BaiGuo ML4 Journey

Tim Kasse
Kasse Initiatives LLC
+1 817 576 3142 USA
+45 (0) 72 19 42 18 Europe
+1 303 275 3285 NREL

Edmond Sung
Processis LTD
+852 34234676 Hong Kong
+86 (0)510 85189677 China
How a focus on high maturity CMMI-based process improvement can add value to the organization even when there are only limited resources
Presentation Topics

- BAI GUO Background and Culture
- BAI GUO Process Improvement Methodology
- GQ(I)M method used to align business goals to indicators and metrics
- Data Analysis Interpretation
- Developing and Evolving the Prediction Model
- Project Managers and Quantitative Project Management
- QPM Story
- Summary of Six Sigma Techniques Used
- Lessons Learned

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BAI GUO Background and Culture
Sponsorship for CMMI-DEV Class A ML 4 Appraisal
BaiGuo Info-Tech Co. Ltd is a high-tech enterprise professional on automation of health care in Shanghai.

30% of leading staff in R&D department have been working on medicine information industry and long-distance info processing industry for more than 10 years in America.

International advanced CMMI quality management model was chosen to be applied to assure high quality products and services.
Culture

- Senior Management and other key members of the organization had a CMMI-based process improvement background from other companies before they formed or joined BAI GUO.

- A culture of “sharing” and supporting colleagues is pervasive and supported by Senior Management.

- Peer Reviews are a key process component of all projects.
  - While the “peer” part of the reviews is honored anyone who has the necessary expertise, including the senior management participates in the peer reviews and truly acts as a “peer” during those sessions.
  - The focus of these peer reviews is to improve the product and processes that were followed to create that product.

- Project Leaders are not only asked to manage their projects but to look at their project and other projects from an organizational point of view.
Culture - 2

- CMMI ML3 thinking and actions are considered the minimum required for BAI GUO to control costs and manage risks.
- High Maturity is seen to be the necessary component to increase the control and accuracy of Management decision making.
- All Project Managers are aware of and can share / teach the Organization’s Set of Standard Processes to other managers and employees.
- EPG Lead not only promotes the Organization’s Set of Standard Processes but also serves as BAI GUO’s Measurement Lead.
How ready is the organization for starting the ML4 journey?

On-site check, using a predefined HM checklist, before taking up the project:

- Meet the senior management, EPG, project leaders, and their measurement group (if it exists)
- Who will analyze the data? Experience?
- Capability of the project leaders to interpret the analysis results for managing their projects
- Questions covering:
  - Vision, business objectives
  - Process: solid ML3 foundation?
  - Measurement repository, measurement system, tools?
  - Stable processes?
  - PPB, PPM
Vision

- Improve customer satisfaction
- Obtain more repeat orders.
- Increase company size to 100 in 3 years, and
- IPO in 2015.
Business Objectives

◊ Improve the Customer Satisfaction by:
  ◊ Improving schedule performance (reduce delivery delays)
  ◊ Improving the quality of the delivered product

◊ Improve the development work by:
  ◊ Controlling or reducing project costs
  ◊ Improving the productivity
Business Objectives

- Customer satisfaction
  - Reduce schedule delay
  - Deliver high quality product

  - Improve productivity
    - Productivity / schedule data:
      - Plot, plot, plot
      - Trends
      - Distributions
      - Control charts
      - Scatter plots

  - y's and x's
    - Analysis indicators, progress indicators

  - Reduce defects / rework
    - Defect data:
      - Plot, plot, plot
      - Trends
      - Distributions
      - Control charts
      - Scatter plots

  - y's
    - Success indicators, Management indicators

  - Analysis indicators, progress indicators

Project: what are leading in-process indicators of success? Where are improvements needed?
Quantitative Objectives

Derived quantitative objectives:

By 12/31/2010 our organization will improve **Productivity (FP/man-hr)**

from today's performance baseline of:
Mean = 0.26 Std. Dev =0.08

to a new performance baseline of:
Mean = 0.28 Std. Dev =0.06

with at least **95%** of confidence.

without sacrificing the product quality:
Derived quantitative objectives:

By 12/31/2010 our organization will improve **Defect Density (Defects/FP)**

from today's performance baseline of:
Mean = 0.46 Std. Dev = 0.2

to a new performance baseline of:
Mean = 0.43 Std. Dev = 0.18

with at least 95% of confidence.

Project delivery time is closely related to the staff productivity and the amount of defects / rework (quality). In Baiguo, it is believed that if productivity and quality are in control, the delivery is also in control.
The Appraisal Team

做 得 更 好 成 为 最 好
DOING BETTER TO BE THE BEST
BAI GUO Process Improvement Methodology

Problem and goal statement (Y)

- Define
- Measure
- Analyze
- Improve
- Control

- Clarify Business Goals
- Process maps
- Prioritize issues

- Define measures
- Collect & verify measures

- Discovery: plots, paretos, histograms, distributions, fishbone
- Understanding: root cause, critical factors
- Performance: Process stable? Process capable?
- Corrective actions to Improve Process

Y = f(method, review rate, experience .....)

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Version 2.3
High Maturity Improvement Cycle

- Duration of an improvement cycle depends on:
  - Project cycle / duration
  - Number of projects per year
  - Quality of project measurement data
  - How long it takes to deploy a change

- Each improvement cycle is around 3 months in BaiGuo

- Key points to consider in preparing for appraisal:
  - Any statistics specialist in the team to analyze the data (Project leaders / EPG should be able to INTERPRET the data)
  - For the HM PA, evidences should be prepared to the subpractice level
  - Use a Q&A at SP/GP level to set the appraisal expectation to the organization
## 6 Sigma techniques used - an overview

<table>
<thead>
<tr>
<th>Define</th>
<th>Measure</th>
<th>Analyze</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice of Customer</td>
<td><strong>Metrics: defects, project mgmt</strong></td>
<td>Regression</td>
<td>Design of Experiments</td>
<td>Statistical Controls</td>
</tr>
<tr>
<td>Voice of Business</td>
<td>Data Collection Methods</td>
<td>Cause &amp; Effect</td>
<td>Modeling</td>
<td>Control Charts</td>
</tr>
<tr>
<td>Project Charter</td>
<td>Sampling Techniques</td>
<td>Diagrams, Matrix</td>
<td>Eliminate waste</td>
<td>Time Series methods</td>
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<tr>
<td>Kano model</td>
<td>Measurement System Evaluation</td>
<td><strong>Failure Model Effects Analysis FMEA</strong></td>
<td>Robust Design</td>
<td>Other control tools</td>
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<tr>
<td>QFD</td>
<td>Quality of Data</td>
<td>7 Basic Tools</td>
<td>Kaizen</td>
<td>Sustain improvement</td>
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<tr>
<td>Process Flow Map</td>
<td></td>
<td>Hypothesis Tests</td>
<td>Decision &amp; Risk Analysis</td>
<td>Procedural adherence</td>
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<tr>
<td>“Management by Fact”</td>
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<td>Root Cause Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliability Analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Measurement and Analysis
Descriptive statistics are provided to show mean and standard deviation for Productivity and Total Defects.

Statistical techniques used through MiniTab and Crystal Ball include:

- Scatter Plots to determine correlation between Requirements elicitation and size in Function Points and Design and size in Function Points and CUT and size
- Regression Analysis was used for Requirements elicitation and size, Design, and Code and Unit Test
- Analysis of Variance was run to determine statistical significance
- Stepwise regression was run for Requirements Elicitation, Design, and CUT vs. Size FP vs. Team Experience vs. Requirements Volatility
A linear regression relationship was able to be built between Requirements elicitation effort and the size:

- A similar regression relationship was built for Coding and Size
- For the design effort it was found that Team Experience is also a factor in addition to size (in FP) for predicting the design effort.

- Scatterplots, Regression Analysis and Stepwise regression were also applied to Reviews
  - Regression Analysis: Prep versus Reviewed Size
  - Regression Analysis: Conduct Review versus Reviewed Size

- Boxplots and ANOVA were applied to Preparation Time + Conduct Review time versus Review Type
Regression analysis – an example

1. **Relationship of Requirement, Design, Coding to Size (FP)?**

2. **Regression analysis:**
   
   \[
   \text{Design} [Y] = 24.8 + 0.224 \times \text{Size (FP)}
   \]
   
   \(P=0.008\) significant

3. **Effect of independent factors, such as team experience, reuse, requirement volatility?**
   
   Design = f(team experience, size)
   
   \(R^2 \text{ (adj.)} = 92\%\), \(P=0.007\) significant
Organizational Process Performance
Establish Quality and Process-Performance Objectives

- SMART Objectives were used to define the Quantitative Measurement Objectives.
- BAI GUO is in the Medical Hospital Industry and has built IT systems to transfer patient records from remote farming areas to nearest Hospitals and from Hospitals to Hospitals in bigger cities. Time to market and quality are crucial.

GQM approach is used to determine the measures for each objective.
The definitions of all the required measures are documented in the metrics definition guideline – **BAI GUO Metrics Definition Guideline**

- Name of metric
- Business objective
- Unit of measure
- Formula
- Source of data
- Frequency of collection
- Where the data is stored
- Owner of the data
- Tool used to collect basic measures (automatic collection for basic measures)
- Collecting requirements to ensure data validation
- Recommended statistical technique
A Table of Basic measures with their units of measure has been created and is part of the Metrics Definition Guideline.

Significant time was put in to define what basic measures were needed along with their units of measure.
Select Processes - Approach taken in BAI GUO

- Looked at all the available historic data, by project phase
- Tried to validate the data by scatter plot, and calculate the summary statistics (mean, standard deviation) to see if the data were reasonable
- Correlation was used to see what factors affected the effort and build the regression relationship between the outcomes and the factors
- Steps were repeated by decomposing the subprocesses. Again correlation was used to see what factors affected the effort and the regression relationship was built
- Preliminary findings were validated with the consumers (Project Leaders) to ensure the model and analysis made sense
Total Defects Segmentation

Opportunities for Improvement were identified

- Improve development work
- Improve productivity
- Reduce rework and Cost of Quality to improve overall productivity (Total Rework and rework per defect)

- Defects from each lifecycle phase were examined
- Defect Data was collected from multiple small projects
Defects were broken down by A, B, and C defect categories with full explanation behind them in the Testing Process document.

- A - Serious
- B - Major
- C - Minor

Systems Testing produced the most defects → Upstream activities were examined.

Pareto Charts of A, B, and C categories of defects that contributed to rework were developed by lifecycle phase.
FMEA was conducted to further categorize the CAT B defects per lifecycle phase and reduce the defects coming into and going out of Systems Test.

- Invite all project leaders, and EPG; Delphi Method were used.
- FMEA Table included:
  - Potential Failure Mode
  - Potential Failure Effects
  - Severity (1-10)
  - Potential causes
  - % of Occurrence (1-10)
  - Current Control
  - % of detection (1-10)
  - RPN = Severity x Occurrence x Detection
<table>
<thead>
<tr>
<th>Process Step</th>
<th>Potential Failure Mode (from checklist)</th>
<th>Potential Failure Effects</th>
<th>Potential Cause (1-10)</th>
<th>OCC (1-10)</th>
<th>Current Controls</th>
<th>DET (1-10)</th>
<th>RPN</th>
<th>Actions Recommended</th>
<th>Responsibility</th>
<th>Take</th>
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<tbody>
<tr>
<td>Requirement</td>
<td>Contradicting/ repeated requirements</td>
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<td>7</td>
<td>4</td>
<td>224</td>
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<td>3</td>
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<tr>
<td></td>
<td>Others</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>144</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>Incomplete, not testable</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>168</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td>Design not traceable to requirement</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>140</td>
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<td></td>
<td>Not match interface spec</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>144</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Others</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>128</td>
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<td>Coding</td>
<td>Module too complicated / complex</td>
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<td>5</td>
<td>6</td>
<td>180</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Did not avoid floating point operation</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>175</td>
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<td></td>
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<tr>
<td></td>
<td>Loop, branch, logic not correct</td>
<td>7</td>
<td>5</td>
<td>6</td>
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<td></td>
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<td></td>
<td>No check for input parameters</td>
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<td>6</td>
<td>6</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Others</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>210</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The purpose is to reduce the rework effort in project, to find out the defect source from review checklist which impacts rework effort most. Here lists the checklist items which impact the defect most.
Organizational Process Performance Highlights - 8

- Highest priority areas were examined as input and a Cost-Tradeoff Analysis was conducted.

- Defects coming out of Coding were focused on first as the most practical and cost effective area to concentrate on.
  - Upgraded Code Review guidelines were developed with enhanced guidelines which emphasized lower level categories from Coding.

- If results from the focus on Coding were not sufficient, the next alternative solution was discussed with Senior Management to determine feasibility.
Subprocess Selection Guideline

Developed to support the traceability of subprocesses back to Business Objectives and vice versa

- Business Goal
- Goal type
- Stakeholder Perspective
- Typical Questions
- Metrics
- Impacting Sub-processes
- Sub-process control measure
Organizational Process Performance Highlights - 10

❖ Statistical Control (Stable Processes)
❖ XmR control charts are used for Requirements and Coding to ensure productivity is statistically managed

❖ EXAMPLE: A spike in productivity was noticed. Causal analysis was conducted. It was determined that there was a high use of “re-use” at that point. However, it was decided that this was an anomaly and the control limits were not changed
Control chart - example

X Chart for Code productivity

<table>
<thead>
<tr>
<th>Code productivity</th>
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</thead>
<tbody>
<tr>
<td>2.00</td>
</tr>
<tr>
<td>1.50</td>
</tr>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>0.50</td>
</tr>
<tr>
<td>0.00</td>
</tr>
<tr>
<td>-0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MeanX</td>
</tr>
<tr>
<td>LCLX</td>
</tr>
<tr>
<td>UCLX</td>
</tr>
<tr>
<td>USL</td>
</tr>
<tr>
<td>Target</td>
</tr>
<tr>
<td>LSL</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Process Stability</th>
<th>Process Capability</th>
<th>Cpk</th>
<th>Cpm</th>
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</thead>
<tbody>
<tr>
<td>Stable</td>
<td>Capable</td>
<td>3.25</td>
<td>2.11</td>
</tr>
</tbody>
</table>
Organizational Process Performance Highlights - 11

(process performance baselines)

The organization’s Process Performance Baselines (PPBs) were derived through analyzing the distribution of the data to establish the central tendency and dispersion (sigma) to characterize the expected performance and variation for the selected processes or subprocesses.

- EPG provides templates to Project Teams and provides training on their use
- Project Teams collect required data and give it to the EPG - automated
- Training was also provided on how to interpret the Excel or Minitab analysis results based on historic data
The PPB and related measurements are reviewed regularly in the EPG meetings (by the EPG group and the PMs), in the project meetings (by PMs and project team members), and the senior management meetings (by GM, EPG, QA, PMs).

PPB Summary Report
- Processes
- Subprocesses
- XmR Charts for productivity

PPBs are updated every six months – ANOVA is used to determine statistical significance of productivity change.
Process Performance Models (PPMs)

There is a Crystal Ball predictive model for productivity and quality.

Besides the crystal ball, there are also other PPMs (e.g. linear regression) for Project Leaders to reference to.

E.g. relating the upstream process factors to predict the activities downstream in the Minitab.
## Crystal Ball prediction model – an example

<table>
<thead>
<tr>
<th>Requirements Elicitation</th>
<th>Prototyping</th>
<th>Std Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort</td>
<td>LL</td>
<td>Avg</td>
</tr>
<tr>
<td>48</td>
<td>66</td>
<td>84</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Quality</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reqs Review</th>
<th>PeerReview(Low)</th>
<th>ExpertReview(Low)</th>
<th>Pee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort</td>
<td>LL</td>
<td>Avg</td>
<td>UL</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Quality</td>
<td>82.00%</td>
<td>95.00%</td>
<td>98.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design</th>
<th>SA / SD</th>
<th>Hig Exp SA / SD</th>
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</thead>
<tbody>
<tr>
<td>Effort</td>
<td>LL</td>
<td>Avg</td>
</tr>
<tr>
<td>43.748</td>
<td>68.948</td>
<td>94.148</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>40</td>
<td>45</td>
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<tr>
<td>Quality</td>
<td>0</td>
<td>9.96</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Design</th>
<th>PeerReview(Low)</th>
<th>ExpertReview(Low)</th>
<th>Pee</th>
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</thead>
<tbody>
<tr>
<td>LL</td>
<td>Avg</td>
<td>UL</td>
<td>LL</td>
</tr>
<tr>
<td>PeerReview(Low)</td>
<td>ExpertReview(Low)</td>
<td>Pee</td>
<td></td>
</tr>
</tbody>
</table>
Integrated Project Management
Project Closure meeting is held at end of each project to capture:

- Project size and effort tracking results
- Actual work effort for each phase
- Deviation of effort/schedule for every milestone
- Measurements to update PPBs
- Sent to EPG Lead for consideration to be included in the Organization’s Measurement Repository or Process Asset Library
Project Monitoring and Control – Highlights

◊ Actuals to estimates tracked include:
  ◊ Size, Effort, Risks, Stakeholder Involvement, Resources, Quality, Non-compliances

◊ Schedule Variance is calculated and acts as a threshold for corrective action

◊ Cost Variance is calculated and acts as a threshold for corrective action

◊ XmR Control Charts are used to ensure process stability – Special Causes of Variation are analyzed and corrected

◊ At the end of each Milestone, Crystal Ball is run using last phase’s data to predict next phase results (Interim targets) and all subsequent phases
Quantitative Project Management
Projects make use of Organizational selection of processes and subprocesses created from OPP

Project Managers conduct an analysis of data in the PPB to determine which subprocesses will contribute most to meeting the measurement objectives of the project. These are placed into the Project Quantitative Management Plan.

Crystal Ball model was also rerun after each phase (e.g. req ph) milestone to predict the outcome from the downstream processes.
Subprocesses with the most variation were selected - Requirements, and Coding+UT.

Other subprocesses are less affected, and have less variation.

E.g. defects at the requirement phase will affect the defects and rework in the testing phase.

Similar to OPP, analysis was carried out on various factors to determine the critical subprocesses

XmR charts were used on past project data to show that the productivity of those subprocesses were stable
● At the end of each phase the control chart was used to show if the selected subprocess are meeting the specification

● Cpk was calculated to see that the degree of meeting the customer specification limits are met

● Crystal Ball was used to recalculate confidence level for to predict meeting the overall project goals at the end of each phase
The definitions of the common measures, units are found in the organizational guideline BG Metrics Definition Guideline.

The USL and LSL of the objectives of the critical subprocesses were specified in the Project Performance Measurement Plan.

These USL/LSL are compared with the model and the baseline figures in a summary table.

The correctness of these USL/LSL of selected critical subprocesses are reviewed.

Statistical techniques used include: Xmr charts, u-chart, confidence interval, and Pareto charts for the defects by category.
The Project Performance Measurement Plan contains the description of the 'responsibilities', 'by/to whom', 'how often', 'data storage', 'analysis'

- Quality objective
- Priority
- Metric – Unit of Measure
- Target
- USL – Upper Specification Limit
- LSL – Lower Specification Limit
- Reason for Target
- PPM used
- Remarks
Operational Definitions found in the Metrics Definition Guideline [See OPP Sp 1.3]

- Name of metric
- Business objective
- Unit of measure
- Formula
- Source of data
- Frequency of collection
- Where the data is stored
- Owner of the data
- Tool used to collect basic measures (automatic collection for basic measures)
- Collecting requirements to ensure data validation
- Recommended statistical technique
Data was collected at Project Closure and presented to EPG

PPBs were updated by EPG Lead as appropriate

Metrics Definition Guideline was updated as appropriate
Summary and Lessons Learned

- **Look before you jump** – a thorough initial readiness check before starting the high maturity journey

- **Upfront high maturity training** to the process champions so that they, who understand the strengths and weaknesses of the current processes, can drive the SPI

- **Periodic assessment** – a knowledgeable Appraisal Team, mostly from the organization, can also direct the organization towards the right direction

- **Talk, talk, talk** – the measurement team and the external consultant(s) should communicate with the project managers periodically to validate the measurement findings; the Project managers are always the people best equipped to ‘interpret’ the analysis findings
Doing better to be the best.

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Processis
Edmond Sung

◇ President & Principal Consultant of Processis Ltd.

◇ Edmond has more than 25 years of experience in the information technology and related service industry

◇ Edmond’s current focus is to assist companies to improve their processes, products and service quality using an effective combination of CMMI and Six Sigma.

◇ Edmond has more than eight years of experience in CMMI-based training / consulting / and appraisal services.
CEO and Principal Consultant of Kasse Initiatives LLC

Visiting Scientist - Software Engineering Institute

Visiting Fellow - Institute for Systems Science / National University of Singapore

Author of Action Focused Assessment for Software Process Improvement

Author of Practical Insight Into CMMI
Practical Insight Into CMMI – 2nd Edition (Sept 2008)

Software Engineering

The newly revised and expanded edition of the bestseller, Practical Insight into CMMI is an essential reference for engineering, IT and management professionals striving to grasp the "look and feel of a successful business oriented process improvement implementation". The second edition brings practitioners up to speed on CMMI® Version 1.2 and includes new material on:

- Reviews and testing;
- Quality factors, quality criteria, and quality metrics;
- Physical architecture;
- Change control boards;
- Supplier agreement management;
- Interfaces;
- Constraints on alternative solutions;
- Causal analysis techniques;
- Evolving measurements;
- Applying CMMI® to manufacturing.

Written by a world-renowned expert in the field, the book offers a clear picture of the activities an organization would be engaged in if their systems and software engineering processes were based on CMMI®. The book teaches the roles and responsibilities of professionals at all levels, from senior and middle management to project leaders and quality assurance personnel. Offering a full appreciation of the power of CMMI® to enhance systems and software process improvement initiatives, this invaluable reference captures the essence of each of process area by presenting it in a practical context. From project monitoring and control, quality management, and requirements engineering, to risk management, integrated teams, and measurement programs, this authoritative volume provides a complete understanding of CMMI® and the benefits of this integrated approach in an organization.

Tim Kasse is CEO and Principal Consultant for Kasse Initiatives, LLC. He has over 38 years of systems/software engineering experience and has conducted over 100 assessments worldwide based on the Capability Maturity Model® and CMMI®. Mr. Kasse is also the author of Action Focus Assessment for Software Process Improvement (Arttech House, 2002). He holds a B.S. in systems engineering from the University of Arizona, Tucson and an M.A.S. in computer science from Southern Methodist University.

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