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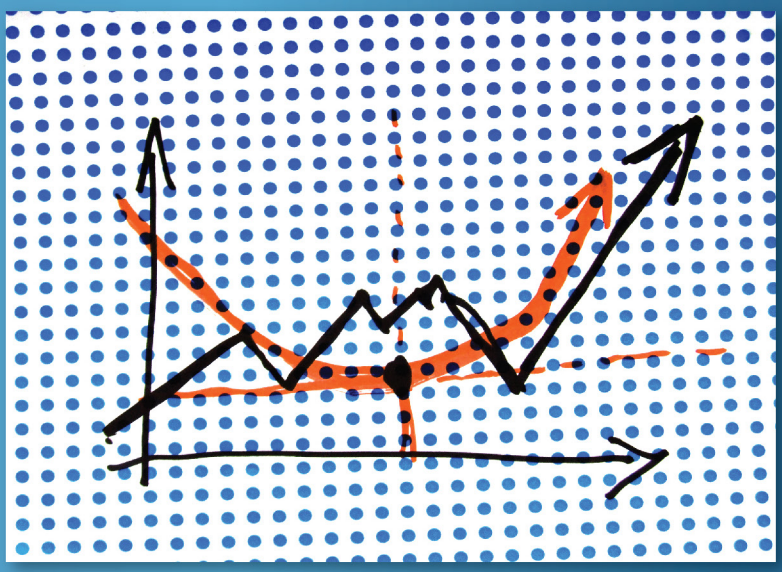

ГОДИНА 1

VOLUME 1

GOCE DELCEV UNIVERSITY – STIP
FACULTY OF ECONOMICS

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СОДРЖИНА
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SIX SIGMA and CMMI APPLICATIONS and SYNERGY

Stojan Kocev MSc
Makedonski Telekom AD

Abstraction

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

This topic is given answer the above few questions, which relate to implementing CMMI along with Six Sigma. A brief summary of CMMI fundamentals and an overview of what Six Sigma is and what it is not, are included here. The paper also explores the relationships between CMMI and Six Sigma and how they integrate together.

Key words: *organization's improvement, customer requirements, performance, variation*

Introduction

Organizations begin the road 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 researching 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 model. And the result should be a set of organizational processes, used by everyone--from developer to software engineering process group (SEPG) member to manager--that reflect the features of the improvement initiatives chosen.

Overview of Six Sigma and CMMI

Role of the 1.5 sigma shift

Experience has shown that in the long term, processes usually do not perform as well as they do in the short. As a result, the number of sigmas that will fit between the process mean and the nearest specification limit is likely to drop over time, compared to an initial short-term study. To account for this real-life increase in process variation over time, an empirically-based 1.5 sigma shift is introduced into the calculation. According to this idea, a process that fits six sigmas between the process mean and the nearest specification limit in a short-term study will in the long term only fit 4.5 sigmas – either because the process mean will move over time, or because the long-term standard deviation of the process will be greater than that observed in the short term, or both.

Hence the widely accepted definition of a six sigma process is one that produces 3.4 defective parts per million opportunities (DPMO). This is based on the fact that a process that is normaly distributed will have 3.4 parts per million beyond a point that is 4.5 standard deviations above or below the mean (one-sided capability study). So the 3.4 DPMO of a "Six Sigma" process in fact corresponds to 4.5 sigmas, namely 6 sigmas minus the 1.5 sigma shift introduced to account for long-term variation.] This is designed to prevent underestimation of the defect levels likely to be encountered in real-life operation.

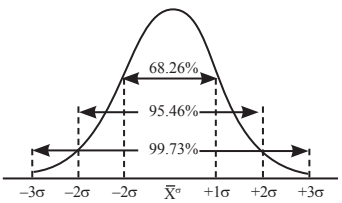
Sigma levels

Short-term sigma levels correspond to the following long-term DPMO (defect per million opportunities) values (one-sided):

- 1 sigma = 690,000 DPMO = 31% efficiency
- 2 sigma = 308,000 DPMO = 69.2% efficiency
- 3 sigma = 66,800 DPMO = 93.32% efficiency
- 4 sigma = 6,210 DPMO = 99.379% efficiency
- 5 sigma = 230 DPMO = 99.977% efficiency
- 6 sigma = 3.4 DPMO = 99.9997% efficiency

These figures assume that the process mean will shift by 1.5 sigma towards the side with the critical specification limit some time after the initial study determining the short-term sigma level. The figure given for 1 sigma, for example, assumes that the long-term process mean will be 0.5 sigma beyond the specification limit, rather than 1 sigma within it, as it was in the short-term study. Figure -1 depict % of items included between certain values of the standard deviation.

Figure-1



Percent of items included between certain values of the standard deviation

Complementary Technologies

Complex it is, to quickly illustrate the ways in which Six Sigma may be intertwining with other schemes or vice versa. To broadly understand the possible interrelationship between initiatives, it can be explained from Six Sigma and improvement approaches such as CMM (Capability Maturity Models), CMMISM, PSPSM/TSPSM that are complementary and mutually supportive. Depending on existing organizational, project or individual circumstances, Six Sigma could be an enabler to launch CMM®, CMMISM (Capability Maturity model Integration-service mark), PSPSM, (Personal software process) or TSPSM (Team software process). Alternatively, it could work as a refinement toolkit / methodology within these initiatives. As for example, it may be used to choose uppermost priority Process Areas within CMMISM or to select highest advantage metrics within PSPSM. Examination of the Goal-Question-Metric (GQM), Initiating-Diagnosing-Establishing-Acting-Leveraging (IDEALS), and Practical Software Measurement (PSM) paradigms, likewise, shows compatibility and consistency with Six Sigma. GQ (I)M interconnects well with the Define-Measure steps of Six Sigma. IDEAL share many common features with Six Sigma, with IDEALSM being slightly more focused on change management and organizational issues and Six Sigma being more focused on tactical, data-driven analysis and decision-making. PSM provides a software-tailored approach to measurement that may well serve the Six Sigma improvement framework (Harry 2000)

The Six Sigma was originally developed as a set of practices designed to improve manufacturing processes and eliminate defects, but its application was subsequently extended to other types of business processes as well. In Six Sigma, a defect is defined as anything that could lead to customer dissatisfaction. Bill Smith at Motorola first formulated the specifics of the methodology. The Six Sigma was greatly motivated by six previous decades of excellence

improvement methodologies such as quality control, TQM, imperfections, based on the work of pioneers such as Shewhart, Deming, Juran, Ishikawa, Taguchi and others. (Snee 2002)

Like its predecessors, Six Sigma asserts that continuous efforts to achieve stable and predictable process results, like reduce process variation are of fundamental importance to business success. The manufacturing and business procedures have distinctiveness that can be measured, analyzed, improved, and controlled. To attain continued quality improvement entails commitment from the whole organization, predominantly from top-level management.

Features that set Six Sigma apart from previous quality improvement initiatives include:

1) a clear focus on achieving measurable and quantifiable financial returns from any Six Sigma project; 2) an increased emphasis on strong and passionate management leadership and support; 3) a special infrastructure of Champions; 4) Master Black Belts, Black Belts, and others to lead and implement the Six Sigma approach; 5) A clear commitment to making decisions on the basis of verifiable data, rather than assumptions and guesswork. (Pyzdek, T.2003)

The term Six Sigma came from a field of statistics recognized as process capability studies. It referred, originally, to the ability of manufacturing processes to create a very high amount of output within requirement. Processes that function with six-sigma quality over the short term are understood to produce long-term imperfection levels below 3.4 imperfections per million opportunities (DPMO). Six Sigma's inherent objective is to get better the all processes to that level of quality or better. The Six Sigma is a registered service mark and trademark of Motorola, Inc. and has documented over US$17 billion in savings from Six Sigma as of 2006.

The early adopters of Six Sigma who attained well publicized success include Honeywell International, previously known as Allied Signal and General Electric, wherein the method was introduced by Jack Welch. During the 1990s, almost two thirds of the Fortune 500 organizations had begun Six Sigma schemes with the aim of reducing costs and improving quality.

Up to date, Six Sigma has sometimes been combined with lean manufacturing to yield a methodology named Lean Six Sigma. The normal distribution's graph motivates the statistical assumptions of the Six Sigma model.

Six Sigma Costs and Savings

The financial benefits of implementing Six Sigma at your company can be significant. It is a saying by most people that it takes money to make money. In the world of quality methodology of the Six Sigma, the saying also holds true: it has to be money to put aside money. You cannot expect to significantly reduce costs and increase sales using Six Sigma without investing in train-

ing, organizational infrastructure and culture evolution. It is true that one can reduce costs and increase sales in a localized area of a business using the Six Sigma quality methodology and this can probably be done inexpensively by hiring an ex-Motorola or GE Black Belt, a "get rich quick" scenario with the use of Six Sigma. Nevertheless, is it going to last when the one managing the business is elevated to a different area or perhaps resigned? There is no exact answer but it could be no. If a company needs to produce a culture shift within your organization, like 1) a shift that makes each employee to think about how his or her actions influence the customer; and 2) to communicate within the business using a consistent language, it is going to involve a resource commitment. It is true that it takes money to save money and that how much financial obligation does Six Sigma necessitate and what scale of financial benefit can a company expect to receive? There are people that we must answer to and making speeches do not pay bills or maintain the stockholders happy. It should be noted that all types of companies whatever dimension are in the center of a quality revolution. Take note that: 1) GE saved $12 billion over five years and added $1 to its income for every share; 2) Honeywell (AlliedSignal) documented more than $800 million in savings. In addition, 1) GE produces annual benefits of over $2.5 billion across the organization from Six Sigma; 2) Motorola reduced manufacturing costs by $1.4 billion from 1987-1994; 3) Six Sigma reportedly saved Motorola $15 billion over the last 11 years.

The above given quotes may in truth be factual, but dragging the numbers out of the framework of the organization's profits does not do anything to help a company decipher if Six Sigma is really perfect for them. However, investigation on what the companies themselves had in mind about their Six Sigma costs and savings were taken. The following information was based on the supposition that these Six Sigma companies operate with integrity until proven otherwise. An investigation was done on Motorola, Allied Signal, GE and Honeywell and choosing these four companies was a priority because they are the companies that invented and refined Six Sigma and they are the most established in their deployments and culture changes: 1) As the Motorola website claims, they invented it in 1986; 2) Allied Signal deployed Six Sigma in 1994; 3) GE in 1995; 4) Honeywell was considered because Allied Signal merged with Honeywell in 1999 and launched their own initiative in 1998. More companies have set up Six Sigma between the years of GE and Honeywell. (Dodson 2001)

Six Sigma and the SEI's CMMI (Software Engineering Institute's Capability Maturity Model Integration (CMMI®) can together contribute to the overall success of IT based quality initiatives in any organization. Implementing both the models can lead to:

- Greater focus on the customer leading to customer delight and healthier bottom lines
- Continuous process improvements and synergy
- A data driven organization
- Metrics based decision making culture
- and the list goes on…

Numerous questions have arisen, including:

- Should I pick Six Sigma or CMMI?
- Can I leverage Six Sigma with software process improvement initiatives already underway in my organization?
- Can I have a system to check if Six Sigma works in software and systems engineering?
- How do I train IT professionals when Six Sigma training is geared for manufacturing?

Overview of CMMI

CMMI® (Capability Maturity Model® Integration) is a process improvement maturity model for the development of products and services. It consists of best practices that address development and maintenance activities that cover the product or service lifecycle from conception through delivery and maintenance.

CMMI process areas are categorized into several disciplines. The base model contains 22 process areas that cover the systems and software engineering disciplines. 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.

CMMI has grouped all the process areas into 4 categories. They are:

- Process Management
- Project Management
- Engineering
- Support

Although the process areas are grouped, they often interact and have an effect on one other regardless of their group.

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.

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 variations in a product, service, or process which prevent customers from having their needs met or add cost, whether or not that cost is

detected. Business profitability and customer focus are the central motive of Six Sigma. The quest to achieve the desired level of performance (as measured by sigma or any other gauge) is based on the following key underlying principles of statistical thinking:

- Everything is a process
- All processes have inherent variability
- Variation produces defects

Six Sigma is a breakthrough strategy leading to healthier bottom lines. The methodology uses data to measure the effectiveness of current processes and to validate improvement; it uses proven statistical and quality tools to identify process gaps and solutions for improvement; and integrates improvements in the operational processes with business strategy.

Schleusener urges service companies to adopt three principles of statistical thinking: All work is a process, all processes have variability and all processes create data that explains variability.

For example, if you were to apply Six Sigma to a company that provides housekeeping services, you must first understand what the work (process) involves. Using Six Sigma's define-measure-analyze-improve-control method, a housekeeping service company can implement quality:

Define. Because Six Sigma is aimed at reducing defects, the first step is to figure out what a defect would be. For example, the company may decide that leaving streaks on the windows is a defect because it is a source of customer dissatisfaction.

Measure. The next step is to collect data to find out why, how, and how often this defect occurs. This might include a process flow map of where employees start and finish cleaning houses. Other metrics may include recording what products and tools the employees use to clean the houses.

Analyze. After the data is measured, the company's Six Sigma team realizes that a particular employee is better at cleaning windows than the other employees.

Improve. The team implements that employee's process as a standard way of cleaning windows.

Control. The company teaches new employees the correct technique to wash the windows. Over time, there's significant improvement in customer

satisfaction and increased business.

It may have taken the Six Sigma team one or two brainstorming sessions to clearly define its process, but the DMIAC model remains the same for housekeeping services as it is for a window manufacturer.

CMMI and Six Sigma – Complementing Each Other

Initially, the focus of Six Sigma was to improve production or manufacturing processes only. Over time, it has been more widely used by organizations to the rest of their business life cycles and supply chains. Data is used to understand variation and to drive decisions to improve the processes.

CMMI provides an effective framework for project management and software engineering. The software engineering process definition is guided by a framework like CMMI. The efficiency of these processes is complemented by the usage of the Six Sigma methodologies. The process defines the data and that the data indicates the performance of the process. In totality, the CMMI and Six Sigma complement each other and in practice enhance the process efficiency and effectiveness in an organization.

Define, Measure, Analyze, Improve, Control – these steps, more commonly called DMAIC, the Six Sigma methodology, statistically measure and reduce variation, and thus decrease defects and improve quality. Over a period of time, IT organizations have been adopting Six Sigma methodology, or some variation of the methodology thereof, to improve software quality and efficiency and better meet customer requirements.

The characteristic of CMMI maturity level 5 is continuous improvement, wherein Six Sigma provides methodologies for the journey of breakthrough improvement.

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 would be heavy and offers little practical value. What is useful is to understand the way these two approaches harmonize and the ways in which they are associated. Coupling this understanding with a conscious strategy enables an organization to create tactical plans and specific mappings to support their implementations. The following sections depict and describe the CMMI and Six Sigma relationships at various phases.

Relationships between CMMI Process Areas and the DMAIC Framework

We focus here on the connection between DMAIC and CMMI Process areas. The CMMI model should be mapped to an organization's processes rather than re-designing the processes to exactly match the model's practices. Simi-

larly, DMAIC should be incorporated into the measurement and improvement processes rather than changing the existing defined organizational processes to match the steps of DMAIC.

Several CMMI process areas and generic practices align with DMAIC roadmap steps. 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.

The organization's measurement process can be mapped to the generic practices that apply to all the CMMI process. The generic practices that are oriented to the organization's measurement process are listed below.

- Monitor and Control the Process
- Collect Improvement Information
- Establish Quality Objectives
- Stabilize Sub process Performance
- Ensure Continuous Process Improvement
- Correct Common Causes of Problems

CMMI Representation with Six Sigma

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 Matrix
- Risk Management (RSKM) can use Failure Modes & Effects Analysis (FMEA)
- Technical Solution (TS) can use Design FMEA

Connections can be made between DMAIC roadmap steps and the specific goals of process areas. Starting as a driving force and accelerator at Level 1 and progressing to the organization-wide application of what were originally local improvements,

Level 5 is reached when an organization can focus on continuous process improvements.

Taking specific levels, let's see how Six Sigma and CMMI play an important role at Level 4 and Level 5.

Maturity Level 4: Quantitatively Managed

At maturity level 4, the organization and projects establish quantitative objectives for quality and process performance and use them as criteria in managing processes. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers.

Quantitative Project Management, a level 4 process area, is to manage the project with metrics to achieve the project's established quality and process-performance objectives.

- Identifying goal metrics, (contract, MSA, SLA, for identifying applicable metrics) targets, lower limit and upper limit values
- Identifying control metrics for each goal metric in order to monitor & control the metric during the execution of the project
- Determine target, lower limit and upper limit values for control metrics from the organization level baselines
- Statistically analyzing the control metrics data to identify and understand process variation
- Predict the performance of goal metrics based on control metric performance
- Implementing corrective actions in case control metrics are operating outside the established limits

Organization Process Performance, a level 4 process area, is to establish and maintain a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and to provide the process-performance data, baselines, and models to quantitatively manage the organization's projects.

- Relationship between goal metrics and control metrics are identified and established
- Business unit / organization level metrics baselines are established
- Defect prediction model is used to predict delivered defect density based on defect injection rate, defect detection efficiencies, etc.

Quality and process performance is evaluated in statistical terms and is managed throughout the life of the processes by implementing Six Sigma. Six sigma projects can be executed and improvements demonstrated at each CMMI process area.

Maturity Level 5: Optimizing

At maturity level 5, an organization continually improves its processes based on a quantitative understanding of the common causes of variation inherent in processes. The level also focuses on continually improving process performance through incremental and innovative process and technological improvements. A critical distinction between maturity levels 4 and 5 is the type of process variation addressed. At maturity level 4, the organization is concerned with addressing special causes of process variation and providing statistical predictability of the results. Although processes may produce predictable results, the results may be insufficient to achieve the established objectives. At maturity level 5, the organization is concerned with addressing common causes of process variation and changing the process (to shift the mean of the process performance or reduce the inherent process variation experienced) to improve process performance and to achieve the established quantitative process improvement objectives.

Achieving breakthrough improvements at Level 5 can lead to Organizational innovation and development. This is an area where incremental and innovative improvements, that measurably improve the organization's processes and technologies, are addressed and established. Enabling of Six Sigma projects through improvements can be identified via the following means:

- Process improvements identified based on process performance data
- Best practices and project innovations from Six Sigma projects
- Initiatives identified by Senior Management
- Technology improvements
- Inputs and ideas from an external industry practice

Causal Analysis and Resolution, a level 5 process area, is to identify causes of defects and other problems and take action to prevent them from occurring in the future.

Defect data is gathered from Reviews, Inspections and Testing. A subset of this data is subjected to causal analysis and resolution to identify the potential causes for the same.

- Pareto chart is used for prioritizing
- Root cause analysis (using fish-bone diagram) is done for identifying the root causes
- Corrective & preventive actions are initiated and tracked to closure

The WHAT's of CMMI and HOW's of Six Sigma

CMMI very significantly tells us WHAT to do in a process area. For example in the process area of Quantitative Project Management [QPM], a level 4 Process area, the purpose of QPM is to quantitatively manage the project's defined process to achieve the project's established quality and process performance objectives. And the specific goals of this process area are - SG1. Quantitatively

Manage the project; SG2. Statistically manage the sub-process performance. But CMMI does not tell us how to establish this in projects. Six Sigma shows us HOW this can be achieved through the use of systematic methodology and tools. For the same example stated above, a project can be statistically controlled through the use of Control Charts. Similarly, let's take another example of Risk Management, which is a Level 3 CMMI process area,

The objective is to identify potential problems before they occur so that risk-handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives. And the specific goals are – SG1. Prepare for Risk Management, SG2.

Identify and Analyze Risk, SG3. Mitigate Risks. Here again it is evident that Six Sigma can play a major role by showing HOW a tool called Failure Mode Effect Analysis [FMEA] can be used to help achieve the specific goals of Risk Management. The FMEA identifies the potential failure modes and rates

the severity of the effect; it offers an objective evaluation of the occurrence of causes and has the ability to indicate the likelihood of their occurrences. And finally FMEA focuses on eliminating the process and product concerns.

The following table depicts a sample of the process areas where Six sigma can be applied and help organizations enhance their business performance relationships.

WHAT's of CMMI >>> HOW TO's of Six Sigma

Requirements Development >>> VOC, Affinity Diagram, QFD, FMEA

Causal Analysis and Resolution >>> Ishikawa Pareto chart, Fish Bone diagram

Quantitative Project Management >>> Control Charts, Trend Charts

Organizational Process Definition >>> SIPOC, Project Charter

Risk Management >>> Failure Mode Effect Analysis (FMEA)

Decision Analysis and Resolution >>> Criteria Based Matrix, Pugh Matrix, QFD

Six Sigma and CMMI help organizations enhance their business performance through

breakthrough improvements in quality and productivity and increase ROI

Aligning DMAIC with CMMI Process Areas

The following table depicts mapping of CMMI Process areas to the DMAIC methodology. The asterix (..) indicates that for a particular Process area the respective DMAIC phase is applicable.

CMMI level	Process Area	Define	Measure	Analyze	Improve	Control
Level 5	Organizational Innivation and Deployment					
	Causal Analyzes and Resolution					
Level 4	Quantitative Project Management					
	Organizational Process Performance					
Level 3	Requirements Development					
	Technical Solution					
	Product Integration					
	Validation					
	Verification					
	Risk Management					
	Integrated Project Management					
	Decision Analyzes and Resolution					
	Organizational Process Definition					
	Organizational Process Focus					
	Organizational Training					

Level 2	Requirements Management					
	Project Planning					
	Project Monitoring and Control					
	Measurement and Analyzes					
	Configuration Management					
	Process and Product Quality Assurance					
	Supplier Agreement Management					

Synergy in Benefits

Six Sigma can thus be integrated in the CMMI journey focusing on effective process improvements thus leading to customer delight and healthier bottom lines. Organizations that adopt an integrated approach can:

- Address major performance flaws in requirements and architecture
- Enable continuous process improvements
- Improve on-time delivery and reduce defects
- Employ metric-based decision making for product development
- Empower as a data driven organization
- Enable leadership to realistically set high expectations and demand evidence
- Achieve breakthrough improvements aligning to customer delight
- Help encourage a change in behavior as opposed to 'achieving a level'
- Reinforce change as a way of life
- Ensure good measurements essential for Six Sigma implementation and CMMI goals
- Use Six Sigma to accelerate CMMI implementation at ALL levels of maturity
- Use the combined [Six Sigma and CMMI] initiative as a tactical engine for high capability and high maturity

Conclusion

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 07].

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