# CMMI® High Maturity Appraisal Considerations

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Steve Masters
SEC(R)
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Software Engineering Institute | Carnegie Mellon

# Acknowledgements

The CMMI implementation examples in the second half of this tutorial are derived from the October 17, 2007 CMMI Workshop presentation *If You Are Living the "High Life", You Are Living the Informative Material* by Rusty Young, Bob Stoddard, and Mike Konrad.

# Outline

SCAMPI[SM] Overview

High Maturity Skills in the SLA BOK

Statistical and Quantitative Thinking

Organizational Process Performance (OPP)

Quantitative Project Management (QPM)

Casual Analysis and Resolution (CAR)

Organizational Innovation and Deployment

Summary

[SM] SCAMPI and SCAMPI Lead Appraiser are service marks of Carnegie Mellon University
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# SCAMPI OVERVIEW

# Three Classes of Appraisals

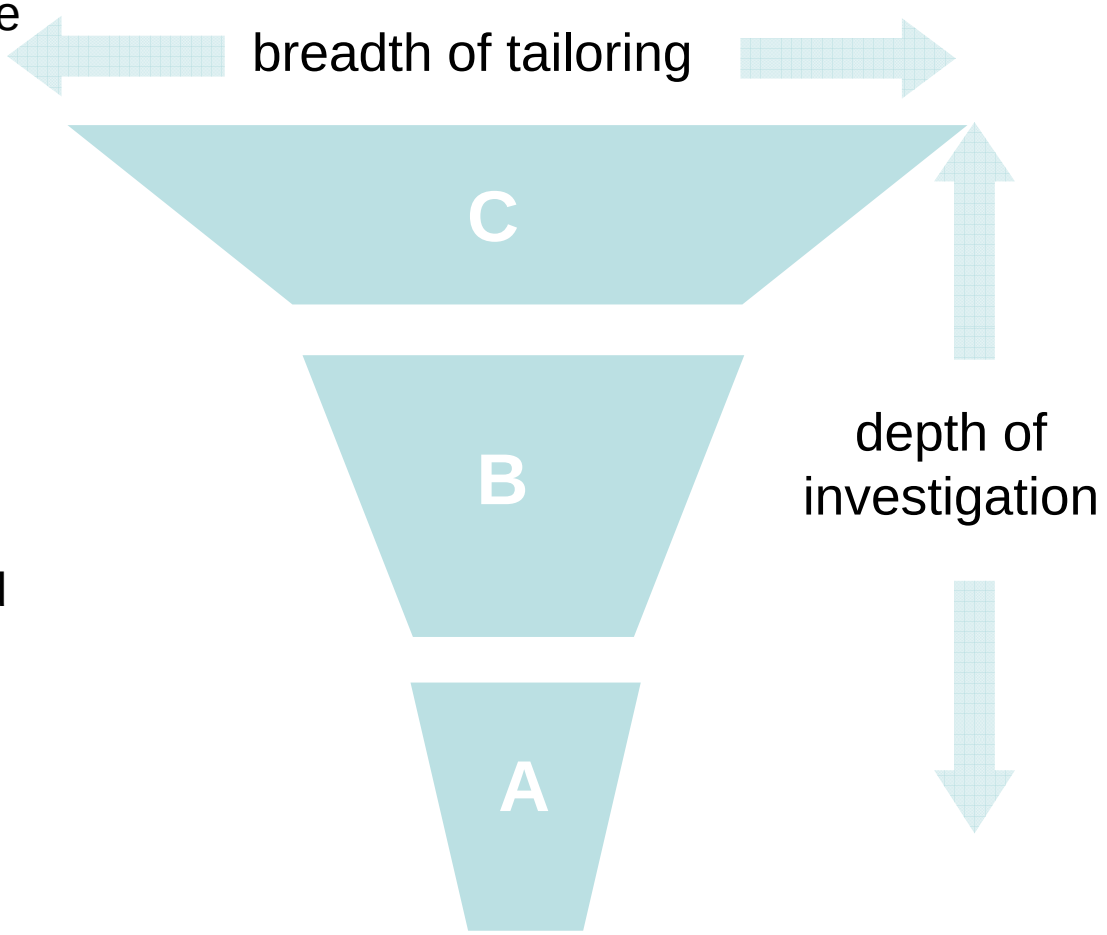
| Characteristic | Class C | Class B | Class A |
|---|---|---|---|
| Amount of objective evidence | Low | Medium | High |
| Ratings generated | No | No | Yes |
| Resource needs | Low | Medium | High |
| Team Size | Small | Medium | Large |

# SCAMPI Family

**SCAMPI C:** provides a wide range of options, including characterization of planned approaches to process implementation according to a scale defined by the user

**SCAMPI B:** provides options in model scope and organizational scope, but characterization of practices is fixed to one scale and is performed on implemented practices

**SCAMPI A:** Is the most rigorous method, and is the only method that can result in ratings



# Approach, Deployment, Institutionalization

| | Approach | Deployment | Institutionalization |
|---|---|---|---|
| A | Green | Green | Green |
| B | Green | Green | Yellow |
| C | Green | Yellow | Red |

SCAMPI family methods can be used in a range from

- looking at the approach planned to satisfy process improvement goals, to
- examining deployment of processes in selected instances in an organizational unit (OU), to
- benchmarking the institutionalization of CMMI in an OU

# SCAMPI Class A Objectives

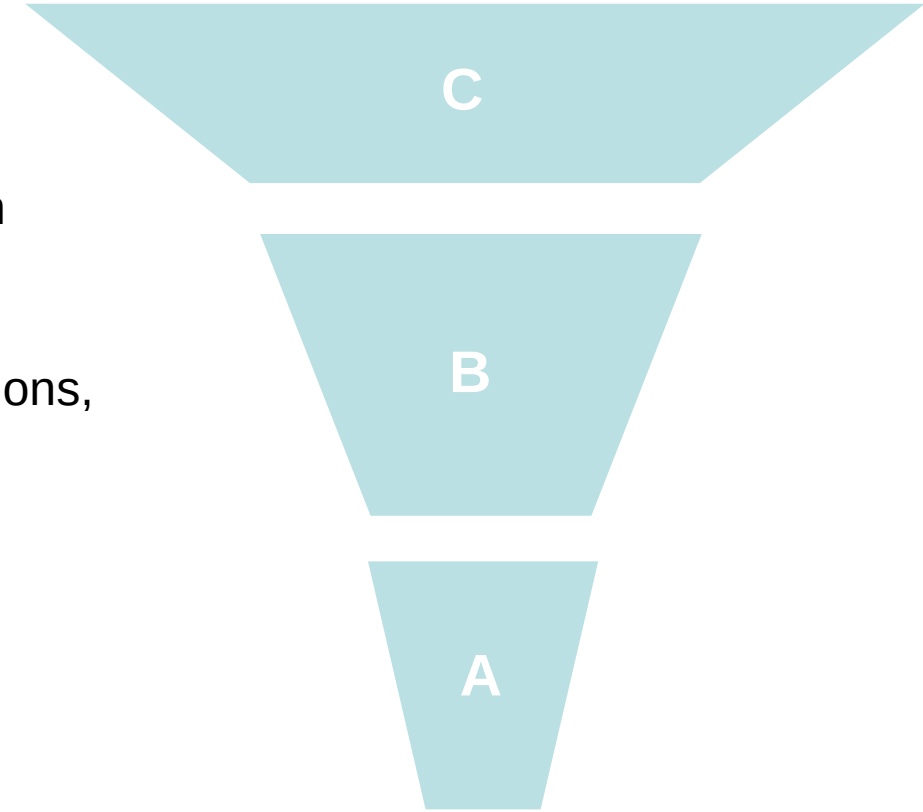
Provide an accurate picture of the organization's processes relative to CMMI:

- Understand the current implemented process.
- Identify process weaknesses (and strengths) in the organizational unit.
- Determine degree of satisfaction of CMMI Process Area goals investigated.
- Assign ratings, if requested by appraisal sponsor.

# Comparison to SCAMPI A

SCAMPI B provides more options in model scope and organizational scope, but characterization of practices is fixed to one scale and is performed on Implemented practices.

SCAMPI C provides a wide range of options, including characterization of planned approaches to process implementation according to a scale defined by the organization and appraisal team. This allows SCAMPI C to be used in a planning and consultation context.



# Discipline Model (CMMI-DEV)

In making inferences about the extent to which practices are or are not in place (i.e., implemented), appraisers are expected to draw upon the entire model document as the basis for their decisions.

Examples

- glossary definitions
- front matter
- subpractices
- related process areas

# Determination of Practice Implementation

Assumptions

1. The appraisal team understands the context in which the practice is being implemented.
2. The appraisal team understands the practice intent.

The basic approach to determination of practice implementation is to

1. Characterize the degree to which the practice is implemented.
2. Note any factors which should be considered in addition as the instantiation data is aggregated (strengths, weaknesses, etc.).

# SCAMPI A Practice Characterization

| | |
|---|---|
| **Fully Implemented (FI)** | • Direct artifacts present and adequate<br>• Supported by indirect artifact and/or affirmation<br>• No weaknesses noted |
| **Largely Implemented (LI)** | • Direct artifacts present and adequate<br>• Supported by indirect artifact and/or affirmation<br>• One or more weaknesses noted |
| **Partially Implemented (PI)** | • Direct artifacts absent or judged inadequate<br>• Indirect artifacts or affirmations indicate some aspects of the practice are implemented<br>• One or more weaknesses noted<br>OR<br>• Direct artifacts present and adequate<br>• No other evidence supports direct artifacts<br>• One or more weaknesses noted |
| **Not Implemented (NI)** | • Direct artifacts absent or judged inadequate<br>• No other evidence supports the practice<br>• One or more weaknesses noted |
| **Not Yet (NY)** | • Project has not yet reached the stage in lifecycle |

# SCAMPI B: Practice Characterization

| Label | Meaning |
|---|---|
| Red | The intent of the model practice is judged to be absent or poorly addressed in the set of implemented practices – gaps or issues that will prevent goal achievement, if the deployment occurred in this way across the organizational unit, were identified. |
| Yellow | The intent of the model practice is judged to be partially addressed in the set of implemented practices – some gaps or issues were identified, which might threaten goal achievement if the deployment occurred in this way across the organizational unit. |
| Green | The intent of the model practice is judged to be adequately addressed in the implemented set of practices examined – in a manner that would support goal achievement, if the practice were deployed across the organizational unit. |
| Not Yet (NY) | Project has not yet reached the stage in lifecycle. |

# SCAMPI C: Example Characterization Scale-Appraisal Focus "Approach"

| Label | Meaning |
|---|---|
| LOW | The intent of the model practice is judged absent, or inadequately addressed in the approach – goal achievement is judged unlikely because of this absence or inadequacy. |
| MEDIUM | The intent of the model practice is judged to be partially addressed in the approach – and only limited support for goal achievement is evident. |
| HIGH | The intent of the model practice is judged to be adequately addressed in the set of practices (planned or deployed) – in a manner that supports achievement of the goal in the given process context. |

# Aggregation Across Instantiations

When there is objective evidence for two or more instantiations of a practice, how is the organizational unit characterization derived?

SCAMPI A and SCAMPI B provide aggregation rules to assist the team in efficiently, effectively, and consistently aggregating across instantiations.

# SCAMPI A Aggregation Rules

| Instantiations | Outcome |
|---|---|
| All FI/NY with at least one FI | FI |
| All LI/FI/NY with at least one LI | LI |
| At least one LI/FI and at least one PI/NI | LI or PI* |
| All PI/NI/NY with at least one PI | PI |
| All NI/NY with at least one NI | NI |
| All NY | NY** |

* Team judgment is applied to choose LI or PI based on whether the weaknesses, in aggregate, have a significant negative impact on goal achievement
** If all instantiations in the OU have not reached the stage in the OU to have implemented a practice, no associated goal rating can be given

# SCAMPI B Aggregation Rules*

| OU Characterization | Instance Characterizations |
|---|---|
| Red | All instantiations characterized Red |
| Yellow | All instantiations characterized Yellow |
| Green | All instantiations characterized Green |
| Team judgment subject to below** | All conditions not included above |

**The OU characterization shall not be Red unless at least one instance characterization is Red and shall not be Green unless at least one instance characterization is Green

*Optional

# Goal Rating Rules for SCAMPI A

The goal is rated “satisfied” if and only if

- There are no findings that document weaknesses associated with a goal.

OR

- (a) All associated practices are characterized at the organizational unit level as either Largely Implemented or Fully Implemented, and (b) the aggregate of weaknesses associated with the goal does not have a significant negative impact on goal achievement.

Otherwise, the goal is rated “unsatisfied.”

# Rating Process Areas for SCAMPI A

When a process area is determined to be outside of the organizational unit's scope of work, the process area is designated as "not applicable" and is not rated. The only PA in CMMI-DEV that can be not applicable is SAM (as determined by the appraisal team).

When a process area is outside of the appraisal reference model scope, the process area is designated as "out of scope" and is not rated. If the associated findings do not meet the method's defined criteria for data coverage, the process area is designated as "not rated" and is not rated.

**Continuous Representation**

The process area is given a capability level rating based upon the highest level for which the generic goal is satisfied. If no generic goals are satisfied then the capability level rating is 0.

**Staged Representation**

The process area is "satisfied" if and only if all of its specific and generic goals are rated "satisfied."

# Assigning Maturity Level in SCAMPI A

A maturity level for a staged representation is achieved if all process areas within the level and within each lower level are either satisfied or not applicable.

A maturity level for a continuous representation is achieved if the capability level profile is at or above the target profile for all process areas for that maturity level and all lower maturity levels in the equivalent staging, excepting those process areas that are designated as not applicable.

# HIGH MATURITY SKILLS IN THE SCAMPI LEAD APPRAISER BODY OF KNOWLEDGE (SLA BOK)

# What the SLA BOK is

The SCAMPI Lead Appraiser[SM] Body of Knowledge (SLA BOK) is a multi-dimensional view of the competencies and skills needed to be an effective and successful SCAMPI A Lead Appraiser.

- Codifies what Lead Appraisers have been doing
- Intended to document explicitly much that has been implicit for many years

The SLA BOK has recently been published as an SEI technical report (CMU/SEI-2007-TR-019).

# What the SLA BOK is not

The SLA BOK is **not**

- An articulation of detailed CMMI practice requirements (it does not replace the CMMI model)
- A definition of the requirements for conducting a SCAMPI A appraisal (it does not replace the SCAMPI MDD)
- A detailed reference on the theory and concepts underlying High Maturity practices
- A definition of competencies required for process improvement consulting or organizational change management

# SLA BOK Uses

Serves as the foundation for Lead Appraiser certification process

- Selecting competencies that are suitable to measure through a written examination
- Guiding the writing and validating of questions, and supporting the identification of test coverage requirements

In conjunction with the Competency Lifecycle Framework, serves as the basis for integrated Lead Appraiser curriculum and training development

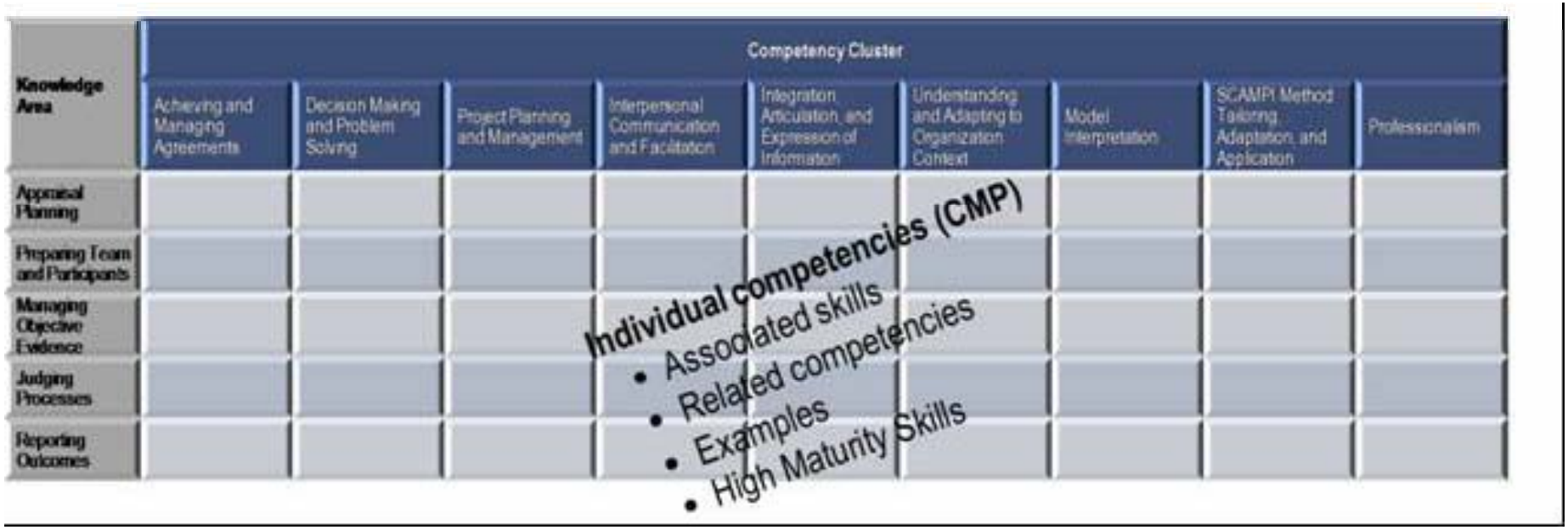
Serves as the basis for updating the Lead Appraiser Observation Worksheet, along with guidelines and criteria for Observations

Individuals may use the SLA BOK to understand what is expected of people who become Lead Appraisers, or to find areas for professional development

# Architecture of the SLA BOK

Horizontal axis shows Nine Competency Clusters.

Vertical axis shows Five Knowledge Areas
(based on MDD activity phases).



# SLA BOK Matrix Fold-Out

The SLA BOK matrix, with all Competency Clusters, Knowledge Areas, and top-level Competencies, has been included as a one-sheet fold-out in appendix B of the Technical Report.

Some statistics

- Of the 45 cells in the matrix, only 1 has no Competencies identified.
- 105 Competencies have been identified.
- Of these, 9 contain high maturity skills.

# The Evolution of High Maturity Skills

With the exception of a few specific skills (mostly related to high maturity model understanding), there are no differences between the competencies needed for high maturity appraisals and the competencies needed for appraisals in general.

- At the SLA BOK workshop: Development began with a separate “Judging High Maturity Processes” Knowledge Area.
- Developer review baseline:  Analysis led to combining the Judging Processes and Judging High Maturity Processes KAs, and resulted in a few stand-alone High Maturity Competencies and some scattered High Maturity Considerations within other Competencies.
- Stakeholder review baseline:  It became clear that every instance of a High Maturity Competency has or should have an ML/CL 2/3 Competency equivalent.
- Final outcome:  All Competencies are applicable; a few have High Maturity Skills.

# Competencies that contain HM Skills

| | |
|---|---|
| CMP 3.2.1 | Selecting appraisal team members |
| CMP 5.5.2 | Delivering appraisal results |
| CMP 6.1.2 | Clarifying the OU's process improvement history |
| CMP 6.1.3 | Understanding the OU's business context and drivers for process improvement |
| CMP 6.2.1 | Identifying and managing language issues |
| CMP 6.4.4 | Recognizing mature organizational behavior |
| CMP 7.2.1 | Preparing appraisal team members for model interpretation |
| CMP 7.4.1 | Evaluating implementations of CMMI practices |
| CMP 8.5.1 | Completing the Appraisal Disclosure Statement (ADS) |

# CMP 3.2.1 Selecting appraisal team members

## High Maturity Skills

Determining when appraisal team members with specialized knowledge and experience are needed to judge high maturity practices

# CMP 5.5.2 Delivering appraisal results

## High Maturity Skills

Explaining results in detail and answering questions on the technical basis for characterizations or ratings of the high maturity practices and goals

# CMP 6.1.2 Clarifying the OU's process improvement history

## High Maturity Skills

Determining CMMI process implementations that may impact appraisal planning including both high maturity practice implementations and other practice implementations

# CMP 6.1.3 Understanding the OU's business context and drivers for process improvement

## High Maturity Skills

Determining the relationship of business goals and concerns to the definition of quantitative targets, the establishment of baselines and models, and the selection of subprocesses to be statistically controlled

# CMP 6.2.1 Identifying and managing language issues

## High Maturity Skills

Preparing appraisal teams to recognize terminology, based on statistical and quantitative methods, that OU's use when describing high maturity activities

# CMP 6.4.4 Recognizing mature organizational behavior

**High Maturity Skills**

Understanding the OU and project behaviors that demonstrate high maturity

Identifying the processes or subprocesses that are being statistically controlled

Understanding the intent of CMMI high maturity practices

Understanding how high maturity concepts are applied appropriately in different contexts

# CMP 7.2.1 Preparing appraisal team members for model interpretation

**High Maturity Skills**

Determining what knowledge is needed for a given appraisal

Clarifying what knowledge is available on the appraisal team

Clarifying high maturity concepts for appraisal team members

Clarifying the difference between quantitative management and statistical management

Explaining why maturity level 3 behavior is required to address the maturity level 4 process areas

Explaining that the maturity level 5 process areas depend on the organization's maturity level 4 quantitative baselines, models, and methods

Addressing common misinterpretations and misconceptions associated with high maturity

Ensuring that all members of the appraisal team have adequate knowledge of high maturity concepts and techniques

# CMP 7.4.1 Evaluating implementations of CMMI practices

**High Maturity Skills**

Understanding the quantitative and statistical management techniques that can be applicable depending on the context

Judging the validity of the application of the selected statistical methods

Evaluating whether statistically managed subprocesses are important in achieving the business goals of the OU

Evaluating whether approaches to establishing quality and process performance objectives meet model expectations

Understanding process performance baselines and their uses

Understanding process performance models and their uses

Evaluating whether causal analysis and resolution techniques meet model expectations

Evaluating whether an OU's process for selection and deployment of incremental and innovative improvements meets model expectations

# CMP 8.5.1 Completing the Appraisal Disclosure Statement (ADS)

## High Maturity Skills

Knowing the information that must be included in the ADS and the final findings related to high maturity appraisals

# STATISTICAL AND QUANTITATIVE THINKING

# What Is High Maturity All About?

High maturity involves the following qualities:

- Statistical and other quantitative methods are used, at the organizational and project levels, to understand past and predict future quality and process performance.
- Organizations establish objectives for quality and process performance based on their business objectives.
- Projects establish their objectives based on those of the organization and the needs of customers and end users.
- Projects and individuals use statistical and quantitative methods in their activities to plan, monitor, and control progress against their objectives.
- Organizations use the resulting information to understand process performance, understand variation, target areas for continuing improvement, and evaluate the impact of proposed improvements.

# Fundamental Axioms of Statistical Thinking

All product development and services are a series of interconnected processes.

All processes are variable.

Understanding variation is the basis for management by fact and systematic improvement:

- understand the past–quantitatively
- control the present–quantitatively
- predict the future–quantitatively

# High Maturity Is Not Management by Rear-View Mirror

Many uses of measurement at maturity level (ML) 1-3 and capability level 1-3 are purely retrospective:

- Do you know where you are (actual vs. plan)?
- Do you know what corrective action to take?

It is difficult to use these types of measurement results to answer the following questions:

- Will you be successful?
- What if you were to do something different?

# High Maturity Is Management with a Navigation System

Measurement is used routinely by those who are proactive:

- Are you confident you know where you are, where you are going, and your performance outcomes (quantitative understanding)?
- Do you understand variation?

Use measurement results to answer the following questions:

- Will you be successful?
- Are your customer's expectations and what you are capable of doing aligned?
- What if you were to do something different?

# Statistical and Quantitative Management

**Statistical management**
Management involving statistical thinking and the correct use of a variety of statistical techniques, such as run charts, control charts, and confidence intervals.

**Quantitative management**
The process of using data from statistical and other techniques to manage the project, enabling you to do the following:

- predict whether the project will be able to achieve its quality and process-performance objectives
- identify what corrective action (if any) should be taken

# Seven Traditional Data Visualization Techniques

The following are used at all levels (1-5) but for high maturity are accompanied by a statistical analysis:

- Scatter diagrams
- Run charts
- Cause-and-effect diagrams
- Histograms
- Bar charts
- Pareto charts

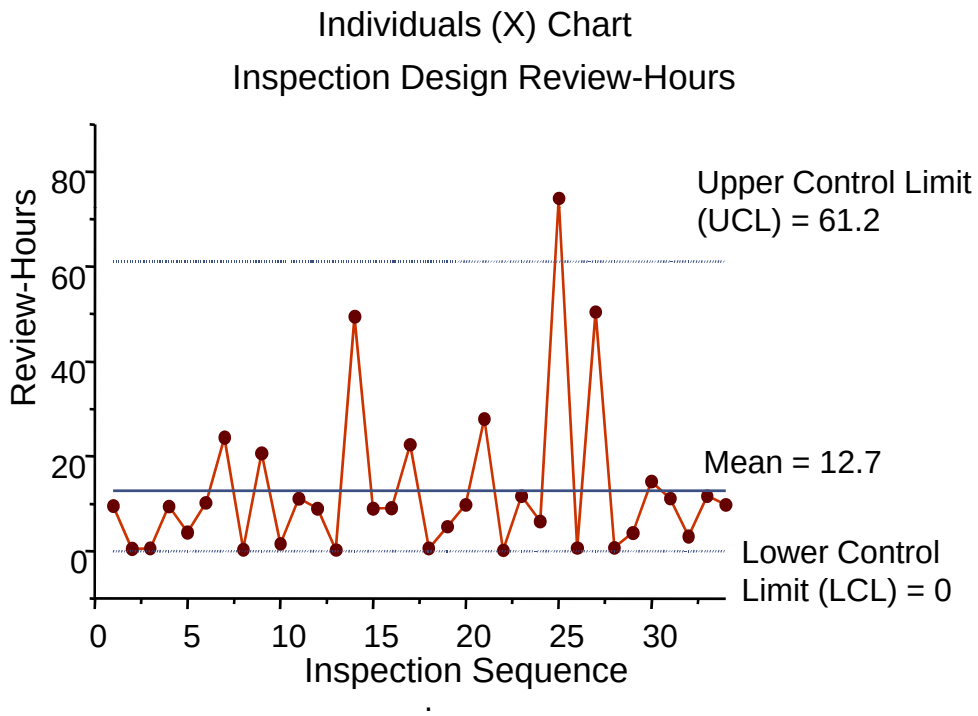
The following involves a statistical analysis:

- Control charts

# Control Charts

Focus attention on detecting and monitoring process variation over time

Distinguish special from common causes of variation



# Understanding Process Behavior

Real process behavior must be understood before making conclusions about the performance of products or services.

Ask these questions to find out about real process behavior:

- What is the normal or inherent process variation?
- What differentiates inherent from anomalous variation?
- What is causing the anomalous variation?

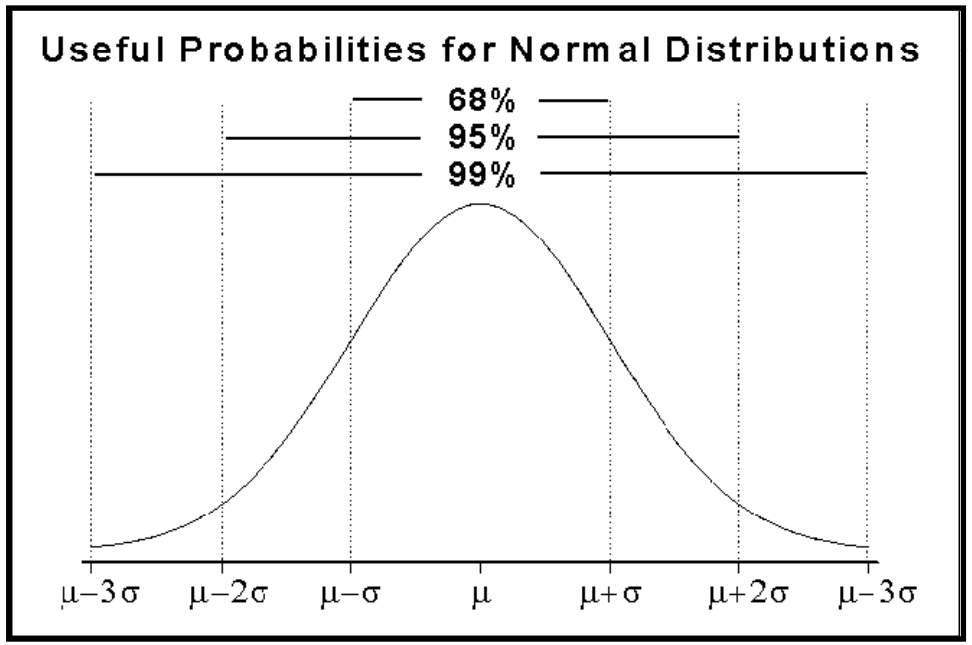
Statistical Process Control provides the methods and tools needed to measure and analyze process behavior, draw conclusions, and drive improvement.

# What Is a Statistic?

A summary or characterization of a distribution (i.e., a set of numbers)

A characterization of a central tendency (e.g., mean, median, and mode)

A characterization of dispersion (e.g., variance, standard deviation, interquartile range, and range)



# Central Tendency and Dispersion

Central tendency implies location:

- middle of a group of values
- balance point
- examples include mean, median, and mode

Dispersion implies spread:

- distance between values
- how much the values tend to differ from one another
- examples include range and (sample) standard deviation

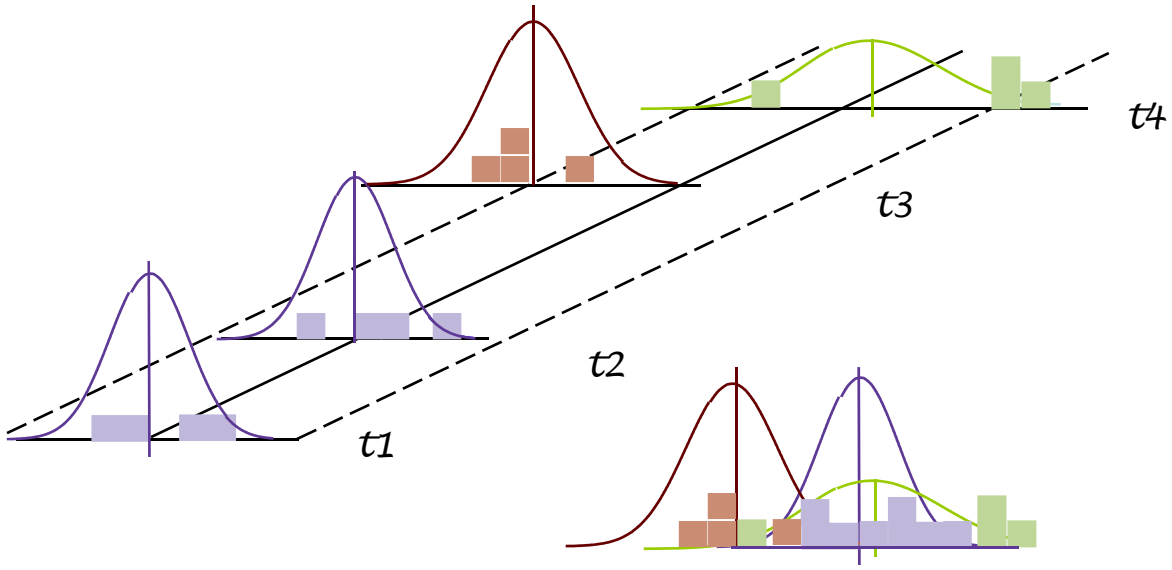
These two are used together to understand the baseline of a process-performance factor and/or outcome.

# Uncontrolled (Unpredictable) Variation

Process behavior measured at times t1, t2, t3, and t4

Not all measurements

- have same central tendency and dispersion
- fall within the same limits

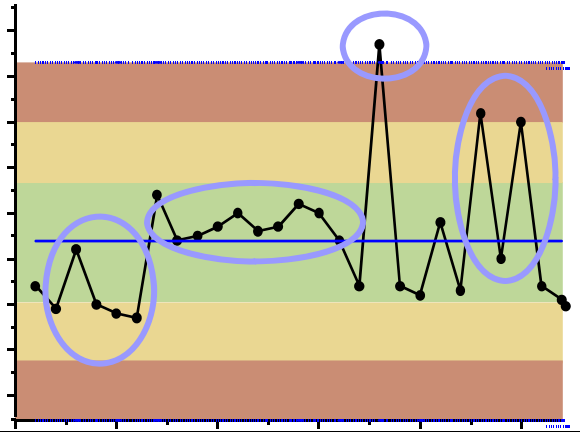


# Anomalous Variation: Special Causes of Process Variation

**Special causes of process variation (aka assignable cause)**
A source of variation that is specific to some circumstance and not an inherent part of a process.

- Is the variation in process performance due to events that are not part of the normal process?
- Does it represent sudden or persistent abnormal changes in one or more of the process components?
- Are there signals that the process may not have behaved as it should have? If so, it is time to understand why not and take corrective action if necessary.

Level 4 covers removal of special causes of process variation.



# Stable Process

The state in which all special causes of process variation have been removed and prevented from recurring so that only the common causes of process variation of the process remain

A process that is in control

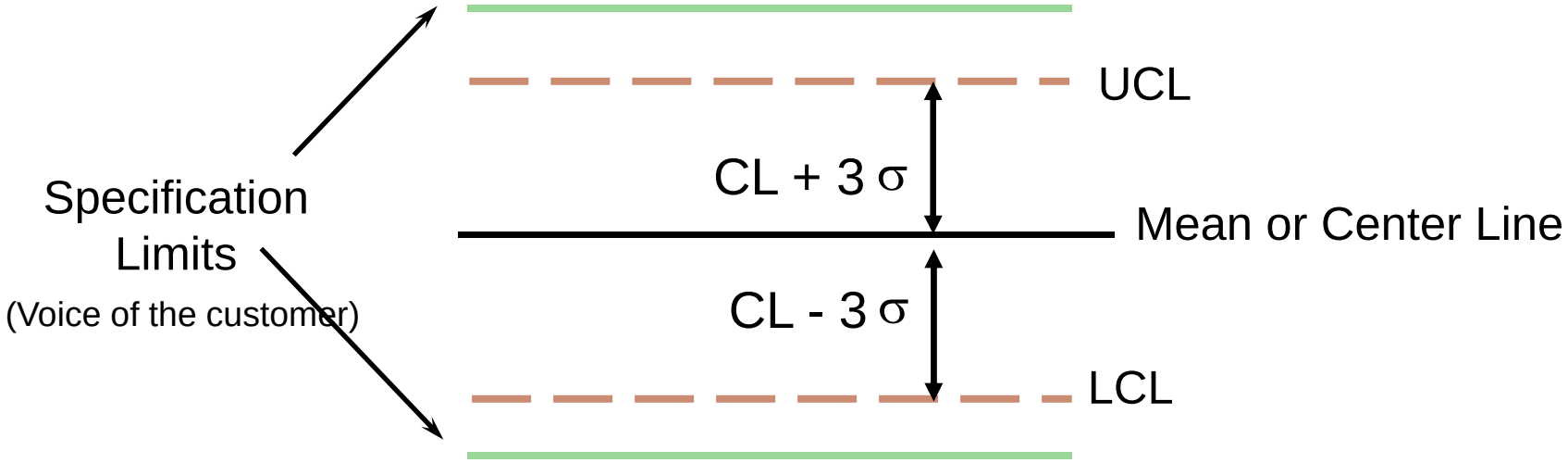
Stability of a process depends on the following:

- sufficient support (e.g., process description, measures, tools, and training) for the process
- faithful execution of the process
- a good fit of the process into its operating context

# Capable Process

A process that can satisfy its specified product quality, service quality, and process-performance objectives

Capable process = stable process + performance within specification limits



# Stability and Capability

**Stability**

Is the process being managed behaving predictably?

Business value: foundation for estimating (predicting) and making commitments

**Capability**

Is the process capable of delivering products that meet requirements?

Does the performance of the process meet the business needs of the organization?

Business value: foundation for making commitments

# Maturity Level 4 in a Nutshell

At maturity level 4, organization and project objectives for quality and process performance are expressed quantitatively.

Performance of key subprocesses is known and used to compose a process to meet organization and project objectives.

Subprocess performance is analyzed in real time to do the following:

- understand status
- detect wrong turns (special causes of process variation) and take timely corrective action
- predict whether objectives can still be achieved

Projects use measurable objectives, process-performance baselines, and process-performance models to meet the needs of customers, end users, and the organization.

Managers and engineers use the data with statistical and other quantitative techniques in managing the processes and results.

# Level 4 Thinking

Level 4 organizations understand what they are capable of doing with assurance and confidence.

Example

Is the organization capable of delivering products that meet requirements and does the performance of the process meet the business needs of the organization?

If a customer would like a feature added in 9 days and you know that in the past year, it took 8-10 days to develop and implement new features in a particular component, you should be able to make a commitment with the understanding that there is some risk of missing this deadline.

This example is level 4 thinking and behavior. You know your limitations, and you make decisions based on data.

# Prerequisites for Maturity Level 5

The following prerequisites exist for ML 5:

- stable processes
- capable processes
- quantitatively managed processes

This foundation allows the organization to be able to react in a disciplined manner to change (e.g., customer, technology, environment, and legal).

# Optimizing our Process

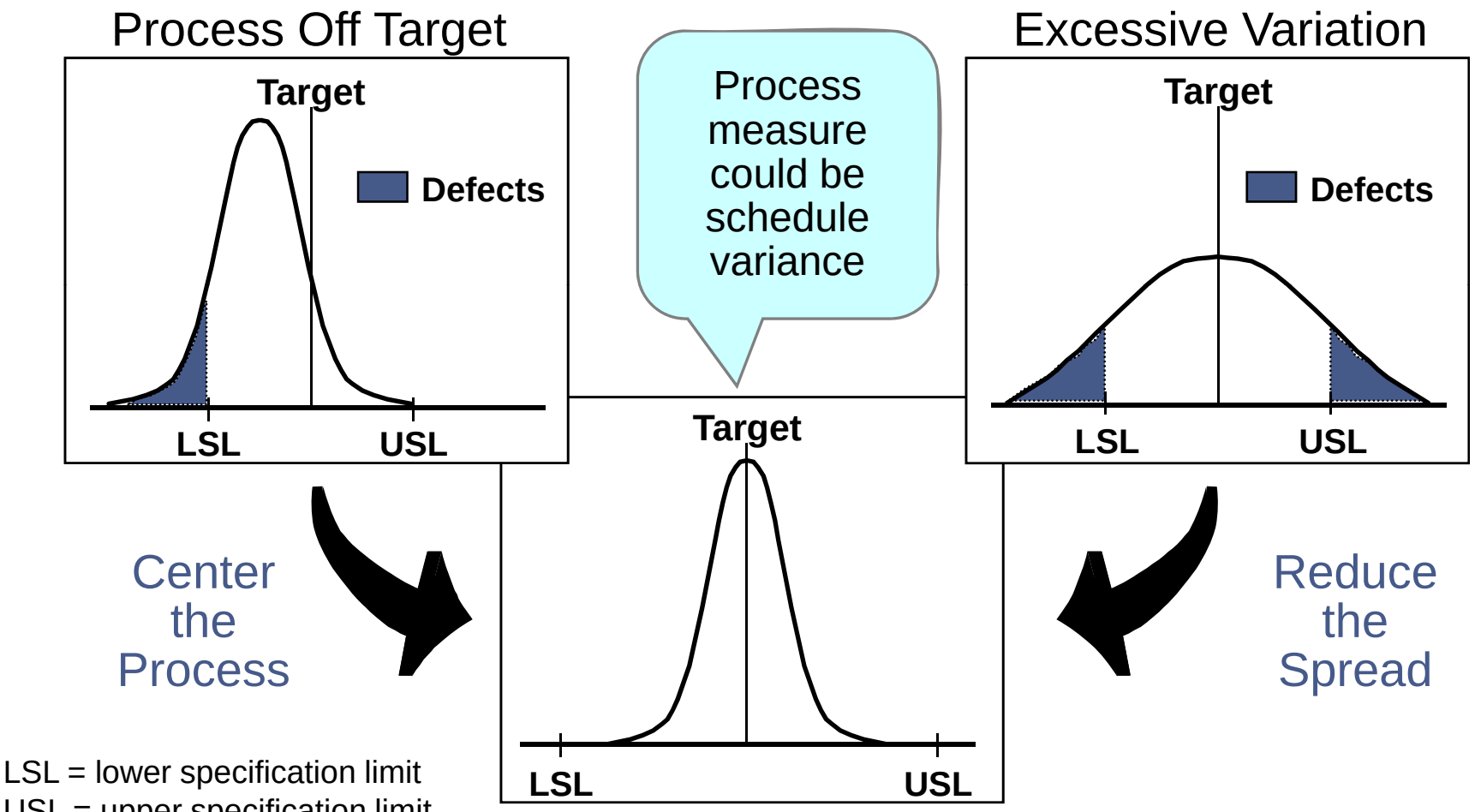
The processes for projects can be optimized in several ways

- Through optimizing the PDP using PPMs
- Optimizing through elimination of defects and problems (CAR)
- Optimizing the process using OID
  - Incremental
  - Innovative

Optimization also occurs at the organization level

- Lessons learned from projects
- OID

# We Improve Performance in Two Ways…



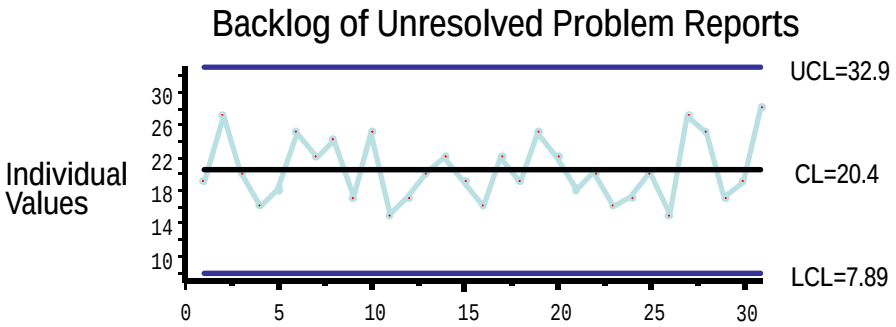

LSL = lower specification limit
USL = upper specification limit

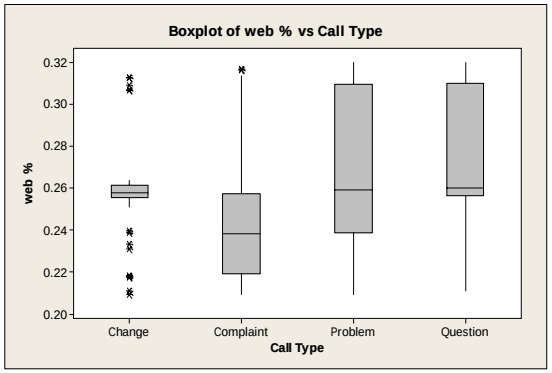
# Common Causes of Variation

Common causes are the sources of variation of a process that exist because of normal and expected interactions among the components of a process (i.e., people, machines, material, environment, and methods).

Common causes represent the noise of the process.

Level 5 addresses common causes of process variation.



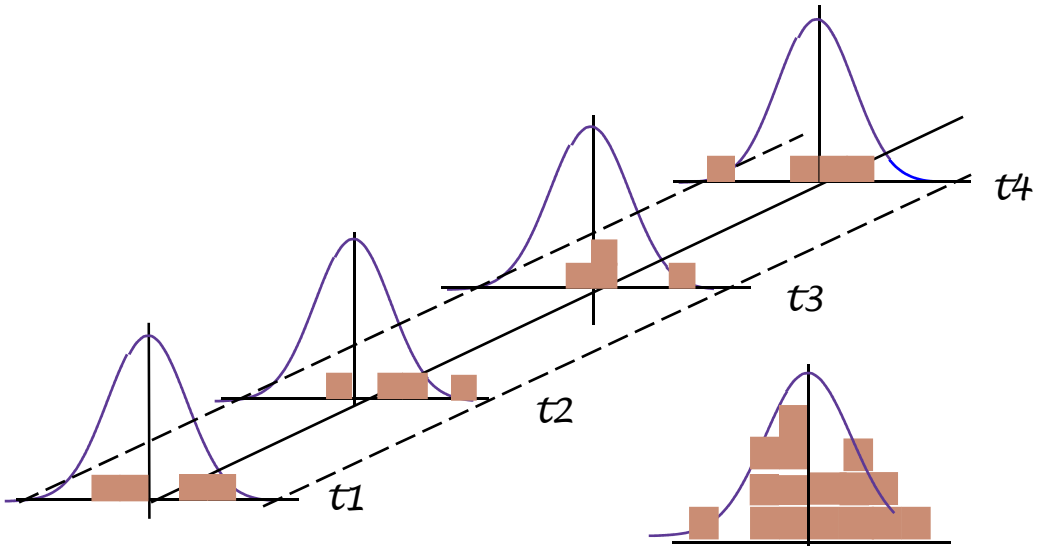



# Controlled (Predictable) Variation

Process behavior measured at times t1, t2, t3, and t4

All measurements

- have same central tendency and dispersion
- fall within the same limits



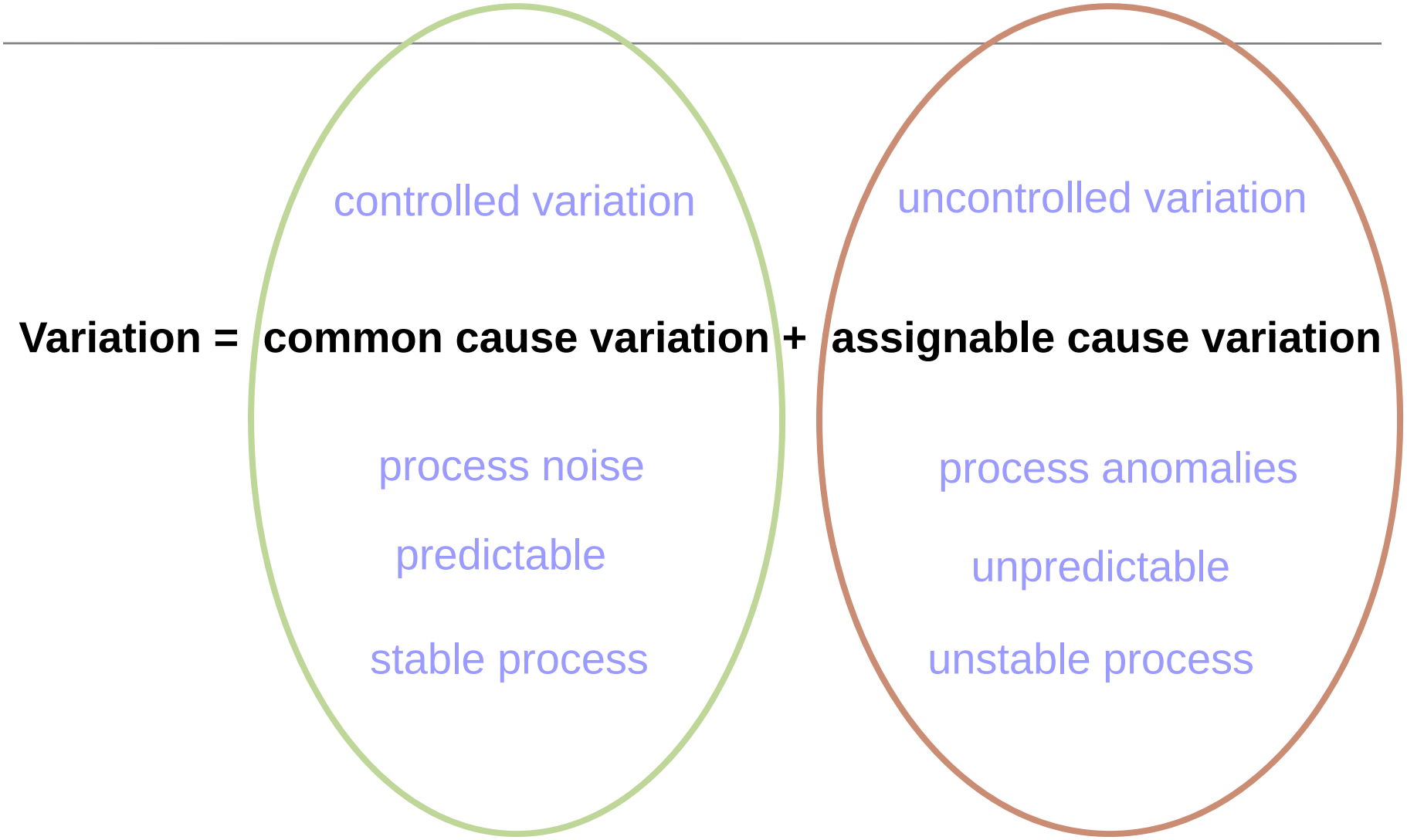

Distribution

# Discussion: Two Sources of Variation

**Common cause variation**
What are some examples in your work ?

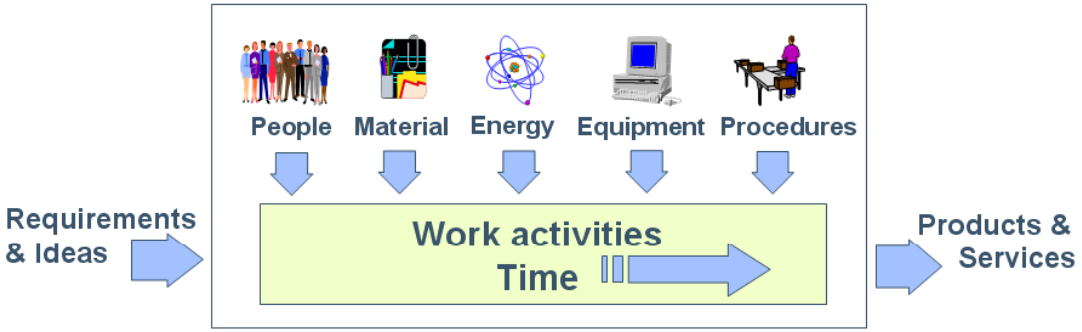
**Assignable cause (special) variation**
What are some examples?

# Synonyms for Variation



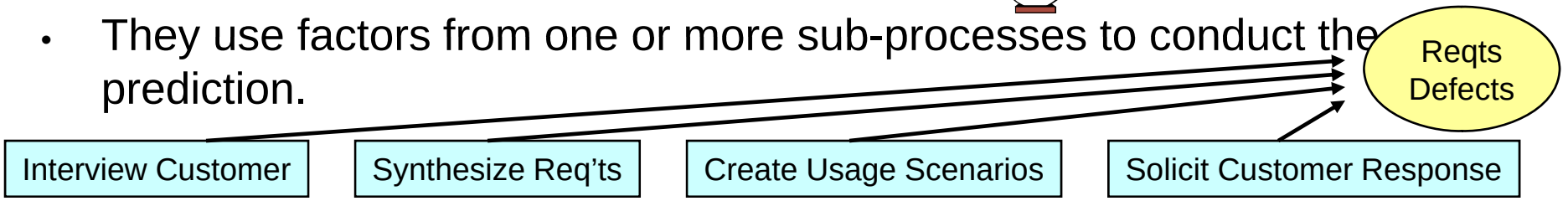
# Essential Ingredients of Process Performance Models -1

- They relate the behavior or circumstance of a process or sub-process to an outcome.




- They predict future outcomes based on possible or actual changes to factors (e.g. support “what-if” analysis).

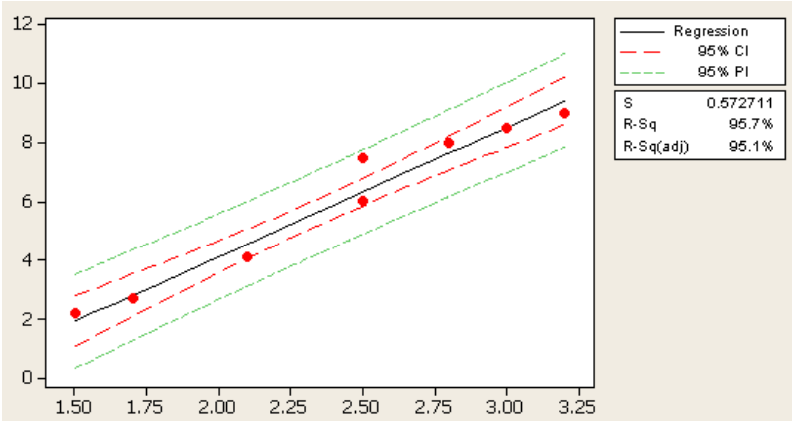
- They use factors from one or more sub-processes to conduct the prediction.



# Essential Ingredients of Process Performance Models -2

- **The factors used are preferably controllable** so that projects may take action to influence outcomes.

- **They are statistical or probabilistic** in nature rather than deterministic (e.g. they account for variation in a similar way that QPM statistically accounts for variation; they model uncertainty in the factors and predict the uncertainty or range of values in the outcome).



# Essential Ingredients of Process Performance Models -3

- High maturity organizations generally possess **a collection of process-performance models** that go beyond predicting cost and schedule variance, based on Earned Value measures, to include other performance outcomes.

Quality

Productivity

Escaped Defects

Interim & Final Outcomes

Process Effectiveness

Cycle Time

Customer Satisfaction

- Specifically, the models predict quality and performance outcomes **from factors related to one or more sub-processes** involved in the development, maintenance, service, or acquisition processes.

Root causes of outcomes

Factors correlated with outcomes

Leading Indicators of outcomes

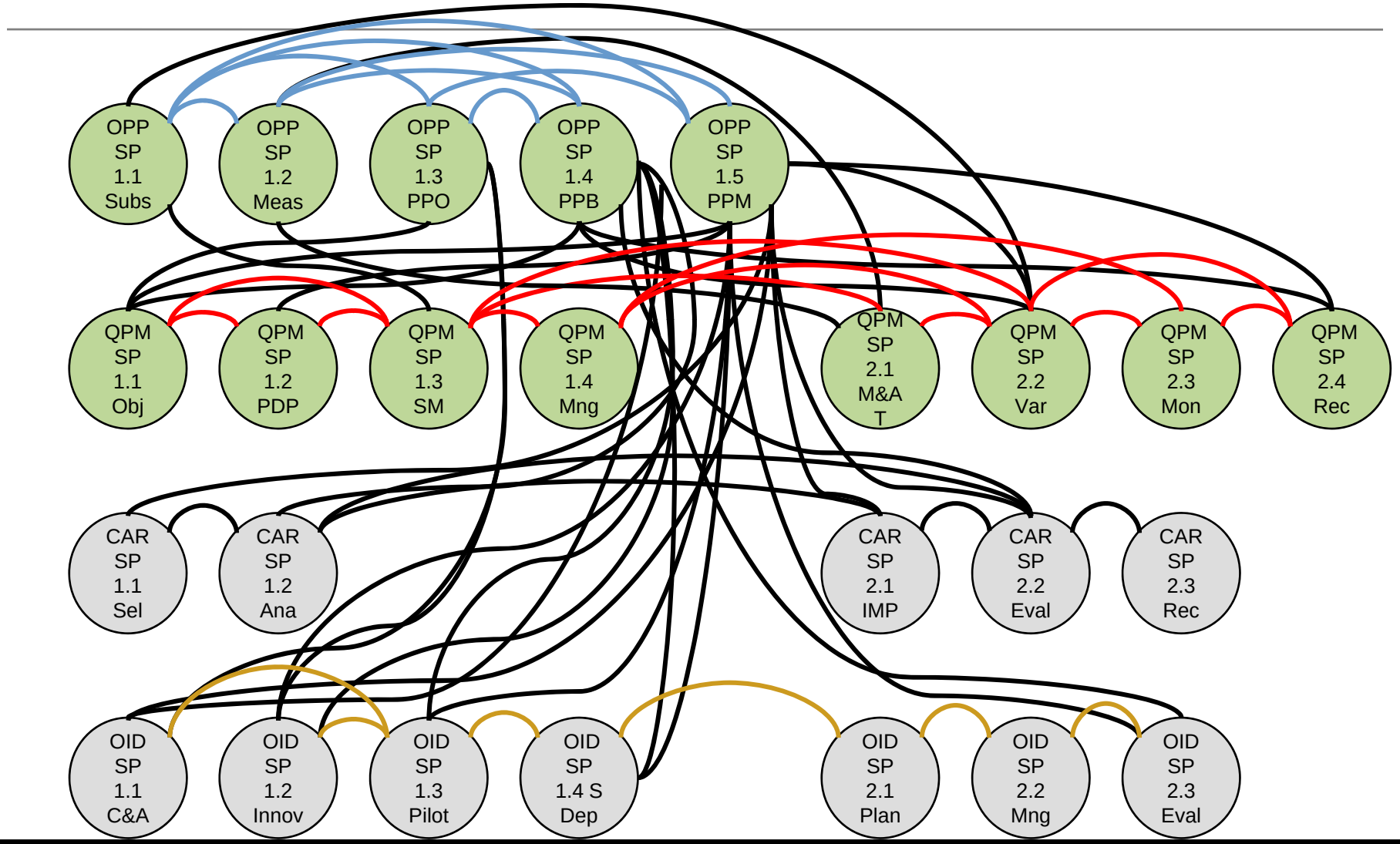
# CMMI is a Set of Interrelated Practices

Interrelationships are key to understanding levels 4 and 5.

- These interrelationships are not always obvious.
- By understanding these interrelationships, the richness of levels 4 and 5 becomes evident.
- The interrelationships become evident in the informative material – read it!

You cannot abandon your lower level practices as you become more mature—you need to evolve them and incorporate them.

# You Cannot Understand Levels 4 and 5 One Practice at a Time



# Informative Material

When implementing CMMI level 4-5 practices in an organization and when appraising an organization against the CMMI practices at levels 4-5, special attention must be given to the informative material at these levels in a CMMI model.

The model material at these levels is quite dense in concepts and terminology.

The informative material at levels 4-5, therefore, takes on a critical role in explaining the following:

- intent of the practice
- outputs of the practice
- implementation of the practice (in particular, the statistical analyses to be performed)
- the practice's dependencies with other parts of the model

For more information, see http://www.sei.cmu.edu/cmmi/adoption/cmmilevels45.html.

# MDD on Use of Informative Material and Subpractices -1

The MDD states on page I-20

- "Appraisal teams compare the objective evidence collected against the corresponding practices in the appraisal reference model. In making inferences about the extent to which practices are or are not implemented, appraisal teams draw on the entire model document to understand the intent of the model, and use it as the basis for their decisions. This comparison includes the required and expected model components (i.e., generic and specific goals, generic and specific practices) as well as informative material, such as model front matter, introductory text, glossary definitions, and subpractices."

# MDD on Use of Informative Material and Subpractices -2

Additionally on page I-24 in discussing direct artifacts for PIIs

- "The tangible outputs resulting directly from implementation of a specific or generic practice. An integral part of verifying practice implementation. May be explicitly stated or implied by the practice statement or associated informative material."

And from page II-110

- "The use of informative material in the appraisal reference model to form a checklist is explicitly discouraged."

And from page III-50 the glossary definition for direct artifact

- “The tangible outputs resulting directly from implementation of a specific or generic practice. An integral part of verifying practice implementation. May be explicitly stated or implied by the practice statement or associated informative material. "

# Prerequisites for High Maturity Practices

Before an organization can perform high maturity activities, it has the following in place:

- the capability to gather and use data at all organizational levels, i.e., project members who
  - gather data on their own work
  - understand and use the data in planning and performing their work
- project-defined processes that specify how and when data are gathered
- execution of the defined process consistently, where tailoring is handled in a controlled and disciplined fashion

# Legend Used for Implementation Examples

Text in the yellow boxes is an example description of implementing the practice consistent with the glossary, using the standard English meaning of words instead of the statistical meaning, and without using the informative material. For example, interpreting variation to mean the difference between two items.

Text in the green boxes is an example description of implementing the practice consistent with the glossary, the statistical meaning of words, and accounting for the informative material. For example, interpreting variation (in the level 4 & 5 practices) to mean central tendency and dispersion.

Note: The examples in yellow boxes are meant to be superficial implementations of a practice and the examples in green boxes are meant to be one way and not the only way to implement a practice.

# Glossary Use

"The CMMI glossary of terms is not a required, expected, or informative component of CMMI models. You should interpret the terms in the glossary in the context of the model component in which they appear".

"We developed the glossary recognizing the importance of using terminology that all model users can understand. We also recognized that words and terms can have different meanings in different contexts and environments. The glossary in CMMI models is designed to document the meanings of words and terms that should have the widest use and understanding by users of CMMI products."

# ORGANIZATIONAL PROCESS PERFORMANCE (OPP)

# Embedded Glossary Terms for OPP (1)

process performance

- A measure of the actual results achieved by following a process. It is characterized by both process measures (e.g., effort, cycle time, and defect removal efficiency) and product measures (e.g., reliability, defect density, and response time).

process-performance baseline

- A documented characterization of the actual results achieved by following a process, which is used as a benchmark for comparing actual process performance against expected process performance. (See also “process performance.”)

# Embedded Glossary Terms for OPP (2)

process-performance model

- A description of the relationships among attributes of a process and its work products that are developed from historical process-performance data and calibrated using collected process and product measures from the project and that are used to predict results to be achieved by following a process.

quality- and process-performance objectives

- Objectives and requirements for product quality, service quality, and process performance. Process-performance objectives include quality; however, to emphasize the importance of quality in the CMMI Product Suite, the phrase *quality- and process-performance* objectives is used rather than just *process-performance objectives*.

# OPP SP 1.1 Select Processes

Select the processes or subprocesses in the organization's set of standard processes that are to be included in the organization's process-performance analyses.

Pick a few processes from the OSSP for which we have measures.

Select processes/subprocesses that will help us understand our ability to meet the objectives of the organization and projects, and the need to understand quality and process performance. These subprocesses will typically be the major contributors and/or their measures will be the leading indicators.

# OPP SP 1.2 Establish Process-Performance Measures

Establish and maintain definitions of the measures that are to be included in the organization's process-performance analyses.

Provide definitions for the measures and update as necessary.

Select measures, analyses, and procedures that provide insight into the organization's ability to meet its objectives and into the organization's quality and process performance. Create/update clear unambiguous operational definitions for the selected measures. Revise and update the set of measures, analyses, and procedures as warranted. In usage, be sensitive to measurement error. The set of measures may provide coverage of the entire lifecycle and be controllable.

# OPP SP 1.3 Establish Quality and Process-Performance Objectives

Establish and maintain quantitative objectives for quality and process performance for the organization.

Write down quality and process performance objectives such as improve cycle time, quality, and the percent of improvement we want.

These objectives will be derived from the organization's business objectives and will typically be specific to the organization, group, or function. These objectives will take into account what is realistically achievable based upon a quantitative understanding (knowledge of variation) of the organization's historic quality and process performance. Typically they will be SMART and revised as needed.

# OPP SP 1.4 Establish Process-Performance Baselines

Establish and maintain the organization's process-performance baselines.

Store measures in our spreadsheet repository on a periodic basis indicating the end date of the period they represent and baseline them in our CM system.

Baselines will be established by analyzing the distribution of the data to establish the central tendency and dispersion that characterize the expected performance and variation for the selected process/subprocess. These baselines may be established for single processes, for a sequence of processes, etc. When baselines are created based on data from unstable processes, it should be clearly documented so the consumers of the data will have insight into the risk of using the baseline. Tailoring may affect comparability between baselines.

# OPP SP 1.5 Establish Process-Performance Models

Establish and maintain the process-performance models for the organization's set of standard processes.

We have historical productivity and defect injection/detection rates by phase which we update periodically and include in reports.

Rather than just a point estimate, PPMs will address variation in the prediction. PPMs will model the interrelationships between subprocesses including controllable/uncontrollable factors. They enable predicting the effects on downstream processes based on current results. They enable modeling of a PDP to predict if the project can meet its objectives and evaluate various alternative PDP compositions. They can predict the effects of corrective actions and process changes. They can also be used to evaluate the effects of new processes and technologies/innovations in the OSSP.

# OPP SG 1 Establish Performance Baselines and Models

Baselines and models, which characterize the expected process performance of the organization's set of standard processes, are established and maintained.

The aforementioned data and models characterize OSSP performance.

Central tendency and variation are the cornerstones of our implementation. Our baselines and models incorporate our understanding of these, allow us to understand risks in our organizations and its projects, and allow us to create and execute effective strategies to mitigate and manage risks.

# You Might Have Misunderstood OPP If…

A table showing projected defects by phase looks like a Process Performance Model to you…

The corporate average “Lines of Code Per Staff Day” by year looks like a Process Performance Baseline or a Process Performance Model to you…

A control chart used to ‘manage’ defects escaping into the field looks like a Process Performance Model to you…

An Earned Value Management System seems to fulfill the requirements of Maturity Level 4…

# QUANTITATIVE PROJECT MANAGEMENT (QPM)

# Embedded Glossary Terms for QPM (1)

capable process

- A process that can satisfy its specified product quality, service quality, and process-performance objectives. (See also “stable process,” “standard process,” and “statistically managed process.”)

common cause of process variation

- The variation of a process that exists because of normal and expected interactions among the components of a process. (See also “special cause of process variation.”)

quantitatively managed process

- A defined process that is controlled using statistical and other quantitative techniques. The product, quality, service quality, and process-performance attributes are measurable and controlled throughout the project. (See also “defined process,” “optimizing process,” and “statistically managed process.”)

# Embedded Glossary Terms for QPM (2)

special cause of process variation

- A cause of a defect that is specific to some transient circumstance and not an inherent part of a process. (See also “common cause of process variation.”)

stable process

- The state in which all special causes of process variation have been removed and prevented from recurring so that only the common causes of process variation of the process remain. (See also “capable process,” “common cause of process variation,” “special cause of process variation,” “standard process,” and “statistically managed process.”)

# Embedded Glossary Terms for QPM (3)

statistical process control

- Statistically based analysis of a process and measurements of process performance, which will identify common and special causes of variation in the process performance and maintain process performance within limits. (See also “common cause of process variation,” “special cause of process variation,” and “statistically managed process.”)

statistically managed process

- A process that is managed by a statistically based technique in which processes are analyzed, special causes of process variation are identified, and performance is contained within well-defined limits. (See also “capable process,” special cause of process variation,” “stable process,” “standard process,” and “statistical process control.”)

# QPM SP 1.1 Establish the Project's Objectives

Establish and maintain the project's quality and process-performance objectives.

Project Manager documents project objectives such as "Produce the system better, cheaper, faster" in the project plan.

These objectives will be based on the organization's quality and process performance objectives and any additional customer and relevant stakeholder needs and objectives. These objectives will be realistic (based upon analysis of historical quality and process performance) and will cover interim, supplier, and end-state objectives. Conflicts between objectives (i.e., trade-offs between cost, quality, and time-to-market) will be resolved with relevant stakeholders. Typically they will be SMART, traceable to their source, and revised as needed.

# QPM SP 1.2 Compose the Defined Process

Select the subprocesses that compose the project's defined process based on historical stability and capability data.

Look at our data spreadsheets to select the subprocesses that have the highest performance, best quality, and most stability -- the ones that have changed the least.

The PDP is composed by:

- selecting subprocesses
- adjusting/trading-off the level and depth of intensity of application of the subprocess(es) and/or resources

to best meet the quality and process performance objectives. This can be accomplished by modeling/simulating the candidate PDP(s) to predict if they will achieve the objectives, and the confidence level of (or risk of not) achieving the objective.

# QPM SP 1.3 Select the Subprocesses that Will Be Statistically Managed

Select the subprocesses of the project's defined process that will be statistically managed.

Select the subprocesses that we must already measure.

Subprocesses that are the major contributors to or predictors of the accomplishment of the project's interim or end-state objectives will be selected. Additionally, these need to be suitable for statistical management. Statistically managing the selected subprocesses provides valuable insight into performance by helping the project identify when corrective action is needed to achieve its objectives. Select the attributes that will measured and controlled.

# QPM SP 1.4 Manage Project Performance

Monitor the project to determine whether the project's objectives for quality and process performance will be satisfied, and identify corrective action as appropriate.

Compare the actual versus estimated and corresponding actual trend versus estimated trend. If we're not meeting our objectives or based on the actual trend it looks like we won't achieve our objectives in the future, document what we might do to fix the shortcoming/potential shortcoming.

Monitor the project

- Manage stability and capability of selected subprocesses.
- Track quality and process performance data including suppliers'
- Update/calibrate PPMs and predictions based on results to date.
- Identify deficiencies/risks to achieving objectives (e.g., where current performance is outside tolerance intervals, or prediction/confidence intervals are not contained within specification limits).

# QPM SG 1 Quantitatively Manage the Project

The project is quantitatively managed using quality and process-performance objectives.

Project processes are managed against objectives using the standard data and statistical management spreadsheets*.

* Explained in QPM goal 2

Projects are managed through the use of:

- measuring and controlling quality and process performance attributes.
- statistical techniques to ensure stable and capable subprocesses
- PPMs to predict if objectives will be met based on current performance
- spec limits to indicate when the performance of current processes will adversely affect the project's ability to meet its objectives

# QPM SP 2.1 Select Measures and Analytic Techniques

Select the measures and analytic techniques to be used in statistically managing the selected subprocesses.

Select effort, size, and defects (estimated and actual for each) and use trend charts to analyze them and investigate spikes that appear to be unusually large as special causes.

Identify the measures that will provide insight into the performance of the subprocesses selected for statistical management and the statistical techniques that will be used for analysis. These measures can be for both controllable and uncontrollable factors. Operational definitions will be created/updated for these measures. Where appropriate (i.e., they are critical to meeting downstream objectives), spec limits will be established for the measures.

# QPM SP 2.2 Apply Statistical Methods to Understand Variation

Establish and maintain an understanding of the variation of the selected subprocesses using the selected measures and analytic techniques.

For each subprocess measure, compare the actual to the estimated (using trends) to understand how much variation there is between what we expected and what we are actually getting.

Selected measures for the subprocesses will be statistically controlled to identify, remove, and prevent reoccurrence of special causes of variation, or in other words, stabilize the process. When control limits are too wide, sources of variation are easily masked and further investigation is warranted.

# QPM SP 2.3 Monitor Performance of the Selected Subprocesses

Monitor the performance of the selected subprocesses to determine their capability to satisfy their quality and process-performance objectives, and identify corrective action as necessary.

Compare the actual versus estimated and corresponding actual trend versus estimated trend. If we're not meeting our objectives or based on the actual trend it looks like we won't achieve our objectives in the future, document what we might do to fix the shortcoming/potential shortcoming.

For a stable subprocess, determine if the control limits (natural bounds) are within the specification limits which indicates a capable subprocess. If it is not, document corrective actions that address the capability deficiencies.

# QPM SP 2.4 Record Statistical Management Data

Record statistical and quality management data in the organization's measurement repository.

Put the data in our statistical management spreadsheet.

Record the data along with sufficient information to understand the context for the data and thus make the data usable by the organization and other projects.

# QPM SG 2 Statistically Manage Subprocess Performance

The performance of selected subprocesses within the project's defined process is statistically managed.

Systemization of our process is achieved through planning and execution of the plans.

Selected subprocesses are statistically managed to ensure stability and capability (i.e., special causes of variation are identified, removed, and prevented from recurring and the control limits of the subprocess are kept within the specification limits).

# You Might Have Misunderstood QPM If…

"Tracking bugs across the lifecycle" looks like statistical management to you…

You plan to "re-baseline" the control limits used to manage critical subprocesses on a quarterly basis…

'Management judgment' is used to 'adjust' control limits used as thresholds to drive corrective actions…

Schedule variance and defect density look like perfectly good subprocesses to statistically manage…

# CAUSAL ANALYSIS AND RESOLUTION (CAR)

# Embedded Glossary Terms for CAR

Causal analysis

- The analysis of defects to determine their cause.

# CAR SP 1.1 Select Defect Data for Analysis

Select the defects and other problems for analysis.

Select first ten defects/problems on the list

Defects and other problems are selected for further analysis based on factors such as clustering and analysis of the clusters of similar defects or problems including impact to the project's objectives, predicted ROI, etc. PPMs may be used in the prediction of impact, calculation of cost and benefits, ROI, etc.

# CAR SP 1.2 Analyze Causes

Perform causal analysis of selected defects and other problems and propose actions to address them.

Perform causal analyses on the selected defects and problems using Fishbone diagrams. The analysis is qualitatively driven. Propose actions to address the identified causes.

The causal analysis can include:
- analysis of PPBs and PPMs to help identify potential sources of defects and problems
- causal analysis meetings with the involved parties
- formal root cause analysis.

The analysis is both quantitative and qualitative.
Actions are proposed to not only address the defect/problem but also to correct the root cause and prevent reoccurrence.

# CAR SG 1 Determine Causes of Defects

Root causes of defects and other problems are systematically determined.

Systemization of our process is achieved through planning and execution of the plans.

Processes, plans and methods are used to identify the root cause(s) of defects and other problems and identify the actions necessary to fix and prevent future occurrences.

# CAR SP 2.1 Implement the Action Proposals

Implement the selected action proposals that were developed in causal analysis.

Execute proposed actions.

Prioritize the actions based on factors such as impact, ROI, availability of resources/budget, interdependencies, etc. Implement the actions. Additionally, identify and remove similar defects and other problems that may exist in other processes and work products. Where appropriate, submit proposals to improve the OSSP.

# CAR SP 2.2 Evaluate the Effect of Changes

Evaluate the effect of changes on process performance.

Did process performance go up/down (e.g., more/less productivity, less/more defects).

Measure and analyze the change to determine if process performance has been positively affected and there are no harmful side-effects. This may involve hypothesis testing using a before and after PPBs to determine if the change is statistically significant. May also involve comparing the change to the PPM predicted change to see if the predicted performance benefits were achieved. Further analysis may use a PPM to determine if the change will positively contribute to meeting downstream quality and process performance objectives.

# CAR SP 2.3 Record Data

Record causal analysis and resolution data for use across the project and organization.

Put the data in our spreadsheet.

Record the data along with sufficient information to understand the context for the data. Data related to project adoption experience and other data that will assist deployment in other parts of the organization should be collected.

# CAR SG 2 Address Causes of Defects

Root causes of defects and other problems are systematically addressed to prevent their future occurrence.

Systemization of our process is achieved through planning and execution of the plans.

The changes are made and measures taken and analyzed to determine if the changes are positive and statistically significant. Similar processes and work products are also modified and sufficient data is recorded to understand the context and assist other projects. When appropriate, proposals are submitted to the organization to improve the OSSP.

# You Might Have Misunderstood CAR If…

You always respond to “High Severity” defects by saying “Let’s run a causal analysis and see what’s going on”…

Causal analysis is used only to find and resolve the root cause of defects…

You don’t see the value of applying DAR to select when and how to apply CAR…

You don’t see the value of applying CAR to select when, what and how to apply OID…

You don’t see how Process Performance Models and Process Performance Baselines contribute to CAR…

# ORGANAZATIONAL INNOVATION AND DEPLOYMENT (OID)

# OID SP 1.1 Collect and Analyze Improvement Proposals

Collect and analyze process- and technology-improvement proposals

Put the process and technology improvement proposals in a spreadsheet, think about each one, and tag with a plus if you think it will improve or a minus if you think it will decrease quality and process performance.

Collect improvement proposals and analyze for costs, benefits, and risks. Select those that will be piloted. Document the results of analyses and selection. PPMs may be used to predict effects of the change to the process, the potential benefits, evaluate side effects, and evaluate the effects of multiple interrelated improvement proposals.

# OID SP 1.2 Identify and Analyze Innovations

Identify and analyze innovative improvements that could increase the organization's quality and process performance.

Identify improvements that seem to be "out of the box" and look like they will increase quality and process performance.

Actively seek, both inside and outside the organization, innovations to improve processes and product technologies and analyze them for possible inclusion, predicting cost and benefits (using PPMs). Use PPMs and PPBs to analyze the OSSP and identify areas or targets of opportunity for change. Submit improvement proposals for changes that are predicted to be beneficial. Select those to be piloted.

# OID SP 1.3 Pilot Improvements

Pilot process and technology improvements to select which ones to implement.

Try the improvements or use someone else's results and see which ones might be selected.

Plan the pilot including documenting the criteria for evaluating the success or failure of the pilot. Select pilot environments that are representative of the typical use of the improved process and/or technology. Evaluate the results using the documented criteria. This will typically involve the use of PPMs to see if the processes behaved as predicted and PPBs to see it the change is statistically significant (through the use of hypothesis testing).

# OID SP 1.4 Select Improvements for Deployment

Select process and technology improvements for deployment across the organization.

Pick the improvements to be deployed across the organization.

Prioritize the improvements for deployment (typically involves evaluating the predicted ROI from PPMs and other factors such as availability of resources, impact, etc.) and begin to determine a deployment strategy.

# OID SG 1 Select Improvements

Process and technology improvements, which contribute to meeting quality and process-performance objectives, are selected.

Improvements that appear to help us meet our goals are selected.

The improvements which will contribute most to achieving the organizations objectives, provide the best ROI and most desirable impact, and can be accomplished with available resources will be chosen.

# OID SP 2.1 Plan the Deployment

Establish and maintain the plans for deploying the selected process and technology improvements.

Schedule the deployment of the improvements and update the schedule as necessary.

Determine modifications necessary for deploying the new/revised process to the projects' environments. Define how the value of the deployed process/technology improvements will be measured. Determine the deployment risks. Devise a plan for the deployment, get commitment from stakeholders, and revise as necessary.

# OID SP 2.2 Manage the Deployment

Manage the deployment of the selected process and technology improvements.

Track against the schedule and reschedule as necessary.

Monitor the deployment against the plan and determine that the deployed processes have not adversely affected the ability to meet quality and process performance objectives. Update the appropriate PPMs and PPBs.

# OID SP 2.3 Measure Improvement Effects

Measure the effects of the deployed process and technology improvements.

Measure whether people like the change.

Measure the cost and value of the improvement in the deployed process. Through the use of PPMs determine if the predicted performance is being achieved. Use hypothesis testing or other statistical/probabilistic techniques of the before and after PPBs to determine if the improvement is statistically significant.

# OID SG 2 Deploy Improvements

Measurable improvements to the organization's processes and technologies are continually and systematically deployed.

Measured improvements that help are adopted according to our approved plans.

We have ensured through measurements and analyses that the deployed processes have indeed been systematically and continually improved in a statistically significant way.

# You Might Have Misunderstood OID If…

You think 42 Six Sigma projects – all focused on the inspection process – make a company Maturity Level 5…

A 5% boost in the performance of a process that fluctuates by ±7% looks like a best practice to roll out immediately…

The strength of an improvement proposal can only be measured by the persuasiveness of the author…

You work-off improvement proposals only in the order in which they were received…

You don't see how Process Performance Models and Process Performance Baselines contribute to OID…

# Capability Evolution of Measurement via Generic Practices

| Generic Practice | Focus |
|---|---|
| **2.8 Monitor and control the process** | Monitor and control the process against the plan for performing the process and take appropriate corrective action |
| **3.2 Collect improvement information** | Collect work products, measures, measurement results, and improvement information derived from planning and performing the process to support the future use and improvement of the organization's processes and process assets |
| **4.1 Establish quality objectives** | Establish and maintain quantitative objectives for the process about quality and process performance based on customer needs and business objectives |
| **4.2 Stabilize sub-process performance** | Stabilize the performance of one or more subprocesses to determine the ability of the process to achieve the established quantitative quality and process performance objectives |
| **5.1 Ensure continuous process improvement** | Ensure continuous improvement of the process in fulfilling the relevant business objectives of the organization |
| **5.2 Correct root causes of problems** | Identify and correct the root causes of defects and other problems in the process |

# Summary

High maturity organizations do the following:

- gather and use data at all levels of the organization
- provide insight into the operation of an organization and its processes based on data and statistical analyses
- use statistical and other quantitative methods at the organizational, project, and subprocess levels, to do the following:
  - understand past quality and process performance
  - target areas for improvement and evaluate the impact of proposed improvements
  - predict future quality and process performance
- focus on innovation and learning to be more competitive

# If You Want to Lean More About High Maturity

There are many good courses on statistical analysis.

In particular, the SEI offers the following courses:

- Understanding CMMI High Maturity Practices
- Improving Process Performance Using Six Sigma
- Designing Products and Processes Using Six Sigma

# Useful CMMI-related Internet sites

Software Engineering Information Repository (SEIR)
https://seir.sei.cmu.edu/seir/

Public area of the BSCW Shared Workspace Server
https://bscw.sei.cmu.edu/

CMMI Process Improvement Discussion Group on yahoo
http://tech.groups.yahoo.com/group/cmmi_process_improvement/

# General SEI Information

SEI Customer Relations +1 (412) 268-5800, +1 (412) 268-5758 - fax

Email Address: customer-relations@sei.cmu.edu

Mailing Address:

Customer Relations

Software Engineering Institute, Carnegie Mellon University

4500 Fifth Avenue, Pittsburgh, PA 15213-3890

External internet site: http://www.sei.cmu.edu

cmmi-comments@sei.cmu.edu – CMMI model suite related questions or comments

scampi-quality@sei.cmu.edu – SCAMPI quality issues or questions

# Contact Information

Steve Masters

- Phone: +1 (412) 268-9085
- E-mail: smm@sei.cmu.edu