

## Software Quality Assurance & Testing

x Software : Program + Associated documentation, support & resources.

User → Appn S/W → OS → H/W  
(Indirectly communicating w/ H/W).

x Types of S/W :

- [ Application S/W : Word processors, browsers, etc.]
  - System S/W : Essential for system o/p (OS soft., drivers)
  - Utility S/W : Antivirus S/W, Disk Utilities.
- [ General-Purpose  
Customized

? - Programming S/W : Editors, IDE, compilers, interpreters.

x Quality :

- Associated with satisfaction of requirements (Customer/Consumer)
- Associated with function compliance of software with proposed requirements. (Producer)

x Requirement Types -

Implied : Not stated explicitly, to be inferred.

Explicit : Specified by a user.

- All requirements cannot be explicitly as :
    - Requirements may arise from competition.
    - All requirements cannot be identified.
    - Requirements may be dependent on current trends in tech.
  - General-purpose S/W must cater needs of millions, so all requirements (especially those in conflict) may not be met.
- Further, requirements may change over time.

Quality of Conformance : How well a product meets specified standards.

QoD - Transforming stated requirements from implied requirements.

- Minimizing implied requirements (due to miscommunication).
- Minimize set of unfulfilled requirements (defects).
  - Design for varying markets, budget-range, etc.
- Requirements must be repeatedly assured. Fulfilling once is not enough, must be constantly reassured.

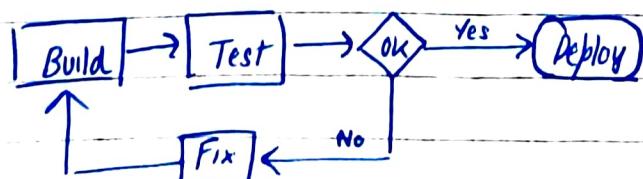
- Meeting these requirements in a consistent & repeatable manner.

### x Importance of Quality in S/W -

- Extreme dependency, especially over life-saving & mission critical softwares for which proper function is critical w/ no defects.
- Increasing requirements & expectations based on increasing competition.
- High scope of error due to tight deadlines, less resources for development.
- No second chance in mission-critical applications.

### x Minimizing & Eliminating Defects -

- Quality Control : Testing after a given time to detect defects.



- ~ Expensive in nature (time & cost expectations)
- ~ Possible during build phases only (not after deployment)

- Quality Assurance : Testing in parallel before deployment based on reviews, examinations, etc.

- × IEEE Definition of S/W : Comprises of code, proper procedure, associated documentation & data necessary for operation of s/w system. (additional dependencies).
  - × ISO Definition of S/W : Software comprises of a computer program, procedure, documentation & necessary data.

## X. Faults , Errors & Failures :

- Errors : May cause improper functioning of sw completely or of a component of the sw, or may not affect at all.
  - Faults : Errors detectable by users, making software vulnerable.
  - Failures : Faults activated at user end, leading to software crash.  
May never occur due to conditions required for fault never occurring in the system.

Eo : Pharma - Plus : Debt system , max limit \$ 200 -

Programmer faults : limit changed to \$500.

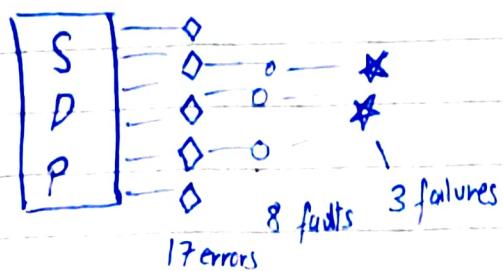
Consequences : Higher Losses

: Super-Customer, X purchases in Y months

Analyst fault: purchases → products

**Consequences** Failure for companies implementing the concept (all customers gone loyal).

- \* Only a portion of s/w faults turn into s/w failures.



## X Causes of Errors -

- Faulty requirements
- Incomplete definition of requirements
- Missing vital requirements
- Unnecessary requirements.
- Client - developer communication failure / misinterpretation.
- Human error.
- Deliberate deviations from specified requirements, owing to low budgets, resources, or feasibility or reuse to preserve required efforts.
- Non-compliance with documentation or coding definitions.
- Shortcomings in testing process.
- Procedural, or documentation errors (in docs for devs, testers, end-users).  
(causes errors during maintenance)
- Errors in instructions given to end-users.
- Listing of ~~non-functional~~ non-existing software functionality.

## X IEEE Definition of S/W Quality :

- Degree to which system component / process meets specified requirements.
- Degree to which system component / process meets user or customer's needs & expectations

## X IEEE Definition of SQA :

- Planned & systematic pattern of actions necessary to provide adequate confidence that the software performs to established technical requirements.
- Excludes maintenance, timeline & design issues.

## X SQA Definition (author, expanded) :

Applications of actions comprising of planning, tracking, identification of potential risks & eliminate / reduce their impact determine their impact, the requirements, produce design & obtain feedback & test & correct problems to ensure conformance under applicable constraints.

- Complies w/ ISO 9000 standard & CMM (Component) Capability Maturity Model).

CMM Levels : 1 Initial

- 2 Repeatable
- 3 Defined
- 4 Managed
- 5 Optimizing

X ISO 9126 : Standard for IT, providing characteristics for quality:

- Extent to which software is reliable (Reliability)
- Extent to which software is maintainable (Maintenance)
- Portability : Ease of transforming s/w to a different environment.
- Efficiency : Efficiency of s/w.
- Usability : Usability of s/w ; extent to which users judge it as easy to use.
- Functionality : Extent to which required functions are available in the software.



Product : Tangible output or service, as a result of a process.

Process : Procedure to develop a software, affecting s/w quality.

- × Product Quality : Should satisfy user requirements
- × Process Quality : Quality associated w/ development of s/w .

#### × Process Based Quality Assurance :

- 1 - Define set of processes to be followed [Define Process] →
- 2 - Develop the product following the process [Develop Prototype] →
- 3 - Assess product for conformance to reqmts. [Assess Product Quality] →  
(Product Quality dependent on Process Quality)
- 4 - Assess product quality :   
 A - If not OK, improve process [Improve Process]  
 to improve product quality. (dependent on process)  
 - & repeat step 2 onwards.
- B - If OK, standardize process for [Standardize Process]  
 future projects of similar scale.

[Define Process] → [Develop Product] → [Assess Product Quality]



- × In context of quality, evaluation defined as addressing satisfaction of requirements.
- × Evaluations help

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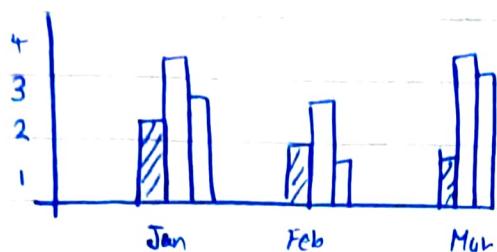
SQA

- × Evaluation includes reviews, tests.
- × May be qualitative or quantitative in nature.
- × Evaluations requiring reasoning or judgments are termed as assessments. Includes assessment of maturity of organization wrt maturity models (CMM) or quality standards (ISO 9000 2000).
- × CMMI (Capability Maturity Model Integration) : Assigns levels to IT companies based on assessment.
  - Low-Maturity Organizations : Experimental evaluation.
  - High-Maturity Organizations : Metrics & Statistical Analysis.
  - Types : Initial, Repeatable, Defined, Managed, Optimizing.
- × Measurement : Process by which #s are assigned to attributed or entities in real world according to defined rules.
 

Eg : Top speed of 250 km/h  
entity      #/symbol unit

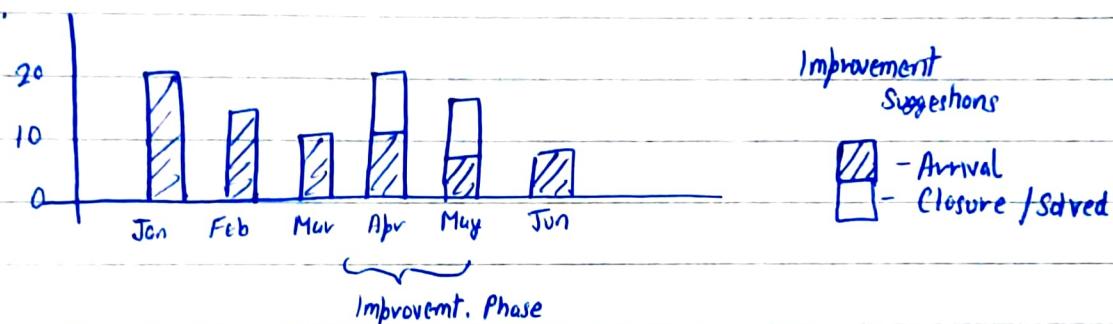
: For s/w measurements allow gaining an understanding of current capability, for devising improvements.
- × Metrics for Organizations -
  - Human Resource Area : # of Employees
  - Customer Satisfaction Area :
  - Supplier Quality
  - Internal Audit Results
  - Project Management, requirements & development & testing.
  - Process Improvement
- × Customer Satisfaction Measurements :
  - Feedback, Promotions, Surveys
  - Surveys : Provide information about customer satisfaction.
  - Evaluation of satisfaction, ability of company to meet deadlines & deliver, ease of s/w use, quality of doc. & value for money.

Eg. Survey Data :

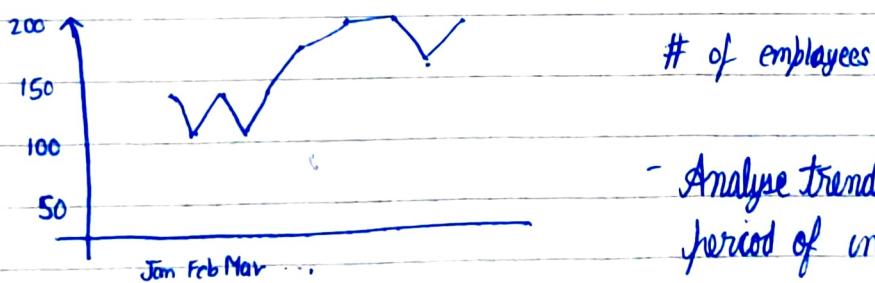


□ - Reliability.

× Process Improvement Metrics :-



× Human Resource & Training Metrics :



- Analyse trends, gain peried, period of unemployment.

Year	Turnover	Turnover %
1999	10	10%
2000	12	11%
2001	15	15%

- Turnover : # employees leaving company.

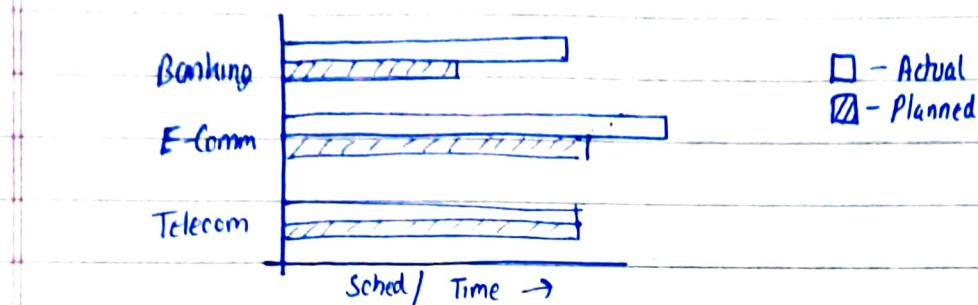
- Useful for HR evaluation.

- Goal : Attract & retain best employees.
- HR data allows for evaluation of reasons of employees leaving company to identify & rectify problems.
- Resignation Rate : identify reach of company.
- # of interviews scheduled.
- # of employees receiving appraisal.

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## xx Project Management Metrics :

- Timelines, costs, etc. for projects.



- Goal : deliver high quality product w/ agreed requirements satisfying budget & time constraints.

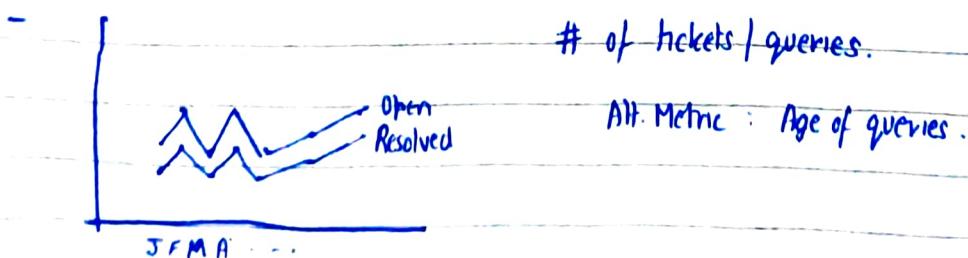
## x Development & Quality Metrics :

- Provide visibility into development & testing of s/w products.
- Based on # of identified defects, # of changes required, severity.
- Provide insight into stability of requirements.

## x Quality Audit Metrics :

- Provide visibility into audit programs in an organization, including # of audits & status of audit transactions.
- Audit : independent examination of s/w to assess compliance & quality.

## x Customer Care Metrics :



- To ensure customer receives highest quality services.
- Determined by efficiency of company in resolving queries, number of queries, availability of s/w at website, age of open queries.

### × Miscellaneous Metrics :

- Metrics over CMM maturity, configuration management build (efficacy of configuration management) & other aspects.

### × Standards :-

- ISO, IEEE & US Military Stds.
- Standards cover tasks to be performed for SQA.
- May evolve with time.

### × Modern SQA :- (Unit 1.6, Regan)

- S/W Product (Faulty) released : 1M \$old, 10K defects detected.
  - Option 1 : Refind all  $\Rightarrow$  Heavy Loss
  - Option 2 : Fix known faults ASAP (at phase of min. cost)
- In s/w terms, cost of correction of fault increases across stages of product development / SDLC.
- Error detection within the phase of error detection is most desirable. If not possible, error must be fixed prior to next phase to minimize cost.
- Methods of detection of errors at phases of development.
  - Software inspection :

Michael Fagan : 7-stage process :

- Inspect requirement docs., s/w docs., source & test plans.
- Moderator : Responsible for s/w inspection, skilled.
- Author : Responsible for s/w development
- Moderators are skilled in inspection, responsible for documenting major & minor errors. Also responsible for moderation / process speed.
- Inspection Process :-

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## Auditing :-

- 1) Ensure design is correct wrt specified requirements.
- 2) Ensure source code is correct wrt design.

## 7-Stage Inspection Process :-

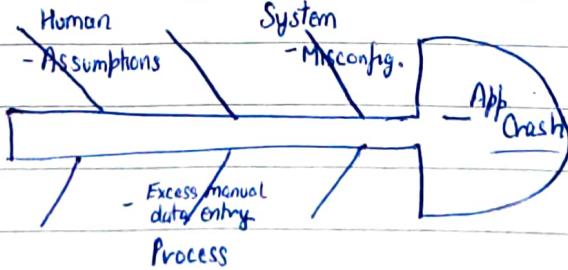
- 1) Planning : Assign roles to inspectors by Mod.
- 2) Overview : Author provides overview to inspectors.
- 3) Prepare : Inspectors prepare for inspection & assigned role.
- 4) Inspection : Find / Discover major & minor error, & document.
- 5) Process Improvement : Devise ways to improve process of development & inspection.
- 6) Rework : Fix discovered documented errors, resolve errors.  
Side-by-side, investigate for erroneous conditions.
- 7) Follow-Up : Mod verifies that author makes agreed corrections.  
& errors are resolved.

## Quality Assurance Group :

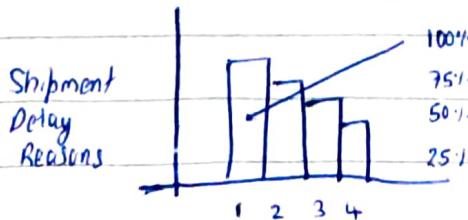
- Perform activities such as software correctness verification & audits.

## Problem Solving Team :

- Analyses problems, suggests corrective measures.
- Utilizes fish-bone diagrams : Cause & Effect Diagrams

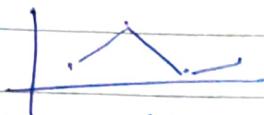


- Histograms : Analyze frequencies / distribution.
- Pareto Chart : Identify key problems by arrangement.



- 1) Payment Issues
- 2) Stock Out
- 3) Mac.
- 4) Traffic

- Trend Graph : Observation over time



- Scatter Graph : Relations b/w properties.
- Failure Mode Effect Analysis :

Identify modes of failure & associated impacts. Used in design phase.

Modeling : Aids in understanding of the s/w, for explaining behaviour.

Cost of Quality : Emphasis on improvement activities.

- Includes costs of internal & external failures.
- Includes prevention costs : costs to prevent occurrence of problems.
- Includes appraisal / verification costs : Infrastructure to verify correctness

A.V. Feigenbaum, 1950 : Categorization of cost of quality :

Cost External, Cost Internal, Cost Preventive, Cost Appraisal

Process Improvement : Improving capability of org. in delivering high-quality s/w on time consistently & reducing cost of quality.

Improvement Goals : Short-Term (3-6 months)

Long-Term (2-3 yrs)

Customer Satisfaction :

- Effectiveness of quality management system judged by customer.
- Approach : survey, prepare & execute action plan, resurvey.

Assessments :

- Aim : Rate organization wrt standard or model.
- Using assessment results, plan & prioritize improvements.

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X Total Quality Management :-

- Attention on quality & focus on integration of quality in culture.
- Quality to be addressed at company-level.
- Goal: Total customer satisfaction, holistic process.
- Components :-
  - 1) Customer Focus :- Focus on needs & requirements of customer.  
Meet customer expectations & rights, to be satisfied everytime.
  - 2) Process :- Focus on process & improvement via problem-solving, to reduce waste & eliminate error.
  - 3) Measurement & Analysis :- Setting up a measurement program to enable objective & effective analysis of quality.
  - 4) Human Factors :- Involves developing culture of quality & customer satisfaction throughout organization.
- Procedure - Identify problem, collect data & analyze, draw action plan, implement actions, monitor.
- Implementation - Identify improvement area
  - Problem evaluation
  - Data collection
  - Data Analysis
  - Action Plan
  - Implementation of action plan
  - Monitor effectiveness
  - Repeat

SQA

## + Comm. & Gov. Standards for use in SQA [Handbook of SQA, 2008] :

- Use in certification & audit.

- ISO, IEEE, US Military Stds.

### \* SQA in ISO Standards :-

- Non-Govt. org, Geneva, Switzerland

- Standards :

- ISO 9000:2005 & 9001:2000

+ ISO 9000 : Collection of standards (Incl. 9001, 9002, ...)

: Aim : facilitate international trade of

: goods & services for uniformity.

+ ISO 9000:2005 : Used in conjunction w/ ISO 9001:2000

: Defines vocabulary used in 9001:2000

: TOC, Headings (Clauses).

+ ISO 9001:2000 : Defines framework for SQA specifying reqmts.

Clauses 4 Quality Mgmt. System :

4.1 General Requirements

4.2 Documentation Requirements

## 5 Management Responsibility :

5.1 Management Commitment : Establish mgmt. policy.

5.2 Customer Focus

5.3 Quality Policy :

5.4 Planning :

5.5 Responsibility, Authority & Communication :

5.6 Mgmt. Review : Review I/O.

6 Resource Management : Deals w/ human, infra resources

7 Product Realization & Feedback

8 Measurement Analysis & Improvement

- To conform to standard, provide requirements as mentioned in standard, & follow specified guidelines to comply, dispatch for verification & gain certification.
- + ISO/IEC 9003: For auditing purposes, to audit quality mgmt system 9003:2004
  - : 8 clauses, mentioning ways of implementing reqmts from 9001
- Incorporate standards into workflow.
  - : Product of Joint Technical Committee 1 (JTC1).
  - : From ISO & IEC. (Intl. Electrotechnical Comm.)
  - : Unlike other stds, no conformation required, as standard states guidelines.
- + ISO/IEC 2500n - ISO/IEC 2504n (SQUARE):
  - : Collection / Family of 14 stds, referred as SQUARE.
  - : Contains descriptions of reqpts
  - : Software product Quality Requirements & Evaluation
  - : SQuaRE : Document w/ 5 divisions :
    - Quality Mgmt., Qual. Model, Qual. Measurements,
    - Quality Reqmts & Qual. Evaluation.
- + ISO/IEC 9126 series & ISO/IEC 14578 series :
  - : Older standards, replaced by SQUARE.
- + Square stds (in 2008) :
  - ISO/IEC 25000: 2005
  - ISO/IEC 25001 : 2007
- + ISO/IEC 25000 : 2005 : Multiple clauses.
  - Clause 5 : Describes documents planned for SQUARE series.  
Defines structure & lifecycle of s/w product quality.
  - Clause 4 : 64 definitions.
  - Annexure C : Methods from upgradation from older std.

- + ISO/IEC 25001:2007 : Planning & management std.
  - : Usable at project level as well as corporate / dept. lvl.
  - : Clause 4 : Defines eval. activity, eval. group, eval. tech.
  - : Clause 5 : Role of evaluation group.
  - : Clause 6 : Regmts. for software quality spec. & quality eval.
    - General requirements
    - 7 kinds of regmts for mgmt at org. lvl.
  - : For conformance : Satisfy regmts in clause 6, explaining exclusions.
    - : Map own requirements to specifications

+ ISO/IEC 14598 & ISO/IEC 15504

+ ISO/IEC 14598 : Collection of stds. to give methods for measurement, assessment & evaluation of software product quality.

14598-1 : Provides foundation, defines vocabulary & explaining where characteristics & metrics defined in ISO 9126 are used.

14598-2 : Replaced by ISO/IEC 25001:2007

14598-3 : Used at project level, elaborates generic eval. process.

14598-4 : Expansion of process for regmts for acquirers.

+ ISO/IEC 15504 : Provides structured approach for assessment of processes. Replacement for ISO/IEC TR 15504-1:1998 to ISO/IEC TR 15504-9:1998 (focus on slw processes)

: Focus on processes of any kind (broadened).

- Process Ref. Model : Model linking lifecycle process w/ purpose.

- Process Assess. Model : Model based on It PRM, incorporating capability levels, process attrs. & rating scale to assess capability of process.

15504-2 : Requirements for PRM & PAM.

15504-3 : Competency of assessors.

- + ISO/IEC 9126 : Defines model of product quality & related metrics, in 4-part series.
  - : Used jointly w/ 14598.
  - : 9126 defines metrics, used for assessment.
  - : Concepts for prod. quality :
    - Internal : Product specific attrs.
    - External : Attrs of product upon execution in system.
    - Quality in Use : Extent to which product meets needs in specified situations.

9126-1 : Organizes attrs of internal & external quality into characteristics.

- + ISO/IEC 12207 : Defines vocabulary & architecture of 17 SDLC processes & 1 tailoring process.
  - : Used in situations w/ 2-party binding agreement to acquire products or services applies
  - : Serves as normative desc. of s/w LC for other stds.

x SQA in IEEE Standards —