Quality Assurance

Outline

Motivation

Background

Broad Picture of QA

Software Quality Assurance

QA Standards

Quality Assurance Plan

What Is Quality

```
1qual-i-ty ´kwaˆ:l-et-eˆ-  pl -ties
[ME qualite, fr. OF qualite', fr. L qualitat-,
     qualitas, fr. qualis of what kind ]

2a: degree of excellence: GRADE <the quality of
     competing air service>
2b: superiority in kind <merchandise of >
```

> "Quality is the relationship between what I expected and what I got."

> "[Q]uality has much in common with sex. Everyone is for it. (Under certain conditions, of course.) Everyone feels they understand it. (Even though they wouldn't want to explain it.) Everyone thinks it is only a matter of following natural inclinations. (After all, we do get along somehow.) And, of course, most people feel that problems in these areas are caused by other people. (If only *they* would take the time to do things right.)"
>
> – P. Crosby, *Quality is Free*, 1979

What Is Quality Assurance

Reexamine preceding quote:

> "Quality is the relationship between what I expected and what I got."

That is, how can I assure that I get what I expect.

What QA is there for:

- slot machine
- cooking
- manufactured item
- software

Why Q.A. ?

External Factors

- competitive pressure
  - ◊ product evaluation commonplace
  - ◊ poor quality destroys an organization's reputation
- customer demand
- regulatory requirement

Internal Factors

- fixing a problem after completion of a project is 100 times more expensive than catching the problem during specification and design
- for every dollar spent for development of software, two dollars are spend on maintenance

Professionalism

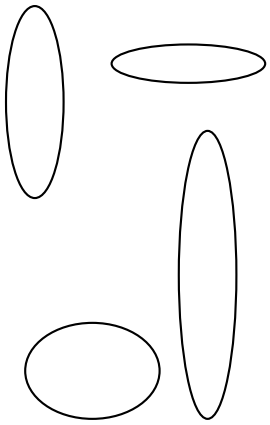
- *professional obligation* to produce quality software

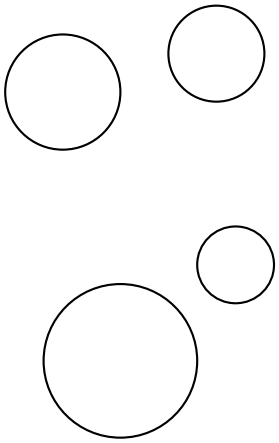
Increasing Cost of (Low) Quality

defect found at	*impact*
origin step	very minor
next step	minor delay
end of line	rework rescheduled work
final inspection	significant rework delay in delivery additional inspection
end user's hand	liabilities warranty cost administrative cost damage to reputation loss of market share

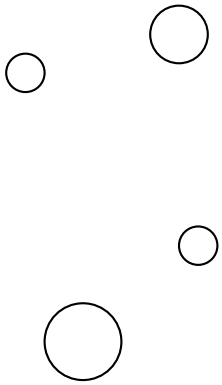
QA Yields Improvements

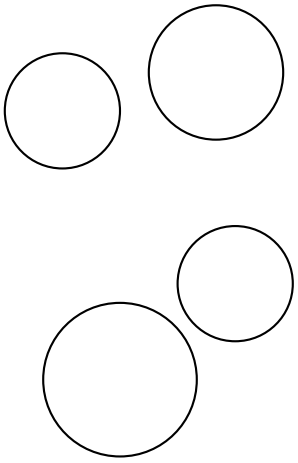
Gain control:



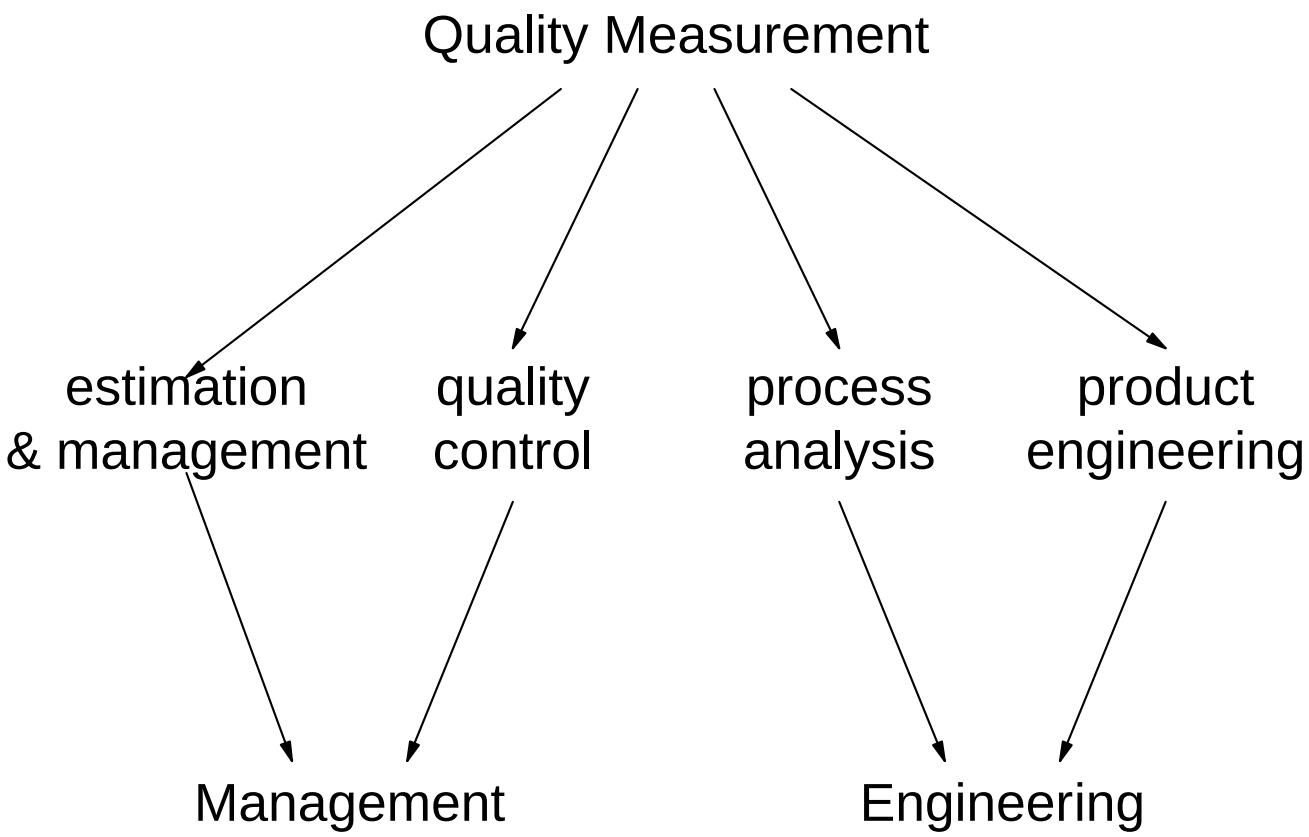


Increase capability:





Uses of Quality Measurement



Nature of Faults

Error	(cause)
⇓	
Defect	(location)
⇓	
Fault	(occurrence)
⇓	
Failure	(appearance)
⇓	
Accident	(result)

Reliability Terminology

MTTF = **m**ean **t**ime **to** **f**ailure

MTTR = **m**ean **t**ime **to** **r**epair

$$\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}}$$

Early Quality Assurance Efforts

- applied to manufacturing in the early 20th Century through production monitoring.

- used statistical methodologies to predict undiagnosed failure rates and locate defect "hot spots."

QA for Hardware

Hardware in the sense of manufactured objects

Steps in assuring quality of a toaster:

1. test toaster at the end of the assembly line

   ⇓

   many throw-aways or re-works

   ⇓

2. test toaster components during assembly

   ⇓

   assembly line bottle-necks at some failure-prone step

   ⇓

3. monitor & measure assembly process itself

∴ QA plan is mostly concerned with process, not product

QA Agents

Traditional QA relies on:

Technical

- Measurement
- Monitoring
- Feedback

Interpersonal

- Objectives
- Evaluation
- Empowerment

Management Support

Industrial Quality Continuum

- ✯ Deming Prize
- ☆ Baldrige Award
- \+ QS 9000 (US auto industry)
- \+ ISO 9000
- • Military standards
- ○ Meets specifications
- \- No quality system

ISO 9001/9002 Elements

4.1 Management Responsibility
4.2 Quality System
4.3 Contract Review
4.4 Design Control
4.5 Document & Data Control
4.6 Purchasing
4.7 Customer Supplied Components
4.8 Product Identification & Traceability
4.9 Process Control
4.10 Inspection & Testing
4.11 Control of Test Equipment
4.12 Inspection & Test Status
4.13 Control of Non-conforming Product
4.14 Corrective & Preventive Action
4.15 Handling, Packaging, *etc.*
4.16 Control of Quality Records
4.17 Internal Quality Audits
4.18 Training
4.19 Servicing
4.20 Statistical Techniques

Software *versus* Hardware QA

Comparing manufactured products with software:

manufactured products	*software*
internal variability	variability in external environment
continuous behavior	discrete
basically additive	highly non-linear
	scalability issue
manufacturability issue	complexity issue

Characterizations

"[S]oftware quality is the whole issue of software engineering."

- A. Macro, 1990

"[Software quality is] conformance to explicitly stated functional and performance requirements, explicitly documented development standards, and implicit characteristics that are expected of all professionally developed software."

- Pressman, 1987

Special Characteristics of SQA

Process

- methods and tools
- configuration management and change control
- standards and standard compliance mechanisms
- reporting mechanisms

Verification and Validation

- formal technical reviews
- multi-tiered testing strategy
- measurement
- ○ symbolic execution
- ☞ formal verification techniques

Software Quality Factors/Goals

Utility/Correctness: extent to which program satisfies specifications (presence of function)

Reliability: precision with which program performs as expected (absence of failure)

Modifiability: effort required to modify

Maintainability: effort required to locate and fix errors

Security: extent to which access is controlled

Efficiency: amount of computing resources required

Usability: effort required to learn, operate, and interpret behavior

Testability: effort required to test

Interoperability: effort required to couple to another system

Portability: effort required to transfer to different environment

Reusability: extent to which program can be used in other applications

- after McCall, 1977

Sources of Non-Clerical Errors

81%	design
11%	requirements
8%	language and environment
2%	other

- Weiss & Basili, 1985

Program Complexity Metrics

"Software Science"

- begins with count of operations and distinct operands, combined using various formulas
- has both strong proponents and strong detractors

Cyclomatic Complexity

- counts number of simple cycles in flow graph
- applies at design stage
- relates to testing complexity

Higher-Order Measures

- length * *f* (data flow)

Quality Models

Specification		
focus on product	parts meet specifications	any inspection system
ISO 9000		
focus on process	process under control	QS 9000
Capability Maturity Model		
focus on culture	organization under control	SEI certification

Capability Maturity Model

"Levels of Maturity"

1. Initial
   ⇓ disciplined process
2. Repeatable
   ⇓ standard, consistent process
3. Defined
   ⇓ predictable process
4. Managed
   ⇓ continuously improving process
5. Optimizing

IEEE Standard

Outline of *IEEE Standard for Quality Assurance Plans (STD 730-1984)*

1. Purpose and Scope
2. References
3. Organization, Tasks, and Responsibilities ✧
4. Documentation Required
5. Standards, Practices, and Conventions ✧
6. Reviews and Audits ✧
7. Configuration Management ✧
8. Problem Reporting and Corrective Action ✧
9. Tools, Techniques, and Methodologies
10. Code Control ✧
11. Media Control
12. Supplier Control †
13. Records Collection, Maintenance, and Retention

✧ important

† not applicable to InfoSys

Quality is NOT Optional

Management will require QA

Management will specify overall QA plan

Management will indicates what variations are

- allowed
- required