Costs and Benefits of Quality

• ‘We never have the time to do a correct job the first time, but we always manage to find time to redo the job one or two times’.

• ‘I’d rather have it wrong than have it late. We can always fix it later’.
Contents

1. Cost of Quality (COQ) Equation
2. Cost of rework
3. Raytheon Case Study
4. BDM International – TRW Case Study
5. General Dynamics Case Study
6. Motorola Case Study
7. Boeing Case Study
8. AIS Case Study
9. Space Shuttle Data
10. COQ Implementation
11. Extended COQ
12. Problems during implementation

To be completed

- There are about ‘Y errors’ per 1000 lines of code
- It takes about ‘Z minutes’ to find each error
- It takes about ‘U hours’ to fix each error
Answers

- There are about ‘5 to 15 errors’ per 1000 lines of code
- It takes about ‘75 minutes’ to find each error
- It takes about ‘2 to 9 hours’ to fix each error

Where are the Costs of Non Quality?

1. Canceled software projects
2. Unsuccessful software products
3. Unnecessary features and functions
4. Hard to use software
5. Defective software
6. Difficult to maintain software
7. Poorly designed for growth and change
8. Non readiness
9. Difficult to integrate components
10. Less than excellent software process(es)

Why Use COQ?
The Visibility Problem – Invisible Costs

- excessive turnover
- poor teamwork
- lack of planning
- lack of competitive knowledge
- excessive systems costs
- poor problem handling
- stress due to constant overtime
- lost market opportunities
- lack of good practices & stds
- ineffective project performances


Traditional Cost of Poor Quality

Total Cost of Poor Quality

Project Cost

- Cost of Quality
  - Appraisal Costs: Reviews, Inspections, Testing, IV&V, Audits
  - Prevention Costs: Training, Methodologies, Tools, Data gathering

- Cost of Performance
  - Generation of plans
  - SW Development

- Cost of Conformance
  - Re-reviews
  - Fixing defects
  - Updating source code

Cost of Rework

1. Effort to recreate the problem
   – What the user did, what was the user’s configuration
   – May require setting up hardware, database, etc
2. Effort to trace failure to the cause
   • May require utilization of tools (e.g. debuggers)
3. Effort to implement a fix
   • May involve design change and changes to many components
4. Effort to develop and run tests
   – May require setting up hardware, database
5. Effort to update and run regression test suite
   – May require setting up hardware, database, etc
6. Effort to document the change, modify process or procedure and manage configuration changes (CCB)
7. Effort to package the fix and ship it to customers
8. Effort to inform or train users of the changes


Customer Failure Costs

• Types of costs absorbed by the customer who buys a defective product.
  – Wasted time
  – Lost data
  – Lost business
  – Embarrassment
  – Frustrated employees quit
  – Demos or presentations to potential customers fail because of the software
  – Failure when attempting other tasks that can only be done once
  – Cost of replacing product
  – Cost of reconfiguring the system
  – Cost of recovery software
  – Cost of tech support
  – Injury / death
  – Cost of lawsuits
  – Cost of bad publicity

Adapted from: Kaner, C., Quality Cost Analysis: Benefits and Risks, 1996.
Use of COQ

1. Provide a measure to compare the success/failure of various projects, and/or organizations
2. Provide cost/benefit justification and tracking for improvement initiatives
3. Provide cost data to demonstrate the relationship of employee efforts to the bottom line (e.g. effort vs. results)
4. Provide a basis for budgeting the quality management and assurance functions
5. Identify quality improvement candidates through causal analysis
6. Compare proposed process improvements and identify the most cost effective ones
7. Tune the quality costs on a particular project
   • By altering the process prior to, or even in situ.
8. Determine the potential cost/risk impact of specific quality trade-off decisions on specific projects


Cost of Quality Trade-offs

Examples of rework

<table>
<thead>
<tr>
<th>Company</th>
<th>Rework Rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRW</td>
<td>30%</td>
<td>(Boehm, 1987)</td>
</tr>
<tr>
<td>NASA-SEL</td>
<td>40%</td>
<td>(McGarry, 1987)</td>
</tr>
<tr>
<td>Hewlett-Packard</td>
<td>33%</td>
<td>(Duncker, 1992)</td>
</tr>
<tr>
<td>Raytheon</td>
<td>41%</td>
<td>(Dion, 1993)</td>
</tr>
</tbody>
</table>

CMMI – Staged Representation

<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Process Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Optimizing</td>
<td>Continuous Process</td>
<td>Organizational Innovation and Deployment</td>
</tr>
<tr>
<td></td>
<td>Improvement</td>
<td>Causal Analysis and Resolution</td>
</tr>
<tr>
<td>4 Quantitatively Managed</td>
<td>Quantitative Management</td>
<td>Organizational Process Performance</td>
</tr>
<tr>
<td>3 Defined</td>
<td>Process Standardization</td>
<td>Requirements Development, Technical Solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Product Integration, Verification, Validation</td>
</tr>
<tr>
<td>2 Managed</td>
<td>Basic Project</td>
<td>Requirements Management, Project Planning, Project Monitoring and Control</td>
</tr>
<tr>
<td></td>
<td>Management</td>
<td>Supplier Agreement Management, Measurement and Analysis, Process and Product</td>
</tr>
<tr>
<td>1 Initial</td>
<td></td>
<td>Quality Assurance, Configuration Management</td>
</tr>
</tbody>
</table>

Source: Software Engineering Institute, Carnegie Mellon University

Cost Predictability

-40 % Overrun

3 % Range

Productivity Increase

170 % Increase
Defect Density

\[ \text{Defect Density} = \frac{\text{Defects}}{\text{Thousand LOC}} \]

Cost Reduction
Costs and Benefits

- CMM level 1
- CMM level 3
- TCoSQ
- Prevention
- Appraisal
- Rework

Cost of Conformance

Cost of Prevention

Cost of Appraisal

Cost of Rework

Cost of Performance

Quality (Defects/KLOC)

Site A
- USA Engineers (19)
- USA Managers (5)
- Europe Engineers (13)
- Europe Engineers (14)
- Europe Engineers (9)

Site A
- USA Engineers (5)
- USA Managers (13)
- Europe Engineers (14)
- Europe Engineers (9)

Site B
- Europe Engineers (11)
- Europe Engineers (16)
- Europe Engineers (8)
- Europe Engineers (7)

Site C
- Europe Engineers (11)
- Europe Engineers (16)
- Europe Engineers (8)
- Europe Engineers (7)

Site D
- Europe Engineers (11)
- Europe Engineers (16)
- Europe Engineers (8)
- Europe Engineers (7)

Cost of Non Conformance and Quality of Product

- In a Multi National Organization*

* Transport Domain
Cost of Non Conformance and Quality of Product

- Data from graduate students of SQA courses

<table>
<thead>
<tr>
<th></th>
<th>Course A 2008* (8)</th>
<th>Course B 2008 (14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Performance</td>
<td>29%</td>
<td>43%</td>
</tr>
<tr>
<td>Cost of Rework</td>
<td>24%</td>
<td>18%</td>
</tr>
<tr>
<td>Cost of Appraisal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Prevention</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>Quality (Defects/KLOC)</td>
<td>403</td>
<td>19</td>
</tr>
</tbody>
</table>

* (X) = Number of students
A = Aerospace Domain (Mirabel)

Software Defect Injection

System Development Phase

Range of Cost to Find and Fix Defects
In-Phase and Out-of-Phase

<table>
<thead>
<tr>
<th>Found</th>
<th>Inception</th>
<th>Elaboration</th>
<th>Construction</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injected</td>
<td>$25 to $100/defect</td>
<td>$50 to $250/defect</td>
<td>$75 to $500/defect</td>
<td>Not enough data</td>
</tr>
<tr>
<td>Inception</td>
<td>$100 to $500/defect</td>
<td>$250 to $1.5K/defect</td>
<td>$500 to $3K/defect</td>
<td></td>
</tr>
<tr>
<td>Elaboration</td>
<td>$500 to $1K/defect</td>
<td>$1.5K to $5K/defect</td>
<td>$3K to $10K/defect</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>$8K to $10K/defect</td>
<td>$1.5K to $5K/defect</td>
<td>$500 to $10K/defect</td>
<td></td>
</tr>
<tr>
<td>Transition</td>
<td>$10K/defect</td>
<td>$5K/defect</td>
<td>$3K/defect</td>
<td></td>
</tr>
</tbody>
</table>

Defect costs computed for the entire engineering organization at large.
Burdened cost per person-month again averages $15K (2005 year $).

Intangible Benefits of SPI

- Improved quality of work life/working conditions
  - Fewer overtime hours
  - Fewer problems/crises
  - Less stress/pressure
  - Increased levels of confidence
  - More stable work environment
- Improved organisation communications
  - Improved communications upwards to management
  - Improved communications downwards from management
  - Improved communications across projects/teams
- Improved organisation learning and efficiencies
  - Improved ability to educate/train software professionals
  - Improved understanding of how the organisation develops software
  - Improved portability of people across projects/teams
  - Improved ability to change
- Improved ability to attract, retain and develop software professionals
  - Improved ability to recruit new staff
  - Fewer resignations
  - Better opportunities for promotion and development
- More coherent organisation culture
  - Improved understanding of the organisation’s mission and vision
  - Shared sense of pride
  - Participation in process improvement activities
  - Improved morale

Reifer, D., Profiles of Level 5 CMMI Organizations, Crosstalk, January 2007, p24-28
BDM International - TRW

- BDM International is a $1 billion per year IT company.
  - In December 1997 BDM International was acquired by TRW
- Operates in three interrelated markets:
  - Systems and software integration,
  - Computer and technical services and
  - Enterprise management and operations
- From 1985 to 1994, BDM’s Systems Integration group developed approximately 3.5 million lines of code for the requirement determination portion of a material requirements planning (MRP) system.


Process Improvement Initiatives

- **Process Improvement #1:**
  - Creation of life-cycle [development standards](#)
  - Introduction of computer-aided software engineering (CASE) tools.
- **Process Improvement #2:**
  - Increasing minimum [educational](#) requirements for hiring,
  - Integration of BDM’s Software Blueprint® [methodology](#) with the CASE tools,
  - Creation of detailed [style guides](#) for documentation,
  - Institutionalization of [weekly](#) program management [status reviews](#).
- **Process Improvement #3:**
  - Integration of the CASE technology with the [publications department](#),
  - Addition of schedule and [performance metrics](#), automated development cost estimation, [automated software configuration](#), and [Pareto analysis*](#).
- **Process Improvement #4:**
  - Cycle time analysis
  - Development of an automated support [cost estimation methodology](#).
BDM International - TRW

Pareto Analysis

<table>
<thead>
<tr>
<th>Defect Category</th>
<th>Number of Defects</th>
<th>Cumulative Percent of Defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>JCL</td>
<td>51</td>
<td>6.1%</td>
</tr>
<tr>
<td>Program Logic</td>
<td>26</td>
<td>72.1%</td>
</tr>
<tr>
<td>Support Documentation</td>
<td>46</td>
<td>81.1%</td>
</tr>
<tr>
<td>Database</td>
<td>18</td>
<td>87.6%</td>
</tr>
<tr>
<td>Specification</td>
<td>13</td>
<td>93.0%</td>
</tr>
<tr>
<td>CICS</td>
<td>11</td>
<td>97.0%</td>
</tr>
<tr>
<td>Migration</td>
<td>8</td>
<td>100.0%</td>
</tr>
<tr>
<td>Test Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirement Change</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

COQ at BDM

Defect Density

COQ at BDM in $ per LOC

Return on Investment (ROI) at BDM

- Cost of non-conformance decreased from 32$ to 9$ per line of code
- Conformance cost is largely fixed over the project at 14$ per line of code

<table>
<thead>
<tr>
<th>Return Type</th>
<th>Improvement #1</th>
<th>Improvement #2</th>
<th>Improvement #3</th>
<th>Improvement #4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPVCF</td>
<td>$1,814,370</td>
<td>$1,193,420</td>
<td>$2,099,510</td>
<td>$1,115,470</td>
</tr>
<tr>
<td>NPVQC</td>
<td>$227,150</td>
<td>$226,720</td>
<td>$3,580,990</td>
<td>$1,058,850</td>
</tr>
<tr>
<td>ROSQ</td>
<td>194%</td>
<td>53%</td>
<td>59%</td>
<td>105%</td>
</tr>
<tr>
<td>SQPI</td>
<td>3.81</td>
<td>3.65</td>
<td>2.94</td>
<td></td>
</tr>
</tbody>
</table>

ROSQ = Return on software quality
SQPI = Software quality profitability index
General Dynamics
Decision Systems

- Supplier of Communications and Information Technology for military and government customers
- 1,500 engineers
  - 360 software engineers
- Process Improvement **Budget**
  - 2.5% of base staffing of 360 engineers


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General Dynamics
Customer Reported Unique Defects (CRUD)

[Graph showing CRUD Density Improvement vs. CMM Level (Based on Latent Defect Predictions)]

*6/21/2008 35*
Phase Containment
- Detection of defects within the same phase in which it was created
- Goal of 85%. Causal analysis is used to improve

General Dynamics
Productivity Increase
General Dynamics
Reduction of Rework

In Process Rework vs. CMM Level

<table>
<thead>
<tr>
<th>CMM Level</th>
<th>CRUD for 100 KSLOC</th>
<th>Post Release Rework (hrs)</th>
<th>Pre Release Rework (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 5</td>
<td>19.11567615</td>
<td>306</td>
<td>2.397</td>
</tr>
<tr>
<td>Level 4</td>
<td>22.0952381</td>
<td>354</td>
<td>3.358</td>
</tr>
<tr>
<td>Level 3</td>
<td>88.25757576</td>
<td>1,412</td>
<td>5.043</td>
</tr>
<tr>
<td>Level 2</td>
<td>315.8653846</td>
<td>5,054</td>
<td>8,208</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CMM Level Transition</th>
<th>Cost for SPI in hrs (2.5% of Base)</th>
<th>Cost Savings on Rework (hrs)</th>
<th>Return on Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 to 5</td>
<td>984</td>
<td>1,009</td>
<td>14%</td>
</tr>
<tr>
<td>Level 3 to 4</td>
<td>1,310</td>
<td>2,744</td>
<td>199%</td>
</tr>
<tr>
<td>Level 2 to 3</td>
<td>2,544</td>
<td>6,806</td>
<td>167%</td>
</tr>
</tbody>
</table>

- ROI for level 5 should be higher after at least one year at that level
General Dynamics
Better-Faster-Cheaper

![Table of CMM Levels and Measures](image)


### Motorola

<table>
<thead>
<tr>
<th>CMM Level</th>
<th>Quality</th>
<th>Cycle Time</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defects/MAELOC</td>
<td>X Factor</td>
<td>Relative</td>
</tr>
<tr>
<td>1</td>
<td>n/a</td>
<td>1.0</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>890</td>
<td>3.2</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>411</td>
<td>2.7</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>205</td>
<td>5.0</td>
<td>2.3</td>
</tr>
<tr>
<td>5</td>
<td>126</td>
<td>7.8</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Vu, John, ‘Software Process Improvement Journey (From Level 1 To Level 5), SEPG Conference, 1997.'
Defect Management: Benefit Ratio
Introduction of Review/Inspection

Implementing Formal Review/Inspection increased design effort by 4%
decreased rework effort by 31%

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

Quality Level at Acceptance Tests

Advanced Information Services Inc (AIS), SEPG 2000
### Space Shuttle

**Space Shuttle Error Rate Test Trend**

<table>
<thead>
<tr>
<th>Flight Software Operational Increments (releases)</th>
<th>Actual</th>
<th>Expected</th>
<th>95% High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

Keller (1992)

### Thorn EMI (Racal), UK

**Thorn EMI (Racal), UK**

<table>
<thead>
<tr>
<th>Defect found at stage:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defect occurred at stage:</td>
<td>1. Proposal / contract</td>
<td>1.0</td>
<td>1.3</td>
<td>2.4</td>
<td>3.3</td>
<td>6.8</td>
<td>26</td>
</tr>
<tr>
<td>2. System requirements</td>
<td>-</td>
<td>1.0</td>
<td>1.8</td>
<td>2.4</td>
<td>5.1</td>
<td>19</td>
<td>72</td>
</tr>
<tr>
<td>3. Preliminary design</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>1.3</td>
<td>2.8</td>
<td>11</td>
<td>39</td>
</tr>
<tr>
<td>4. Detailed design</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>2.1</td>
<td>8.0</td>
<td>30</td>
</tr>
<tr>
<td>5. Unit test</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>3.8</td>
<td>14</td>
</tr>
<tr>
<td>6. System integration</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>3.7</td>
</tr>
<tr>
<td>7. Operation/usage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Example:** A defect that occurred at stage 2 (system requirements) and is detected at stage 6 (system integration) is 19 more expensive to fix.
Pouvez-vous énumérer des coûts des anomalies internes et externes ?

---

Coûts de la non-qualité
Le coût des anomalies internes pendant le développement

1. Détection des défauts
2. Réparation des défauts
3. Modifications
4. Rebuts
5. Produits déclassés
6. Achats inemployables
7. Produits à refaire d’une version à l’autre
Coûts de la non-qualité
Le coût des anomalies externes

1. Pertes de clients
2. Pénalités
3. Réparations des défauts pendant l’exploitation
4. Remises pour défauts
5. Assistance technique
6. Modifications ou adaptations prohibitives
7. ‘Retrofits’ sur le produit
8. Entretien des matériels de maintenance corrective et des compétences

Les enjeux

• Commerciaux
  – Relations avec le client
  – Réputation
• Économiques
  – Rencontre du coût prévu
  – Rencontre de l’échéancier prévu
• Techniques
  – Rencontre des objectifs
    • De productivité,
    • De maintenance
    • De performance
    • De sécurité, etc.
Ce qui détermine les qualités d’un système

1. Vies humaines en danger (sécurité, fiabilité, ergonomie, conformité)
2. Grande durée de vie (maintenabilité, portabilité, flexibilité)
3. Système expérimental (testabilité)
4. Application embarquée (disponibilité, testabilité)
5. Données sensibles (robustesse, intégrité)
6. Impact d’une défaillance (fiabilité, sécurité)
7. Appartenance à une gamme de produits (réutilisabilité, portabilité)
8. Ressources disponibles (efficacité, portabilité)

Notes: 1. A defect found at requirement phase costs $25 to fix.
2. UT= Unit Test
SIT/SAT= System Integration & Test/System Acceptance Test
Defect Detection Changes as Process Maturity Increases

Where Defects are Introduced

<table>
<thead>
<tr>
<th>Req'ts</th>
<th>Design</th>
<th>Code</th>
<th>Functional Test</th>
<th>System Test</th>
<th>Field Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Relative Cost to Fix

<table>
<thead>
<tr>
<th>Level</th>
<th>Where Defects Are Detected</th>
<th>0%</th>
<th>0%</th>
<th>2%</th>
<th>15%</th>
<th>50%</th>
<th>33%</th>
<th>Relative Cost for 100 Fixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>15%</td>
<td>50%</td>
<td>33%</td>
<td>$4,000</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>30%</td>
<td>17%</td>
<td></td>
<td>$2,500</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>0%</td>
<td>2%</td>
<td>20%</td>
<td>38%</td>
<td>32%</td>
<td>8%</td>
<td>$1,400</td>
<td></td>
</tr>
<tr>
<td>Level 4</td>
<td>3%</td>
<td>12%</td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Level 5</td>
<td>5%</td>
<td>20%</td>
<td>10%</td>
<td>20%</td>
<td>10%</td>
<td>&lt;5%</td>
<td>$800</td>
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Extended COQ

Cost of software quality

Costs of Control costs

- Prevention costs
- Appraisal costs
- Managerial preparations and control costs

Costs of Failure of control costs

- Internal failure costs
- External failure costs
- Managerial failure costs

Extended COQ  
Managerial Preparation and Control Costs

- Costs of carrying out contract reviews  
- Costs of preparing project plans, including quality plans  
- Costs of periodic updating of project and quality plans  
- Costs of performing regular progress control  
- Costs of performing regular progress control of external participants’ contributions to projects


Extended COQ  
Managerial Failure Costs

- **Unplanned costs** for professional and other resources, resulting from underestimation of the resources in the proposal stage.  
- **Damages** paid to customers as compensation for late project completion, a result of the unrealistic schedule in the Company’s proposal.  
- Damages paid to customers as compensation for late completion of the project, a result of management’s failure to recruit team members.  
- **Domino effect**: Damages to other projects planned to be performed by the same teams involved in the delayed projects. The domino effect may induce considerable hidden external failure costs.

**Tips on Implementing COQ**

1. **Initiating a COQ effort**
   - Convincing management, modest investment, KISS.

2. **Accounting and gathering the quality cost data**
   - Sources of data may not fully exist; rough estimates are OK; whose job is it?

3. **Gathering the related quality metrics**
   - May be scattered around QA, developers, customer support

4. **Presenting and using the results**
   - Look first at the trends in quality costs as a percent of sales, profit and/or total development costs; and then the deeper meanings

5. **Improving the COQ program continuously**
   - Expect difficulties which can be overcome with appropriate training/coaching - learn and apply the lessons from trials and early adopters


**Project Charge Codes**

- Codes for charging time to project activities are 10 characters: **TT_PPPP_ANN_Q**
  - TT = 2 characters for process type, for example SW for software
  - PPPP = 4 characters that designate a project
  - ANN = 3 characters that designate the activity in the WBS, such as A01
  - Q = 1 character that designates the category relative to quality costs. The value of Q is one of the following:
    - D Initial Development of Work Products
    - P Defect Prevention Activities
    - T Initial Test of Work Product
    - R Product Rework
    - M Miscellaneous/Other

**Tips on Implementing COQ**

<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>P</th>
<th>T</th>
<th>R</th>
<th>M</th>
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<tbody>
<tr>
<td>A01</td>
<td>Project Management Planning</td>
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<tr>
<td>A02</td>
<td>Requirements Development/Validation</td>
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<tr>
<td>A03</td>
<td>Product Concept Development</td>
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<td>Requirements Analysis</td>
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<td>Functional Concept Development</td>
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<td>Define Architecture</td>
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<td>Test Plan Development</td>
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<td>A08</td>
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**Implementing COQ**

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<thead>
<tr>
<th>Year</th>
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<th>Testing</th>
<th>Rework</th>
<th>Total</th>
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<td>1995</td>
<td>1.16</td>
<td>1.023</td>
<td>0.685</td>
<td>2.874</td>
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<tr>
<td>1996</td>
<td>3.316</td>
<td>5.499</td>
<td>0.635</td>
<td>9.440</td>
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BSCE Cost of Software Quality

Cost ($1000)
Problems in the application of COQ

• General problems
  – Inaccurate and/or incomplete identification and classification of quality costs.
  – Negligent reporting by team members
  – Biased reporting of software costs, especially of “censored” internal and external costs.
  – Biased recording of external failure costs - “camouflaged” compensation of customers for failures.

• Problems arising when collecting data on managerial costs
  – Contract review and progress control activities are performed in a “part-time mode”. The reporting of time invested is usually inaccurate and often neglected.
  – Many participants in these activities are senior staff members who are not required to report use of their time resources.
  – Difficulties in determination of responsibility for schedule failures.
  – Payment of overt and formal compensation usually occurs quite some time after the project is completed, and much too late for efficient application of the lessons learned.

Conclusion

1. COQ is a useful technique
   • it uses the common metric of $$$,
   • it helps unify business and technical decisions about software quality
2. COQ will make the economics of software quality visible in your organization
   • allowing quality to participate in decisions equally with cost and schedule concerns
3. COQ has been used successfully to measure the impact (ROI) of organizational software improvement programs (PI)
4. COQ is now being used to guide, as well as measure, effective software quality improvement programs
5. Introducing COQ into an organization will cause useful discussions about what is quality and the value of software quality

Summary

1. Cost of Quality (COQ) Equation
2. Cost of rework
3. Raytheon Case Study
4. BDM International – TRW Case Study
5. General Dynamics Case Study
6. Motorola Case Study
7. Boeing Case Study
8. AIS Case Study
9. Space Shuttle Data
10. COQ implementation

‘It cost a lot to build bad products’.
Norman Augustine, Former CEO - Martin Marietta.