Capability Levels at CMMI
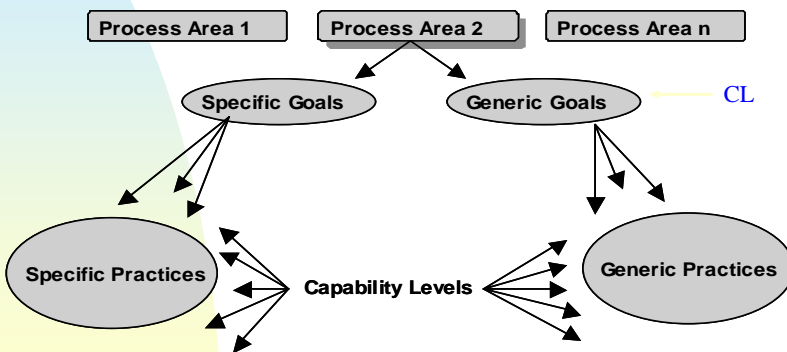
2 S/W Management ( )

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CMMI Model Components
Continuous representation

2

Required, Expected, and Informative Components

○ **Required**: Specific and generic goals (what must be implemented)

○ **Expected**: Specific and generic practices (activities expected)

○ **Informative**: Subpractices, typical work products, discipline amplifications, generic practice elaborations, goal and practice titles, goal and practice notes, and references

Model Components -1

1. **Process areas**: a PA is a cluster of related practices in an area, when performed collectively, satisfy a set of goals considered important for *making significant improvement* in that area.

2. **Specific goals**: apply to a process area and address the unique characteristics that describe **what must be implemented to satisfy the PA**.

3. **Specific practices**: a specific practice is **an activity expected**.
   - Base practices: level 1 practices
   - Advanced practices: levels of 2 or higher

4. **Typical work products**
   - Provide example outputs from a specific or generic practice.

Model Components -2

5. **Subpractices**: <u>detailed descriptions</u> that provide guidance for interpreting specific or generic practices.

6. **Discipline amplification**

7. **Generic goals**: <u>describe the institutionalisation</u> that the organization must achieve at that capability level.

8. **Generic practices**: <u>provide institutionalisation</u> to ensure that the processes associated with the PA will be effective, repeatable, and lasting.

9. **Generic practices elaborations**

10. **References**

Example: Requirements Development

SG 1 Develop Customer Requirements
  SP 1.1-1 Collect Stakeholder Needs
  SP 1.1-2 Elicit Needs
  SP 1.2-1 Develop the Customer Requirements
SG 2 Develop Product Requirements
  SP 2.1-1 Establish Product & Product-Component Requirements
  SP 2.2-1 Allocate Product-Component Requirements
  SP 2.3-1 Identify Interface Requirements
SG 3 Analyze and Validate Requirements
  SP 3.1-1 Establish Operational Concepts and Scenarios
  SP 3.2-1 Establish a Definition of Required Functionality
  SP 3.3-1 Analyze Requirements
  SP 3.4-3 Analyze Requirements to Achieve Balance
  SP 3.5-1 Validate Requirements
  SP 3.5-2 Validate Requirements with Comprehensive Methods

GG 1 Achieve Specific Goals
  GP 1.1 Perform Base Practices
GG 2 Institutionalize a Managed Process
  GP 2.1 Establish an Organizational Policy
  GP 2.2 Plan the Process
  GP 2.3 Provide Resources
  GP 2.4 Assign Responsibility
  GP 2.5 Train People
  GP 2.6 Manage Configurations
  GP 2.7 Identify and Involve Relevant Stakeholders
  GP 2.8 Monitor and Control the Process
  GP 2.9 Objectively Evaluate Adherence
  GP 2.10 Review Status with Higher Level Management
GG 3 Institutionalize a Defined Process
  GP 3.1 Establish a Defined Process
  GP 3.2 Collect Improvement Information
GG 4 Institutionalize a Quantitatively Managed Process
  GP 4.1 Establish Quantitative Objectives for the Process
  GP 4.2 Stabilize Subprocess Performance
GG 5 Institutionalize an Optimizing Process
  GP 5.1 Ensure Continuous Process Improvement
  GP 5.2 Correct Root Causes of Problems

25 Process Areas
Continuous Representation

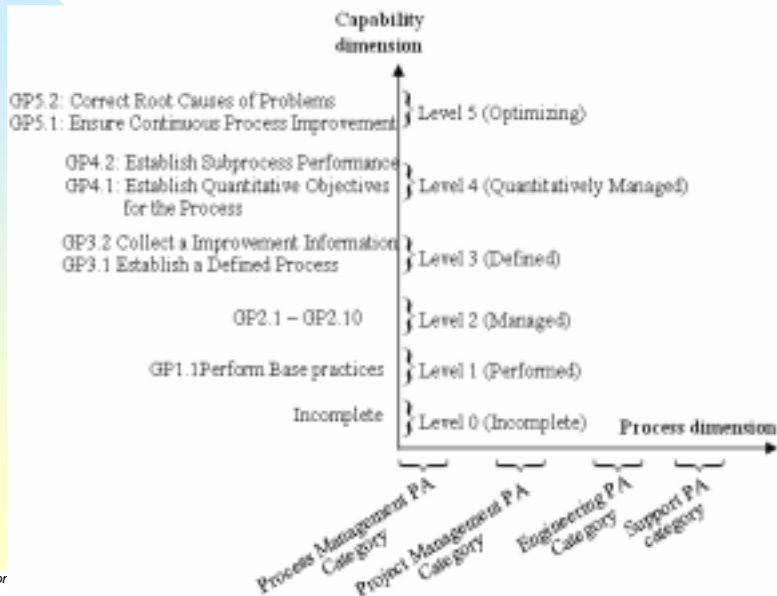| Category	Process Areas
Process management	Organizational Process Focus
	Organizational Process Definition
	Organizational Training
	Organizational Process Performance
	Organizational Innovation and Deployment
Project management	Project Planning
	Project Monitoring and Control
	Supplier Agreement Management
	Integrated Project Management for IPPD
	Risk Management
	Integrated Teaming (IPPD)
	Integrated Supplier Management (SS)
	Quantitative Project Management
Engineering	Requirements Management
	Requirements Development
	Technical Solution
	Product Integration
	Verification
	Validation
Support	Configuration Management
	Process and Product Quality Assurance
	Measurement and Analysis
	Decision Analysis and Resolution
	Organizational Environment for Integration (IPPD)
	Causal Analysis and Resolution

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CMMI GPs

Capability level	Generic practices
CL0 (Incomplete)	
CL1 (Performed)	GP1.1: Perform base practices
CL 2 (Managed)	GP2.1: Establish an organizational policy
	GP2.2: Plan the process
	GP2.3: Provide resources
	GP2.4: Assign responsibility
	GP2.5: Train people
	GP2.6: Manage configurations
	GP2.7: Identify and involve relevant stakeholders
	GP2.8: Monitor and control the process
	GP2.9: Objectively evaluate adherence
	GP2.10: Review status with higher management
CL 3 (Defined)	GP3.1: Establish a defined process
	GP3.2: Collect improvement information
CL 4 (Quantitatively managed)	GP4.1: Establish quantitative objectives for the process
	GP4.2: Stabilize subprocess performance
CL 5 (Optimizing)	GP5.1: Ensure continuous process improvement
	GP5.2: Correct root causes of problems

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A Two-Dimensional Architecture of CMMI

Capability dimension

GP5.2: Correct Root Causes of Problems
GP5.1: Ensure Continuous Process Improvement } Level 5 (Optimizing)

GP4.2: Establish Subprocess Performance
GP4.1: Establish Quantitative Objectives
for the Process } Level 4 (Quantitatively Managed)

GP3.2 Collect a Improvement Information
GP3.1 Establish a Defined Process } Level 3 (Defined)

GP2.1 – GP2.10 } Level 2 (Managed)

GP1.1 Perform Base practices } Level 1 (Performed)

Incomplete } Level 0 (Incomplete)   Process dimension

Process Management PA Category   Project Management PA Category   Engineering PA Category   Support PA category

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Improving a Process Area

	SP x.y-1 (GP1.1)	SP x.y-2 & GP1.1 ~ GP2.10	SP x.y-3 & GP3.1 & GP3.2	GP4.1 & GP4.2	GP5.1 & GP5.2
CL 1	S				
CL 2	S	S			
CL 3	S	S	S		
CL 4	S	S	S	S	
CL 5	S	S	S	S	S

Advanced practices, SP x.y-2 and SP x.y-3, exist in only the Engineering PAs.

: Base practices: SP x.y- 1

Staged Representation
25 process areas

Level	Focus	Process Areas
5 Optimizing	Continuous process improvement	1. Organizational Innovation and Deployment (ORG5) 2. Causal Analysis and Resolution (SUP6)
4 Quantitatively Managed	Quantitative management	1. Organizational Process Performance (ORG4) 2. Quantitative Project Management (PRJ8)
3 Defined	Process standardization	1. Requirements Development (ENG2) 2. Technical Solution (ENG3) 3. Product Integration (ENG4) 4. Verification (ENG5) 5. Validation (ENG6) 6. Organizational Process Focus (ORG1) 7. Organizational Process Definition (ORG2) 8. Organizational Training (ORG3) 9. Integrated Project Management (PRJ4) 10. Risk Management (PRJ5) 11. Integrated Teaming (PRJ6) 12. Integrated Supplier Management (PRJ7) 13. Decision Analysis and Resolution (SUP4) 14. Organizational Environment for Integration (SUP5)
2 Managed	Basic project management	1. Requirements Management (ENG1) 2. Project Planning (PRJ1) 3. Project Monitoring and Control (PRJ2) 4. Supplier Agreement Management (PRJ3) 5. Measurement and Analysis (SUP3) 6. Process and Product Quality Assurance (SUP2) 7. Configuration Management (SUP1)
1 Initial		

Example: RD (Specific Practices)

Continuous representation	Staged representation
SG 1 Develop Customer Requirements SP 1.1-1 Collect Stakeholder Needs SP 1.1-2 Elicit Needs SP 1.2-1 Develop the Customer Requirements	**SG 1 Develop Customer Requirements** SP 1.1 Elicit Needs SP 1.2 Develop the Customer Requirements
SG 2 Develop Product Requirements SP 2.1-1 Establish Product & Product-Component Requirements SP 2.2-1 Allocate Product-Component Requirements SP 2.3-1 Identify Interface Requirements	**SG 2 Develop Product Requirements** SP 2.1 Establish Product & Product-Component Requirements SP 2.2 Allocate Product-Component Requirements SP 2.3 Identify Interface Requirements
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Example: RD (Generic Practices)

Continuous representation	Staged representation
GG 1 Achieve Specific Goals GP 1.1 Perform Base Practices **GG 2 Institutionalize a Managed Process** GP 2.1 Establish an Organizational Policy GP 2.2 Plan the Process GP 2.3 Provide Resources GP 2.4 Assign Responsibility GP 2.5 Train People GP 2.6 Manage Configurations GP 2.7 Identify and Involve Relevant Stakeholders GP 2.8 Monitor and Control the Process GP 2.9 Objectively Evaluate Adherence GP 2.10 Review Status with Higher Level Management **GG 3 Institutionalize a Defined Process** GP 3.1 Establish a Defined Process GP 3.2 Collect Improvement Information **GG 4 Institutionalize a Quantitatively Managed Process** GP 4.1 Establish Quantitative Objectives for the Process GP 4.2 Stabilize Subprocess Performance **GG 5 Institutionalize an Optimizing Process** GP 5.1 Ensure Continuous Process Improvement GP 5.2 Correct Root Causes of Problems	**GG2 Institutionalize a Managed Process** GP 2.1 (CO 1) Establish an Organizational Policy GP 2.2 (AB 2) Plan the Process GP 2.3 (AB 3) Provide Resources GP 2.4 (AB 4) Assign Responsibility GP 2.5 (AB 5) Train People GP 2.6 (AB 5) Manage Configurations GP 2.7 (DI 1) Identify and Involve Relevant Stakeholders GP 2.8 (DI 2) Monitor and Control the Process GP 2.9 (VE 1) Objectively Evaluate Adherence GP 2.10 (VE 2) Review Status with Higher Level Management **GG 3 Institutionalize a Defined Process** GP 3.1 (AB 1) Establish a Defined Process GP 3.2 (DI 3) Collect Improvement Information

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Equivalent Staging (Continuous → Staged)

Common Terminology with Special Meaning (26)

- Establish and maintain (in goals and practices)
    - formulated, documented, and used throughout the organization
- Customer
    - is the party (individual, project, or organization) responsible for <u>accepting the product</u> or <u>authorizing payment</u>.
    - external to the project, but not necessarily external to the organization.
    - subset of stakeholders
- Stakeholder
    - a group or individual that <u>is affected</u> by or in some way <u>accountable for</u> the outcome of an undertaking.
    - example: project managers, suppliers, customers, end users, and others.
- Relevant stakeholder
    - designate a stakeholder that is <u>identified</u> for involvement in specified activities and is <u>included</u> in an appropriate plan.


- **Product**
    - <u>Any tangible output or service</u> that is a result of a process and that is intended <u>for deliver to a customer or end user</u>.
    - Product is a work product that is delivered to the customer.
- **Work product**
    - <u>Any artefacts produced by process</u>. e.g., files, documents, parts of product, services, processes, specifications, and invoices.
    - Manufacturing process, training process, and disposal process for the product. *A work product need not be engineered or part of the end product.*
- **Product component**
    - Lower level components of the product.
    - Any work product that must be engineered.

○ Quality and process-performance (QPP) objectives
  ▪ Covers *objectives and requirements* for product quality, service quality, and process performance.
    ● Process measurements (e.g., effort, cycle time, and defect removal effectiveness) and
    ● Product measurements (e.g., reliability and defect density).

○ **Organization's set of standard processes (OSSPs)**
  ▪ Contains the definitions of the processes (process descriptions) that guide all activities in an organization.
  ▪ These process description covers the fundamental process elements (their relationships to each other) that must be incorporated into the defined process. (process architecture)

Standard processes ——— **Tailoring** ——→ **Defined processes**
(project level)
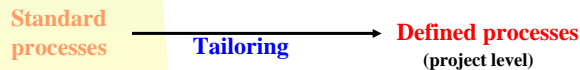
CMMI-Specific terminology (14)

○ **Organization's process asset library (OPAL)**
  ▪ <u>Examples of process-related documentation:</u> policies, defined processes, checklists, lessons-learned documents, templates, standards, procedures, plans, and other artefacts.

○ **Organization's measurement repository (OMR)**
  ▪ <u>Examples of process and work product data</u>: estimated size of work products, actual effort expended, and actual costs; peer review efficiency and coverage statistics; and the number of and severity of defects.

○ **Organization process assets (OPAs)**
  ▪ <u>Org's process assets at CMMI; (5+2)</u>
    ● Organization's set of standard processes, including the <u>process architectures</u> and <u>process elements</u>.
    ● Descriptions of life-cycle models approved for use
    ● Guidelines and criteria for tailoring the organization's set of standard processes
    ● Organization's measurement repository
    ● Organization's process asset library
    ● *Organizational process performance baselines*
    ● *Organizational process performance models*

4. Capability Levels and Generic Model Components

Introduction to CMMI

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Capability Level 0: Incomplete

○ Process is either <u>not performed</u> or <u>partially performed</u>.
○ <u>One</u> or more of the specific goals of the PA are not satisfied.

A process performance is not step function (by Ho-Won).

Capability Level 1: Performed

- <u>All</u> specific goals of the PA are satisfied.
- Produce identified output work products using identified input work products.
- The process may be unstable and inconsistently implemented.

- **GG 1:** Achieve specific goals.
- **GP 1:** Perform *base practices of the PA* to develop work products and provide services to achieve the specific goals of the PA.

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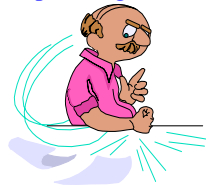
Capability level 2: Managed

- A managed process is a performed process that
  - is also planned and executed in accordance with policy;
  - employs skilled people having adequate resources;
  - involves relevant stakeholders;
  - is monitored, controlled, and reviewed;
  - is evaluated for adherence to its process description.
- Processes are managed to achieve <u>process objectives</u> such as cost, schedule, and quality.

<u>Process objectives: cost, schedule, and quality.</u>

GG 2: **Institutionalize a Managed Process**

○ **GP 2.1 Establish an Organization Policy**
  ▪ Establish and maintain <u>an organization policy</u> for *planning and performing <u>the process</u>.*
  ▪ The purpose is to define organizational <u>expectations for the</u> process and make these expectations visible to *those affected in the organization.*

○ **GP 2.2 Plan the Process**
  ▪ Establish and maintain <u>the plan</u> for performing the process.
  ▪ The purpose is:
    • to determine <u>what is needed</u> to <u>perform the process and achieve the established objective</u>;
    • to prepare a plan for performing the process;
    • to prepare a process description;
    • to get agreement on the plan from relevant stakeholders.
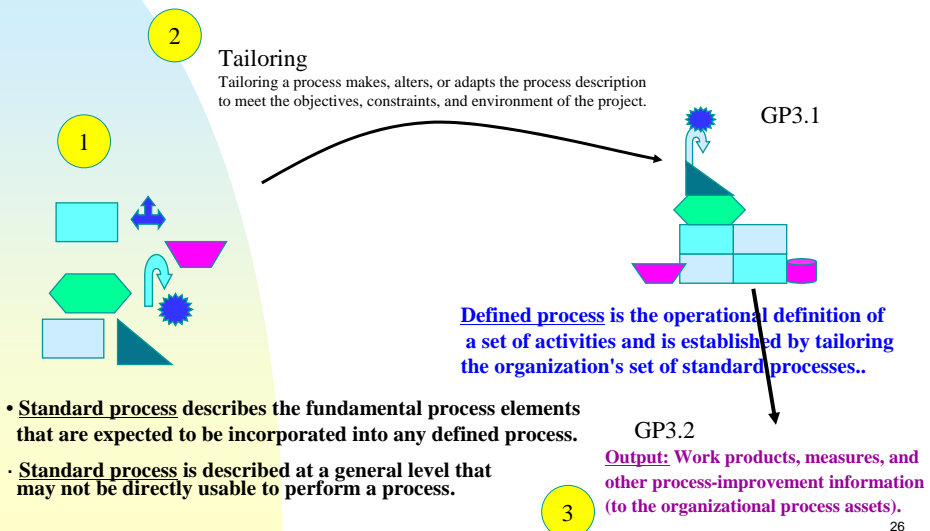 ▪ Plan may be from other processes (PMC plan   PP)

○ **GP 2.3 Provide Resources**
  ▪ *Provide adequate resources* for <u>performing the process, developing the work products,</u> and <u>providing the services of the process</u>.
    • Resources: Funding, people, tools, facilities

○ **GP 2.4 Assign Responsibility**
  ▪ *Assign responsibility and authority* for <u>performing the process, developing the work product,</u> and <u>providing the services of the process</u>.

○ **GP 2.5 Train People**
  ▪ *Train the people* performing or supporting the process as needed.
  ▪ <u>Refer to the Organizational Training (OT)</u>

○ **GP 2.6 Manage Configuration**
  ▪ *Place designated work products of the process* (identified in the plan for performing the process) under appropriate levels of CM.

○ **GP 2.7 Identify and Involve Relevant Stakeholders**
  ▪ The purpose is to establish and maintain <u>the expected involvement of stakeholders</u> during the execution of the process, and to ensure that <u>interactions</u> necessary to the process are accomplished.

○ **GP 2.8 Monitor and Control the Process**
  ▪ Monitor and control the process <u>against the plan</u> for performing the process and <u>take appropriate corrective action</u>.

○ **GP 2.9 Objectively Evaluate Adherence**
  ▪ Objectively evaluate adherence of the process against its process description, standard, and procedures, and <u>address non-compliances</u>.

○ **GP 2.10 Review Status with Higher Level Management**
  ▪ Review the activities, status, and results of the process with higher-level management and <u>resolve issues</u>.
  ▪ The purpose is to provide higher-level management with the appropriate visibility into the process.

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Capability Level 3: Defined

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Tailoring
Tailoring a process makes, alters, or adapts the process description to meet the objectives, constraints, and environment of the project.

GP3.1

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Defined process is the operational definition of a set of activities and is established by tailoring the organization's set of standard processes..

• **Standard process** describes the fundamental process elements that are expected to be incorporated into any defined process.

· **Standard process** is described at a general level that may not be directly usable to perform a process.

GP3.2

Output: Work products, measures, and other process-improvement information (to the organizational process assets).

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GG 3: Institutionalize a Defined Process

○ GP 3.1 Establish a Defined Process.

- Establish and maintain <u>the description of a defined process</u> that is tailored from the OSSPs (Organization's Set of Standard Processes).
  - Variability of performing process across the organization is reduced
  - Process asset, data, and learning can be shared effectively.

○ GP 3.2 Collect Improvement Information.

- Collect <u>work products, measures, measurement results, and improvement information</u> derived from planning and performing the process <u>to support</u> the future use and improvement of the OPPAs (Organization's Processes and Process Assets).
  - The information and artefacts are stored in <u>the organization's measurement repository</u> and the <u>organization's process library</u>.
  - The process and product measures are primarily those that are defined in the common set of measures for the OPPAs.

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Capability Level 4: Quantitatively Managed

- Quantitatively managed process is a defined process that
  - is controlled using <u>statistical and other quantitative techniques.</u>
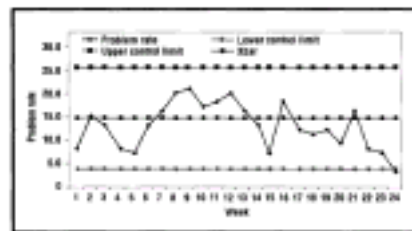
· Predictability (stability): variation within control limits.

· Capable process: meet specification, objective, or requirement

Do not confuse the differences between ″predictability″ and ″prediction″.

QPP: Quality and process-performance

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Source of process performance variation

[Total variation] = [Special cause variation]

+

[Common cause variation]

Special cause = Assignable cause

Special (assignable) Causes

- Preventable variations
- Events from not part of the normal process.
- Removing all special causes results in a stable and predictable process.
- Examples of special causes of variation
  - Failures to follow the process (lack of process compliance)
  - Changes in the quality of raw materials (uncontrolled inputs to the subprocess)
  - Changes to work environment
  - Inadequately trained people
  - Schedule pressure
  - Tool failures
  - Changes in methods used
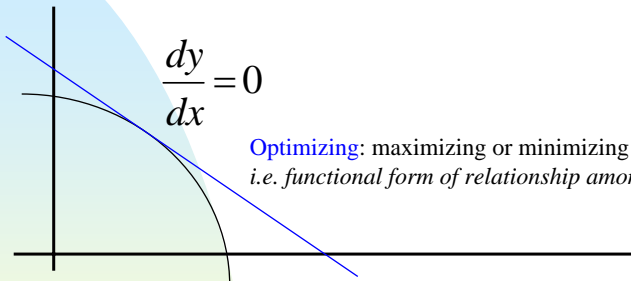 - Inappropriate sampling or grouping of data

GG 4: **Institutionalize a Quantitatively Managed Process**

- GP 4.1 Establish Quantitative Objectives for the Process.
  - Establish and maintain <u>quantitative objectives for the process</u>.
  - The purpose is to determine and obtain <u>agreement</u> from <u>relevant stakeholders</u> about specific quantitative objectives for the process.

- GP 4.2 Stabilize Subprocess Performance.
  - Stabilize <u>the performance of one or more subprocesses</u> to determine the ability of the process to achieve the established QPP objectives.
    - <u>Refer to the QPM SG 2 (Statistically Manage Subprocess Performance</u>

Capability Level 5: Optimizing

$$\frac{dy}{dx} = 0$$

Optimizing: maximizing or minimizing <u>objective,</u>
i.e. functional form of relationship among variables.

Process Attribute (x) → Quality- and process-performance objectives

Context factors

$$Performance = f(x_1, x_2, \ldots, x_n)$$

<Research hypothesis>

SPC: passive approach
Level 5 requires more rigorous analyses such as regressions.
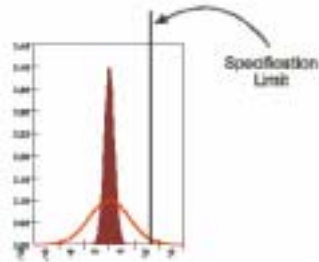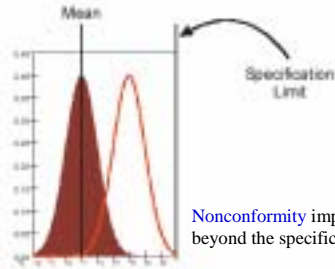
Continuous Process Improvement

GP5.1

If the process is both stable and capable, then the organization should continuously seek ways to improve the variation (narrower control limits) and improve the capability of the process

o Changing the mean results in reducing the proportion of the nonconformities.

Nonconformity implies the proportion beyond the specification limit.

o Reducing the variation results in reducing the proportion of the nonconformities.

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o GP 5.1 Ensure Continuous Process Improvement.

- Ensure continuous improvement of the process in fulfilling the relevant business objectives of the organization.
- The purpose is to select and systematically deploy process and technology improvements that contribute to meeting "established quality and PI objectives".

o GP 5.2 Correct Root Causes of Problems.

- Identify and correct the root causes of defects and other problems in the process.
- The purpose is to analyze defects and other problems, to correct the root causes of these types of defects and problems, and to prevent these defects and problems from occurring in the future.