Process Improvement Journey
(From level 1 to Level 5)

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Software Engineering
The Boeing Company
Questions

Is process improvement a good investment?

Are Capability Maturity Models (SW-CMM, P-CMM, etc.) the right frameworks for process improvement?

As an organization moves to higher levels of the SW-CMM, are software quality, cost, time and performance getting better?

Should we stop after achieved CMM Level 3?

Do PSP and TSP help accelerate process improvement?
Software Process Improvement (SPI)

• The Boeing Company has used the SW-CMM as the framework for software process improvement since 1991.
• Over 200 organizations have been assessed.
• Over 11,000 people trained in SW-CMM.
• Several higher levels of maturity organizations (Level 3, 4 & 5).
• Well-established SEPG infrastructure.
• P-CMM is used as the framework to improve workforce practices since 1997.
• PSP/TSP techniques are used to accelerate the rate of improvement since 1998.
Company-Wide Approach Benefits

• Process Improvement is a company-wide activity.

• A well-defined infrastructure of SEPG helps ensure implementation success.

• Management commitment is at all levels.

• Process improvement strategy is part of company strategy.

• Process improvement goals align with business goals.

• Redundant activities are avoided or reduced.

• Standardization of software process is accelerated.
Improvement Strategy

Business Goals & Objectives

Quality          Cost          Schedule
                Process (SW-CMM)  People (P-CMM)  Technology (PSP/TSP)
Maturity Levels In Boeing

Based on 216 assessments in Boeing between 1991 to 2000
Process Improvement Results

120 projects in Boeing Information Systems participated in the validation study of the SW-CMM.

Measurements baseline established in 1991.

Data collected and analyzed independently by Dr. Kay Nelson of University of Kansas.
Software Estimates

(Efforts = Labor Hours)

Without Historical Data
Variance between + 20% to - 145%
(Mostly Level 1 & 2)

With Historical Data
Variance between - 20% to + 20%
(Level 3)

(Based on 120 projects in Boeing Information Systems)
Based on 120 projects in Boeing Information Systems.

Schedule Performance

Number of Milestones/Deliverables

Actual:
Plan:

Level 1                                        Level 2                         Level 3

Time
Post Release Defects

Average Number of Defects

Level 1                            Level 2                               Level 3

16% improvement

28% improvement

(Based on 120 projects in Boeing Information Systems)
Cycle time
(Average time to complete a request for services)

(Based on 120 projects in Boeing Information Systems)
Productivity

Reduced Staff Support per System = Increase Productivity

(Based on 120 projects in Boeing Information Systems)
Is Level 3 Good Enough?

Many managers believe that level 3 is good enough.

Limited data at higher levels discourage the community to go further.

Many organizations stopped their process improvement at level 3 and found that they slipped back to lower level.

Few realized that the journey has just begun…..

We only had the appetizer…..

We have not start the main course…..Yet.
Process Improvement Results

6 organizations in Boeing (28 projects) participated in the study of higher maturity levels (Level 4 & 5).

Measurements baseline established in 1996.

Data collected and analyzed independently by Dr. Kay Nelson of University of Kansas.
Schedule Variance

Schedule variance: Number of estimates vs. actuals in days

Based on 6 organizations assessed at level 4 & 5

85% more accurate

Level 3

Level 4

UCL

LCL

UCL

LCL

UCL

LCL

UCL

LCL
Based on 216 organizations assessment between 1991 to 2000
Software Reuse

Code reuse: No modification
Other reuse: Templates, Test cases etc.
Pre-Released Defects

Based on 216 organizations assessment between 1991 to 2000

- Level 1: 28% improvement
- Level 2: 16% improvement
- Level 3: 28% improvement
- Level 4: 42% improvement
- Level 5: 28% improvement
Formal Review & Inspection Benefit Ratio

<table>
<thead>
<tr>
<th></th>
<th>Before Review/Inspection</th>
<th>After Implemented Review/Inspection</th>
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</thead>
<tbody>
<tr>
<td>Rework Effort</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Req.</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>Design</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td>Code</td>
<td>19%</td>
<td>4%</td>
</tr>
<tr>
<td>Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Release</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formal Review & Inspection increased design effort by 4% and decreased rework effort by 31%.

Reduce 31% in rework.

Cost: Benefit ratio is 4% : 31% or 1 : 7.75

Based on 6 organizations assessed at level 4 & 5.
People Improvement Results

Boeing Information Systems conducted the first joint assessment for Software and People CMM in 1996.

Boeing Information Systems began to use the P-CMM as framework to improve its workforce practices and retain skilled workers in 1997.

12 joint assessments of software and people conducted to date - 4 organizations achieved P-CMM level 2
## Results

### Employee Turnover (Software):

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry data</td>
<td>16% (1998 benchmark data)</td>
</tr>
<tr>
<td>Boeing</td>
<td>10% - 12%</td>
</tr>
<tr>
<td>Boeing (P-CMM L2)</td>
<td>3% (75% left return within a year)</td>
</tr>
</tbody>
</table>

### Employee Satisfaction (Scale from 1 to 10):

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry data</td>
<td>6.8 (1998 benchmark data)</td>
</tr>
<tr>
<td>Boeing</td>
<td>5.7</td>
</tr>
<tr>
<td>Boeing (P-CMM L2)</td>
<td>8.9</td>
</tr>
</tbody>
</table>
Employee Satisfaction

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Number of Employees</th>
<th>Before Process Improvement</th>
<th>Number of Employees</th>
<th>After Process Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely satisfied</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly Satisfied</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very satisfied</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Quite Satisfied</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not excited About</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Dissatisfied</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly Dissatisfied</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean = 5.7

Mean = 8.9

Before Process Improvement

96%

After Process Improvement

74%
Technology Improvement

The Boeing Company conducted 3 pilots of the Personal Software Process (PSP) and Team Software Process (TSP) in 1998 in organizations already achieved level 3.

Two organizations achieved level 4 in 2000 - 10 months faster than other level 3 organizations.

Data analysis indicated that PSP and TSP did accelerate the rate of improvement by 30% and have better product quality, cost, and cycle time performance.
Time To Move Up A Maturity Level

Based on 216 organization assessments conducted between 1991-2000

- Level 2: 34 months
- Level 3: 25 months
- Level 4: 30 months
- Level 4 + PSP/TSP: 20 months
- Level 5: 10 months
PSP Benefits

- # of Defect Detected
- Release # 6
- Release # 7
- Release # 8
- Release # 9
- PSP/TSP trained

- Software Size
- 2.36X more Sloc count
- 75% lower Defect

John D. Vu
The Boeing Company
ekeynote2001.PPT 1.0
PSP Benefits

System Test time

Release # 6 Release # 7 Release # 8 Release # 9

PSP/TSP trained

Software Size

2.36X more Sloc count

94% less time

4 days

Release # 6: 32 days
Release # 7: 41 days
Release # 8: 28 days
Release # 9: 4 days

Sloc count:

Release # 6: 32 days
Release # 7: 41 days
Release # 8: 28 days
Release # 9: 4 days

Software Size:

Release # 6: 32 days
Release # 7: 41 days
Release # 8: 28 days
Release # 9: 4 days
Summary: The Journey at Higher Levels

Most organizations meet projected business goals
90% of defects are captured before release
94% of projects meet schedule estimates
Software reuse increases 64%
Test time reduces by 94%
Organization productivity increases 70% over level 3
Customers satisfaction increases 12% over level 3
Employees satisfaction increases 20% over level 3
Employee turnover is 3% vs. industry at 12%
Un-quantifiable Benefits: Organization Culture

Users and developers working together as one team

Greater cooperation between teams (Different projects)

Roles and responsibilities are clear and better defined

Minimum impact when staff changes occur

People understand & appreciate this new way of working together

Increase mentoring among senior & junior people

“We have lots of fun here”
We Believe

There is a **systematic approach** to improve the way software is developed and maintained.

There are **stages of process maturity** in which the organization will improve by following a recommended sequence to decrease risk and increase software performance.

By **following an evolutionary path** the organization will continuously improve their knowledge to produce better, faster, higher quality products, and achieve customer satisfaction.
Conclusion

Process Improvement using the Capability Maturity Models such as SW-CMM, P-CMM will help organization improve its software process, attract and retain skilled workers, and achieve its business objectives.

Adopting PSP/TSP in concert with process improvement activities will accelerate organization maturity and determine which organization has the potential to deliver higher quality products at reasonable cost to the customer.