

Implementing and Improving Quality Management Systems in the Capital Facilities Delivery Industry



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Implementing and Improving Quality Management Systems in the Capital Facilities Delivery Industry

Prepared by the

*Quality Management in the Capital Facilities Delivery Industry
Research Team*

Implementation Resource 254-2

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Contents

<i>Chapter</i>	<i>Page</i>
Executive Summary	v
Introduction	1
Step 1: Define and Implement Your QMS	3
Step 2: Assess the Maturity of Your QMS	7
Step 3: Improve Your QMS	13
Appendix A: Glossary of Key Terms	17
Appendix B: Quality Management/Business Excellence Systems Correlation Matrix	21
Appendix C: Developing a CFD Process	39
Appendix D: Typical Subprocesses and CII Implementation Resources	43
Appendix E: ISO 9001 Compliance Checklist	47
Appendix F: Quality Maturity Matrix for Capital Facilities Delivery	55
Appendix G: QMS Implementation Drivers	59
Appendix H: RT 254 Recommended QM Practices: Differences among High- and Low-rated QM Systems	63

Executive Summary

Many challenges confront organizations involved in the capital facilities delivery (CFD) industry. Periods of tremendous growth may be interrupted by economic downturn. Capital assets are aging and costs to maintain and replace them are increasing. Changing workforce demographics and the availability of resources are affecting the planning and execution of capital projects. These challenges call for a renewed focus on proactively managing quality, and demand an increased awareness of the impact an effective Quality Management System (QMS) can have on the success of an organization.

The CII body of knowledge (BOK) on quality management (QM) from past research is extensive; however, advancements in technologies, tools, and processes have changed how quality management systems (QM systems) are currently being used for capital facilities project management. Furthermore, practices once thought to be valuable may have lost some of their effectiveness. For these reasons, CII created the Quality Management in the Capital Facilities Delivery Industry Research Team to re-examine the best practices in the CFD industry.

This implementation resource (IR) has been written to give owners and contractors in the CFD industry an understanding of what constitutes a modern quality management system (QMS). It also offers the following three-step process for implementing and improving a QMS:

1. Define and implement your QMS.
2. Assess the maturity of your QMS.
3. Improve your QMS.

In addition, to support this three-step process, this IR presents, a set of resources tailored to the CFD industry and developed from the CII research on quality management. These resources include the following key tools:

- **The Quality Management/Business Excellence Systems Correlation Matrix** allows users to compare the strategies, approaches, and tools that comprise different quality systems.
- **The ISO 9001 Compliance Checklist** assists in the evaluation of an existing QMS against ISO 9001.
- **The Quality Maturity Matrix for Capital Facilities Delivery** is a self-assessment tool for determining QMS maturity.

- **QMS Implementation Drivers** show the distinctly different sequences that drive the evolution of QMS priorities in both owner and contractor organizations.
- **RT 254 Recommended QM Practices** identify the most significant differences between organizations that report highly effective QMS and those that report less effective QMS in the CFD industry.

Together, these tools provide a new and simple framework for implementing, recognizing, and prioritizing opportunities for improving the QM systems employed by both owners and contractors.

Introduction

CII has been a research leader in applying quality management (QM) in the capital facilities industry since the 1980s. This research has shown that an effective quality management system (QMS)—one that includes processes for its continuous improvement—is critical to the consistent and successful planning and execution of capital projects. Organizations that rate their QMS as highly effective believe that the QMS is an essential and integrated element of the organization's business processes, and they rely on their QMS to drive improvement.

This implementation resource is intended as a QMS tool kit to assist owners and contractors who are engaged in capital project delivery in the implementation and continuous improvement of their QM systems. For organizations that may not yet have a formal QMS, this document provides information and tools to assist in understanding the basics of a QMS, and in establishing organizational and personal accountability for successful implementation. This kit also provides more advanced tools to assess and improve a QMS.

The QMS tool kit is built around the simple three-step process illustrated in Figure 1. Because most QM systems in the capital facilities industry are based on the international standard, ISO 9001, this process assumes that a QMS that is compliant with or certified to ISO 9001 is being implemented.



Figure 1. QMS Implementation and Improvement Process

The key elements in these three steps are summarized below. The specific actions recommended to implement each step are described in subsequent sections of this document.

- **STEP 1: Define and Implement Your QMS.** This first step asks users to develop an understanding of what constitutes a modern QMS. Implementing a new process or improving an existing process is not a simple task. Users new to quality management may want to review the Glossary of Key Terms provided in Appendix A to familiarize themselves with terms that will be used throughout this document.

- **STEP 2: Assess the Maturity of Your QMS.** This step provides users with tools for evaluating the elements of the most common quality management and business excellence systems, further building on the foundation of understanding quality management practices. Metrics in use by organizations that rate their QM systems as highly effective and the Quality Maturity Matrix (QMM) are provided to assist with the establishment of organizational objectives and QMS improvement.
- **STEP 3: Improve Your QMS.** This step allows users to understand the key drivers and best practices for improving a QMS. In-depth analysis of both owners' and contractors' ratings of the effectiveness of their QMS reveals different drivers that govern why and how these systems are implemented, evolve, and mature. Increasing the effectiveness of a QMS can be accomplished through a look at the current best practices.

For further access to any of the quality standards, business excellence systems, and management models cited in this implementation resource, please refer to Research Report 254-11.

Step 1: Define and Implement Your QMS

This step is designed first to ensure that an organization and, particularly, its management team, both fully understand the requirements governing a QMS. It then helps the organization's management team members tailor a QMS to their business by giving them a process for defining and implementing a comprehensive and effective QMS. Three key actions are required in this step, as shown in Figure 2.

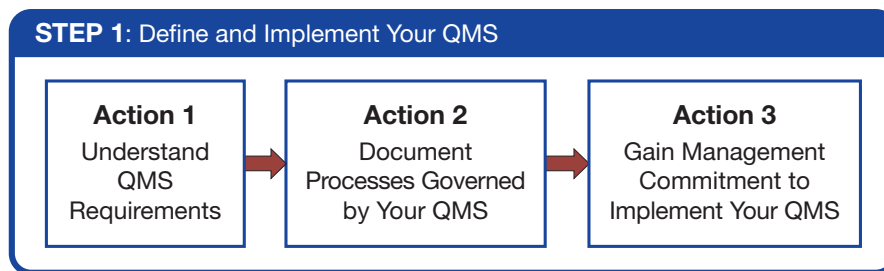


Figure 2. Actions to Define and Implement Your QMS

Action 1: Understand the Requirements for a QMS

A quality management system can be defined as a set of policies, processes, and procedures that govern the planning and execution of capital facilities delivery projects so that owners' business and project objectives are achieved. In effect, a QMS is the organization's project execution "assembly line," a system that defines how all disciplines participate and interact on a project, not only the quality assurance (QA) and quality control (QC) functions. This system also defines how QMS will be evaluated and continuously improved within the organization.

Within the capital facilities delivery community, many owners and contractors design their QM systems to satisfy the requirements set by ISO 9001. This internationally recognized standard requires that a QMS be documented in a quality manual that defines the organization's policies, processes, and procedures; it also requires the documentation of the responsibilities and actions necessary to plan, execute, measure, control, and improve the organization's production, development and/or service processes.

Organizations that have not yet implemented a formal QMS should first obtain and study the ISO 9000 documentation that is applicable to the CFD industry. (See Figure 3.) Before proceeding, the management team should understand these requirements, along with the roles and responsibilities that must be assumed to satisfy them.

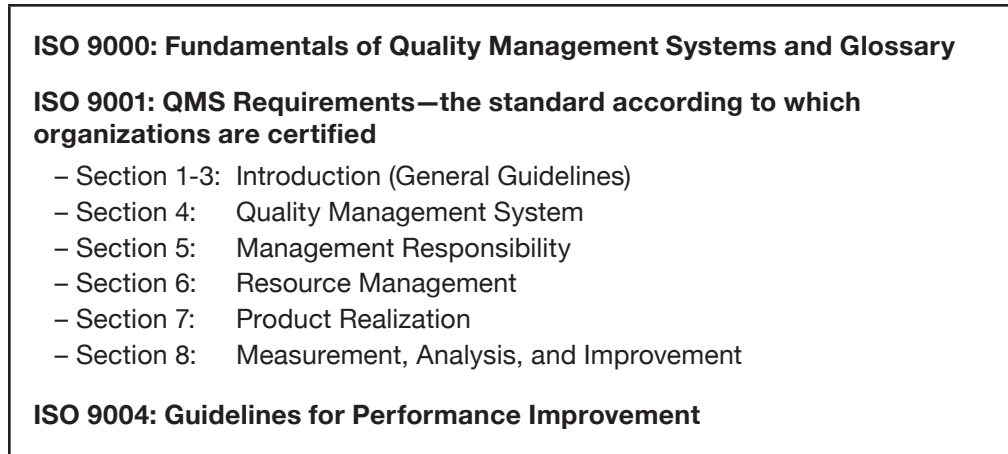


Figure 3. ISO 9000 Documentation

In addition to ISO 9000, many other quality standards and models are in use within the CFD industry; these systems provide valuable guidance in managing quality and continually improving the performance of an organization's project delivery process and supporting business processes.

The Quality Management/Business Excellence Systems Correlation Matrix (Appendix B) provides an easy-to-use tool that shows the correlations between various quality standards, business excellence systems, and management models. This matrix can be used by an organization to help identify the specific quality system models, standards, and/or processes that they might best deploy within their organization.

Action 2: Document Processes Governed by Your QMS

An effective QMS in any business integrates the various internal processes within an organization and provides a process approach for planning and executing capital facilities projects. This systematic approach requires organizations to identify, measure, control, and improve the various project execution processes that, once improved, will ultimately lead to better overall performance. Each process governed by the QMS should be documented or diagrammed to ensure the organization-wide integration of the following QM elements:

- a common understanding across the organization of the activities involved in the steps of each process
- the sequence of the activities and their inter-relationships
- the responsibilities for their execution
- how the risks in these processes are recognized and managed.

The Capital Facilities Delivery Process diagram (Figure 4) will help organizations that have not yet implemented a formal QMS understand the key processes or activities in planning and executing capital facilities projects. This diagram can be used as the starting point for developing standard project execution processes that can then be tailored to each project.

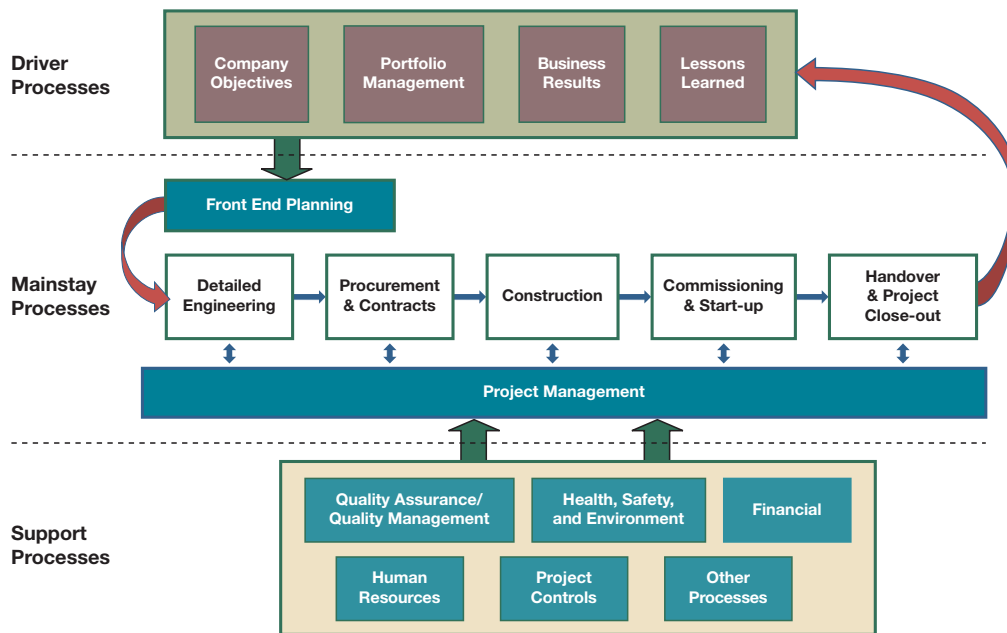


Figure 4. Capital Facilities Delivery Process

For organizations that are interested in developing their own capital facilities delivery process, *Appendix C: Developing a Capital Facilities Delivery Process*, provides additional guidance on the processes that are typically included in a QMS. CII also has a number of recommended practices and tools that support the development and implementation of the processes and subprocesses shown in Figure 4. These resources are summarized in *Appendix D: Typical Subprocesses with Complementary CII Implementation Resources*.

Action 3: Gain Management Commitment to Implement Your QMS

ISO 9001:2008 assigns primary ownership of the QMS to top management, along with the responsibility for resourcing and directing its implementation. The results of the surveys conducted as part of this research have again verified that in organizations that rate their QMS as highly effective, management support for it is viewed as essential to the success of capital facilities development projects. A leader, such as a quality manager or quality director, is usually appointed to assist top management with this responsibility.

This ownership by top management begins with the development of both a quality policy and performance objectives that are focused on understanding customers' requirements and ensuring that they are successfully fulfilled. The requirements governing the implementation of a QMS and its continual improvement over time are based on the organization's quality policy and the performance objectives associated with it.

Step 2: Assess the Maturity of Your QMS

Once an organization has defined and implemented its QMS, the next step is to evaluate its effectiveness at fulfilling the organization's quality policy and quality objectives, and to determine whether it is delivering the results expected by its customers. Three actions, as defined in Figure 5, are involved in this assessment process.

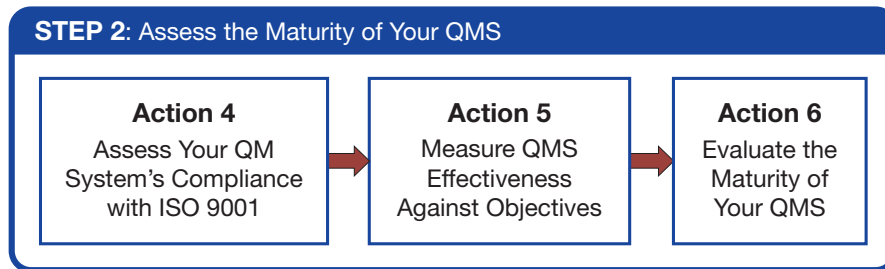


Figure 5. Actions to Assess the Maturity of Your QMS

Action 4: Assess Your QM System's Compliance with ISO 9001

As mentioned above, ISO 9001 is the most frequently used QMS in capital facilities development. The ISO 9001 standard requires an organization to audit itself against ISO 9001 requirements to verify that it is managing its processes effectively and to identify areas that may require improvement. In addition, clients may audit the organization's QMS in order to give them confidence that the organization is capable of delivering products or services that will meet the client's requirements. Typically, client QMS audits are also based on the requirements in the ISO 9001 standard.

As part of the QMS Took Kit, an ISO 9001 Compliance Checklist has been developed to help organizations assess which elements of the ISO 9001 criteria their existing QMS does or does not address, and to determine the extent of compliance. This checklist, included in Appendix E, summarizes the ISO 9001 requirements and relates them to the specific category titles, headings, sections, and subsections within the ISO 9001 document. A portion of the ISO 9001 Compliance Checklist is given in Figure 6.

Heading	Section	Sub-Sec.	ISO-9001 REQUIREMENTS		CURRENT LEVEL OF COMPLIANCE (Enter an "X" in Appropriate Box)		
			Title	ISO-9001:2000 Requirement Summary			
1			SCOPE		Full	Partial	None
1	1		General	ISO-9001 defines requirements for a Quality Management System.			
1	1	a	Delivering Quality Product	Company needs to deliver product that meets customer and regulatory requirements.			
1	1	b	Enhancing Customer Satisfaction	Company aims to enhance customer satisfaction through its QMS.			
1	2		Application	ISO-9001 requirements apply, except if they cannot be applied due to nature of the organization and/or its product.			
2			NORMATIVE REFERENCE		Full	Partial	None
2			General	ISO 9000:2000 Quality Management Systems -- Fundamentals and Vocabulary apply by reference.			
3			NORMATIVE REFERENCE		Full	Partial	None
3			General	ISO-9001 uses terms and definitions in ISO 9000:2000 Quality Management Systems -- Fundamentals and Vocabulary.			
4			QUALITY MANAGEMENT SYSTEM		Full	Partial	None
4	1	a	General Requirements	Company needs to define, implement and continually improve its Quality Management System.			
4	1	b	Control of Outsourced Processes	Processes needed for application of the Quality Management System needs to be defined, implemented and improved.			
4	2	1	Documentation Requirements – General	Required documentation include quality policy, quality objectives, quality manual, procedures, documents needed to plan, operate and control processes and required records.			
4	2	2	Quality Manual	Quality Manual needs to define scope, processes and their interaction and procedures comprising the Quality Management System.			
4	2	3	Control of Documents	Documents required by the Quality Management System need to be controlled by a documentation procedure.			
4	2	4	Control of Records	Records are to be maintained to provide evidence of conformity to requirements and effective operation of the Quality Management System.			

Figure 6. Excerpt from ISO 9001 Requirements Compliance Matrix

To use the ISO 9001 Compliance Checklist for self-assessment, proceed with the following steps:

1. Audit your QMS.
2. Review the audit results carefully to determine the relative compliance to each ISO requirement.
3. Identify the most appropriate corresponding level of compliance for each requirement by looking at the column headings to the far right of the checklist, i.e., Full, Partial or None.
4. Record an "X" in the most appropriate level for each requirement.
5. Review the completed checklist. Use it to identify targeted improvements and their priorities.

The ISO 9001 Compliance Checklist provides a convenient summary of your current QMS status, and provides a ready reference for your organization's management and staff to see what requirements still need to be met in order to achieve full compliance with ISO 9001.

When a QMS has been implemented and the organization seeks an independent assessment that its system satisfies ISO 9001 requirements, an independent quality system certification body can be used to obtain an ISO 9001:2008 Certificate of Conformity. Some owners in the engineering-construction industry require ISO 9001 certification as a contractual condition for winning work.

Action 5: Measure QMS Effectiveness against Objectives

In addition to conforming to ISO 9001 requirements (or other quality strategies as listed in Appendix B), it is important to determine how effective the QMS is in achieving an organization's established quality policy and QMS performance objectives. This requires the organization to identify, collect, and analyze key performance metrics that define its "effectiveness." Five steps are recommended in this evaluation process.

1. Review the organization's critical business drivers, processes, and desired results.
2. Determine what performance needs to be measured in order to assess whether the QMS is adequately contributing to the desired results.
3. Implement data gathering tools/processes to consistently and accurately obtain the required measurements.
4. Assemble the information into appropriate reports for analysis.
5. Analyze the results by comparing them against the desired outcomes.

This assessment methodology is known as Plan-Do-Check-Act (PDCA), and it should be conducted within a simple, standing framework for developing and maintaining an effective QMS. PDCA is also described in ISO 9001. In particular, the third step in PDCA (Check) refers to monitoring, measuring, and analyzing QMS processes to ensure that they have the desired impact on the organization's products, services, and overall business objectives. This step is based on the key performance metrics that have been established.

CII research has found that there is no standard set of performance metrics associated with owners or contractors' QM systems. Therefore, each organization needs to establish metrics tailored to its desired quality outcomes, to its specific priorities, and to those of its customers.

Examples of metrics currently used by CII members in their capital facilities delivery efforts are provided in Table 1. It may be particularly useful to examine the metrics used in benchmarking project performance within the industry, including within CII's benchmarking program, and to review other metrics referenced in quality-related publications.

The results of this assessment will confirm that a QMS is performing as desired and/or will identify opportunities for improving it. However, it is also useful to compare the maturity of the QMS at its existing level of effectiveness against the QM systems in place in other owner and contractor organizations. This industry-level comparison is the next step in this process.

Table 1. Performance Metrics

Quality Metrics	Cost Metrics
Weld Defects	Total Cost
Weld Repairs	Work Hours vs. Budget
Percentage of Welds Complete	Cost vs. Progress
Percentage of PMI Rejected Material	Cost vs. Plan
Percentage of Rework	Activity Cost
Number of Nonconformance Reports Open	Cost of Rework
Supplier Deviation Reports	Schedule Metrics
Number of Identified Quality Issues	Schedule Growth – Baseline vs. Current
Number of Open vs. Closed Quality Issues	Progress vs. Plan
Number of Corrective Actions Open vs. Closed	Schedule vs. Plan
Number of Deviation Reports	Cycle Time or Throughput
Number of Successful Tests	Yield
Inspection and Test Plan Completion Status	Schedule to Completion
Customer Satisfaction	Supplier On-Time Delivery
Audit Percent Complete vs. Plan	Required-at-Site (RAS) Date vs. Actual Delivery
Safety Metrics	Change Order Response Time
Total Recordable Incidents Rate (TRIR)	Engineering Work-hours per Major Equipment
Days Away, Restricted, Transfer Rate (DART)	Operability Metrics
Days Away Rate	Percentage of Startup Time (Actual vs. Planned Time)
Near Misses	Percentage of Capacity (Actual Maximum vs. Design)

Action 6: Evaluate the Maturity of Your QMS

This action guides an organization through the steps of the Quality Maturity Matrix (QMM) for capital facilities delivery. Research Team 254 developed this tool to help organizations determine the maturity of their existing QM systems relative to those of other CII organizations that rated their QMS as highly effective. The QMM compares the different levels of deployment of the six key elements that the research found to be common to the CFD organizations that reported having highly effective QM systems. These six key elements are as follows:

- QMS Management
- QMS Training
- Supplier QMS
- Measurement, Analysis, and Improvement
- Process Management
- QMS Certification.

The QMM, a portion of which is illustrated in Figure 7, is a matrix of these six key QMS elements at five maturity levels. (See Appendix F for entire matrix.) Starting with any one of the QMS elements in the top row of the table (e.g., QMS Management or Supplier QMS) and progressing down the column, the contents of each cell describe the typical behaviors associated with the element at each maturity level. For example, the behaviors listed in the row labeled Level 1 were identified in the research as representative of a less mature QMS, whereas Level 5 behaviors were exhibited by the systems considered mature.

There are five steps to using the QMM to assess an organization's QMS maturity:

1. Identify the appropriate people to participate in the self-assessment, based on the scope of the application of the QMS (e.g., office, division, company). A cross-functional team is recommended for conducting this assessment. Team members should represent the major functional groups involved in the project delivery process.
2. Assemble the assessment team and select the first key element of the QMS to be assessed.
3. Review the various behaviors at each maturity level (Levels 1 to 5). Then select the level that lists the behaviors that are most characteristic of those currently exhibited by the organization.
4. Once the current level of maturity has been determined for each key element, review the attributes of a more mature QMS to identify the areas needing improvement and the benefits of improving them.
5. Repeat Steps 1 through 4 for the remaining key QMS elements.

	QMS MANAGEMENT	QMS TRAINING	SUPPLIER QMS	MEASUREMENT, ANALYSIS, AND IMPROVEMENT	PROCESS MANAGEMENT	QMS CERTIFICATION
LEVEL 1	The organization lacks a QMS and sound management. Quality management practices are not followed and quality is thought to be the responsibility of the quality department	Formal training for QMS is non-existent. Employees and management do not grasp basic fundamentals of quality. Only informal training exists with a general view that quality can be compromised, provided that the customer does not find out. Quantity of training: None.	The organization has no requirements for a supplier/contractor QMS.	Performance measurement depends on the capabilities of teams or individuals and varies with their innate skills, knowledge, and motivations. No formal system is in place but a few measures exist for some of the processes that are reviewed.	Lacking a QMS, the organization is reactive rather than proactive regarding problem situations. Focus is on placing blame instead of finding solutions. There are no specific goals and objectives for quality, and therefore, no accountability. No systematic approach for quality improvement exists.	The organization's QMS is not certified.
LEVEL 2	Management begins to accept that a QMS may be of value, but does not commit the necessary resources to support it. Reservations exist about whether the effort will hinder performance and increase cost. Commitment is seldom spoken of or seen within the organization.	Management acknowledges that formal training is needed to avoid the mishaps that routinely occur at the process level. A degree of effectiveness develops as a result of QMS training. Management views training as non-essential until the higher cost associated poor quality is evident. Quantity of training: Approximately 10 hours per year on average.	The organization requires that the supplier/contractor has a QMS and that the QMS is verified/audited, but no standards are applied.	Measurement is in place for a few processes and is implemented across the organization with varying levels of genuine intent. Only a few individuals understand how and why measurement is used. Some in the organization would prefer not to be measured and, thus, they avoid the process.	The organization begins to focus on quality improvement, with implementation of a QMS as a near-term goal. Although teams form to address problem situations, they are often not given proper authority or resources. Short-term fixes are typically the chosen course of action as opposed to long-term solutions. Quality improvement goals and objectives may be ill-defined and people are not being made fully accountable. Some measure of success is established depending on management commitment.	The organization's QMS is certified and the certification is reviewed intermittently.

Figure 7. Excerpt from Quality Maturity Matrix for Capital Facilities Delivery

Step 3: Improve Your QMS

Once the maturity of your QMS has been assessed, the next step is to identify where and how it should be improved. This improvement plan should be based on the ISO-9001 requirement for the continuous improvement of a QMS. CII research results suggest that in order to identify which elements of a QMS need improvement, it is important to understand the key QMS improvement drivers as well as the best practices used by organizations that rate their QM systems as highly effective. (See Figure 8.)

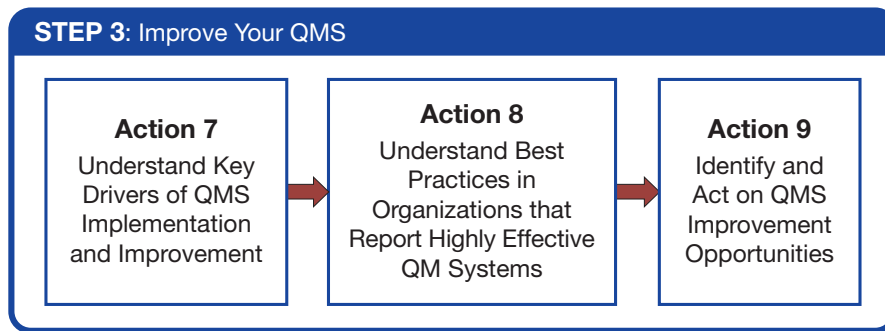


Figure 8. Actions to Improve the Effectiveness of Your QMS

Action 7: Understand Key Drivers of QMS Implementation and Improvement

Analysis of the surveys of owners and contractors conducted by the research team showed that there are six key elements of a QMS that significantly differentiated organizations that rated their systems as highly effective from those that considered their QM systems less effective. These key elements, (discussed above in Step 2), are the following:

- QMS Management
- QMS Training
- Supplier QMS
- Measurement, Analysis, and Improvement
- Process Management
- QMS Certification.

Further analysis of the various degrees of QMS maturity in terms of these six key elements has suggested that owners and contractors tend to implement these elements in respectively different sequences because QMS implementation and improvement drivers vary between them. (See the QMS Evolution-Key Drivers model in Figure 9.) In this model, these key elements are sequenced in accordance with their average effectiveness scores in the surveys, a result that—it is assumed—is indicative of a higher level of QMS maturity and effectiveness.

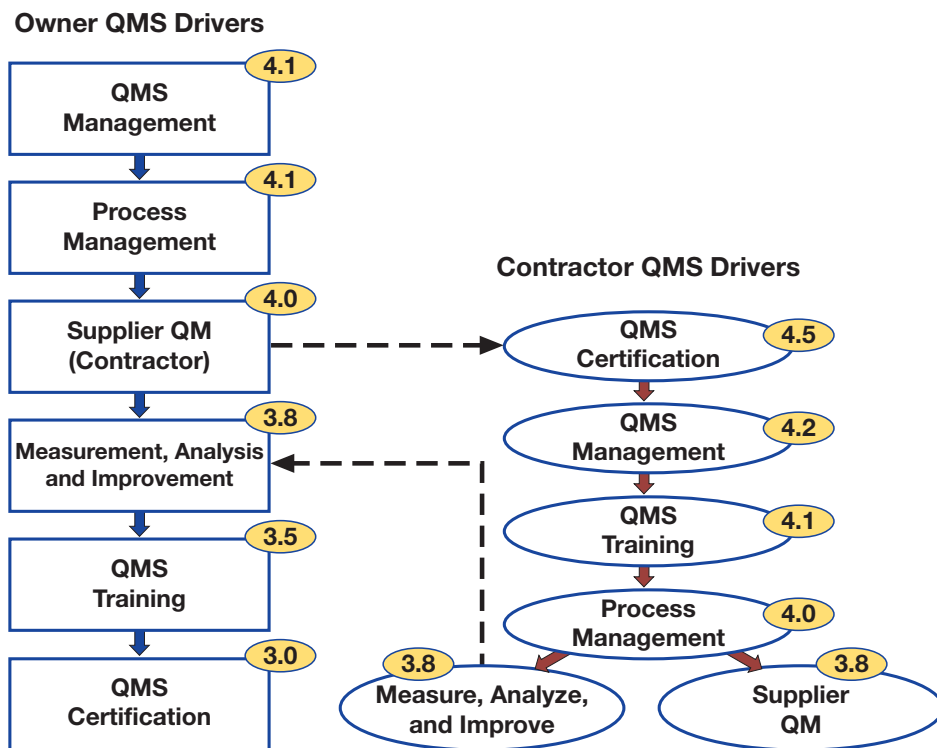


Figure 9. QMS Evolution – Key Drivers

This model suggests that owner and contractor organizations each have distinctly different sequences that drive the evolution of their respective QMS priorities. The details and the rationales for these two distinct sequences are provided in Appendix G: Sequence of QMS Drivers.

Understanding the order of these two sequences for QMS implementation and improvement and the reasons that they differ between owners and contractors may help an organization focus its improvement efforts at various stages in the maturity

of its QMS. For example, according to the QMS Evolution – Key Drivers model, if an owner organization in the early stages of QMS implementation were to focus on QMS certification first, it would only serve as a key motivator for improvement if the owner already had a QMS in place, and only if it were effectively governing how contractors develop and apply their QMS to projects. Likewise, a contractor's initial focus on measurement, analysis, and improvement would be less likely to result in an effective QMS than would be getting management on board first, providing QMS training to the workforce, and focusing on improving the effectiveness of the organization's project execution process.

Action 8: Understand Best Practices in Organizations that Report Highly Effective QM Systems

Once an organization understands the six key elements common to the highly-rated QM systems and the sequence in which they should be implemented, the focus should shift to determining which practices should be put into place to mature these six QMS elements.

The research results identified the practices that differentiated organizations reporting highly effective QM systems from those reporting less effective systems. Understanding these “best practices” provides organizations with insights into where to focus the improvement efforts that are likely to have an significant impact on improving the effectiveness of their QMS. More detailed descriptions of these practices are included in RT 254 Recommended QM Practices: Differences among High-rated vs. Low-rated QM Systems found in Appendix H.

Therefore, if owners identify supplier/contractor QMS as the key driver that needs improvement at the current level of maturity in their QM systems, strong consideration should be given to the two best practices of organizations that report having highly effective QMS: 1) suppliers/contractors' QM systems are audited; 2) training and assistance are provided to suppliers/contractors with non-compliant and/or inadequate QM systems. Likewise, a contractor wanting to focus on QMS management should seriously consider taking the following three key actions: 1) use QMS standards and guidelines (e.g., ISO) instead of project-specific standards; 2) ensure that consistent visible leadership is diffused throughout the organization; and 3) establish a long-term strategy for improvement of the QMS.

Action 9: Identify and Act on QMS Improvement Opportunities

Once an organization identifies the specific QMS key element(s) requiring improvement and understands the best practices within that element, the owner or contractor is ready to formulate the specific improvement initiatives needed to improve the effectiveness of the organization's QMS. These initiatives, of course, will differ significantly from organization to organization, depending on the current level of QM effectiveness and the key drivers for QMS improvement that the organization faces in the marketplace.

To be effective, these QMS initiatives need to be assembled into a QMS improvement plan that has the endorsement and active involvement of the organization's management team, and that fits within its long-term strategy for improvement. Progress against this plan needs to be reviewed on a periodic basis. The overall effectiveness of the QMS, including any improvement in the results stemming from these initiatives, needs to be part of a formal management review, as required by an ISO 9001-compliant QMS.