A Unified Approach to the CMM and RCM for RSP Adopters

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Introduction

Traditionally, the productivity and quality that result from a software process are highly variable. The Software Engineering Institute created the Capability Maturity Model (CMM) [3] as a means to guide organizations in making their practices more disciplined and consistent, for more predictable results. The Software Productivity Consortium created the Reuse Capability Model (RCM) [2] to help an organization determine its needs and capabilities for reuse within its software process. Additionally, part of the motivation for the RCM was to refine particular CMM goals to better address issues associated with reuse that are beyond the scope of conventional development process concerns.

At the same time, a new approach to the software process, based on reuse as a key driver, has arisen. The approach, known as domain-specific engineering, introduces constraints on what products an organization can build in return for substantially greater productivity and product quality based on reuse and a streamlined process. The most extensive definition of a domain-specific software methodology is the Reuse-driven Software Processes (RSP) methodology [1] from the Software Productivity Consortium.

This report proposes a unified model of process capability and improvement tailored to the needs of RSP adopters. It clarifies the use of the CMM and the RCM in an RSP context. This is accomplished in 3 parts:

- Define for each RCM critical success factor goal which RSP activities contribute to attaining that goal.
- Clarify the role of each RCM goal, as either an extension of a CMM goal, a focus for further improvement of an RSP process, or a guide to selecting and tailoring the most appropriate type of RSP process for adoption.
- Informally describe an RSP-specific approach to process adoption, tailoring, and improvement based on the CMM and RCM as complementary models of process capability.

Assumptions

The CMM and RCM are fundamentally sound models for understanding the capabilities provided by a software process and planning how it can be improved. The weakness addressed by this report is that neither the CMM nor the RCM has ever been properly interpreted from the perspective of a domain-specific methodology such as RSP.

In the case of the CMM, goals are oriented to a conventional single-product development process. In contrast, an RSP process consists of a full lifecycle process for both a product family and each instance product. Nevertheless, the same issues that determine the quality of a conventional process affect the quality of the RSP two-lifecycle process as well. The required task is to look at the wording of CMM goals to see how these should be understood in light of the larger scope of an RSP process. There are also other process improvement factors related to evolution of the product family or instance products which are beyond the scope of the CMM; these are addressed here only in so far as they have already been identified as factors within the RCM.

In the case of the RCM, goals were conceived and defined to support analysis of factors that encompassed any reuse-based process, not just RSP. As such, goals are stated in a more general form than appropriate to RSP and require some interpretation for proper understanding and use. Assuming an RSP context, RCM goals should be viewed as having 3 distinct purposes:

- To refine specific CMM goals, to ensure that corresponding concerns are properly addressed from an RSP perspective
- To extend the CMM with RSP-specific goals, to motivate a higher quality, more consistent RSP process
- To identify a factor that guides an organization in targeting an RSP capability that is at the right level for its particular business needs and technical capabilities

The 4 stages identified by the RCM implementation model remain a good characterization of 4 different levels of RSP capability, corresponding to distinct cost-risk/benefit profiles.

Correlating RCM Goals to RSP Activities

The correlation of RCM goals to RSP activities is shown in the table labeled “RCM to RSP Mapping”. This table shows which RSP activities are responsible for improvements needed to achieve each RCM goal. The purpose of this is to clarify the focus of process improvement actions within an RSP process after an organization has established a particular set of goals as most critical to success.

The responsibility for an RCM goal can be associated with one or more of the domain engineering activities of an RSP process, the application engineering activities of an RSP process, or supporting activities outside the scope of RSP. Each domain engineering activity that has a leaf-level definition in the RSP guidebook is represented in the table by a separate column. Because the definition of the application engineering process is a responsibility of domain engineering, all application engineering activities are represented by a single column. All activities that are outside the scope of an RSP process, including organizational management, process adoption and improvement, sales and marketing, and organizational infrastructure, are represented by a single column labeled “Mgmt/Mktg/RA”.

In many cases, responsibility for an RCM goal is shared among organizational, domain, and application project management. In other cases, responsibility for a goal is shared among several domain engineering activities. This is not only appropriate but necessary to reflect the proper scope of concern intended by these goals. This is more common with the RCM than it is with the CMM because CMM goals tend to be more narrowly focused on the role of management in achieving improved process quality.

Renormalizing RCM Goals to the CMM and RSP

A renormalized mapping of RCM goals to the CMM and RSP is shown in the table labeled "RCM to CMM mapping". This table shows RCM goals mapped into one of three categories: refining a CMM goal, defining an RSP-specific improvement goal, or establishing a factor for targeting the proper level of RSP capability.

RCM Goals that Refine CMM Goals

The CMM emphasizes factors related to the management of the software development process and resulting work products. Within the RCM, most goals of the Process and Technology group correspond to CMM goals. This includes all the goals of Process Definition and Integration, Measurement, Continuous Process Improvement, Training, and Technology Innovation. The exception is the Tool Support goal set which is outside the scope of the CMM. In addition, only 3 other RCM goals, concerning quality assurance, configuration management, and intergroup coordination, correspond to CMM goals. All of these goals should be viewed as partial elaborations of the corresponding CMM goals and should be applied within the context of CMM assessments for RSP adopter organizations.

RCM Goals for RSP Process Improvement

Most RCM goals in the Management, Asset Development, and Application Development groups, as well as the Tool Support goals in the Process and Technology group, relate to practices that are common to all RSP processes. Their treatment in the RCM reflects distinctions between RSP and other reuse-based processes. Within a strict RSP context, these goals provide insight into improving a particular RSP process but do not assist in choosing among the 4 levels of RSP capability. The use of these goals in improving an RSP process, in the way that CMM goals can guide improvements in any software process, has not yet been formalized. In particular, the implications of each goal need to be clarified in RSP-specific terms, particularly for higher levels of capability. A clear caution is that each goal should be considered only within the context of the adopted RSP process and with regard for the level of costs/risks and benefits appropriate to that level of RSP capability.

RCM Goals for Targeting RSP Capability Level

The RCM implementation model defined 4 stages of reuse capability implementation: opportunistic, integrated, leveraged, and anticipating. Having separated out goals related to process quality, including reuse-oriented refinements of CMM goals and reuse-specific extensions, the remaining goals allow these 4 stages to be viewed in an RSP context as 4 levels of increasing capability, with corresponding increased costs, risks, and benefits. An organization can use these goals as guides to targeting the level of RSP capability that is best suited to its needs and objectives.

The RCM goals that guide adopters in targeting a level of RSP capability correspond to factors that were identified in the RSP guidebook, in different terms, as characterizing the 4 types of RSP process. The following 4 sets of goals correspond to those factors and can be read as indicating, or enabling, particular RSP capabilities as noted:

- The Planning and Direction area of Management, along with one goal from the Organizational Commitment area, indicates the nature and degree of management integration of the domain and application projects:
  - PD-1 – (Opportunistic) Application projects will be independently managed, with the domain as a provider of shared knowledge, expertise, and assets.
  - OC-4 and PD-3 – (Integrated) Domain and application projects will be cooperatively managed for coordinated planning.
  - PD-2 – (Leveraged) Application projects will be managed for optimum use of domain capabilities with exceptions seen as opportunities for domain improvement.
  - PD-4 – (Anticipating) Application projects will be chartered by the domain and managed as its agents for market liaison and capability evolution.

- The Needs Identification area of Asset Development indicates the focus the domain will have in creating an enhanced software capability:
  - NI-1 – (Opportunistic) The domain will work to provide greatest recurring value to one or more current application projects.
  - NI-2 – (Integrated) The domain will work to meet the common and diverse needs of all application projects.
  - NI-3 – (Leveraged) The domain will work to meet the common and diverse needs of all current customers.
  - NI-4 – (Anticipating) The domain will work to meet the needs of the targeted market (current and potential customers).

- The Asset Interface and Architecture Definition and the Needs and Solutions Relationships areas of Asset Development together indicate the level of product integration within the domain:
  - AD-1 – (Opportunistic) The product family will be represented by a well-defined set of work product components.
  - AD-2 – (Integrated) The product family will be represented by a set of adaptable integrated work products.
  - NS-1 – (Leveraged) The product family will be represented by an adaptable integrated product.
  - NS-2 – (Anticipating) The product family will be represented by an evolving adaptable product.

- The Asset Identification area of Application Development indicates the tradeoff in how people work between cultural stability and the potential for process optimization:
  - AI-1 – (Opportunistic) The application process will be a conventional software development workflow comprising activities enhanced to exploit reusable work product components.
  - AI-2 – (Integrated) The application process will be streamlined to focus on variabilities that distinguish among different instances of each work product.
  - AI-3 – (Leveraged) The application process will be streamlined to focus on variabilities that distinguish different products.
  - AI-4 – (Anticipating) The application process will be structured for iterative refinement of a context/problem/constraints model and derivation of a customized product.

The proper level of RSP capability that an organization should target for a domain is the highest level satisfied by all 4 areas. For each the above 4 areas, the organization analyzes the indicated goals to establish a targeted level of capability. The goals should be evaluated in the form suggested by the RCM. The RSP capability implied by each goal is then determined by referring to the above descriptions. For example, if all goals indicating Opportunistic and Integrated levels are satisfied, but not all of the goals indicating a Leveraged level are satisfied, then the highest level of RSP capability that should be targeted is Integrated.

Because determining whether these RCM goals can be satisfied is somewhat subjective, there are three issues that may mitigate against adopting the indicated level of capability. First, higher management or marketing may decide that future market opportunities are inadequate to justify the corresponding level of investment in a domain capability. Second, management may judge the costs or risks of a transition from project-centric toward domain-centric development as too great regardless of potential benefits. Third, required use of particular commercial tools may penalize a family-oriented approach, forcing the family to be represented as a set of distinct, or at best discretely overlapping, instances. In these cases, a more limited capability may offer more realistic benefits.

An RSP-specific Capability Model

The intent of an RSP-specific capability model is to provide a more precise framework for defining and improving an RSP process to fit the needs and capabilities of an adopting organization. This model assumes a process improvement effort comprising 2 stages. The assumed starting point is an organization that has an established software development capability based on a traditional single-product process. The purpose of stage 1 is to assess the organization's current process capability and improvement priorities using CMM and RCM assessments and to institute use of an RSP process based on those results. The purpose of stage 2 is to apply the CMM and RCM jointly to guide improvements in an established RSP capability.

Stage 1 steps are performed only in preparation for instituting a domain and the associated transition to an RSP process. The steps of stage 1 are:

- Perform organizational CMM assessment and establish a process improvement action plan.
- Identify a product line business area appropriate to RSP adoption and obtain management commitment.
- Perform an RCM assessment for the targeted business area organization and develop an adoption strategy, which includes determining the level of RSP capability to be targeted.
- Develop an RSP adoption action plan which includes setting business objectives for a domain, creating the responsible organization with associated resources, and creating a tailored definition of the RSP process to be followed.

Instituting use of an RSP process initiates stage 2 for continuous improvement of the process. Stage 2 steps, which are revisited periodically for each domain, are:

- Perform combined CMM and RCM assessments for the domain business to identify weaknesses and improvement opportunities.
- Develop an action plan to exploit improvement opportunities.
- Reevaluate the cost-risk/benefit of moving to a different level of RSP capability; create a corresponding RSP adoption action plan and seek necessary organizational commitments if a change is found to be justified.

Summary

This report has defined the relationship of RCM critical success factor goals to CMM key process area goals and to RSP activities. For the first time, there is a definitive distinction between the great majority of RCM goals which aid process improvement and the handful of RCM goals that guide an organization in targeting a process to be adopted to be at the proper level of RSP capability. The distinction between process maturity and RSP capability, which the RCM tended to blend improperly, is now more specifically defined through the partitioning of RCM goals to these two purposes.

As future follow-on to this report, there are 4 areas needing further work:

- A systematic analysis of whether and how RCM process improvement goals that are outside the scope of CMM coverage should be considered relative to the 5 levels of process maturity.
- An analysis to formalize factors, based on RSP-common RCM goals and factors of the Domain Assessment Model [2], that influence whether an organization should adopt RSP for a given business area product line.
- A comprehensive definition of the factors, beyond the RCM goals for RSP capability targeting, for deriving a tailored RSP process. Informally, these factors include the management approach, the engineering methods, and the tools to be used and which the process must be tailored to accommodate most effectively.
- Complete guidance for the unified RSP adoption/improvement process proposed in overview here. The interactions of the domain lifecycle, consisting of concept, elaboration, expansion, and consolidation phases, with this understanding of process adoption and improvement must be considered further as part of this effort.

References

1. Software Productivity Consortium, *Reuse-driven Software Processes Guidebook*, SPC-92019-CMC, version 2.0, 1993.
2. Software Productivity Consortium, *Reuse Adoption Guidebook*, SPC-92051-CMC, Version 2.0, 1993.
3. Software Engineering Institute, *Capability Maturity Model for Software*, CMU/SEI-93-TR-024, version 1.1, 1993.

Abbreviations

General

CMM	Capability Maturity Model
RCM	Reuse Capability Model
RSP	Reuse-driven Software Processes

CMM Key Process Areas

DP	Defect Prevention
IC	Intergroup Coordination
ISM	Integrated Software Management
OPD	Organization Process Definition
OPF	Organization Process Focus
PCM	Process Change Management
PR	Peer Reviews
QPM	Quantitative Process Management
RM	Requirements Management
SCM	Software Configuration Management
SPE	Software Product Engineering
SPP	Software Project Planning
SPTO	Software Project Tracking and Oversight
SQA	Software Quality Assurance
SQM	Software Quality Management
SSM	Software Subcontract Management
TCM	Technology Change Management
TP	Training Program

RCM Critical Success Factors

AA	Asset Awareness and Accessibility
AD	Asset Interface and Architecture Definition
AE	Asset Evaluation and Verification
AI	Asset Identification
AN	Application Integrability
AQ	Asset Quality
AR	Asset Reusability
AV	Asset Value Determination
CI	Continuous Process Improvement
CP	Costing and Pricing
CV	Commonality and Variability Definition
IC	Intergroup Coordination
LC	Legal and Contractual Constraints
MS	Measurement
NI	Needs Identification
NS	Needs and Solutions Relationships
OC	Organizational Commitment
PD	Planning and Direction
PI	Process Definition and Integration
TI	Technology Innovation
TR	Training
TS	Tool Support

RCM to RSP Mapping

Oppor	Mgmt/Mktg/RA	Domain Mgmt	Domain Defn	Dec Model	Product Req	Process Req	Product Arch	Compon Des	Gen Des	Domain Verif	Compon Impl	Gen Impl	Proc Sup Dev	Domain Val	Domain Deliv	Appl Eng
AA-1											X				X	
AI-1						X										X
AE-1						X										X
AE-2						X										X
NI-1			X	X		X										
NI-5					X											
AD-1								X								
CV-1			X		X		X	X	X		X	X				
AQ-1		X														
OC-1	X															
OC-2	X															
OC-3	X															
PD-1	X	X														X
CP-1	X	X														X
LC-1		X														X
PI-1						X										X
MS-1																X
TR-1													X		X	

Integ	Mgmt/Mktg/RA	Domain Mgmt	Domain Defn	Dec Model	Product Req	Process Req	Product Arch	Compon Des	Gen Des	Domain Verif	Compon Impl	Gen Impl	Proc Sup Dev	Domain Val	Domain Deliv	Appl Eng
TS-1													X			
AA-2											X				X	X
AI-2						X										X
AN-1													X			X
NI-2			X	X		X										
AD-2							X									
CV-2							X	X	X		X	X				
AR-1								X			X	X	X			
AQ-2															X	
AQ-3							X	X		X	X					
AQ-4										X						
OC-4	X	X														
PD-3	X	X														
CP-2	X	X														
IC-1		X														
PI-2	X	X				X										
PI-3	X	X				X								X		
MS-2		X														
TS-2													X			

Lever	Mgmt/Mktg/RA	Domain Mgmt	Domain Defn	Dec Model	Product Req	Process Req	Product Arch	Compon Des	Gen Des	Domain Verif	Compon Impl	Gen Impl	Proc Sup Dev	Domain Val	Domain Deliv	Appl Eng
AI-3						X										X
NI-3			X	X	X											
NS-1					X		X	X	X	X	X	X				
NS-2													X			
AQ-5										X						
PD-2	X	X														
CP-3	X	X														X
CI-1										X						
CI-2		X														
TR-2															X	
TR-3													X			
TS-3						X							X			
TI-1														X		

Antic	Mgmt/Mktg/RA	Domain Mgmt	Domain Defn	Dec Model	Product Req	Process Req	Product Arch	Compon Des	Gen Des	Domain Verif	Compon Impl	Gen Impl	Proc Sup Dev	Domain Val	Domain Deliv	Appl Eng
AI-4						X										X
NI-4			X	X	X											
AV-1		X														
AV-2		X														
PD-4	X	X														
LC-2		X														
PI-4						X								X		X
MS-3											X	X	X			X
TS-4													X			
TI-2														X		

RCM to CMM Mapping

Appl Dev	CMM Level 2 Repeatable	CMM Level 3 Defined	CMM Level 4 Managed	CMM Level 5 Optimizing	RSP Com	RSP Var
AA-1					X	
AA-2					X	
AI-1						X
AI-2						X
AI-3						X
AI-4						X
AE-1					X	
AE-2					X	
AN-1					X	

Asset Dev	CMM Level 2 Repeatable	CMM Level 3 Defined	CMM Level 4 Managed	CMM Level 5 Optimizing	RSP Com	RSP Var
NI-1						X
NI-5					X	
NI-2						X
NI-3						X
NI-4						X
AD-1						X
AD-2						X
NS-1						X
NS-2						X
CV-1					X	
CV-2					X	
AV-1					X	
AV-2					X	
AR-1					X	
AQ-1	SCM-3					
AQ-2					X	
AQ-3					X	
AQ-4					X	
AQ-5	SQA-2					

Mgmt	CMM Level 2 Repeatable	CMM Level 3 Defined	CMM Level 4 Managed	CMM Level 5 Optimizing	RSP Com	RSP Var
OC-1					X	
OC-2					X	
OC-3					X	
OC-4						X
PD-1						X
PD-3						X
PD-2						X
PD-4						X
CP-1					X	
CP-2					X	
CP-3					X	
LC-1					X	
LC-2					X	
IC-1		IC-3				
Proc & Tech	CMM Level 2 Repeatable	CMM Level 3 Defined	CMM Level 4 Managed	CMM Level 5 Optimizing	RSP Com	RSP Var
PI-1	SPP-2					
PI-2		OPD-1				
PI-3		ISM-1				
PI-4					X	
MS-1	SPP-1, SPTO-1					
MS-2		OPD-2				
MS-3				TCM-2		
CI-1			QPM-2			
CI-2				PCM-1		
TR-1		TP-1, TP-2, TP-3				
TR-2			QPM-2			
TR-3				PCM-1		
TS-1					X	
TS-2					X	
TS-3					X	
TS-4					X	
TI-1					X	
TI-2				TCM-3		