for each piece of equipment used for inspection and test acceptance (See Exhibit 9-1)

9.4 PROCEDURES

The contractor's or supplier's procedures for control of inspection, measuring and testing equipment will be submitted to the ST Quality Assurance or designee for review and approval prior to the start of work. The procedure can be part of either a Quality Program Plan or an Inspection and Test Plan.

9.5 RESPONSIBILITIES

A. The entity responsible for the inspection and testing will be responsible for monitoring, controlling, calibrating, and maintaining inspection testing equipment.

B. Inspection, measuring, and test equipment used by the contractor or supplier will be subject to review by the Design Consultant.

EXHIBIT 9-1
CALIBRATION RECORD AND INSTRUMENT STATUS (CRIS)

Sounder Commuter Rail
Quality Assurance and Control Operation
Calibration and Instrument Report

Equipment---	**Period ---**
Serial No. ---	**Location---**

Date Calibrated	Inspection Code	Due Date	Inspector

Element 10:
Inspection and Test Status

The following is Section 10 of Revision 0 (May 2010) of the Sound Transit Quality Assurance Program Plan, which has been generously provided by Sound Transit – Seattle, WA.

This example shows that it is important to establish requirements for inspection and test status that meet the needs of the grantee agency or project. It also specifies that contractors/suppliers submit a written plan for inspection and test status, and goes into what this Plan should contain.

10.0 INSPECTION AND TEST STATUS

10.1 OBJECTIVE

The objective is to establish a process that defines, develops and implements requirements for identifying the inspection and test status of work items.

10.2 SCOPE

These requirements apply to all inspections and tests of materials, parts, components, equipment, products, and constructed works.

10.3 POLICY

A. Procedures will be established for identifying the inspection and test status of work during production and installation to ensure that only work that has passed inspections and tests is incorporated into the project. The status identification will indicate conformance or nonconformance to inspections and tests.

B. In accordance with their contract requirements, contractors and suppliers will submit a written inspection and test plan which addresses the following:

1. Description of the work item and applicable inspections and tests.
2. Method of identifying the status of each item or lot, such as markings, tags, labels, routing cards, inspection and test records, or other suitable means.
3. Procedures for authorized removal of identification status.
4. The names of the individuals, and their ID numbers, authorized to perform inspections and tests.
5. Documentation of the above procedures and the means to maintain records for the activity.

10.4 PROCEDURES

A. The contractor's or supplier's procedures for inspection and testing status will be submitted to ST Quality Assurance or designee for review and approval prior to implementation.

R. Required submittals are described in specific contract documents.

10.5 RESPONSIBILITIES

A. ST Quality Assurance or designee will be responsible for monitoring contractor inspection and test status identification and for the status identification of specific inspection and testing that the contract names as "Resident Engineer's" responsibility.

B. Contractors and suppliers will establish procedures for identifying the status of inspection and testing and ensuring that inspection and test status procedures are implemented on the work covered by their contract.

C. Contractors and suppliers will establish procedures for identifying the inspection and test status of materials, parts, components, equipment, and products during production and installation to ensure that the only work that has passed inspections and tests is incorporated into the project.

D. The status identification will indicate conformance or non-conformance with regard to inspections and tests.

E. Identification of inspection and test status will be the responsibility of the entity inspecting or testing the particular work element.

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Element 11:
Nonconformance

The following is Section 11 of Revision 0 (August 2007) of the Maryland Transit Administration (MTA) Quality Assurance Program Plan, which has been generously provided by MTA - Baltimore, MD.

This example contains an attached Nonconformance Report (NCR) from. NCR forms are commonly used in transit projects, though the stipulation that NCR forms be utilized to document nonconforming conditions was an addition in this update to Element 11 of the *Guidelines*. NCR form templates differ from grantee to grantee or project to project, but the information logged on the NCR forms often includes aspects of Element 12, "Corrective Action". Some grantees combine these two elements in their Quality Plans.

11. NONCONFORMANCE

11.1 Purpose

To describe the procedures for controlling nonconformances from the point of identification through disposition, corrective action, and verification.

11.2 Scope

These Nonconformance requirements apply to all Office of Engineering and Construction staff, consultants and contractors who perform activities that affect quality on MTA engineering projects and on all other projects undertaken by the Office of Engineering and Construction.

11.3 Policy

A nonconformance procedure shall be implemented to assure that items and services that do not conform to established requirements are identified, segregated and removed from work operations to prevent their use until appropriate disposition is made.

11.4 Procedure

11.4.1 Nonconformances have two levels of control – a Deficiency Notice (DN) and a Nonconformance Report (NCR). Consideration of the disposition shall include a review of potential hazards.

- **Deficiency Notice (DN)/Deficiency Correction Request (DCR)**

  A deficiency notice or deficiency correction request shall be used for rejected or in-process notification for routine discrepancies that may be corrected by rework within a short period of time. Deficiencies shall be recorded on a Deficiency Notice Log, which tracks the disposition of all deficiencies. The person issuing the DN/DCR shall be responsible for assigning the disposition, which may include any of the following resolutions:

  REJECT The item is unsuitable for its intended use and economically or physically incapable of being repaired or reworked. This item should be scrapped or if prominently identified, may be used for training or other non-prime use.

  REPAIR The item can be repaired to make it acceptable for its intended use although it will still not meet its original requirements.

  USE-AS-IS Although it does not meet its original requirements, this item can be used with no adverse conditions while

continuing to meet all engineering functional requirements of safety, performance and fit.

REWORK The item can be reworked so that it is brought into conformance with the original requirements.

If a disposition is **REPAIR** or **USE-AS-IS**, the item shall be transferred to a Nonconformance Report (NCR), noting the assigned NCR reference number on the Deficiency Notice Log.

If the disposition is **REWORK**, the organization responsible for correcting the deficiency shall propose, in detail, the actions required to rework the item and return it to conformance with the requirements, including re-inspection and/or testing. All such proposals shall be subject to the approval of the MTA's Project Manager/Resident Engineer and the consultant's/contractor's Quality Manager.

- **Nonconformance Report (NCR)**

A Nonconformance Report (see Figure 11-1) shall be used when a discrepant item cannot be returned to its original condition, but may be used or repaired such that it is fit for its intended purpose. The NCR shall be prepared and logged on a Nonconformance Report Log with one of the following dispositions:

REPAIR The item can be repaired to make it acceptable for its intended use, although it will still not meet its original requirements.

USE-AS-IS Although it does not meet its original requirements, this item can be used with no adverse conditions while continuing to meet all engineering functional requirements of safety, performance and fit.

A disposition of **USE-AS-IS** or **REPAIR** shall require concurrence by the MTA's Project Manager and the consultant's/contractor's Quality Manager.

The organization responsible for the nonconformance shall prepare a report that details the root cause of the condition and the actions that shall be taken to preclude recurrence. When the disposition is REPAIR, the report shall detail the actions required to repair the item to make it acceptable, including re-inspection and/or re-testing. All such reports shall be reviewed and approved by the MTA's Project Manager/Resident Engineer and reviewed by the QA/QCM.

11.4.2 Close out

Discrepancies dispositioned as **REWORK** or **REPAIR** shall be inspected or tested to the original requirements and verified, after correction, by the responsible quality organization.

Following verification, the DN/DCR or NCR shall be signed off by the responsible quality organization and filed. The Deficiency Notice Log or Nonconformance Report Log shall be updated to reflect that the action has been taken and verified.

Each NCR shall be reviewed by the appropriate quality organization to determine if the conditions indicated a breakdown in the controls established to ensure quality. If it is determined that such a breakdown existed, a Corrective Action Request (CAR) shall be initiated, with copies to the MTA's Project Manager/Resident Engineer.

	MARYLAND TRANSIT ADMINISTRATION	**NONCONFORMANCE REPORT** **No.:** **Date:**
Project:	Specification/Drawing No.	Revision No.
Item Identification:		
Description of Nonconformance:		
Root Cause of Nonconformance:		
Nonconformance Report Prepared By: Name Department Date		
Disposition:	( ) See attached sketch	Anticipated Date of Compliance:
Justification of Disposition:		
Disposition Approval: Resident Engineer/Project Manager Date	Quality Assurance /Quality Control Manager Date	
Corrective Action to Prevent Recurrence: Name of Person Responsible for Implementing Corrective Action	Anticipated Date of Implementation:	
Final Disposition Compliance Actual Date of Disposition Compliance	Verification of Disposition Compliance: Inspector/Resident Engineer/Project Mgr Verification Date	
Corrective Action Implementation: Actual Date of Corrective Action Implementation	Verification of Corrective Action Implementation Resident Engineer/Project Mgr /Quality Mgr Verification Date	
Approvals: Project Manager/Area Manager/Section Chief Date	Quality Manager/Division Manager Date	

Figure 11-1

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Element 12:
Corrective Action

The following is Section 8.5 of Revision 2 (June 2010) of the RTD FasTracks Quality Assurance Program Plan, which has been generously provided by the Regional Transit District of Denver (RTD) – Denver, CO.

This example is unlike other excerpts from other Quality Plans that have been provided, in that its sections are organized according to the ISO 9001:2008 standard rather than following the format of the 15 FTA elements. In the example section, titled "Improvement" to coincide with ISO, RTD addresses preventive action and continual improvement in addition to corrective action. These two concepts have also been emphasized in this update to the *Guidelines*. Some other forms of continual improvement not addressed here include benchmarking and utilizing lessons learned.

8.5 Improvement

8.5.1 Continual improvement

RTD will implement corrective and preventive action procedures based on the magnitude of the perceived deficiencies, and level of risk. When opportunities for improvement within RTD's team are identified through internal audits, 3rd party audits, or other means, RTD will initiate an "Improvement Action". This will require the responsible party to investigate the matter, and propose a solution. Improvement Actions will require follow-up to determine the effectiveness of the proposed approach. If necessary, alternative approaches will be tried until an acceptable solution has been found.

8.5.2 Corrective action

Contractors must implement corrective actions, as appropriate, when nonconformances are identified. Such action should include an investigation by the contractor to determine what caused the deficiency or nonconformity, and what will be done to prevent its reoccurrence. Root cause analysis should be used by management to identify trends, based on analysis of nonconformances and audit findings.

If RTD representatives determine that a breakdown has occurred in the contractor's quality management system that could have an adverse impact on product quality, RTD project managers may initiate a Corrective Action Request (CAR), see RTD FasTracks *Quality Oversight Program Manual*. CARs indicate a negative trend or systemic problem that requires immediate attention by the contractor. The CAR shall be forwarded to the contractor, with copies sent to document control.

If the CAR proves ineffective, punitive measures may be invoked in accordance with the contract, up to and including termination of the contract.

Contractors shall describe their corrective action procedures within their quality plans submitted to RTD.

8.5.3 Preventive Action

Preventive action includes evaluation of quality programs prior contract award, effective testing and inspection programs, regular quality meetings, quality audits, sound designs, and appropriate certifications for personnel and subcontractors performing special processes.

Contractors shall describe their preventive measures within their quality plans submitted to RTD.

Element 13:
Quality Records

The following is Section 13 of Revision 0 (August 2007) of the Maryland Transit Administration (MTA) Quality Assurance Program Plan, which has been generously provided by MTA - Baltimore, MD.

This example goes into detail listing different types of quality records and examples of each. Other important items covered this example include the specification that records be prepared, filed, and maintained in a way that ensures they are readily retrievable and the statement that retention requirements for the various types of records be specified in contract documents.

13. QUALITY RECORDS

13.1 Purpose

To define the requirements for the accumulation and maintenance of records for MTA engineering projects which provide the objective evidence that the quality requisites of the contract documents have been met.

13.2 Scope

These Quality Records requirements apply to all Office of Engineering and Construction staff, consultants and contractors who perform activities that affect quality on MTA engineering projects and on all other projects undertaken by the Office of Engineering and Construction.

13.3 Policy

It is the policy of the Office of Engineering and Construction that records for engineering projects be maintained to show achievement of quality objectives and appropriate functioning of the quality management system. Records providing objective evidence of conformance to requirements shall be identified, collected and stored in a readily retrievable manner and preserved to preclude damage, loss or deterioration. These records shall be provided in the required format, and with retention periods defined, at the completion of the project.

13.4 Requirements

13.4.1 Quality Records are defined as documents that provide objective evidence of compliance of materials, products and services to specified acceptance criteria, including compliance with approved procedures.

13.4.2 Quality Records shall be identified by title, contract number, revision, and activity description, with dated signatures of responsible personnel as appropriate.

13.4.3 Quality Records shall be made available to authorized persons as required.

13.4.4 The following list is a guide to documents considered to be Quality Records that are required to be collected, stored, and preserved in a manner that precludes damage, loss, or deterioration, and should not be construed as a complete listing:

- **Design Records**

  - Consultant's response to MTA's Quality Management Plan (QMP)
  - Design procedures and manuals
  - Applicable criteria used in design
  - Design calculations and checks

- Drawings (Reference, Directive, Contract, As-Built, Shop, Working)
- Standards
- Design Review reports
- Design deviations and changes
- Contract Specifications
- Quality Assurance system compliance review records
- Nonconformance Reports and tracking logs
- Corrective Action Requests

- **Procurement Records**

  - Procurement procedures and manuals
  - Surveillance inspection reports
  - Pre-Award Surveys
  - Contract Specifications and modifications
  - Certificates of Compliance
  - Quality Assurance system compliance review records
  - Manufacturers'/suppliers' test results
  - Applicable contract data items

- **Construction, Manufacturing, and Installation Records**

  - Drawings
  - Contractor data submittals
  - Quality Assurance manuals
  - Contractor Quality Control (CQC) Plans
  - Process and personnel certifications
  - Daily inspection reports
  - Material certifications
  - Test procedures
  - Test results
  - Nonconformance Reports and tracking logs
  - Quality Assurance system compliance review records
  - Surveillance reports
  - Release for Shipment notices
  - Inspection and test plans
  - Calibration records
  - Quality Assurance process compliance reviews/audits
  - Specific documentation required for the Safety Certification program
  - Test witness reports
  - Semi-final and final inspection reports
  - Punchlists and resolution of status reports
  - Acceptance Reports
  - Corrective Action Requests
  - Contract Closeout documentation

13.5 Procedure

13.5.1 Quality Records shall be considered valid only if stamped, initialed or signed, and dated by authorized personnel. These records may be either the original or a reproducible copy.

13.5.2 Corrections/revisions to Quality Records, as a minimum, shall receive the same review and approval as the original document.

13.5.3 Quality Records shall be subject to Quality Assurance compliance reviews.

13.5.4 Transmission and Retention of Quality Records

- Quality Records shall be prepared, filed and maintained in such a manner that will make them readily retrievable when requested by authorized personnel.

- Consultants and contractors, including their subcontractors, vendors, and suppliers generating Quality Records, shall be responsible for their retention during the period of construction, inspection, assembly and/or installation, testing, and during period of storage as per Federal and State regulations.

- Storage facilities for Quality Records shall include fire-resistant steel file cabinets that preclude damage from fire, condensation, and extreme temperature variation. In lieu of fire-resistant files, a second (backup) copy of each Quality Record can be maintained at an off-site location.

- Specific retention requirements for Quality Records shall be enumerated in contract documents.

- Unless otherwise stated in the contract, Quality Records shall be turned over to the MTA's Project Manager/Resident Engineer at the completion of the contract.

Element 14:
Quality Audits

The following is Section 13 of Revision 0 (May 2010) of the Sound Transit Quality Assurance Program Plan, which has been generously provided by Sound Transit – Seattle, WA.

This example extends the requirements of Element 14 of the *Guidelines* to surveillances (external audits). This update of the *Guidelines* specifies that requirements apply to external audits as well as internal audits. It also stipulates that pre- and post-audit conferences (or meetings) be held as a part of the audit process, which reflects another statement that was added in this update to the *Guidelines*. In addition, this example includes many of their associated forms and work instructions, which may provide further insight into the audit process.

13.0 QUALITY AUDITS & SURVEILLANCES

13.1 OBJECTIVE

The objective is to establish a process that defines, develops and implements an effective program of Quality Audits and Surveillances.

13.2 SCOPE

Includes quality audits and surveillances performed by ST Quality Assurance, or its designee, on Sounder projects.

13.3 POLICY

A comprehensive program of planned and periodic audits and periodic process-specific quality surveillances will be established to verify that applicable elements of the Quality Assurance Program are acceptable and have been developed, documented, and effectively implemented in accordance with specified requirements.

13.4 REQUIREMENTS

A. Audits of quality activities will be scheduled by Quality Assurance on a frequency commensurate with the activities of the project.

B. Internal ST audits will be conducted to verify compliance with and evaluate the effectiveness of the QA/QC Program.

C. External audits of consultants and contractors will be conducted to verify compliance with requirements established by contract(s).

D. Auditors will have experience or training commensurate with the scope, complexity or special nature of the activities to be audited.

E. Auditors are to have no direct responsibility in the activities to be audited.

F. Surveillances of specific work processes will be periodically performed to evaluate the Contractor's or consultant's adherence to specific approved work plans and procedures.

13.5 PROCEDURES

A. Sound Transit Quality Assurance or its designee will develop and publish schedules for quality audits to all participating entities. When possible, this schedule will identify responsible auditors for each specific audit to be conducted.

B. Audits will be performed in accordance with a specific format utilizing the forms at the end of this section (Reference Exhibits 13-1 through 13-6).

C. The Lead Auditor will assemble and review reference documentation (contracts, procedures, specifications, etc.) to prepare the Audit Plan and the Audit Checklist.

D. After approval of the Audit Plan by the Sound Transit Agency QA/QC Manager, the lead auditor will notify the auditee in writing at least five (5) working days in advance of the audit.

The notification memo (internal audits) or letter (external audits) will include:

1. Purpose of the audit
2. Scope of the audit
3. Date, time, and location of pre-audit conference, if any
4. Identification of specific personnel for attendance or request to auditee to provide appropriate personnel that have responsibilities in areas of audit
5. Identification of auditors
6. Reference documents
7. Special concerns

Auditors will:

1. Conduct a pre-audit conference, if determined necessary, to advise auditee of audit agenda and establish tentative dates/time/location for audits and post-audits conference.
2. Perform the audit utilizing interviews, review of documents, files, tests, and other techniques. Auditor(s) will establish required sampling.
3. Complete the Audit Checklist and prepare an Audit/Surveillance Finding Report (ASFR) for each audit element requiring corrective action.
4. Conduct a post-audit conference at the conclusion of the audit with the Auditee and the appropriate members of management to discuss the audit findings, if any.
5. Request Auditee to commit to corrective action to resolve audit findings by a certain date. Note commitment in the ASFR.
6. Collect, review, and finalize all ASFR's.

Audit Reports will be prepared for each audit, they will include:

1. Cover Sheet
2. Table of Contents
3. Executive Summary
4. Discussion of Audit Performance and identification of elements audited
5. Audit/Surveillance Finding Reports (when applicable)
6. Exhibits

G. Quality Surveillances require only a verbal or e-mail notification to the RE or Maintenance Supervisor and the Sounder Construction Manager will also be notified as appropriate. A Quality Surveillance will involve the review of process requirements, interviews with Contractor, CM or Maintenance Supervision.

13.6 Responsibilities

A. The lead auditor assigned is responsible for all elements of the audit. Audit records include audit schedules, audit plans, audit reports, audit checklists, audit performance records, and Corrective Action Requests as applicable.

H. Personnel responsible for the area audited and surveyed will respond to the Audit/Surveillance Finding Reports and address recommended solutions and propose corrective actions to resolve audit findings. The completed ASFR will be returned to the Lead Auditor.

I. The lead auditor will, as required, schedule follow-up audits and surveillances to verify completion and the effectiveness of corrective action.

J. The lead auditor will ensure audit and surveillance records are maintained as designated Quality Records, and made available for review. Audit records will include audit schedules, checklists for quality audits, audit reports, written replies to the report and the record of completion of corrective action.

K. Audit results will be initially reported to the organization audited (auditee) at an audit debriefing meeting, at which the auditee will have an opportunity to clarify or refute preliminary audit findings. Subsequent to the Audit Debriefing Meeting, audit results and recommendations will be discussed with ST Management and the Agency QA/QC Manager.

L. The Lead Auditor will sign and submit the final Audit Report to the ST QA Manager for review and approval.

EXHIBIT 13-1
AUDIT SCHEDULE

SOUNDTRANSIT

SOUNDER COMMUTER RAIL

AUDIT SCHEDULE

Page____ of ____

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Prepared By: _____ Date: _____

Approved By: _____ Date: _____

EXHIBIT 13-2
QUALITY AUDIT PLAN

SOUNDTRANSIT

QUALITY ASSURANCE

Audit No:
Date:

AUDIT PLAN

Department: _____

Project: _____ Contract: _____

Organization/ Individual: _____

Activities to be Audited: _____

Reference Documents: _____

Notification: _____
(copy attached)

Audit Schedule:
Pre-Audit Conference: _____

Conduct Audit: _____ Through: _____

Post-Audit Entrance Meeting: _____

Audit Team: _____

Special Concerns: _____

Written Checklist Attached: Yes _____ No _____

Prepared By: _____
Lead Auditor Date

Approved By: _____
Division Manager Date

EXHIBIT 13-3
AUDIT CHECKLIST

SOUNDTRANSIT

SOUNDER COMMUTER RAIL

AUDIT CHECKLIST

Audit No.:	**Organization/Contract No.**	**Lead Auditor:**	**Audit Date(s):**
Activity to be Audited	**Key Contacts:**	**Audit Team Members:**	**Audit Location:**

Audit Type: ☐ Construction Audit ☐ Systems Audit ☐ Supplier Audit ☐ Design Audit

Item	Audit Element	Method of Verification	Results
1			
2			
3			
4			
5			
6			
7			

EXHIBIT 13-4
AUDIT CONFERENCE-ATTENDANCE LIST

SOUNDTRANSIT

QUALITY ASSURANCE

Audit No:

Date:

AUDIT ATTENDANCE LIST

Department:_____ Project/Contract: _____ .

Location: _____Time: _____ Pre-Audit Entrance ☐ Audit ☐ Post-Audit Debriefing ☐

Name (please print)	Title	Organization	Phone Number	e-mail

EXHIBIT 13-5
AUDIT/SURVIELLANCE FINDING REPORT (ASFR) FORM

SOUNDTRANSIT

Audit/Surveillance Finding Report (ASFR)

1. Project/Contract/Supplier:	2. Location:	3. Finding Number:	
4. Subject:	5. Audit Number:	6. Discussed With:	7. Issue Date:
8. Responsible Authority: Phone Number:		9. Auditor: Phone Number:	
10. Requirement Reference and Description of Condition:			
11. Cause of the Problem:			
12. Corrective Action:			
13. Responsible Authority:	14. Response Due Date:	15. Response Date:	16. Effective Date:
17. Corrective Action: ☐ Accept ☐ Reject		18. Auditor: Date:	
19. Verification of Corrective Action(s):			
20. Implementation: ☐ Accept ☐ Reject		21. Auditor Signature: Date:	

SOUNDTRANSIT

AUDIT/ SURVEILLANCE FINDING REPORT (ASFR) INSTRUCTIONS

Blocks 1 through 10 & 14 are completed by the originating Quality organization

1. Project Name (i.e. D to M Street Construction); Contract Number (i.e. RTA/CP 128-07)
2. Describe location of the audited item.
3. ASFR Number – obtained from the ASFR log which consists of the contract number, year and sequence number (e.g. A-SND-D2M-09-01-01).
4. Brief description of the audited item.
5. Audit Number: (i.e. A-SND-D2M-09-01).
6. Name or names of persons contacted.
7. Issue date. (mm/dd/yyyy).
8. Enter name and title of person responsible for investigating problem and providing corrective action(s).
9. Name of Auditor and phone no.
10. Describe the finding in detail. Note requirements, i.e. section, paragraph, drawing, etc.

Blocks 11 through 13, 15 & 16 will be completed by the individual responding to the ASFR.

11. Determine and describe the cause of the problem.
12. Describe the actions and responsibilities for correcting the nonconformance and preventing recurrence.
13. Enter the name and title of the person responsible for investigating problem and providing corrective action(s).
14. Date the reply is due back (entered by originating organization).
15. Enter the date response returned to originator. (mm/dd/yyyy).
16. Enter the effective date the corrective action is implemented. (mm/dd/yyyy)

Blocks 17 through 21 are completed by the originating Quality organization.

17. Check-mark the square that identifies the status of the corrective action.
18. Enter the name of the person (auditor) evaluating the corrective action.
19. Describe the means of verification that nonconforming work is corrected according to the disposition.
20. Check-mark the square that identifies the status of the verification of implementation.
21. Signature of Auditor that verified the implementation, and date of verification.

EXHIBIT 13-6
AUDIT LOG

SOUNDTRANSIT QUALITY ASSURANCE

AUDIT LOG

Department:

Audit No.	Organization or Contract	Audit Scope	Audit Date	Qty of AFR(s)	C/A Due Date	Date C/A Rec'd	Date C/A Verified	Lead Auditor	Audit Status

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Element 15:
Training

The following is Section 6.2.2 of Revision 2 (June 2010) of the RTD FasTracks Quality Assurance Program Plan, which has been generously provided by the Regional Transit District of Denver (RTD) – Denver, CO.

This example, like the one provided for Element 12, is from a Quality Plan which is organized to reflect the structure of ISO 9001:2008, rather than the structure of the 15 elements in the FTA *Quality Management System Guidelines*. The section is also very brief. This should serve as a reminder that the organization and depth of a Quality Plan are to reflect the needs of the grantee organization. Additionally, even in its brevity, section 6.2.2 of the plan touches on the identification of the need for and evaluation of training, both of which are concepts that have been added to the *Guidelines* in this update.

6.2.2 Competence, awareness, and training

Because RTD will be serving primarily in an oversight capacity, each team member will undergo training on quality assurance and auditing. Other specialized training will be conducted as needs are identified. Training needed to maintain professional certifications and credentials shall be evaluated and approved in accordance with RTD policies.

RTD will prescribe certain qualifications for contractor personnel within the terms of the respective contract. Personnel qualifications may also be included as a basis for best-value selection of contractors.

Resumes for QA staff shall be included within the contractor's quality management plans, as well as qualifications for personnel who check the work of others.

Contractors shall describe their methods for providing and documenting training on project QA procedures and standards for all personnel assigned to the project (including sub-contractors).

Appendix B: Quality in Transit Operations and Maintenance

B-1. Background

These *Quality Management System Guidelines* were written to address quality as it applies to capital projects, but the fifteen quality elements also apply to Operations and Maintenance (O&M) activities in transit agencies. The purpose of this appendix is to define and demonstrate how these elements can be applied to a total O&M operation.

Delivery of quality services results in safe, accessible, easy-to-use, reasonably priced, reliable, and dependable transportation. Acknowledging and working to the quality elements can lead to increased ridership; opportunities for increased funding and growth; improved image; lower life-cycle costs; an involved, interested, and satisfied work force; and more public support for transit.

To better understand the differences between quality applications in capital projects and O&M activities, it is helpful to consider the construction of a transit system from initiation. The capital project quality program applies to the project phase of building the system, including right of way acquisition and construction, vehicle procurement, contract administration, etc. After an estimated five years of operation, all components of the system have worn to varying degrees, but the need to maintain quality has remained the same. The objective of this appendix will be to show how the 15 quality elements can be applied to the O&M of the system to maintain a state of good repair and operational quality.

Briefly stated, the quality process during the construction phase focuses on the delivery of the administrative devices that bring the project into being, e.g., designs through the various phases of the project, project specifications, procurement of all the contracts and materials which comprise the project, inspection and testing of project elements, product traceability, and the records that are kept, such as as-built drawings, to document how the project was constructed. In other words, is the project being delivered in the manner intended and are all the records in place?

The purpose of Quality Assurance (QA) in the O&M phase of a transit operation is more centered on whether or not the system components are being properly maintained to both internal and external parameters. An example of an internal parameter which needs to be met would be compliance with the organization's maintenance standards for the particular component, e.g., does the track comply with the organization's maintenance standards or are the signals being inspected on the prescribed organizational schedule? Also, consider the processes by which these parameters themselves are established, reviewed, updated, and disseminated throughout the O&M organization. External parameters which may need to be met include regular inspection and documentation of vehicles, tracks, signals, etc. for compliance with Federal Transit Administration (FTA) or Federal Railroad Administration (FRA) standards.

B-2. Application of the 15 Quality Elements

B-2.1 Element 1: Management Responsibility

Much of what appears in the Chapter 2, Section 2.2.1 discussion of *Management Responsibility,* also applies to O&M. The management of every organization is always responsible to develop, implement, update, and maintain that organization's quality program, regardless of whether it is a project organization or an O&M organization. In this regard, there is no difference between the project and O&M organizations. What does differ, however, may be the organization of a quality staff, the types of activities monitored, and the manner in which the quality elements are applied. Subsequent sections of this appendix will present examples of how the quality elements can be applied within an O&M organization.

When feasible, QA Personnel should retain independence from O&M staff and report directly to agency managers. Due to the nature of O&M organizations where there is limited, if any, funding for quality, most grantees will not have an individual to devote to quality functions, even on a part-time basis. Nonetheless, this does not relieve the organization from the need to dedicate attention to its Quality Management System (QMS). The goal of any transit agency is to deliver a quality product to its customers as efficiently and consistently as possible and an effective QMS helps to ensure that this occurs.

This cannot be done unless proper attention is paid to quality. In many cases within an O&M organization, it is the senior line manager's responsibility to not only manage the day-to-day operations/maintenance of the system, but to administer the quality program as well. This designation, including the associated authority and required interrelationships, should be defined in the O&M Quality Plan.

B-2.2 Element 2: Documented Quality Management System

Much of what appears in the Chapter 2, Section 2.2.2 discussion of *Documented Quality Management System,* applies to O&M. The agency's documented Quality Management System (QMS) should contain written procedures and instructions for the processes used to manage and control the O&M activities of the transit agency.

The agency's O&M processes must evolve over time to match the changing nature of the ongoing activities that it controls. Just as in Chapter 2's discussion of Element 2, these O&M processes should be regularly evaluated and updated. The regularity of these updates should be determined by the agency based on the need.

B-2.3 Element 3: Design Control

After a system has been constructed and operating for a length of time, the original designs of the various components which comprise the system are of concern to the O&M management when they must remediate something that doesn't work. The O&M manager's primary concern will be to maintain all of the system components to their respective standards and configuration as set forth in the organizations' maintenance manuals. An example is: "What is the allowable size of flat spots on rail wheels before wheel truing becomes necessary?"

The development of these maintenance standards and their subsequent inclusion in an organization's documented maintenance manual and/or processes then becomes, in essence, a form of configuration control for O&M. Procedures that explain how these documents are to

be established and maintained should exist within the O&M organization and be complied with by O&M management and support staff.

It is also the responsibility of senior management to provide manuals and procedures either by engaging an external subject matter expert or by using internal organizational experience to develop them. The line manager then becomes responsible to implement and manage the various inspections and to assure compliance with the organization's manual(s)/procedure(s). In the case of a small organization, this responsibility may belong to only one individual, in which case the check-and-balance nature of the quality program is particularly critical.

For additional guidance, see Chapter 2, Section 2.2.3, *Design Control*, some of which applies to O&M.

B-2.4 Element 4: Document Control

Documents such as updated procedures, work instructions, manufacturer's maintenance and operations manuals, completed checklists, and many more have to be controlled to ensure that the organization's staff is using the most current approved documents and they are following the most recently approved procedures and standards. To control such documents, an organization must establish a prescribed procedure for the proper dissemination of each document. This includes, at a minimum, who should receive it, when it was received, and how receipt should be acknowledged. The document control procedure also includes a summary of these actions.

As mentioned previously, all system components need to be inspected on a regular basis to assure their respective fitness for continued service. Documentation of these inspections by qualified inspectors is required to comply with FTA or FRA regulations. If the records of these inspections are not kept in the manner prescribed by the organization, or if the written or electronic records are deficient in any way, the organization and/or the individual inspector is subject to fine and/or imprisonment. Records of remedial action taken to correct particular identified conditions are also part of the document control process.

Some examples of operations and maintenance documents that need to be controlled include the following:

- Policies/procedures
- Inspection/test procedures and maintenance procedures
- Manufacturer-provided maintenance manuals, service bulletins, and operating manuals
- Drawings and specifications
- Work instructions
- Templates for reports, checklists, and other forms

For additional guidance, see Chapter 2, Section 2.2.4, *Document Control*, some of which applies to O&M.

B-2.5 Element 5: Purchasing

Much of what appears in the Chapter 2, Section 2.2.5 discussion of *Purchasing,* applies to O&M. Purchasing's role in an O&M organization can tend to be overlooked, but it can become very critical depending upon the given situation. Assuming contracts were only let during the construction phase of a transit system, the major function of purchasing in an O&M organization is to purchase materials for worn system components. The operating system itself is comprised

of the infrastructure and the vehicles, both of which have hundreds of specific items that make each work. The replacement of one component, even a set of trucks on a vehicle, cannot be left to chance. It is the responsibility of Purchasing (with strong support from the O&M department) to ensure the material procured for replacement will perform properly for the given situation.

B-2.6 Element 6: Product Identification and Traceability

Product identification and traceability is as important in an O&M organization as it is during the project phase. Chances are greater that system components will fail during operation after full loads have been applied rather than during the construction phase of a project. As a result, it is just as important for an O&M organization to establish an effective product identification and traceability process as it is during the construction phase of a project.

Vehicles, as well as track and signal components, have identification numbers on them allowing traceability back to the beginning of the manufacturing process. For example, rail that has been installed in track has a series of identification symbols on it traceable back to the ingot from which the molten steel was poured.

Traceability is particularly important because, if a factory defect results in an in-service failure, the organization needs to know if it has components from the same batch still in service and, if so, where they are. In this manner, the organization can install a pre-emptive replacement to prevent additional failures. In a large system, particularly a railroad which has thousands of miles of right of way, other locations on the system where similar components have been installed can be identified and replaced if necessary.

As a result, it is incumbent on each O&M organization to establish a written procedure to keep track of where its in-service system components are, maintain a history of service failures and their causes, and develop a list of potential solutions to the given failures. From these, a "lessons learned" file could be generated, which can help the organization revise its existing standards, procedures, etc., at the proper time.

For additional guidance, see Chapter 2, Section 2.2.6, *Product Identification and Traceability,* which offers additional relevant guidance on the application of this element to transit maintenance activities.

B-2.7 Element 7: Process Control

Much of what appears in the Chapter 2, Section 2.2.7 discussion of *Process Control,* also applies to O&M. Process control within an O&M organization will provide the details and parameters around which the system is intended to operate. Functions such as dispatching of buses, trains, or vans, emergency communications, employee qualifications, etc., will be contained in an organization's Operating Book of Rules, Safety Manuals, Maintenance Standards, respective discipline procedures, Procedures Manuals (for administration), etc.

B-2.8 Element 8: Inspection and Testing

The primary activities of most operations and maintenance organizations are focused on the inspection and testing of their system components. The main purpose of an operating system is to perpetuate its own existence. As a result, O&M organizations, whether bus, light rail,

railroad, or other, dedicate a majority of their efforts to the two separate functions of inspection and testing.

Every system component needs to be inspected periodically to ensure its fitness to remain in service and to ensure the safety of the travelling public. Buses, light rail vehicles, rail cars, and other vehicles used to transport the public are all subject to inspections that are based upon federal guidelines. Similarly, infrastructure components such as track, trolley wire, third rails, and rail and highway signal systems are also subject to inspections based on other federal guidelines. All of these systems must work in concert with one another for the entire system to operate properly. Those elements found to be deficient through inspection must be repaired or removed from service and replaced.

There are also two levels of testing which must occur on an operating system. The first is testing of the individual working components such as traffic signals or the brakes of a vehicle to ensure they are working properly. The second level of testing is for the component operators to ensure they maintain their fitness for duty. Conditions on a right of way will change over time and an organization must assure itself that its operators keep current with the changes.

For additional guidance, see Chapter 2, Section 2.2.8, *Inspection and Testing*, some of which applies to O&M.

B-2.9 Element 9: Inspection, Measuring, and Test Equipment

Much of what appears in the Chapter 2, Section 2.2.9 discussion of *Inspection, Measuring, and Test Equipment,* also applies to O&M. Because component wear and suitability is so critical to an operating system, it is extremely important to use tools that are properly calibrated, whether provided by the employer or maintained individually by the employee. There are many meters, gages, and other measuring devices used in operations and maintenance to perform inspection and testing of system components. Examples include wheel gages, track gages, signal meters, and meggars. All such devices can become worn and/or go out-of-calibration at any time. Each device should be inspected before every use by the inspector to determine suitability for use at the moment. Additionally, all measuring and test equipment should be periodically tested by an independent agency to determine if re-calibration or replacement is necessary. A list of all calibrated equipment should be maintained. This list should contain the equipment name, model, serial number, date the equipment was calibrated, and the due date of the next calibration. The proper procedure for employee inspection and independent inspection should be detailed in the organizations' inspection manual.

B-2.10 Element 10: Inspection and Test Status

Much of what appears in the Chapter 2, Section 2.2.10 discussion of *Inspection and Test Status,* also applies to O&M. It is important for management staff in the O&M organization to be aware of, and maintain documentation related to, the status of inspections. Use of an inspection schedule may be an effective way to achieve this. Test status for a particular device should be kept on file as part of the organization's test program until an ultimate disposition for that device is determined.

B-2.11 Element 11: Nonconformance

Much of what appears in the Chapter 2, Section 2.2.11 discussion of *Nonconformance,* also applies to O&M. In addition to equipment and hardware, O&M management should also consider driver/operator performance as either conforming or nonconforming. If a dispatcher is not performing in accordance with established requirements, or if a bus or train operator is not performing in accordance with established procedures and training, then their work should be considered nonconforming. For safety's sake, all equipment, hardware, and personnel that do not conform within allowable O&M parameters should be documented and removed from service.

B-2.12 Element 12: Corrective Action

Much of what appears in the Chapter 2, Section 2.2.11 discussion of *Corrective Action,* also applies to O&M.

B-2.13 Element 13: Quality Records

It is important that an O&M organization maintain all its records as quality documents. It must be remembered that many system components may be in service for as long as 30, 40, or maybe even 50 years. The history of what maintenance has been done to particular system components can be extremely helpful when estimating how long the life of the component can be prolonged, if at all.

It is crucially important that any federally mandated inspection records be kept as quality records. This is because the federal agencies that monitor these records review not only the content of the reports, but also the frequency of inspection and the locations inspected. As a result, it is imperative that the O&M organization develop a record monitoring procedure that senior management can review to quickly determine if its record keeping system is being properly administered.

Some examples of operations and maintenance records that need to be controlled include the following:

- Dispatch records, operator qualification and training records, and audio and/or video records generated in the operations center and on transit vehicles
- Daily track inspection reports, test reports, inspection reports, receiving inspection reports, non-conformance reports, corrective action reports, and audit reports
- Customer survey data and accident data
- Checklists
- Parts inventories

For additional guidance, see Chapter 2, Section 2.2.13, *Quality Records*, some of which applies to O&M.

B-2.14 Element 14: Quality Audits

Much of what appears in the Chapter 2, Section 2.2.14 discussion of *Quality Audits,* also applies to O&M. Because O&M organizations may not have dedicated quality personnel, it may be

necessary for these organizations to perform self-administered audits. An important factor in these audits is for the auditor to remain as objective as possible.

Although self-audits are not the accepted method of quality auditing, nonetheless, they can be effective because the entire organization is responsible for the safety of the travelling public. To provide a safe operation, it is essential that everyone with responsibility within a given discipline be aware of the existing operating conditions. Oftentimes, the only practical way to accomplish this is to have a strong audit program. The entire audit program should be detailed in the organization's O&M manual and may also be supported by independent audits and/or reviews performed by federal, state, and local regulatory/oversight agencies.

B-2.15 Element 15: Training

Much of what appears in the Chapter 2, Section 2.2.15 discussion of *Training,* also applies to O&M. O&M management should take special care in ensuring that the training for certain transit personnel, such as drivers/operators, dispatchers, and maintainers establishes the requirements for performance set by the grantee organization.

The training of employees is an integral part of every program, regardless of whether it's for a construction project or an operations and maintenance organization. It is particularly important in an O&M organization because O&M is an ongoing, long term function as opposed to a construction project that has a fixed life. The more qualified personnel a system has, the easier it is for everyone within the organization to do their respective jobs. A robust training program also assures that there will be sufficient trained personnel available when attrition or other job vacancies occur.

B-3. Final Thoughts

Ensuring that O&M activities have procedures for the work they perform is the responsibility of O&M management and is a quality function. If the transit agency has a quality function, then O&M management should coordinate with that function to make sure that O&M *is* part of the transit agency's overall QMS. Working under this QMS umbrella will afford O&M management the greatest opportunity to consistently deliver the highest quality service to its customers.

O&M activities operating in a transit agency that does not have a formal agency-wide quality function are encouraged to establish a QMS for their activities. Using these *Guidelines* and consulting with other transit agencies, O&M management can develop a quality program that will result in the safe, reliable, and efficient delivery of transit services to the traveling public.

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Appendix C: Documented Case Studies

A Collection of 8 Quality Case Studies

The following case studies document past quality practices and their successes and/or failures. Each study identifies one or more lessons, though the reader can draw other lessons from these selections as well. Case studies 7 and 8 appeared in the 2002 revision of the Guidelines. The other 6 case studies are new to this revision.

- **Quality Case Study #1: Benefits of Implementing "Cost of Quality" and "Proactive Walk Down/Turnover and Project Closeout" Processes** details the benefits yielded by activities with upfront quality costs on two different projects
- **Quality Case Study #2: Southeastern Pennsylvania Transportation Authority Market-Frankford Rehabilitation Program** compares preventative quality cost activities to the cost of nonconformance, and deals with dismissive attitudes toward quality
- **Quality Case Study #3: Design-Build: Baltimore Central Light Rail Line Phase II Extensions Project** discusses the grantee's role in quality assurance
- **Quality Case Study #4: Regional Transportation District of Denver FasTracks Program** discusses the contractor's role in both quality assurance and quality control, as well as the elements of a successful quality management system (including continual improvement)
- **Quality Case Study #5: Dallas Area Rapid Transit Light Rail Project** details the correction of a nonconformance, including the root cause analysis
- **Quality Case Study #6: Southeastern Pennsylvania Transportation Authority Market-Frankford Rehabilitation Procurement** details the difficulties encountered during a procurement process involving an ISO-certified supplier
- **Quality Case Study #7: New York City Transit 63rd Street Connection Project** provides an overview of the quality program utilized for the project, focusing on preparatory phase effort, performance measurement, and just-in-time training
- **Quality Case Study #8: Washington Metropolitan Area Transit Authority Metrorail Project** recounts the institution of a quality awareness program that was later deemed to be unsuccessful

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Quality Case Study #1	
Benefits of Implementing "Cost of Quality" and "Proactive Walk Down/Turnover and Project Closeout" Processes	
Delivery Methods:	1. Design-Build for Tri-Rail 2. Contract Manager/General Contractor (CMGC) for RTD West Corridor LRT
Program Description:	**1. <u>Tri-Rail</u>** The $340 million Tri-Rail project is a commuter rail line linking Miami, Fort Lauderdale, and West Palm Beach, Florida, United States. It is run by the South Florida Regional Transportation Authority (SFRTA). The 70.9-mile-long (114.1 km) system has 18 stations along the South Florida coast. The system connects directly to Amtrak at numerous stations, and the Metrorail in Hialeah (Miami) at the Tri-Rail and Metrorail Transfer Station. Tri-County Commuter Rail's (TCRC's) Quality Plan was structured in conformance with IS0-9001:1994 (ANSI/ASQC Q91:1994) and related standards. The Quality Management Plan incorporated the provisions of the 2002 update of the *FTA Quality Assurance and Control Guidelines* and SFRTA's Quality Assurance Program. **2. <u>West Corridor Light Rail Transit</u>** The $430 million West Corridor LRT Project consists of 12.1 miles of Light Rail Transit (LRT) extending from the existing light rail line at Auraria West Station, west across the South Platte River, then west traversing the existing Associated Railroad right-of-way between Decatur Street in Denver and Quail Street in Lakewood as well as through the Lakewood Industrial Park, and crossing West 6th Avenue into the Denver Federal Center. West of the Denver Federal Center, the alignment, which was to run on the north side of West 6th Avenue along US 6 is being shifted to the south side of US 6 up to Indiana street where it will cross back over to the north side and parallel the highway at-grade within the CDOT right-of-way to the Jefferson Country Government Center. The LRT Alternative includes the development of twelve stations: Auraria West, Federal/Decatur, Knox, Perry, Sheridan, Lamar, Wadsworth, Garrison, Oak, Denver Federal Center, Red Rocks and Jefferson County Government Center. Parking will be provided at six of the 12 stations, providing approximately 5,614 parking spaces. This project is a component of the FasTracks program being managed through a team approach consisting of Regional Transportation District of Denver (RTD) staff, supported by a Program Management Consultant with expertise in program management, budget and schedule controls; a Quality Management Consultant for documentation and quality oversight; a Public Involvement /Information Consultant; and other expertise required to form an integrated team to manage, oversee design and deliver the FasTracks program on schedule and within budget. Individual

	corridor consultants have been retained for environmental, preliminary engineering, final civil design and systems design. Denver Transit Construction Group (DTCG) is the established joint venture company consisting of Herzog Contracting Corporation of St. Joseph, Missouri as LEAD PARTNER and Stacy and Witbeck, Inc. of Alameda, California.
Total Program Costs:	1. Tri-Rail - $340 million 2. RTD West Corridor LRT - $430 million
Lessons Learned:	

Lesson 1 - Cost of Quality

A. Tri-Rail Project Experience

Assessments of project procedures implementations at various project sites were performed to identify not only non-conformities, but also areas of excellence and good practices, opportunities for improvement, corrective and preventive actions. After careful review and analysis of "root causes" of findings from the mini-audits, it was determined that a serious need to establish a "quality cost database" to record all costs resulting from conformance to quality (preventive and appraisal costs) and nonconformance to quality (internal failures impacting Herzog or the joint venture partners and external failures or losses involving the customer). The four cost of quality categories (prevention, appraisal, internal failure and external failure) were collected and stored in a database with necessary details and breakdown of costs into elements and cost drivers for analysis.

At Tri-Rail, the total number of non-conformance reports was **50**. The estimated rework cost was 0.45% of the total project cost. Please see Table C-1 and Figure C-1.

Table C-1: Estimated Cost of Rework

COST ITEMS	% of Cost Revenue
Costs of Internal Failure (Rework)	0.45
Cost of Appraisal	0.55
Cost of Prevention	0.35
Total Costs of Quality	1.35

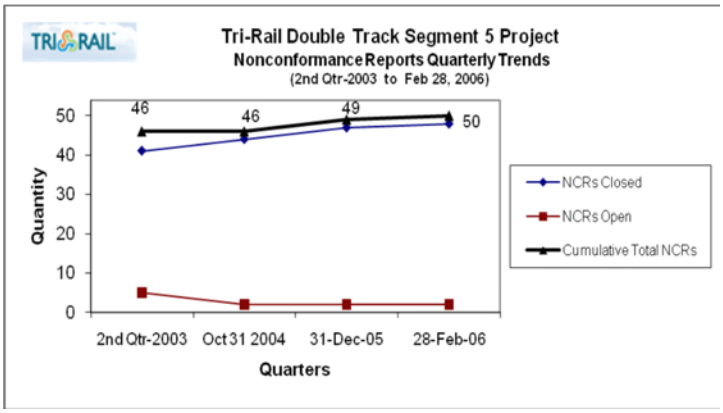

Figure C-1: Nonconformance Reports Quarterly Trends

B. RTD West Corridor LRT Project Experience

Quality failures or losses can be associated with particular strategic objectives, and improvement projects selected that will have a direct impact on those objectives. The costs were pulled from expenses due to reworks, testing, warranties, inspections, services, damaged reputations, claims and even litigations.

After introducing the concept of "cost of quality" monitoring to the DTCG project manager, construction managers, cost engineers and field engineers, the DTCG quality team, under the direction of Herzog's Corporate Quality Manager, commenced its collection and analysis of quality cost data from reworks/repairs due to nonconformities, bad materials, or poor design beginning the 1st quarter of 2010. Refer to the Figure C-2 below (*Cost vs Activity*). Herzog Procedure # 060.191 – *Costs of Quality Data Collection, Analysis and Reporting* (see attached) describes the process for collecting, analysis and reporting quality cost data base.

Through the cost categories, the DTCG project management team identified potential operational savings in terms of cost reduction (expenses or capital savings), cost avoidance (cost prevention) and labor productivity (time savings).

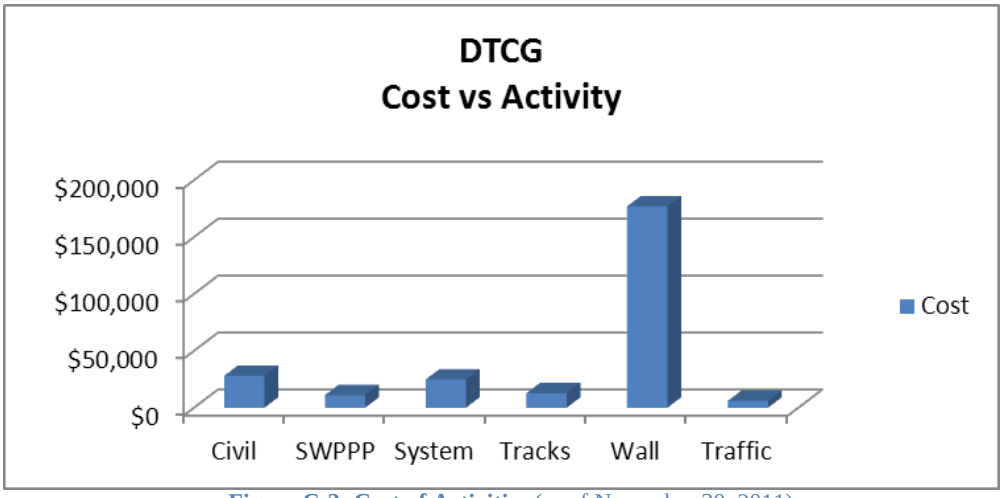

Figure C-2: Cost of Activities (as of November 30, 2011)

Lesson 2 - Proactive Area/Systems Walk Downs/Turnover and Project Closeout

A. Tri-Rail Project Experience

From commencement of the first construction package, the TCRC project management team implemented its project procedure for area/systems walk downs, punch listing and turnover of completed construction/installation works. The TCRC Project Quality Manager directed the entire process through active participation of the Construction Quality Manager, the various discipline construction managers, Quality Control (QC) inspectors, field engineers,

subcontractors representatives, and discipline design managers or their representatives. A very key factor in the success of this process was the full support and participation of the SFRTA Quality Manager, and representatives from Florida DOT, CSX, and city inspectors. The status of area/systems walk downs/turnovers were monitored, updated and periodically transmitted to all concerned TCRC project management team as well as SFRTA and stakeholders. Refer to the spreadsheet showing status of walk downs/turnovers below. There were two major types of walk downs, namely:

1. **Preliminary Walk Down** – A preliminary walk down was conducted when the work was approximately 70% complete, or whenever a part of a system or structure was to be enclosed or buried. The objective of this walk down was to evaluate the quality of the work performed to that point. The walk downs were documented in a preliminary punch list. Required repairs or reworks of identified nonconforming conditions were completed and verified that the corrections were done prior to the final joint walk down with the clients (SFRTA, CSX, Amtrak, city representatives, and/or other stake holders).

2. **Final Walk Down** – A joint "Final Walk Down" was conducted when a work element was complete. The purpose of this walk down was to verify that the system has been installed in accordance with the approved design. This walk down included a verification that the supporting inspection and test documentation have been compiled and provided evidence that the installed system was acceptable.

B. RTD West Corridor LRT Project Experience

The area/system walk down/turnover project procedure describes the walk down process performed by DTCG to verify that a unit of work, work area or systems, is complete and acceptable (installed per the applicable drawings, specifications and approved field changes), and that all nonconformance reports and open items have been satisfactorily corrected, accepted and closed out prior to turnover to RTD. A walk down verifies the completeness of both the physical work and the supporting documentations. DTCG will also submit an installation safety certificate for the completed area of FasTracks West Corridor LRT Project being turned over to RTD.

Walk downs are conducted using approved drawings, specifications, design changes and field change requests. During walk downs, drawings are "redlined" to identify conditions that do not conform to the approved drawings and specifications and that no changes to the as-installed condition will be made. To the extent possible, photos are taken as a part of a walk down. This is especially true of areas where work will be buried or enclosed. When photos are taken, they are to be numbered using the oversight inspection report number and the punch list item number. If more than one photo is taken, an additional sequential number should be appended to the oversight inspection report number. For a given item number, a description of what is shown by each photo taken is entered in the punch list under the "Punch List Description" heading. The walk down process includes verification that required testing has been performed and is acceptable. This verification is performed by the Construction Quality Manager or his designee.

<u>Walk Down Planning</u>

The Construction Quality Manager plans for a walk down by generating Walk down Records that describe the scope of the inspection, the names of the walk down participants, the

applicable drawings, specifications, design changes and other related documents and punch lists identified. The Construction Quality Manager obtains input from the field engineers, construction manager, Engineer-on-Record and RTD representatives when developing the walk down record. Walk down records are organized by work area number. Given the scope of most work areas, it is expected that there will be multiple walk down records for any given work area. The walk down requires a review of the list of outstanding items, such as Nonconformance Reports (NCRs), and tracking log to identify whether or not there are any open NCRs affecting the area covered by the walk down. Any open NCR or open issue affecting the scope of the walk down shall be listed under one line item and the line item is recorded as a "Reject."

Walk Down Closeout

The Construction Quality Manager combines the Walk Down Record cover sheet with the punch list(s). When all items listed on the PL are closed, the original of the PL is turned over to RTD. An Installation Safety Certificate shall be routed for signature, signed by the DTCG PE, authorized representatives of RTD and other project stake holders certifying that installations and conditions permit beneficial occupancy of the area in accordance with contract documents and permits the partial systems tests to start or revenue operation.

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Quality Case Study #2	
Southeastern Pennsylvania Transportation Authority Market-Frankford Rehabilitation Program	
Delivery Methods:	Design-Bid-Build, Program Manager/General Contractor, and Southeastern Pennsylvania Transportation Authority (SEPTA) Force Account Labor
Program Description:	The Frankford Transportation Center (FTC) was the largest single-site construction project ever undertaken by SEPTA and the work had to be performed with minimal disruption to the 50,000 riders that passed through the terminal each day. FTC consisted of six overlapping projects as follows: 1. Demolition of existing buildings at Pratt Street and Frankford Avenue. 2. Construction of two new bus bays on the South side of the Bus Depot and demolition of the existing front of the old building to make room for the new Terminal 3. Construction of new East and West guideways. 4. Construction of a new Multi-Modal Terminal 5. Construction of a new Parking Garage. 6. Rehabilitation of the existing Railcar Storage yard. The program required constructing a major terminal facility for the Market-Frankford Elevated line in a confined space with little room for storage of material and equipment. At the same time, service had to be maintained for 16 separate bus and trackless trolley routes that interchange with the elevated line at the terminal, requiring close coordination with SEPTA's Bus Operations. Although the buses only required replacement storage space in the rehabilitated bus depot, the trackless trolleys (Trolley Buses) required their overhead wiring and switching to be completely rearranged to get out of the way of the Terminal building and still operate properly. Except for a scheduled nine-day power outage, rail service was not interrupted. During these nine days, the guideways were reconstructed and shifted to the west. As Project 3, the Guideway and Systems contract, a temporary trestle was constructed to support the elevated rail line while a new portion of Bridge Street was constructed below. In order to complete the entire task within the outage time, construction was performed around-the-clock. The new transportation center features enclosed, climate-controlled waiting areas; a four-level, 1,000-vehicle parking garage adjacent to Bustleton Avenue; renovation of the historic Bridge Street station building; a two-story main hall; 7,000 square feet of retail space; and escalators and elevators to comply with the federal Americans with Disabilities Act.
Total Program Costs:	$187 Million (based on actual costs)
Lessons Learned:	
In order to construct the new Terminal Building while maintaining access for SEPTA's 50,000	

daily riders, the existing Rail yard had to be reconfigured to accommodate the new system alignment and maintain the same capacity. This involved shifting one existing turnout from Track 15 to Track 14 and installing multiple new turnouts along with all of the controls. Included in this work were two Triplex turnouts, which allow shifting a train from one track to three tracks.

All of the Westbound trains were stored in this yard and its availability for daily operations was critical. The contractor needed to deliver the yard back on time early any Monday after a weekend of installing a new turnout. Preplanning was critical.

Lesson 1. A contractor's attitude toward quality is often indicative of the quality of their work.

The Track Contractor arrived on site with a superintendent, who resisted contractual requirements, including the requirement for a Quality Plan. The Program Manager's (PM's) Quality Manager expended much effort getting him to produce a workable Quality Plan. The contractor finally hired a subcontractor to produce a corporate plan, which he adjusted for each specific project and hired a Quality Manager.

Based on the contractor's initial inability to deliver the plan, the PM decided the contractor should start by moving the existing turnout to see how close to completing on time he would be. This became problematic.

For several weeks prior to the actual work, the PM suggested the contractor install gauge rods to hold the old turnout together, since some of the existing ties were loose, and the PM was concerned that the turnout would rack when lifted. This was brought up at the weekly progress meetings and put in the minutes. Furthermore, the PM had insisted the contractor ensure his surveying was accurate and the turnout moved to its correct new position.

On Friday evening of the weekend for the move, the contractor began by disconnecting the turnout and installing lifting straps to move it to its new position. Of course the contractor failed to install gauge rods to save money and the turnout racked when lifted. Now instead of being able to place it directly in its new spot, he had to reassemble it piece by piece. This of course took longer than planned.

Lesson 2. Prevention quality costs save money over the cost of nonconformance.

On Saturday morning around 4:00 AM, the PM came to check how the work was proceeding and how his inspectors were performing. The Owner of the company was personally directing the work, which the PM noted was not correct. The final location was out of position by one full gauge. The contractor insisted he had surveyed the point several times and it was correctly in place. The PM insisted the contractor physically measure the distance, the results of which revealed that the turnout was out by one gauge width. The contractor had attempted to save money by using an inexperienced surveyor, resulting in major cost due to crew delays.

Naturally, the work finished late and the yard was not turned back on time, which upset the Owner. He agreed to bring in a new superintendent among other corrective actions, including the institution of weekly telephone conferences to bring the contractor, supplier and PM together to check weekly progress.

Once the work shifted from moving an existing turnout to assembling and installing new turnouts, the PM noted that the crew was having trouble assembling them in a timely manner. The foreman complained he had no plan from the supplier to show how they went together and

he was using his track experience to get them done. The PM suggested the contractor send his foreman out to the supplier's plant to get the information he needed to complete the turnout for installation. In order to save money, the contractor chose to not send the foreman to the supplier, but ended up paying more in labor time than needed as a result.

After further job progress, the contractor appeared to have improved performance. However, his crew encountered great difficulty assembling the first triplex, because they had never performed similar work before and had difficulty getting the parts to properly align. Consequently, this portion of the project was delayed. The contractor was not allowed to proceed until the turnout was correct. The supplier finally sent a man to the site and he helped get the first turnout corrected. Had the contractor sent the foreman to the supplier, these delays would have been significantly mitigated.

As a result of the delay and the fact the schedule could not afford another equally long delay, the PM insisted the contractor correct his planning and recommended again that the foreman go to the supplier plant. The Supplier also suggested the foreman come to the plant to get first-hand knowledge in the assembly. This time, the contractor agreed.

At the plant, the foreman learned the tricks of proper assembly for triplexes and got a marked up plan with working lines on it to help his assembly. As a result, the contractor was able to assemble the Triplex directly in track, which saved time and the rental costs for a second crane. The contractor made several decisions based on immediate savings throughout the project, but in many cases, profits would have been greater if the contractor had invested in quality costs related to prevention, rather than paying the cost of nonconformance afterward.

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Quality Case Study #3	
Design-Build: Baltimore Central Light Rail Line Phase II Extensions Project	
Delivery Method:	Design-Build (DB)
Program Description:	The Maryland Mass Transit Administration (MDMTA), now called the Maryland Transit Administration (MTA), was responsible for a fixed guideway system, including heavy and light rail lines, in the Baltimore region. The Central Light Rail Line (CLRL) component was phased. The Phase II project, put into operation during 1997 by the MTA, involved three major extensions of the light rail line: a 4.3-mile northward extension; a second 2.5 mile southward line to BWI Airport; and a connection between the Mt. Royal station and Pennsylvania Station. The project was awarded the 1998 “Outstanding Civil Engineering Project” award by the Maryland section of the American Society of Civil Engineers (ASCE).
Total Program Costs:	Total Project Cost of $106 Million for all three, simultaneous extensions

Lessons Learned:

In the project, the grantee (MTA) provided the DB contractor with responsibility for quality requirements, including audits and inspections of all materials and facilities not supplied by the grantee. The grantee originally planned to provide a minimal effort of monitoring, while retaining the option to provide inspection deemed necessary to assure implementation of the contractor's Quality Program and thereby assure the quality of the DB contractor’s work. This type of quality function implementation was new to both the grantee and the contractor. This process was adapted from the US Army Corps of Engineers’ approach to the quality review process in DB projects.

Lesson 1. The grantee should maintain a Quality Assurance (QA) role over the DB contractor.

The MTA required the bidders to certify that they would conform to MTA’s Quality Plan requirements instead of developing their own during the procurement process. In addition, MTA required review and approval of the control process and staffing plan. However, the transfer of virtually all of the Quality Program responsibilities to the contractor, as was done on other federal DB projects at that time, created unplanned limitations on the ability of MTA to adequately oversee the project. This may have had an unintended result of decreasing consideration of the Quality Plan during the procurement process.

The CLRL Extensions project demonstrated initial constraints over roles and responsibilities between the grantee and the DB contractor, especially in regard to the DB contractor’s role regarding indirect reporting of the construction management functions. Additional effort was required by MTA to get the contractor to implement the defined program within the DB project team and maintain adequate oversight once the project was underway. The MTA has maintained a larger role in the quality assurance and document control since this initial DB contract.

Lesson 2. The grantee should always maintain some QA role over the contractor and their subcontractors.

This lesson does not only apply in projects that follow the DB delivery method. In large, multi-tiered Mega Projects, the grantee may be separated from the contractors and subcontractors by a Project or Construction Management Consultant (PMC or CMC) and/or a Construction Manager (CM). In these cases, it is still beneficial to the grantee to maintain some QA role even at the contractor level. They may attend and observe meetings with the contractor/sub or quarterly audits of their activities or even perform their own audits if there is cause for concern. These additional management layers may serve a more in-depth QA role on the project, but this does not absolve the grantee of all involvement.

Quality Case Study #4	
Regional Transportation District of Denver FasTracks Program	
Delivery Methods:	Design-Bid-Build, Construction Manager/General Contractor, Design-Build, and Design-Build-Finance-Operate-Maintain
Program Description:	The *FasTracks Plan* consists of nine rail lines (new or extended), two Bus Rapid Transit (BRT) lines, redevelopment of Denver Union Station, a new Commuter Rail Maintenance Facility, and an expanded light rail maintenance facility. The Plan adds approximately 64 miles of commuter rail (East Rail, Gold Line, North Metro Rail, and Northwest Rail – Phase 1 and 2); approximately 28 miles of light rail (Southeast Rail and Southwest Rail Line Extensions, Central Rail Line Extension, I-225, and West Rail Line); Park-n-Ride improvements and/or relocations at existing Park-n-Ride lots along US 36 (US 36 BRT – Phase 1), and up to 80 miles of BRT (US 36 BRT – Phase 2 and Northwest Corridor BRT).
Total Program Costs:	$7.4 Billion (based on 2012 Annual Program Evaluation)

Lessons Learned:

After the *FasTracks Plan* was passed by voters along with a Sales and Use Tax initiative in November 2004, the Regional Transportation District of Denver (RTD) needed to re-define its quality management program to accommodate multiple concurrent projects in different phases of delivery, multiple project delivery methods, and multiple transit technologies. RTD was able to achieve this through several approaches:

Lesson 1. Develop a written quality management philosophy.

RTD published its quality philosophy in March 2005, which included the following elements:

- Public Responsibility and Citizenship – a commitment to RTD's mission of delivering safe, clean, reliable, accessible, and cost-effective transportation services that promote improved quality of life within the region.
- Building Quality In – a recognition that quality must be built in, rather than inspected in. All contractors and consultants delivering products and services to RTD shall implement effective and comprehensive quality management programs.
- Management by Fact – a commitment to requirements-based assessment of contractor processes and products, and utilization of information management tools to capture and globally analyze those assessments.
- Process Management – an internal focus on RTD's own key processes, and periodic assessment through internal quality audits, peer reviews, and other means.

This philosophy remained largely unchanged until 2012 when a fifth element was added for Teamwork, and the recognition that everyone on the FasTracks team is part of the quality oversight program.

Lesson 2. Emphasize the contractor's role in Quality Assurance/Quality Control.

RTD requires all contractors and consultants delivering work (environmental clearance documents, design products, manufactured products, and construction) to implement effective Quality Management programs, documented in written Quality Management Plans that must be

approved by RTD. These plans comply with the 2002 update of the *FTA Quality Assurance and Quality Control Guidelines* or ISO 9001:2008. For the DBFOM Eagle Project, RTD took the requirement one step further. The Concessionaire was required to achieve ISO 9001 registration through an accredited registrar within 12 months of notice to proceed.

RTD rejects the traditional notion that contractors are only responsible for "quality control" while owners conduct "quality assurance." RTD's accepted definition of Quality Assurance is "all of the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that the product will fulfill quality requirements and will satisfy given needs." Consistent with RTD's quality philosophy of "Building Quality In," RTD expects contractors to implement quality assurance approaches that go beyond quality control techniques.

Lesson 3. Implement a comprehensive Quality Oversight Program.

While RTD places much responsibility for quality assurance upon its contractors, RTD does not abdicate its role in overseeing the contractor's program to ensure that it complies with the approved Quality Management Plan. RTD's deploys several quality oversight approaches including: environmental review, design review, construction verification inspection, owner's verification testing, process audits, management systems audits, and priority planning to provide RTD management with confidence that the contractor is effectively managing its quality program.

Consistent with RTD's quality philosophy of "Management by Fact," RTD's Quality Oversight Program utilizes a database to store and maintain each project's requirements, develop assessments against those requirements, produce reports of each assessment, and track any nonconformances until satisfactory resolution.

In 2011, RTD received an ISO 9001 registration certificate from Orion Registrars for the RTD Quality Oversight Program. This certificate helps assure RTD management and its stakeholders that RTD has implemented an effective oversight program compliant with the international quality standard and the *FTA Quality Assurance and Quality Control Guidelines* that were derived from that standard.

Lesson 4. Implement methods for continuous improvement.

Consistent with RTD's quality philosophy of "Process Management" and FTA Element 12, Corrective Action, RTD has implemented several tools to identify opportunities for improvement, and take corrective or preventive action. These tools include:

- Internal Quality Audits – A structured review of RTD's management processes conducted by an independent and certified auditor. These audits are conducted in accordance with ISO 19011, *Guidelines for Quality and Environmental Management Systems Auditing*.
- Peer Reviews – Conducted periodically through APTA or setup directly by RTD to review RTD's management organization and approaches.
- Rocky Mountain Performance Excellence Assessments – Conducted at the state level through a non-profit organization that utilizes the Malcolm Baldridge Criteria for Performance Excellence. In 2011, RTD was recognized with the Rocky Mountain Performance Excellence Timberline Award for performance excellence.
- Improvement Actions – A documented approach for identifying problems or opportunities

for improvement, and proposed actions for resolution. These can result from any of the approaches in this list, or can be self-initiated.

- Quarterly Quality Management Reviews – a structured review of the quality oversight program goals and results, consistent with Element 1, Management Responsibility, of the *FTA Quality Assurance and Quality Control Guidelines*.
- Lessons Learned – A structured approach that utilizes a database to capture organizational knowledge, so the project teams can learn from their predecessors.

Lesson 5. Foster a teamwork environment.

The FasTracks team is composed of RTD staff, stakeholders, and management consultants retained to provide specific expertise. These team members come from a variety of backgrounds and experience levels. Since RTD strives to maintain consistency in its oversight approaches, each team member undergoes just-in-time training on the oversight procedures they will be involved in.

Teamwork is also fostered with each contractor at the project level through formal partnering. Quality performance is reviewed by RTD's quality oversight staff and the contractor's QA staff at least monthly, utilizing a color-coded matrix that categorizes issues as Steady Performance, Good Trends, Current Challenges, and Ongoing Challenges. In this way, RTD and the contractor can achieve concurrence on those issues representing the greatest risk to the project, and development of corrective action plans to resolve them.

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Quality Case Study #5	
Dallas Area Rapid Transit Light Rail Project	
Delivery Methods:	Construction Manager/General Contractor (CM/GC)
Program Description:	The LRT Buildout Phase II consists of approximately 46.1 miles of light rail transit lines extending northward from the Dallas Central Business District to the City of Carrollton (Northwest Corridor), including a branch from Northwest Highway out to Dallas/Fort Worth Airport (Irving/Dallas/Fort Worth Corridor). Phase II also extends the light rail transit lines southeasterly from the Dallas Central Business District to Buckner Blvd. in South Dallas (Southeast Corridor) and easterly from the Downtown Garland Station to the Rowlett Park and Ride (Rowlett Extension). The construction of Phase II includes two CM/GC contracts inclusive of pre-construction services, facilities construction, trackwork, landscaping, and systems elements installation; three design-build contracts inclusive of facilities construction, trackwork, landscaping, and systems elements installation; Northwest Rail Operating Facility contracts consisting of five lots; and contracts for major equipment, material, and vehicle procurements. Construction will be done in two phases: Phase IIA, which includes the Southeast and Northwest corridors (26.8 miles), and Phase IIB, which includes the Irving/Dallas Fort Worth Corridor and Rowlett Extension (19.3 miles).
Total Program Costs:	$1.7 billion

Lessons Learned:

In June 2011, Dallas Area Rapid Transit (DART) track maintenance personnel noted several direct fixated track plinths that appeared to have become delaminated from the bridge deck and were visibly seen moving on the Union Pacific Railroad (UPRR) Bridge in the SE-2 Line Section. Additionally, several other track plinths, including the moving plinths, it was noted that a white powder residue was observed adjacent to the plinth in the same area. DART Operations immediately initiated a 15 mph “slow order” through the area and track maintenance personnel installed track gauge rods to ensure that track would not move laterally until further investigation could be performed to determine the full limits and the cause of the delamination.

Lesson 1. Regular Quality Control (QC) inspections are necessary for the timely detection of nonconformance.

Investigation

DART engaged the original design team to review the design of the SE-2 bridges. The design of the bridge deck, plinths and the attachment between the two proved to meet design codes and DART’s design criteria. An outside consultant was also engaged to perform a similar design check and oversight of the review process also reported that the noted plinth failures do not appear to be the result of a design flaw. Also, a review of the thermal rail stresses with respect to bridge geometry was made and was found to have a very insignificant, if any, contribution to the plinth failures.

Concurrently, an investigation program was implemented with DART staff, consultant staff, and Contractor personnel to perform destructive and non-destructive testing of the track plinths in an effort to determine the cause of the delamination. This investigation consisted of four major

areas; demolition of several plinths that were visibly moving with the intent to inspect the rebar stirrups that used to tie the plinths to the concrete deck; a sample of the white powder residue was tested for chemical make-up; a survey of top of rail elevations compared to top of plinth elevations; and side load testing of the plinths to validate the bond strength between the plinth and deck.

Lesson 2. Root Cause Analysis should involve investigation into areas where there could be previously undetected failures, as a problem may be more pervasive than is apparent.

Also concurrently, all other bridges with direct fixated track were inspected to ensure similar plinth failures. Delaminated plinths were only found on the SE-2 Line Section, specifically on the UPRR and White Rock bridges.

Investigation Conclusions

Results of investigations revealed several plausible contributors to the conditions observed. The chemical make-up of the powder residue was consistent with a latex concrete bonding agent. There is an appearance that in several locations, the bonding agent was allowed to be washed or diluted and released from the formwork where it ran adjacent to the plinth on the concrete deck. A test was performed to determine the bonding capacity of the bonding agent. It was found, assuming proper application, the bonding agent should have had an adequate capacity to resist the vertical and horizontal design loads the plinths would experience.

During the demolition of the selective plinth and core samples, it was found that a plastic sleeve that was temporarily installed to protect the rebar stirrup (between the concrete bridge deck and the subsequent concrete plinth placement) was allowed in some cases to cover at least one leg of the stirrup into the bridge deck. This reduced the overall development length of the rebar leg allowing a plinth to move vertically as the train passes. It appeared the rebar stirrup provided the same or at least very near the same shear capacity as one properly installed.

The survey that compared the top of rail to top of plinths indicated that there were several plinths that were not properly shimmed. The most prevalent noncompliant condition found was the plinth and fastener was installed slightly lower than the adjacent fastener. This condition provided a significant uplift force from the rail and clip onto the plinth. However, it was determined that if the bonding agent has been properly installed, the bond should have been adequate to resist this upward force.

It appears that some of the plinths were experiencing an upward force because of improper vertical rail alignment and improper shimming of the rail fastener. This force coupled with rebar stirrups with an inadequate bonding agent applied between the concrete bridge deck and the subsequent concrete plinth placement and rebar stirrups with inadequate development length, was the plausible explanation for the track plinths that delaminated on the SE-2 UPRR and White Rock bridges.

From the site survey, 27 plinths were found to be visually moving and 15 additional plinths were found with the white powder residue out of approximately 938 total plinths installed on the UPRR bridge. Sixteen (16) plinths were found to be visually moving and 159 additional plinths were found with the white powder residue out of 2,204 total plinths installed on the White Rock Creek bridge.

Implementation

Several non-destructive test methods (ultrasound, ground penetrating radar, etc.) were

researched to definitely determine if a plinth had delaminated from the concrete deck and none were found to be successful. The rail operations and maintenance personnel were concerned that additional plinths would delaminate over time and that there was not a quick way to determine if a plinth had delaminated until a track inspector saw a specific plinth move under a train load.

To address the known plinth failures, as well as, potential future failures, the following measures were implemented on the UPRR and the White Rock Creek bridges:

1. All plinths on the entire Green Line system were checked for proper vertical track alignment and shimming. Where needed, the shimming was adjusted to remove any imposed loading of the plinth that the misaligned rail may have induced.

2. All plinths that were found to be delaminated from the concrete bridge deck were drilled and pinned with rebar dowels that were epoxied into the plinth and underlying bridge deck. The cross-section area of the new pins replaced the rebar stirrups that had potentially loosened from the bridge deck. After the pins were installed, epoxy adhesive was injected between the plinth and the bridge deck to fill the void created by the delamination to ensure full bearing of the plinth.

3. Any plinth where the white powder residue was found and had not been pinned to the bridge deck as described in the previous step had the joint sealed with a rigid epoxy adhesive. The joint between the plinth and the concrete deck was routed 1/4" deep and 1/4" wide, where the epoxy sealant was installed sealing the joint. It was determined that should the plinth further delaminate in the future, either the concrete of the plinth or the concrete deck would fail prior to the original joint widening, providing the track inspectors with a positive and quicker way to identify a delaminated plinth.

4. Due to the lack of a proven non-destructive test to definitely determine the full limits of any potentially delaminated plinths, the remaining plinths (those that as of the completion of the initial repairs had not shown any signs of a problem) had two epoxy "inspection tabs" installed at two opposing corners. Should there be any future plinths delaminate, these tabs are a positive means to determine a failure before complete delamination.

<u>Conclusion</u>
It appears that workmanship issues are the primary reasons for the plinth failures. It also appears that there were breaches in the Contractor's QC program and possibly with the Construction Manager's QA surveillance and procedures. With proper QC inspections and checks, it would be expected that these issues could have been resolved much earlier. However, from an overall perspective, 43 plinths were found to be delaminated and another 174 were suspected as potential to delaminated as a result of the investigation parameters of the 3,142 plinths installed on the two SE-2 bridges or 6.9% potential failure rate. There were 42,438 plinths installed as part of 20.8 miles of direct fixated track on DART's Green Line, equating to 0.5% potential failure rate.

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Quality Case Study #6	
Southeastern Pennsylvania Transportation Authority Market-Frankford Rehabilitation Procurement	
Delivery Methods:	Design-Bid-Build, Program Manager/General Contractor, and Southeastern Pennsylvania Transportation Authority (SEPTA) Force Account Labor
Program Description:	The Frankford Transportation Center (FTC) was the largest single-site construction project ever undertaken by SEPTA and the work had to be performed with minimal disruption to the 50,000 riders that passed through the terminal each day. FTC consisted of six overlapping projects as follows: 7. Demolition of existing buildings at Pratt Street and Frankford Avenue. 8. Construction of two new bus bays on the South side of the Bus Depot and demolition of the existing front of the old building to make room for the new Terminal 9. Construction of new East and West guideways. 10. Construction of a new Multi-Modal Terminal 11. Construction of a new Parking Garage. 12. Rehabilitation of the existing Railcar Storage yard. The Program Manager maintained close coordination with SEPTA's Capital and Operations Departments, the designer, contractors, the community, and SEPTA riders. Quality Assurance, Safety, and Community Relations were essential elements of the Program Management services, in addition to the usual tasks that are included in Construction Management. The PM substantiated the inspection and certification of the contractors' material before it was shipped to the terminal as well as when it arrived on site. Except for a scheduled nine-day power outage, rail service was not interrupted. During these nine days, the guideways were reconstructed and shifted to the west. As Project 3, the Guideway and Systems contract, a temporary trestle was constructed to support the elevated rail line while a new portion of Bridge Street was constructed below. In order to complete the entire task within the outage time, construction was performed around-the-clock. The new transportation center features enclosed, climate-controlled waiting areas; a four-level, 1,000-vehicle parking garage adjacent to Bustleton Avenue; renovation of the historic Bridge Street station building; a two-story main hall; 7,000 square feet of retail space; and escalators and elevators to comply with the federal Americans with Disabilities Act.
Total Program Costs:	$187 Million (based on actual costs)
Lessons Learned:	
In order to construct the new Terminal Building while maintaining access for SEPTA's 50,000 daily riders, the existing Trackless Trolley overhead Hardware had to be relocated away from	

the Terminal footprint and installed in the future alignment.

The existing frogs in the overhead switching devices had been fabricated for the old layout and did not fit the new. Therefore, new switching devices with their own specially fabricated frogs had to be procured. Since this was a long lead item that could delay the project if not delivered timely, SEPTA procured the material and listed it in the contract as agency furnished material. There are few trackless trolley systems in the United States and few manufacturers that produce this material.

Lesson 1. A quality plan or certification does not guarantee conforming product.

The manufacturer chosen to produce the frogs was in North Carolina and was ISO 9000 certified, which normally means that their work is inspected to specification before leaving the plant. However, when the material arrived, it was inspected by the contractor, who discovered that many of the welds on the frogs were cracked leaving the material unusable in its current state.

The Program Manager (PM) and Quality Manager (QM) for the project met with SEPTA's QM and the contractor to develop a corrective action to keep the project on schedule. The manufacturer was called to determine the cause and to get the corrective action moving immediately. The problem stemmed from the manufacturer using a non-certified welder to fabricate the frogs. Since the manufacturer did not have a welder certified for that type weld, he was asked to produce replacement material and to have it welded by a certified welded. He was able to hire a welder who was certified for that weld. The replacement parts were delivered by this welder to be on site in case of further problems. Under inspection, it was determined that the brace that came was too long and had to be fixed by the manufacturer.

There were several overarching lessons that can be derived from this case:

1. When an agency procures critical long lead material to give to a contractor, they need to have an inspection plan to verify the material is as specified. Either have the agency's quality personnel visit the plant or contract with a quality consultant to perform the plant inspection and subsequent materiel inspections. This precludes the wrong material ending on the job site. The agency needs to perform a plant inspection and material checks in the same manner as they specify for the contractor.
2. Just because a company is certified to ISO or any other specification, a plant inspection with all of the checks for certifications and samples of finished work still ads value and should not be seen as redundant.
3. Although a plant may have personnel that meet the specification for performing the work, make sure those people are actually the ones who do the work.

Quality Case Study #7	
New York City Transit 63rd Street Connection Project	
Delivery Methods:	Design-Bid-Build
Program Description:	One-third mile of new tunnel construction to connect the 63rd Street tunnel in Manhattan to the Queens Boulevard Line in Long Island City, Queens and relieve congestion in the existing 53rd Street tunnel. The project also consisted of widening the Queens Boulevard subway line between Queens Plaza and 36th Street in order to accommodate new ramps from the 63rd Street tunnel to come up between the local and express rail tracks in both directions. Other project components included new ventilation plants, pump rooms, circuit breaker houses, substations, tunnel lighting, computer-based control systems, communications equipment, and property acquisition. The project was completed while regular subway operations continued. Final track and signal work was completed in September 2001. The project was divided into five phases from project planning to testing and start-up. Innovative construction techniques were applied during the early tunnel excavation and underpinning phases.
Total Program Costs:	$645 million
Lessons Learned:	

The 63rd Street Connection Project to the Queens Boulevard Lines is a very large and complex subway project that has involved six construction contracts and various construction activities including cut and cover, drill and blast, and pit and beam underpinning tunneling methods. Construction has spanned over 7 years while the subway has been in full operation.

The project required that all general contractors possess a quality program, which New York City Transit (NYCT) monitored and evaluated. The agency also initiated and successfully implemented a quality program for the project. This program was originally intended to ensure contractor conformance for quality and safety, but evolved into a more comprehensive tool to support continuous improvements of methods and products. It was also accepted by all project participants (i.e., contractors, NYCT program personnel, designers, FTA, MTA, and their respective oversight consultants), ensuring strong and dynamic partnerships that minimized rework, improved communications, and provided guidance. The lessons identified by the NYCT in the documented project lessons learned of October 2000 involved three key elements of the quality program:

- Preparatory phase construction inspection
- Contractor performance rating system
- Just-in-time training

These lessons are detailed below.

Lesson 1. Place emphasis on quality during the preparatory phase of construction.

An emphasis on the preparation phase of each new construction activity enabled project participants to coordinate their efforts and review the upcoming work together to ensure that the job was done right the first time and expeditiously. A preparatory phase before construction is specified by NYCT contracts; however, the first time it was fully implemented was in the 63rd Street project. Previously, preparatory activities for construction performed by contractors were limited in scope and independent of the NYCT. Consequently, the NYCT began requiring several joint procedures before all major construction so that all activities were understood and coordinated, to clearly communicate expectations about the final product, and to limit nonconformance. These goals were accomplished by a series of meetings and other activities identified by the NYCT, which included:

a. **Review of Contract Requirements with the Contractor**

This is a joint effort with the contractor to review the status of submittals (i.e., materials, shop drawings, procedures, and methods); clarify installation methods; define records to be maintained; develop checklists; determine hold and witness points; outline responsibilities; identify critical safety issues; and assess training needs for NYCT and contractor staff.

b. **Review of Physical Field Conditions**

This is another joint effort by the NYCT, contractors, installers, the contractor's quality engineer, and the designer's field engineers to ensure that the scheduled work is ready to be performed according to a risk assessment; the availability of materials, workers, and equipment on the site; the condition of the work site; and sample work already completed (where applicable).

c. **Kick-off Meeting/Summary of Preparation Phase**

The kick-off meeting brings together all members of the team to discuss preparatory phase findings, points out concern, and reach agreement on the process of upcoming work. Attendees from NYCT usually included the field engineer, resident engineer, representative from the user group, project QA personnel, project safety personnel, and specialized consultant. The contractor is usually represented by the installer (superintendent and foreman), quality assurance engineer, safety engineer, and project manager. Agenda items at the meeting include discussion of the work approach, action plan, requirements, anticipated difficulties, and a contingency plan.

d. **Leadership**

The highest ranking NYCT project executive, usually the program manager, personally discusses with the field engineers and contractors the importance of preparations to construction, periodically attending preparatory phase meetings to reinforce the message.

The results from the enhanced preparatory phase of the quality program identified during the 63rd Street Connection project included:

- Better relationships between contract parties;
- Contractors (who were initially reluctant to participate) became more active participants;

- Preparatory phase inspections and consequent revisions to the work plan assisted the contractors in meeting budget and schedule targets;
- The original design was improved from consultant and contractor input;
- NYCT was able to provide better support to contractors and field staff;
- A baseline agreement was established that provided guidance when discrepancies arose; and most importantly,
- The vast majority of the work was performed correctly, minimizing punchlist items, rework, and the turnover time of the project.

Lesson 2. Measure Contractor Compliance

A second key lesson learned during the 63rd Street Connection project involved the contractor performance rating system that measured contractor compliance and became a driving force for improvement.

In the very beginning of the project, the NYCT evaluated all six, project contractors on the implementation of their quality programs on a quarterly basis. The outcome of the original process was a qualitative attribute rating (i.e., satisfactory, needs improvement, and unsatisfactory) that did not satisfy the NYCT, contractors, or oversight agencies. As a result and in partnership with the contractors, the NYCT developed a more objective numeric ratings criteria and evaluation process of contractor performance. The process was consistently implemented every quarter and for each contractor until project close-out. The goals were to "create a performance evaluation system to ensure consistent ratings for satisfactory performance, recognize success and outstanding results with uniformity for all six contractors." The steps involved in the new rating system are listed below.

- Ten basic "elements" of the contractor's quality program evaluated:
  1. Quality organization
  2. Submittal management and document control
  3. Receiving, handling and storage of materials and equipment
  4. Subcontractor and supplier control
  5. Inspection and test program
  6. Control of construction processes
  7. Control of measuring and testing equipment
  8. Control of nonconforming conditions
  9. Internal audits
  10. Documentation by quality records.
- Quarterly evaluations were performed on five of the ten elements as identified by NYCT and each contractor, including two key elements that were evaluated every quarter "control of nonconforming conditions" and "inspection and test program." All ten elements were evaluated at least once per year.
- Under the new system, each quality program element was evaluated for the approach or planning, deployment or implementation, and results or effectiveness. Therefore, a successful element is evident from a combination of planning, implementation, and demonstrated results.
- In scoring an element, several "checkpoints" were verified and evaluated. These checkpoints can be documentation or construction activities, depending on the element or nature of the work observed. The checkpoints are rated up to 30 points for being complete (planned), up to 40 points for being current and correct (implemented as planned), and up to 30 points for achieving the desired results. The ratings are tabulated directly on the

checkpoint forms along with comments and an average score is calculated for each element.

- An overall contractor rating for the quarter is simply the average of the five individual element scores for the quarter. The contractor's performance is considered "satisfactory" if the final rating is greater than 75 points, "needs improvement" if between 50 and 75 points, and "unsatisfactory" if less than 50 points.
- The contractor is allowed to review and comment on the preliminary ratings during a 48-hour grace period. The construction manager approves the final ratings.

As a result of this document review and compliance process, the NYCT saw steady progress from the contractors in achieving quality program requirements. Outstanding contractors were also recognized from the ratings process. In sum, the majority of the work for the project was done right and with minimal rework. The results justify the application of this process to other projects and contracts.

Lesson 3. Utilize just-in-time training when possible.

Training was once viewed as taking time away from "real work" and a "costly overhead expense." However, the experience of NYCT in the 63rd Street Connection project has proven that proper and timely training can provide large returns by eliminating direct charges for rework and mistakes, and providing a safer and more productive work environment.

The challenges faced by NYCT that prompted the creation of a specific project training program, known as New Routes, included:

The NYCT program staff that managed the project ranged from veterans and experts to college interns or others with no experience in the construction methods proposed.

Standard construction hazards were exacerbated on this project by continuous subway operations, stability issues of surrounding buildings, and highway settlement.

While conscious of project and contractor budget constraints, quality and an effective interface of the program team to many disciplines and contractors were critical concerns.

The objectives of the New Routes training program were to focus on near future work activities to provide "just-in-time" training, improve the field engineering skills, increase quality and safety awareness, and help with self-improvement and team building. Therefore, the scope of the training program included technical engineering disciplines, specific work element installation processes, field engineering, construction management, project management, QA/QC procedures, general and project specific safety, and team building. The instructors came from a variety of backgrounds, both inside and outside the project, as dictated by the training needs. They included outside experts, project managers, project team members with specialized knowledge, contractors, consultants, and FTA and MTA oversight consultants. The training was organized more like workshops rather than lectures. In fact, a number of sessions were conducted in the field to demonstrate tasks such as waterproofing, rail weld grinding, jet grouting, and concrete placement. Other training sessions were held in the project offices.

The training participants included NYCT field and office personnel on the project, user/maintenance groups, QA, safety, contractors, consultants, and project management oversight consultants. The twice-a-week training sessions were scheduled in advance, and

usually fell on the same time and day of the week or at night to encourage participation from the night shift of this 24-hour operation. A training database was developed using Microsoft Access to record the training completed by each participant. This tool allowed the project to maintain an inventory of skills and disciplines and further identify the needs.

Part of the success of the training program was due to its constant emphasis by the project leadership. Although the quality representative within the program group administered the training program, the project manager did follow up on training status and attendance, and was one of the most enthusiastic participants of the sessions. Training needs and results were discussed at biweekly staff meetings and monthly quality update meetings. A training summary, including future schedules and reports, was issued monthly. Each course had a written outline and other handout materials that became a part of the technical library. The sessions were also evaluated by the participants who provided feedback to the instructors.

The results of the New Routes training program are characterized by the NYCT as a general increase in the level of professional and technical skills. About 120 sessions were held from 1995 to 1999 that included topics such as scheduling, specifications, concrete, signal design, steel installation, general orders, waterproofing, blasting, ISO 9000 quality standards, and utilities with over 1800 participants attending. The training ensured that project safety indicators exceeded industry standards, that the proper material was installed, and that proper procedures were followed. For instance, a session on the rail weld grinding process and inspection criteria was given after mistakes and defects prompted the stop of all work on this task. After the training, no additional defects were detected. Specialized outside knowledge also enhanced productivity and reduced mistakes. For example, the NYCT inspectors received training on two complicated construction procedures, jet grouting and slurry walls.

Finally, the NYCT also believes that training improved morale and strengthened relationships between the people who performed the work and those who provide oversight. In the end, the majority of the project work was completed correctly with little to no rework and the NYCT has recommended the training program on future projects.

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Quality Case Study #8	
Washington Metropolitan Area Transit Authority Metrorail Project	
Delivery Methods:	Design-Bid-Build
Program Description:	The 103-mile Adopted Regional Metrorail System in Metropolitan Washington was completed in January 2001 after a 32-year construction effort by the Washington Metropolitan Area Transit Authority (WMATA). The engineering and construction of this heavy rail transit system is considered one of the largest single public works projects of its type in the United States. During the first phase of the system's construction (89.5 miles), construction duration of a “typical “ station and a line section from the start of excavation to systems testing and start-up was 50 and 60 months, respectively. For the second phase of the construction program (13.5 miles), construction duration of a “typical” station and a line section from the start of the excavation to systems testing and start-up was 45 and 50 months, respectively. The second phase fast-track construction program included the following projects completed from June 1997 to January 2001: • Blue Line from Van Dorn Street to Franconia-Springfield: $74.7 million • Red Line from Wheaton to Glenmont: $52 million • Green Line from U St-Cardozo to Fort Totten: $7.1 million • Green Line extension from Anacostia to Branch Ave: $145.4 million Presently, two design-build contracts are being considered for a Blue Line Extension to Largo scheduled for completion within 42 months, for both track (3.1 miles) and 2 stations with parking, respectively.
Total Program Costs:	$9.4 billion (cost of first and second phases of Metrorail, not adjusted for inflation)
Lessons Learned:	
WMATA's Construction Contract Quality Assurance Program: WMATA required a Contractor Quality Control System (CQCS) in major civil construction contracts (in excess of $10 million), from the mid 1980's through 2001. The construction contracts included minimum requirements for the CQCS and instructed contractors to describe the CQCS in a Quality Plan that was to be submitted and approved by WMATA prior to the start of work. Upon approval, WMATA's Resident Engineer and QA/QC staff monitored the implementation and effectiveness of the CQCS through field observations, inspections and audits. **Lesson 1.** Review results after implementing a new quality initiative or program. The success of the CQCS program varied depending upon the attitude of the contractor's job site personnel towards the CQCS program and the willingness of the contractor personnel to work as a team. Many contractors believed that the CQCS added little value to contractor	

operations. QA/QC staff was viewed as a contract requirement as opposed to an essential part of the project staff. In those instances where the CQCS program was successful, the CQCS staff performed as an integral part of the Contractor's job site team and was fully involved in the planning and execution of the work.

WMATA attempted to motivate Contractors to have a more positive attitude towards the CQCS program by introducing a Quality Awareness Program. The program included payments to the contractor for implementing an effective CQCS. The value of the program equaled 1% of the bid items and was included in the total bid price. Programmatic payments were made monthly if the CQCS was effective. Payments withheld because of an ineffective CQCS were forfeited and the value of the contract was reduced accordingly.

The contract included specific conditions that had to be met in order for a programmatic payment to be made. The conditions were mandatory and not up to the discretion of the Resident Engineer. Programmatic payments were not paid in those months according to the following conditions:

- Payment was denied for a portion of the work that was determined to be deficient and non-compliant.
- The Engineer had determined that the contractor had installed unapproved or unsatisfactory material, components, or equipment.
- The Engineer had notified the contractor of deviations from the contract requirements for work in progress that resulted in the stoppage of the production of the work activity.
- The Engineer had written one or more stop work orders because work in progress was not in compliance with the contract requirements.
- The Engineer has provided more than three written notices, for work performed within the payment period, to initiate corrective action on construction work, procedures, or operations that do not meet the contract requirements.
- The Contracting Officer had determined that one or more of the Engineer's written corrective action or deviation notices demonstrate the severity, repetitive nature, or criticality of circumstances that the CQCS staff and/or procedures were not effectively controlling the quality of construction.
- The CQCS had been without the service of the approved full-time CQCS Manager and/or staff except where absences were for bona fide emergencies and the Contractor took appropriate steps, in the Engineer's judgment, to continue effective control of the quality.

WMATA anticipated that the program would motivate contractors possessing a marginal or ineffective CQCS to raise performance to an acceptable level. The program was introduced as a trial on a single contract in 1990. The contractor had previously performed work for WMATA and was familiar with the CQCS requirements. The contractor initially proposed a CQCS Manager who was unacceptable to WMATA. However, the second proposed candidate was found to be acceptable and was approved. The CQCS Manager proved to be an effective member of the project team and was recognized by the contractor as an asset to the project organization. An effective CQCS was implemented and the full programmatic payment was made. The program did appear to motivate the contractor to have an effective CQCS although the trial itself was not conclusive.

The program was included in some subsequent contracts. Multiple programmatic payments were withheld on two separate contracts with little or no improvement in CQCS effectiveness. One of the two contractors who had programmatic payments withheld had also been awarded a

contract without the program. Ironically, the contractor's CQCS on the contract without the program was highly effective and was viewed as a model for the rest of the WMATA contracting community. The CQCS was successfully implemented on this contract because the CQCS Manager effectively worked with the contractor's project staff in planning the work and thereby managed to prevent costly errors. Based on these results, WMATA had discontinued the program.