Achieving Quality QPPO via Effective Usage of PPBs and PPMs

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Outline

- PPBs and PPMs’ usage in quality goal setting
- PPMs and PPBs’ usage in quality goal management
- Controllable factors
  Improvement Observed
- Some lessons learnt
The Context of the Case Studies

- Org is serving one customer
- High quality is the most Important Product Requirement
- Business goals are set up by the client
Customer’s Product Quality Requirement

- 4 Nines - 99.99%:

  Escaped defects < 0.1 per KLOC
Org’s Quality Objective

- Defects density identified in acceptance test is less than 0.11/KLOC which is based on the AT performance baseline.

  - Historical data shows that the lower bug rate identified by acceptance test, the lower of delivered bug rate. With 95% confidence, it has been show that if the acceptance test bug rate lower than 0.11个/KLOC, delivered bug rate will be lower than 0.1个/KLOC.
The Rationale for Choosing the Quality Objective

• It meets clients’ quality requirement.

• Org’s baseline supports it.

• The org’s metrics support it.

• It can be easily used by project team.
The following quality control activities are conducted before the acceptance test is performed by the independent Testing Center:

- Requirement Peer Review
- System Design Peer Review
- Detailed Design Peer Review
- Code Inspection + Unit Test
- System Test

The related interim goals need to be developed to ensure achieving the Quality Objective, thus the goal becomes a manageable one.
PPBs Needed to Support the Interim Goals

• Defect injection distribution

• Defect removal rate in requirement/design/code review + UT and system test

• Efforts devoted to these quality control activities
Abnormal Analysis

Effort baselines is needed to support this analysis
### Quality Related Baselines – Measured by defect removal rate

<table>
<thead>
<tr>
<th>序号</th>
<th>Q C 活动</th>
<th>中值</th>
<th>下限</th>
<th>平均值</th>
<th>上限</th>
<th>标准差</th>
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</thead>
<tbody>
<tr>
<td>B115</td>
<td>验收测试缺陷密度—工程升级</td>
<td>8.11</td>
<td>3.82</td>
<td>8.09</td>
<td>12.35</td>
<td>2.13</td>
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<tr>
<td>B116</td>
<td>验收测试缺陷密度—工程新开发</td>
<td>11.13</td>
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<td>10.73</td>
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<td>1.13</td>
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<td>验收测试缺陷密度—研发升级</td>
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<td>4.76</td>
<td>7.42</td>
<td>1.33</td>
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<tr>
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<td>验收测试缺陷密度—研发新开发</td>
<td>4.47</td>
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<td>5.49</td>
<td>10.53</td>
<td>2.52</td>
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<tr>
<td>B119</td>
<td>需求评审效率</td>
<td>1.44</td>
<td>0.76</td>
<td>1.39</td>
<td>2.03</td>
<td>0.316</td>
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<td>B120</td>
<td>设计评审效率</td>
<td>1.25</td>
<td>0.62</td>
<td>1.28</td>
<td>1.93</td>
<td>0.327</td>
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<tr>
<td>B121</td>
<td>审查效率</td>
<td>9.86</td>
<td>6.24</td>
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<td>11.23</td>
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<td>B122</td>
<td>系统测试效率</td>
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<td>0.22</td>
<td>0.52</td>
<td>0.81</td>
<td>0.148</td>
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<tr>
<td>B123</td>
<td>系统测试用例密度—工程升级</td>
<td>168.32</td>
<td>93.41</td>
<td>159.31</td>
<td>225.21</td>
<td>32.95</td>
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<td>B124</td>
<td>系统测试用例密度—工程新开发</td>
<td>182.95</td>
<td>150.20</td>
<td>181.55</td>
<td>212.90</td>
<td>10.45</td>
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<td>B125</td>
<td>系统测试用例密度—研发升级</td>
<td>131.30</td>
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<tr>
<td>B126</td>
<td>系统测试用例密度—研发新开发</td>
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<td>119.90</td>
<td>171.50</td>
<td>223.10</td>
<td>25.80</td>
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<tr>
<td>B127</td>
<td>需求评审_清除率</td>
<td>63.60%</td>
<td>36.34%</td>
<td>61.50%</td>
<td>99.24%</td>
<td>0.252</td>
</tr>
<tr>
<td>B128</td>
<td>设计评审_清除率</td>
<td>55.62%</td>
<td>23.23%</td>
<td>50.72%</td>
<td>91.96%</td>
<td>0.275</td>
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<tr>
<td>B129</td>
<td>代码审查_工程清除率</td>
<td>19.04%</td>
<td>12.91%</td>
<td>18.27%</td>
<td>34.35%</td>
<td>0.054</td>
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<tr>
<td>B130</td>
<td>代码审查_研发清除率</td>
<td>25.64%</td>
<td>13.93%</td>
<td>27.61%</td>
<td>68.65%</td>
<td>0.137</td>
</tr>
<tr>
<td>B131</td>
<td>系统测试清除率</td>
<td>86.10%</td>
<td>81.98%</td>
<td>86.30%</td>
<td>94.94%</td>
<td>0.043</td>
</tr>
<tr>
<td>B132</td>
<td>需求阶段植入率</td>
<td>11.58%</td>
<td>6.38%</td>
<td>11.56%</td>
<td>16.74%</td>
<td>0.026</td>
</tr>
<tr>
<td>B133</td>
<td>设计阶段植入率</td>
<td>8.98%</td>
<td>3.58%</td>
<td>9.81%</td>
<td>16.05%</td>
<td>0.031</td>
</tr>
<tr>
<td>B134</td>
<td>代码阶段植入率</td>
<td>78.49%</td>
<td>69.66%</td>
<td>78.33%</td>
<td>87.01%</td>
<td>0.043</td>
</tr>
</tbody>
</table>

2009-11-18
Quality Related QPPOs

Acceptance test bug rate lower than 0.11 defects/KLOC:

① Requirement review identifies at least 0.09* total number of estimated defects;
② System design review identifies at least 0.1* total number of estimated defects;
③ Detail design review identifies at least 0.02* total number of estimated defects;
④ Code Review and UT identifies at least 0.36* total number of estimated defects;
⑤ System test identifies at least 0.41* total number of estimated defects.
Another Example

- Requirement Peer Review should at least identify 80% of defects introduced so far.

- Design Peer Review should at least identify 70% of remaining defects introduced so far.

- Code Inspection should at least identified 40% of remaining defects introduced so far.

- System Testing should at least identify 90% remaining defects introduced so far.
Interim Goals and Overall Quality Objective

• Statistical studies show that if the Interim Goals are achieved, the overall goal will be achieved too.

• QPM is all about managing the goal achievement.
Prediction models needed for quality goal management

- Number of defects introduced in Requirement Phase
- Number of defects introduced in Design Phase
- Number of defects introduced in Coding Phase
- Number of defects removed by Requirement Peer Review
- Number of defects removed by Design Peer Review
- Number of defects removed by Code Review for Java and .Net
- Number of defects removed by Code Review for C and C++
- Number of defects removed by System Test
- Gompertz Model – a Reliability Growth Model
Monte Carlo is used for managing risks in obtaining Quality Goals during the planning phase and throughout the LC.
Relationship between Goals and Key Subprocesses

Developing software applications with high quality

Continuously refine management system

UAT Bug Rate

Effort variation rate

RA defect removal
HD defect removal
DD defect removal
SI defect removal
ST defect removal

Walk-through+Peer Review
Code review+UT + IT
System Test
RA to ST engineering activities
Critical Key Sub-process Selection Criteria

- Customer’s concerns
- The Impact to the QPPOs
- Statistical impact analysis

Largest impact occurs in system test 70.3%

The impact of system test and code review are 47.3% and 22.7%. 
# The Goal-Model-Baseline Matrix

<table>
<thead>
<tr>
<th>Quality and Process Performance Goals</th>
<th>Key Processes</th>
<th>Metrics</th>
<th>Statistical Method Used</th>
<th>Related Models</th>
<th>Related Baselines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project验收测试bug率不高于0.11个/KLOC，且截止系统测试阶段结束，项目缺陷发现数不小于项目计划数</td>
<td>验收测试活动</td>
<td>验收测试发现的缺陷数</td>
<td>XMR、Gompertz</td>
<td>项目缺陷发现分布及预测模型</td>
<td>1. 验收测试bug率</td>
</tr>
<tr>
<td>2. 总体设计阶段缺陷排除</td>
<td>审查+同行评审</td>
<td>每规模问题数</td>
<td>XMR</td>
<td>项目缺陷发现分布及预测模型</td>
<td>2. 总体设计阶段缺陷发现占比（%）</td>
</tr>
<tr>
<td>3. 详细设计阶段缺陷排除</td>
<td>审查性评审</td>
<td>每规模问题数</td>
<td>XMR</td>
<td>项目缺陷发现分布及预测模型</td>
<td>3. 详细设计阶段缺陷发现占比（%）</td>
</tr>
<tr>
<td>4. 程序实现阶段缺陷排除</td>
<td>代码复查</td>
<td>代码复查发现的缺陷数</td>
<td>Gompertz</td>
<td>项目缺陷发现分布及预测模型</td>
<td>4. 程序实现阶段缺陷发现占比（%）</td>
</tr>
<tr>
<td>5. 系统测试阶段缺陷排除</td>
<td>系统测试</td>
<td>系统测试发现的缺陷数</td>
<td>Monte Carlo方法</td>
<td>项目缺陷发现分布及预测模型</td>
<td>5. 系统测试阶段缺陷发现占比（%）</td>
</tr>
</tbody>
</table>

**PPOs**

- Critical Processes
- Measures
- Indicators
- Statistical Method used

**PPMs**

- PPMs

**PPBs**

- PPBs
How Models fit in the Quality Goal Mgt
It is all about achieve the goals!

Risks, Issues, and Corrective/Preventive Actions

Proj QPPOs

Set Goal
Adjust Goal
Monitor Goal
Select the Key Activities
Measure
Understand Variation
Manage Process Performance

Support

Statistically Manage the Key Activities

PPBs, PPMs

Buz Goal

Org QPPOs

Clients’ Needs

Clients’ Needs
Overview on How PPBs and PPMs are Used

![Diagram showing the relationship between project quality control targets and defect models]

- **需求评审目标** (Demand Review Target)
- **设计评审目标** (Design Review Target)
- **代码走查目标** (Code Walkthrough Target)
- **系统测试目标** (System Test Target)

- **验收缺陷密度** (Defect Density)

**Crastal Ball**
- **目标达成** (Goal Achievement)
- **风险分析** (Risk Analysis)
- **因子调整** (Factor Adjustment)
- **缓解措施** (Mitigation Measures)

**项目质量控制目标** (Project Quality Control Targets)

- **需求植入缺陷模型** (Demand Insertion Defect Model)
- **设计植入缺陷模型** (Design Insertion Defect Model)
- **编码植入缺陷模型** (Coding Insertion Defect Model)

Mathematical equations:

\[ y = f(x_1, x_2, \ldots) \]

- **需求开发** (Requirement Development)
- **设计** (Design)
- **编码实现** (Coding Implementation)
- **测试** (Testing)

**项目计划** (Project Plan)

Date: 2009-11-18
Monte Carlo Simulation on Goal Achievement
Controllable Factors

• Sources of variation
  - HM means you truly understand your critical processes.

• Where you might make adjustments

• Key areas to improve your process
Which model allows you to adjust?

• **Defect Removal Predictive Model for Requirement Peer Review:**

\[ f(\text{Size, Type, Complexity}) \]

\[ f(\text{Size, Review Effort, Review Team Ability Index, Type}) \]
Defect removal rate improved in code review and UT&IT.

Defect removal Rate (Y2007-Y2008)

- Code Review (KLOC)
- UT&IT (Per FP)
- Peer Review (Technical Solution, Per page)
- Peer Review (RA, Per page)
- Peer Review (HD, Per page)
Defect Removal Pattern Moves to Front

Defect Removal Rate (Y2007–Y2008)

- walk-through: 4.11% (Y2007), 4.15% (Y2008)
- Peer Review: 9.08% (Y2007), 8.10% (Y2008)
- Code Review: 11.62% (Y2007), 15.65% (Y2008)
- UT&IT: 17.05% (Y2007), 20.10% (Y2008)
- ST: 40.63% (Y2007), 67.70% (Y2008)
- UAT: 2.43% (Y2007), 2.04% (Y2008)
Less Number of Defects Fund at UAT

<table>
<thead>
<tr>
<th>UAT date</th>
<th>UAT defect density</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-12-10</td>
<td>0.0</td>
</tr>
<tr>
<td>2008-1-15</td>
<td>0.4</td>
</tr>
<tr>
<td>2008-2-25</td>
<td>0.3</td>
</tr>
<tr>
<td>2008-3-10</td>
<td>0.2</td>
</tr>
<tr>
<td>2008-5-9</td>
<td>0.1</td>
</tr>
<tr>
<td>2008-6-21</td>
<td>0.0</td>
</tr>
<tr>
<td>2008-8-14</td>
<td>0.0</td>
</tr>
<tr>
<td>2008-9-5</td>
<td>0.0</td>
</tr>
<tr>
<td>2008-10-10</td>
<td>0.0</td>
</tr>
<tr>
<td>2008-11-21</td>
<td>0.0</td>
</tr>
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</table>

**trend analyse graph (UAT Defect density)**

二次趋势模型

\[ Y_t = 0.1097 - 0.0064t + 0.000057t^2 \]

<table>
<thead>
<tr>
<th>准确度度量</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>平均百分误差（MAPE）</td>
<td>250.637</td>
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<tr>
<td>平均绝对误差（MAD）</td>
<td>0.054</td>
</tr>
<tr>
<td>平均偏差平方和</td>
<td>0.006</td>
</tr>
</tbody>
</table>
2007-2008产品质量对比（验收测试缺陷率）

2007年验收测试缺陷率基线值：0.147个/KLOC

根据目前各缺陷消除活动基线水平进行仿真模拟，模拟的验收测试缺陷率结果低于2007年水平。
Clients’ Quality Goal is Met

2007-2008 产品质量对比（产品生产 bug 率）
Some Lessons Learnt - I

• Set up the big picture first with clearly defined overall goals and interim goals.

• Clearly think through how the PPBs and PPMs will be used. You may want to write the PPBs and PPMs’ User Guidelines before actually developing them. The PPBs and PPMs will be refined from time to time but how they are used will change much less frequently.

• Model development process is to really get to know your process: factors in the model – sources of variations. It is not enough if you only master the statistical techniques and know how to use Minitab.

• Model development process can also help you to identify areas to improve.
Some Lessons Learnt - II

• When conducting regression analysis, do not just look at R square but also think “will the model allow you do What-If analysis?”

• Benchmarking a process does not make it a key process. A key process should also be the focus of your improvement. The factors in a good process performance model are the candidate areas to improve.

• PPBs can support the use of Monte Carlo simulation.

• Spec limits and control limits can get people confused.

• QPPOs and Controllable Factors!!!
Thank you!