Topics to be covered

• Purpose of Quality Assurance
• Classical Approach to Quality Assurance
  • How It Works
  • Deficiencies of Classical Approach
• Defect Model Approach to Quality Assurance
  • Premise
  • How It Works
  • Types of Defects
  • Benefits of this Quantitative Approach
• Conclusion
Purpose of Quality Assurance

• To provide staff & management insight into processes being used and work products being built
  • Determine process adherence
  • Evaluate work products during development and prior to delivery
Classical Approach to Quality Assurance

- Separate group from developers
  - A way of insuring independence
- QA group examines/reads the work product to be evaluated
  - Often after the work product is completed
  - Defects found are costly to correct
- QA group typically does not have the domain knowledge to judge technical quality
  - Technical quality not determined
  - Determine if formatted properly
  - Meets standards imposed
Premise

- Products are created by executing processes
- In a mature organization, process performance is known, repeatable and controlled
- Defects are inserted at statistically known rates
- Therefore by monitoring defects detected
  - Estimate of defects remaining in product can be made
  - A statement of the product quality can be quantitatively made
  - Corrective action can be taken early in the life cycle
    - Least costly to correct
Defect Modeling

\[
\begin{align*}
\alpha_1 &= \beta_1 + \gamma_1 \\
\gamma_1 &= \alpha_1 - \beta_1
\end{align*}
\]

\[
\begin{align*}
\alpha_2 &= \beta_2 + \gamma_2 \\
\gamma_2 &= \alpha_2 + \gamma_1 - \beta_2
\end{align*}
\]

\[\alpha = \text{Defects In}\]
\[\beta = \text{Defects Out}\]
\[\gamma = \text{Remaining Defects}\]

“Defects In” is known, “Defects Out” is monitored --> Therefore “Remaining Defects” left in product can be determined
Defect Modeling

1 = New
2 = Mod
3 = Revised

\( \alpha = \text{Defects In} \)
\( \beta = \text{Defects Out} \)
\( \gamma = \text{Remaining Defects} \)

\[
\begin{align*}
\alpha_1 &= \beta_1 + \gamma_1 \\
\gamma_1 &= \alpha_1 - \beta_1 \\
\alpha_2 + \gamma_1 &= \beta_2 + \gamma_2 \\
\gamma_2 &= \alpha_2 + \gamma_1 - \beta_2
\end{align*}
\]
CNIR (Cluster 5) (Requirements)

Product Size

Individ.: cl: 365 ucl: 850.722 lcl: -120.722 * Rule violation
Range: cl: 182.632 ucl: 596.71 lcl: 0 Subgrp Size 1

Product Size (Lines)

Mean

Range

Mean

3sp Lim: (-291.2, 1021.2)

Samples: 20
Mean: 365
Std Dev: 218.73
Skewness: 1.4814

Causal Analysis
CNIR (Cluster 5) (Requirements)

Defect Density


- Defect Density (OP_DEF/KLines)

<table>
<thead>
<tr>
<th>ROW</th>
<th>DATE</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7/26/05</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>7/27/05</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>7/28/05</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>8/2/05</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>8/3/05</td>
<td>20</td>
</tr>
<tr>
<td>16</td>
<td>8/4/05</td>
<td>20</td>
</tr>
</tbody>
</table>

Causal Analysis

| SPC Indicator | Problem Description | Correction of Problem | Root Cause of Problem | Prevention of Root Cause |

- Mean: 10.899
- Std Dev: 14.95
- Skewness: 1.2704
- 3sp Lim: (-2.5568, 37.579)
α₁ = β₁ + γ₁
γ₁ = α₁ − β₁

α₂ + γ₁ = β₂ + γ₂
γ₂ = α₂ + γ₁ − β₂

Defect Modeling

α = Defects In
β = Defects Out
γ = Remaining Defects

"Defects In" is known, "Defects Out" is monitored --> Therefore “Remaining Defects” left in product can be determined
Expanded $\alpha\beta\gamma$ Chart

- $\alpha$: Prep Rate
- $\beta$: Inspect Rate
- $\gamma$: Effectiveness
- Size

Flowchart:
- Code
- Inspection

Connections:
- $\alpha$ from Code to Inspection
- $\beta$ from Inspection to Code
- $\gamma$ from Code to Inspection
- Size from Inspection to Code
Defect Detection Methods

- “Peer Reviews”
  - Inspections (Fagan)
  - Structured Walk-Through
  - Active Reviews

- Modeling and Simulation

- Testing
  - Unit
  - Integration
  - Formal/ Sell-off

- Various Effectiveness in Methods
Sources of Defect

- Ambiguous Requirements
- Incomplete Analysis of Requirements
- Misunderstood Requirements
- Poor Design
  - No Flexibility
  - Too General
- Error in Coding
- Complexity
- Miss-execution
- COTS
- Open Source
Types of Defects

- Logic (Most Prevalent)
- Computation
- Interface
  - External
  - Internal
- Data
Acceptable Defect Levels

- **Categories of Software:**
  - Demonstration (Proof of Concept)
  - Windows
  - Military
  - DO-178B
    - 5 Categories (affect of failure)
  - Manned Space Flight

- Level of latent defects permissible varies
  (Do not want to overkill; Too costly)
Defect Model (By the Numbers)

- **Know the Pedigree of Reused Code**
  - Reused (Fielded)
  - Reused (Not Fielded)
  - Modified
  - New

What is the Defect Density? **Not Simple**

- **0.2 Defects/ KSLOC**
- **25 Defects/ KSLOC**
## CNIR Defect Model

### New Functionality

<table>
<thead>
<tr>
<th>Phase</th>
<th>Insert</th>
<th>Detect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>Design</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Coding</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Test</td>
<td>0.2</td>
<td>≤4.6</td>
</tr>
<tr>
<td>FQT</td>
<td>0.1</td>
<td>≤2.5</td>
</tr>
</tbody>
</table>

CNIR #'s
## CNIR Defect Model

### Mod Functionality

<table>
<thead>
<tr>
<th>Phase</th>
<th>Insert</th>
<th>Detect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Design</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Coding</td>
<td>5.8</td>
<td>10</td>
</tr>
<tr>
<td>Test</td>
<td>0.2</td>
<td>≤4.6</td>
</tr>
<tr>
<td>FQT</td>
<td>0.1</td>
<td>≤2.5</td>
</tr>
</tbody>
</table>

**CNIR #'s**
Defect Cost Example

= 195.2 Total Defects

Therefore, 19.5 Defects/ KSLOC
Defect Cost Example (continued)

• 195 Defects in 9 KSLOC
  @ 100% Fagan Coverage
    ➔ 45 Fagan Inspections
  @ 20 Man Hours/ Inspection
    ➔ 900 Man Hours
Removing 156 Defects
  • 39 Defects Remaining

• 39 Defects
  @ 20 Man Hours/ Defect
    ➔ 780 Man Hours
  @ 40 Man Hours/ Defect
    ➔ 1,560 Man Hours

Total Cost: 1,880 – 2,460 Man Hour

Code/ Unit Test/ Integration
At 2 SLOC/ Man Hour, Total Cost = 4,500 Man Hours
Defect Cost Example (continued)

- 195 Defects in 9 KSLOC
  - @ 50% Fagan Coverage
    - 23 Fagan Inspections
  - @ 20 Man Hours/ Inspection
    - 460 Man Hours
  - Removing 62 Defects
    - 133 Defects Remaining

- 133 Defects
  - @ 20 Man Hours/ Defect
    - 2,660 Man Hours
  - @ 40 Man Hours/ Defect
    - 5,320 Man Hours

Total Cost: 3,120 - 5,780 Man Hours
Benefits of Method

• Quality of product is estimated quantitatively as components are created
  • Defects least costly to correct
• Systemic problems identified and steps taken to prevent repeating defects
• Additional defect detection activities can be added if deemed necessary
Conclusion

- Defect Modeling and Statistical Control of Quality provides the following advantages over the classical method
  - Technical Product Quality is objectively evaluated by personnel with domain knowledge using a formal proven approach
  - Estimate of defects remaining in product can be made throughout the product lifecycle
    - Corrective action can be taken early in the life cycle
    - Least costly to correct
  - The quality of the end product is known
    - Additional defect detection activities can be added if deemed necessary
  - Trend analysis of defects and root cause analysis can lead to proactively preventing future defects not only on the project, but throughout the organization
Contacts

Name: Randall Varga

Tel: 1-973-633-3470

email: Randall.Varga@BAESystems.com