



**SE-3002**

# **SOFTWARE QUALITY ENGINEERING**

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## **Quality types & quality cost**

Overview and Basics

### **Lecture # 4,5,6**

# TODAY'S OUTLINE

- Types of Quality
- QA VS QC
- Cost of Quality
- SQE activities
- SQE activities and software processes
- QIP
- Effort profile



# KIND OF QUALITY

- Quality?
- Two kinds of quality
  - Quality of design
  - Quality of Conformance



# QUALITY OF DESIGN

- Quality of design is the degree to which the designers is intending to provide its customers.
- In the manufacturing industry, an example of quality of design could be the difference between a Honda and a Mercedes. Both cars provide implied uses ,however both cars differ in their features and are designed for two different sets of customers.
- In the service industry, an example of quality of design could be the difference between an economy hotel and a five star hotel. Both provide basic need for customers ,however their different features are designed for two different customers.

# QUALITY OF CONFORMANCE

- Quality of conformance is the degree to how well a product or service meets its specifications.
- In the manufacturing industry, an example of quality conformance could be a wrench that has a specific dimension for it's intended use that can be observed and measured.
- In the service industry, an example of quality of conformance could be the implied wait for food in the restaurant to be fifteen to twenty minutes. When the food takes thirty minutes to arrive then it can be assumed that there has been poor quality of conformance.



Quality Assurance



Quality Control

# QC AND QA

## Quality

In order to maintain or enhance the quality of the offerings, manufacturers use two techniques, *Quality Control* and *Quality Assurance*.

These two practices make sure that the end product or the service meets the quality requirements and standards defined for the product or the service.



# ARE QA AND QC SAME TERMS?

- BIG NO, these both terms are effectively different.
- Most of the time we use both terms randomly, hence to study and understand the difference between them is important.



# ARE QA AND QC SAME TERMS?

Lets differentiate according to the below points.

- Definition
- Focus on
- Goal
- How to achieve
- Example
- Responsibility

# DEFINITION OF QUALITY ASSURANCE AND QUALITY CONTROL

**Quality Assurance** is *process* oriented and focuses on *defect prevention*.

**Quality Assurance** is a set of activities for ensuring quality in the processes by which products are developed.

**Quality Control** is *product* oriented and focuses on *defect identification*.

**Quality Control** is a set of activities for ensuring quality in products. The activities focus on identifying defects in the actual products produced.

# QA AND QC FOCUSES ON



Focus On

**Quality Assurance** aims to prevent defects with a focus on the process used to make the product.

It is a proactive quality process.

It identifies weakness in processes to improve them.

**Quality Control** aims to identify and correct defects in the finished product.

It is a reactive process.

# GOAL OF QA AND QC



The goal of **Quality Assurance** is to improve development and test processes so that defects do not arise when the product is being developed.

The goal of **Quality Control** is to identify defects after a product is developed and before it's released.

# TO ACHIEVE QA AND QC GOALS

How To  
Achieve



Establish a good quality management system and the assessment of its adequacy.

Periodic conformance audits of the operations of the system.

Prevention of quality problems through planned and systematic activities including documentation.

Finding & eliminating sources of quality problems through tools & equipment so that customer's requirements are continually met.

The activities or techniques used to achieve and maintain the product quality, process and service.



# QA AND QC EXAMPLES

## Example

### Example:

- A QA audit
- Process documentation
- Establishing standards
- Developing checklists
- Conducting internal audits

### Example:

- A QC review
- Performing inspections
- Preforming testing

## RESPONSIBLE FOR QA AND QC

### Responsibility



Everyone on the team involved in developing the product is responsible for Quality Assurance.

Quality Control is usually the responsibility of a specific team that tests the product for defects.



## QA AND QC



Working Together

QC detected a recurrent problem with the quality of the products. QC provides feedback to QA person that there is a problem in the process or system that is causing product quality problems. QA determines the root cause of the problem and then brings changes to the process to ensure that there are no quality issues in future.

# QUALITY MANAGEMENT

- The term Quality management has a specific meaning within many business sectors. This specific definition can be considered to have the following main components:
  - Quality Assurance (QA)
  - Quality Planning (QP)
  - Quality Control (QC)
  - Quality Steering (QS)



# QUALITY MANAGEMENT (CONT...)

## Quality Assurance

The establishment of a framework of organizational procedures & standards that lead to high-quality software.

## Quality Control

The definition and enactment of processes that ensure the software development team have followed project quality procedures and standards.

## Quality Planning

The selection of appropriate procedures and standards from this framework, adapted for a specific software project.

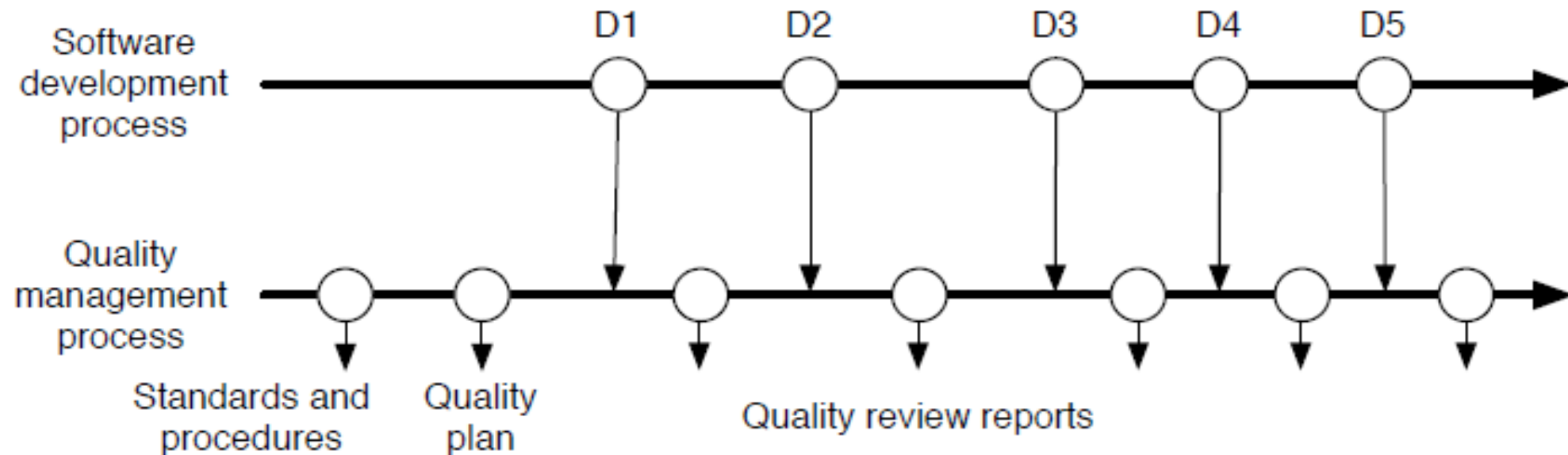
## Quality Steering

Planning constructive QA measures & re-planning based on quality control results.

# ORIGIN OF QUALITY MANAGEMENT

- The concept of 'quality' came out with industrial revolution.
- Earlier the product would be crafted by a single person or a team of people overseeing all aspects of 'quality' criteria.
- Mass production brought large teams working on a product in different stages of production.

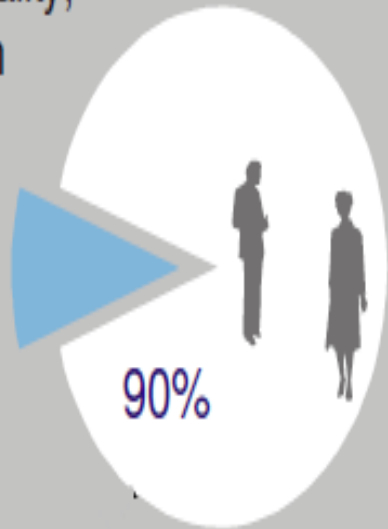
# SOFTWARE DEVELOPMENT & QUALITY MANAGEMENT



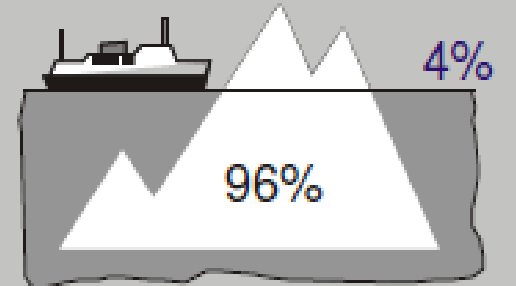
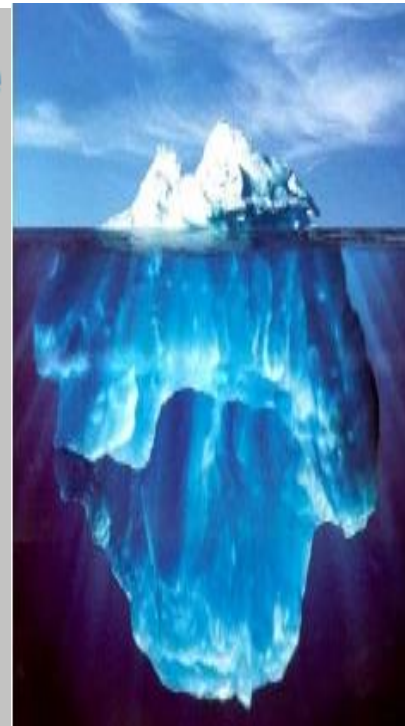
*Quality management must occur continually during software development.*

# CONSEQUENCES OF BAD QUALITY

"90 % of customers, which are dissatisfied with the product quality, avoid the product in the future."



"Each customer will communicate his dissatisfaction to at least 9, sometimes 20, people."



"Only 4% of the dissatisfied customers complain about the bad quality."

# CONSEQUENCES OF BAD QUALITY

Consequences of bad quality	
Product quality	<ul style="list-style-type: none"><li>-Customer dissatisfaction</li><li>-Image damage</li><li>-Reduction of market value</li><li>-Complaints</li><li>-Product recalls</li><li>-High financial effort</li><li>-...</li></ul>
Process quality	<ul style="list-style-type: none"><li>-Waste</li><li>-Deficiency of efficiency and eventually even effectiveness</li><li>-Internal customer dissatisfaction</li><li>-Demotivation</li><li>-...</li></ul>
System quality	<ul style="list-style-type: none"><li>-Bad differentiation from competition</li><li>-Demotivating company culture</li><li>-Disorientation caused by imprecise responsibilities</li><li>-Demotivation by lack of attraction</li><li>-Fear caused by lack of competence</li><li>-...</li></ul>

# SOFTWARE QUALITY AND PRODUCTIVITY

- The most effective way of improving software productivity and shortening project schedules is to reduce defect levels.
- Defect reduction can occur through:


## **Defect Prevention Techniques**

- Structured design and JAD
- Structured code
- Use of inspections, static analysis
- Reuse of certified components

## **Defect Removal Techniques**

- Design inspections
- Code inspections, static analysis
- Formal Testing using mathematical test case design





## ■ COST of Quality (CoQ)

## COST OF QUALITY - CONCEPT

- Organizations need to be aware of the costs associated with making errors as a way of identifying **areas for improvement**.
- Money is lost due to **rework** if the work is not performed in a way that it should be.

“Do it right first time every time” attitude is necessary.

# THE QUALITY IS FREE CONCEPT



## COST OF QUALITY - DEFINITION

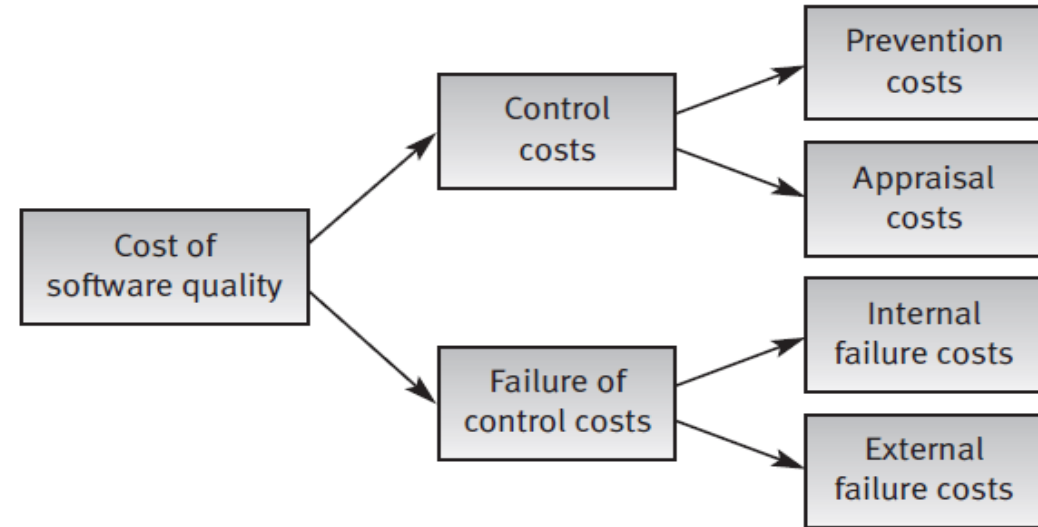
- The total costs incurred on quality activities and issues and often split into prevention costs, appraisal costs, internal failure costs and external failure costs.
- Money spent beyond expected production costs (labor, materials, equipment) to ensure that the product the customer receives is a quality (defect free) product. The Cost of Quality includes prevention, appraisal, and correction or repair costs.

## COST METRICS/PARAMETERS FOR THE EVALUATION OF AN SQA PLAN

- Percentage of cost of software quality out of total software development costs
- Percentage of software failure costs out of total software development costs
- Percentage of cost of software quality out of total software maintenance costs
- Percentage of cost of software quality out of total sales of software products and software maintenance.

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- The classic quality cost model, developed in the early 1950s by Feigenbaum and others, provides a methodology for classifying the costs associated with product quality assurance from an economic point of view.
- The model classifies costs related to product quality into two general classes:



Broken down into two classifications and four categories:

## **Conformance**

Prevention costs

Appraisal costs

## **Non conformance**

Internal failure costs

External failure costs

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- **Costs of control** include costs that are spent to prevent and detect software errors in order to reduce them to an accepted level.
- **Prevention costs** include investments in quality infrastructure and quality activities that are not directed to a specific project or system, being general to the organization.
- **Appraisal costs** include the costs of activities performed for a specific project or software system for the purpose of detecting software errors.

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- **Costs of failure of control** include costs of failures that occurred because of failure to prevent and detect software errors.
  - **Internal failure costs** include costs of correcting errors that have been detected by design reviews, software tests and acceptance tests (carried out by the customer) and completed before the software is installed at customer sites.
  - **External failure costs** include all costs of correcting failures detected by customers or the maintenance team after the software system has been installed



# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

## ■ Prevention costs

- Investments in development of new or improved SQA infrastructure components or, alternatively, regular updating of those components:
  - Procedures and work instructions
  - Support devices: templates, checklists, etc.
  - Software configuration management system
  - Software quality metrics (product, process, project)
- Regular implementation of SQA preventive activities:
  - Instruction of new employees in SQA subjects and procedures related to their positions
  - Instruction of employees in new and updated SQA subjects and procedures
  - Certification of employees for positions that require special certification
  - Consultations on SQA issues provided to team leaders and others.

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- **Prevention costs**

- Control of the SQA system through performance of:

- Internal quality reviews
    - External quality audits by customers and SQA system certification organizations
    - Management quality reviews.

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- **Appraisal costs**

- Reviews:

- Formal design reviews (DRs)
    - Peer reviews (inspections and walkthroughs)
    - Expert reviews

- Costs of software testing

- Unit tests
    - Integration tests
    - Software system tests

- Costs of assuring quality of external participants, primarily by means of design reviews and software testing. These activities are applied to the activities performed by:

- Subcontractors
    - Suppliers of COTS software systems and reusable software modules
    - The customer as a participant in performing the project.

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

## ■ Internal failure costs

- internal failure costs represent the costs of error correction subsequent to formal examinations of the software during its development, prior to the system's installation at the customer's site.
  - Costs of redesign or design corrections subsequent to design review and test findings
  - Costs of re-programming or correcting programs in response to test findings
  - Costs of repeated design review and re-testing (regression tests).
  - Importantly, although the costs of regular design reviews and software tests are considered appraisal costs, any repeated design reviews or software tests directly resulting from poor design and inferior code quality are considered internal failure costs

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

## ■ External failure costs

- External failure costs entail the costs of correcting failures detected by customers or maintenance teams after the software system has been installed at customer sites.
- These costs may be further classified into “overt” external failure costs and “hidden” external failure costs. In most cases, the extent of hidden costs is much greater than that of overt costs. Typical **overt external failure** costs include:
  - Resolution of customer complaints during the warranty period
  - Correction of software bugs detected during regular operation (often performed at customer’s site)
  - Correction of software failures after the warranty period is over even if the correction is not covered by the warranty.
  - Damages paid to customers in case of a severe software failure detected during regular operation.
  - Reimbursement of customer’s purchase costs, including handling, in case of total dissatisfaction (relates to COTS software packages as well as to custom-made software).
  - Insurance against customer’s claims in case of severe software failure

# THE CLASSIC MODEL OF COST OF SOFTWARE QUALITY

- Typical examples of hidden external failure costs are:
  - Damages of reduction of sales to customers suffering from high rates of software failures
  - Severe reduction of sales motivated by the firm's damaged reputation
  - Increased investment in sales promotion to counter the effects of past software failures
  - Reduced prospects to win a tender or, alternatively, the need to underprice to prevent competitors from winning tenders.

# COST OF QUALITY - EXPLANATION

- The cost of quality includes all costs incurred in the pursuit of quality or in performing quality related activities.
- It is also a powerful tool for identifying waste whether is of effort, or time or resources.

**COQ = Cost of conformance + Cost of non-conformance**

***Cost of Quality = Cost of Control + Cost of Failure of Control***

where

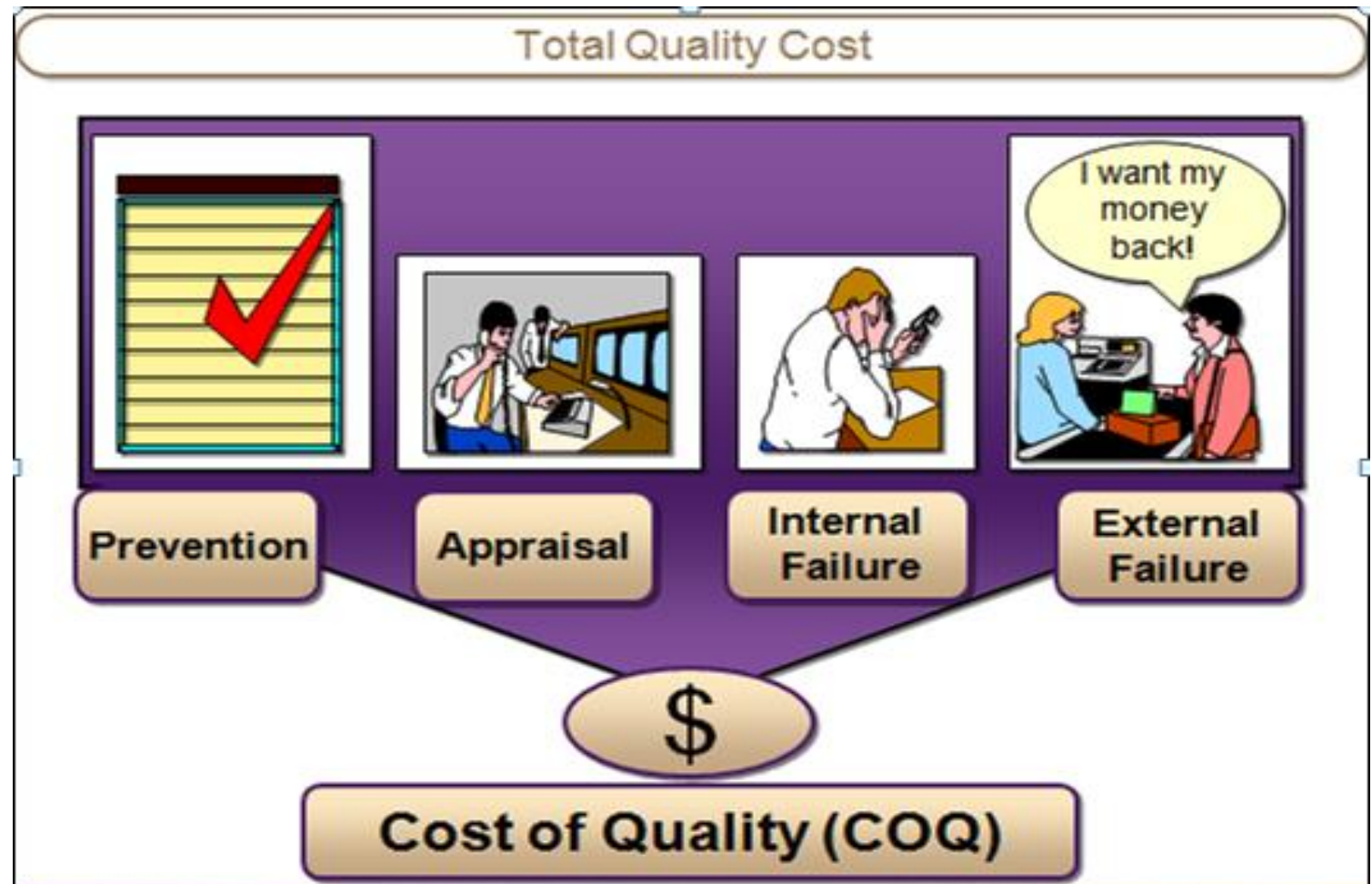
***Cost of Control = Prevention Cost + Appraisal Cost***

and

***Cost of Failure of Control = Internal Failure Cost + External Failure Cost***

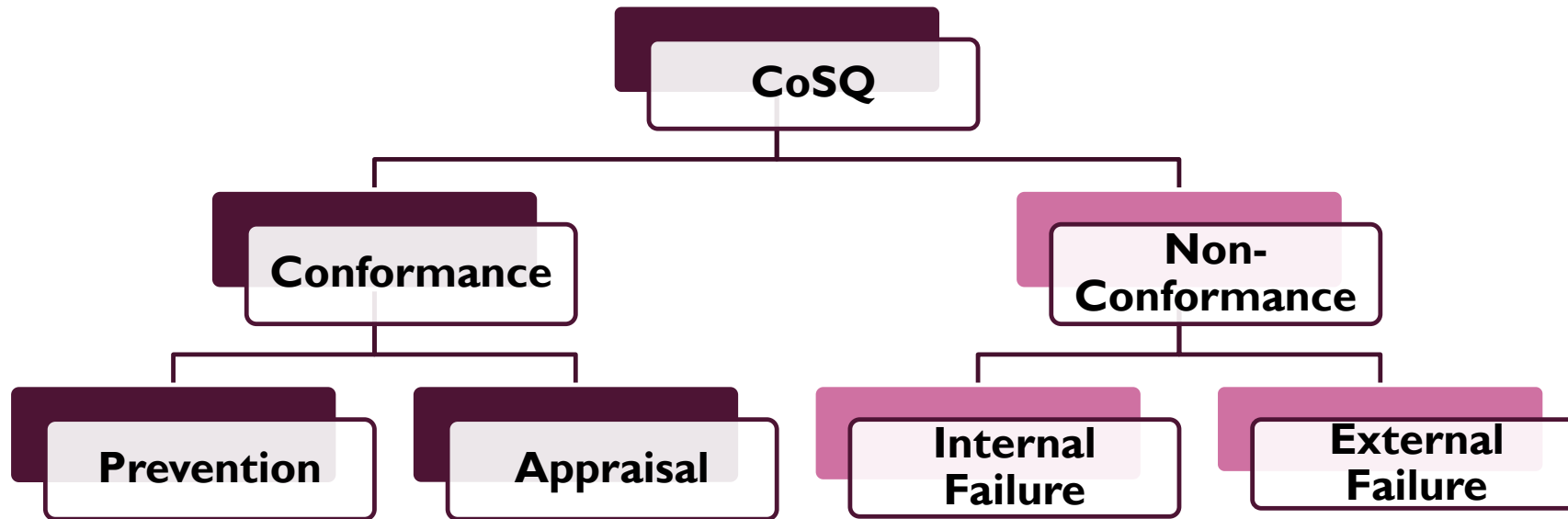
# COST OF QUALITY - EXPLANATION

- CoSQ generally focuses on three major components:
  - Cost of monitoring defects
  - Cost of correcting defects
  - Cost of reducing defects





# COST OF QUALITY



# COMPONENTS OF QUALITY COST

## Prevention Cost:

The cost of activities specifically designed to prevent poor quality in products or services.

- **Training:** Educating employees on how to do their jobs correctly.
- **Process Planning:** Designing processes to minimize errors.
- **Quality Improvement Projects:** Implementing methods like Six Sigma to improve quality.

## Appraisal Cost:

The cost associated with measuring, evaluating or auditing products or services to assure conformance to quality standards and performance requirements.

- **Testing:** Checking products for defects.
- **Audits:** Regular quality checks to ensure processes are being followed.
- **Inspections:** Evaluating products at different stages of production.

# COMPONENTS OF QUALITY COST

## Failure Cost:

The cost resulting from products or services not conforming to requirements or customer/user needs i.e. the cost resulting from poor quality.

Failure cost is divided into **internal** and **external** failure cost categories.



## COMPONENTS OF QUALITY COST (CONT..)

### Internal Failure Cost:

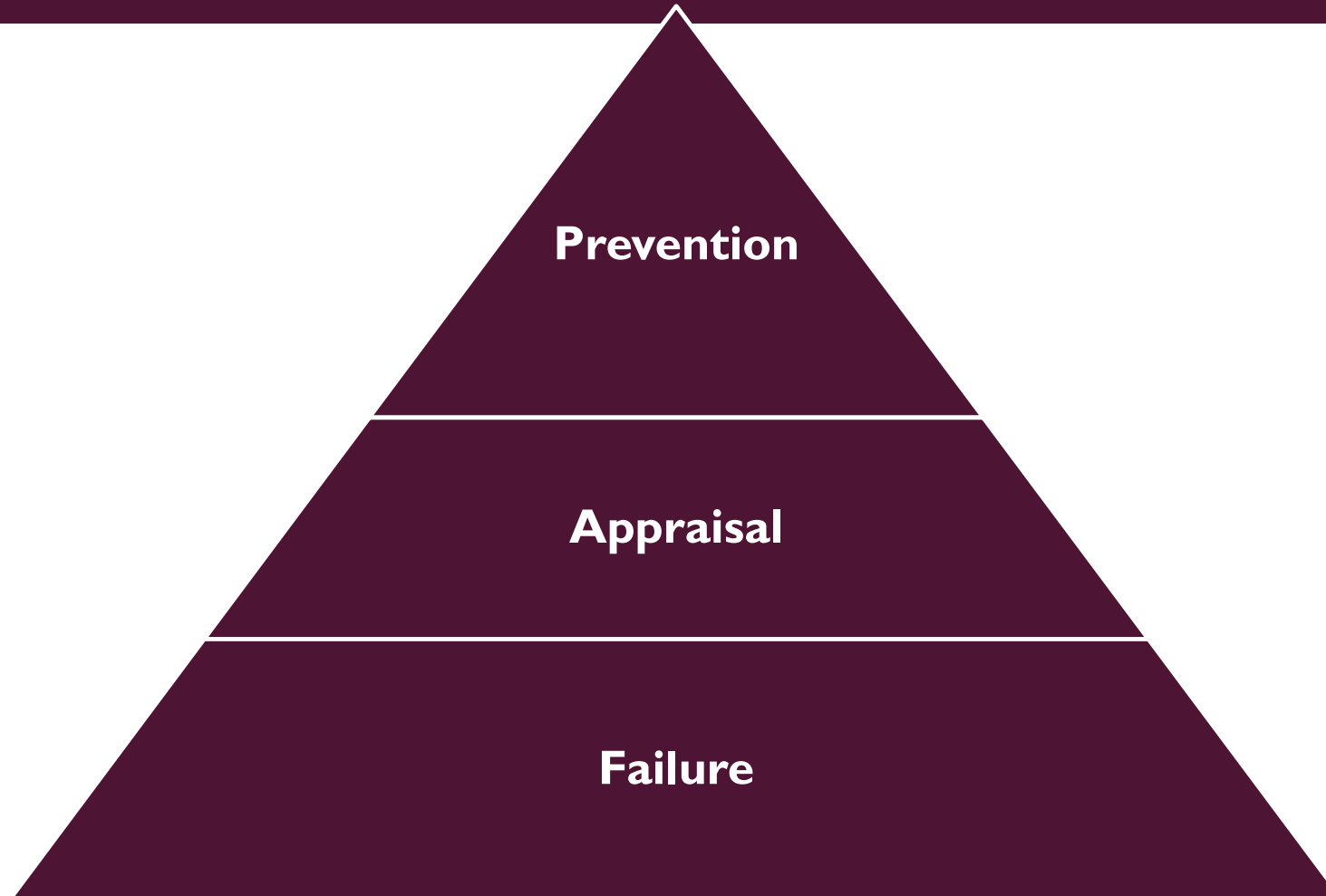
Failure cost which occur prior to delivery or shipment of the product, or the furnishing of a service, to the customer.

### External Failure Cost:

Failure cost which occur after shipment of the product or a service to the customer.



## COMPONENTS OF QUALITY COST (CONT..)



# COMPONENTS OF QUALITY COST (CONT..)

## Prevention Cost

- Quality Planning
- Formal Technical Reviews
- Staff Training
- Requirement Analysis
- Early Prototyping
- Process Control
- Consulting

## Appraisal Cost

- Design Review
- Code Inspection
- Testing
- Test Automation
- Training Testers
- Auditing
- Monitoring

# COMPONENTS OF QUALITY COST (CONT..)

## Internal Failure

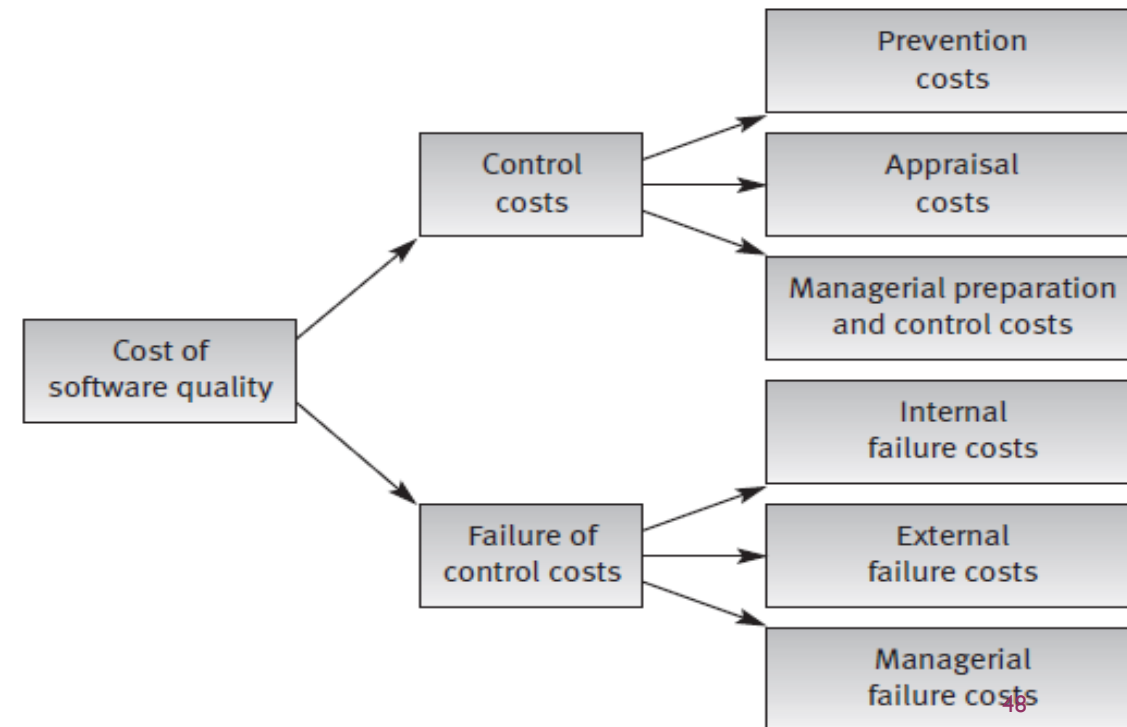
- Bug Fixes
- Regression Testing
- Employee Turnover
- Direct cost of late shipment
- Wasted Advertisement
- Rework
- Scrap

## External Failure

- Technical Support Calls
- Penalties
- Warranty Costs
- Investigation of complaints
- Lost of customer goodwill
- Shipping of updated product
- Cancelled licenses or orders

# AN EXTENDED MODEL FOR COST OF SOFTWARE QUALITY

- The *extended cost of software quality model*, extends the classic model to include management's “**contributions**” to the total cost of software quality. According to the extended model, two subclasses are added to complete the model's coverage: managerial preparation and control costs, and managerial failure costs.





# AN EXTENDED MODEL FOR COST OF SOFTWARE QUALITY

- **Managerial preparation and control costs**
  - Costs of carrying out contract reviews (proposal draft and contract draft reviews).
  - Costs of preparing project plans, including quality plans and their review.
  - Costs of periodic updating of project and quality plans.
  - Costs of performing regular progress control of internal software development efforts.
  - Costs of performing regular progress control of external participants' contributions to the project.

# AN EXTENDED MODEL FOR COST OF SOFTWARE QUALITY

## ■ Managerial failure costs

- Managerial failure costs can be incurred throughout the entire course of software development, beginning in the pre-project stage. Typical managerial failure costs include:
  - Unplanned costs for professional and other resources, resulting from underestimation of the resources upon which the submitted proposals are based.
  - Damages paid to customers as compensation for late completion of the project, a result of the unrealistic schedule presented in the company's proposal.
  - *Domino effect*: damages to other projects performed by the same teams involved in the delayed projects. These damages should be considered managerial failure costs of the original project, whose scheduling problems interfered with the progress of other projects.

# PROBLEM

- **Calculating Total Cost of Quality**
- A company has the following cost components for a particular year:
  - Prevention Costs: \$50,000
  - Appraisal Costs: \$30,000
  - Internal Failure Costs: \$20,000
  - External Failure Costs: \$10,000
- **Question:** Calculate the total cost of quality.
- **Solution:** The Total Cost of Quality (COQ) is the sum of Prevention Costs, Appraisal Costs, Internal Failure Costs, and External Failure Costs.
- $\text{Total COQ} = \text{Prevention Costs} + \text{Appraisal Costs} + \text{Internal Failure Costs} + \text{External Failure Costs}$
- The total cost of quality is **\$110,000**

# PROBLEM

- A company incurs the following costs:
- Prevention Costs: \$80,000 , Appraisal Costs: \$40,000 , Internal Failure Costs: \$25,000 , External Failure Costs: \$35,000
- Question: What proportion of the total cost of quality is due to failure costs?
- Total COQ =  $80,000 + 40,000 + 25,000 + 35,000 = 180,000$
- Next, calculate the total failure costs.
- Total Failure Costs = Internal Failure Costs + External Failure Costs =  $25,000 + 35,000 = 60,000$
- Now, calculate the proportion of failure costs.
- Proportion of Failure Costs =  $(\text{Total Failure Costs} / \text{Total COQ}) \times 100$
- Proportion of Failure Costs =  $(60,000 / 180,000) \times 100 = 33.33\%$
- Answer: The proportion of the total cost of quality due to failure costs is 33.33%.

# I-10-100 RULE



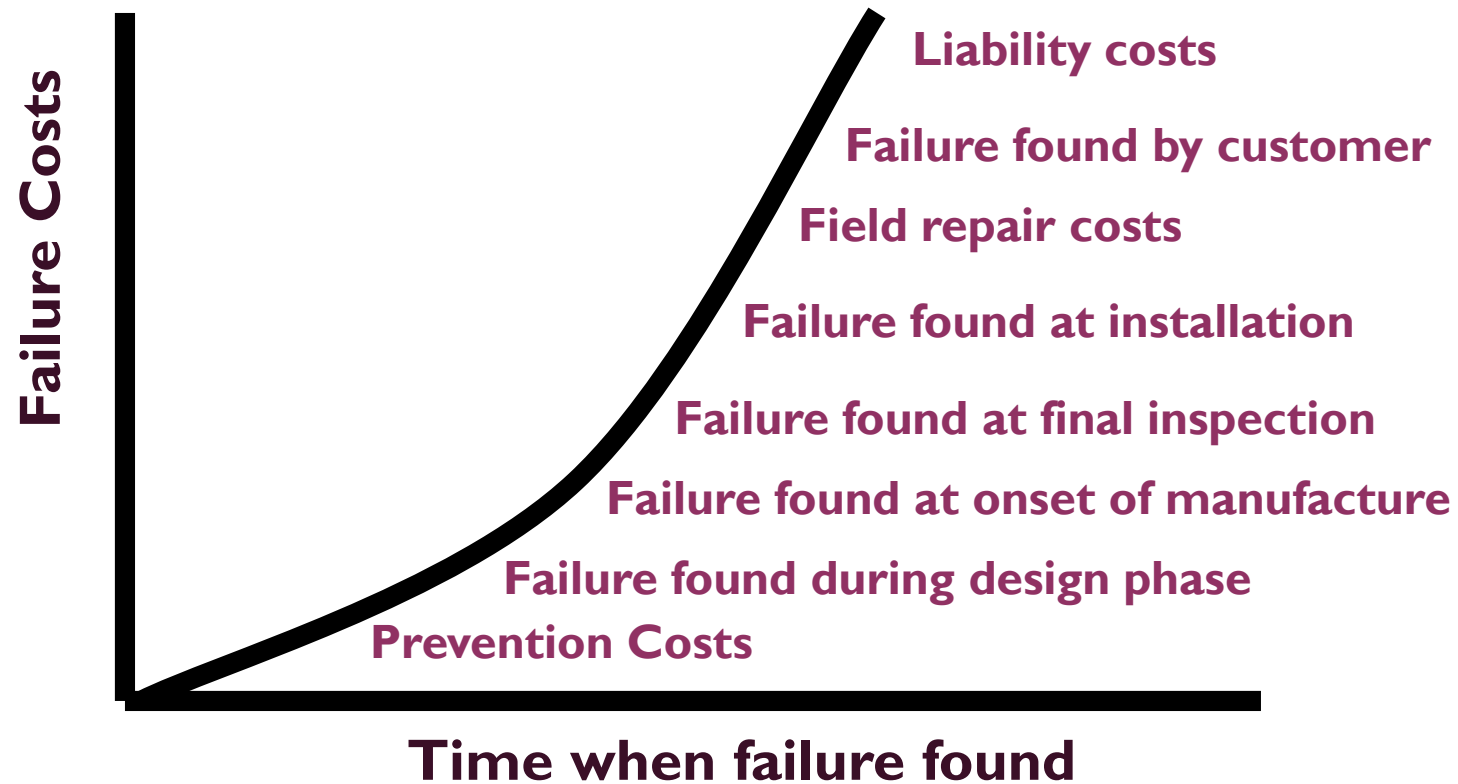
## THE 1-10-100 RULE

- One dollar spent on prevention will save \$10 on appraisal and \$100 on failure costs.
- This rule helps one to prioritize expenditure on prevention, which is sure to bring in greater returns.

## THE 1-10-100 RULE - EXPLANATION

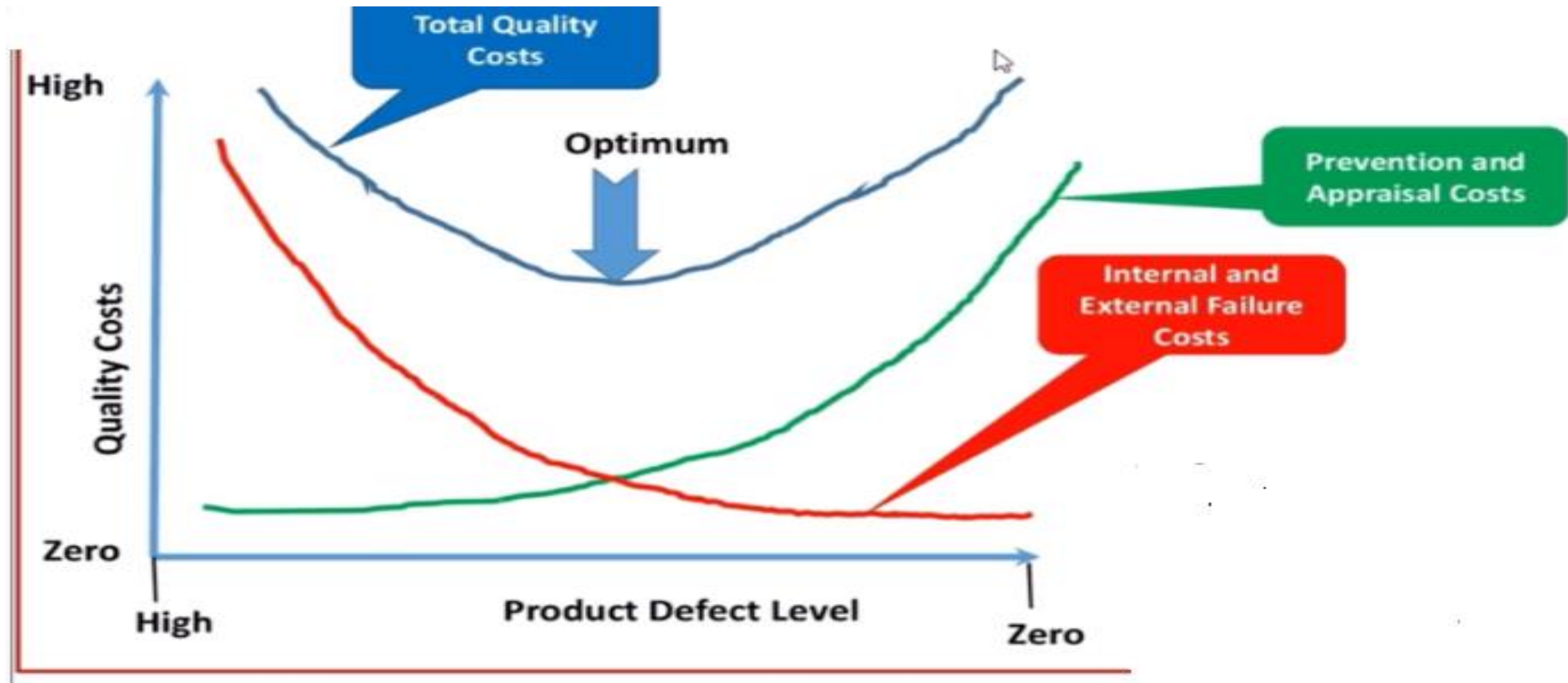
- The earlier you detect and prevent a defect the more you can save. If you catch a two cent resistor before you use it and throw it away, you lose two cents.
- If you don't find it until it has been soldered into a computer component, it may cost \$10 to repair the part. If you don't catch the component until it is in the computer user's hands, the repair will cost hundreds of dollars.
- Indeed, if a \$5000 computer has to be repaired in the field, the expense may exceed the manufacturing cost.

# Quality costs increase over time

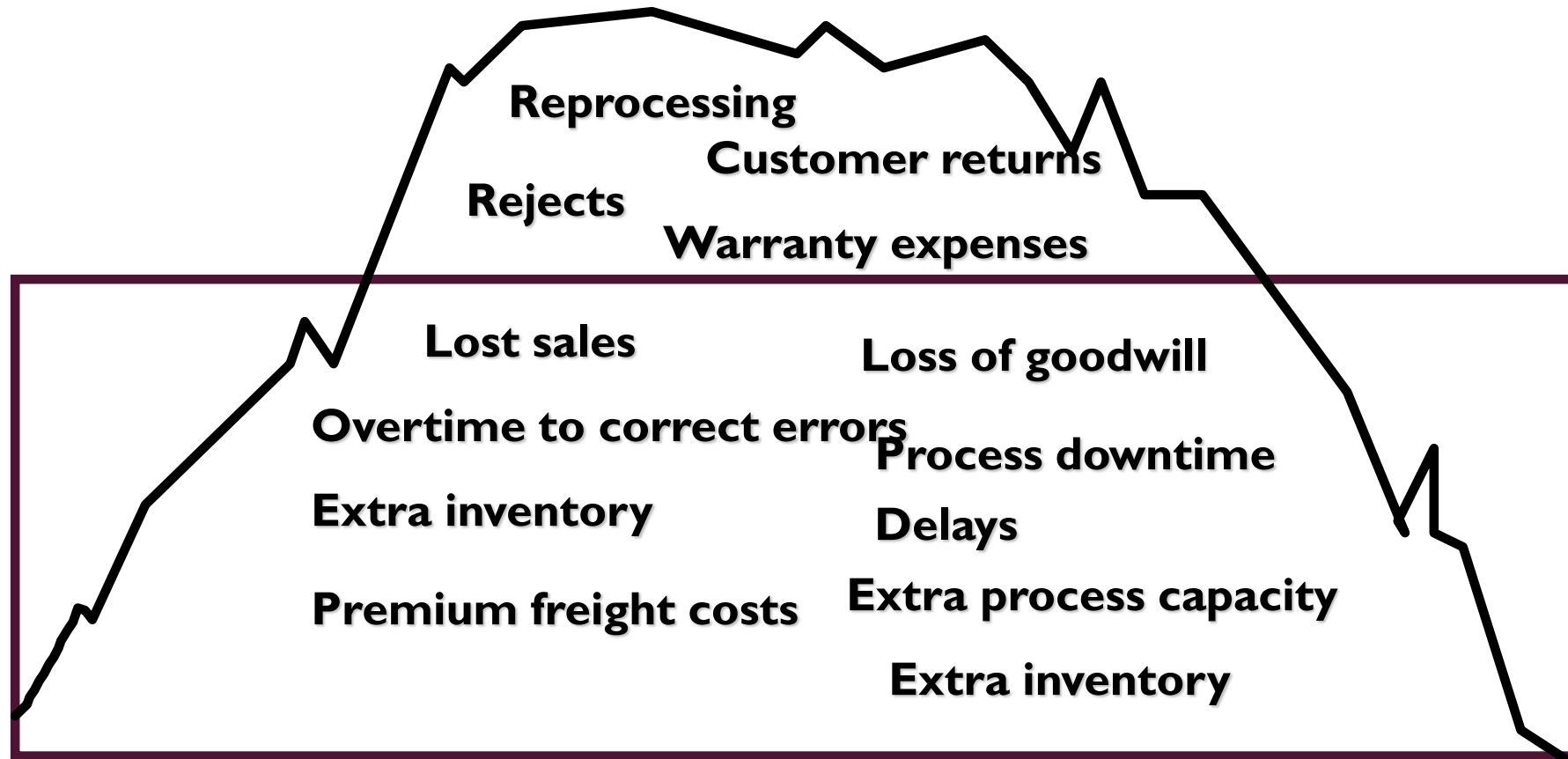




# RELATION BETWEEN DIFFERENT QUALITY COST



# HIDDEN COSTS OF POOR QUALITY



# Numerical:

## **Problem: Identifying and Categorizing Quality Costs**

A company reports the following costs:

- 1.\$15,000 for training employees on quality standards.
- 2.\$10,000 for inspection and testing of products before shipment.
- 3.\$5,000 for rework of defective products found during production.
- 4.\$7,000 for returns and warranty claims from customers.

### **Tasks:**

- 1.Identify and categorize each cost as either Prevention Cost, Appraisal Cost, Internal Failure Cost, or External Failure Cost.
- 2.Calculate the total cost for each category.
- 3.Determine the total cost of quality.
- 4.Calculate the proportion of each type of cost with respect to the total cost of quality.

# RELATION BETWEEN DIFFERENT QUALITY COST



## Calculation of cost of quality as the percentage of sales

Particular	Amount
Sales	1,000,000
Quality checks and inspection	10,200
Raw materials appraisal cost	30,000
Repairs on finished goods	15,000
Warranty cost and product returns	5,000
Total cost of good quality	?
Total cost of poor quality	?
Total cost of quality	?

# QUALITY ENGINEERING

- Different customers and users have different quality expectations under different market environments. Therefore, we need to move beyond just performing QA activities toward quality engineering by managing these quality expectations as an engineering problem.
  - A goal might be to minimize the cost and project risk

# SOFTWARE QUALITY ENGINEERING/ SQE- COOPERATION

- 1) The application of a continuous, systematic, disciplined, quantifiable approach to the development and maintenance of quality throughout the whole life cycle of software products and systems; that is, the application of quality engineering to software,
- 2) The study of approaches as in (1).







That is all