Evolutionary Differences Between CMM for Software and the CMMI

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CMM to CMMI Evolution

Adapting an An Integrated Approach

Why an Integrated Approach?

- Software Engineering is not considered an engineering discipline throughout the world when compared to electrical engineering, mechanical engineering, and civil engineering
- Software Engineering's brief history has been filled with problems:
  - Cost overruns
  - Schedule slippage
  - Poor performance compared to specification
  - Unsatisfied customers

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Why an Integrated Approach? - 2

- Software is becoming such a large factor in the systems that are being built today that it is virtually impossible to logically separate the two disciplines
- Demands for software-intensive systems have been growing steadily in the government and commercial marketplaces
- Some organizations have developed “product lifecycles” that include systems, software, hardware, marketing, manufacturing, etc.
  - Motorola Microsystems - 1985

Why an Integrated Approach? - 4

- AT&T realized an increase in productivity and product quality by creating integrated teams that forced marketing, systems, software, and hardware representatives to work together and be accountable as a team for the delivery of the product – 1990
- Integrating Systems and Software engineering activities enabled Ford Aerospace to regain its competitive position in the command and control market place and reach CMM Level 3 at the same time – 1989 - 1992

The CMM Explosion

The CMM Explosion

- The first CMM (CMM v1.0) was developed for software and released in August 1990
- Based on this success and the demand from other interests CMMs were developed for other disciplines and functions
  - Systems Engineering
  - People
  - Integrated Product Development
  - Software Acquisition
  - Software Quality Assurance
  - Measurement
  - Others…….

The CMM Explosion - 2

- While organizations found these various CMMs to be useful they also found them to be:
  - Overlapping
  - Contradicting
  - Lacking clean, understandable interfaces
  - Lacking standardization
  - Displaying different levels of detail
- In addition, many organizations also had to deal with ISO 9001 Audits or TickIT audits based on ISO 9000-3
- This resulted in expensive, confusing and conflicting process improvement programs

The CMMI Project

The CMMI Project

- The CMM Integration Project was formed to:
  - Establish a framework to integrate current and future models
  - Build an initial set of integrated models
- The source models that served as the basis for the CMMI include:
  - CMM for Software v2.0 Draft C
  - EIA – 731 Systems Engineering
  - IPD CMM (IPD) v0.98a

CMMI Overview

Level	Process Characteristics	Process Areas
Optimizing	Focus is on quantitative continuous process improvement	Causal Analysis and Resolution Organizational Innovation and Deployment
Quantitatively Managed	Process is measured and controlled	Quantitative Project Management Organizational Process Performance
Defined	Process is characterized for the organization and is proactive	Requirements Development Technical Solution Product Integration Verification Organizational Process Focus Integrated Project Management Validation Organization Process Definition Organizational Training Risk Management Decision Analysis & Resolution
Managed	Process is characterized for projects and is often reactive	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Product and Process Quality Assurance Configuration Management Measurement and Analysis
Initial	Process is unpredictable, poorly controlled, and reactive	

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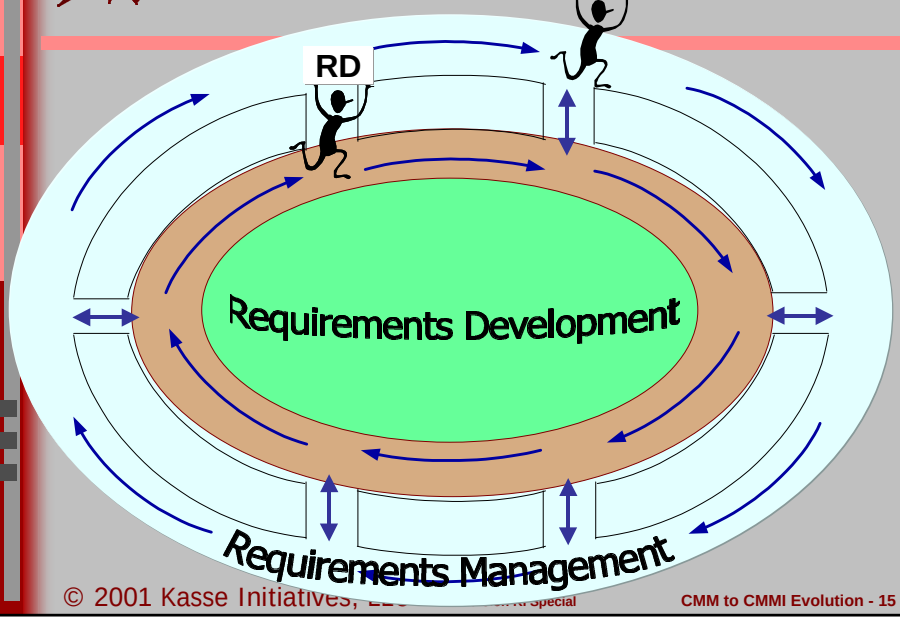
The Evolution of CMM into CMMI

Requirements Management

- Bi-Directional Traceability is now explicitly asked for in Requirements Management
  - Hard to determine if the delivered product matches the requirements and approved requirements change requests and nothing more without requirements traceability
  - Always been necessary but not clearly demanded
- Requirements Management is expected to operate in parallel with Requirements Development and offer support as new requirements are discovered and requirements change requests are made

The Requirements Management and Requirements Development Partnership



Requirements Management - 2

- Requirements cannot be managed effectively without bi-directional requirements traceability
- A requirement is traceable if:
  - You know the source of each requirement
  - Why the requirement exists
  - What requirements are related to it
  - How that requirement relates to other information such as systems designs, implementations, and user documentation
- Traceability information is used to find other requirements which might be affected by proposed changes

Project Planning

- There is a heavier emphasis on having a detailed Work Breakdown Structure
- Includes a focus on the project having the necessary Knowledge and Skills to execute the project according to the estimations and plan
- Data Management or the planning and maintaining of project data items and their contents has been added to the list of project management concerns

Data Management

- **Requires** administrative control of project data, both deliverable and non-deliverable
  - Some large, critical projects demand that even Engineering Notebooks with daily entries be placed under control for audit purposes
  - Covers all other forms of data such as CD-ROMs, Disks, Notebooks, etc
  - Part of Project Planning process area

Project Planning - 2

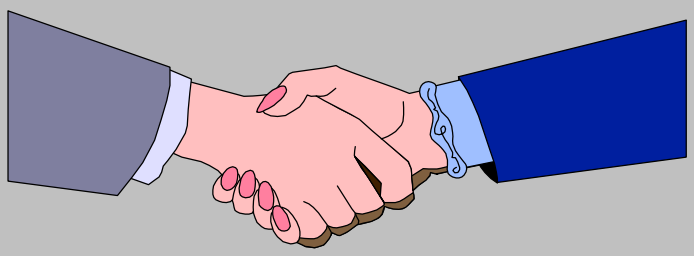
- Estimation focuses on size and complexity while effort and cost, and schedule are determined and established respectively based on the size estimation
- Estimate size and/or relative difficulty or complexity
- Determine the project effort and cost based on the size and complexity estimations
- Establish and maintain the project schedule based on the size and complexity estimations

Project Planning - 3

- The **identification and involvement of stakeholders** is an important evolution of the "all affected groups" statement that appeared frequently in the SWCMM
- The required plan for stakeholder interaction includes:
  - List of all relevant stakeholders
  - Rationale for stakeholder involvement
  - Expected roles and responsibilities
  - Relationships between stakeholders
  - Relative importance of stakeholder to project success by phase
  - Resources needed to ensure relevant stakeholder interaction
  - Schedule for phasing of stakeholder interaction

Project Planning - 4

- The commitment process is now explicitly defined in Specific Practice 3.3



Project Monitoring and Control

- Monitoring Commitments has also been elevated to specific practice level - (SP 1.2)
- Monitoring Risks and Stakeholder Involvement is also more strongly emphasized in the CMMI compared to the SWCMM
- Monitoring Stakeholder Involvement is explicitly brought out and enables the Generic Practice 2.6 – Identify and Involve Relevant Stakeholders

Process and Product Quality Assurance

- Stresses the **objective evaluation** of products as well as processes!!
- Evaluation criteria must be established based on business objectives
  - What will be evaluated?
  - When or how often will a process be evaluated?
  - How will the evaluation be conducted?
  - Who must be involved in the evaluation?

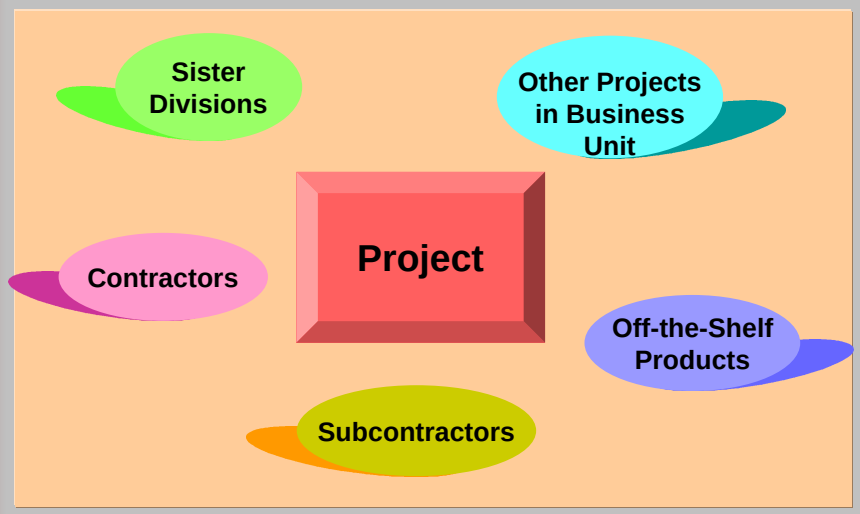
Configuration Management

- The idea of “Software Library” has been replaced by the more encompassing “Configuration Management System”
- A **configuration management system** includes:
  - The storage media
  - The procedures
  - The tools for accessing the configuration system

Supplier Agreement Management

- Replaces the initial ideas found in Subcontract Management
- Now incorporates the original intent of Subcontract Management as well as lessons learned over the past 7 years ☺

Supplier Agreement Management - 2



Measurement and Analysis

- Provides a description of a measurement initiative that involves the following:
  - Specifying the objectives of measurement and analysis such that they are aligned with established information needs and business objectives
  - Defining the measures to be used, the data collection process, the storage mechanisms, the analysis processes, the reporting processes, and the feedback processes
  - Implementing the collection, storage, analysis, and presentation of the data
  - Providing objective results that can be used in making business judgments and taking appropriate corrective actions

Measurement and Analysis - 2

- An organization that barely passes the Measurement and Analysis Common Feature requirements of CMM for Software would not pass the measurement requirements of CMMI
- Sets up the organization to evolve its measurement program from basic project management measures to those based on the organization's set of standard processes to statistical control of selected subprocesses according to the organization's business needs

Requirements Development

- The concepts presented in Requirements Development are consistent with very modern publications on Requirements Engineering
- Clearly defines the need for identification and care of **stakeholders**
- Incorporates the interface ideas of Systems Engineering and Software Engineering with regards to gathering, analyzing, documenting, and maintaining requirements found in CMM for Software v1.1 and expands on them

Requirements Development -2

- Requirements Development together with Technical Solution truly shows the recursive and iterative nature of developing requirements:

Stakeholder Needs

Customer Requirements

Product and Product Component Requirements

Requirements Analysis

Derived Requirements

Allocation to Product Functions and Product Components including Objects, People, and associated Processes or People

Requirements Development - 3

- The Requirements Development PA includes a description of developing an operational concept and operational scenarios to refine and discover new requirements, needs, and constraints that include the interaction of the product, the end user and the environment
- It also includes a strong focus on **interface** requirements
- It suggests the use of models, simulations, and prototyping to perform risk assessments to reduce the cost and risk of product development
- It is very tightly coupled to the Technical Solution process area

Requirements Development - 4

- It emphasizes the idea of starting the process of **requirements validation** very early in the product lifecycle

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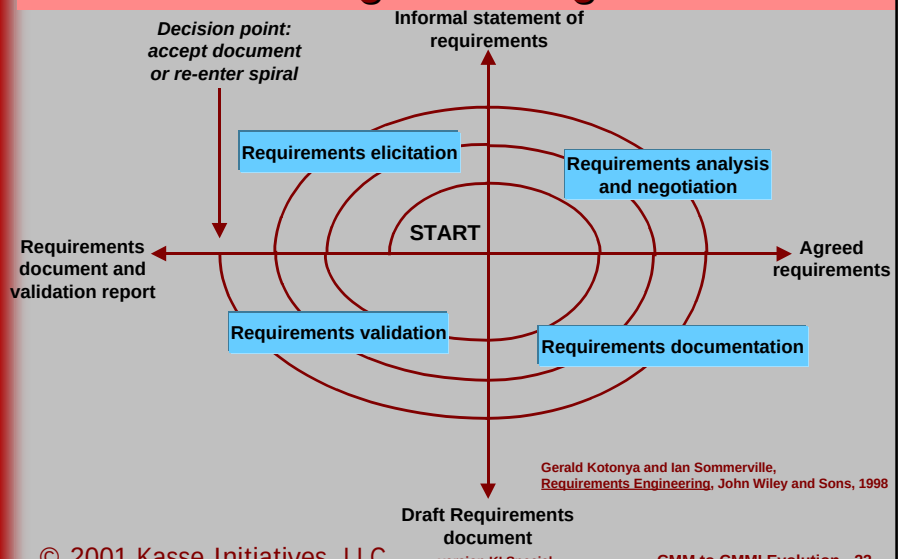
Spiral Model of the Product Requirements Engineering Process



Gerald Kotonya and Ian Sommerville, Requirements Engineering, John Wiley and Sons, 1998

Technical Solution

- Technical Solution practices apply not only to the product and product components but also to services and product-related processes
- Technical Solutions are presented as being developed **interactively** with product or product component requirements definition
- Technical Solution stresses the need for developing **alternative** solutions

Technical Solution - 2 (Engineer in Quality)

- To engineer in quality means to add quality to software during the engineering process
- To achieve this, software engineers must be aware of quality requirements at the same time they are building the functional requirements
- Quality requirements thus take on the same relationship to the product as functional requirements do
- If we engineer quality in, we add quality to the product as we build it

Technical Solution - 3

- Quality Factors (e.g., maintainability, expandability, reliability) were discussed in the CMM/SW Level 4 KPA Software Quality Management – “Quality goals for the project’s software products are defined, monitored, and revised throughout the software lifecycle”
- CMMI discusses the quality factors first in Requirements Development and emphasizes their importance in Technical Solution

Technical Solution - 4

- Design criteria are often established to ensure that the product or product component exhibits one or more of the following quality attributes:
  - Modularity
  - Clarity
  - Maintainability
  - Expandability
  - Portability
  - Efficiency
  - Reliability
  - Security
  - Usability
  - Scalability

Product Integration

- Product Integration presents the concepts to achieve complete product integration through progressive assembly of product components, in one stage or in incremental stages, according to a defined integration strategy
- It stresses the careful analysis and selection of the optimum integration strategy
  - The basis for effective product integration is an integration strategy that uses combinations of techniques in an incremental manner

Product Integration - 2

- It points out the need to establish and maintain the **environment** required to support the integration of the product components
- It introduces the concept of product component and product assembly **Checkout,** to evaluate its performance and suitability
- It presents the idea of applying (Product Integration, Verification, and Validation) in successive triplets until the product is ready for packaging and delivery

Product Integration - 3

- It stresses the effective management of all interfaces to ensure that all interfaces will be complete and compatible
  - Interface descriptions
  - Interface data
- Packaging and Delivery is specifically called out in Specific Practice 3.4 – an improvement over the information provided in the SWCMM
- Inspecting Product Elements Upon Receipt is an activity that is not well done in the industry today and deserves the attention that is now defined in the CMMI!

Verification

- Verification is used to assure that selected work products meet their specified requirements
- Verification assures “You built it right”
- Expects a verification strategy that addresses the specific actions, resources, and environments that will be required for work product verification to be developed
  - Developed concurrently and iteratively with the product and product component designs

Verification - 2

- Captures the ideas of using:
  - Peer Reviews
  - Load, stress and performance testing
  - Functional decomposition based testing
  - Simulation
  - Prototypes
  - Observations and demonstrations
  - Operational scenario testing

  as they apply to ensuring that the requirements are being addressed at each phase of the development lifecycle from a systems, and software point of view

Validation

- Validation is used to demonstrate that a product or product component fulfills its intended use when placed in its intended operational environment
- Validation assures “You built the right thing”

Risk Management

- The concepts inherent to Risk Management finally made it to Process Area status
  - Risk Identification
  - Risk Assessment
  - Risk Analysis
  - Risk Prioritization
  - Risk Mitigation
  - Risk Contingency Planning
- The ideas behind Risk Contingency Planning and Risk Mitigation have been merged but are definitely clearer

Decision and Analysis

- Decision and Analysis presents the concepts of **identifying** alternatives to issues that have a significant impact on meeting objectives, **analyzing** the alternatives, and **selecting** one or more alternatives that best support prescribed objectives
- Decision and Analysis is a new concept for the software world whose time has certainly come

Criteria for Using Formal Decision Analysis Techniques

- Decision and Analysis helps determine which issues should be examined by formal decision analysis – typical criteria for when to require formal decision making includes:
  - When a decision is directly related to topics assessed as being of medium or high risk
  - When a decision is related to changing work products under configuration management
  - When a decision would cause schedule delays over a certain percentage or specific amount of time
  - When a decision has an impact on the ability to achieve project objectives
  - When a decision's costs are reasonable compared to the decision's impact

Assistance from Operations Research

- Understanding decision making models from Operations Research can help in making full use of this Process Area
  - Linear Optimization Models
    - Simplex Method for executive decision making
  - Stochastic Programming Models
  - Dynamic Optimization Models
  - Unbounded Horizon Models
  - Queuing Decision Models

Organizational Process Definition

- The wording for this process area has changed subtly but significantly from that of the SWCMM
  - Establish and maintain a **usable set** of organizational process assets including the organization's set of standard processes
  - Acknowledges that an organization may utilize more than one standard process to handle its product lines and business needs
- Process Database evolved into **Organizational Measurement Repository**

Integrated Project Management

- Integrated Project Management takes on the aspects of Integrated Software Management and Intergroup Coordination that were found in the SWCMM
  - The project is conducted using a defined process that is tailored from the organization's set of standard processes
- It also emphasizes the need to proactively integrate the concepts in the Project Plan and all supporting plans such as:
  - Quality assurance plans
  - Configuration management plans
  - Risk management strategy
  - Verification strategy
  - Validation strategy
  - Product integration plans

Organizational Process Performance

- The Organizational Process Performance process area was developed to help organizations set the stage for quantitative process management:
  - Baselines and models that characterize the expected process performance of the organization's set of standard processes are established and maintained

Performance Baselines

- The organization's process performance baselines measure performance for the organization's set of standard processes at various levels including:
  - Individual processes (e.g., test case inspection element)
  - Sequence of connected processes
  - Processes for the complete lifecycle
  - Processes for developing individual work products

Performance Baselines - 2

- There may be several process performance baselines to characterize performance for subgroups of the organization – Examples include:
  - Product Line
  - Application domain
  - Complexity
  - Team size
  - Work product size

Quantitative Project Management

- This Process Area combines the concepts of Quantitative Process Management and Software Quality Management from the SWCMM point of view
- The concepts of quantitative management and statistical process control are strongly present in this process area.
- Quantitative Project Management is tightly coupled with Organizational Process Performance, taking standard process measures from it to achieve stability of subprocesses and providing information back to it once the statistical control boundaries are established

Quantitative Management Concepts

- Quantitative Management is tied to the organization's strategic goals for product quality, service quality, and process performance
- When higher degrees of quality and performance are demanded, the organization and projects must determine if they have the ability to improve the necessary processes to satisfy the increased demands

Quantitative Management Concepts - 2

- Achieving the necessary quality and process performance objectives requires stabilizing the processes that contribute most to the achievement of the objectives
- Assuming the technical requirements can be met, the next decision is to determine if it is cost effective

Quantitative Management Concepts - 3

- Reducing process variation is an important aspect to quantitative management:
  - It is important to focus on subprocesses that can be controlled to achieve a predictable performance
- Statistical process control is often better focused on organizational areas such as Product Lines where there is high similarity of processes, than on the organization's entire set of products

Quantitative Management Concepts - 4

- Successful application of Quantitative Management concepts must look closely to:
  - The business demands
  - The capability of existing processes
  - The ability of the organization to bring processes and **subprocesses** under statistical control in a cost effective manner

Quantitative Project Management Concepts References

- Two sources that can help to really understand what is behind this Process Area are:
  - Measuring the Software Process by William Florac and Anita Carleton.
  - Statistical Methods for Software Quality by Adrian Burr and Mal Owen
  - Understanding Variation by Donald Wheeler

Organizational Innovation and Deployment

- Combined Process Change Management and Technology Change Management from the SWCMM point of view
- Just Do It! – Or once one has the innovation ideas identified and analyzed against the organization's business objectives and cost measures, get it tried and expanded wherever possible throughout the organization
- Subpractices are excellent and provide a solid picture of what is required for this process area

Organizational Innovation and Deployment Overview

- The Organizational Innovation and Deployment process area selects and deploys improvements that can improve the organization's ability to meet its quality and process performance objectives
- Quality and process performance objectives that this process area might address include:
  - Improved product quality
  - Increased productivity
  - Decreased developed cycle time
  - Greater customer and end user satisfaction

Organizational Innovation and Deployment Overview - 2

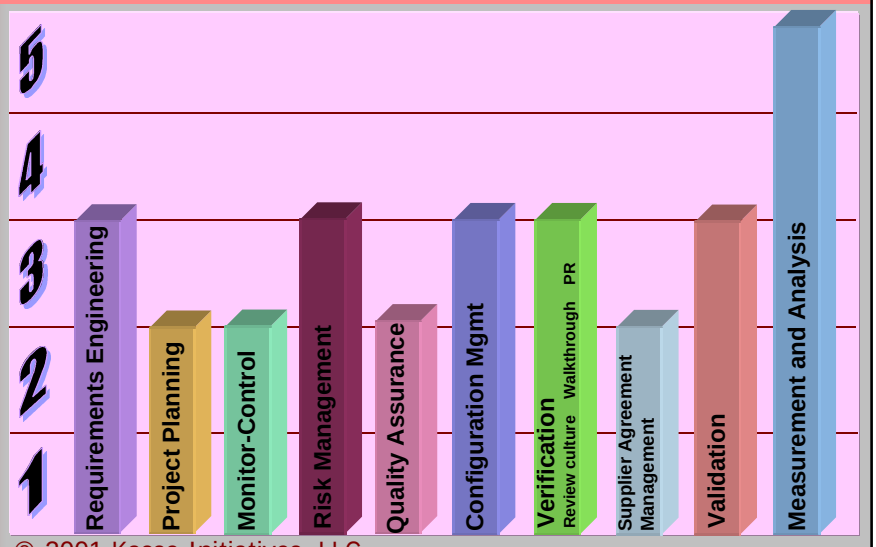
- Process and technology improvements that will be deployed are selected from proposals based on the following criteria:
  - A quantitative understanding of the organization's current quality and process performance
  - Estimates of the improvement resulting from the deployment
  - The resources and funding available for that deployment
  - The expected benefits weighed against the cost and impact to the organization

Constageduous Viewpoint

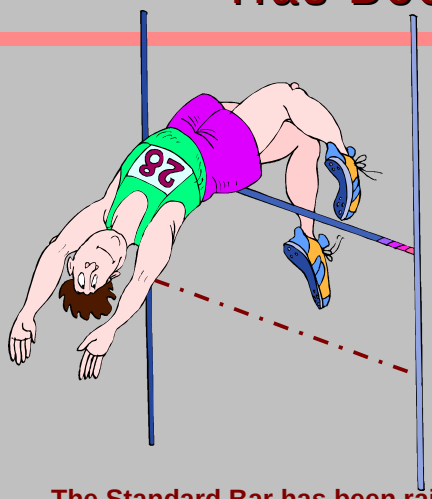
Constageduous Viewpoint

- CMMI Framework provides the opportunity to apply the principles of both the staged and continuous representations in a process improvement oriented manner or a manner that might be labeled “Constageduous”

Constageduous Viewpoint - 2



The Standard Bar Has Been Raised



New Standard Height

Lessons Learned

Old Standard Height

The Standard Bar has been raised – Lessons learned over the past 7 years have now been incorporated into this integrated CMM

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