CMMI®- An Executive Summary

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Objective

The purpose of this document is to provide a brief overview of the Capability Maturity Model Integration - **CMMI**[1], its application in industry and relation to other models and approaches for systematic process evaluation and process improvement.

CMMI is a model and de-facto industry standard that consists of best practices that address the development and maintenance of products and services. It covers the lifecycle of a product from conception through delivery to maintenance.

CMMI integrates essential bodies of knowledge for developing products, such as software engineering, systems engineering, and acquisition.

Please note that it is beyond the purpose of this document to discuss other complementing technologies and approaches like ATAM - Architecture Tradeoff Analysis Method or PSP - Personal Software Process, nor does it provided means on how to safely introduce or accelerate CMMI-based improvements in particular organizational settings.

For further information please refer to KUGLER MAAG CIE.

[1] CMM, CMMI, and Capability Maturity Model are registered in the U.S. Patent and Trademark Office by Carnegie Mellon. CMM Integration, IDEAL, SCAMPI, ATAM, Architecture Tradeoff Analysis Method, PSP, and Personal Software Process are service marks of Carnegie Mellon University.

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1. CMMI - The Model

1.1. Why CMMI?

More now than ever, companies are forced to deliver their products better, faster and cheaper. At the same time, products are becoming more and more complex and the same is true for the way the products are developed. Today, a single company usually does not develop all the components that compose a product. Also, own components are usually not developed at one single location but rather in a multi-national effort at different development locations. Since most of the innovations are based on software and electronics, software and systems engineering has become a critical part of their business.

In this context, the Capability Maturity Model Integration (CMMI) Product Suite was designed to help organizations improve the way they do business. Process improvement has proven to increase product and service quality as organizations apply it to achieve their business objectives. Originating to Deming's work on Quality today, the CMMI Product Suite, through the SEI and its contributors, is at the forefront of process improvement by providing the latest best practices for product and service development and maintenance.

The CMMI can help to
- Improve product quality
- Improve the ability to meet project targets (on-time, on-spec, on-budget)
- Reduce cost and cycle time
- Control suppliers
- Master multi-national development cooperation

1.1.1. History

Since 1991, Capability Maturity Models have been developed for a myriad of disciplines. Some of the most notable include models for systems engineering, software engineering, software acquisition, workforce management and development, and Integrated Product and Process Development.

Following source models have been used as input to form CMMI:
- SEI's Capability Maturity Model for Software (SW-CMM®)
- Electronic Industries Alliance Systems Engineering Capability Model, Interim Standard (EIA/IS 731)—the result of the merger of the SE-CMM, created by the Enterprise Process Improvement Collaboration (EPIC), and the SECAM, created by INCOSE
- A draft model covering Integrated Product and Process Development (IPPD), the IPD-CMM, previously released in draft form by EPIC

Developing a set of integrated models has involved more than simply adding existing model materials together. Using processes that promote consensus, the CMMI Product Team has built a framework that accommodates multiple disciplines and is flexible enough to support two different representations (staged and continuous).

Early CMMI versions were publicly reviewed and used in initial pilot activities. More than 4,500 change requests followed from public reviews, lessons learned from piloting organizations, and results from various focus group sessions to be reviewed by the CMMI Product Team. The result was the current CMMI version 1.1.

1.2. Achievements and Investments

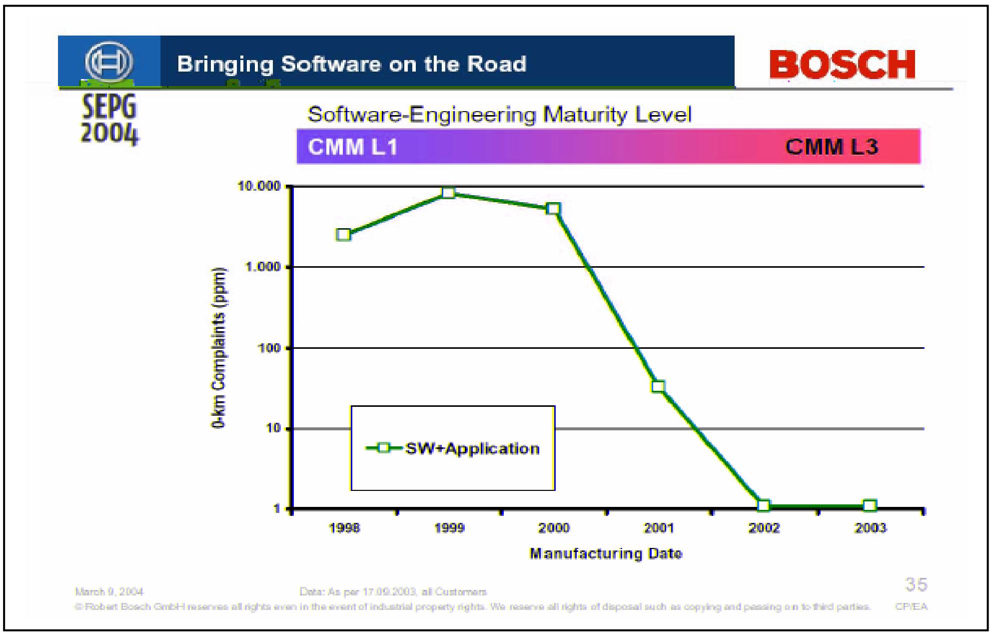
1.2.1. Results

Systematic field studies have been performed and reported (see [1], [2]) by the SEI. They highlight performance achievements from applying CMMI. It shall be noted that the following figures (see [2], for detailed reports see [5]) are summary results from wide variety of cases, i.e., various sources based on various application and projects scope and organization type, maturity levels, and sizes. Hence, the performance measures might not be repeatable in the own organizational context however, they provide a proof of concept.

Improvements	Median	Low	High	# of data points
Cost	38%	5%	87%	14
Schedule	50%	20%	90%	14
Productivity	50%	11%	376%	13
Quality	50%	29%	94%	16
Customer Satisfaction	14%	10%	55%	5
Return on Investment	3 : 1	2 :1	13 :1	8

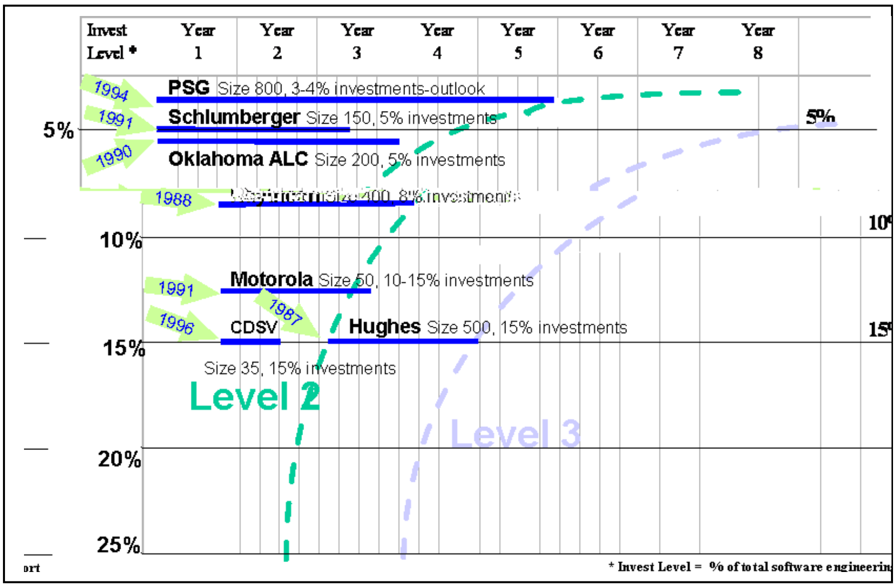
N=18, as of March 5th 2005, organizations with results expressed as change over time; http://www.sei.cmu.edu/cmmi/results.html

Within the automotive industry performance results from CMM/I-based improvements are rarely published. One example (see [3]) is provided by the Robert Bosch GmbH in Germany, reporting among other achievements significant quality improvements moving from Maturity Level 1 to Maturity Level 3 on the CMM within one Business Unit.



1.2.2. Investments

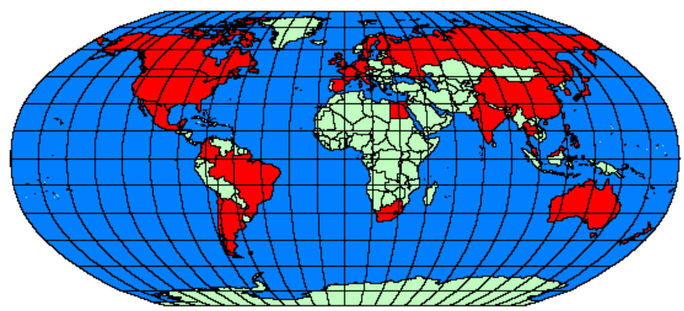
The investment levels in a CMMI-based improvement program correlate directly with the elapse time to increase the maturity level as reported below. Investment levels are stated as percentage of an organizations engineering effort (staff size). E.g., Raytheon invested 8% of its engineering capacity (of staff size 400) in moving from Maturity Level 1 to 2 in 2.5 years.



Investments in the Automotive Industry are in the same order of magnitude as reported above. Although significant experiences have been gathered in applying the CMMI its successful implementation remains a program of managing cultural change - in the case of the automotive industry also among organizational borders.

2. Outreach - Worldwide Adoption

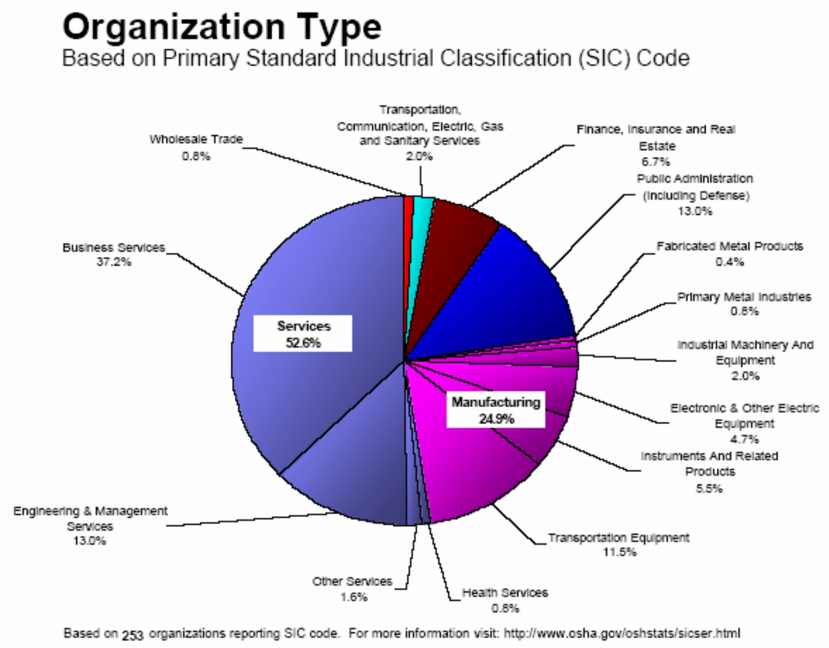
The Capability Maturity Model Integration (CMMI) Product Suite received a tremendous response from organizations around the world. CMMI is being adopted worldwide, including North America, Europe, India, Australia, Asia Pacific, and the Far East.



Argentina	Australia	Belarus	Brazil	Canada	Chile	China
Colombia	Czech Republic	Denmark	Egypt	Finland	France	Germany
Hong Kong	India	Ireland	Israel	Italy	Japan	Korea, Republic of
Malaysia	Mexico	Netherlands	New Zealand	Philippines	Russia	Singapore
South Africa	Spain	Sweden	Switzerland	Taiwan	Thailand	United Kingdom
United States						

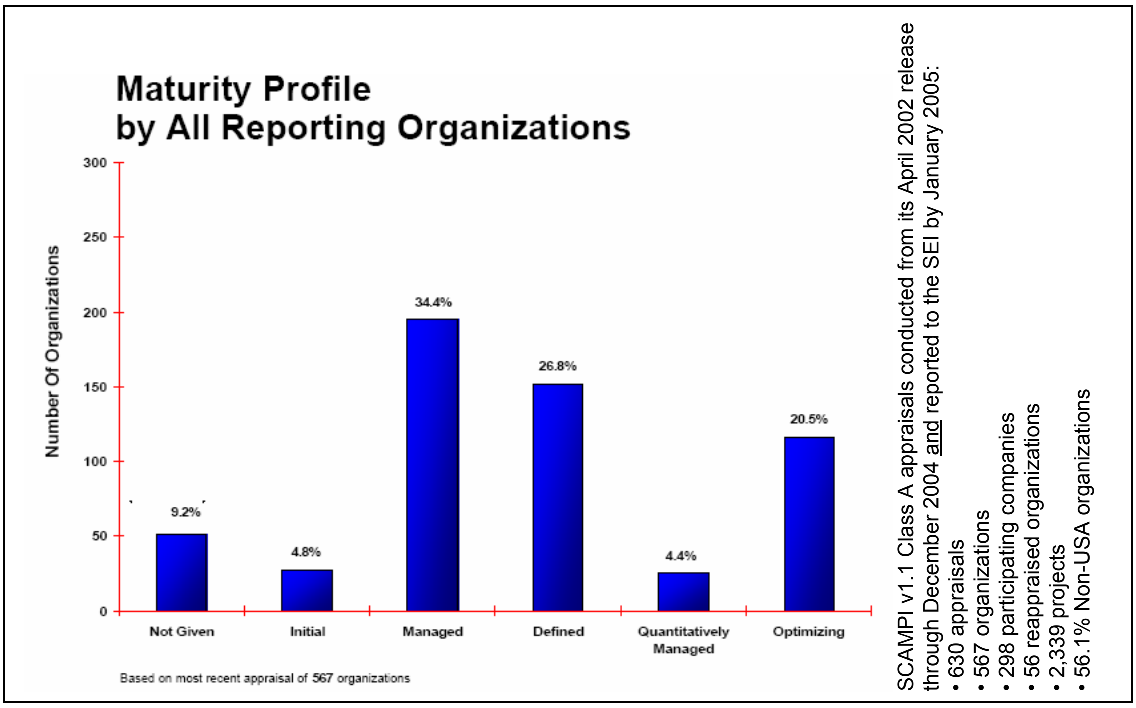
The community is organizing annual conferences, e.g., in U.S., South America, Europe, Australia, etc. with the largest and oldest one being the U.S. Software Engineering Process Group (SEPG) Conference being held the 17th year and gathering approx. 1.800 delegates. This years European SEPG gathered approx. 450 delegates and had its 10th anniversary.

Transition Partners of the SEI provide consultancy support transitioning technology like the CMMI into industry and feeding back their experiences with the application by actively being involved in reviewing and upgrading.



The SEI maintains rigid quality standards by selecting, qualifying, authorizing, and reviewing transition partners as well as the results reported from industry.

Benchmarking results against the model are published regularly. Following figures showing the distribution against CMMI Maturity Levels, e.g., 34.4% of all assessed and reported results are on Maturity Level 2 - ‘Managed’, as published in March 2005 (see [4]).



Please note that past results from more than 10 years of CMM-based figures are not included since the release of CMMI has taken place in April 2002.

3. The Model - [illegible]re and Application

3.1. Struc[illegible]

3.1.1. Scope[illegible]

Systems Engineering - [illegible]gineering covers the development of total systems, which may or may not in[illegible]e. Systems engineers focus on transforming customer needs, expectations, and[illegible]nto product solutions and supporting these product solutions throughout the [illegible]duct.

Software Engineering - [illegible]gineering covers the development of software systems. Software engineers focu[illegible] systematic, disciplined, and quantifiable approaches to the development, operat[illegible]tenance of software.
1
Integrated Product and [illegible]velopment - Integrated

Process Management Process Areas

- Contain the overarching practices related to implementing a successful and mature process improvement program
- Provide capability to document and share best practices, process assets, and learning
- Provide advanced capability to achieve quantitative objectives for quality and process performance

Process Area	Description
Organizational Process Focus (OPF)	Helps organization establish and maintain understanding of its processes and identify, plan, coordinate, and implement improvement
Organizational Process Definition (OPD)	Establishes and maintains organization's set of standard processes and supporting assets
Organizational Training (OT)	Identifies strategic training needs of organization, as well as tactical training needs common across projects and support groups
Organizational Process Performance (OPP)	Derives common, quantitative objectives for quality and process performance from organization's business objectives
Organizational Innovation and Deployment (OID)	Selects and deploys proposed incremental and innovative improvements to improve organization's ability to meet quality and process performance objectives

Project Management Process Areas

- Cover the project management activities related to planning, monitoring, and controlling a project
- Provide mechanisms to establish, maintain, and monitor commitments to customers and from suppliers
- Provide mechanisms to establish and maintain collaborative teaming environment
- Provide common method to proactively and quantitatively manage project

Process Area	Description
Project Planning (PP)	Develops and maintains project plan, involves stakeholders appropriately, obtains commitment to the plan
Project Monitoring and Control (PMC)	Monitors activities and takes corrective action, including re-planning
Integrated Project Management (IPM)	Adapts organization's processes to project, and establishes project's shared vision
Integrated Teaming (IT)	Identifies and organizes stakeholders into collaborative teams and develops shared vision aligned with project and organization shared vision
Risk Management (RSKM)	Develops and implements proactive strategy to continuously identify, assess, prioritize, and handle program risks
Quantitative Project Management (QPM)	Collects project process and product metrics, and analyzes results to identify process improvement opportunities
Supplier Agreement Management (SAM)	Manages the acquisition of products from suppliers for which there exists a formal agreement

Engineering Process Areas

- Support product development life cycle activities, from initial requirements development to transition to operational use

Process Area	Description
Requirements Development (RD)	Collects and harmonizes stakeholder needs to plan, develop, integrate, field, and sustain products, and translates needs into product requirements
Requirements Management (RM)	Ensures that agreed-to requirements are understood and managed
Technical Solution (TS)	Converts requirements into product architecture, design, and development
Product Integration (SI)	Combines product components and ensures interfaces
Verification (VER)	Ensures product meets specifications ("the thing is built right"), and that deficiencies are tracked, re-worked, and re-tested
Validation (VAL)	Ensures product fills intended use when placed in intended environment ("we built the right thing")

Support Process Areas

- Provide essential processes to support product development and maintenance
- Support establishment and maintenance of a work environment that facilitates and stimulates integration and manages people to enable and reward integrative behaviors
- Provide support functions used by all process areas during product development

Process Area	Description
Measurement and Analysis (MA)	Establishes metrics program to provide objective results that can be used in making informed decisions, and in taking appropriate corrective actions
Configuration Management (CM)	Establishes and maintains integrity of work products
Process and Product Quality Assurance (PPQA)	Provides practices for objectively evaluating processes, products, and services
Decision Analysis and Resolution (DAR)	Provides structured decision-making process that ensures alternatives are compared against established criteria, and best alternative is selected
Causal Analysis and Resolution (CAR)	Identifies causes of defects and other problems, and takes action to prevent them from occurring in the future
Organizational Environment for Integration (OEI)	Establishes approach and environment for the implementation of integrated teams

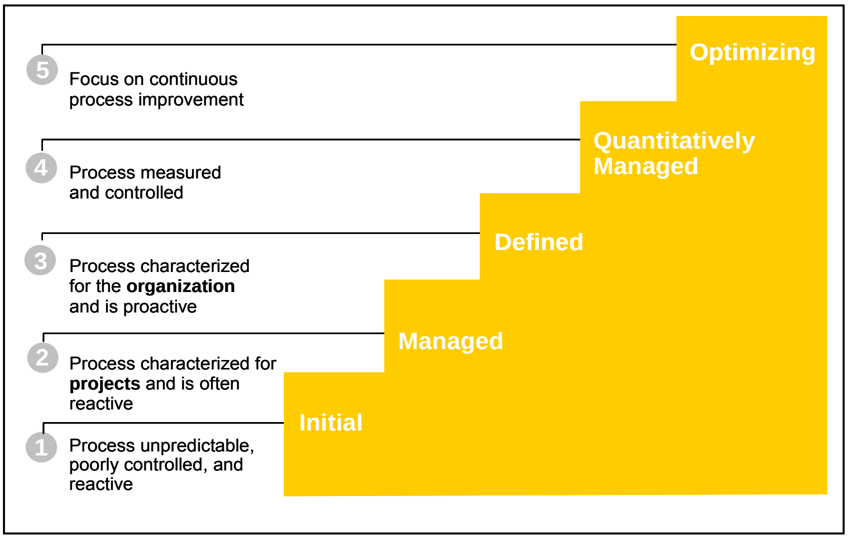
3.1.3. Representation

CMMI models are organized in two representations, continuous and staged. They provide alternative approaches to process improvement that leverage users' familiarity with either approach.

The Continuous Representation - The continuous representation is based on process capability—the range of expected results that can be achieved by following a process. Process improvement is measured in capability levels that relate to the achievement of specific and generic goals in each process area.

The continuous representation provides flexibility for organizations to choose which processes to emphasize for improvement, as well as how much to improve each process. It enables selection of the order of process improvement that best meets the organization's business objectives and that most mitigates risk.

The Staged Representation - The staged representation is based on organizational maturity—the combined capabilities of a set of related processes. Organizational improvement is measured in maturity levels. This representation has a recommended order for approaching process improvement, beginning with basic management practices and progressing along a proven path.



Above picture illustrates the recommended improvement path as well as it describes the characteristics of an organization at each stage of maturity.

Equivalent Staging - Sometimes it may be desirable to convert an organization's capability level achievements into a maturity level. This conversion is made possible by "equivalent staging." The CMMI model includes rules for determining which capability levels must be satisfied in each process area to achieve each maturity level.

3.2. Application

The CMMI as a model supports assessments ('appraisals') and guides improvements.

3.2.1. Appraisals

Used as an assessment model the Standard CMMI Assessment Method for Process Improvement (SCAMPI) helps organizations to benchmark their process capability or organizational maturity by identifying strengths and weaknesses of their current processes towards the processes and practices of the CMMI.

A SCAMPI assessment either determines the maturity of an organization's processes and/or serves as baseline for a process improvement program. An appraisal is led by an experienced SEI-Authorized Lead Assessor.

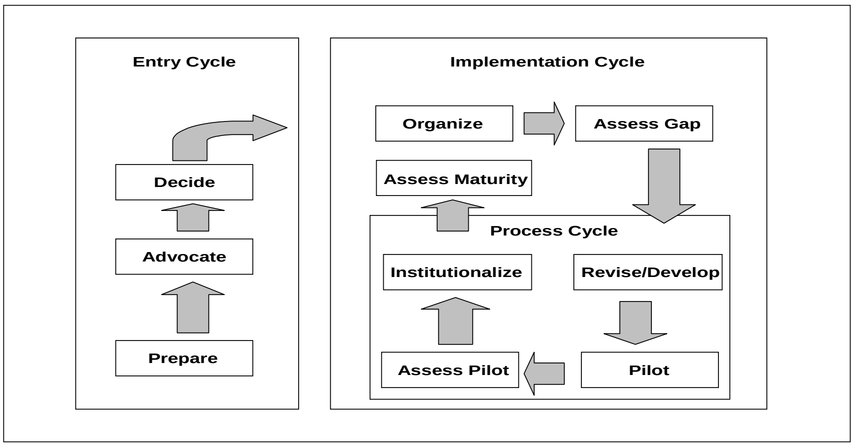
3.2.2. Acquisition decisions based on CMMI and ISO/IEC 15504 (SPICE)

Many organizations worldwide use process maturity level ratings of their potential suppliers to evaluate their ability to deliver high quality on time and on budget. European car manufacturers, for example, use ISO/IEC 15504 (called 'SPICE') ratings to classify their suppliers. Suppliers constantly showing low ratings are out of business.

In the US, many government organizations consider maturity level ratings when making their acquisition decisions. Some of these organizations accept the results of appraisals conducted by the organization being evaluated for a contract. Other organizations request government-run evaluations.

3.2.3. Improvements

An approach to implement CMMI, based upon IDEAL is shown in the following roadmap diagram.

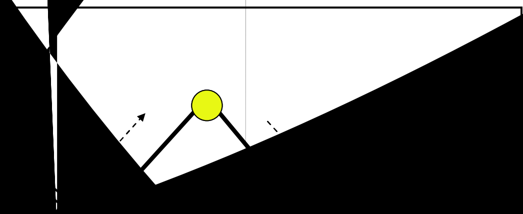


The purpose of the roadmap is to:

- provide a general framework for assisting organizations in making the transition to CMMI
- show the process required to move an organization to an enterprise based on CMMI principles and practices
- prepare the organization for change by focusing on organizational and people issues that need to be addressed prior to implementation

[redacted] in order

[redacted] deliver lasting performance experience show [redacted] addressing the organization’s processes in a [redacted]



[redacted]

- Exists for the duration of the process improvement activity in the organization, possibly in perpetuity

Process Action Teams (PATs), chaired by a “change agent” who understands the organization’s culture and history and has the ability to effect change in concert with, and sometimes despite, the culture and history, does the following:
- Develops and maintains action plans to address specific process area work that must be initiated and subsequently improved
- Exists for the period of time necessary to get the organization or project from one assessment to the next

4. Relation to ISO/IEC 15504 and Six Sigma

4.1. ISO/IEC 15504 (SPICE)

SPICE is an international standard for software process capability assessment. Note that it is not an approach which provides explicit model-based guidance for improvement like. It is an assessment standard developed mainly in Europe and Australia and was initially applied in the Avionics Industry. Since 2000 SPICE is the de-facto standard of the Automotive Industry introduced by the Vehicle Manufactures (initially through the HIS - Vehicle Manufacturer Software Initiative in Germany, i.e., Audi, BMW, DaimlerChrysler, Porsche, and Volkswagen; see [6]) to assess the process capability of their suppliers. The HIS has selected 14 processes of SPICE which they regard as important to be mastered by their suppliers’ engineering projects and organization. The purpose is to identify a process risk profile in order to secure development projects’ objectives like the SOP (start-of-production) when addressed consequently and systematically.

Appraisal results performed with CMMI can be mapped onto SPICE. Very few matters not adequately addressed will need special considerations in the appraisal process (see [6]).

The Automotive Industry has launched the Autosar Initiative (a development partnership, see [8]) in 2003 - it has the objective to establish an open standard for automotive E/E architecture. It will serve as a basic infrastructure for the management of functions within both future applications and standard software modules. Its members include Vehicle Manufacturers like Opel, Toyota, Ford, and PSA, as well as Suppliers like BOSCH and Siemens. It is expected that the results and working groups of the HIS will be merged into Autosar.

4.2. Six Sigma

The goal of Six Sigma is flawless performance, i.e., zero defects, which also result in lower cost. A defect is defined as anything that results in customer dissatisfaction. Hence, it is a business-focused philosophy based on statistical thinking with an ultimate process capability goal, i.e., 6σ. It provides an approach to manage process performance.

In contrast, CMMI, going back to the same roots like Deming, is a structured approach to systematically increase an organizational maturity through its process capabilities. The link to business objectives is weak and not build-in into the model. Following table contrast some of the (significant) differences (see [9]).

Six Sigma	CMM/CMMI
Assumes processes have been identified and defined	Focus on defining management and technical processes early
Doesn't distinguish organizational standard and project processes	Organizational process definition used to capture best practices
Emphasis on training to motivate and communicate skills	Emphasis on infrastructure to ensure key processes addressed
Reliance on statistical methods to manage performance	Statistical approach intended often not implemented
Focus on learning from internal experience and data	Additional mechanisms to leverage external technology
Prioritization of efforts based on business payoff	Link to strategic planning weak and often ignored
Certification of individual practitioners, not organizations	Certification of assessors and organizations, not practitioners

Six Sigma is a challenging and time consuming endeavour to be implemented in a 'Level 1' type of organisation, i.e., lack of basic processes and lack of process discipline.

However, Six Sigma complements CMMI and facilitates organisations working towards Level 4/5 delivering business results.

Within the Software Engineering field there are very few applications of Six Sigma. It is expected that this will change as soon as the Engineering Development Processes achieve - what we would call - a basic level.

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6. About the Authors

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