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- Vice-Chair Planning, IEEE Software & Systems Standards Committee
- Secretary, TL 9000 SIG
- Membership, Electronics & Communication Division, ASQ
- Blog Author, ASQ Sarbanes-Oxley

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Foundations and layers

- ISO 9001 Quality Management System Requirements
- TL 9000 Quality Management System Requirements
- IS 12207 & 15288 Software & System Life Cycle Processes
- IEEE 1074 Developing a Software Project Life Cycle Process
- Capability Maturity Model Integrated – Development
- IEEE 1061 Software Quality Metrics Methodology
- TL 9000 Quality Management System Measurements
- Lean
- Six Sigma
- Lean Six Sigma
Management Systems
ISO 9001 Model of a process-based quality management system
ISO 9001 Quality Management System

• Quality management principles •
  – Customer focus
  – Leadership
  – Involvement of people
  – Process approach
  – System approach to management
  – Continual improvement
  – Factual approach to decision making
  – Mutually beneficial supplier relationships

The organization shall:
  – Determine the needs and expectations of customers and other interested parties
  – Establish policies, objectives and a work environment necessary to motivate the organization to satisfy these needs
  – Design, resource and manage a system of interconnected processes necessary to implement the policy and attain the objectives
  – Measure and analyze the adequacy, efficiency and effectiveness of each process in fulfilling its purpose and objectives and
  – Pursue the continual improvement of the system from an objective evaluation of its performance.
ISO 9001 Quality Management System

- *Foundation of several industry sector standards*
  - Aerospace AS9100,
  - Telecom TL 9000,
  - Automobile ISO/TS 16949,
  - Chemical RC 14001,
  - Medical devices ISO 13485,
  - Petroleum and natural gas ISO/TS 29001
TL 9000

Quality Management System,
QuEST Forum
TL 9000 Model

Hardware Measurements

Software Measurements

Services Measurements

Common TL 9000 Measurements

Hardware-Specific Requirements

Software-Specific Requirements

Services-Specific Requirements

Common TL 9000 Requirements

TL 9000 QMS and Measurements System

- ISO 9001 + best practices + best measures = TL 9000
  - 90 Requirement Adders by engineering domains: H, S, V, C
  - 10 Measurements areas for 100+ Product Categories
- TL 9000 requires
  - Life Cycle Model [7.1.C.1],
  - Effectiveness of each process [8.2.3.C.1], &
  - Error elimination [7.3.5.HS1,2]
Life Cycle Models
TL 9000 Life Cycle Model

7.1.C.1 Life Cycle Model

- The organization shall establish and maintain an integrated set of method(s) that covers the life cycle of its products. The method(s) shall contain, as appropriate, the processes, activities, and tasks involved in the
  - concept,
  - definition,
  - development,
  - introduction,
  - production,
  - operation,
  - maintenance, and
  - (if required) disposal of products, spanning the life of the products.
Life Cycle Models

- IS 12207 Software Engineering Life Cycle
  - 18 processes
- IS 15288 System Engineering Life Cycle
  - 25 processes
- IS 2000 Service Management
  - 11 processes
- Control Objectives for Information and related Technology (CobiT)
  - 34 processes
- CMMI-DEV Process Areas (PA)
  - 22 processes
Life Cycle Process Groups, IS12207, IS 15288

System Life Cycle Processes

**Agreement Processes**
- Acquisition Process (Clause 6.1.1)
- Supply Process (Clause 6.1.2)

**Project Processes**
- Project Planning Process (Clause 6.3.1)
- Project Assessment and Control Process (Clause 6.3.2)
- Decision Management Process (Clause 6.3.3)
- Risk Management Process (Clause 6.3.4)
- Configuration Management Process (Clause 6.3.5)
- Information Management Process (Clause 6.3.6)
- Measurement Process (Clause 6.3.7)

**Technical Processes**
- Stakeholder Requirements Definition Process (Clause 6.4.1)
- System Requirements Analysis Process (Clause 6.4.2)
- System Architectural Design Process (Clause 6.4.3)
- Implementation Process (Clause 6.4.4)
- System Integration Process (Clause 6.4.5)
- System Qualification Testing Process (Clause 6.4.6)
- Software Installation Process (Clause 6.4.7)
- Software Acceptance Support Process (Clause 6.4.8)
- Software Operation Process (Clause 6.4.9)
- Software Maintenance Process (Clause 6.4.10)
- Software Disposal Process (Clause 6.4.11)

**Software Life Cycle Processes**

**SW Implementation Processes**
- Software Implementation Process (Clause 7.1.1)
- Software Requirements Analysis Process (Clause 7.1.2)
- Software Architectural Design Process (Clause 7.1.3)
- Software Detailed Design Process (Clause 7.1.4)
- Software Construction Process (Clause 7.1.5)
- Software Integration Process (Clause 7.1.6)
- Software Qualification Testing Process (Clause 7.1.7)

**SW Support Processes**
- Software Documentation Management Process (Clause 7.2.1)
- Software Verification Process (Clause 7.2.4)
- Software Validation Process (Clause 7.2.5)
- Software Review Process (Clause 7.2.6)
- Software Audit Process (Clause 7.2.7)
- Software Problem Resolution Process (Clause 7.2.8)

**Software Reuse Processes**
- Domain Engineering Process (Clause 7.3.1)
- Reuse Program Management Process (Clause 7.3.3)
Service Management processes, IS 20000
Developing software project life cycle process, IEEE 1074

**Legend**
- In Scope of Standard
- Out of Scope of Standard
- x.y.z Clause Number

**Activities from 1074, Annex A**
- 4.1, 4.4

**Provide Framework 1.7**

**Organizational Process Assets 4.2.3**

**Collect Collection of SPLCMs 4.2.1**

**Select 5.2**

**Map**

**SPLCM 4.2.1**

**SPLC 4.2.2**

**SPLCP 4.2.4**

**SPLCM**: Software Project Life Cycle Model
**SPLC**: Software Project Life Cycle
**SPLCP**: Software Project Life Cycle Process
Where CobiT fits…

IT Lifecycle

- Governance
- Policy
- Development
- Delivery

Governance Frameworks

CobiT

Domain Standards

Debbie Lew, CISA, Ernst & Young, LLP
[Member, CobiT Steering Committee]
For 34 CobiT processes you have ...

- Process description
- IT domains & Information Indicators
- IT goals
- Process goals
- Key practices
- Key measurements
- IT Governance & IT resource indicators
CobiT IT Processes

PO1 Define a strategic IT plan
PO2 Define the information architecture
PO3 Determine technological direction
PO4 Define the IT processes, organisation and relationships
PO5 Manage the IT investment
PO6 Communicate management aims and direction
PO7 Manage IT human resources
PO8 Manage quality
PO9 Assess and manage IT risks
PO10 Manage projects

ME1 Monitor and evaluate IT performance
ME2 Monitor and evaluate internal control
ME3 Ensure regulatory compliance
ME4 Provide IT governance

DS1 Define and manage service levels
DS2 Manage third-party services
DS3 Manage performance and capacity
DS4 Ensure continuous service
DS5 Ensure systems security
DS6 Identify and allocate costs
DS7 Educate and train users
DS8 Manage service desk and incidents
DS9 Manage the configuration
DS10 Manage problems
DS11 Manage data
DS12 Manage the physical environment
DS13 Manage operations

AI1 Identify automated solutions
AI2 Acquire and maintain application software
AI3 Acquire and maintain technology infrastructure
AI4 Enable operation and use
AI5 Procure IT resources
AI6 Manage changes
AI7 Install and accredit solutions and changes

Jimmy Heschl, Senior Manager, KPMG Austria
CMMI®

Capability Maturity Model Integrated for Development, V1.2, SEI
CMMI-DEV Model Structure

Staged V1.2

- Maturity Levels
- Process Area 1
- Process Area 2
- Process Area n
  - Specific Goals
  - Generic Goals
  - Specific Practices
  - Generic Practices

Continuous V1.2

- Capability Levels
- Process Area 1
- Process Area 2
- Process Area n
  - Specific Goals
  - Generic Goals
  - Specific Practices
  - Generic Practices
# CMMI-DEV Process Areas

<table>
<thead>
<tr>
<th>Process Areas</th>
<th>Process Management</th>
<th>Project Management</th>
<th>Engineering</th>
<th>Support</th>
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<tbody>
<tr>
<td>Organization Process Focus</td>
<td>Organizational Process Definition (+ IPPD Elements)</td>
<td>Project Planning</td>
<td>Requirements Management</td>
<td>Process and Product Quality Assurance</td>
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<td>Organization Process Definition</td>
<td>Organizational Training</td>
<td>Project Monitoring and Control</td>
<td>Requirements Development</td>
<td>Configuration Management</td>
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<td>Organization Innovation and Deployment</td>
<td>Organization Process Performance</td>
<td>Supplier Agreement Management</td>
<td>Technical Solution</td>
<td>Measurement and Analysis</td>
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<td>Integrated Project Management (+ IPPD Elements)</td>
<td>Product Integration</td>
<td>Decision Analysis and Resolution</td>
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<td>Risk Management</td>
<td>Verification</td>
<td>Causal Analysis and Resolution</td>
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<td>Quantitative Project Management</td>
<td>Validation</td>
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CMMI-DEV Product Suite

• Provides a set of best practices structured around the concept of a capability maturity model for organizations which produce products
• Set of appraisal methods
• Training courses.
• Provide a framework for organizations striving to improve their product development capabilities.
• Applicable to the development of products which contain one or more of the following elements – hardware, software, firmware and people.
CMMI-DEV

- **Process areas (or PAs)**
  - The primary structural element of a CMMI model
  - Composed of best practices which, when implemented result in satisfaction of associated goals for that process area.
  - Structure is common and includes required, expected and informative components
- **Capability Levels**
  - Each of the six capability levels represents a plateau of capability associated with a particular process area
- **Maturity Levels**
  - Each of the five maturity levels represents a plateau of organizational capability for developing products
- **Institutionalization**
  - Ingrained way of doing business that an organization follows routinely as part of its corporate culture
    - The process is ingrained in the way the work is performed and there is commitment and consistency to performing the process.
  - Generic Practices (GP) describe activities that address these aspects of institutionalization.
  - Progression of process institutionalization
CMMI-DEV Appraisal

• Examination of product development processes
• By a trained team of engineering professionals
• Using CMMI-DEV process reference model
• Reviews and/or collects objective evidence
• Determines of extent of practice implementation
• For identifying process strengths and weaknesses
CMMI Appraisals Published

Click the column header to sort by Organization, Organizational Unit, Team Leader, Sponsor, End Date, or Maturity Level. Click the Maturity Level or Appraisal Year to filter the list.

<table>
<thead>
<tr>
<th>Organization - Organizational Unit</th>
<th>Team Leader - Sponsor</th>
<th>Appraisal End Date</th>
<th>Maturity Level - Representation</th>
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<td>WIPRO Corporation - Wipro Infotech: Business Solutions Division</td>
<td>SanthanakrishnanSrinivasan</td>
<td>Aug 14, 2003</td>
<td>ML: 5 - Staged</td>
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<td>Wipro Technologies - Wipro Technologies Limited, SJFR Road, Bangalore</td>
<td>Rajat Mathur</td>
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<td>WISCO Engineering Technology Group Auto Co. Ltd. - WISCO Engineering &amp; Technology Group Automation Company, Ltd.</td>
<td>KrishnamurthyKothandaraman - Sambuddha Deb</td>
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<td>WISCOM SYSTEM CO., LTD. - Wiscom System CO., LTD.</td>
<td>RalphBowden - Bo Huang</td>
<td>May 30, 2006</td>
<td>ML: 3 - Staged</td>
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<td>Wistron Information Technology and Services (Beijing), Inc. - Wuhan Software Development Center</td>
<td>WanJuyong - Chao Guo</td>
<td>Dec 15, 2006</td>
<td>ML: 3 - Staged</td>
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<td>Wolters Kluwer - Corporate Legal Services - CT Corporation &amp; CCH CORSEARCH</td>
<td>EmanuelBaker - Yu Yang</td>
<td>Jan 28, 2005</td>
<td>ML: 3 - Staged</td>
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<td>Wolters Kluwer - Corporate Legal Services - UCC Direct Services</td>
<td>MichaelD Ambrosa - Chris Jutkiewicz</td>
<td>Sep 30, 2005</td>
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<td>World Information Technology -</td>
<td>SoowanLee - Jong Shik Kim</td>
<td>Nov 24, 2006</td>
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<td>SeshadriVenkatesan</td>
<td>Nov 27, 2007</td>
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SEI Appraisal Program http://sas.sei.cmu.edu/pars/pars.aspx
CMMI to TL 9000

• A CMMI Maturity Level 3 Apprised software organization will meet ISO 9001 / TL 9000 requirements with gaps in the following areas:
  • Post deployment support
  • Customer satisfaction surveys
  • Quality partnering
• TL 9000 hardware (H) adders are not addressed in CMMI
Isn’t CMMI Level 3 good enough?

Organizational Process Performance
• Establishes a quantitative understanding of the performance of the organization’s set of standard processes

Quantitative Project Management
• Quantitatively manage the project’s defined process to achieve the project’s established quality and process-performance objectives.
Measurements
Bottom Line

• Process improvement for its own sake will soon die,
• Process improvement should be done to help the business

“In God we trust, All others bring data.”

W. Edwards Deming
TL 9000 Model

- Hardware Measurements
- Software Measurements
- Services Measurements

Common TL 9000 Measurements

- Hardware-Specific Requirements
- Software-Specific Requirements
- Services-Specific Requirements

Common TL 9000 Requirements

8.2.3 Monitoring and measurement of processes

- The organization shall apply suitable methods for monitoring and, where applicable, measurement of the quality management system processes.
- These methods shall demonstrate the ability of the processes to achieve planned results.
- When planned results are not achieved, correction and corrective action shall be taken, as appropriate, to ensure conformity of the product.

8.2.3.C.1 Process measurement

- Expanded: to include appropriate design process measurements and require performance targets or control limits for key process measurements.

7.2.3.HS.2 Design and Development Process Quality Measurements Data Reporting

- New: Provide design and development process measurements when requested by the customer

7.3.1.HS.2 Design and Development Process Quality Measurement Planning and Implementation

- New: Planning during the design and development phase to select and report appropriate design and development process quality measures
Software quality metrics framework, IEEE 1061
Statistical Thinking

Software Engineering Institute | Carnegie Mellon

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SEI Course "Measuring for Performance-Driven Improvement"
Lean
Lean Principles

- Lean Manufacturing Processes
  - Helps eliminate production waste, introduce value-added measurements, and push for continuous improvements
- Continuous pursuit of improving the processes
- Philosophy of eliminating all non-value adding activities & reducing waste within the organization
  - Uncover and reduce waste.
    - Engineering defects
    - Wasted time and effort
  - A new way of thinking
  - Whole systems approach
- Lean concept of value flow, or the uninterrupted value flow at the pull of the customer
- Closely associated with "Kaizen", which means “Continuous Improvement”
- Lean implementation precedes Six Sigma
Six Sigma
Six Sigma

• A measurement standard in product variation
  – A statistical concept measures a process in terms of defects

• DMAIC method
  – Define, Measure, Analyze, Improve, and Control

Continuous improvement methodology

– To improve business processes and products
– Forces organizations to define their vision of quality in numerical terms.
– Offers phases, tools, and techniques that help an organization improve their processes
– Uses data and statistical analysis tools to identify, track and reduce problem areas and defects in products and services
– Defects are isolated and eliminated and thereby lower the overall costs of rework during production and post production maintenance
DMAIC Roadmap

Define
- Define project scope
- Establish formal project
- Evaluate data quality
- Summarize & baseline data

Measure
- Identify needed data
- Obtain data set

Analyze
- Explore data
- Characterize process & problem
- Update improvement project scope & scale

Improve
- Identify possible solutions
- Select solution
- Implement (pilot as needed)
- Evaluate

Control
- Define control method
- Implement
- Document

Phase Exit Review
Focus on tools?

• It’s not about CMMI or Lean or Six Sigma, it’s all about Business Improvement. CMMI and Six Sigma are not ends in themselves but are simply important techniques for leveraging more effective Business Performance.

• The successful use of CMMI, Lean, Six Sigma by various industries is challenging the traditional mantra of being able to use one method only.

• Lean and Six Sigma, with CMMI can be used as complimentary set of improvement methods to provide a lower risk and faster approach, Otherwise:
  - CMMI can yield behavior changes without benefit
  - Six Sigma improvements based solely on data, may miss innovative improvements (assumes a local optimum)

Grant Holdom, 2006

Hefner-Northrop Grumman-2005
SEI’s IDEAL\textsuperscript{SM} Approach (and Six Sigma DMAIC)

“C”
Control the processes with measures and analyses

“D”
Define the Problem(s) to be solved (improve Quality, Cycle Time, etc.)

“M”
Measure the Process against the CMMI Reference Model

“I”
Implement the changes

“A”
Analyze the best ways to implement the changes
CMMI Process Areas & DMAIC Steps

1. Define Phase (D) - Specify Business Objective & Performance Thresholds
   - Gather Data
   - Identify Possible Causes (Brainstorm)
   - Prioritize Actual Causes
   - Develop Action Plan

2. Measure Phase (M) - Measure Baseline
   - Establish capability models, etc.
   - Project Performance
   - Measures Quality
   - SPI Implementation

3. Analyze Phase (A) - Perform Causal Analysis
   - Goal Refinement
   - Analyze Data

4. Improve Phase (I) - Implement Improvement
   - No "Issues"
   - Draft Improvement Goal (DMAIC IT) or
   - Start sub-process selection
   - Prioritize Issues

5. Control Phase (C) - Implement Potential Solutions
   - Improvements
   - Identify for focus areas

Key:
- DMAIC Steps: D (Define), M (Measure), A (Analyze), I (Improve), C (Control)
- CMMI Process Areas: OPP (Organizational Process Performance), OPM (Organizational Project Management), CMM (Causal Analysis & Resolution)
Lean Six Sigma
Lean Six Sigma (LSS)

• Lean Six Sigma is the combination of two techniques, Lean and Six Sigma; as they are complementary
  – Lean focuses on increasing the speed of a process, or in the elimination of any non-value added steps or activities within a process
  – Six Sigma focuses more on quality than speed.
  – Lean defines and refines the customer value flow and
  – Six Sigma helps ensure that the value continues to flow smoothly and to improve.

• Fundamentals
  – Delight your Customers
  – Base Decisions on Data & Facts
  – Work Together for Maximum Gain
  – Improve Your Processes

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Lean Six Sigma

• Does not provide processes or process descriptions
• Emphasizes that speed is directly related to process excellence
• Combines general quality guidance with a process-based management approach, describing the criteria that the processes should support.
• Uses data to identify and eliminate process problems
LSS Implementation

- The implementation of both Six Sigma and Lean techniques will address and change similar management and technical staff behaviors. The organizational change management approach with both techniques will be quicker and less costly than a sequential approach and provides more benefits than an “Either / Or” approach.
Organizational change management

• Top management has the responsibility of providing overall direction, resources, and the control framework for managing the change process.

• The organizational changes result in changes to participant’s skills, their tools, and their work processes and artifacts.
Robust Management System Foundation

- LSS requires a robust management, sound engineering practices, and process measurement system foundation prior to the application of its improvement methodologies, like Lean, Six Sigma, or combined Lean Six Sigma.
- Organizations, with a robust management system foundation, such as ISO 9001, TL 9000, or CMMI-DEV, are pursuing process improvement by establishing a set of organizationally adopted processes to be applied by all of their projects, and then improving them on the basis of their experience.
- This “experience” is factored by both the Lean principles and the Six Sigma principles; resulting in the use of specific Lean Six Sigma improvement techniques that validate specific process changes to be deployed across the organization.
Measures and Analysis: What & How

CMMI: what should be done, not how to do it.

Lean Six Sigma: how to do it – a performance-based methodology for applying measurement and analysis to problem solving and project management.
Resources for Improvements

• Whenever objective experiences demonstrate the need for changes to processes and artifacts,
• Then the appropriate IEEE software & system engineering standards can be selected and analyzed for their best practices to be incorporated into
  – processes,
  – internal plans,
  – procedures, and
  – other artifacts,
• to support of Lean Six Sigma implementation.
Conclusions
1st Foundation, 2nd Improvement

• Foundation
  – Management System
  – Life cycle models, Software & system engineering, Service, etc.
  – Measurement System

• Improvement
  – Only then can organizations move forward to trim the waste and increase their overall production value and product quality.
    • Lean
    • Six Sigma
    • Lean Six Sigma
  – The alternate is improving an undocumented 'fuzzy' process, which means making assumptions about what the process is; Hoping the participants of the next iteration understand and continue the changes.
Building for Business Success

- Improvement Methods
  - CMMI-DEV
- Lean Six Sigma
  - Lean
  - Six Sigma
- IS 12207 & 15288
  - Life Cycle Model
- TL 9000 QMS Requirements
  - Measurement System
  - Management Systems
- TL 9000 QMS Measurements
Backup
Development Life Cycle Model steps, IEEE 1074

- Selection of Development Life Cycle Model
- Tailoring of existing software & system engineering processes to create Project Development Life Cycle
- Development of project schedules of major artifacts and project roles
- Project members assigned to roles
- Project members create, review, revise, and transmit project artifacts to other project members or stakeholders. The work products or artifacts can be:
  - Process & product records, as simple as process start and end dates
  - Documents to share or review with team members or the customer
  - Final artifacts are customer deliverables, installations, and / or training
- Project artifacts are stored and managed as part of the project configuration management system
- Engineering processes & associated artifacts can be assessed
IEEE 1220 Systems engineering process

PROCESS INPUTS

Requirements Analysis
- Requirements baseline

Requirements Validation
- Validated requirements baseline

Functional Analysis
- Functional architecture

Functional verification
- Verified functional architecture

Synthesis
- Physical architecture

Design verification
- Verified physical architecture

Control

PROCESS OUTPUTS

Requirement and constraint conflicts

Requirement trade-offs and impacts

Decomposition and requirement allocation alternatives

Decomposition/allocation trade-offs and impacts

Requirements trade studies and assessments

System

Functional trade studies and assessments

Analysis

Design trade studies and assessments