Relationships Between CMMI® and Six Sigma

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Abstract

Organizations that endeavor to improve their processes often find themselves juggling many approaches to achieve that improvement. To be most effective, all improvement initiatives selected should be implemented in an integrated fashion, not as layered or stovepiped efforts. This document focuses on the joint use of two popular improvement initiatives: Capability Maturity Model® Integration (CMMI®) and Six Sigma.

Successfully implementing CMMI and Six Sigma together requires an understanding of the relationships between the two. This report contains a brief summary of each initiative and then outlines the connections between frameworks commonly used in Six Sigma and the CMMI process areas. Coupling this knowledge with a conscious strategy enables an organization to create tactical plans and specific mappings to support implementation. Example strategies and tactics that organizations have used to integrate these initiatives are also provided.

1 Introduction

Organizations begin the journey of process improvement for many different reasons. Some realize the need for improvement when their products fail after release and must be repaired. Others are driven by mandates and regulatory requirements, such as the need to achieve a Capability Maturity Model® Integration (CMMI®) Maturity Level 3 to be able to bid on a contract or show that they comply with the Sarbanes-Oxley Act. Significant business issues, such as a lost contract or a new market opportunity, can also draw attention to process improvement.

The most effective and sustained improvement of any type is done in response to performance needs, not compliance goals. Whether an organization's improvement is focused on the performance of a product, project, or process, its purpose should be to close the gap between actual and desired performance—where "desired" is driven by factors such as customer requirements and the needs of the business.

Organizations that endeavor to improve often find themselves juggling many solutions: maturity models, EIA standards, acquisition standards, ISO standards, measurement best practices, codified life-cycle processes such as Team Software Process℠ (TSP℠), software development principles, and more. All improvement initiatives selected by an organization should be implemented in an integrated fashion, not as layered or stovepiped efforts. And the result should be a set of organizational processes, used by everyone—from developer to software engineering process group (SEPG)[1] member to manager—that reflect the features of the improvement initiatives chosen.

This document focuses on two popular improvement initiatives: CMMI and Six Sigma. As CMMI has become more widely institutionalized and Six Sigma has made its way into engineering disciplines, numerous questions have arisen, including the following:

- How do I leverage Six Sigma with software process improvement initiatives already underway in my organization?
- Should I pick Six Sigma or CMMI? Or, how do I convince my management that it's not an either/or decision?
- What evidence is there that Six Sigma works in software and systems engineering?
- How do I train software engineers when Six Sigma training is geared for manufacturing?
- How has Six Sigma been used in software projects? In IT?

[1] SEPGs work with organizations to improve process quality by helping to assess current status, plan and implement improvements, and transfer technology to facilitate improvement in practice. For more information about SEPGs, see the *Software Engineering Process Group Guide*, available online at http://www.sei.cmu.edu/publications/documents/90.reports/90.tr.024.html.

- Isn’t Six Sigma only about advanced statistics?
- What is a software “opportunity?” And how do I calculate sigma?

The primary focus of this document is to answer the first two questions, which relate to implementing more than one initiative at a time. If multiple initiatives are going to be integrated successfully under the umbrella of standard organizational processes, those designing the processes must understand the relationships and synergies among the initiatives.

After providing a brief summary of CMMI fundamentals and an overview of what Six Sigma is and what it is not, this document explores the relationships between CMMI and Six Sigma and how they can be used together.

2 Overview of CMMI

The Software Engineering Institute (SEI) has been involved in the creation and maintenance of various capability models for many years. These models are non-prescriptive collections of best practices that infuse quality into products through the use of better processes throughout the entire product life cycle. The CMMI model, developed by a group of industry, government, and SEI representatives, is made up of best-of-the-best processes gleaned from multiple disciplines. It provides guidance in specific process areas by providing goals and a set of expected practices needed to meet those goals.

In practice, if an organization plots its typical business rhythms, it can organize its practices into groups. One way of grouping like activities is the CMMI process areas. The process areas are divided into four categories: Process Management, Project Management, Engineering, and Support.

CMMI process areas are also categorized into several disciplines. The base model contains 22 process areas that cover the systems and software engineering disciplines. To satisfy a process area, certain unique characteristics must be present. These characteristics are described in what the CMMI calls *specific goals*. The model also includes *generic goals*, which are goals that appear in multiple process areas. The activities that are expected to result in the achievement of specific goals are called *specific practices*, while *generic practices* appear in multiple process areas and are considered important in achieving associated generic goals. All process areas are also classified as *Fundamental* or *Progressive*. Fundamental process areas should be implemented first to ensure that the prerequisites are met to successfully implement the Progressive process areas [Chrissis 03].

In addition to the 22 process areas in the base model, there are 3 process areas that cover integrated product and process development (IPPD) and 1 that covers supplier sourcing. IPPD is a systematic approach that achieves a timely collaboration of relevant stakeholders throughout the life of the product to better satisfy customer needs, expectations, and requirements [Chrissis 03]. Team structure plays a part in the successful development of products. Many organizations are adopting team structures and enabling better group dynamics. Projects and organizations frequently obtain product components from suppliers and subcontractors outside the company. Although it is often more cost effective to acquire something from outside than build it from scratch inside, the relationship with suppliers must be managed within the project to avoid schedule slips and identify team dependencies.

2.1 Process Management

The Process Management process areas provide the framework for institutionalization and consistent execution of processes across an organization. They provide an organization with the capability to document and share best practices, organizational process assets, and learning across the organization [Chrissis 03]. The process areas in this category are

- **Organizational Process Focus**—helps the organization to plan and implement organizational process improvement based on an understanding of the current strengths and weaknesses of the organization's processes and process assets.
- **Organizational Process Definition—**establishes and maintains the organization's set of standard processes and other assets based on the process needs and objectives of the organization. These other assets include descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process-related documentation, and data.
- **Organizational Training—**identifies the strategic training needs of the organization and the tactical training needs that are common across projects and support groups.
- **Organizational Process Performance—**derives quantitative objectives for quality and process performance from the organization's business objectives. The organization provides projects and support groups with common measures, process performance baselines, and process performance models.
- **Organizational Innovation and Deployment**—selects and deploys proposed incremental and innovative improvements that increase the organization's ability to meet its quality and process-performance objectives.

2.2 Project Management

Organizations are made up of individual projects or programs, which usually deliver the organization's products. The Project Management process areas cover the project-management activities related to planning, monitoring, and controlling projects [Chrissis 03].The process areas in this category are

- **Project Planning—**includes developing the project plan, involving stakeholders appropriately, obtaining commitment to the plan, and maintaining the plan. Projects need defined plans containing all key elements, including the project definition, allocation of resources, staff, budget, and schedule.
- **Project Monitoring and Control—**includes monitoring activities and taking corrective action. By monitoring progress against the plan, management can gain insight into how the project is performing.
- **Supplier Agreement Management—**addresses the need of the project to effectively acquire those portions of work that are produced by suppliers. The acquirer should obtain agreement with the supplier on schedule, budget, milestones, status meetings, quality audits, acceptance criteria, and reviews.

- **Integrated Project Management—**establishes and maintains the project's defined process that is tailored from the organization's set of standard processes. The involvement of the stakeholders in the project is a key element for effective management. In a successful project, all relevant stakeholders are involved in the management, planning, and status reporting of the project.
- **Integrated Project Management for IPPD (supports IPPD discipline)—**supports the use of a project's shared vision and an integrated team structure to carry out the objectives of the project. (All of the practices of Integrated Project Management are retained in this version of the process area, but goals and practices specific to IPPD are added.)
- **Risk Management—**takes a more continuing, forward-looking approach to managing risks than is given in the Project Planning and Project Monitoring and Control process areas. It includes activities for the identification of risk parameters, risk assessments, and risk handling.
- **Integrated Teaming (supports IPPD discipline)—**forms and sustains an integrated team for the development of selected work products. The team is composed of individuals representing relevant stakeholders who generate and implement decisions for the work product being developed. The members of the integrated team are collectively responsible for delivering the work product.
- **Integrated Supplier Management (supports supplier sourcing discipline)—**proactively identifies sources of products that may be used to satisfy project requirements and monitors risks associated with selected supplier work products and processes while maintaining a cooperative project-supplier relationship.
- **Quantitative Project Management—**applies quantitative and statistical techniques to manage process performance and product quality. Measures should be collected throughout all critical processes and management activities. These measures will provide valuable insight into the project's performance.

2.3 Engineering

Engineering process areas cover development and maintenance activities that are shared across engineering disciplines (e.g., systems engineering and software engineering). They apply to the development of any product or service in the engineering development domain [Chrissis 03].The process areas in this category are

- **Requirements Development—**identifies customer needs and translates them into product requirements. These requirements are supplied to activities described in the Technical Solution process area, where the requirements are mapped into the product architecture, product-component design, and the product component itself (e.g., coding, fabrication).
- **Requirements Management—**maintains the requirements and describes activities for controlling requirement changes and ensuring that other relevant plans and data are kept current. Requirements must be stabilized, and all changes should be understood and traced through the work products to determine their impact.

- **Technical Solution—**architects the product and develops technical data packages for product components that will be used by the Product Integration process area. After the requirements are allocated and a product's components are defined, the engineers need to decide how the components will be produced. Will they be developed in house, by a subcontractor, or bought off the shelf?
- **Product Integration—**prepares the product for delivery to the customer, including assembly of product components and confirmation that the assembled products function properly.
- **Verification—**ensures that selected work products meet the specified requirements. Verification includes the use of peer reviews as well as other verification methods.
- **Validation—**incrementally validates products against the customer's needs. Validation can be applied to any aspects of the product in its intended end-use environment.

2.4 Support

All projects include a group of activities which are the underpinning of the production and development efforts. Support process areas cover the activities that support product development and maintenance [Chrissis 03]. The process areas in this category are

- **Configuration Management—**supports all process areas by establishing and maintaining the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits. Configuration management assures that the deliverable is reproducible, traceable, and approved for release.
- **Process and Product Quality Assurance—**supports all process areas by providing specific practices for objectively evaluating performed processes, work products, and services against the applicable process descriptions, standards, and procedures and ensuring that any issues arising from these reviews are addressed.
- **Decision Analysis and Resolution—**supports all the process areas by providing a formal evaluation process that ensures that alternatives are evaluated and the best is selected. Throughout production there are decisions which must be made. These decisions, similar to risks, must be managed to assure standardized resolution.
- **Measurement and Analysis—**supports all process areas by providing specific practices that guide projects and organizations in using identified measurement needs and objectives to derive a measurement approach that will provide objective results. These results can be used in making informed decisions and taking appropriate corrective actions.
- **Organizational Environment for Integration (supports IPPD discipline)—**establishes the approach and environment for the implementation of IPPD. A shared vision must be established by the organization that clearly gives focus to the projects and teams.
- **Causal Analysis and Resolution—**is used for understanding the common causes of variation inherent in processes and removing them. The good parts of a process are repeated, and bad parts are removed.

3 Overview of Six Sigma

Six Sigma is a holistic approach to business improvement that includes philosophy, performance measurements, improvement frameworks, and a toolkit—all of which are intended to complement and enhance existing engineering, service, and manufacturing processes. Because of its many dimensions, Six Sigma can serve as both an enterprise governance model and a tactical improvement engine.

Initially, the focus of Six Sigma was to improve manufacturing processes. As it has matured and become more widely used, organizations have been applying this data-driven improvement initiative to the rest of their business life cycles and supply chains. Applications in service or transactional organizations are sometimes termed the "second wave" of Six Sigma implementation. Applications in engineering, including those in software and systems, are sometimes termed the "third wave" of Six Sigma implementation.

The Six Sigma philosophy is to improve customer satisfaction through the prevention and elimination of defects and, as a result, increase business profitability. Six Sigma defines defects in terms of the customer's (not the engineer's) viewpoint. Therefore, defects are product, service, or process variations which prevent customers from having their needs met, or which add cost, whether or not that cost is detected. Business profitability is the central motive of Six Sigma.

The quest to achieve the desired level of performance (as measured by sigma or another gauge) is based on the following key underlying principles of statistical thinking:

- Everything is a process.
- All processes have inherent variability.
- Data is used to understand variation and to drive decisions to improve the processes.

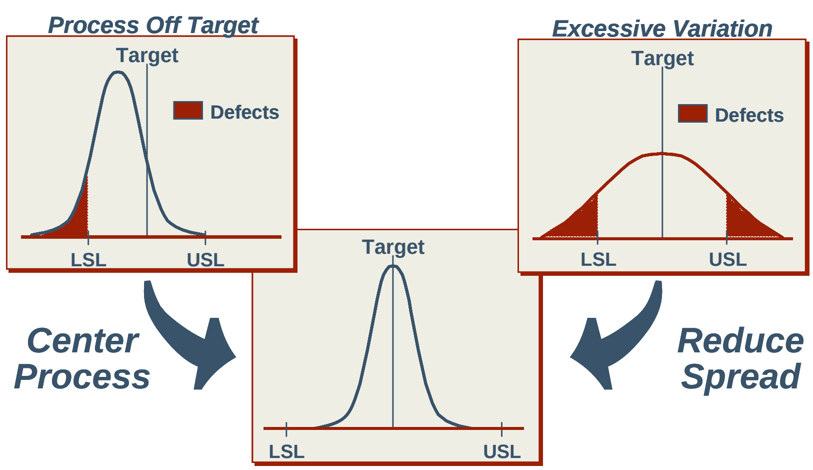

Figure 1: Representation of Statistical Thinking

The paradigm of statistical thinking is embodied in Six Sigma's methodologies, which are used as a basis for executing improvement projects. The following frameworks currently prevail:

- **DMAIC** (Define, Measure, Analyze, Improve, Control) is used to improve and optimize existing processes and products. An example DMAIC roadmap is shown in Figure 2.
- **DFSS** (Design for Six Sigma) is used to design new products and processes, and to redesign existing products and processes that have been optimized but still do not meet performance goals. The latter case has sometimes been observed when moving from a 5-sigma level of performance to a 6-sigma level. DFSS is more varied than DMAIC in its implementation. One example sequence of DFSS is Define, Measure, Analyze, Design, Verify.
- **Lean**[2] combined with Six Sigma is an increasingly occurring variant of the Six Sigma movement. The tactical aspects of Lean—Kaizen Events, in particular—can be implemented within the existing DMAIC or DFSS frameworks. In a Kaizen Event, people examine the current state of a process or product and identify waste (i.e., non-value-added) areas. Through the elimination of waste, they can propose an improved future state.[3] Lean is being increasingly implemented as an enterprise-governance model, within which organizations are being asked to explain how Six Sigma or CMMI fits. The questions being asked are similar to those regarding the relationship between CMMI and Six Sigma.

As organizations institutionalize Six Sigma and the other initiatives of their choosing, they go through a data-driven journey of discovery about their goals and processes, the characterization of those processes, the identification of critical control factors, and the improvement of those processes, all of which lead to the ability to predict performance. As their data usage matures, they better understand their processes' behaviors, interrelationships, and dynamics, and how this information can be used to gain competitive advantage.

The Six Sigma toolkit supports process improvement with a comprehensive suite of statistical and non-statistical methods from previous evolutions of quality- and business-improvement initiatives. It is important to remember that the Six Sigma toolkit is dynamic and organization-specific. The decision to adapt, add, or focus on specific methods should be made to better meet customer needs and increase business benefits. Additionally, the toolkit should be adapted for the domain. Figure 3 shows a DMAIC toolkit that has been adapted for use by an SEPG that is using the Goal-Question-Indicator-Measure (GQIM)[4] and Practical Software and Systems Measurement (PSM)[5] methods to support their CMMI implementation. Other possible

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[2] Lean is a process in which waste—activities a customer would not want to pay for or that add no value to the product or service from the customer's perspective—are identified and eliminated. *Lean Thinking* by James Womack and Daniel T. Jones explains the principles of Lean. Additional information is also available at http://www.lean.org

[3] For more information about Kaizen Events, see http://www.isixsigma.com/dictionary/Kaizen_Event-411.htm.

[4] GQIM is a method that translates informal goals into executable measurement structures. See *Goal-Driven Software Measurement—A Guidebook* for more information, available at http://www.sei.cmu.edu/pub/documents/96.reports/pdf/hb002.96.pdf.

[5] PSM is an information-driven measurement process that addresses the unique technical and business goals of an organization. For more information, see http://www.psmsc.com.

adjustments would be to elaborate on “modeling” to show that it includes Bayesian modeling,[6] or to make explicit parametric vs. non parametric methods.

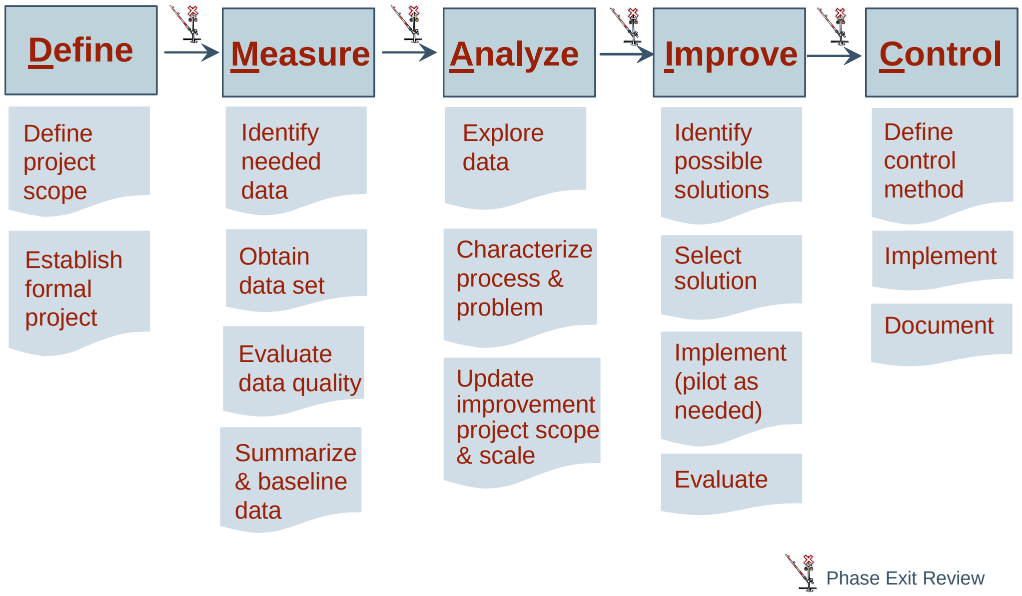

Figure 2: DMAIC Roadmap from SEI Course “Measuring for Performance-Driven Improvement”

Define	Measure	Analyze	Improve	Control
Benchmark	GQ(I)M and Indicator Templates	Cause & Effect Diagrams/Matrix	Design of Experiments	**Statistical controls:**
Contract/Charter	Data Collection Methods	Failure Modes & Effects Analysis	Modeling	o Control Charts
Kano Model	Measurement System Evaluation	Statistical Inference	ANOVA	o Time Series Methods
Voice of the Customer		Reliability Analysis	Tolerancing	**Non-Statistical controls:**
Voice of the Business		Root Cause Analysis, including 5 Whys	Robust Design	o Procedural Adherence
Quality Function Deployment		Hypothesis Test	Systems Thinking	o Performance Management
			Decision & Risk Analysis	o Preventative Measures
			PSM Performance Analysis Model	
Basic Tools (Histogram, Scatter Plot, Run Chart, Pareto Chart, Cause & Effect Diagram, Control Chart, Descriptive Statistic), Baseline, Process Flow Map, Project Management, Management by Fact, Sampling Techniques, Survey Methods, Defect Metrics.				

Figure 3: Tailored DMAIC Toolkit from SEI Course “Measuring for Performance-Driven Improvement”

[6] Bayesian modeling uses probability methods to remove meaningless relationships in a model and quantify the meaningful ones. For more information, see http://research.microsoft.com/adapt/MSBNx /msbnx/Basics_of_Bayesian_Inference.htm.

There are several misconceptions about Six Sigma that need to be addressed before we elaborate on its connections with CMMI.[7]

Six Sigma is **not**

- just about statistics
- just for manufacturing
- exclusively about defect density
- limited to large organizations
- equivalent to compliance with standards and models, and vice versa
- necessarily synonymous with Level 4
- limited to use in high-maturity organizations
- a competitor to CMMI or other process models and standards
- always the performance goal (Sometimes it's "7" sigma; sometimes it's 3 sigma.)

Three of these statements, in particular, merit elaboration. They are discussed briefly below, and more information is provided in Section 4.

Six Sigma success is *not* equivalent to compliance with standards and models, and vice versa.

Industry models and standards frequently demand measurements, monitoring, and control. Frequently used standards include CMMI models, ISO, IEEE standards, and ISO 12207. Six Sigma can be used to achieve compliance with aspects of each of these standards. However, interpreting Six Sigma usage as achievement of model compliance, and likewise assuming Six Sigma when compliance is found, is a mistake.

Six Sigma is *not* limited to use in high maturity organizations.

In organizations that primarily use CMMI, many people associate Six Sigma with the high maturity process areas. However, there is a direct connection between Six Sigma and the generic practices, which are used for process areas at all maturity levels. Six Sigma enables a tactical approach to the implementation of the generic practices, and therefore much of the intent of the high-maturity process areas is implemented at lower maturity or within the continuous representation. This drastically accelerates the cycle time required for the final steps to high maturity by putting the building blocks for the high-maturity process areas in place.

Six Sigma is *not* a competitor to CMMI or other process models and standards.

There are many domain-specific models and standards. Six Sigma is not domain specific and can be a governance model or a tactical improvement engine. It can provide the problem definition and statement of benefit against which a decision about adopting a technology can be made. It can help solve specific problems and improve specific products or processes within the larger context of overall organizational process improvement. Or, in more general terms, it can serve as an enabler for the successful implementation of domain-specific improvement models [Bergey 04].

[7] There are also misconceptions about CMMI. For more information, see "CMMI Myths and Realities," available at http://www.stsc.hill.af.mil/crosstalk/2004/06/0406Heinz.html.

4 Integrating CMMI & Six Sigma: Strategies

An increasing number of papers have been published about organizations' successful integration of CMMI and Six Sigma. These organizations have found ways to overcome the perception that the initiatives are competitors or mutually exclusive alternatives and are effectively blending them to achieve their organizational missions.

From the published information available, we abstracted the following strategies for using these initiatives together. This is not an exhaustive list, but rather reflective of patterns we have observed, overlaid with what our experience tells us works well. This list does not presume that CMMI precedes Six Sigma adoption or vice versa.

Implement CMMI process areas as Six Sigma projects.

In the most straightforward sense, this means that the objective of the Six Sigma project team is to implement a process area or a group of process areas. Their task is to define the problem or opportunity and to use available data to inform the improvement or design of processes that will serve the organizational mission and meet model requirements. Depending on whether the process area implementation involves updating existing processes or defining new processes, DMAIC, DFSS, or Lean might be appropriate. Examples of this have been shown in presentations by Northrop Grumman and Raytheon.

When using CMMI and Six Sigma in this fashion, it is important to remember this conventional wisdom: "map the model to the process, not the process to the model."

Use Six Sigma as the tactical engine for high capability and high maturity.

From a process definition standpoint, there is natural synergy between the high maturity process areas and the tenets of Six Sigma's DMAIC framework. As such, the tactics of Six Sigma can be used to directly enrich the defined processes that address the high maturity process areas. For instance, the processes related to the Quantitative Process Management and Causal Analysis and Resolution process areas would reflect both the specific practices of those process areas and the roadmap steps, substeps, and tools of DMAIC.

Staff members from Northrop Grumman have given presentations on their use of Six Sigma to achieve high maturity. While other organizations are also using this approach, they have not shared their identities and experiences [Bergey 04].

A variation on this theme is to use Six Sigma as a tactical engine for the engineering process areas. In this instance, tenets of DFSS would be used to enrich the processes that address the engineering process areas. Then DMAIC could be coupled with the generic practices to institutionalize, optimize, and achieve high capability in those processes.

Apply Six Sigma to improve or optimize an organization's improvement strategy and processes.

Six Sigma can be used in making decisions about the adoption of improvement initiatives and in the management and overhead associated with adoption. Here are different ways of applying Six Sigma in this context:

1. appraisal streamlining and cost reduction for ARC Class B and C methods
2. identification of highest priority organizational problems to inform decisions about improvement project selection and portfolio management
3. optimization of the CMMI and overall improvement program execution

DMAIC and Lean seem particularly well suited to these approaches, although DFSS could have a role in the initial definition of SEPG processes. If combined with the previous strategies, an organization might use the "Define, Measure, Analyze" steps of DMAIC to define an improvement project portfolio that serves the organization's mission. Using CMMI for guidance and possibly as governance for specific improvements, the organization could then employ DMAIC, Lean, or DFSS for each respective improvement effort and propel itself toward "control" and "optimization" one project at a time. A focus on mission and performance ultimately results in compliance to the model.

Integrate CMMI, Six Sigma, and all other improvement initiatives to provide a standard for the execution of every project throughout its life cycle.

While the previous three approaches are tactical (i.e., they provide a course of action), this is an approach for setting an organization's strategy. It is longer term and more visionary. It promotes the idea that an organization should take control of its destiny and manage its initiatives rather than be managed by them. Six Sigma methods can be leveraged to design the organization's standard processes, but the focus here is embedding Six Sigma alongside other initiatives in the organizational business and engineering processes.

This approach can be executed at any maturity level, with any maturity level as the end goal. When possible, it's best to start while at low maturity. Many people describe this idea in different ways. It has been called, among other things, "integrated process architecture," "interoperable process architecture," and "internal integrated standard process." Lockheed Martin IS&S labels its approach a "program process standard" [Penn 03].

Regardless of the label, the idea remains the same: the organization establishes a set of standard processes that incorporates all the features of the initiatives of choice. This idea assumes that conscious decisions have been made at the organizational level to adopt these initiatives. Also assumed is that the process is adaptable with time (i.e., capable of iterative refinement) and instrumented and robust to the realities of the organization (e.g., the types of work done and the degree of organizational acquisition).

In addition to Lockheed Martin IS&S, whose mapped program process standard has been presented at a high level at conferences, Northrop Grumman Mission Systems (formerly TRW) has also presented its enterprise strategy showing how it jointly leveraged CMMI, Six Sigma, and other initiatives. Both organizations have made presentations showing how their approach has evolved with time. (See the References and Selected Additional Reading sections for pointers to some of these presentations.)

5 Integrating CMMI & Six Sigma: Tactics

Successfully implementing CMMI and Six Sigma together requires an examination of the relationships between the two. People often create a mapping when comparing another improvement initiative with CMMI. Because CMMI and Six Sigma are two different types of initiatives with many different connections and overlaps, a complete mapping of the "general case" is unwieldy and offers little practical value. What is useful for the general case is to understand their complementary focus and the ways in which they are connected. Coupling this understanding with a conscious strategy enables an organization to create tactical plans and specific mappings to support their implementations.

5.1 Complementary Focus

CMMI is used to create an organizational process infrastructure by addressing particular domains, such as software and systems engineering. Six Sigma is a top-down initiative that cuts across the entire enterprise, including areas such as engineering, sales, marketing, and research. Six Sigma is intended to be implemented with a focus on problems and opportunities, often with narrow scopes, that will yield significant business benefits. It focuses on the performance of processes and practices as implemented rather than checking for compliance against a definition or model. While these two improvement initiatives are different by design, they are interdependent in their use. In practice, a back and forth focus is often effective. For instance, Six Sigma could be used to discover that processes need to be more repeatable, CMMI could be used to institute processes based on community best practice, and then Six Sigma could be used to optimize those processes.

In this integrated approach the high-level synergies between the two become evident. As shown by Rick Hefner in his presentation at the 2005 Software Engineering Process Group Conference, CMMI offers institutionalization features that are lacking in Six Sigma [Hefner 05]. Six Sigma reinforces mission focus, and its enterprise deployment strategy fosters culture change that is supportive of CMMI implementation.

5.2 Relationships Between CMMI Process Areas and the DMAIC Framework

In this section, we focus on connections between DMAIC and the CMMI process areas and include a few notes on connections between Lean's Kaizen Events and the process areas. Remember: just as the CMMI model should be mapped to an organization's processes rather than designing the processes to exactly match the model's practices, DMAIC should be incorporated into the measurement process rather than changing the organization's defined processes to match the steps of DMAIC.

5.2.1 Connection 1: CMMI Process Areas, DMAIC Steps, and Generic Practices

Several CMMI process areas and generic practices align with DMAIC roadmap steps. The diagram in Figure 4 shows a flowchart of an organization's overall measurement process, overlaid with DMAIC steps and selected process areas. While this organization's process was designed with model compliance in mind, it represents an integrated approach to the overall use of measurement instead of a replication of the specific practices of each process area. Similarly, this organizational process leverages ideas of DMAIC, but is not a replication of the DMAIC steps.

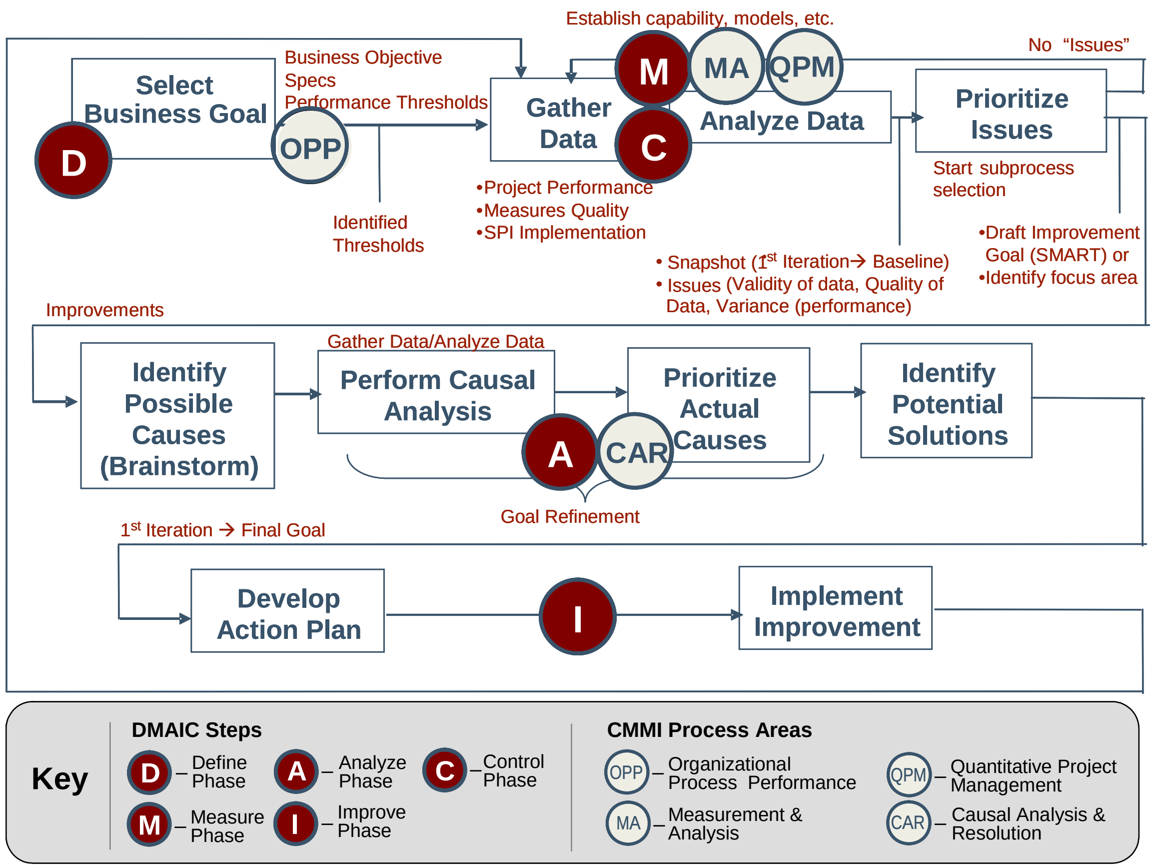

Figure 4: CMMI Process Areas and DMAIC Steps

The organization's measurement process could also be mapped to the generic practices that apply to all the CMMI process areas shown. The generic practices that are oriented to this organization's measurement process are listed below.

- Generic Practice 2.8, Monitor and Control the Process
- Generic Practice 3.2, Collect Improvement Information
- Generic Practice 4.1, Establish Quality Objectives
- Generic Practice 4.2, Stabilize Subprocess Performance

- Generic Practice 5.1, Ensure Continuous Process Improvement
- Generic Practice 5.2, Correct Common Causes of Problems

5.2.2 Connection 2: CMMI Project Management Process Areas and Six Sigma Project Management

The CMMI process areas involving project management can be leveraged in the management of Six Sigma projects. This enables Six Sigma project teams to rely on the organizational norms for things like project launches, resource commitments, and schedule tracking.

The process areas that can be useful in this context are

- Project Planning (PP)
- Project Monitoring and Control (PMC)
- Integrated Project Management (IPM)
- Organizational Process Performance (OPP) (for organization-level execution, management, and oversight of the aggregate set of Six Sigma projects)

5.2.3 Connection 3: Incorporating DMAIC Steps Within CMMI-Based Processes

As alluded to in Figure 4, aspects of DMAIC can be incorporated into the fabric of an organization's process. As such, it would become part of the organizational approach and should be documented within Organizational Process Focus (OPF) and Organizational Process Deployment (OPD).

5.2.4 Connection 4: DMAIC-Based Improvement of Process Areas

All CMMI process areas are eligible for DMAIC-based improvement. For instance, the measurement process shown in Figure 4 was created based on CMMI but also contained aspects of DMAIC. The defined process for measurement in that example, and for other processes defined based on each of the other process areas, could also be improved by applying multiple iterations of DMAIC.

5.2.5 Connection 5: Six Sigma Toolkit and CMMI Process Areas

Numerous process areas have links to the Six Sigma analytical toolkit. Some examples are listed below.

- Decision Analysis & Resolution (DAR) can use concept selection methods such as Pugh's concept.[8]
- Risk Management (RSKM) can use Failure Modes & Effects Analysis (FMEA).[9]

[8] Pugh's concept is a selection technique, set up in a matrix format, which assists in evaluating and synthesizing concept alternatives. See http://www.isixsigma.com/dictionary/Pugh_Matrix-384.htm for more information.

- Technical Solution (TS) can use Design FMEA.

Connections can be made between DMAIC roadmap steps (shown earlier in this document) and the specific goals of process areas. Although DMAIC roadmaps vary from organization to organization, we have included one sample of these connections in Appendix A.

For those using Lean by itself or in conjunction with DMAIC or DFSS, the process areas listed below can be connected with Kaizen Events.

- Validation (VAL) provides an opportunity for the work-product customer to participate in the process of streamlining the product.
- Measurement & Analysis (MA) provides the measurement infrastructure and basic reporting that enables the Kaizen baselines and current states to be factual and quantitative, not subject to opinion and interpretation.
- OPD, OPP, and IPM build on the capability provided by MA by providing the organizational measurement baseline.
- OPP and Quantitative Project Management (QPM) build on the capability provided by MA by providing performance baselines based on controlled processes, which provide higher confidence. The result is lower risk in estimation and decision making.
- Causal Analysis and Resolution (CAR) is a stimulus or catalyst for Kaizen Events. For instance, when causal analysis is done, a list of candidate processes can be generated for performance analysis and waste reduction.
- Technical Solution (TS) can be a pivotal part of the trade studies done in conjunction with Kaizen Events.

The connections we have listed in this section are not exhaustive. We invite you to contact us with other differences, synergies, and thematic connections between CMMI and Six Sigma that you have leveraged in your work.

5.3 Staged and Continuous Views

When considering the implementation of Six Sigma alongside a staged implementation of CMMI, you may wonder what a Six Sigma implementation might look like for an organization at a lower maturity level. Before addressing this question, we will first consider what happens to many organizations when transitioning from CMM Maturity Level 3 to CMMI or moving from lower to higher maturity. Often the organization discovers that its measurement infrastructure and associated skill base in analysis methods is not sufficient for its new goal. Going back to the drawing board is not unheard of.

This situation is not unique to software engineering and shows the need for finding a balance between a top-down policy to "do measurement" and bottoms-up foundation building through

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[9] FMEA is an engineering quality method that helps you to identify and counter weak points in the early conception phase of products and processes. See http://www.fmeainfocentre.com for more information.

small wins and successes. Building a strong foundation for a transition to CMMI or a move to high maturity involves the use of available data to improve processes long before the model says you have to. When at a lower maturity level, this selective improvement likely means conducting improvement projects in subsets of the organization, for instance in a specific development project, group, or product line. These projects can be managed as pilots for potential institutionalization across the organization.

If Six Sigma is included in the strategy to improve an organization's processes, Six Sigma philosophy, frameworks, and toolkits can all be leveraged. Even its measures can be used, although they may not reflect organizational performance (yet). And, if Six Sigma project portfolio management and methods are being employed, there is reasonable assurance that local improvements are value-added for the organization, not just isolated exercises that will not contribute to the greater good. As such, there is a greater likelihood that the efforts will accelerate the CMMI solution because people will gain experience with the effective use of measurement and analysis to gain control of a situation and possibly optimize a process, albeit a local one. CMMI-compliant processes may be piloted and refined as part of individual project efforts. As an organization scales the maturity ladder, the use of Six Sigma can continue, but Six Sigma projects can be applied across organizational processes. Then, what was being done at low maturity in a local fashion is now used across the organization.

Figure 5 shows how Six Sigma can be used at each maturity level, starting as a driving force and accelerator at Level 1 and progressing to the organization-wide application of what were originally local improvements when Level 5 is reached.

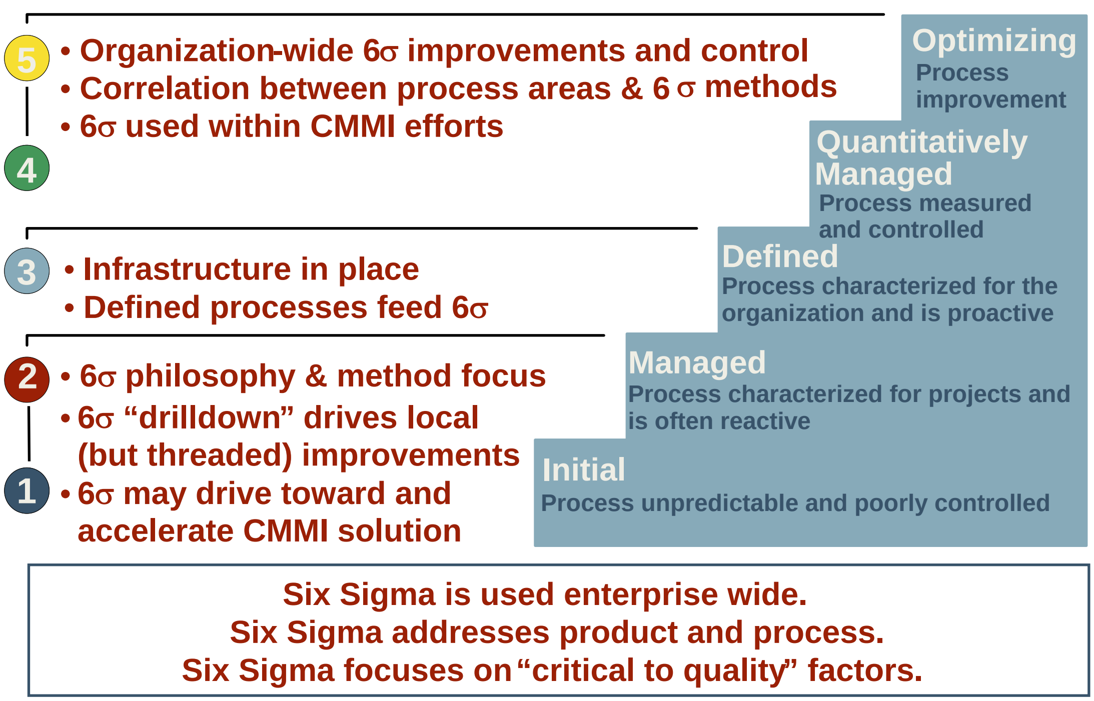
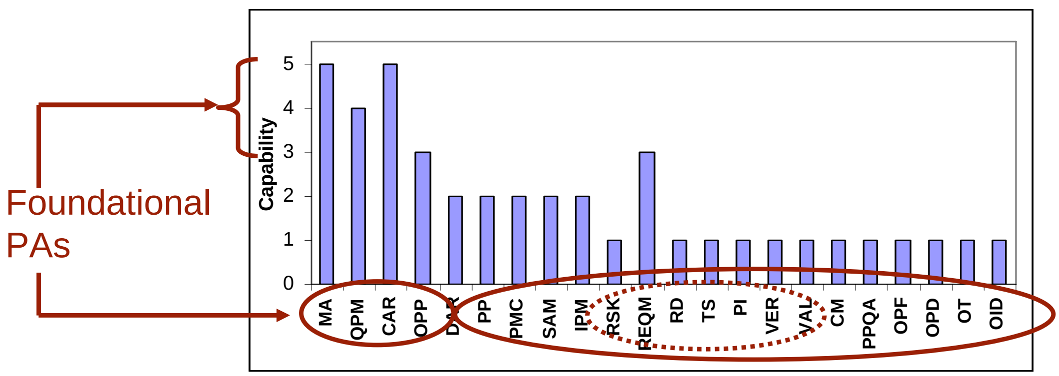


Figure 5: CMMI Staged Representation and Six Sigma

A similar approach can be used in a continuous implementation of CMMI. One approach is to use Six Sigma to drive improvement or process design associated with each process area that has been selected for implementation. In this approach, Six Sigma assumes the role of "tactical engine" within CMMI implementation.

As an alternative to using Six Sigma as a tactical engine, an organization could use Six Sigma thinking to establish its highest priority issues and the requisite process areas that need to be implemented to solve them. Doing this successfully might prompt an organization to develop its capability in process areas that are tightly coupled with Six Sigma skills and methods, including MA, QPM, and CAR. This capability, in turn, could be used to prioritize remaining process areas, using data analysis to substantiate the prioritization. Figure 6 shows a possible scenario that could result when Six Sigma is used to prioritize issues and decide the order of implementation of the CMMI process areas.



Remaining PAs ordered by business factors, improvement opportunity, and so forth, which are better understood using foundational capabilities. CMMI Staged groupings and DMAIC vs. DMADV (Define, Measure, Analyze, Design, Verify) are also factors that may drive the remaining order.[10]

Figure 6: CMMI Continuous Representation and Six Sigma: A Possible Scenario

[10] The idea to strategically select these process areas as the first in which to achieve Level 5 was offered by Robert Vickroy, ABS Group, during a CMMI course in 2003. The idea has evolved through subsequent conversations as part of courses, conferences, and collaborations.

6 Conclusions

In today's highly competitive environment, it is more crucial than ever for organizations to invest in process improvement to serve their missions, not as an exercise in compliance. Many organizations wisely realize that they don't have to invent their process improvement effort from scratch: they can leverage existing, demonstrated improvement initiatives and practices. However, they often find themselves in "initiative overload." Those responsible for rolling out organizational process improvement efforts must design their implementation strategy and tactics so that the multiple initiatives chosen interoperate.

Determining what is appropriate requires an understanding of the selected initiatives and their differences, synergies, and connections. While some models can be mapped where one model subsumes the other, CMMI and Six Sigma cannot because they are different types of models. Their joint deployment is synergistic. The potential value that is added is the accelerated achievement of performance goals, accelerated achievement of CMMI adoption (as a "meta goal" toward performance), stronger foundational measurement and analysis skills to enable better quantification of results, and all of the corresponding culture change that goes along with these improvements [Bergey 04].

While the quantity and depth of publications and presentations about CMMI and Six Sigma have greatly increased over the past four years, this is still an emerging topic. We invite your feedback on the thoughts we have shared in this document. Please send your comments to customer-relations@sei.cmu.edu.

Appendix A DMAIC Connections to Specific Goals and Generic Practices

Following are lists of specific goals (listed by number, not name) that reflect similar intent to DMAIC roadmap steps. This list is provided as a simple cross-reference which an organization may choose to use as a guide while defining its processes

- "Define" Roadmap Steps
  - Define project scope; align process improvements with business objectives
    - Organization Process Focus (SG 1)
    - Organization Process Performance (SG 1)
    - Organization Innovation, and Deployment (SG1)
    - GP 2.2, GP 3.1, GP 4.1, GP 5.1, GP 5.2
  - Establish formal project; establish improvement projects
    - Organization Process Focus (SG 1)
    - Organization Innovation and Deployment (SG 1)
    - Implied by GP 4.1, GP 5.1
- "Measure" and "Analyze" Roadmap Steps
  - Define data and establish repositories
    - Measurement and Analysis (SG 1)
    - Organization Process Definition (SG 1)
    - Organization Process Performance (SG 1)
    - Causal Analysis and Resolution (SG 2)
    - Quantitative Project Management (SG 2)
    - GP 2.8, GP 3.2, GP 4.2, GP 5.1 and GP 5.2
  - Baseline data
    - OPD (SG1)
    - Organizational Process Performance (SG 1)
  - Analyze data
    - Measurement and Analysis (SG 2)
    - Organization Process Performance (SG 1)
    - Causal Analysis and Resolution (SG 1)

        - OID (SG2)
        - GP 2.8, GP 3.2, GP 5.2

- "Improve" and "Control" Roadmap Steps
    - Identify improvement alternatives
        - Decision Analysis and Resolution (SG 1)
        - Organization Innovation and Deployment (SG 1)
            - Organization Process Performance (SG 1)
            - GP 5.1
    - Control processes
            - Measurement and Analysis (SG 2)
            - Organization Process Performance (SG 1)
            - Organization Innovation and Deployment (SG 2)
            - Causal Analysis and Resolution (SG 2)
            - Quantitative Project Management (SG 2)
            - GP 2.8, GP 4.2, GP 5.1, GP 5.2

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Organizations that endeavor to improve their processes often find themselves juggling many approaches to achieve that improvement. To be most effective, all improvement initiatives selected should be implemented in an integrated fashion, not as layered or stovepiped efforts. This document focuses on the joint use of two popular improvement initiatives: Capability Maturity Model® Integration (CMMI®) and Six Sigma.

Successfully implementing CMMI and Six Sigma together requires an understanding of the relationships between the two. This report contains a brief summary of each initiative and then outlines the connections between frameworks commonly used in Six Sigma and the CMMI process areas. Coupling this knowledge with a conscious strategy enables an organization to create tactical plans and specific mappings to support implementation. Example strategies and tactics that organizations have used to integrate these initiatives are also provided.

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