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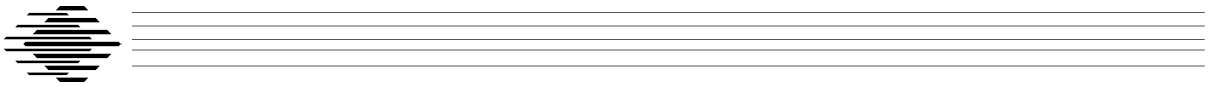

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FOR THE COMMANDER

(signature on file)

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Contents

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1 Cleanroom and the CMM for Software

The Capability Maturity Model[sm] for Software (CMM) [CMU 95] developed by the Software Engineering Institute, and Cleanroom Software Engineering [Mills 87, Linger 93, Linger 94] developed by Dr. Harlan Mills and his associates in IBM and other organizations, share a common concern with software quality and the effectiveness of software development. The principal focus of the CMM is on process management maturity; the principal focus of Cleanroom is on rigorous engineering processes. The CMM management processes and the Cleanroom engineering processes are complementary and mutually reinforcing.

The Capability Maturity Model for Software describes the principles and practices underlying software process maturity. It is intended to help software organizations improve the maturity of their software processes through an evolutionary path from ad hoc, chaotic processes to mature, disciplined software processes. The CMM is organized into five maturity levels. The maturity levels are defined in terms of 18 key process areas (KPAs) that characterize project performance at each level.

Cleanroom software engineering is a theory-based engineering process for development and certification of high-reliability software systems under statistical quality control. Cleanroom is intended to help software organizations improve their ability to apply engineering discipline to software development. Cleanroom is defined in terms of 14 processes that implement the technology and operations involved in Cleanroom software development.

This report defines the Cleanroom software engineering implementation of the Capability Maturity Model for Software. The definition is expressed in terms of a mapping of the 14 Cleanroom processes into the 18 CMM key process areas. The CMM key process areas and the Cleanroom processes are briefly summarized in this report. They are defined in detail in the following references:

> Carnegie Mellon University, Software Engineering Institute (Principal Contributors and Editors: Mark C. Paulk, Charles V. Weber, Bill Curtis, and Mary Beth Chrissis), *The Capability Maturity Model: Guidelines for Improving the Software Process*, ISBN 0-201-54664-7, Addison-Wesley Publishing Company, Reading, Ma., 1995.

[sm] CMM and the Capability Maturity Model are service marks of Carnegie Mellon University.

Linger, Richard C. and Carmen J. Trammell, *Cleanroom Software Engineering Reference Model* (CMU/SEI-96-TR-022). Pittsburgh, Pa.: Carnegie Mellon University, Software Engineering Institute, November 1996.

The *Cleanroom Software Engineering Reference Model* is intended to be a companion document in reading this technical report.

2 The Capability Maturity Model for Software

This section characterizes the objectives, organization, and content of the Capability Maturity Model for Software. 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 processes for both management and engineering activities are 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 The 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:

Level 2	
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:

Level 3	
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 project 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:

Level 4	
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:

Level 5	
Defect Prevention (DP)	Identify the root 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 and Key Practices

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, 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.

Each key process area is described in terms of the key practices that contribute to satisfying its goals. The key practices characterize the infrastructure and activities that contribute most to the effective implementation and institutionalization of the key process area and are described in [CMU 95].

3 Cleanroom Software Engineering Processes

Cleanroom software engineering is a software development and certification process based on theoretical foundations in mathematical function theory and applied statistics [Mills, 87, Mills 92]. A principal objective of the Cleanroom process is development of software that exhibits zero failures in use. The Cleanroom name is borrowed from hardware Cleanrooms, with their emphasis on rigorous engineering methods and focus on defect prevention rather than defect removal. Cleanroom combines mathematics-based methods of software specification [Mills 86], design, and correctness verification [Linger 79] with statistical testing [Mills 92, Poore 95, Trammell 95, Walton 95] to certify software fitness for use. Cleanroom projects have reported substantial gains in quality and productivity [Hausler 94, Linger 94, Sherer 96]. Key Cleanroom publications are collected in [Poore 96].

The practice of Cleanroom software engineering has been defined in a set of 14 processes organized into management, specification, development, and certification categories. This section provides a brief characterization of the processes in terms of tasks and principal work products. A complete description of the processes and work products can be found in [Linger 96]. Work product names are shown in italics.

3.1 Cleanroom Management Processes

Project Planning Process

Define and document plans for a Cleanroom project, and revise as necessary to accommodate changes. Review plans with the project team, peer groups, and the customer for agreement.

> ***Cleanroom Engineering Guide*** - Process documentation for a specific Cleanroom project, including tailored Cleanroom processes, work product definitions, and local policies, protocols, and standards that define how the project will be conducted.
>
> ***Software Development Plan*** - A set of management plans for a specific Cleanroom project: Project Mission Plan, Project Organization Plan, Work Product Plan, Schedule and Resource Plan, Measurement Plan, Reuse

Analysis Plan, Risk Analysis Plan, Standards Plan, Training Plan, and Configuration Management Plan.

Project Management Process

Manage the Cleanroom incremental development and certification process to deliver software and associated work products on schedule and within budget. Manage customer interaction. Establish and train Cleanroom teams. Meet process performance standards and product quality objectives. Initiate and monitor Cleanroom processes. Manage project risks and team performance. Use quantitative measurements of product and process performance produced by statistical testing and certification of successive increments for objective management decision making.

Project Record - Documentation of actions, reviews, decisions, measures, and other events throughout a project.

Performance Improvement Process

Continually evaluate and improve Cleanroom team performance based on process control standards and causal analysis of software failures. Analyze and pilot prospective improvements in Cleanroom processes and tools, and introduce them to the project as appropriate.

Performance Improvement Plan - Documentation of plans to refine the current Cleanroom process and/or introduce new software processes and tools.

Engineering Change Process

Correct and change the evolving software and associated work products under a protocol that preserves correctness and is consistent with the *Configuration Management Plan*. Maintain configuration management discipline and implement engineering change control for all changes.

Engineering Change Log - The record of engineering change proposals, evaluations, impacts, and status.

3.2 Cleanroom Specification Processes

Requirements Analysis Process

Analyze and define initial customer requirements for the software product, as well as requirements changes arising from customer assessment of evolving increments. Express requirements in user terms and review with the customer for agreement.

> ***Software Requirements*** - The functional, usage, performance, and environment requirements for a software system to be developed under the Cleanroom process.

Function Specification Process

Use mathematics-based methods to define the required external behavior of a software product in all possible circumstances of use based on the *Software Requirements*. Express the specification in box structure form. Create complete, consistent and correct specifications, and review with the customer for agreement.

> ***Function Specification*** - A complete representation of the external view of a system, typically expressed in terms of the mapping of all possible stimuli to their corresponding responses in all possible circumstances of use; the top-level black box in the box structure usage hierarchy.

Usage Specification Process

Define all classes of users, major patterns of usage, and usage environments for a software product based on the *Software Requirements.* Create complete, consistent, and correct usage specifications, and review with the customer for agreement.

> ***Usage Specification*** - A description of the expected users, uses, and environments of the software. Usage is typically expressed in high-level Markov models.

Architecture Specification Process

Analyze architectural assets and define the architecture strategy for the software product, including major components, high-level structure, and software design strategies and conventions. Review with the customer for agreement.

Software Architecture - The overall structure of the software, typically expressed as a top-level state box and clear box in the box structure usage hierarchy, together with design strategies and conventions to be used throughout development.

Increment Planning Process

Create an incremental development and certification plan for the software product such that the increments implement user function, accumulate into the final system, execute in the system environment, and permit systematic feedback on process control and product function and quality. Use increment planning to manage risks and maintain intellectual control over the evolving software.

Increment Construction Plan - A plan that specifies the number of increments into which a software system will be divided, the functions that will be implemented in each increment, and the schedule and resources allocated for development and certification of each increment.

3.3 Cleanroom Development Processes

Software Reengineering Process

Evaluate and if necessary reengineer candidate reused software for incorporation into a software product. Restructure reused software and document and verify its functional semantics as necessary to maintain intellectual control and avoid failures in execution. Determine the fitness for use of reused software as necessary through statistical testing in order to achieve project certification goals.

Reengineering Plan - A technical plan for evaluation and possible reengineering of candidate reused software.

Reengineered Software - Reused software that has been reengineered to meet product function and quality requirements.

Increment Design Process

Specify, design, and code the increments for a software product through stepwise decomposition of box structures, typically from stimulus-history-based black box specifications into state-based state box specifications, and then into procedure-

based clear box designs containing lower-level black boxes for further refinement. Prepare designs for correctness verification by embedding intended function definitions that specify the effect on data of corresponding control structure decompositions.

> ***Increment Design*** - The complete specification, design, and code for a software increment, typically represented in black box, state box, and clear box forms.

Correctness Verification Process

Carry out correctness verification of designs to identify and correct software faults prior to first execution. Apply function-theoretic methods of correctness verification in team reviews. Document all faults found and rereview their corrections.

> ***Increment Verification Report*** - The record of correctness verification reviews, including staff members participating, time spent, identification and classification of faults found, and any other information relevant to assessment of the correctness of the design and code.

3.4 Cleanroom Certification Processes

Usage Modeling and Test Planning Process

Create the usage models to be used for software testing and certification, typically expressed in terms of Markov models defining software usage states and probabilities of transitions between them. Develop models to satisfy project objectives, such as certification for expected operational use, and certification of infrequently used functions with high consequences of failure. Analyze usage model statistics to provide insight into the testing effort required to meet certification goals. Develop a statistical test plan, prepare the test environment, and generate the statistical test cases.

> ***Usage Models*** - The models to be used to generate test cases for software certification.

> ***Increment Test Plan*** - All information required for statistical testing, including schedules, staffing, training, hardware and software environment, test case evaluation procedures, certification goals, and statistical models.

Statistical Test Cases - Test cases randomly generated from usage models for use in statistical testing.

Statistical Testing and Certification Process

Demonstrate the fitness for use of the software in a formal statistical experiment. Execute statistical test cases under experimental control, evaluate results, and initiate engineering change activity if failures are encountered. Compare the values of certification measures obtained in statistical testing to certification goals to assess the software's fitness for use. Compare measures of testing progress to process control standards to assess the likelihood of reaching certification goals with planned schedules and resources.

Executable System - The executable load modules for testing.

Statistical Testing Report - The record of statistical testing, including test cases executed, failures observed, and any other information relevant to assessing correctness of the software.

Increment Certification Report - The record of measures of product quality and process control, plus assessments of the measures for test management and product release decisions.

4 Cleanroom Implementation of the CMM for Software

4.1 Cleanroom and the CMM

This section discusses the overall mapping of the Cleanroom processes [Linger 96] to the Capability Maturity Model for Software [CMU 95].

4.1.1 Cleanroom/CMM Correspondences

The CMM key process areas define required capabilities at each level of maturity. The general correspondence between the KPAs and the Cleanroom processes is summarized in the following tables:

CMM Level 2: Repeatable	
Key Process Area	**Principal Cleanroom Processes**
Requirements Management	Project Planning Project Management Requirements Analysis
Software Project Planning	Project Planning Increment Planning
Software Project Tracking & Oversight	Project Management
Software Subcontract Management	Project Planning Project Management Increment Planning
Software Quality Assurance	Project Planning Project Management Correctness Verification Statistical Testing & Certification
Software Configuration Management	Project Planning Project Management Engineering Change

CMM Level 3: Defined	
Key Process Area	**Principal Cleanroom Processes**
Organization Process Focus	Project Planning Project Management Performance Improvement
Organization Process Definition	Project Planning Project Management Performance Improvement
Training Program	Project Planning Project Management
Integrated Software Management	Project Planning Project Management Increment Planning
Software Product Engineering	Project Planning Project Management Engineering Change Requirements Analysis Function Specification Usage Specification Architecture Specification Increment Planning Software Reengineering Increment Design Correctness Verification Usage Modeling & Test Planning Statistical Testing & Certification
Intergroup Coordination	Project Planning Project Management
Peer Reviews	Project Planning Project Management Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Correctness Verification Usage Modeling & Test Planning

CMM Level 4: Managed	
Key Process Area	**Principal Cleanroom Processes**
Quantitative Process Management	Project Planning Project Management Performance Improvement Statistical Testing & Certification
Software Quality Management	Project Planning Project Management Performance Improvement Correctness Verification Statistical Testing & Certification

CMM Level 5: Optimizing	
Key Process Area	**Principal Cleanroom Processes**
Defect Prevention	Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Correctness Verification Usage Modeling & Test Planning Performance Improvement
Technology Change Management	Project Management Performance Improvement
Process Change Management	Project Management Performance Improvement

The recurring process management attributes used in the KPAs are variously covered in the Cleanroom process definition sections (Objectives, Participants, Entry, Tasks, Verification, Measurement, and Exit) and in the Cleanroom work products, as summarized in the following table. The first column lists process management attributes found in the KPAs, and the second column defines their principal location in the Cleanroom processes, in terms of process names, process sections, and work products (shown in italics):

KPA Process Management Attribute	Location in Cleanroom Processes
A written policy to do the work exists.	Organization's *Cleanroom Engineering Guide*
A documented procedure for doing the work exists.	Project Planning: *Cleanroom Engineering Guide* tailored to the specific project
Responsibility for doing the work has been established.	Project Planning: *Project Organization Plan*
Affected groups agree to their roles.	Project Planning: Verification section
Resources and funding for the work exists.	Project Planning: *Schedule and Resource Plan* Project Management
People are trained to perform the work.	Project Planning: *Training Plan* Project Management
Work products documenting the work are created.	Project Planning: *Work Product Plan* All processes: Task sections
Baselines for work products are established.	Project Planning: *Configuration Management Plan*
Changes to work products occur in a controlled fashion.	Project Planning: *Configuration Management Plan* Project Management Engineering Change
The status of work is measured.	All processes: Measurement sections
The status of work is reviewed by senior management.	All processes: Verification sections
The status of work is reviewed by the project manager.	All processes: Verification sections
The status of work is reviewed by the SQA group.	Intent is addressed to large degree by Verification and Exit sections of all processes, and by independent Statistical Testing & Certification process.

In Sections 4.2 through 4.5 below, each key process area of the CMM is mapped to elements of the Cleanroom processes. KPA Goals, Commitments, Abilities to Perform, Activities, Measurements, and Verifications are listed, together with the principal Cleanroom Process implementation and an assessment of the correspondence of Cleanroom to the KPA elements. Correspondence is evaluated according to the following categories:

Correspondence Category	Keyword
The CMM element is consistent with Cleanroom processes, and implementation by Cleanroom processes is high.	High (H)
The CMM element is consistent with Cleanroom processes, and implementation by Cleanroom processes is partial.	Partial (P)
The CMM element is consistent with Cleanroom processes, and implementation by Cleanroom processes is low.	Low (L)
The CMM element is consistent with Cleanroom processes, but is not implemented in the Cleanroom processes, or is implemented in an indirect way.	Consistent (C)
The CMM element is not included in Cleanroom processes, and an alternative implementation is defined by Cleanroom processes.	Alternative (A)

4.1.2 Summary of the Cleanroom/CMM Mapping

The following tables summarize the mapping of Cleanroom into the CMM KPAs in terms of the correspondence categories defined above. The mappings are detailed in Sections 4.2 through 4.5. The first column in the tables lists the KPAs, the second column defines the overall mapping.

It should be noted that there is a scoping consideration in mapping Cleanroom to the organizational KPAs (i.e., Organizational Process Focus, Organizational Process Definition, Training Program, Technology Change Management, and Process Change Management). If Cleanroom is the only process standardized by a software development organization, it might fully address the concerns of an organizational KPA, and the correspondence would be rated as High. The case is more likely to be, however, that multiple methodologies will be supported by an organization, one of which is Cleanroom. In that case, the implementation of the organizational KPAs goes beyond the Cleanroom processes, and the Cleanroom mapping cannot be more than Partial. This latter case is reflected in the tables below.

Level 2 KPAs: Repeatable

Key Process Area	Cleanroom Implementation
Requirements Management	High
Software Project Planning	High
Software Project Tracking & Oversight	High
Software Subcontract Management	Consistent
Software Quality Assurance	Partial
Software Configuration Management	Partial

Level 3 KPAs: Defined

Key Process Area	Cleanroom Implementation
Organization Process Focus	Consistent
Organization Process Definition	Partial
Training Program	Partial
Integrated Software Management	High
Software Product Engineering	High
Intergroup Coordination	High
Peer Reviews	High

Level 4 KPAs: Managed

Key Process Area	Cleanroom Implementation
Quantitative Process Management	High
Software Quality Management	High

Level 5 KPAs: Optimizing

Key Process Area	Cleanroom Implementation
Defect Prevention	High
Technology Change Management	Partial
Process Change Management	Partial

The CMM and the Cleanroom processes are highly compatible and mutually supportive. The focus of the CMM is on management and organization; the focus of Cleanroom is on technology and its implementation in engineering processes. The combination of these two paradigms provides substantial management and engineering capability.

4.1.3 Interpreting the Cleanroom/CMM Mapping Tables

The following format is used in defining the mappings in the tables of Sections 4.2 through 4.5, based on the definition of the Cleanroom Software Engineering Reference Model given in [Linger 96]:

Cleanroom Process names are shown with initial capital letters, e.g.,

Project Planning

If particular sections and/or work products are especially relevant to the mapping, the Cleanroom process name is followed by a colon and a more detailed description. The description may name an entire section in the Cleanroom process, e.g.,

Project Planning: Verification section

or identify a more specific item, e.g.,

Project Planning: T1.1

where T1.1 refers to Task 1.1 (the first subtask in Task 1) of Project Planning. The following abbreviations for the sections in the Cleanroom processes are used in these descriptions:

O	Objectives
P	Participants
En	Entry
T	Tasks
V	Verification
M	Measurement
Ex	Exit

Any such item prefixed with “CE” refers to the Common Elements section of the Cleanroom process definitions, for example, CEV1 refers to the Common Elements Verification 1 item. (The Common Elements were factored out of the individual processes to achieve a more compact definition of the Cleanroom Reference Model.)

Relevant Cleanroom process work products are shown in italics, e.g.,

Project Planning: T1, *Cleanroom Engineering Guide*

Mappings for KPA elements which have no corresponding Cleanroom element are shown with a dash symbol (---).

The mappings defined in the following sections are intended to provide guidance and highlight principal areas of correspondence. Tailoring and refinement of the Cleanroom Reference Model for specific projects may expand or modify the mappings.

4.2 Cleanroom Implementation of Level 2 KPAs

4.2.1 Requirements Management

Correspondence Analysis

Software requirements analysis and documentation are essential Cleanroom activities. Requirements management is a major aspect of Cleanroom incremental development. Ongoing confirmation or clarification of requirements occurs through planned customer evaluation of successive increments. New or changed requirements are accommodated through top-down evaluation of impacts on all work products at the outset of each increment's development cycle. As with all Cleanroom work products, the requirements document and all modifications to it are subject to peer review and engineering change control.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	System requirements allocated to software are controlled to establish a baseline for software engineering and management use.	Project Planning: CEEn Project Planning: T2.10, *Configuration Management Plan* Requirements Analysis: O3 Requirements Analysis: T1, *Software Requirements* Requirements Analysis: T2	H
GO2	Software plans, products, and activities are kept consistent with the system requirements allocated to software.	Project Planning: CEO1 Project Planning: CEEn Project Planning: T2, *Software Development Plan* Project Planning: CEV2 Project Management: T5 Requirements Analysis: En2 Increment Planning: *Increment Construction Plan*	H

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for managing the system requirements allocated to software.	Project Planning: T2.10, *Configuration Management Plan* Requirements Analysis	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	For each project, responsibility is established for analyzing the system requirements and allocating them to hardware, software, and other system components.	Project Planning: T2.2, *Project Organization Plan* Requirements Analysis	H
AB2	The allocated requirements are documented.	Requirements Analysis: T1, *Software Requirements*	H
AB3	Adequate resources and funding are provided for managing the allocated requirements.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB4	Members of the software engineering group and other software-related groups are trained to perform their requirements management activities.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software engineering group reviews the allocated requirements before they are incorporated into the software project.	Requirements Analysis: V1	H

AC2	The software engineering group uses the allocated requirements as the basis for software plans, work products, and activities.	Project Planning: T2 Project Management: T4 Function Specification: En1 Usage Specification: En1 Architecture Specification: En1 Increment Planning: En1	H
AC3	Changes to the allocated requirements are reviewed and incorporated into the software project.	Project Planning: En1 Engineering Change: En2 Requirements Analysis: En2 Function Specification: En2 Usage Specification: En2 Architecture Specification: En2 Increment Planning: En2	H

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the activities for managing the allocated requirements.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Requirements Analysis: CEM1, *Project Record* Requirements Analysis: CEV1 Performance Improvement: T1	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for managing the allocated requirements are reviewed with senior management on a periodic basis.	Requirements Analysis: CEV1	H
VE2	The activities for managing the allocated requirements are reviewed with the project manager on both a periodic and event-driven basis.	Requirements Analysis: CEV1	H

VE3	The software quality assurance group reviews and/or audits the activities and work products for managing the allocated requirements and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.2.2 Software Project Planning

Correspondence Analysis

Cleanroom project planning is robust, with emphasis on an incremental development process for managing requirements, risks, resources, reuse, and other technical factors influencing project success. The Cleanroom Reference Model incorporates additional CMM requirements for effective planning, such as ensuring adequate funding for the planning period itself, using estimates that are derived according to a documented procedure, and gaining explicit agreements from all individuals and groups who have responsibilities related to the project.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Software estimates are documented for use in planning and tracking the software project.	Project Planning: T2.4, *Schedule and Resource Plan* Increment Planning: T2, *Increment Construction Plan*	H
GO2	Software project activities and commitments are planned and documented.	Project Planning: O2 Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan* Increment Planning: T1, *Increment Construction Plan*	H
GO3	Affected groups and individuals agree to their commitments related to the software project.	Project Planning: O3 Project Planning: V1 Increment Planning: O3 Increment Planning: V1	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	A project software manager is designated to be responsible for negotiating commitments and developing the project's software development plan.	Project Planning: T2.2, *Project Organization Plan*	H

CO2	The project follows a written organizational policy for planning a software project.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: CEV1	H

CMM Process Element		**Cleanroom Process Implementation**	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A documented and approved statement of work exists for the software project.	Project Planning: En1	H
AB2	Responsibilities for developing the software development plan are assigned.	Project Planning: T2.2, *Project Organization Plan*	H
AB3	Adequate resources and funding are provided for planning the software project.	Project Planning: T2.2, *Project Organization Plan* Project Planning: T2.4, *Schedule and Resource Plan*	H
AB4	The software managers, software engineers, and other individuals involved in the software project planning are trained in the software estimating and planning procedures applicable to their areas of responsibility.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		**Cleanroom Process Implementation**	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software engineering group participates on the project proposal team.	Project Planning: T2.2, *Project Organization Plan* Project Management: T2	C
AC2	Software project planning is initiated in the early stages of, and in parallel with, the overall project planning.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	C

AC3	The software engineering group participates with other affected groups in the overall project planning throughout the project's life.	Project Planning: T2.2, *Project Organization Plan* Project Planning: V1 Project Planning: V2 Project Management: T2 Project Management: T4 Project Management: T5 Project Management: CEV1 Increment Planning: O3 Increment Planning: V1	C
AC4	Software project commitments made to individuals and groups external to the organization are reviewed with senior management according to a documented procedure.	Project Planning: T2.2, *Project Organization Plan* Project Planning: CEV1	H
AC5	A software life cycle with predefined stages of manageable size is identified or defined.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.2, *Schedule and Resource Plan* Increment Planning: T1, *Increment Construction Plan* Increment Planning: T2	H
AC6	The project's software development plan is developed according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan*	H
AC7	The plan for the software project is documented.	Project Planning: T2, *Software Development Plan*	H
AC8	Software work products that are needed to establish and maintain control of the software project are identified.	Project Planning: T2.3, *Work Product Plan*	H
AC9	Estimates for the size of the software work products (or changes to the size of software work products) are derived according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.5, *Measurement Plan* Increment Planning: T1, *Increment Construction Plan*	H
AC 10	Estimates for the software project's effort and costs are derived according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule and Resource Plan* Project Planning: T2.5, *Measurement Plan* Increment Planning: T1, *Increment Construction Plan*	H
AC 11	Estimates for the project's critical computer resources are derived according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule and Resource Plan* Project Planning: T2.5, *Measurement Plan* Increment Planning: T1, *Increment Construction Plan*	H

AC 12	The project's software schedule is derived according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule and Resource Plan*	H
AC 13	The software risks associated with the cost, resource, schedule, and technical aspects of the project are identified, assessed, and documented.	Project Planning: T2.7, *Risk Analysis Plan* Project Management: T6	H
AC 14	Plans for the project's software engineering facilities and support tools are prepared.	Project Planning: T1.2, *Cleanroom Engineering Guide*	H
AC 15	Software planning data are recorded.	Project Planning: T2, *Software Development Plan*	H

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the software planning activities.	Project Planning: CEM1 Project Planning: CEV1	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software project planning are reviewed with senior management on a periodic basis.	Project Planning: CEV1	H
VE2	The activities for software project planning are reviewed with the project manager on both a periodic and event-driven basis.	Project Planning: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for software project planning and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.2.3 Software Project Tracking and Oversight

Correspondence Analysis

Cleanroom emphasizes not only tracking plans against performance, but statistical control of the software process. As is the case in statistical process control in general, process performance is measured and compared with performance targets, and deviations are evaluated in the context of the range of historical deviations in performance. The very name of CMM level 2, Repeatable, reflects the importance of such an evaluation. The framework for statistical process control, first introduced in the Software Tracking and Oversight KPA, matures to the Quantitative Process Management and Software Quality Management KPAs at CMM level 4.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Actual results and performance are tracked against the software plans.	Project Planning: T2, *Software Development Plan* Project Management: T5 Project Management: CEM1	H
GO2	Corrective actions are taken and managed to closure when actual results and performance deviate significantly from the software plans.	Project Management: T5 Project Management: CEV1	H
GO3	Changes to software commitments are agreed to by the affected groups and individuals.	Project Planning: V1 Project Planning: V2 Increment Planning: V1	H

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	A project software manager is designated to be responsible for the project's software activities and results.	Project Planning: T2.2, *Project Organization Plan*	H
CO2	The project follows a written organizational policy for managing the software project.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan*	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A software development plan for the software project is documented and approved.	Project Planning: T2, *Software Development Plan* Project Planning: CEV1	H
AB2	The project software manager explicitly assigns responsibility for software work products and activities.	Project Planning: T2.2, *Project Organization Plan* Project Planning: T2.3, *Work Product Plan* Project Management: T4	H
AB3	Adequate resources and funding are provided for tracking the software project.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB4	The software managers are trained in managing the technical and personnel aspects of the software project.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H
AB5	First-line software managers receive orientation in the technical aspects of the software project.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	A documented software development plan is used for tracking the software activities and communicating status.	Project Planning: T2 *Software Development Plan* Project Management: T5 Project Management: CEV1	H

AC2	The project's software development plan is revised according to a documented procedure.	Project Planning: En2, T1 *Cleanroom Engineering Guide*	H
AC3	Software project commitments and changes to commitments made to individuals and groups external to the organization are reviewed with senior management according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2 *Software Development Plan* Project Management: CEV1	H
AC4	Approved changes to commitments that affect the software project are communicated to the members of the software engineering group and other software-related groups.	Project Planning: T2, *Software Development Plan* Project Planning: V2 Project Management: T2 Project Management: CEV1 Project Management: CEV2	H
AC5	The sizes of the software work products (or sizes of the changes to the software work products) are tracked, and corrective actions are taken as necessary.	Project Management: T5 Project Management: CEM2	H
AC6	The project's software effort and costs are tracked, and corrective actions are taken as necessary.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T5 Project Management: CEM1	H
AC7	The projects critical computer resources are tracked, and corrective actions are taken as necessary.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T5	H
AC8	The project's software schedule is tracked, and corrective actions are taken as necessary.	Project Management: T5 Project Management: CEM1	H
AC9	Software engineering technical activities are tracked, and corrective actions are taken as necessary.	Project Management: T5 Project Management: CEM1	H
AC 10	The software risks associated with cost, resource, schedule, and technical aspects of the project are tracked.	Project Planning: T2.7, *Risk Analysis Plan* Project Management: T6 Project Management: CEM1	H

AC 11	Actual measurement data and replanning data for the software project are recorded.	Project Planning: T2.5 *Measurement Plan* Project Management: T5, *Project Record* Project Management: CET4	H
AC 12	The software engineering group conducts periodic internal reviews to track technical progress, plans, performance, and issues against the software development plan.	Project Management: CEV1 Performance Improvement: T1	H
AC 13	Formal reviews to address the accomplishments and results of the software project are conducted at selected project milestones according to a documented procedure.	Project Management: CEV1 Performance Improvement: T1	H

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the software tracking and oversight activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software project tracking and oversight are reviewed with senior management on a periodic basis.	Project Management: CEV1	H
VE2	The activities for software project tracking and oversight are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	H

VE3	The software quality assurance group reviews and/or audits the activities and work products for software project tracking and oversight and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.2.4 Software Subcontract Management

Correspondence Analysis

The Cleanroom processes do not define explicit management and organizational activities for software subcontracting, and thus the overall correspondence with the Software Subcontract Management KPA is rated as Consistent.

However, Cleanroom provides modern technology and engineering methods that can provide effective support for software subcontracting. In this approach, the prime contractor subcontracts for Cleanroom software engineering services. The prime contractor can apply Cleanroom processes in defining the contract and tracking and evaluating subcontractor performance. Cleanroom requires rigorous specification, design, and certification work products whose properties can be objectively assessed by the prime contractor. For example, a subcontract could include an agreement on required software function and certification goals, such that the prime contractor will

- provide software function and usage requirements
- define certification goals to be achieved
- conduct statistical acceptance testing based on agreed usage models

and the subcontractor will

- develop box structure specifications based on function requirements
- develop usage models based on usage requirements
- carry out incremental development and delivery
- demonstrate achievement of certification goals through statistical testing based on agreed usage models

Such an agreement defines precise objectives, work products, and completion criteria for successful subcontract management. In this case, managing the subcontract amounts to managing a Cleanroom project.

Overall correspondence: Consistent

Correspondence Mapping

CMM Process Element		Cleanroom Process Implementation	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The prime contractor selects qualified software subcontractors.	Ability to perform the Cleanroom processes forms a basis for subcontractor selection.	C
GO2	The prime contractor and the software subcontractor agree to their commitments to each other.	---	C
GO3	The prime contractor and the software subcontractor maintain ongoing communications.	---	C
GO4	The prime contractor tracks the software subcontractor's actual results and performance against its commitments.	Project Management: Prime contractor can track results of Cleanroom specification, development and certification.	C

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for managing the software subcontract.	Project Planning: T2.2, *Project Organization Plan*	C
CO2	A subcontract manager is designated to be responsible for establishing and managing the software subcontract.	Project Planning: T2.2, *Project Organization Plan*	C

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for selecting the software subcontractor and managing the subcontract.	Project Planning: T2.4, *Schedule and Resource Plan*	C
AB2	Software managers and other individuals who are involved in establishing and managing the software subcontract are trained to perform these activities.	Project Planning: T2.9, *Training Plan*	C
AB3	Software managers and other individuals who are involved in managing the software subcontract receive orientation in the technical aspects of the subcontract.	Project Planning: T2.9, *Training Plan*	C

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The work to be subcontracted is defined and planned according to a documented procedure.	Project Planning Requirements Analysis: *Software Requirements* Function Specification: *Function Specification* Usage Specification: *Usage Specification* Increment Planning: *Increment Construction Plan*	C
AC2	The software subcontractor is selected, based on an evaluation of the subcontract bidder's ability to perform the work, according to a documented procedure.	Ability to perform the Cleanroom processes forms a basis for subcontractor evaluation.	C
AC3	The contractual agreement between the prime contractor and the software subcontractor is used as the basis for managing the subcontract.	---	C
AC4	A documented subcontractor's software development plan is reviewed and approved by the prime contractor.	Project Planning: V2	C

AC5	A documented and approved subcontractor's software development plan is used for tracking the software activities and communicating status.	Project Management: T5	C
AC6	Changes to the software subcontractor's statement of work, subcontract terms and conditions, and other commitments are resolved according to a documented procedure.	Project Management: CET3 Engineering Change	C
AC7	The prime contractor's management conducts periodic status / coordination reviews with the software subcontractor's management.	Project Management: CEV1	C
AC8	Periodic technical reviews and interchanges are held with the software subcontractor.	Project Management: T2 Project Management: V1	C
AC9	Formal reviews to address the subcontractor's software engineering accomplishments and results are conducted at selected milestones according to a documented procedure.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: CEV1 Performance Improvement: CEV1 Increment Planning: T2, *Increment Construction Plan*	C
AC 10	The prime contractor's software quality assurance group monitors the subcontractor's software quality assurance activities according to a documented procedure.	---	C
AC 11	The prime contractor's software configuration management group monitors the subcontractor's activities for software configuration management according to a documented procedure.	---	C

AC 12	The prime contractor conducts acceptance testing as part of the delivery of the subcontractor's software products according to a documented procedure.	Prime contractor applies Usage Specification Usage Modeling & Test Planning Statistical Testing & Certification	C
AC 13	The software subcontractor's performance is evaluated on a periodic basis, and the evaluation is reviewed with the subcontractor.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: CEV1 Performance Improvement: CEV1 Increment Planning: T2, *Increment Construction Plan*	C

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the activities for managing the software subcontract.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	C

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for managing the software subcontract are reviewed with senior management on a periodic basis.	Project Management: CEV1	C
VE2	The activities for managing the software subcontract are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	C
VE3	The software quality assurance group reviews and/or audits the activities and work products for managing the software subcontract and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.2.5 Software Quality Assurance

Correspondence Analysis

The Cleanroom processes do not require a separate Software Quality Assurance function, although such a function is compatible with Cleanroom operations. Cleanroom does not define explicit management and organizational activities for SQA group operations. The addition of an SQA group would justify an overall correspondence rating with the Software Quality Assurance KPA of High.

However, quality control is a key element of the Cleanroom processes, which provide modern methods for integrating software quality assessment and assurance functions into Cleanroom operations as an intrinsic activity. In particular, Cleanroom provides technology and methods for precise software specification and design, correctness verification, scientific quality measurement and certification, and engineering change control. These alternative methods satisfy the intent of SQA goals 1, 2, and 3, and a rating of High might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that required SQA activities are accomplished through alternate methods. A conservative rating of overall correspondence with the Software Quality Assurance KPA is Partial.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element	**Cleanroom Process Implementation**	
Goals	**Process Name: Section, *Relevant Work Products***	**Corr**
GO1 Software quality assurance activities are planned.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.2, *Project Organization Plan* Project Planning: T2.5, *Measurement Plan* Project Planning: T2.7, *Risk Analysis Plan* Project Planning: T2.10, *Configuration Management Plan* Correctness Verification Usage Modeling and Test Planning Statistical Testing and Certification	H

GO2	Adherence of software products and activities to the applicable standards, procedures, and requirements is verified objectively.	Project Management: O1 Project Management: O2 Project Management: T5 Project Management: CEV1 Performance Improvement T1 Correctness Verification Statistical Testing & Certification	A
GO3	Affected groups and individuals are informed of software quality assurance activities and results.	Project Planning: V1 Project Planning: V2 Project Planning: CET1 Project Management: CEV1	H
GO4	Noncompliance issues that cannot be resolved within the software project are addressed by senior management.	Project Management: CEV1	C

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for implementing software quality assurance (SQA).	Project Planning: T1.1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan*	H

CMM Process Element		**Cleanroom Process Implementation**	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A group that is responsible for coordinating and implementing SQA for the project (i.e., the SQA group) exists.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A
AB2	Adequate resources and funding are provided for performing the SQA activities.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB3	Members of the SQA group are trained to perform their SQA activities.	Project Planning: T2.9, *Training Plan* Project Management: T3	A

AB4	The members of the software project receive orientation on the role, responsibilities, authority, and value of the SQA group.	Project Planning: T2.9, *Training Plan* Project Management: T3	A

CMM Process Element		**Cleanroom Process Implementation**	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	A SQA plan is prepared for the software project according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.2, *Project Organization Plan* Project Planning: T2.5, *Measurement Plan* Project Planning: T2.7, *Risk Analysis Plan* Project Planning: T2.10, *Configuration Management Plan* Correctness Verification Usage Modeling and Test Planning Statistical Testing and Certification	H
AC2	The SQA group's activities are performed in accordance with the SQA plan.	Project Management: O1 Project Management: O2 Project Management: T4 Project Management: T5 Project Management: CEV1 Performance Improvement T1 Correctness Verification Statistical Testing & Certification	A
AC3	The SQA group participates in the preparation and review of the project's software development plan, standards, and procedures.	Project Planning: T2, *Software Development Plan* Project Planning: V2	A
AC4	The SQA group reviews the software engineering activities to verify compliance.	SQA review elements are distributed among Cleanroom processes, especially the following: Project Management: T5 Project Management: CEV1 Performance Improvement T1 Correctness Verification Statistical Testing & Certification	A
AC5	The SQA group audits designated software work products to verify compliance.	Project Management: T5 Project Management: CEV2 Correctness Verification: T2 Statistical Testing & Certification: T6	A

AC6	The SQA group periodically reports the results of its activities to the software engineering group.	---	C
AC7	Deviations identified in the software activities and software work products are documented and handled according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Management: T5 Project Management: CET4	H
AC8	The SQA group conducts periodic reviews of its activities and findings with the customer's SQA personnel, as appropriate.	---	C

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the cost and schedule status of the SQA activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The SQA activities are reviewed with senior management on a periodic basis.	Project Management: CEV1	A
VE2	The SQA activities are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	A
VE3	Experts independent of the SQA group periodically review the activities and software work products of the project's SQA group.	---	C

4.2.6 Software Configuration Management

Correspondence Analysis

Cleanroom requires procedures for configuration management of all work products associated with specification, development, and certification. Cleanroom processes focus on explicit control of change management activities. However, Cleanroom does not prescribe procedures for defining work product baselines; this addition and associated management processes would justify a change in the overall correspondence rating from Partial to High.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Software configuration management activities are planned.	Project Planning: T2.10, *Configuration Management Plan*	P
GO2	Selected software work products are identified, controlled, and available.	Project Planning: T2.3, *Work Product Plan* Project Planning: T2.10, *Configuration Management Plan* Project Management: T4	P
GO3	Changes to identified software work products are controlled.	Project Planning: T2.10, *Configuration Management Plan* Project Management: CEEn2 Project Management: CET3 Engineering Change	H
GO4	Affected groups and individuals are informed of the status and content of software baselines.	Project Management: T1 Project Management: T2 Project Management: CEV2	L

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for implementing software configuration management.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.10, *Configuration Management Plan*	P

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A board having the authority for managing the project's software baselines (i.e., a software configuration control board - SCCB) exists or is established.	---	C
AB2	A group that is responsible for coordinating and implementing SCM for the project (i.e., the SCM group) exists.	Project Planning: T2.2, *Project Organization Plan*	P
AB3	Adequate resources and funding are provided for performing the SCM activities.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	P
AB4	Members of the SCM group are trained in the objectives, procedures, and methods for performing their duties.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	C
AB5	Members of the software engineering group and other software-related groups are trained to perform their SCM activities.	Project Planning: T2.9 *Training Plan* Project Management: T3 Project Management: CET1	P

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	A SCM plan is prepared for each software project according to a documented procedure.	Project Planning: T2.10, *Configuration Management Plan*	P

AC2	A documented and approved SCM plan is used as the basis for performing the SCM activities.	Project Planning: T2.10, *Configuration Management Plan* Project Planning: V2 Project Management: T4	P
AC3	A configuration management library system is established as a repository for the software baselines.	---	C
AC4	The software work products to be placed under configuration management are identified.	Project Planning: T2.3, *Work Product Plan* Project Planning: T2.10, *Configuration Management Plan*	P
AC5	Change requests and problem reports for all configuration items / units are initiated, recorded, reviewed, approved, and tracked according to a documented procedure.	Engineering Change: *Engineering Change Log*	H
AC6	Changes to baselines are controlled according to a documented procedure.	Project Planning: T2.10, *Configuration Management Plan* Project Management: CEEn2 Project Management: CET3 Engineering Change: *Engineering Change Log*	L
AC7	Products from the software baseline library are created and their release is controlled according to a documented procedure.	---	C
AC8	The status of configuration items / units is recorded according to a documented procedure.	Project Planning: T2.10, *Configuration Management Plan* Engineering Change: *Engineering Change Log*	P
AC9	Standard reports documenting the SCM activities and the content of the software baseline are developed and made available to affected groups and individuals.	---	C
AC 10	Software baseline audits are conducted according to a documented procedure.	---	C

CMM Process Element		Cleanroom Process Implementation	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the SCM activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	P

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The SCM activities are reviewed with senior management on a periodic basis.	Project Management: CEV1	P
VE2	The SCM activities are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	P
VE3	The SCM group periodically audits software baselines to verify that they conform to the documentation that defines them.	---	C
VE4	The software quality assurance group reviews and/or audits the activities and work products for SCM and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.3 Cleanroom Implementation of Level 3 KPAs

4.3.1 Organization Process Focus

Correspondence Analysis

The Cleanroom processes generally focus on the software project level, and do not define management activities at the organizational level. If Cleanroom is instantiated at the project level only, therefore, the overall correspondence with the Organization Process Focus KPA is Consistent. If Cleanroom is the standard organizational process, however, the correspondence could be Partial or High.

Overall correspondence: Consistent

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Software process development and improvement activities are coordinated across the organization.	---	C
GO2	The strengths and weaknesses of the software processes used are identified relative to a process standard.	Project Planning: T2.4, *Measurement Plan* Performance Improvement: M1, *Performance Improvement Plan*	P
GO3	Organization-level process development and improvement activities are planned.	---	C

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written organizational policy for coordinating software process development and improvement activities across the organization.	*Cleanroom Engineering Guide* for the organization	C
CO2	Senior management sponsors the organization's activities for software process development and improvement.	---	C
CO3	Senior management oversees the organization's activities for software process development and improvement.	Project Planning: CEV1, *Cleanroom Engineering Guide* Performance Improvement: CEV1, *Performance Improvement Plan*	C

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A group that is responsible for the organization's software process activities exists.	Project Planning: T2.2, *Project Organization Plan*	C
AB2	Adequate resources and funding are provided for the organization's software process activities.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	C
AB3	Members of the group responsible for the organization's software process activities receive required training to perform these activities.	Project Planning: T2.9, *Training Plan* Project Planning: CET1 Project Management: T3 Project Management: CET1	C
AB4	Members of the software engineering group and other software-related groups receive orientation on the organization's software process activities and their roles in those activities.	Project Planning: T2.9, *Training Plan* Project Planning: CET1 Project Management: T3 Project Management: CET1	C

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software process is assessed periodically, and action plans are developed to address the assessment findings.	Performance Improvement: T1, *Performance Improvement Plan*	P
AC2	The organization develops and maintains a plan for its software process development and improvement activities.	Performance Improvement: *Performance Improvement Plan*	C
AC3	The organization's and project's activities for developing and improving their software processes are coordinated at the organization level.	---	C
AC4	The use of the organization's software process database is coordinated at the organizational level.	---	C
AC5	New processes, methods, and tools in limited use in the organization are monitored, evaluated, and, where appropriate, transferred to other parts of the organization.	Performance Improvement: T2, *Performance Improvement Plan* Performance Improvement: M1	P
AC6	Training for the organization's and project's software processes is coordinated across the organization.	---	C
AC7	The groups involved in implementing the software processes are informed of the organization's and project's activities for software process development and improvement.	Project Planning: T2.2, *Project Organization Plan* Project Planning: V1 Performance Improvement: CEV1	C

CMM Process Element		Cleanroom Process Implementation	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the organization's process development and improvement activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Project Management: T7 Performance Improvement: T1, *Performance Improvement Plan* Performance Improvement: Measurement section Performance Improvement: CEV1	P

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software process development and improvement are reviewed with senior management on a periodic basis.	Project Planning: CEV1 Project Management: CEV1 Performance Improvement: CEV1	P

4.3.2 Organization Process Definition

Correspondence Analysis

The Cleanroom processes generally focus on the software project level, and do not define management activities at the organizational level. If Cleanroom is instantiated at the project level only, therefore, the overall correspondence with the Organization Process Focus KPA is Partial. If Cleanroom is the standard organizational process, however, many of the KPA elements would be rated as having a High correspondence, and the overall rating could be High.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	A standard software process for the organization is developed and maintained.	*Cleanroom Engineering Guide* for the organization	P
GO2	Information related to the use of the organization's standard software process by software projects is collected, reviewed, and made available.	Project Planning: T1, *Cleanroom Engineering Guide* Project Management: T5 Project Management: CET4 Project Management: CEV1, *Project Record* Performance Improvement: T1, *Performance Improvement Plan*	P

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written policy for developing and maintaining a standard software process and related process assets.	---	C

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for developing and maintaining the organization's standard software process and related process assets.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	C
AB2	The individuals who develop and maintain the organization's standard software process and related process assets receive required training to perform these activities.	Project Planning: T2.9, *Training Plan* Project Management: T3	C

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The organization's standard software process is developed and maintained according to a documented procedure.	---	C
AC2	The organization's standard software process is documented according to established organization standards.	---	C
AC3	Descriptions of software life cycles that are approved for use by the projects are documented and maintained.	*Cleanroom Engineering Guide* for the organization	P
AC4	Guidelines and criteria for the project's tailoring of the organization's standard software process are developed and maintained.	*Cleanroom Engineering Guide* for the organization	P
AC5	The organization's software process database is established and maintained.	---	C

AC6	A library of software process-related documentation is established and maintained.	---	C

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the organization's process definition activities.	Project Planning: T2.5, *Measurement Plan* Performance Improvement: CEM1, *Project Record* Performance Improvement: CEV1 Performance Improvement: T1	P

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The software quality assurance group reviews and/or audits the organization's activities and work products for developing and maintaining the organization's standard software process and related process assets and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.3.3 Training Program

Correspondence Analysis

The Cleanroom processes generally focus on the software project level, and do not define training activities at the organizational level. If Cleanroom is instantiated at the project level only, therefore, the overall correspondence with the Organization Process Focus KPA is Partial. If Cleanroom is the standard organizational process, however, the correspondence could be High.

The Cleanroom processes emphasize and require formal training in project management, incremental development, software specification, design, and correctness verification, and statistical testing and certification.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Training activities are planned.	Project Planning: T2.9, *Training Plan*	P
GO2	Training for developing the skills and knowledge needed to perform software management and technical roles is provided.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	P
GO3	Individuals in the software engineering group and software-related groups receive the training necessary to perform their roles.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	P

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written policy for meeting its training needs.	Project Planning: T2.9, *Training Plan* Project Management: T3	C

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A group responsible for fulfilling the training needs of the organization exists.	---	C
AB2	Adequate resources and funding are provided for implementing the training program.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	P
AB3	Members of the training group have the necessary skills and knowledge to perform their training activities.	---	C
AB4	Software managers receive orientation on the training program	Project Planning: T2.9, *Training Plan* Project Planning: V2 Project Planning: CET1	P

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	Each software project develops and maintains a training plan that specifies its training needs.	Project Planning: T2.9, *Training Plan*	H
AC2	The organization's training plan is developed and revised according to a documented procedure.	---	C
AC3	The training for the organization is performed in accordance with the organization's training plan.	Project Planning: T2.9, *Training Plan* Project Management: T3	P
AC4	Training courses prepared at the organization level are developed and maintained according to organization standards.	---	C

AC5	A waiver procedure for required training is established and used to determine whether individuals already possess the knowledge and skills required to perform in their designated roles.	---	C
AC6	Records of training are maintained.	---	C

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the training program activities.	---	C
ME2	Measurements are made and used to determine the quality of the training program.	---	C

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The training program activities are reviewed with senior management on a periodic basis.	Project Management: CEV1	P
VE2	The training program is independently evaluated on a periodic basis for consistency with, and relevance to, the organization's needs.	---	C
VE3	The training program activities and work products are reviewed and/or audited and the results are reported.	---	C

4.3.4 Integrated Software Management

Correspondence Analysis

Cleanroom project plans are developed and tailored based on the Cleanroom Reference Model, and the Cleanroom incremental development life cycle affords a stepwise, controlled framework for managing project performance, reducing risk, and reviewing and revising project plans.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The project's defined software process is a tailored version of the organization's standard software process.	Project Planning: O1 Project Planning: T1, *Cleanroom Engineering Guide*	H
GO2	The project is planned and managed according to the project's defined software process.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan* Project Management Project Management: T5 Project Management: CEV1	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy requiring that the software project be planned and managed using the organization's standard software process and related process assets.	Project Planning: O2 Project Planning: T1, *Cleanroom Engineering Guide* Project Management	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for managing the software project using the project's defined software process.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB2	The individuals responsible for developing the project's defined software process receive required training in how to tailor the organization's standard software process and use the related process assets.	Project Planning: T2.9, *Training Plan* Project Planning: CET1 Project Management: T3 Project Management: CET1	H
AB3	The software managers receive required training in managing the technical, administrative, and personnel aspects of the software project based on the project's defined software process.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The project's defined software process is developed by tailoring the organization's standard software process according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide*	H
AC2	Each project's defined software process is revised according to a documented procedure.	Project Planning: En2 Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T1, *Performance Improvement Plan*	H

AC3	The project's software development plan, which describes the use of the project's defined software process, is developed and revised according to a documented procedure.	Project Planning: En1 Project Planning: En2 Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan*	H
AC4	The software project is managed in accordance with the project's defined software process.	Project Management: T4 Project Management: T5	H
AC5	The organization's software process database is used for software planning and estimating.	---	C
AC6	The size of the software work products (or size of changes to the software work products) is managed according to a documented procedure.	Project Planning: T2.3, *Work Product Plan* Project Planning: T2.5, *Measurement Plan* Project Management: T4 Project Management: T5 Increment Planning: T1, *Increment Construction Plan*	H
AC7	The project's software effort and costs are managed according to a documented procedure.	Project Planning: T2.4 ,*Schedule and Resource Plan* Project Management: T4 Project Management: T5	H
AC8	The project's critical computer resources are managed according to a documented procedure.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T5	H
AC9	The critical dependencies and critical paths of the project's software schedule are managed according to a documented procedure.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4 Project Management: T5 Increment Planning: T1, *Increment Construction Plan* Increment Planning: T2	H
AC 10	The project's software risks are identified, assessed, documented, and managed according to a documented procedure.	Project Planning: T2.7, *Risk Analysis Plan* Project Management: T6 Project Management: CEV1	H

AC 11	Reviews of the software project are periodically performed to determine the actions needed to bring the software project's performance and results in line with the current and projected needs of the business, customer, and end users, as appropriate.	Project Management: CEV1	H

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the effectiveness of the integrated software management activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for managing the software project are reviewed with senior management on a periodic basis.	Project Management: CEV1	H
VE2	The activities for managing the software project are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for managing the software project and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.3.5 Software Product Engineering

Correspondence Analysis

The Cleanroom processes and work products provide a complete implementation of the Software Product Engineering KPA for software management, requirements, specification, architecture, design, verification, testing, and certification. Cleanroom also supports reuse and reengineering of software within the SPE context.

With respect to SPE Activity 6, integration testing is not a separate activity in the Cleanroom process. In Cleanroom, integration is intrinsic to the stepwise incremental development and certification process. Certification testing of successive increment accumulations is carried out in the system environment.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The software engineering tasks are defined, integrated, and consistently performed to produce the software.	Project Planning: *Cleanroom Engineering Guide, Software Development Plan* Project Management: *Project Record* Engineering Change: *Engineering Change Log* Requirements Analysis: *Software Requirements* Function Specification: *Function Specification* Usage Specification: *Usage Specification* Architecture Specification: *Software Architecture* Increment Planning: *Increment Construction Plan* Software Reengineering: *Reengineering Plan, Reengineered Software* Increment Design: *Increment Design* Correctness Verification: *Increment Verification Report* Usage Modeling & Test Planning: *Usage Models, Increment Test Plan, Statistical Test Cases* Statistical Testing & Certification: *Executable System, Statistical Testing Report, Increment Certification Report*	H

GO2	Software work products are kept consistent with each other.	Project Planning: T2.10, *Configuration Management Plan* All GO1 processes: CEO1 All GO1 processes: CET3 Engineering Change	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for performing the software engineering activities.	Project Planning: T1, *Cleanroom Engineering Guide* Project Management: T4	H

CMM Process Element		**Cleanroom Process Implementation**	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for performing the software engineering tasks.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB2	Members of the software engineering technical staff receive required training to perform their technical assignments.	Project Planning: T2.9, *Training Plan* Project Management: T3	H
AB3	Members of the software engineering technical staff receive orientation in related software engineering disciplines.	Project Planning: T2.9, *Training Plan* Project Management: T3	H
AB4	The project manager and all software managers receive orientation in technical aspects of the software project.	Project Planning: T2.9, *Training Plan* Project Management: T3	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	Appropriate software engineering methods and tools are integrated into the project's defined software process.	Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T2, *Performance Improvement Plan*	H
AC2	The software requirements are developed, maintained, documented, and verified by systematically analyzing the allocated requirements according to the project's defined software process.	Project Planning: T1, *Cleanroom Engineering Guide* Requirements Analysis: *Software Requirements*	H
AC3	The software design is developed, maintained, documented, and verified, according to the project's defined software process, to accommodate the software requirements and to form the framework for coding.	Project Planning: *Cleanroom Engineering Guide, Software Development Plan* Project Management: *Project Record* Engineering Change: *Engineering Change Log* Requirements Analysis: *Software Requirements* Function Specification: *Function Specification* Architecture Specification: *Software Architecture* Increment Planning: *Increment Construction Plan* Software Reengineering: *Reengineered Software* Increment Design: *Increment Design* Correctness Verification: *Increment Verification Report*	H
AC4	The software code is developed, maintained, documented, and verified, according to the project's defined software process, to implement the software requirements and software design.	Project Planning: *Cleanroom Engineering Guide, Software Development Plan* Project Management: *Project Record* Engineering Change: *Engineering Change Log* Increment Planning: *Increment Construction Plan* Software Reengineering: *Reengineered Software* Increment Design: *Increment Design* Correctness Verification: *Increment Verification Report*	H
AC5	Software testing is performed according to the project's defined software process.	Project Planning: T1, *Cleanroom Engineering Guide* Project Management: *Project Record* Usage Specification: *Usage Specification* Increment Planning: T2, *Increment Construction Plan* Usage Modeling & Test Planning: *Usage Models, Increment Test Plan, Statistical Test Cases* Statistical Testing & Certification: *Executable System, Statistical Testing Report, Increment Certification Report*	H

AC6	Integration testing of the software is planned and performed according to the project's defined software process.	In Cleanroom, integration is accomplished through incremental development. Each increment is tested in the system environment, as described in AC7.	H
AC7	System and acceptance testing of the software are planned and performed to demonstrate that the software satisfies its requirements.	Project Management: T2.4, *Schedule and Resource Plan* Usage Specification: *Usage Specification* Increment Planning: *Increment Construction Plan* Usage Modeling & Test Planning: *Usage Models, Increment Test Plan, Statistical Test Cases* Statistical Testing & Certification: *Executable System, Statistical Testing Report, Increment Certification Report*	H
AC8	The documentation that will be used to operate and maintain the software is developed and maintained according to the project's defined software process.	Project Planning: T2.3, *Work Product Plan*	H
AC9	Data on defects identified in peer reviews and testing are collected and analyzed according to the project's defined software process.	Project Planning: T2.5, *Measurement Plan* All GO1 processes: CEO2 All GO1 processes: Verification section All GO1 processes: CEM1 All GO1 processes: CEM2 Engineering Change: *Engineering Change Log* Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report, Increment Certification Report* Performance Improvement: T1, *Performance Improvement Plan*	H
AC 10	Consistency is maintained across software work products, including the software plans, process descriptions, allocated requirements, software requirements, software design, code, test plans, and test procedures.	Project Planning: T2.10, *Configuration Management Plan* All GO1 processes: CEO1 All GO1 processes: CET3 Engineering Change	H

CMM Process Element		Cleanroom Process Implementation	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the functionality and quality of the software products.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 All GO1 processes: Measurement and Verification sections Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report*, *Increment Certification Report*	H
ME2	Measurements are made and used to determine the status of the software product engineering activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 All GO1 processes: Measurement and Verification sections Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report*, *Increment Certification Report* Performance Improvement: T1	H

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software product engineering are reviewed with senior management on a periodic basis.	All GO1 processes: CEV1	H
VE2	The activities for software product engineering are reviewed with the project manager on both a periodic and event-driven basis.	All GO1 processes: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for software product engineering and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.3.6 Intergroup Coordination

Correspondence Analysis

Cleanroom specifies the roles, responsibilities, and dependencies among individuals and groups on the project team by prescribing the engineering methods through which they will work and the work products through which they will communicate. In addition, Cleanroom processes require customer and peer group review, coordination, and concurrence throughout the period of software project performance.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The customer's requirements are agreed to by all affected groups.	Project Planning: T2, *Software Development Plan* Project Planning: V2 Requirements Analysis: T1, *Software Requirements* Requirements Analysis: V2	H
GO2	The commitments between the engineering groups are agreed to by the affected groups.	Project Planning: T2.2, *Project Organization Plan* Project Planning: V2	H
GO3	The engineering groups identify, track, and resolve intergroup issues.	Project Management: CEV1	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for establishing interdisciplinary engineering teams.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.2, *Project Organization Plan* Project Management: T3	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for coordinating the software engineering activities with other engineering groups.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB2	The support tools used by the different engineering groups are compatible to enable effective communication and coordination.	Project Planning: T1.2, *Cleanroom Engineering Guide*	C
AB3	All managers in the organization receive required training in teamwork.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H
AB4	All task leaders in each engineering group receive orientation in the processes, methods, and standards used by the other engineering groups.	Project Planning: T2.9, *Training Plan* Project Management: T2 Project Management: T3 Project Management: CET1	H
AB5	The members of the engineering groups receive orientation in working as a team.	Project Planning: T2.9, *Training Plan* Project Management: T3	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software engineering group and the other engineering groups participate with the customer and end users, as appropriate, to establish the system requirements.	Project Planning: T2.1 *Project Mission Plan* Project Planning: V2 Project Management: T1 Requirements Analysis: T1 Requirements Analysis: T2	H
AC2	Representatives of the project's software engineering group work with representatives of the other engineering groups to monitor and coordinate technical activities and resolve technical issues.	Project Planning: T2.2, *Project Organization Plan* Project Management: T2 Project Management: T4 Project Management: V1 Project Management: CEV1	H

AC3	A documented plan is used to communicate intergroup commitments and to coordinate and track the work performed.	Project Planning: T2.2, *Project Organization Plan* Project Management: T2, *Project Record* Project Management: CEV1	H
AC4	Critical dependencies between engineering groups are identified, negotiated, and tracked according to a documented procedure.	Project Planning: T2.2 *Project Organization Plan* Project Planning: V2 Project Management: T2 Project Management: T5 Project Management: CEV1	H
AC5	Work products produced as input to other engineering groups are reviewed by representatives of the receiving groups to ensure that the work products meet their needs.	Project Management: T2	P
AC6	Intergroup issues not resolvable by the individual representatives of the project engineering groups are handled according to a documented procedure.	Project Planning: T2.2, *Project Organization Plan* Project Management: T2 Project Management: CEV1	P
AC7	Representatives of the project engineering groups conduct periodic technical reviews and interchanges.	Project Planning: T2.2, *Project Organization Plan* Project Management: T2 Project Management: CEV2	P

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the intergroup coordination activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Performance Improvement: T1	P

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for intergroup coordination are reviewed with senior management on a periodic basis.	Project Management: CEV1	H

VE2	The activities for intergroup coordination are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for intergroup coordination and reports the results.	---	C

4.3.7 Peer Reviews

Correspondence Analysis

Cleanroom is a team-based process involving ongoing peer review in every task and of every work product. Peer review is essential to the Cleanroom objective of intellectual control of evolving products. Cleanroom provides technology and processes for mathematics-based correctness verification of software specifications, designs, and implementations in team reviews.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Peer review activities are planned.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule & Resource Plan* Increment Planning: T2, *Increment Construction Plan* Correctness Verification	H
GO2	Defects in the software work products are identified and removed.	Following processes, CEO2 and Verification sections: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Usage Modeling & Test Planning Correctness Verification Engineering Change: T4	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for performing peer reviews.	Project Planning: T1, *Cleanroom Engineering Guide* Correctness Verification	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for performing peer reviews on each software work product to be reviewed.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB2	Peer review leaders receive required training in how to lead peer reviews.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H
AB3	Reviewers who participate in peer reviews receive required training in the objectives, principles, and methods of peer reviews.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	Peer reviews are planned, and the plans are documented.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule & Resource Plan* Increment Planning: T2, *Increment Construction Plan* Correctness Verification	H
AC2	Peer reviews are performed according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Following processes, Verification sections: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Usage Modeling & Test Planning Correctness Verification	H
AC3	Data on the conduct and results of the peer reviews are recorded.	Following processes, Verification sections and *Project Record*: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Usage Modeling & Test Planning Correctness Verification: T2, *Increment Verification Report*	H

CMM Process Element		Cleanroom Process Implementation	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the peer review activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Following processes, Measurement and Verification sections: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Usage Modeling & Test Planning Correctness Verification: *Increment Verification Report* Performance Improvement: T1	H

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The software quality assurance group reviews and/or audits the activities and work products for peer reviews and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.4 Cleanroom Implementation of Level 4 KPAs

4.4.1 Quantitative Process Management

Correspondence Analysis

Cleanroom process management is based on incremental development under statistical process control, in particular, the measures produced by statistical testing and certification. Statistical process control is a defining characteristic of Cleanroom. As is the case in statistical process control in general, process performance is measured and compared with performance targets, and deviations are evaluated in the context of the range of historical deviations in performance. In the absence of historical data, quantitative process decisions may be based on industry standards, expected values, customer requirements, or some combination of these criteria.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The quantitative process management activities are planned.	Project Planning: T2.5, *Measurement Plan*	H
GO2	The process performance of the project's defined software process is controlled quantitatively.	Project Management: O2 Project Management: O3 Project Management: T5 Statistical Testing & Certification: T5 Statistical Testing & Certification: T6 Statistical Testing & Certification: T7	H
GO3	The process capability of the organization's standard software process is known in quantitative terms.	Project Planning: T2.5, *Measurement Plan*	H

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for measuring and quantitatively controlling the performance of the project's defined software process.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Statistical Testing & Certification	H
CO2	The organization follows a written policy for analyzing the process capability of the organization's standard software process.	Project Planning: T2.5, *Measurement Plan* Performance Improvement T1, *Performance Improvement Plan*	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A group that is responsible for coordinating the quantitative process management activities for the organization exists.	Project Planning: T2.2, *Project Organization Plan*	C
AB2	Adequate resources and funding are provided for the quantitative process management activities.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB3	Support exists for collecting, recording, and analyzing data for selected process and product measurements.	Project Planning: T2.5, *Measurement Plan* Project Planning: T2.4, *Schedule and Resource Plan*	H
AB4	The individuals implementing or supporting quantitative process management receive required training to perform these activities.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H
AB5	The members of the software engineering group and other software-related groups receive orientation on the goals and value of quantitative process management.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software project's plan for quantitative process management is developed according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.5, *Measurement Plan*	H
AC2	The software project's quantitative process management activities are performed in accordance with the project's quantitative process management plan.	Project Management: T4 Project Management: T5 Project Management: CEV1 Performance Improvement: T1	H
AC3	The strategy for the data collection and the quantitative analysis to be performed are determined based on the project's defined software process.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.5, *Measurement Plan*	H
AC4	The measurement data used to control the project's defined software process quantitatively are collected according to a documented procedure.	Project Management: T2.5, *Measurement Plan* Project Management: T5 Usage Modeling & Test Planning: T5, *Increment Test Plan* Statistical Testing & Certification: *Statistical Testing Report*, *Increment Certification Report*	H
AC5	The project's defined software process is analyzed and brought under quantitative control according to a documented procedure.	Project Management: T2.5, *Measurement Plan* Project Management: T5 Project Management: T5 Project Management: T7 Statistical Testing & Certification: T6 Performance Improvement: T1	H
AC6	Reports documenting the results of the software project's quantitative process management activities are prepared and distributed.	Statistical Testing & Certification: T6, *Increment Certification Report* Performance Improvement: T1, *Performance Improvement Plan*	H
AC7	The process capability baseline for the organization's standard software process is established and maintained according to a documented procedure.	*Cleanroom Engineering Guide* for the organization	C

CMM Process Element		Cleanroom Process Implementation	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the activities for quantitative process management.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Statistical Testing & Certification: T5, *Increment Certification Report* Statistical Testing & Certification: T6 Statistical Testing & Certification: T7 Performance Improvement: T1	H

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for quantitative process management are reviewed with senior management on a periodic basis.	Project Management: CEV1 Performance Improvement: CEV1	H
VE2	The software project's activities for quantitative process management are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1 Performance Improvement: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for quantitative process management and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.4.2 Software Quality Management

Correspondence Analysis

Development of high quality software products is a defining characteristic of Cleanroom. Extensive analysis of requirements, precise specification of function and usage, rigorous design, correctness verification, and continual customer feedback all contribute to software quality.

Objective measurement of software quality is a key Cleanroom activity. Software is certified to be fit for use if it exhibits specified characteristics in statistical certification testing. Certification goals may be specified by the customer, set by the product team, or given as a combination of the two. Progress toward software quality goals is assessed at regular intervals in increment testing and certification.

Overall correspondence: High

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	The project's software quality management activities are planned.	Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T1	H
GO2	Measurable goals for software product quality and their priorities are defined.	Project Planning: T2.5, *Measurement Plan* Usage Modeling & Test Planning: T5, *Increment Test Plan*	H
GO3	Actual progress toward achieving the quality goals for the software products is quantified and managed.	Project Management: T5, *Project Record* Statistical Testing & Certification: T5 Statistical Testing & Certification: T6 Statistical Testing & Certification: T7, *Increment Certification Report* Performance Improvement T1	H

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The project follows a written organizational policy for managing software quality.	Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T1	H

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	Adequate resources and funding are provided for managing the quality of the software products.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	H
AB2	The individuals implementing and supporting software quality management receive required training to perform their activities.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H
AB3	The members of the software engineering group and other software-related groups receive required training in software quality management.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The project's software quality plan is developed and maintained according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan* Correctness Verification Usage Modeling & Test Planning: T5, *Increment Test Plan* Performance Improvement T1, *Performance Improvement Plan*	H
AC2	The project's software quality plan is the basis for the project's activities for software quality management.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan* Project Management: T4 Project Management: T5 Project Management: T7 Performance Improvement T1, *Performance Improvement Plan* Statistical Testing & Certification	H

AC3	The project's quantitative quality goals for the software products are defined, monitored, and revised throughout the software life cycle.	Project Planning: T2.5, *Measurement Plan* Project Management: T5 Usage Modeling & Test Planning: T5, *Increment Test Plan* Statistical Testing & Certification: T5, *Increment Certification Report* Statistical Testing & Certification: T6 Performance Improvement T1, *Performance Improvement Plan*	H
AC4	The quality of the project's software products is measured, analyzed, and compared to the project's quantitative quality goals on an event-driven basis.	Project Management: T5 Project Management: CEV2 Project Management: CEM2 Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report, Increment Certification Report* Performance Improvement T1, *Performance Improvement Plan*	H
AC5	The software project's quantitative quality goals for the products are allocated appropriately to the subcontractors delivering software products to the project.	Increment Planning: *Increment Construction Plan*	C

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the software quality management activities.	Project Management: T2.5, *Measurement Plan* Project Management: T5 Project Management: CEM1, *Project Record* Project Management: CEV1 Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: T5, *Increment Certification Report* Statistical Testing & Certification: T6 Statistical Testing & Certification: T7 Performance Improvement: T1	H

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software quality management are reviewed with senior management on a periodic basis.	Project Management: CEV1	H
VE2	The activities for software quality management are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1	H
VE3	The software quality assurance group reviews and/or audits the activities and work products for software quality management and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.5 Cleanroom Implementation of Level 5 KPAs

4.5.1 Defect Prevention

Correspondence Analysis

Cleanroom is first and foremost about defect prevention. The Cleanroom name was borrowed from the semiconductor industry, in which a physical Cleanroom exists to prevent the introduction of defects in chip fabrication. Defect prevention is intrinsic to the technologies embodied in the Cleanroom processes. Defects are prevented through mathematically-based engineering methods for specification, design, and correctness verification, as well as through peer review, engineering change control, and continuous process improvement.

Overall correspondence: High

Correspondence Mapping

CMM Process Element	**Cleanroom Process Implementation**	
Goals	**Process Name: Section, *Relevant Work Products***	**Corr**
GO1 Defect prevention activities are planned.	Project Planning: T1, *Cleanroom Engineering Guide* Planned development activities in the following processes prevent defects through mathematically-based engineering methods: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Correctness Verification Usage Modeling & Test Planning Performance Improvement: T1, *Performance Improvement Plan*	H

GO2	Common causes of defects are sought out and identified.	Performance Improvement T1, *Performance Improvement Plan* Correctness Verification: T2, *Increment Verification Report* Statistical Testing & Certification: T4, *Statistical Testing Report*	H
GO3	Common causes of defects are prioritized and systematically eliminated.	Performance Improvement T1, *Performance Improvement Plan*	H

CMM Process Element		**Cleanroom Process Implementation**	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written policy for defect prevention activities.	*Cleanroom Engineering Guide* for the organization	P
CO2	The project follows a written organizational policy for defect prevention activities.	*Cleanroom Engineering Guide* for the organization	P

CMM Process Element		**Cleanroom Process Implementation**	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	An organization-level team to coordinate defect prevention activities exists.	---	C
AB2	A team to coordinate defect prevention activities for the software project exists.	Project Planning: T2.2, *Project Organization Plan*	H
AB3	Adequate resources and funding are provided for defect prevention activities at the project and organization levels.	Project Planning: T2.4, *Schedule and Resource Plan* Project Management: T4	P
AB4	Members of the software engineering group and other software-related groups receive required training to perform their defect prevention activities.	Project Planning: T2.9, *Training Plan* Project Management: T3 Project Management: CET1	H

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The software project develops and maintains a plan for its defect prevention activities.	Project Planning: T1, *Cleanroom Engineering Guide*	H
AC2	At the beginning of a software task, the members of the team performing the task meet to prepare for the activities of that task and the related defect prevention activities.	---	C
AC3	Causal analysis meetings are conducted according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T1, *Performance Improvement Plan*	H
AC4	Each of the teams assigned to coordinate defect prevention activities meets on a periodic basis to review and coordinate implementation of action proposals from the causal analysis meetings.	Performance Improvement: T1, *Performance Improvement Plan* Engineering Change: T1 Engineering Change: T2	H
AC5	Defect prevention data are documented and tracked across the teams coordinating defect prevention activities.	Project Management: T5, *Project Record* Performance Improvement: T1, *Performance Improvement Plan* Correctness Verification: T2, *Increment Verification Report* Statistical Testing & Certification: T4, *Statistical Testing Report*	H
AC6	Revisions to the organization's standard software process resulting from defect prevention actions are incorporated according to a documented procedure.	*Cleanroom Engineering Guide* for the organization Performance Improvement: T1	P
AC7	Revisions to the project's defined software process resulting from defect prevention actions are incorporated according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Project Management: T7 Performance Improvement: T1, *Performance Improvement Plan*	H

AC8	Members of the software engineering group and software-related groups receive feedback on the status and results of the organization's and project's defect prevention activities on a periodic basis.	Project Management: T7 Performance Improvement: T1 Performance Improvement: CEV1, *Performance Improvement Plan* Performance Improvement: CEV2	P

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the defect prevention activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Following processes, Measurement and Verification sections: Requirements Analysis Function Specification Usage Specification Architecture Specification Software Reengineering Increment Design Usage Modeling & Test Planning Correctness Verification: *Increment Verification Report* Statistical Testing and Certification: *Statistical Testing Report, Increment Certification Report* Performance Improvement: T1, *Performance Improvement Plan*	H

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The organization's activities for defect prevention are reviewed with senior management on a periodic basis.	---	C
VE2	The software project's activities for defect prevention are reviewed with the project manager on both a periodic and event-driven basis.	Project Management: CEV1 Performance Improvement: CEV1, *Performance Improvement Plan*	H

VE3	The software quality assurance group reviews and/or audits the activities and work products for defect prevention and reports the results.	While Cleanroom does not include an independent software quality assurance group, the addition of such a group would change this rating to H. However, a rating of H might be justified without an SQA group. The small team approach of Cleanroom with its associated checks and balances in team reviews and verifications helps ensure that SQA activities are accomplished by alternate methods.	A

4.5.2 Technology Change Management

Correspondence Analysis

The Cleanroom processes generally focus on the software project level, and do not define management activities at the organizational level. If Cleanroom is instantiated at the project level only, therefore, the overall correspondence with the Technology Change Management KPA is Partial. If Cleanroom is the standard organizational process, however, the correspondence could be High.

New software technologies are identified, and pilot applications are conducted to evaluate their potential effectiveness. The Cleanroom incremental development life cycle provides for planned and controlled technology introduction. Project data are reviewed and analyzed at the completion of each increment to identify technology improvement opportunities, and appropriate technology changes are implemented in the development of succeeding increments.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Incorporation of technology changes is planned.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2.4, *Schedule & Resource Plan* Project Management: T7 Increment Planning: T2, *Increment Construction Plan* Performance Improvement: T2, *Performance Improvement Plan*	P
GO2	New technologies are evaluated to determine their effect on quality and productivity.	Performance Improvement: T2, *Performance Improvement Plan*	P
GO3	Appropriate new technologies are transferred into normal practice across the organization.	*Cleanroom Engineering Guide* for the organization Performance Improvement: T2, *Performance Improvement Plan*	C

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written policy for improving its technology capability.	*Cleanroom Engineering Guide* for the organization Performance Improvement	C
CO2	Senior management sponsors the organization's activities for technology change management.	---	C
CO3	Senior management oversees the organization's technology change management activities.	---	C

CMM Process Element		Cleanroom Process Implementation	
Ability to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
AB1	A group responsible for the organization's technology change management activities exists.	---	C
AB2	Adequate resources and funding are provided to establish and staff a group responsible for the organization's technology change management activities.	---	C
AB3	Support exists for collecting and analyzing data needed to evaluate technology changes.	Project Planning: T1.2, *Cleanroom Engineering Guide* Project Planning: T2.5, *Measurement Plan* Project Management: T4	C
AB4	Appropriate data on the software processes and software work products are available to support analyses performed to evaluate and select technology changes.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report*, *Increment Certification Report* Performance Improvement: *Performance Improvement Plan*	H

AB5	Members of the group responsible for the organization's technology change management activities receive required training to perform these activities.	---	C

CMM Process Element		**Cleanroom Process Implementation**	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	The organization develops and maintains a plan for technology change management.	*Cleanroom Engineering Guide* for the organization	C
AC2	The group responsible for the organization's technology change management activities works with the software projects in identifying areas of technology change.	Performance Improvement: T2	P
AC3	Software managers and technical staff are kept informed of new technologies.	Performance Improvement: *Performance Improvement Plan*	P
AC4	The group responsible for the organization's technology change management systematically analyzes the organization's standard software process to identify areas that need or could benefit from new technology.	*Cleanroom Engineering Guide* for the organization	C
AC5	Technologies are selected and acquired for the organization and software projects according to a documented procedure.	*Cleanroom Engineering Guide* for the organization Performance Improvement: T2	P
AC6	Pilot efforts for improving technology are conducted, where appropriate, before a new technology is introduced into normal practice.	Performance Improvement: T2 Project Management: T7	P

AC7	Appropriate new technologies are incorporated into the organization's standard software process according to a documented procedure.	*Cleanroom Engineering Guide* for the organization Performance Improvement: T2	C
AC8	Appropriate new technologies are incorporated into the project's defined software process according to a documented procedure.	Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement: T2, *Performance Improvement Plan*	H

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the organization's activities for technology change management.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Performance Improvement: *Performance Improvement Plan*	C

CMM Process Element		**Cleanroom Process Implementation**	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The organization's activities for technology change management are reviewed with senior management on a periodic basis.	---	C
VE2	The software quality assurance group reviews and/or audits the activities and work products for technology change management and reports the results.	---	C

4.5.3 Process Change Management

Correspondence Analysis

The Cleanroom processes generally focus on the software project level, and do not define management activities at the organizational level. If Cleanroom is instantiated at the project level only, therefore, the overall correspondence with the Process Change Management KPA is Partial. If Cleanroom is the standard organizational process, however, the correspondence could be High.

Continuous process improvement is an explicit Cleanroom objective. The Cleanroom incremental development life cycle includes planned periods for process review. Project data are analyzed at the completion of each increment for the purpose of identifying process improvement opportunities, and process changes are implemented in the development of succeeding increments.

Overall correspondence: Partial

Correspondence Mapping

CMM Process Element		**Cleanroom Process Implementation**	
Goals		**Process Name: Section, *Relevant Work Products***	**Corr**
GO1	Continuous process improvement is planned.	Project Planning: T1, *Cleanroom Engineering Guide* Project Planning: T2, *Software Development Plan* Project Management: T7 Performance Improvement: *Performance Improvement Plan*	H
GO2	Participation in the organization's software process improvement activities is organization-wide.	---	C
GO3	The organization's standard software process and the project's defined software process are improved continuously.	*Cleanroom Engineering Guide* for the organization Project Planning: T1, *Cleanroom Engineering Guide* Performance Improvement	P

CMM Process Element		Cleanroom Process Implementation	
Commitment to Perform		**Process Name: Section, *Relevant Work Products***	**Corr**
CO1	The organization follows a written policy for implementing software process improvements.	*Cleanroom Engineering Guide* for the organization	P
CO2	Senior management sponsors the organization's activities for software process improvement.	---	C

CMM Process Element		Cleanroom Process Implementation	
Activities Performed		**Process Name: Section, *Relevant Work Products***	**Corr**
AC1	A software process improvement program is established which empowers the members of the organization to improve the processes of the organization.	*Cleanroom Engineering Guide* for the organization	C
AC2	The group responsible for the organization's software process activities (e.g., software engineering process group) coordinates the software process improvement activities.	---	C
AC3	The organization develops and maintains a plan for software process improvement according to a documented procedure.	*Cleanroom Engineering Guide* for the organization Performance Improvement: *Performance Improvement Plan*	C
AC4	The software process improvement activities are performed in accordance with the software process improvement plan.	Project Management: T7 Performance Improvement: T1, *Performance Improvement Plan* Performance Improvement: CEV1	P
AC5	Software process improvement proposals are handled according to a documented procedure.	Performance Improvement	P

AC6	Members of the organization actively participate in teams to develop software process improvements for assigned process areas.	---	C
AC7	Where appropriate, the software process improvements are installed on a pilot basis to determine their benefits and effectiveness before they are introduced into normal practice.	Performance Improvement: T1, *Performance Improvement Plan*	P
AC8	When the decision is made to transfer a software process improvement into normal practice, the improvement is implemented according to a documented procedure.	Project Management: T7 Performance Improvement: T1, *Performance Improvement Plan*	P
AC9	Records of software process improvement activities are maintained.	Performance Improvement: T1, *Performance Improvement Plan*	P
AC 10	Software managers and technical staff receive feedback on the status and results of the software process improvement activities on an event-driven basis.	Performance Improvement: CEV1	P

CMM Process Element		**Cleanroom Process Implementation**	
Measurement and Analysis		**Process Name: Section, *Relevant Work Products***	**Corr**
ME1	Measurements are made and used to determine the status of the software process improvement activities.	Project Planning: T2.5, *Measurement Plan* Project Management: T5, *Project Record* Project Management: T7 Correctness Verification: *Increment Verification Report* Statistical Testing & Certification: *Statistical Testing Report*, *Increment Certification Report* Performance Improvement: T1, *Performance Improvement Plan* Performance Improvement: Measurement section Performance Improvement: CEV1	H

CMM Process Element		Cleanroom Process Implementation	
Verifying Implementation		**Process Name: Section, *Relevant Work Products***	**Corr**
VE1	The activities for software process improvement are reviewed with senior management on a periodic basis.	Performance Improvement: CEV1	H
VE2	The software quality assurance group reviews and/or audits the activities and work products for software process improvement and reports the results.	---	C

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Cleanroom software engineering is a theory-based engineering process for development and certification of high-reliability software systems under statistical quality control. Cleanroom is intended to help software organizations improve their ability to apply engineering discipline to software development. Cleanroom is defined in terms of 14 processes that implement the technology and operations involved in Cleanroom software development.

This report defines the Cleanroom software engineering implementation of the Capability Maturity Model for Software. The definition is expressed in terms of a mapping of the 14 Cleanroom processes into the 18 CMM key process areas.

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