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A Comparison of ISO 9001 and the Capability Maturity Model for Software

Mark C. Paulk

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Mark C. Paulk

Software Capability Maturity Model Project

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Software Engineering Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

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5 Eglin Street
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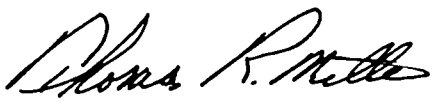

Thomas R. Miller, Lt Col, USAF
SEI Joint Program Office

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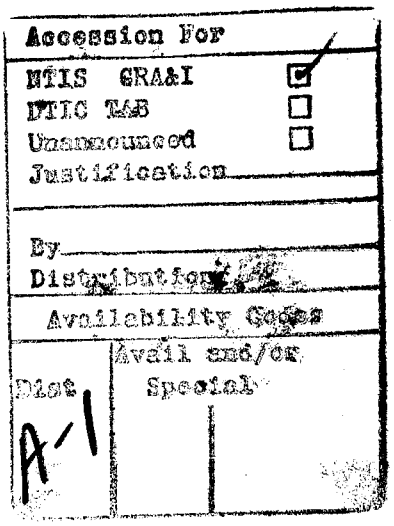

A Comparison of ISO 9001 and the Capability Maturity Model for Software

Abstract: The Capability Maturity Model for Software (CMM), developed by the Software Engineering Institute, and the ISO 9000 series of standards, developed by the International Standards Organization, share a common concern with quality and process management. The two are driven by similar concerns and intuitively correlated. The purpose of this report is to contrast the CMM and ISO 9001, showing both their differences and their similarities. The results of the analysis indicate that, although an ISO 9001-compliant organization would not necessarily satisfy all of the level 2 key process areas, it would satisfy most of the level 2 goals and many of the level 3 goals. Because there are practices in the CMM that are not addressed in ISO 9000, it is possible for a level 1 organization to receive ISO 9001 registration; similarly, there are areas addressed by ISO 9001 that are not addressed in the CMM. A level 3 organization would have little difficulty in obtaining ISO 9001 certification, and a level 2 organization would have significant advantages in obtaining certification.

1 Introduction

The Capability Maturity Model for Software, developed by the Software Engineering Institute, and the ISO 9000 series of standards, developed by the International Standards Organization, share a common concern with quality and process management. The two are driven by similar concerns and intuitively correlated.

The specific standard in the ISO 9000 series of concern to software organizations is ISO 9001. The questions frequently asked include:

- At what level in the CMM would an ISO 9001-compliant organization be?
- Can a level 2 (or 3) organization be considered compliant with ISO 9001?
- Should my software quality management and process improvement efforts be based on ISO 9001 or on the CMM?

The purpose of this report is to compare the CMM and ISO 9001, identify their differences and similarities, and answer these questions. This report should be useful to anyone embarking on a software process improvement program where ISO 9001 certification is an important issue in their business environment. Even if the CMM is not used as the basis for

the improvement program, it provides significant guidance over and above that offered by ISO 9001, ISO 9000-3, or TickIT for implementing an ISO 9001-compliant software process.

Chapter 2 of this report contains a brief overview of the CMM. Chapter 3 contains a brief overview of the ISO 9000 family of standards as relevant to software. Chapter 4 is a clause-by-clause discussion of ISO 9001 and how it relates to the CMM. Chapter 5 contrasts ISO 9001 and the CMM; in particular, it provides a key process area profile for an ISO 9001-compliant organization. Appendix A provides a detailed mapping between ISO 9001 and the CMM; Appendix B does likewise for ISO 9000-3. Appendix C contains a summation of Appendices A and B at the clause level. Appendix D summarizes the practices in the CMM and how (or whether) they are addressed by ISO 9001.

2 The Capability Maturity Model for Software

The Capability Maturity Model for Software [Paulk93a, Paulk93b] describes the principles and practices underlying software process maturity and is intended to help software organizations improve the maturity of their software processes in terms of an evolutionary path from ad hoc, chaotic processes to mature, disciplined software processes. The CMM is organized into five maturity levels. A maturity level is a well-defined evolutionary plateau toward achieving a mature software process. Each maturity level provides a layer in the foundation for continuous process improvement.

2.1 The Five Maturity Levels

The following characterizations of the five maturity levels highlight the primary process changes made at each level:

1) Initial — The software process is characterized as ad hoc, and occasionally even chaotic. Few processes are defined, and success depends on individual effort and heroics.

2) Repeatable — Basic project management processes are established to track cost, schedule, and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.

3) Defined — The software process for both management and engineering activities is documented, standardized, and integrated into a standard software process for the organization. All projects use an approved, tailored version of the organization's standard software process for developing and maintaining software.

4) Managed — Detailed measures of the software process and product quality are collected. Both the software process and products are quantitatively understood and controlled.

5) Optimizing — Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

2.2 Key Process Areas

Except for level 1, each maturity level is decomposed into several key process areas that indicate the areas an organization should focus on to improve its software process. Key process areas identify the issues that must be addressed to achieve a maturity level. Each key process area identifies a cluster of related activities that, when performed collectively, achieve a set of goals considered important for enhancing process capability. The key

process areas and their purposes are listed below. The name of each key process area is followed by its two-letter abbreviation.

By definition there are no key process areas for level 1.

The key process areas at level 2 focus on the software project's concerns related to establishing basic project management controls, as summarized below:

Requirements Management (RM)	Establish a common understanding between the customer and the software project of the customer's requirements that will be addressed by the software project.
Software Project Planning (PP)	Establish reasonable plans for performing the software engineering and for managing the software project.
Software Project Tracking and Oversight (PT)	Establish adequate visibility into actual progress so that management can take effective actions when the software project's performance deviates significantly from the software plans.
Software Subcontract Management (SM)	Select qualified software subcontractors and manage them effectively.
Software Quality Assurance (QA)	Provide management with appropriate visibility into the process being used by the software project and of the products being built.
Software Configuration Management (CM)	Establish and maintain the integrity of the products of the software project throughout the project's software life cycle.

The key process areas at level 3 address both project and organizational issues, as the organization establishes an infrastructure that institutionalizes effective software engineering and management processes across all projects, as summarized below:

Organization Process Focus (PF)	Establish the organizational responsibility for software process activities that improve the organization's overall software process capability.

Organization Process Definition (PD)	Develop and maintain a usable set of software process assets that improve process performance across the projects and provide a basis for cumulative, long-term benefits to the organization.
Training Program (TP)	Develop the skills and knowledge of individuals so they can perform their roles effectively and efficiently.
Integrated Software Management (IM)	Integrate the software engineering and management activities into a coherent, defined software process that is tailored from the organization's standard software process and related process assets.
Software Product Engineering (PE)	Consistently perform a well-defined engineering process that integrates all the software engineering activities to produce correct, consistent software products effectively and efficiently.
Intergroup Coordination (IC)	Establish a means for the software engineering group to participate actively with the other engineering groups so the project is better able to satisfy the customer's needs effectively and efficiently.
Peer Reviews (PR)	Remove defects from the software work products early and efficiently. An important corollary effect is to develop a better understanding of the software work products and of the defects that can be prevented.

The key process areas at level 4 focus on establishing a quantitative understanding of both the software process and the software work products being built, as summarized below:

Quantitative Process Management (QP)	Control the process performance of the software project quantitatively.
Software Quality Management (QM)	Develop a quantitative understanding of the quality of the project's software products and achieve specific quality goals.

The key process areas at level 5 cover the issues that both the organization and the projects must address to implement continuous and measurable software process improvement, as summarized below:

Defect Prevention (DP)	Identify the causes of defects and prevent them from recurring.
Technology Change Management (TM)	Identify beneficial new technologies (i.e., tools, methods, and processes) and transfer them into the organization in an orderly manner.
Process Change Management (PC)	Continually improve the software processes used in the organization with the intent of improving software quality, increasing productivity, and decreasing the cycle time for product development.

2.3 Common Features

For convenience, each of the key process areas is organized by common features. The common features are attributes that indicate whether the implementation and institutionalization of a key process area is effective, repeatable, and lasting. The five common features, followed by their two-letter abbreviations, are listed below:

Commitment to Perform (CO)	Describes the actions the organization must take to ensure that the process is established and will endure. Includes practices on policy and leadership.
Ability to Perform (AB)	Describes the preconditions that must exist in the project or organization to implement the software process competently. Includes practices on resources, organizational structure, training, and tools.
Activities Performed (AC)	Describes the roles and procedures necessary to implement a key process area. Includes practices on plans, procedures, work performed, tracking, and corrective action.
Measurement and Analysis (ME)	Describes the need to measure the process and analyze the measurements. Includes examples of measurements.
Verifying Implementation (VE)	Describes the steps to ensure that the activities are performed in compliance with the process that has been established. Includes practices on management reviews and audits.

2.4 Key Practices

Each key process area is described in terms of the key practices that contribute to satisfying its goals. The key practices describe the infrastructure and activities that contribute most to the effective implementation and institutionalization of the key process area and are described in "Key Practices of the Capability Maturity Model, Version 1.1" [Paulk93b].

3 The ISO 9000 Series of Standards for Quality Management Systems

The ISO 9000 series of standards is a set of documents dealing with quality systems that can be used for external quality assurance purposes. They specify quality system requirements for use where a contract between two parties requires the demonstration of a supplier's capability to design and supply a product. The two parties could be an external client and a supplier, or both could be internal, e.g., marketing and engineering groups in a company.

ISO 9000, "Quality management and quality assurance standards – Guidelines for selection and use," clarifies the distinctions and interrelationships between quality concepts and provides guidelines for the selection and use of a series of international standards on quality systems that can be used for internal quality management purposes (ISO 9004) and for external quality assurance purposes (ISO 9001, 9002, and 9003). The quality concepts addressed by these standards are:

- An organization should achieve and sustain the quality of the product or service produced so as to meet continually the purchaser's stated or implied needs.
- An organization should provide confidence to its own management that the intended quality is being achieved and sustained.
- An organization should provide confidence to the purchaser that the intended quality is being, or will be, achieved in the delivered product or service provided. When contractually required, this provision of confidence may involve agreed demonstration requirements.

ISO 9001, "Quality systems – Model for quality assurance in design/development, production, installation, and servicing," is for use when conformance to specified requirements is to be assured by the supplier during several stages, which may include design, development, production, installation, and servicing. Of the ISO 9000 series, it is the standard that is pertinent to software development and maintenance.[1]

[1] There are several other standards and guidelines in the ISO 9000 series, including ISO 9002, ISO 9003, ISO 9004, and ISO 8402. ISO 9002, "Quality systems – Model for quality assurance in production and installation," is for use when conformance to specified requirements is to be assured by the supplier during production and installation. ISO 9003, "Quality systems – Model for quality assurance in final inspection and test," is for use when conformance to specified requirements is to be assured by the supplier solely at final inspection and test. ISO 9004, "Quality management and quality system elements – Guidelines," describes a basic set of elements by which quality management systems can be developed and implemented. ISO 8402, "Quality – Vocabulary," defines the basic and fundamental terms relating to quality concepts, as they apply to products and services, for the preparation and use of quality standards and for mutual understanding in international communications. There are also a number of guides, such as ISO 9000-3, which are additional parts to standards in the ISO 9000 series.

ISO 9000-3 provides "Guidelines for the application of ISO 9001 to the development, supply, and maintenance of software." Annexes A and B in ISO 9000-3 cross-reference ISO 9000-3 and ISO 9001. A British guide for applying ISO 9001 to software [TickIT] provides additional information on using ISO 9000-3 and 9001 in the software arena.

There is significant room for interpretation in using ISO 9001 in the software world. ISO 9000-3 is a guide to interpreting ISO 9001, yet the many-to-many relationships between their clauses (shown in Appendix E) may cause the reader to suspect that liberties have been taken in creating this guidance. Many might conclude that there are extensions to ISO 9001 in ISO 9000-3; e.g., the purchaser's management responsibility (4.1.2), joint reviews (4.1.3), separate quality plans for the supplier (4.2.3) and the development effort (5.5), the purchaser's requirements specification (5.3), etc. If these are extensions, they seem quite reasonable, yet this leads to significant consistency and reliability issues in performing audits. A program such as TickIT can support consistency and reliability by imposing strong training and auditor qualification requirements.

4 Mapping ISO 9001 to the CMM

There are 20 clauses in ISO 9001, which are summarized and compared to the practices in the CMM in this chapter. The comparison is based on an analysis of ISO 9001, ISO 9000-3, TickIT, and the TickIT training materials [Lloyd's94]. There is judgment involved in making this comparison, and there are differences in interpretation for both ISO 9001 and the CMM. ISO 9000-3 elaborates significantly on ISO 9001, and TickIT training provides significant guidance on how to interpret both ISO 9000-3 and ISO 9001. A common challenge for CMM-based appraisals and ISO 9001 certification is reliability and consistency of assessments, which is partially addressed by strict training prerequisites for TickIT auditors and CMM appraisers.

Each clause in ISO 9001 will be discussed in the sections of this chapter, but not on a sentence-for-sentence basis. A detailed mapping, at the sentence to subpractice level, was performed as part of this analysis and is in Appendix A of this report. Appendix B contains a similar mapping for ISO 9000-3. (A less detailed discussion of the relationship between ISO 9001 and the CMM was published in [Paulk93c]).

4.1 Management Responsibility

ISO 9001 requires that the quality policy be defined, documented, understood, implemented, and maintained; that responsibilities and authorities for all personnel specifying, achieving, and monitoring quality be defined; and that in-house verification resources be defined, trained, and funded. A designated manager ensures that the quality program is implemented and maintained.

In the CMM, management responsibility for quality policy and verification activities is primarily addressed in Software Quality Assurance, although Software Project Planning and Software Project Tracking and Oversight also include activities that identify responsibility for performing all project roles.

Management's responsibility at both the senior management and project management levels to oversee the software project are addressed in the Verifying Implementation common feature. More generically, leadership issues are addressed in the Commitment to Perform common feature, and organizational structure and resource issues are addressed in the Ability to Perform common feature.

One could argue that the quality policy described in Software Quality Management at level 4 is also addressed by this clause, but the level 4 quality policy is quantitative. ISO 9001 is somewhat ambiguous about the role of measurement in the quality management system, as is discussed for clause 4.20, but ISO 9001 requires that quality objectives be defined and documented, not that they be quantitative (see the discussion of statistical techniques in section 4.20 of this report).

4.2 Quality System

ISO 9001 requires that a documented quality system, including procedures and instructions, be established. ISO 9000-3 characterizes this quality system as an integrated process throughout the entire life cycle.

Quality system activities are primarily addressed in the CMM in Software Quality Assurance. The procedures that would be used are distributed throughout the key process areas in the various Activities Performed practices.

The specific procedures and standards that a software project would use are specified in the software development plan described in Software Project Planning. Compliance with these standards and procedures is assured in Software Quality Assurance and by the auditing practices in the Verifying Implementation common feature.

Software Product Engineering requires that the software engineering tasks be defined, integrated, and consistently performed, which corresponds directly to the ISO 9000-3 guidance for interpreting this clause.

One arguable correspondence is to Organization Process Definition, which describes a set of software process assets, including standards, procedures, and process descriptions, at the organization level. Addressing Organization Process Definition would certainly contribute to achieving this clause, but the standards and procedures in this clause of ISO 9001 could be addressed strictly at the project level. ISO 9001 discusses the supplier's quality system, but it does not discuss the relationship between organizational support and project implementation as the CMM does. ISO 9000-3, on the other hand, has two sections on quality planning: clause 4.2.3 discusses quality planning across projects; clause 5.5 discusses quality planning within a particular development effort.

4.3 Contract Review

ISO 9001 requires that contracts be reviewed to determine whether the requirements are adequately defined, agree with the bid, and can be implemented.

Review of the customer requirements, as allocated to software, is described in the CMM in Requirements Management. The software organization (supplier) ensures that the system requirements allocated to software are documented and reviewed and that missing or ambiguous requirements are clarified. Since the CMM is constrained to the software perspective, the customer requirements as a whole are beyond the scope of this key process area.

Software Project Planning describes the development of a proposal, a statement of work, and a software development plan, which are reviewed by the software engineering group and by senior management, in establishing external (contractual) commitments.

The CMM also explicitly addresses the acquisition of software through subcontracting by the software organization, as described in Software Subcontract Management. Contracts may be with an external customer or with a subcontractor, although that distinction is not explicitly made in this clause of ISO 9001.

4.4 Design Control

ISO 9001 requires that procedures to control and verify the design be established. This includes planning design activities, identifying inputs and outputs, verifying the design, and controlling design changes. ISO 9000-3 elaborates this clause with clauses on the purchaser's requirements specification (5.3), development planning (5.4), quality planning (5.5), design and implementation (5.6), testing and validation (5.7), and configuration management (6.1).

In the CMM, the life cycle activities of requirements analysis, design, code, and test are described in Software Product Engineering. Planning these activities is described in Software Project Planning. Software Project Tracking and Oversight describes control of these life cycle activities, and Software Configuration Management describes configuration management of software work products generated by these activities.

ISO 9001 requires design control measures, such as holding and recording design reviews and qualification tests. ISO 9000-3 states that the supplier should carry out reviews to ensure the requirements are met and design methods are correctly carried out. Although design control measures are required, the use of the phrasing "such as" and "should" allows flexibility in what specific control measures are used. In contrast, the CMM calls out a specific quality control mechanism: peer reviews. The Peer Reviews key process area supports processes throughout the life cycle, from requirements analysis through testing.

TickIT training clarifies this issue by listing three examples of design reviews: Fagan inspections, structured walkthroughs, and peer reviews (in the sense of a desk check). The training also states that "an auditor will need to be satisfied from the procedures and records available that the reviews within an organization are satisfactory considering the type and criticality of the project under review." [Lloyd's94, p. 17.10-11]

More formal, quantitative aspects of the design process are described in Software Quality Management, but this degree of formality is not necessarily required by ISO 9001.

4.5 Document Control

ISO 9001 requires that the distribution and modification of documents be controlled.

In the CMM, the configuration management practices characterizing document control are described in Software Configuration Management. The specific procedures, standards, and other documents that may be placed under configuration management in the CMM are distributed throughout the key process areas in the various Activities Performed practices. The documentation required to operate and maintain the system is specifically called out in Activity 8 of Software Product Engineering.

4.6 Purchasing

ISO 9001 requires that purchased products conform to their specified requirements. This includes the assessment of potential subcontractors and verification of purchased products.

In the CMM, this is addressed in Software Subcontract Management. Evaluation of subcontractors is described in Activity 2, while acceptance testing of subcontracted software is addressed in Activity 12.

4.7 Purchaser-Supplied Product

ISO 9001 requires that any purchaser-supplied material be verified and maintained. ISO 9000-3 discusses this clause in the context of included software product (6.8), including commercial-off-the-shelf software.

Activity 6.3 in Integrated Software Management is the only practice in the CMM describing the use of purchased software. It does so in the context of identifying off-the-shelf or reusable software as part of planning. Integration of off-the-shelf and reusable software is one of the areas where the CMM is weak. This clause, especially as expanded in ISO 9000-3, cannot be considered adequately covered by the CMM. It would be reasonable, though not sufficient, to apply the acceptance testing practice for subcontracted software in Activity 12 of Software Subcontract Management to any included software product.

A change request has been written for CMM v1.1 to incorporate practices in Software Product Engineering that address product evaluation and the inclusion of off-the-shelf and nondevelopmental software.

4.8 Product Identification and Traceability

ISO 9001 requires that the product be identified and traceable during all stages of production, delivery, and installation.

The CMM covers this clause primarily in Software Configuration Management, but Activity 10 of Software Product Engineering states the specific need for consistency and traceability between software work products.

4.9 Process Control

ISO 9001 requires that production processes be defined and planned. This includes carrying out production under controlled conditions, according to documented instructions. Special processes that cannot be fully verified after the fact are continuously monitored and controlled. ISO 9000-3 clauses include design and implementation (5.6); rules, practices, and conventions (6.5); and tools and techniques (6.6).

The procedures defining the software production process in the CMM are distributed throughout the key process areas in the various Activities Performed practices. The specific procedures and standards that would be used are specified in the software development plan, as described in Activity 7 of Software Project Planning. The definition and integration of software "production" processes are described in Software Product Engineering. The tools to support these processes are called out in Ability 1.2 of Software Product Engineering. Process assurance is specified in Activity 4 of Software Quality Assurance (product assurance is specified in Activity 5).

Quantitative Process Management addresses the quantitative aspect of control exemplified by statistical process control, but would typically not be required to satisfy this clause.

It is also worth noting that clause 6.6 in ISO 9000-3 states that "the supplier should improve these tools and techniques as required," which corresponds to transitioning new technology into the organization as discussed in Technology Change Management.

4.10 Inspection and Testing

ISO 9001 requires that incoming materials be inspected or verified before use and that in-process inspection and testing be performed. Final inspection and testing are performed prior to release of finished product. Records of inspection and test are kept.

The issues surrounding the inspection of incoming material have already been discussed for clause 4.7. The CMM describes testing in Activities 5, 6, and 7 in Software Product Engineering. In-process inspections in the software sense are addressed in Peer Reviews.

4.11 Inspection, Measuring, and Test Equipment

ISO 9001 requires that equipment used to demonstrate conformance be controlled, calibrated, and maintained. When test hardware or software is used, it is checked before use and rechecked at prescribed intervals. ISO 9000-3 clarifies this clause with clauses on testing and validation (5.7); rules, practices, and conventions (6.5); and tools and techniques (6.6).

This clause is generically addressed in the CMM under the testing practices in Software Product Engineering. Test software is specifically called out in Ability 1.2, which describes the tools that support testing.

4.12 Inspection and Test Status

ISO 9001 requires that the status of inspections and tests be maintained for items as they progress through various processing steps.

This clause is addressed in the CMM by the testing practices in Software Product Engineering and by Activities 5 and 8 on problem reporting and configuration status, respectively, in Software Configuration Management.

4.13 Control of Nonconforming Product

ISO 9001 requires that nonconforming product be controlled to prevent inadvertent use or installation. ISO 9000-3 maps this concept to clauses on design and implementation (5.6); testing and validation (5.7); replication, delivery, and installation (5.9); and configuration management (6.1).

Design, implementation, testing, and validation are addressed in Software Product Engineering. In Software Configuration Management, Activity 8 addresses the status of configuration items, which would include the status of items that contain known defects not yet fixed. Installation is not addressed in the CMM, as is discussed for clause 4.15.

In the manufacturing world this clause is important because it is sometimes necessary to build products using components that do not conform to all of the requirements. When such decisions are made, the resulting nonconforming products must be carefully controlled.

Similarly, in the software world, a system may sometimes use tools or reuse software that does not satisfy all of the pertinent standards. For example, reusing FORTRAN code in an Ada program may be cost-effective if the FORTRAN code has demonstrated its value in previous applications. That code, however, may pose a significant risk to the Ada system, and the risk must be thoughtfully managed.

Nonconforming product is not specifically addressed in the CMM. In ISO 9000-3, it essentially disappears among a number of related processes spanning the software life cycle: design and implementation (5.6); testing and validation (5.7); replication, delivery, and installation (5.9); and configuration management (6.1).

4.14 Corrective Action

ISO 9001 requires that the causes of nonconforming product be identified. Potential causes of nonconforming product are eliminated; procedures are changed resulting from corrective action. ISO 9000-3 quotes this clause verbatim, with no elaboration.

A literal reading of this clause would imply many of the practices in Defect Prevention. Based upon the TickIT Auditors' Guide [TickIT, pp. 139-140] and discussions with ISO 9000 auditors, the corrective action discussed in this clause is driven by customer complaints. The software engineering group should look at field defects, analyze why they occurred, and take corrective action. This would typically occur through software updates and patches distributed to the fielded software. Under this interpretation, an appropriate mapping of this clause would be problem reporting, followed with controlled maintenance of baselined work products. Problem reporting is described in Software Configuration Management in the CMM.

A complementary interpretation described in TickIT training [Lloyd's94, section 23] is that the corrective action is to address noncompliances identified in an audit, whether external or internal. This would be addressed in Software Quality Assurance in the CMM.

In the current revision cycle for ISO 9001, the draft international standard includes separate requirements for corrective and preventive action. Corrective action is directed toward eliminating the causes of actual nonconformities, and preventive action is directed toward eliminating the causes of potential nonconformities [Durand93, p. 27].

This is a controversial issue in applying ISO 9001 to software. Some auditors seem to expect a defect prevention process similar to that which is found in the manufacturing environment. Others only require addressing user problem reports. It is arguable how much of the in-process causal analysis and defect prevention described in Defect Prevention is necessary to satisfy this clause.

4.15 Handling, Storage, Packaging, and Delivery

ISO 9001 requires that procedures for handling, storage, packaging, and delivery be established and maintained. ISO 9000-3 maps this to clauses on acceptance (5.8) and replication, delivery, and installation (5.9)

Replication, delivery, and installation are not covered in the CMM. Acceptance testing is addressed in Activity 7 of Software Product Engineering, and Activity 7 of Software

Configuration Management describes the creation and release of software products. Delivering and installing the product, however, is not described in the CMM.

A change request has been written for CMM v1.1 to incorporate a practice in Software Product Engineering on delivery and installation of the software product.

4.16 Quality Records

ISO 9001 requires that quality records be collected, maintained, and dispositioned.

The practices defining the quality records to be maintained in the CMM are distributed throughout the key process areas in the various Activities Performed practices. Specifically pertinent to this clause are the testing and peer review practices in Software Product Engineering, especially the collection and analysis of defect data in Activity 9. Problem reporting is addressed by Activity 5 in Software Configuration Management, and the collection of peer review data is described in Activity 3 of Peer Reviews.

4.17 Internal Quality Audits

ISO 9001 requires that audits be planned and performed. The results of audits are communicated to management, and any deficiencies found are corrected.

The auditing process is described in Software Quality Assurance. Specific audits in the CMM are called out in the auditing practices of the Verifying Implementation common feature.

4.18 Training

ISO 9001 requires that training needs be identified and that training be provided, since selected tasks may require qualified personnel. Records of training are maintained.

Specific training needs in the CMM are identified in the training and orientation practices in the Ability to Perform common feature. The general training infrastructure is described in Training Program, including maintaining training records in Activity 6.

4.19 Servicing

ISO 9001 requires that servicing activities be performed as specified. ISO 9000-3 addresses this clause as maintenance (5.10).

Although the CMM is intended to be applied in both the software development and maintenance environments, the practices in the CMM do not directly address the unique aspects that characterize the maintenance environment. Maintenance is embedded throughout the practices of the CMM, and they must be appropriately interpreted in the development or maintenance contexts.

Maintenance is not, therefore, a separate process in the CMM. Change requests for CMM v1.0 expressed a concern about using the CMM for maintenance projects, and some wording was changed for CMM v1.1 to better address the maintenance environment. We anticipate that this will remain a topic of discussion as we provide guidance for tailoring the

CMM to different environments, such as maintenance, and begin the next revision cycle for the CMM.

4.20 Statistical Techniques

ISO 9001 states that, where appropriate, adequate statistical techniques are identified and used to verify the acceptability of process capability and product characteristics. ISO 9000-3 simply characterizes this clause as measurement (6.4).

The practices describing measurement in the CMM are distributed throughout the key process areas. Product measurement is typically incorporated into the various Activities Performed practices, and process measurement is described in the Measurement and Analysis common feature.

Activity 5 of Organization Process Definition describes the establishment of an organization process database for collecting process and product data. This database is maintained at the organization level, and it seems likely that most auditors would accept project-level data (as described in the project management key process areas at level 2) to satisfy this clause. At least a few auditors do, however, require an organization-level historical database and the use of simple statistical control charts.

If statistical process control is inferred from this clause, it would be satisfied by Quantitative Process Management and Software Quality Management. Note, however, that statistical techniques are used "where appropriate." Some auditors look for use of any statistical tools, such as Pareto analysis. Other auditors are satisfied by any consistently collected and used measurement data. There is a significant degree of interpretation of this clause by auditors.

5 Contrasting ISO 9001 and the CMM

Clearly there is a strong correlation between ISO 9001 and the CMM, although some issues in ISO 9001 are not covered in the CMM, and some issues in the CMM are not addressed in ISO 9001. The levels of detail differ significantly: chapter 4 in ISO 9001 is about five pages long; sections 5, 6, and 7 in ISO 9000-3 comprise about 11 pages; and the CMM is over 500 pages long. There is some judgment involved in deciding the exact correspondence, given the different levels of abstraction.

The clauses in ISO 9001 with no strong relationships to the CMM key process areas, and which are not well addressed in the CMM, are purchaser-supplied product (4.7) and handling, storage, packaging and delivery (4.15). The clause in ISO 9001 that is addressed in the CMM in a completely distributed fashion is servicing (4.19). The clauses in ISO 9001 for which the exact relationship to the CMM is subject to significant debate are corrective action (4.14) and statistical techniques (4.20).

The biggest difference, however, between these two documents is the emphasis of the CMM on continuous process improvement. ISO 9001 addresses the minimum criteria for an acceptable quality system.[2] It should also be noted that the CMM focuses strictly on software, while ISO 9001 has a much broader scope: hardware, software, processed materials, and services [Marquardt91].

The biggest similarity is that for both the CMM and ISO 9001, the bottom line is "Say what you do; do what you say." The fundamental premise of ISO 9001 is that every important process should be documented and every deliverable should have its quality checked through a quality control activity. ISO 9001 requires documentation that contains instructions or guidance on what should be done or how it should be done. The CMM shares this emphasis on processes that are documented and practiced as documented. Phrases such as conducted "according to a documented procedure" and following "a written organizational policy" characterize the key process areas in the CMM.

The CMM also emphasizes the need to record information for later use in the process and for improvement of the process. This is equivalent to the quality records of ISO 9001 that document whether or not the required quality is achieved and whether or not the quality system operates effectively [TickIT, p. 120].

[2] This statement is controversial in itself. Some members of the international standards community maintain that if you read ISO 9001 with insight (between the lines so to speak), it does address continuous process improvement. There is faith that weaknesses will improve over time, especially given regular surveillance audits. Corrective action can be interpreted in this way, although that may not be consistently done today. This will undoubtedly be one of the major topics for the next revision cycle for ISO 9001.

5.1 The Need for Judgment

When making a more detailed comparison, some clauses in ISO 9001 are easily mapped to their equivalent CMM practices. Other relationships map in a many-to-many fashion, since the two documents are structured differently. For example, the training clause (4.18) in ISO 9001 maps to both the Training Program key process area and the training and orientation practices in all of the key process areas.

Satisfying a key process area depends on both implementing and institutionalizing the process. Implementation is described in Activities Performed; institutionalization is described by the other common features.

In general, practices in Commitment to Perform (policies, leadership) can be considered addressed under ISO 9001's clause on management responsibility (4.1). Practices in Ability to Perform (training, resource allocation, tools, and organizational structures) can be considered addressed under ISO 9001's clauses on management responsibility (4.1) and training (4.18) and ISO 9000-3's clauses on rules, practices, and conventions (6.5) and tools and techniques (6.6). Practices in Measurement and Analysis can be considered addressed under ISO 9001's clauses on quality records (4.16) and statistical techniques (4.20) and ISO 9000-3's clause on measurement (6.4). Practices in Verifying Implementation (senior management oversight, project management review, and audits) can be considered addressed under ISO 9001's clauses on management responsibility (4.1) and quality system (4.2).

As this illustrates, the element of judgment in making this comparison is significant. A preliminary comparison of the concepts in ISO 9001 and the CMM would suggest that an organization with an ISO 9001 certificate should be at level 3 or 4. In reality, there are level 1 organizations with certificates. One reason is variability of interpretation; it is absolutely clear that the design reviews in ISO 9001 correspond directly to the CMM's peer reviews if one has gone through the TickIT training. Another reason, however, is that achieving level 2 implies mastering the level 2 key process areas. Due to the high level of abstraction in ISO 9001, it is unclear what degree of sophistication is required to satisfy an auditor.

5.2 The Key Process Area Profile of an ISO 9001-Compliant Organization

What would be the maturity level of an ISO 9001-compliant organization, if it implemented no management or engineering practices not called out by ISO 9001? This is an extreme case, but it gives a lower bound for the maturity of an ISO 9001-compliant organization.

Figure 1 illustrates the key process area profile of an ISO 9001-compliant organization, which has no quality practices beyond those directly called out in ISO 9001. Where there may be a matter of judgment involved, the judgment interpretation is also illustrated in the profile. The dark shading indicates practices that are directly addressed by ISO 9001 or ISO 9000-3; the light shading indicates practices that may be addressed depending on an interpretation of ISO 9001; and the unshaded areas indicate practices not addressed by ISO 9001. Key process areas may be, therefore, partially or fully satisfied, satisfied under some interpretations, or not satisfied. The size of the bar indicates the percentage of key

practices within the key process area that are addressed in either ISO 9001 or ISO 9000-3 (see the appendices for a detailed listing of what practices are addressed where).

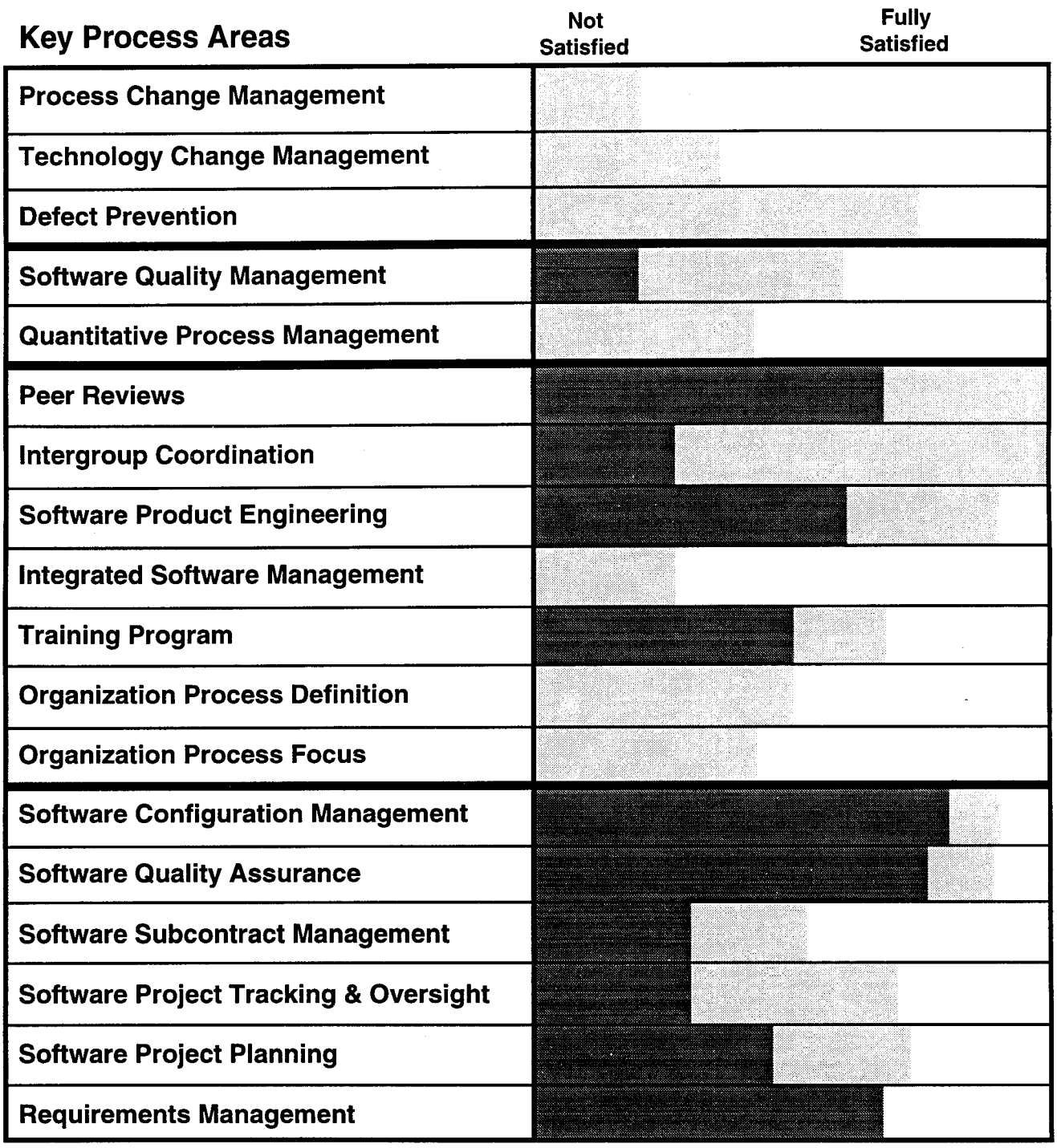

Figure 1. Key process area profile for an ISO 9001-compliant organization

Note the following about Figure 1:

- Every key process area at level 2 is strongly related to ISO 9001.
- Every key process area is at least weakly related to ISO 9001.

Based on this profile, a level 1 organization according to the CMM could be certified as compliant with ISO 9001. That organization would, however, have significant process strengths at level 2 and noticeable strengths at level 3.

Private discussions indicate that many level 1 organizations have received ISO 9001 certificates, although surveillance audits may identify deficiencies later that result in loss of certification. Other organizations have identified significant problems during a CMM-based assessment that had not surfaced during a previous ISO 9001 audit [Coallier94]. Given a reasonable implementation of the software process, however, an organization that obtains and retains ISO 9001 certification should be close to level 2.

If an organization is following the spirit of ISO 9001, it seems probable the organization would be near or above level 2. The level 1 organizations with certificates, however, highlight the differences between the spirit and the letter of ISO 9001 (a similar concern exists for the CMM). This observation also highlights the need for experienced, knowledgeable auditors.

Can a level 3 organization be considered compliant with ISO 9001? Even a level 3 organization would need to ensure that the delivery and installation process described in clause 4.15 of ISO 9001 is adequately addressed and should consider the use of included software product, as described in clause 6.8 of ISO 9000-3. This would be comparatively trivial for a level 3 organization; even a level 2 organization would have little difficulty in obtaining ISO 9001 certification.

6 Conclusion

Although there are specific issues that are not adequately addressed in the CMM, in general the concerns of ISO 9001 are encompassed by the CMM. The converse is less true. ISO 9001 describes the minimum criteria for an adequate quality management system rather than process improvement, although future revisions of ISO 9001 may address this concern. The differences are sufficient to make a rote mapping impractical, but the similarities provide a high degree of overlap.

Should software process improvement be based on the CMM, with perhaps some extensions for ISO 9001 specific concerns, or should the improvement effort focus on certification concerns? A market may require ISO 9001 certification, and level 1 organizations would certainly profit from addressing the concerns of ISO 9001. It is also true that addressing the concerns of the CMM would help organizations prepare for an ISO 9001 audit. Although either document could be used to structure a process improvement program, the more detailed guidance and greater breadth provided to software organizations by the CMM suggest that it is the better choice (a perhaps biased answer).

In any case, building competitive advantage should be focused on improvement, not on achieving a score, whether the score is a maturity level or a certificate. We would advocate addressing the larger context encompassed by the CMM, but even then there is a need to address the still larger business context, as exemplified by Total Quality Management.

7 References

Coallier94 Francois Coallier. "How ISO 9001 Fits Into the Software World," IEEE Software, Vol. 11, No. 1, January 1994, pp. 98-100.

Durand93 Ian G. Durand, Donald W. Marquardt, et al. "Updating the ISO 9000 Quality Standards: Responding to Marketplace Needs." *ASQC Quality Progress*, Vol. 26, No. 7, July 1993, pp. 23-30.

Lloyd's94 *Lloyd's Register TickIT Auditors' Course.* Issue 1.4, Lloyd's Register, March 1994.

Marquardt91 Donald Marquardt, et al. "Vision 2000: The Strategy for the ISO 9000 Series Standards in the '90s." *ASQC Quality Progress*, Vol. 24, No. 5, May 1991, pp. 25-31.

Paulk93a Mark C. Paulk, Bill Curtis, Mary Beth Chrissis, and Charles V. Weber. *Capability Maturity Model for Software, Version 1.1* (CMU/SEI-93-TR-24, ADA 263403), Pittsburgh, PA: Software Engineering Institute, February 1993.

Paulk93b Mark C. Paulk, Charles V. Weber, Suzanne M. Garcia, Mary Beth Chrissis, and Marilyn W. Bush. *Key Practices of the Capability Maturity Model, Version 1.1*, (CMU/SEI-93-TR-25, ADA 263432). Pittsburgh, PA: Software Engineering Institute, February 1993.

Paulk93c Mark C. Paulk. "Comparing ISO 9001 and the Capability Maturity Model for Software." *Software Quality Journal*, Vol. 2, No. 4, December 1993, pp. 245-256.

TickIT *TickIT: A Guide to Software Quality Management System Construction and Certification Using EN29001, Issue 2.0.* U.K. Department of Trade and Industry and the British Computer Society, 28 February 1992.

Appendix A. A Detailed Map Between ISO 9001 and the CMM

The following table maps ISO 9001 into the CMM at the sentence fragment to subpractice level. This mapping goes to a fine level of detail and may be more literal than is useful in truly understanding the underlying relationships between ISO 9001 and the CMM.

The column labeled "Clause" contains the clause and subclause numbers from ISO 9001. The column labeled "ISO 9001 Title" lists the corresponding title of the clause or subclause.

Since ISO 9001 is copyrighted, we cannot include the actual text in this report. Relationships are mapped at the paragraph and sentence level, which are listed in separate rows of this table. The ISO 9001 clause and subclause titles help identify the specific location in ISO 9001 of a relationship.

The column labeled "Basic CMM Practices" contains those CMM practices for which the relationship is relatively straightforward. The column labeled "CMM Practices by Judgment" contains those practices for which a significant degree of judgment (and consequent possibilities of inconsistency) may be used when determining a reasonable relationship between the clauses in ISO 9001 and the practices in the CMM.

Note that the table is divided into clauses, with subclauses also identified. This may make it easier to locate specific correspondences, even in the absence of the ISO 9001 text. Appendix C has a top-level mapping of ISO 9001 to the CMM at the clause to key practice level.

The abbreviations for key process areas and common features are described in the body of this report. Certain themes run throughout each key process area. These themes can be expressed by templates in each common feature. Some themes map generically into a particular clause in ISO 9001, e.g., the training practices map into the training clause (4.18) in ISO 9001. Abbreviations used in this table for the general themes in the CMM include:

.CO.policy	The policy practices in Commitment to Perform
.CO.lead	The leadership practices in Commitment to Perform
.AB.structure	The organizational structure (groups) practices in Ability to Perform
.AB.resource	The resource practices in Ability to Perform
.AB.train	The training practices in Ability to Perform
.AB.orient	The orientation practices in Ability to Perform
.AC.plan	The planning practices in Activities Performed
.AC.procedure	The practices performed according to a documented procedure in Activities Performed
.AC.configure	The practices containing a work product that is "managed and controlled" or under "configuration management" in Activities Performed
.ME.measure	The measurement practices in Measurement and Analysis
.VE.senior	The senior management review practices in Verifying Implementation
.VE.project	The project manager review practices in Verifying Implementation
.VE.audit	The audit practices in Verifying Implementation

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4	**Quality system requirements**		
4.1	**Management responsibility**		
4.1.1	Quality policy		
		QA.CO.1	.CO.policy QM.CO.1
			.CO.lead QA.AB.4
4.1.2	Organization		
4.1.2.1	Responsibility and authority		
		PT.AB.2	PT.CO.1
		QA.CO.1.2	QA.AB.1
			QA.AC.4
		QA.AC.7.1	QA.AC.5
			CM.AC.5
		QA.AC.7.3	
			QA.AC.7 CM.AB.2
4.1.2.2	Verification resources and personnel		
		PP.AC.7.3 QA.AB.1 QA.AB.2	QA.AC.2.7 QA.AC.3.1
			PE.AC.5 PE.AC.6 PE.AC.7 PE.AC.3.6 PE.AC.3.9

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Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
		PT.AC.13 QA.CO.1.2 QA.AC.4 QA.AC.5	.VE.audit QA.VE.3 CM.AC.10 CM.VE.3 PE.AC.2.8 PE.AC.2.9 PE.AC.2.10 PE.AC.3.6 PE.AC.3.9 PE.AC.4.4 PE.AC.5.6 PR.AC.2
4.1.2.3	Management representative		
		QA.AB.2.2	QA.AB.2.1
4.1.3	Management review		
		QA.VE.1	.VE.project .VE.senior QA.CO.1.3 QA.VE.3 PF.AC.1
			QA.ME.1 PF.ME.1 PF.VE.1.3 PF.VE.1.4
		QA.VE.3	
4.2	**Quality system**		
		QA.CO.1	QA.AC.1 PD.CO.1.1 PD.AC.1.1
			QA.AC.3.1 PD.AC.1.2
			.VE.audit
		QA.AC.1 QA.AC.3.1	
		PP.AC.14 PE.AB.1 PE.AC.1	PP.AC.6 PP.AC.7 PR.AB.1

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
			PE.AC.1
			PP.AC.7.9 PP.AC.13 IM.AC.10
		RM.AB.2.3 RM.AC.1	
		PE.AC.10	
			.ME.measure PT.AC.11 QA.AC.7 CM.AC.5 PE.AC.9 PR.AC.3
4.3	**Contract review**		
		PP.AC.3	PP.AC.1 PP.AC.4 PT.AC.3
			PP.CO.2.2 PP.CO.2.3 PP.CO.2.4 PP.CO.2.5
		RM.AB.2 RM.AC.1	SM.AC.1
		RM.AC.1.3	SM.AC.3 SM.AC.6
		RM.AC.1.2	PP.AC.1 SM.AC.2
		RM.AC.2.1	RM.ME.1 PP.ME.1
		RM.AC.1.4	PT.AC.13 IM.AC.11
4.4	**Design control**		
4.4.1	General		
		PE.AC.10.2	PE.AC.2 PE.AC.3
4.4.2	Design and development planning		
		PT.AB.2	PP.AC.7

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
		PP.AC.7 PT.AC.2	IM.AC.11
4.4.2.1	Activity assignment		
		PE.AB.1	PR.AB.1
4.4.2.2	Organizational and technical interfaces		
		IC.AC.2	IC.AC.4 IC.AC.6 IC.AC.7
4.4.3	Design input		
		PE.AC.2.1 PE.AC.2.5 PE.AC.2.8	
		PE.AC.2.4	RM.AC.1.3 RM.AC.1.4
4.4.4	Design output		
		PE.AC.3.8	PE.AC.2.3
			PE.AC.2.1 PE.AC.2.4 PE.AC.3.1 PE.AC.3.2
			PE.AC.2.4 PE.AC.2.6 PE.AC.2.7 PE.AC.3.9
			PE.AC.3.3
			PE.AC.2.2 PE.AC.2.4 PE.AC.3.1
4.4.5	Design verification		
			PR.AB.1 PR.AB.2 PR.AB.3 PE.AB.1 PE.AB.2
			PE.AC.2.8 PE.AC.3.2 PE.AC.10.2

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
			PT.AC.13 PR.AC.2
			PE.AC.7
			PE.AC.2.7 PE.AC.3.4
4.4.6	Design changes		
		RM.AC.3 PT.AC.2 PE.AC.10.4	PE.AC.2.11 PE.AC.2.12 PE.AC.3.10 PE.AC.3.11 PE.AC.4.5 PE.AC.4.6
4.5	**Document control**		
4.5.1	Document approval and issue		
		CM.CO.1 QA.AC.1.3	.AC.configure CM.AC.2 CM.AC.4 CM.AC.6 CM.AC.8
			CM.AB.1 CM.AC.6
			CM.AC.7 PE.AC.8
			CM.AC.7 CM.AC.8 CM.AC.10 CM.VE.3
4.5.2	Document changes/modifications		
			RM.AC.3 CM.AB.1 CM.AC.6
			PT.AC.4 PT.AC.12 IC.AC.7
			CM.AC.8.1
			CM.AC.8.2

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.6	**Purchasing**		
4.6.1	General		
			SM.AC.12
4.6.2	Assessment of sub-contractors		
		SM.AC.2	
			SM.AC.2.2
		SM.AC.1.1 SM.AC.2.2 SM.AC.2.6	
			SM.AC.10
4.6.3	Purchasing data		
		SM.AC.1.2	SM.AC.6
			SM.AC.3.2
			SM.AC.3.5 SM.AC.3.6 SM.AC.3.7
			SM.AC.3.8
		SM.AC.1.3	
4.6.4	Verification of purchased product		
		SM.AC.12	
4.7	**Purchaser-supplied product**		
			IM.AC.6.3 IC.AC.5
4.8	**Product identification and traceability**		
		PE.AC.2.11 PE.AC.3.10 PE.AC.4.5	CM.CO.1 CM.AC.4 CM.AC.8
		CM.AC.4.2	
		CM.AC.4.3 CM.AC.4.4	
4.9	**Process control**		
4.9.1	General		
		PP.AC.6 PP.AC.7	QA.AC.1 QA.AC.2 QA.AC.4

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
		PP.AC.6.1 PP.AC.7.3 PP.AC.14	.AC.procedure PE.AC.1
		QA.AC.4 QA.AC.5	.VE.audit
		PP.AC.6.2 PP.AC.6.3 PP.AC.6.4 PP.AC.14.3	
		PP.AC.6.1	
4.9.2	Special processes		
			PR.AC.2 QP.AC.5
			PP.AC.6.1 PP.AC.6.2 PP.AC.6.3 PP.AC.6.4
			PD.AC.1.1 TP.AC.6 PE.AC.1.2 PE.AC.1.4
4.10	**Inspection and testing**		
4.10.1	Receiving inspection and testing		
4.10.1.1			SM.AC.12 IC.AC.5
			PE.AC.5
4.10.1.2			
			SM.AC.2.4 SM.AC.10
4.10.2	In-process inspection and testing		
		PE.AC.5 PE.AC.6 PE.AC.7	
		QA.AC.4 QA.AC.5 PR.AC.2	PE.AC.2.8 PE.AC.3.9 PE.AC.4.4 PE.AC.5.6 PE.AC.8.5

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
			CM.AC.7.2 PE.AC.7.7
			PT.AC.9 CM.AC.5 CM.AC.8 PE.AC.9 PR.AC.3
4.10.3	Final inspection and testing		
		IM.AC.4.3 PE.AC.5.1	PE.AC.7.7
		PE.AC.7.2 PE.AC.7.5	PE.VE.3
			PE.AC.7.7
4.10.4	Inspection and test records		
		PE.AC.7.7 PE.AC.7.8	
4.11	**Inspection, measuring, and test equipment**		
		PE.AB.1.2	PE.AC.1.2
			PE.AC.5.2
			PE.AC.5.1
			PE.AC.5.3 PE.AC.5.4
			PE.AC.5.3 PE.AC.5.4
			PE.AC.1.2
			PE.AC.1.4
			PE.AC.5.7
			PE.AC.5.5
			PE.AC.5.4
			PE.AC.5.8
			PE.AC.1.4
			PE.AB.1.2
			PE.AC.5.7
			PE.AC.5.7

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.12	**Inspection and test status**		
		CM.AC.8.2 PE.AC.7.7	PR.AC.3
		PE.AC.7.8	CM.AC.5
		PE.AC.7.7	
4.13	**Control of nonconforming product**		
			CM.AC.5
			CM.AB.1 CM.AC.5 CM.AC.8
4.13.1	Nonconformity review and disposition		
			CM.AB.1
			PR.AC.2
			IM.AC.11
		CM.AC.8	
			PE.AC.5 PR.AC.2
4.14	**Corrective action**		
		CM.AC.5	DP.AC.3
			QA.AC.4 QA.AC.5 PF.AC.1 DP.AC.3
			PF.AC.3 IM.AC.10 DP.AC.4
			QA.AC.7 PD.ME.1 DP.ME.1 DP.VE.1 DP.VE.2 DP.VE.3
			DP.AC.5 DP.AC.6 DP.AC.7 DP.ME.1 PC.AC.9

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.15	**Handling, storage, packaging and delivery**		
4.15.1	General		
			CM.AC.7
4.15.2	Handling		
4.15.3	Storage		
			CM.AC.10
4.15.4	Packaging		
			CM.AC.9
4.15.5	Delivery		
4.16	**Quality records**		
			PT.AC.5 PT.AC.6 PT.AC.8 PT.AC.9 PT.AC.11 PE.AC.9 PR.AC.3
			.ME.measure QA.ME.1 CM.AC.5 CM.AC.8
		SM.AC.9.3 SM.AC.12.2	
			PD.AC.5
			QA.AC.8
4.17	**Internal quality audits**		
		QA.AC.4 QA.AC.5	.VE.audit
		QA.AC.2	
		QA.AC.4 QA.AC.5 QA.AC.6 QA.AC.7	
		QA.AC.6	
		QA.AC.7	

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.18	**Training**		
		TP.AC.1 TP.AC.2	
			.AB.train .AB.orient TP.AC.5
		TP.AC.6	
4.19	**Servicing**		
			RM.AB.2.3
4.20	**Statistical techniques**		
			.ME.measure PD.AC.5 QP.AC.3 QM.AC.3

Appendix B. A Detailed Map Between ISO 9000-3 and the CMM

The following table maps ISO 9000-3 into the CMM at the sentence fragment to subpractice level. This mapping goes to a fine level of detail and may be more literal than is useful in truly understanding the underlying relationships between ISO 9000-3 and the CMM.

The column labeled "Clause" contains the clause and subclause numbers from ISO 9000-3. The column labeled "ISO 9000-3 Title" lists the corresponding title of the clause or subclause.

Since ISO 9000-3 is copyrighted, we cannot include the actual text in this report. Relationships are mapped at the paragraph and sentence level, which are listed in separate rows of this table. The ISO 9000-3 clause and subclause titles help identify the specific location in ISO 9000-3 of a relationship.

The column labeled "Basic CMM Practices" contains those CMM practices for which the relationship is relatively straightforward. The column labeled "CMM Practices by Judgment" contains those practices for which a significant degree of judgment (and consequent possibilities of inconsistency) may be used when determining a reasonable relationship between the clauses in ISO 9000-3 and the practices in the CMM.

Note that the table is divided into clauses, with subclauses also identified. This may make it easier to locate specific correspondences, even in the absence of the ISO 9000-3 text. Appendix E has a cross-reference between ISO 9001 and ISO 9000-3 taken from Annexes A and B in ISO 9000-3. This cross-reference may help the reader use Appendix C, which contains a top-level mapping of ISO 9001 to the CMM at the clause to key practice level.

The abbreviations for key process areas and common features are described in the body of this report. Certain themes run throughout each key process area. These themes can be expressed by templates in each common feature. Some themes map generically into a particular clause in ISO 9000-3, e.g., the training practices map into the training clause (6.9) in ISO 9000-3. Abbreviations used in this table for the general themes in the CMM include:

.CO.policy	The policy practices in Commitment to Perform
.CO.lead	The leadership practices in Commitment to Perform
.AB.structure	The organizational structure (groups) practices in Ability to Perform
.AB.resource	The resource practices in Ability to Perform
.AB.train	The training practices in Ability to Perform
.AB.orient	The orientation practices in Ability to Perform
.AC.plan	The planning practices in Activities Performed
.AC.procedure	The practices performed according to a documented procedure in Activities Performed
.AC.configure	The practices containing a work product that is "managed and controlled" or under "configuration management" in Activities Performed
.ME.measure	The measurement practices in Measurement and Analysis
.VE.senior	The senior management review practices in Verifying Implementation
.VE.project	The project manager review practices in Verifying Implementation
.VE.audit	The audit practices in Verifying Implementation

Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
4	**Quality system - Framework**		
4.1	**Management responsibility**		
4.1.1	Supplier's management responsibility		
4.1.1.1	Quality policy		
		QA.CO.1	.CO.policy QM.CO.1
			.CO.lead QA.AB.4
4.1.1.2	Organization		
4.1.1.2.1	Responsibility and authority		
		PT.AB.2	PT.CO.1
		QA.CO.1.2	QA.AB.1
			QA.AC.4
		QA.AC.7.1	QA.AC.5
			CM.AC.5
		QA.AC.7.3	
			QA.AC.7 CM.AB.2
4.1.1.2.2	Verification resources and personnel		
		PP.AC.7.3 QA.AB.1 QA.AB.2	QA.AC.2.7 QA.AC.3.1
			PE.AC.5 PE.AC.6 PE.AC.7 PE.AC.3.6 PE.AC.3.9

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		PT.AC.13 QA.CO.1.2 QA.AC.4 QA.AC.5	.VE.audit QA.VE.3 CM.AC.10 CM.VE.3 PE.AC.2.8 PE.AC.2.9 PE.AC.2.10 PE.AC.3.6 PE.AC.3.9 PE.AC.4.4 PE.AC.5.6 PR.AC.2
4.1.1.2.3	Management representative		
		QA.AB.2.2	QA.AB.2.1
4.1.1.3	Management review		
		QA.VE.1	.VE.project .VE.senior QA.CO.1.3 QA.VE.3 PF.AC.1
			QA.ME.1 PF.ME.1 PF.VE.1.3 PF.VE.1.4
		QA.VE.3	
4.1.2	Purchaser's management responsibility		
			RM.AC.1.3 RM.AC.1.4
			RM.AB.2 RM.AC.1.3 PP.AB.1
			RM.AB.2.3

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
4.1.3	Joint reviews		
			PT.AC.13
			PE.AC.8.7 IC.AC.1
			PE.AC.2.10 PE.AC.4.3 PE.AC.5.1 PE.AC.7.2 PE.AC.7.4
		PE.AC.7	
4.2	**Quality system**		
4.2.1	General		
		QA.CO.1	
			PE.GO.1 DP.CO.1
		QA.VE.3	QA.VE.1
4.2.2	Quality system documentation		
		QA.AC.1	AC.procedure QA.AC.3 PD.AC.1
4.2.3	Quality plan		
		QA.AC.1	QA.AC.4 QM.AC.2
4.3	**Internal quality system audits**		
		QA.AC.4 QA.AC.5	.VE.audit
		QA.AC.2	
		QA.AC.4 QA.AC.5 QA.AC.6 QA.AC.7	
		QA.AC.6	
		QA.AC.7	

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
4.4	**Corrective action**		
		CM.AC.5	DP.AC.3
			QA.AC.4 QA.AC.5 PF.AC.1 DP.AC.3
			PF.AC.3 IM.AC.10 DP.AC.4
			QA.AC.7 PD.ME.1 DP.ME.1 DP.VE.1 DP.VE.2 DP.VE.3
			DP.AC.5 DP.AC.6 DP.AC.7 DP.ME.1 PC.AC.9
5	**Quality system - Life-cycle activities**		
5.1	**General**		
		PP.AC.5	PD.AC.3
5.2	**Contract review**		
5.2.1	General		
		PP.AC.3	PP.AC.1 PP.AC.4 PT.AC.3
			PP.CO.2.2 PP.CO.2.3 PP.CO.2.4 PP.CO.2.5
		RM.AB.2 RM.AC.1	SM.AC.1
		RM.AC.1.3	SM.AC.3 SM.AC.6

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		RM.AC.1.2	PP.AC.1 SM.AC.2
			SM.AC.1
5.2.2	Contract items on quality		
		RM.AB.2.3	
		RM.AC.3	
			CM.AC.5
		PP.AC.14	
		PP.AC.7.3	
5.3	**Purchaser's requirements specification**		
5.3.1	General		
		RM.AC.1.1 RM.AC.1.2	
		RM.AB.2.3	
		RM.AB.2 PP.AB.1.2	
		RM.AC.2.1	
			RM.AC.1.2
5.3.2	Mutual cooperation		
		RM.AB.2	
			RM.AC.1
		RM.AC.1.2	
		RM.AC.2.1	RM.AC.1.3 RM.AC.1.4
5.4	**Development planning**		
5.4.1	General		
		PP.AC.7.1	
		PP.AC.7.7 PP.AC.7.10 PP.AC.11 SM.AC.1	AB.structure AB.resource
		PP.AC.5 PP.AC.7.2	
		PP.AC.7.8 PP.AC.12	
		PP.AC.6.2 PP.AC.6.3	AC.plan

Continued on the next page.

Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		QA.AC.2	
		CM.AC.2	
		PE.AC.6.1	
		PE.AC.7.2	
		PT.AC.2	
		PP.AC.6.4	
5.4.2	Development plan		
5.4.2.1	Phases		
		PP.AC.7.3	
		IM.AC.4.3	PD.AC.2.2
			PE.AC.9
5.4.2.2	Management		
		PP.AC.7	PT.AC.1
		PP.AC.12	
			PT.AC.5 PT.AC.6 PT.AC.7 PT.AC.8 PT.AC.9 PT.AC.10
		PT.AB.2	AB.structure AB.resource
		IC.AC.3	
5.4.2.3	Development methods and tools		
			QA.AC.4
		PP.AC.7.3	PE.AC.2.2 PE.AC.3.4 PE.AC.4.2 PE.AC.5.2
		PP.AC.7.10	PE.AB.1.2
			CM.AC.1 PE.AC.1.3

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
5.4.3	Progress control		
		PT.AC.12	PT.AC.5 PT.AC.6 PT.AC.7 PT.AC.8 PT.AC.9 PT.AC.10
5.4.4	Input to development phases		
		PE.AC.2.5	PE.AC.2.1 PE.AC.3.2 PE.AC.4.1
		PE.AC.2.4 PE.AC.2.6	PE.AC.7.5 PE.AC.6.3
		RM.AB.2.3	
5.4.5	Output from development phases		
		PE.AC.2.5 PE.AC.3.8	
		PE.AC.2.8 PE.AC.2.9 PE.AC.2.10 PE.AC.3.6 PE.AC.3.9 PE.AC.4.4 PE.AC.5.6 PE.AC.6.2 PE.AC.7.2 PE.AC.7.4	
		PE.AC.2.4 PE.AC.2.7 PE.AC.2.6 PE.AC.3.1 PE.AC.5.1 PE.AC.7.2	
		PE.AC.2.2 PE.AC.3.3 PE.AC.3.4 PE.AC.4.2 PE.AC.5.2	

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
5.4.6	Verification of each phase		
		IM.AC.4.3	
		PE.AC.2.8 PE.AC.2.9 PE.AC.2.10 PE.AC.3.6 PE.AC.3.9 PE.AC.4.4 PE.AC.5.6 PE.AC.6.2 PE.AC.7.2 PE.AC.7.4 PR.AC.2	IM.AC.11 PT.AC.12
		PE.AC.5 PE.AC.6 PE.AC.7	
		PR.AC.2.6	
		CM.AC.6.2	
5.5	**Quality planning**		
5.5.1	General		
		QA.AC.1	QM.AC.1
		QA.AC.1.3	PT.AC.2
		QA.AC.1.2	
5.5.2	Quality plan content		
		QM.AC.1.1 QM.AC.1.2 QM.AC.2.2 QM.AC.2.5 QM.AC.3	PE.ME.1
		QA.AC.2.7	PD.AC.2.2
		QA.AC.2.6	PE.AC.5
			PE.AC.5.6 PE.AC.6.1 PE.AC.7.2
			PT.AB.2

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
5.6	**Design and implementation**		
5.6.1	General		
5.6.2	Design		
		PE.AC.3.1 PE.AC.3.3	PE.AC.3.8
		PE.AC.3.4	
			PD.CO.1.4 PD.AC.6 IM.AC.2.1
			IC.AC.4
5.6.3	Implementation		
			PE.AC.1.2
		PE.AC.4.2	
5.6.4	Reviews		
		PT.AC.12 PT.AC.13 PE.AC.2.8 PE.AC.3.9 PE.AC.4.4 PR.AC.2	
			CM.AC.5
		PE.AC.9 PR.AC.3	CM.AC.8.1
5.7	**Testing and validation**		
5.7.1	General		
		PE.AC.5	
		PE.AC.6	
		PE.AC.7	
5.7.2	Test planning		
		PE.AC.5.4 PE.AC.6.2 PE.AC.7.2	
		PE.AC.5.1 PE.AC.6.2 PE.AC.7.4	

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		PE.AC.5.3	
		PE.AB.1.2 PE.AC.7.2	PE.AC.7.1
		PE.AC.5.1	
		PE.AC.8.5 PE.AC.8.7	
		PE.AB.1.1 PE.AB.2	
5.7.3	Testing		
		PE.AC.7.7 PE.AC.9	
		PE.AC.7.6	
		PE.AC.5.5 PE.AC.5.8	CM.AC.5
		PE.AC.5.3	
			PE.AC.7.5
5.7.4	Validation		
		PE.AC.7	
5.7.5	Field testing		
5.8	**Acceptance**		
5.8.1	General		
		PE.AC.7	
5.8.2	Acceptance test planning		
		PE.AC.7.2	
		PE.AC.5.1	
		RM.AB.2.3	
5.9	**Replication, delivery, and installation**		
5.9.1	Replication		
			PE.AC.8.7
5.9.2	Delivery		
5.9.3	Installation		
5.10	**Maintenance**		
5.10.1	General		
			PP.AB.1.1

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
5.10.2	Maintenance plan		
			PP.AC.7 PT.AC.1
5.10.3	Identification of the initial status of the product		
			CM.AC.8
5.10.4	Support organization		
5.10.5	Types of maintenance activities		
			CM.AC.6
5.10.6	Maintenance records and reports		
			CM.AC.5
5.10.7	Release procedures		
			CM.AC.7
			PE.AC.5.5
6	**Quality system - Supporting activities (not phase dependent)**		
6.1	**Configuration management**		
6.1.1	General		
		CM.AC.3.5	
		CM.AC.4.2	PP.AC.8
		CM.AC.4.4	
		CM.AC.8	
			CM.AC.6.3
			CM.AC.6.3
		CM.AC.5	CM.AC.8
6.1.2	Configuration management plan		
		CM.AC.1	
			CM.AB.1 CM.AB.2 CM.AB.3.1
		CM.AC.2.1	
		CM.AC.2.1	CM.AB.3.2
		CM.AC.4.5	

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
6.1.3	Configuration management activities		
6.1.3.1	Configuration identification and traceability		
		CM.AC.4	CM.AC.7
		CM.AC.4.2	
			PE.AC.10.3
		PE.AC.1.4	
			PE.AC.3.8
			PE.AC.10.2
			PE.CO.1.3 PE.ME.1
6.1.3.2	Change control		
		CM.AC.6	
		CM.AC.6.2 CM.AC.6.3	
		CM.AC.6.1	CM.AC.7
			CM.AC.9 PE.AC.10
6.1.3.3	Configuration status report		
		CM.AC.9	
6.2	**Document control**		
6.2.1	General		
			AC.procedure
		CM.AC.4	
			PD.AC.1.6 PD.AC.1.8
		CM.AC.6 CM.AC.7	
6.2.2	Types of documents		
		QA.AC.1.3	PD.AC.1.9
		PP.AC.6.5 PT.AC.11	PT.AC.2
		RM.AC.2.1	

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		PE.AC.2.11 PE.AC.2.12 PE.AC.3.10 PE.AC.3.11 PE.AC.4.5 PE.AC.4.6	
		PE.AC.5.7 PE.AC.5.8 PE.AC.7.8 PE.AC.8.6	
6.2.3	Document approval and issue		
			AC.procedure
			CM.AC.8.2
			CM.AC.10.2 CM.VE.3
6.2.4	Document changes		
			RM.AC.3 CM.AB.1 CM.AC.6
			PT.AC.4 PT.AC.12 IC.AC.7
			CM.AC.8.1
			CM.AC.8.2
6.3	**Quality records**		
			PT.AC.5 PT.AC.6 PT.AC.8 PT.AC.9 PT.AC.11 PE.AC.9 PR.AC.3
			.ME.measure QA.ME.1 CM.AC.5 CM.AC.8

Continued on the next page.

Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
		SM.AC.9.3 SM.AC.12.2	
			PD.AC.5
			QA.AC.8
6.4	**Measurement**		
6.4.1	Product measurement		
		PT.ME.1	.ME.measure
			CM.AC.5
		PE.ME.1	
		IM.AC.4.1	QM.AC.4.2
			QM.AC.4.3
			QM.AC.4.4
			PC.AC.4.3
6.4.2	Process measurement		
		PE.ME.1 PE.ME.2	.ME.measure
		PT.AC.8.1	QP.AC.5.6
			QP.AC.5
6.5	**Rules, practices and conventions**		
		PP.AC.7.3	AC.procedure
			PF.AC.1
6.6	**Tools and techniques**		
		PP.AC.14 PE.AC.1	
			TM.AC.7 TM.AC.8
6.7	**Purchasing**		
6.7.1	General		
		IM.AC.6.3	SM.AC.12
		SM.AC.3.1 SM.AC.3.2 SM.AC.3.3	SM.AC.1
			SM.AC.1.3

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Clause	ISO 9000-3 Title	Basic CMM Practices	CMM Practices by Judgment
6.7.2	Assessment of sub-contractors		
		SM.AC.2	
			SM.AC.2.2
		SM.AC.1.1 SM.AC.2.2 SM.AC.2.6	
			SM.AC.10
6.7.3	Validation of purchased product		
		SM.AC.12	
			SM.AC.3.8 SM.AC.8
		SM.AC.3.7	
			PE.AC.7
6.8	**Included software product**		
			IM.AC.6.3
			SM.AC.12 IC.AC.5
6.9	**Training**		
		TP.AC.1.1 TP.AC.1.2 TP.AC.2.2	
			AB.train AB.orient
		PE.AB.2	
		PE.AB.2	
		TP.AC.6	

Appendix C. A Clause-Level Map Between ISO 9001, ISO 9000-3, and the CMM

The following table maps ISO 9001 and ISO 9000-3 into the CMM at the clause to key practice level. ISO 9001 and ISO 9000-3 are combined as described in Appendix E of this report.

The column labeled "Clause" contains the clause numbers from ISO 9001. The column labeled "ISO 9001 Title" lists the corresponding title of the clause.

The column labeled "Basic CMM Practices" contains those CMM practices for which the relationship is relatively straightforward. The column labeled "CMM Practices by Judgment" contains those practices for which a significant degree of judgment (and consequent possibilities of inconsistency) may be used when determining a reasonable relationship between the clauses in ISO 9001 and the practices in the CMM, with guidance from ISO 9000-3.

The abbreviations for key process areas and common features are described in the body of this report. Certain themes run throughout each key process area. These themes can be expressed by templates in each common feature. Some themes map generically into a particular clause, e.g., the training practices map into the training clause (4.18) in ISO 9001. Abbreviations used in this table for the general themes in the CMM include:

.CO.policy	The policy practices in Commitment to Perform
.CO.lead	The leadership practices in Commitment to Perform
.AB.structure	The organizational structure (groups) practices in Ability to Perform
.AB.resource	The resource practices in Ability to Perform
.AB.train	The training practices in Ability to Perform
.AB.orient	The orientation practices in Ability to Perform
.AC.plan	The planning practices in Activities Performed
.AC.procedure	The practices performed according to a documented procedure in Activities Performed
.AC.configure	The practices containing a work product that is "managed and controlled" or under "configuration management" in Activities Performed
.ME.measure	The measurement practices in Measurement and Analysis
.VE.senior	The senior management review practices in Verifying Implementation
.VE.project	The project manager review practices in Verifying Implementation
.VE.audit	The audit practices in Verifying Implementation

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.1	Management responsibility	PT.AB.2 PT.AC.13 QA.CO.1 QA.AB.1, 2 QA.AC.4, 5 QA.VE.1, 3 PE.AC.7	.CO.policy .CO.lead .VE.project .VE.senior .VE.audit RM.AB.2 PP.AB.1 PT.CO.1 QA.AB.4 QA.AC.7 QA.ME.1 CM.AB.2 CM.AC.5, 10 CM.VE.3 PF.AC.1 PF.ME.1 PE.AC.5, 6 IC.AC.1 PR.AC.2 QM.CO.1
4.2	Quality system	RM.AC.1 PP.AC.14 QA.CO.1 QA.AC.1 QA.VE.3 PE.AB.1 PE.AC.1, 10	.AC.procedure .ME.measure .VE.audit PP.AC.6, 7, 13 PT.AB.2 PT.AC.11 QA.AC.7 QA.VE.1 CM.AC.5 PD.AC.1 IM.AC.10 PE.GO.1 PE.AC.1, 9 PE.ME.1 PR.AB.1 PR.AC.3 QM.AC.1, 2, 3 DP.CO.1

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Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.3	Contract review	RM.AB.2 RM.AC.1, 3 PP.AC.3, 14	RM.ME.1 PP.AC.1, 4 PP.ME.1 PT.AC.3, 13 SM.AC.1, 2, 3, 6 CM.AC.5 IM.AC.11
4.4	Design control	RM.AB.2 RM.AC.1, 3 PP.AC.5, 7, 11, 12 PT.AB.2 PT.AC.2, 12, 13 SM.AC.1 QA.AC.1, 2 CM.AC.1, 2, 4, 5, 6, 8, 9 PE.AB.1, 2 PE.AC.5, 6, 7, 9 IC.AC.2, 3 PR.AC.2, 3 QM.AC.3	.AB.structure .AB.resource .AC.plan PP.AC.8 PT.AC.1, 5, 6, 7, 8, 9, 10, 13 QA.AC.4 CM.AB.1, 2 CM.AC.7 PD.AC.6 IM.AC.11 PE.AB.2 PE.AC.2, 3, 10 PE.ME.1 IC.AC.4, 6, 7 PR.AB.1, 2, 3 PR.AC.2 QM.AC.1
4.5	Document control	PT.AC.11 CM.CO.1 CM.AC.1, 4, 5, 6, 7, 8, 9	.AC.procedure .AC.configure RM.AC.3 PP.AC.8 PT.AC.2, 4, 12 CM.AB.1, 2 CM.AC.2, 10 CM.VE.3 PE.AC.8, 10 PE.ME.1 IC.AC.7
4.6	Purchasing	SM.AC.2, 12	SM.AC.1, 6, 8, 10 PE.AC.7

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Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.7	Purchaser-supplied product		SM.AC.12 IC.AC.5
4.8	Product identification and traceability	CM.AC.1, 4, 5, 6, 8, 9	PP.AC.8 CM.CO.1 CM.AB.1, 2 CM.AC.7 PE.AC.10 PE.ME.1
4.9	Process control	PP.AC.6, 7, 14 PT.AC.12, 13 QA.AC.4, 5 PE.AC.1, 9 PR.AC.2, 3	.AC.procedure .VE.audit QA.AC.1, 2, 4 CM.AC.5 PF.AC.1 PD.AC.6 TP.AC.6 PE.AC.1 IC.AC.4 QP.AC.5 TM.AC.7, 8
4.10	Inspection and testing	QA.AC.4, 5 PE.AB.2 PE.AC.5, 6, 7, 9 PR.AC.2	PT.AC.9 SM.AC.10, 12 CM.AC.5, 8 IC.AC.5 PE.VE.3 PR.AC.3
4.11	Inspection, measuring, and test equipment	PP.AC.14 PE.AB.1, 2 PE.AC.1, 5, 6, 7, 9	.AC.procedure CM.AC.5 PF.AC.1 TM.AC.7, 8
4.12	Inspection and test status	CM.AC.1, 4, 5, 6, 8, 9	PP.AC.8 CM.AB.1, 2 CM.AC.7 PE.AC.10 PE.ME.1 PR.AC.3

Continued on the next page.

Clause	ISO 9001 Title	Basic CMM Practices	CMM Practices by Judgment
4.13	Control of nonconforming product	PT.AC.12, 13 CM.AC.1, 4, 5, 6, 8, 9 PE.AB.2 PE.AC.5, 6, 7, 9 PR.AC.2, 3	PP.AC.8 CM.AB.1, 2 CM.AC.7 PD.AC.6 IM.AC.11 PE.AC.5, 10 PE.ME.1 IC.AC.4 PR.AC.2
4.14	Corrective action	CM.AC.5	QA.AC.4, 5, 7 PF.AC.1, 3 PD.ME.1 IM.AC.10 DP.AC.3, 4, 5, 6, 7 DP.ME.1 DP.VE.1, 2, 3 PC.AC.9
4.15	Handling, storage, packaging, and delivery	PE.AC.7	CM.AC.7, 9, 10
4.16	Quality records		.ME.measure PT.AC.5, 6, 8, 9, 11 QA.AC.8 QA.ME.1 CM.AC.5, 8 PD.AC.5 PE.AC.9 PR.AC.3
4.17	Internal quality audits	QA.AC.2, 4, 5, 6, 7	.VE.audit
4.18	Training	TP.AC.1, 2, 6 PE.AB.2	.AB.train .AB.orient TP.AC.5
4.19	Servicing		
4.20	Statistical techniques	PT.ME.1 PE.ME.1, 2	.ME.measure CM.AC.5 PD.AC.5 QP.AC.3, 5 QM.AC.3

Appendix D. Coverage of CMM Key Practices in ISO 9001

The following table views the relationship between the CMM key practices and ISO 9001 from the CMM perspective. Rather than reproduce the detailed mapping in Appendices A and B, it simply lists whether a key practice is covered by ISO 9001 and was used to generate the key process area profile in Figure 1.

Key Process Area	Activities Covered Under Basic Interpretation	Activities Covered By Judgment of Auditor	Activities Not Covered
Level 2 KPAs			
Requirements Management	1, 3		2
Software Project Planning	3, 5, 6, 7, 11, 12, 14	1, 4, 8, 13	2, 9, 10, 15
Software Project Tracking and Oversight	2, 11, 12, 13	1, 3, 4, 5, 6, 7, 8, 9, 10	
Software Subcontract Management	1, 2, 3, 12	6, 8, 10	4, 5, 7, 9, 11, 13
Software Quality Assurance	1, 2, 4, 5, 6, 7	8	3
Software Configuration Management	1, 2, 4, 5, 6, 7, 8, 9	10	3
Level 3 KPAs			
Organization Process Focus		1, 2, 3	4, 5, 6, 7
Organization Process Definition		1, 5, 6	2, 3, 4
Training Program	1, 2, 6	5	3, 4
Integrated Software Management		3, 10, 11	1, 2, 4, 5, 6, 7, 8, 9

Key Process Area	Activities Covered Under Basic Interpretation	Activities Covered By Judgment of Auditor	Activities Not Covered
Software Product Engineering	1, 5, 6, 7, 9, 10	2, 3, 8	4
Intergroup Coordination	2, 3	1, 4, 5, 6, 7	
Peer Reviews	2, 3		1
Level 4 KPAs			
Quantitative Process Management		1, 3, 5	2, 4, 6, 7
Software Quality Management	3	1, 2	4, 5
Level 5 KPAs			
Defect Prevention		1, 3, 4, 5, 6, 7	2, 8
Technology Change Management		1, 7, 8	2, 3, 4, 5, 6
Process Change Management		3, 9	1, 2, 4, 5, 6, 7, 8, 10

Appendix E. Cross-References Between ISO 9001 and ISO 9000-3

Cross-reference between ISO 9001 and ISO 9000-3 from Annex B in ISO 9000-3

	Clause in ISO 9001	Clause in ISO 9000-3
4	Quality system requirements	4, 5, 6
4.1	Management responsibility	4.1
4.2	Quality system	4.2, 5.5
4.3	Contract review	5.2, 5.3
4.4	Design control	5.3, 5.4, 5.5, 5.6, 5.7, 6.1
4.5	Document control	6.1, 6.2
4.6	Purchasing	6.7
4.7	Purchaser-supplied product	6.8
4.8	Product identification and traceability	6.1
4.9	Process control	5.6, 6.5, 6.6
4.10	Inspection and testing	5.7, 5.8, 5.9
4.11	Inspection, measuring, and test equipment	5.7, 6.5, 6.6
4.12	Inspection and test status	6.1
4.13	Control of nonconforming product	5.6, 5.7, 5.9, 6.1
4.14	Corrective action	4.4
4.15	Handling, storage, packaging, and delivery	5.8, 5.9
4.16	Quality records	6.3
4.17	Internal quality audits	4.3
4.18	Training	6.9
4.19	Servicing	5.10
4.20	Statistical techniques	6.4

Cross-reference between ISO 9000-3 and ISO 9001 from Annex A in ISO 9000-3

	Clause in ISO 9000-3	Clause in ISO 9001
4.1	Management responsibility	4.1
4.2	Quality system	4.2
4.3	Internal quality system audits	4.17
4.4	Corrective action	4.14
5.1	*General (added to Annex A)*	*none*
5.2	Contract review	4.3
5.3	Purchaser's requirements specification	4.3, 4.4
5.4	Development planning	4.4
5.5	Quality planning	4.2, 4.4
5.6	Design and implementation	4.4, 4.9, 4.13
5.7	Testing and validation	4.4, 4.10, 4.11, 4.13
5.8	Acceptance	4.10, 4.15
5.9	Replication, delivery, and installation	4.10, 4.13, 4.15
5.10	Maintenance	4.13, 4.19
6.1	Configuration management	4.4, 4.5, 4.8, 4.12, 4.13
6.2	Document control	4.5
6.3	Quality records	4.16
6.4	Measurement	4.20
6.5	Rules, practices, and conventions	4.9, 4.11
6.6	Tools and techniques	4.9, 4.11
6.7	Purchasing	4.6
6.8	Included software product	4.7
6.9	Training	4.18

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The Capability Maturity Model for Software (CMM), developed by the Software Engineering Institute, and the ISO 9000 series of standards, developed by the International Standards Organization, share a common concern with quality and process management. The two are driven by similar concerns and intuitively correlated. The purpose of this report is to contrast the CMM and ISO 9001, showing both their differences and their similarities. The results of the analysis indicate that, although an ISO 9001-compliant organization would not necessarily satisfy all of the level 2 key process areas, it would satisfy most of the level 2 goals and many level 3 goals. Because there are practices in the

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CMM that are not addressed in ISO 9000, it is possible for a level 1 organization to receive 9001 registration; similarly, there are areas addressed by ISO 9001 that are not addressed in the CMM. A level 3 organization would have little difficulty in obtaining ISO 9001 certification, and a level 2 organization would have significant advantages in obtaining certification.