

Root Cause Analysis for Customer Reported Problems

Software Quality Consulting Inc.

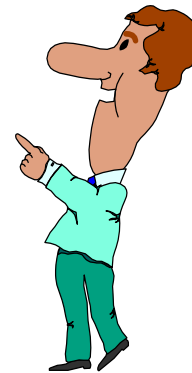
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Slide 1

Topics

- **Introduction**
 - Motivation
 - Software Defect Costs
- **Root Cause Analysis**
 - Terminology
 - Tools and Process
- **Integrating RCA into Defect Life Cycle**
 - Triage Team
- **Summary and Action Plan**



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Slide 2

Motivation

- **Customer Reported Problems (CRPs) are critically important**
 - Represent gaps in knowledge of how customers use software
 - May reflect deficiencies in development and test processes
 - Often lead to disruptive, expensive, unplanned releases
- **CRPs represent opportunities:**
 - To turn potential dissatisfaction into satisfaction
 - To learn more about how customers use your software
 - To identify areas for process improvement...

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Motivation

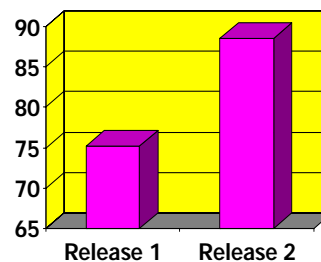
- **How successful are you at finding defects your customers are likely to find?**

$$\frac{\text{Total defects you found}}{\text{Total you found} + \text{Customer-reported defects}}$$

- based on at least n months of Customer use

- **Use of this measure...**

How good a job are we doing of
Act Like a Customer Testing™?



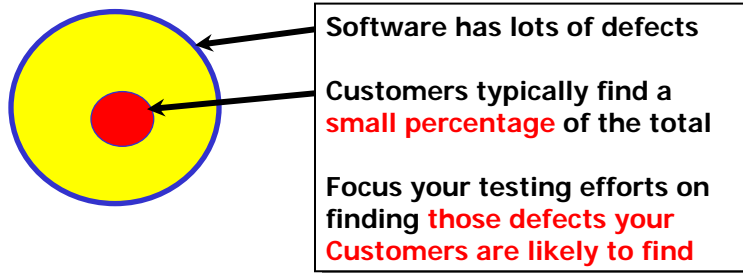
Act Like a Customer Testing is a trademark of Software Quality Consulting, Inc.
Jones, C., "Software defect-removal Efficiency", *IEEE Computer*, Vol. 29, No. 4, April 1996, pp. 94-95.

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Motivation

- **Act Like a Customer Testing™**
 - Testers need **domain knowledge** to be effective
 - Write tests based on customer use in their environment



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Root Cause Analysis

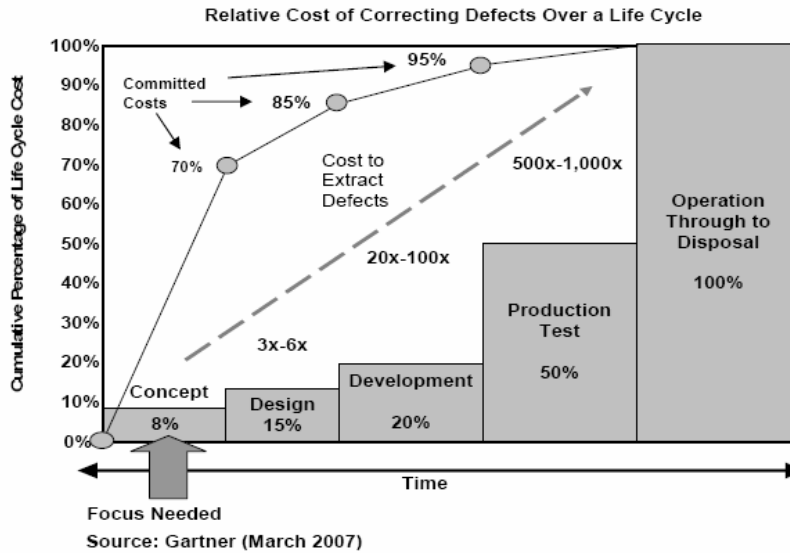
- **Root Cause Analysis (RCA)** helps:
 - understand causes of **customer dissatisfaction**
 - reduce expensive rework by **preventing recurrence**
 - identify **process weaknesses**
 - improve **customer satisfaction**
- **RCA can provide answers to:**
 - **What happened?**
 - **Why did it happen?**
 - **How did we miss it?**
 - **What can we do to prevent it?**



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Software Defect Costs



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Software Defect Costs

- A recent study commissioned by National Institute of Standards and Technology found that **defective software costs US economy \$60 billion annually**
- Are you measuring your defect costs?



The Economic Impacts of Inadequate Infrastructure for Software Testing, NIST Planning Report 02-3, May 2002

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Software Defect Costs

Pre-release Find/Fix Cycle

Cycle can take from **10-30 hours per defect**

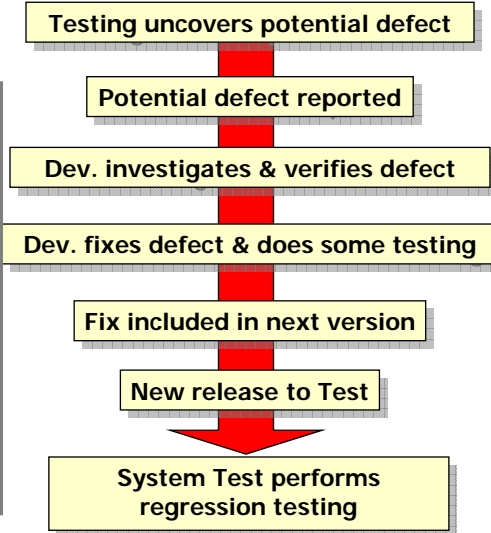
Use **\$150** as **fully loaded labor cost** for Engineering time...

Cost per defect is:

$$30 \times \$150 = \$4,500$$

For 100 defects:

$$3,000 \times \$150 = \$450,000$$



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Software Defect Costs

Post-release Find/Fix Cycle

Cycle can take **20-60 hours per defect**

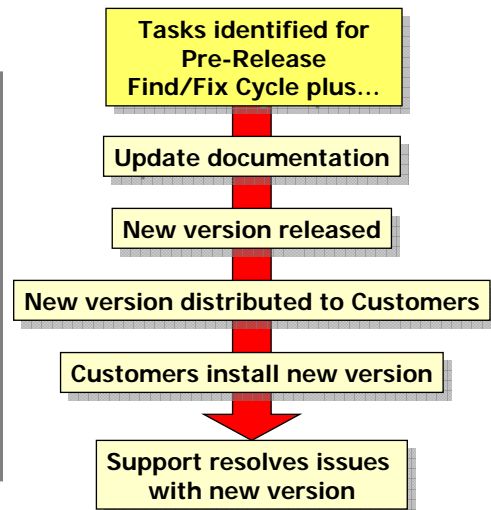
Use **\$150** **fully loaded labor cost** for Engineering time...

Cost per defect is:

$$60 \times \$150 = \$9,000$$

For 100 defects:

$$6,000 \times \$150 = \$900,000$$



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Software Defect Costs



Dr. Harlan Mills
IBM Fellow

“Programs do not acquire bugs as people acquire germs, by hanging around other buggy programs. Programmers must insert them.”



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Software Defect Costs

- **Reported Defect Injection Rates for a sample of 810 experienced software engineers:**

Group	Avg. no. defects injected per (KLOC)
All	120.8 KLOC = 1 defect per 8 LOC
Upper Quartile	61.9
Upper 10%	28.9
Upper 1%	11.2

- **Software is released with some known defects and a significant number of unknown defects**

Humphrey, W., "The Quality Attitude", *news@sei newsletter*, Number 3, 2004.

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Software Defect Costs

- Please try this at work:

$$\frac{\text{Defects injected} - \text{Defects found}}{\text{Estimated no. of unknown defects}}$$

where: **defects injected** = size (KLOC) X 120.8



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Software Defect Costs

- A simple example...
- One million LOC = 1,000 KLOCs
 - Avg. defect injection rate of 120 defects/KLOC
 - **120,000** defects injected
 - Assume 95% found = **114,000** defects found
- **Unknown defects** = defects injected – defects found
 - = (120,000 – 114,000)
 - = **6,000**



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Root Cause Analysis

- Used to investigate **root cause** of major disasters:
 - Airplane crashes
 - Space Shuttle accidents
 - Chemical and nuclear plant disasters
- **RCA** requires effective problem solving skills
- Finding **root cause** may be difficult because:
 - We have an incomplete problem definition
 - **Causal relationships** are unknown
 - We often focus on finding solutions and assigning blame



Gano, D., et. al., [Apollo Root Cause Analysis – A New Way Of Thinking](#), Apollonian Publications, 1999

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Terminology

- **Event**
 - Any failure of software and services (including code, documentation, installation, customization, training, etc.) that impacts customers
- **Causal Factors**
 - Factors that contribute to occurrence of an **event**
- **Causal Relationships**
 - Cause and effect sequence in which a specific action creates a condition that contributes to or results in an **event**



US Dept of Energy, [Root Cause Analysis Guidance Document](#), DOE-NE-STD-1004-92, February 1992

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Terminology

- **Corrective Action (CA)**
 - Action to eliminate **root cause** of a **reported problem**
 - **Immediate CA** is taken **soon after problem is reported to help customer recover...**
 - **workaround, hot fix, etc.**
 - **Long Term CA** taken to prevent **recurrence**
 - **results in changes to process and procedures**

Quality Management Systems – Fundamentals and Vocabulary, ISO-9000:2000

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Terminology

- **Root Cause**
 - Cause that, if corrected, prevents **recurrence** of this and similar **events**
 - **Attributes of root causes:**
 - Represent specific underlying causes of **events...**
 - Can be **reasonably identified...**
 - Can be **fixed by Management...**
 - Lead to effective **corrective actions...**



Rooney, J. and Vanden Heuvel, L., "Root Cause Analysis for Beginners", *ASQ Quality Progress*, July 2004, p. 45-53

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Terminology

- **Root Causes represent specific underlying causes of events...**
 - Goal is to identify **specific underlying causes**
 - More specific investigation is about why an **event** occurred, easier it is to recommend changes that prevent recurrence
- **RCA Process needs to be reasonable...**
 - Investigation must be **cost-effective**
 - Good **RCA Process** helps keep **ROI high**

Rooney, J. and Vanden Heuvel, L., "Root Cause Analysis for Beginners", *ASQ Quality Progress*, July 2004, p. 45-53

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Terminology

- **Root Causes can be fixed by Management**
 - Vague classifications such as "operator error", "hardware failure", or "external factors" are not helpful
 - We need to know exactly **why** an **event** occurred before effective **CA** can be taken to **prevent recurrence**
- **Root Causes lead to effective CA**
 - Corrective Actions should directly address identified **root causes**
 - If recommendations are vague -- specific **root cause** was probably not found

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Terminology

- **Root Cause Analysis (RCA)**
 - Process of investigating, understanding, categorizing **root causes**
 - Performed by **small cross-functional team** as part of **Triage Process**
 - Analysis based on **factual information** obtained from:
 - **Documents and records**
 - **Interviews**
 - **Brainstorming sessions**
 - Use tools such as:
 - **Why Tree**
 - **Pareto Analysis**



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Tools – Why Tree

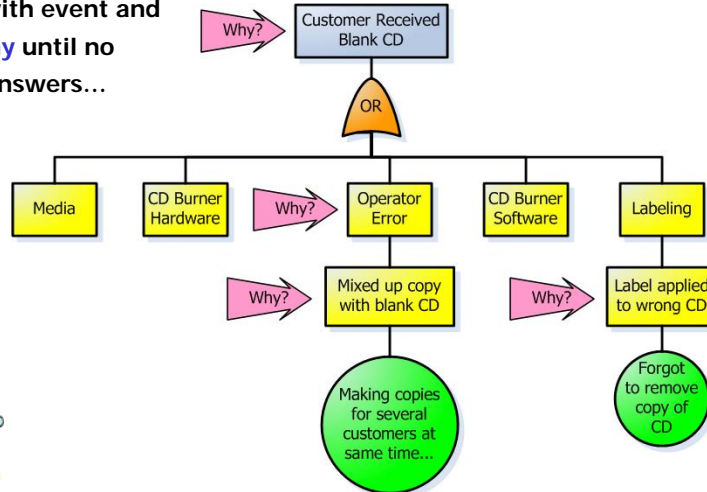
- **Can help identify an appropriate CA...**
 - **What** should be done **immediately** to resolve this **CRP...**
 - **What** should be done **long term** to **prevent recurrence...**
 - What is it about **way we work** that allowed this event to occur?
 - Most **root causes** are found in **way we work...**
- **Start with a specific event** and ask **Why did this happen?**

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Tools – Why Tree

- Start with event and ask **Why** until no more answers...



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Immediate Corrective Action

- Use **Why Tree** to help develop an **Immediate CA**
 - Workaround, hot fix, patch, new CD, config changes, ...
 - Implement **CA**
 - Collect data to determine effectiveness with Customer
 - Document **Immediate CA** in **Bug Tracking System**
 - Add results of **RCA** as attachment to **CRP**...
 - Identify effectiveness measures...
 - determines if **CA** resolves problem...
 - ensures that real **root cause** found



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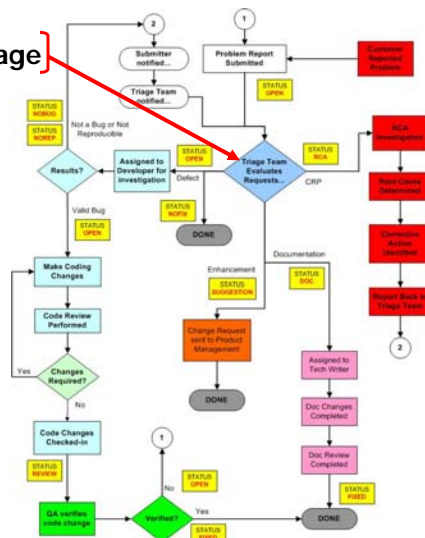
Long Term Corrective Action

- Use **Why Tree** to develop **Long Term CA**
 - Review existing business processes and procedures
 - Identify **process weaknesses** directly related to **root cause**
 - Identify recommendations to **prevent recurrence**
 - Some changes may require Management review and approval...
 - Identify **effectiveness measures**...
 - determine if **long term CA** prevents recurrence
 - **Implement** recommendations...
 - Collect data to determine **effectiveness**...
 - Document **Long Term CA** in **Bug Tracking System**...



RCA Process

- **RCA Process** occurs as part of Triage
- **Triage Team** reviews all **CRPs**
- Consider **RCA** for all **CRPs**
- Triage Team appoints **RCA Team** to investigate...
 - **Support, SQA, Dev**
- Report back to Triage Team...



RCA Process

• Step 1 - Data Collection

- Majority of time analyzing events is spent gathering data and information
- Complete information and thorough understanding of events required to identify **causal factors** and **real root causes**
- Begin with accurate statement of what happened **in Customer's own words**
 - Descriptions of **events** in Customer's language is sometimes "filtered"...
 - Data collection will initially be sketchy – use **Why Tree** to identify additional data to collect...

Rooney, J. and Vanden Heuvel, L., "Root Cause Analysis for Beginners", *ASQ Quality Progress*, July 2004, p. 45-53

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RCA Process

• Step 1 - Data Collection

- **Collect general information about Customer:**
 - Is Customer power user or novice?
 - Has Customer received training?
 - Is Customer's use and/or data unique?
 - **More questions?**
- **Collect information about Customer's environment:**
 - Standard release or customer-specific release?
 - Platform/database/operating system releases?
 - Received hot fixes recently? Installed?
 - **More questions?**
- **Customer Support staff can help gather this information**
 - Use checklist of questions to ask when Customer calls

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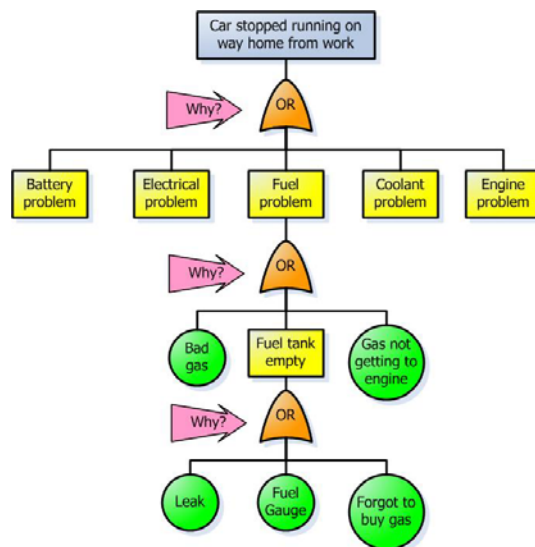
RCA Process

- **Step 2 – Determine What Happened**
 - Start creating a **Why Tree...**
 - Begin with **event** in **Customer's language...**
 - "Application crashed on startup..."
 - Then ask **Why?**
 - Continue asking **Why** until there are no more answers
 - **Process will identify additional information to collect...**
 - Was feature defined in Requirements Spec?
 - Was feature tested? If so, how?
 - Was user training effective?
 - Are there metadata, platform, or configuration issues?
 - **Other questions?**

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Simple Example



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RCA Process

- **Step 3 – Identify Immediate Corrective Action**
 - Based on info collected, RCA Team identifies an **immediate CA** to resolve customer's immediate problem
 - RCA Team also identifies effectiveness checks...
 - Determines if **immediate CA** resolves customer's problem
 - **Immediate CA** is implemented...
 - RCA Team:
 - collects data from customer to verify **effectiveness**
 - **immediate CA** and other relevant info attached to CRP in **Bug Tracking System...**
 - reports back to **Triage Team** with results and effectiveness...

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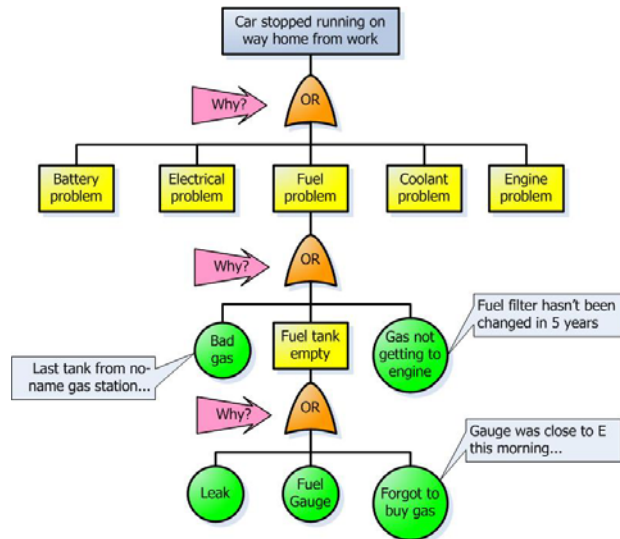
RCA Process

- **Step 4 - Root Cause Identification**
 - Based on **Why Tree and supporting information**
 - **RCA Team** reviews info and identifies most probable **root causes...**
 - Ensure that most probable **root causes** meet criteria:
 - Represent specific underlying causes of **events...**
 - Can be **reasonably identified...**
 - Can be **fixed by Management...**
 - Can lead to effective **corrective actions...**
 - **Root cause** documented and results attached to **CRP** in **Bug Tracking System...**

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Simple Example



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RCA Process

- **Step 5 – Long Term Corrective Action**
 - Most **root causes** found in **way you work**...
 - Review process and procedures...
 - Long term CA often results in changes to **way you work**
 - Are procedures written? Followed?
 - Unwritten procedures result in inconsistent results
 - Are existing procedures/training ineffective?
 - Are additional procedures/training required?
 - **Effectiveness Measures**...
 - How will you know that **root cause** has been eliminated?

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RCA Tools – Pareto Analysis

- 80% problems result from 20% causes
- Can help determine what problems to address
- As **root causes** are identified, add them to list...

RC	Root Cause Description
1	Feature was defined but not tested
2	Feature was tested but the test was inadequate
3	Feature was not defined in Functional Spec
4	Feature was defined in Functional Spec but not in Use Cases
5	Design was inadequate/inappropriate - Design review not held
6	Design was inadequate/inappropriate - Design review didn't catch it
7	Coding was inadequate/incorrect - Code review not held
8	Coding was inadequate/incorrect - Code review didn't catch it
9	Installation / configuration issues...
10	Metadata issues...
11	Environment / Version compatibility issues...
12	User training issues...

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RCA Tools – Pareto Analysis

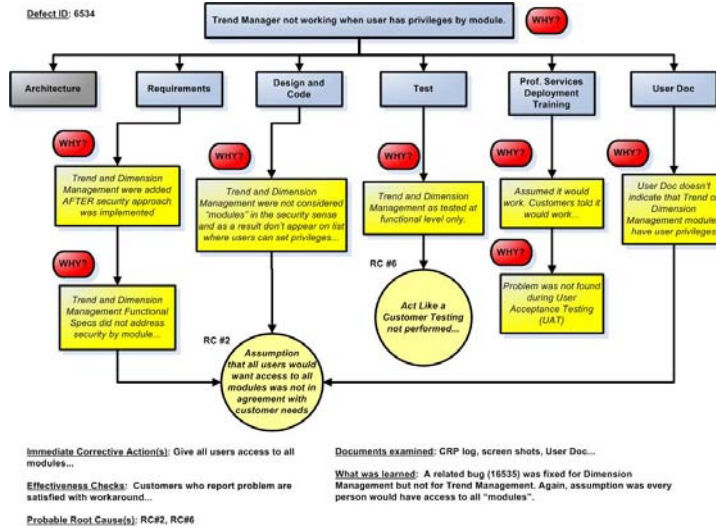
Use Pareto Analysis to identify root causes that warrant long term corrective action

CRP #	RC #1	RC #2	RC #3	RC #4	Etc...
403	✓		✓		
508		✓	✓	✓	
990		✓			
1112	✓	✓		✓	
1133		✓			
1244					
1456		✓			
1789		✓			
2134					
2367		✓			
Totals	2	7	2	2	

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Real Example



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Summary

- **RCA Process...**
 - Can be very effective at discovering **real root causes**
 - Helps identify **WHAT, WHY, and HOW**
 - Leads to **immediate CA and long term CA**
 - Improves Customer Satisfaction
 - Reduces rework and eliminates unplanned releases
 - Fits within **typical Defect Life Cycle Process**
 - Performed by **Triage Team** with support from staff
 - Includes **effectiveness measures** to determine if **CA** is effective

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Additional Workshops

- Software Development for Medical Device Manufacturers
- Peer Reviews and Inspections
- Computer System Validation
- Risk Management
- Writing and Reviewing Requirements for Software
- Software Verification & Validation
- 21 CFR Part 11: Electronic Records and Electronic Signatures
- Process Validation
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Additional Workshops

- Project Retrospectives
- Root Cause Analysis for Customer Reported Problems
- Writing Software Requirements
- Estimating and Scheduling Best Practices
- Software Verification & Validation for Practitioners and Managers
- Accurate Schedules Using the Yellow Sticky Method
- Predictable Software Development TM
- Peer Reviews and Inspections
- Improving the Effectiveness of Testing
- Risk Management for Embedded Software Development
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Thank you...

- If you have questions, please call or e-mail...
- **Subscribe to my e-newsletter...**  The logo for 'Food for Thought' features the text in a red, handwritten-style font, flanked by two circular icons containing a stylized '@' symbol.
- For a free subscription and to view past newsletters, visit www.swqual.com

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