

# Extending the Range of Value of the CMMI To a New Normal

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**Abstract.** Now that the CMMI® has been organized into three constellations for assuring an organization's capability to perform development, acquisition, and service, there is a need to extend the range of value of the CMMI to a new normal. As an organization improves its process maturity, strategic imperatives need to replace waste and neglect as the driver of CMMI value. Only those organizations able to elevate their game and transition from tactical to strategic use of the CMMI will be able to reap its full value.

While the traditional treatment of the value of the CMMI in terms of cost, schedule, productivity, quality, customer satisfaction, and ROI is sufficient to promote adoption of the CMMI and even to sustain a process improvement initiative through the early maturity levels, the value of the CMMI determined in this way is likely to be underestimated as the organization approaches higher maturity levels.

The value of the CMMI can be framed more strategically as the means for carrying out visionary statements of strategic intent in achieving measured outcomes in business and competitiveness, management and predictability, process and improvement, engineering and trustworthiness, and operations and dependability.

Not only that, the value of the CMMI to an organization varies depending on the domain of forces to which it must respond, such as, reputation, economics, mission, competitiveness, outsourcing, and high assurance. The penultimate value of the CMMI is the degree to which its ability to deliver satisfactory responses in a strategic context is demonstrated when faced with these competing forces. It is time to revisit why organizations should adopt the CMMI and to refresh the value proposition.

It is the responsibility and role of the change agent to unlock the value of the CMMI by strategically customizing the CMMI value to the organization. Change agents need to reach beyond compliance-oriented middle managers in composing more non-deterministic strategic statements of value in collaboration with senior executives in forging the new normal.

## State of the CMMI

Watts Humphrey defined software process as the set of tools, methods, and practices used to produce a software product [1]. The quality of the software process largely determines the quality of the software products that result.

The CMMI is being adopted worldwide by government, military, and commercial organizations as the standard for process improvement. The CMMI is a framework of best practices that focus on assuring product quality through process performance (see Figure 1).

Prototyped in 1988 and now retired, the original CMM® focused on software processes [2]. Introduced in 2000, the CMMI focused on software development and was expanded to include systems engineering, product acquisition, integrated team, and requirements development. The CMMI is now organized into three constellations and has become the basis for assuring an organization's capability to perform software development (CMMI-DEV 2006), acquisition (CMMI-ACQ 2007), and service (CMMI-SVC 2009). The current CMMI is labeled Version 1.3 and was released in December 2010 [3].

Due to its origins, the CMMI lacks an explicit correlation to business alignment and strategic planning, sources of essential value to the enterprise [4]. In addition the CMMI may operate best in a closed system with top-down command and control decision-making [5]. In open organization environments with more diverse bottom-up consensus-based decision-making, other choices may be preferred. With pressure mounting on the value of the CMMI, the benefits of Agile and Interactive Development methods known since the 1970s [6], and the wide spread adoption of Six Sigma [7], the source and range of value of the CMMI are being questioned and tested. Even Watts Humphrey has expressed concern.

Asked about the direction the CMMI is headed, Watts Humphrey conceded that the CMMI has a problem with performance for high maturity organizations and specifically cited the use of process performance baselines and models by lead assessors [8]. He made a careful distinction between procedural (the what) and operational (the how) processes. Whereas, the procedural process depends on a bureaucracy to enforce it, the operational process depends on coaching a self-managing trusted workforce to apply its methods.

In accordance with the need to foster innovation, the bureaucratic top-down appraisal-driven compliance may be giving way to more diverse bottom-up self-directing team empowerment and self-determination. Just as the CMMI focuses on the what in assuring product quality through process performance, Agile deals with how to build software through well-defined methods that place an emphasis on increasing customer satisfaction. Similarly, Six Sigma further supplies the how with an emphasis on the systematic use of artifact templates, measurement, and control graphics in data-driven decision-making and the reduction of waste.

## A New Understanding of the Value of CMMI

Change agents must now revisit their understanding of the value of the CMMI. The CMMI organization into three constellations spanning development, acquisition, and service and the

Maturity Level	Project Management	Engineering	Process Management	Support
<b>Level 2</b>	Project Planning (PP); Project Monitoring and Control (PMC); Supplier Agreement Management (SAM)	Requirements Management (REQM)		Configuration Management (CM); Process and Product Quality Assurance (PPOA); Measurement and Analysis (M&A)
<b>Level 3</b>	Integrated Project Management (IPM); Risk Management (RSKM)	Requirements Development (RD); Technical Solution (TS); Product Integration (PI); Verification (VER); Validation (VAL)	Organization Process Focus (OPF)  Organization Process Definition (OPD)  Organization Training (OT)	Decision Analysis and Resolution (DAR)
<b>Level 4</b>	Quantified Project Management (QPM)		Organization Process Performance (OPP)	
<b>Level 5</b>			Organization Innovation and Deployment (OID)	Causal Analysis and Resolution (CAR)

Figure 1. CMMI V1.3 Process Areas by Level and Category

expanded target audience of producers, buyers, and users of software products and systems bring with it change ... change for the change agents as they take the lead in establishing a new normal of expectation for the value of the CMMI. It is time to revisit why organizations adopt the CMMI and to refresh the value proposition.

Change agents have systematically underestimated the value of the CMMI as they service the needs of middle managers seeking benefits that demonstrate compliance with the CMMI through tactical improvements, such as, cost, schedule, productivity, quality, customer satisfaction, and ROI. Instead change agents need to focus on the increasing value of software to the enterprise and engage senior executives by framing the value of the CMMI in their more strategic terms spanning innovative and visionary claims that enhance the reputation of the enterprise, promote superior economic achievement, meet mission performance expectation, achieve global competitiveness, promote trusted outsourcing, and demonstrate high assurance [9].

### Framing the Value of the CMMI

Contrary to the arguments by some that the CMMI is unnecessary [10] and its value is overestimated, the real value of the CMMI is systematically underestimated.

1. In the small, the value of the CMMI is traditionally cast in terms of cost, schedule, productivity, quality, customer satisfaction, and return on ROI [11]. In accordance with the Theory of Expected Utility [12], these outcomes are thought to attain the most benefits and incur the least cost when using the CMMI.

2. Specifically, where the cost of quality includes both the cost to achieve quality and the cost of poor quality, defect avoidance and early defect detection are the principal drivers underlying these benefits [13]. The cost of quality, often consuming two-thirds of the engineering budget, is being cut in half through process improvement.

3. In addition, software productivity improvements approaching 50% have been experienced along with overall cost reductions of 25% [14].

4. While the use of these factors as markers of CMMI value may supply sufficient motivation to adopt the CMMI, especially an attractive ROI, the real value of the CMMI is likely to be underestimated.

The value of the CMMI can be viewed more comprehensively and is ultimately determined by the increasing value of software to the enterprise and the nation. This more expansive vision of software value must take into account the essential role of systems engineering and its tight coupling with software engineering.

1. In the large, the value of the CMMI lies in its role as an enabler of strategic software management. Strategic software management revolves around knowing what the customer needs most, aligning the best capability to provide it, understanding current practice, measuring its critical aspects, selecting the most promising changes, planning for lasting improvement, raising the ability to improve, and staying the course.

2. In framing the issue around strategic intent, means, and measured outcomes, the value of the CMMI can be leveraged in terms of strategic software management, and the statements of strategic intent can be cast directly in the context of the

Value of CMMI	Strategic Intent	Means	Measured Outcomes
Business	Competitiveness	Supplier Control Customer Control Competitor Control Threat Event Control	Staff Churn Personnel Turnover Open Requisitions Employee Moral Personnel Overtime Off-the-Clock Time Span of Responsibility Customer Loyalty Customer Satisfaction Release Frequency Time to Market Reuse Practice Open Source Innovation
Management	Predictability	Commitment Management Requirements Management Planning and Tracking Management Oversight Risk Management	Change Control Cost Control Schedule Control Earned Value Control Productivity Quality Control Span of Responsibility
Process	Improvement	Process Definition Measurement Training	Repeatability Predictability Control Schedule Control Capability Control Capacity Control
Engineering	Trustworthiness	Disciplined Software Engineer- ing Completeness Correctness Consistency Rules of Construction Team Innovation	Reliability Availability Security Resiliency Traceability Defect Free Uniformity Complexity Control Usability Ideas generated, selected, and used
Operations	Dependability	Management Process Engineering Human Resources	Sustainability Repeatability Control Predictability Configuration Management Defect Management Span of Responsibility Capability Control Capacity Control

Table 1. Strategic Intent, Means, and Measured Outcomes

Industry Sector/ Elements of Value	Reputation	Economics	Mission	Competitiveness	Outsourcing	High Assurance
Telecommunications	•		•			•
Financial Services	•	•				•
Manufacturing		•		•	•	
Transportation			•			•
Medical	•		•			•
Utilities and Energy		•				
E-Commerce				•		
Defense			•			•

Table 2. Dominant Cultural Drivers by Industry Sector

business, management, process, engineering, and operations cultural drivers of the organization and its industry sector.

3. The adoption and expert use of the CMMI leverage the means through an organizational culture, professional environment, and process framework.

In reasoning about the value of the CMMI, the business value proposition revolves around how the issue of value is framed. As the means for carrying out statements of strategic intent and achieving measured outcomes, framing the value of the CMMI in the large focuses on the elements of strategic intent, means, and measured outcomes spanning business, management, process, engineering, and operations (see Table 1):

1. Business and competitiveness [15] include control of suppliers, customers, competitors, and threat events [16] and their measured outcomes spanning staff churn, personnel turnover, open requisitions, employee morale, personnel overtime, off-the-clock time, span of responsibility, customer loyalty, customer satisfaction, release frequency, time to market, reuse practice, open source, and innovation.

2. Management and predictability include commitment management; requirements management; planning and tracking cost, schedule, and quality; configuration management; management oversight; and risk [17] management and their measured outcomes spanning change control, cost control, schedule control, earned value control, productivity, quality control, and span of responsibility.

3. Process and improvement include process definition, measurement, and training and their measured outcomes spanning repeatability, predictability control, schedule control, capability control, and capacity control.

4. Engineering and trustworthiness include disciplined software engineering; the standard of excellence for completeness, correctness, consistency, and rules of construction; and team innovation and their measured outcomes spanning reliability; availability; security; resiliency [18]; traceability; defect free; uniformity; complexity control; usability; and ideas generated, selected, and used.

5. Operations and dependability include sustainable management, repeatable and predictable process, trustworthy software engineering, and human resources capability and capacity both in-house and outsource and their measured outcomes spanning sustainability, repeatability, predictability control, configuration management, defect management, span of responsibility, capability control, and capacity control [19].

### The Value of the CMMI Varies

The value of the CMMI varies in accordance with the forces that drive the organization. The culture of the organization is shaped by its strategically intended responses to these forces.

1. The industry sector in which an organization is a competing or participating member exerts influences associated with controlling suppliers, customers, competitors, and event threats. Some examples of industry sectors include telecommunications, financial, manufacturing, transportation, medical, utilities and energy, e-commerce, and defense.

2. The relative size, positioning, and longevity of an organization within its industry sector influence the mix of past, present, and future strategies and tactics it adopts. Some organizations find themselves anchored in the legacy of the past. Others simply glean the benefits of a prosperous economy without a plan for the future. Still others perhaps new on the scene, not well established, and without a legacy are banking on the future.

3. The software products and services and the mix of embedded, organic, and packaged offerings are driving forces in software production, fielding, and maintenance.

The value of the CMMI to an organization is different depending on the domain of forces to which it must respond. Where a valued aspect is dominant, such as, reputation and image, economics and finance, mission and continuity of operations, indicators of competitiveness, supply chain management and outsourcing, and trustworthiness and high assurance, an optimum response may result, thereby, simplifying the making of commitments, setting goals, and conducting tradeoffs. In less optimal situations, a blend of valued but competing aspects may lead to a more diverse response to these forces. Table 2 suggests the dominant cultural drivers by industry sector.

1. An organization driven by reputation and avoiding the risk of loss of trust may place a high value on trustworthiness and security along with the steps needed to assure these attributes. The telecommunications, financial services, and medical sectors where trust is all-important fit the reputation scenario.

2. An organization driven by economics may place a high value on profitability and attributes like cost control, productivity, and span of responsibility. The financial services, manufacturing, and utilities and energy sectors fit the economics scenario.

3. An organization driven by mission may place a high value on sustainability, capability control, and capacity control as well as reliability, availability, security, and resiliency. The telecommunications, transportation, medical, and defense sectors fit the mission scenario.

4. An organization driven by competitiveness may place a high value on release frequency, time to market, and innovation as well as cost and schedule control and predictability control. The manufacturing and e-commerce sectors fit the competitiveness scenario.

5. An organization driven by outsourcing may place a high value on release frequency, time to market, and innovation as well as quality control, configuration management, and span of responsibility of onshore staff. The manufacturing sector fits the outsourcing scenario.

6. An organization driven by high assurance may place a high value on trustworthiness including quality control, defect free, predictability control, resiliency, and frequency of release. The telecommunications, financial services, transportation, medical, and defense sectors fit the high assurance scenario.

Table 3. Ranking Cultural Drivers and CMMI Categories

Cultural Drivers/ CMMI Categories	Reputation	Economics	Mission	Competitiveness	Outsourcing	High Assurance
Project Management	2	1	3	1	2	3
Product Engineering	1	2	1	2	3	2
Process Management	3	3	2	3	1	1

Table 4. Ranking CMMI Categories, Cultural Drivers, and Leading Measured Outcomes

Cultural Drivers/ CMMI Categories	Reputation	Economics	Mission	Competitiveness	Outsourcing	High Assurance
Project Management	2 Release Frequency	1 Span of Responsibility	3 Quality Control	1 Time to Market	2 Change Control	3 Quality Control
Product Engineering	1 Defect Free	2 Complexity Control	1 Resiliency	2 Innovation	3 Traceability	2 Resiliency
Process Management	3 Schedule Control	3 Capability Control	2 Repeatability	3 Capacity Control	1 Predictability Control	1 Predictability Control

Table 5. Ranking CMMI Constellations, Cultural Drivers, and Leading Measured Outcomes

CMMI Constellation/s Cultural Drivers	Reputation	Economics	Mission	Competitiveness	Outsourcing	High Assurance
Development	1 Defect Free	3 Complexity	3 Quality Control	2 Innovation	2 Traceability	1 Quality Control
Acquisition	3 Schedule	1 Span of Responsibility	2 Repeatability	3 Time to Market	3 Predictability Control	3 Predictability Control
Service	2 Release Frequency	2 Capability Control	1 Resiliency	1 Capacity Control	1 Change Control	2 Resiliency

Table 6. Description of Leading Measured Outcomes

Achieving the value of the CMMI in actual application in the wild varies with the profile of the project and organization. The organizational challenges in culture, governance, shared ownership, and accountability may be larger than the challenges of information technology and software engineering [20]. Table 3 ranks the cultural drivers and CMMI categories of project management, product engineering, and process management. Table 4 shows these rankings along with the leading measured outcomes. Table 5 shows these rankings arranged by CMMI constellation. See Table 6 for a description of leading measured outcomes.

Particular CMMI Process Areas are associated with leading measured outcomes. See Table 7 for CMMI Process Areas by Cultural Drivers Leading Measured Outcomes.

Outcomes	Description
Capability Control	Managing and sustaining the knowledge, skills, and abilities of enterprise and project personnel to perform the standard organization process definition and its project tailoring.
Capacity Control	Managing and sustaining the personnel workforce with the knowledge, skills, and abilities of enterprise and project personnel needed to perform the standard organization process definition and its project tailoring.
Change Control	Managing changes to a baseline to form a new baseline.
Complexity Control	Maintaining intellectual control over the interfaces, dependencies, and interactions among software components within a system.
Defect Free	Absence of errors, faults, and failures.
Innovation	The intersection of invention and insight leading to the creation of something of value.
Predictability Control	The application of statistical process control to cost, schedule, and quality metrics and the control of the resulting variances.
Quality Control	Managing quality expectation and actual quality performance.
Release Frequency	Duration between the issuance of quality assured product updates to the field.
Repeatability	The degree to which a process description is faithfully carried out on successive applications.
Resiliency	The ability of a system of systems to anticipate, avoid, minimize, withstand, and recover from the affects of adversity, whether manmade or natural, under all circumstances of use.
Schedule Control	Managing schedule estimation, budgeting, change orders, and actual schedule performance.
Span of Responsibility	Total number of source lines of code on the project divided by the total head count on the project.
Time to Market	Duration between the time of conception and the ship date of a product or service.
Traceability	The alignment of software life cycle artifacts.

Table 7. CMMI Process Areas by Cultural Drivers and Leading Measured Outcomes

Cultural Drivers/ Measured Outcomes	Reputation	Economics	Mission	Competitiveness	Outsourcing	High Assurance
Defect Free	REQM, M&A, PPQA OPD, OT, IPM, TS, PI, VER, VAL QPM, OPP					
Span of Responsibility		PP, PMC, M&A OPD, OT, IPM				
Resiliency			RD, TS, RSKM			RD, TS, RSKM
Time to Market				REQM, PP, PMC		
Predictability Control					PP, PMC, M&A, PPQA OPD, OT, IPM	PP, PMC, M&A, PPQA OPD, OT, IPM
Release Frequency	REQM, PP, PMC					
Complexity Control		REQM, CM RD, TS OPM, OPP				
Repeatability			OPPD, OT			
Innovation				OID		
Change Control					REQM, CM	
Schedule Control	PP, PMC					
Capability Control		OPD, OT, IPM				
Quality Control			PPQA			PPQA
Capacity Control				OPD, OT, IPM		
Traceability					REQM, CM RD, TS, VER, VAL	

## Conclusion

While the value of the CMMI determined in the traditional way is sufficient to promote adoption of the CMMI, the value of the CMMI determined more strategically in terms of the means for carrying out statements of strategic intent in achieving measured outcomes in business and competitiveness, management and predictability, process and improvement, engineering and trustworthiness, and operations and dependability reveals the real value. When the industry sector forces and their cultural drivers, such as, reputation, economics, mission, competitiveness, outsourcing, and high assurance are taken into account, a deeper understanding of which CMMI categories and process areas need to be emphasized is the result.

1. For the enterprise considering adopting the CMMI as its framework for process improvement, framing the value of the CMMI in terms of cost, schedule, productivity, quality, customer satisfaction, and ROI is recommended. Here it needs to be understood that the CMMI may operate best in a closed system with top-down command and control decision making and that

there is a growing preference for open organization environments with more diverse bottom-up consensus-based decision making where other choices may be preferred.

2. For the enterprise already engaged with the CMMI but seeking to extract the true value of the CMMI in the context of industry sector forces and intent on maximizing that value in terms of cultural drivers and specific strategic intents, framing the value of the CMMI more strategically in terms of measured outcomes in business and competitiveness, management and predictability, process and improvement, engineering and trustworthiness, and operations and dependability is recommended. Here it needs to be understood that the CMMI lacks an explicit correlation to business alignment and strategic planning and that innovative strategic thinking is required to connect the CMMI with these sources of essential value to the enterprise. ❖

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## ABOUT THE AUTHOR



**Don O'Neill** is a seasoned software engineering manager and technologist currently serving as an independent consultant. Following his 27 year career with IBM's Federal Systems Division, Mr. O'Neill completed a three-year residency at Carnegie Mellon University's SEI under IBM's Technical Academic Career Program and has served as an SEI Visiting Scientist.

In his IBM career, Mr. O'Neill completed assignments in management, technical performance, and marketing in a broad range of applications including space systems, submarine systems, military command and control systems, communications systems, and management decision support systems. He was awarded IBM's Outstanding Contribution Award three times:

1. Software Development Manager for the GPS Ground Segment.
2. Manager of the FSD Software Engineering Department responsible for the origination of division software engineering strategies, the preparation of software management and engineering practices, and the coordination of these practices throughout the division's software practitioners and managers.
3. Manager of Data Processing for the Trident Submarine Command and Control System Engineering and Integration Project responsible for architecture selections and software development planning.

Mr. O'Neill served on the Executive Board of the IEEE Software Engineering Technical Committee and as a Distinguished Visitor of the IEEE. He is a founding member of the Washington DC Software Process Improvement Network and the National Software Council and served as the President of the Center for National Software Studies from 2005 to 2008. He was a contributing author of "Software 2015: A National Software Strategy to Ensure U.S. Security and Competitiveness", a report on the Second National Software Summit. Mr. O'Neill has served as a reviewer of National Science Foundation software engineering research proposals and has served as a member of the NIST Software Assurance Metrics and Tool Evaluation Advisory Committee (2006-2008). He has authored Business Case articles for the CERT Build Security In web site. His current research is directed at public policy strategies for deploying resiliency in the nation's critical infrastructure.

Mr. O'Neill is an active speaker on software engineering topics and has numerous publications to his credit. He has a Bachelor of Science degree in mathematics from Dickinson College in Carlisle, Pennsylvania.

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17. Risk: Uncertainty and the prospect for loss or gain depending on the outcome of an event.
18. Resiliency: The ability to anticipate, avoid, withstand, mitigate, recover from the effects of adversity whether natural or manmade under all circumstances of use.
19. A software system that is trustworthy sustains attributes associated with properties, such as, completeness, correctness, consistency, predictability, availability, dependability, interoperability, security, safety, resilience, privacy, and usability and does so under all circumstances of use.
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