UNIT IV

TEST MANAGEMENT

People and organizational issues in testing – Organization structures for testing teams – testing services – Test Planning – Test Plan Components – Test Plan Attachments – Locating Test Items – test management – test process – Reporting Test Results – Introducing the test specialist – Skills needed by a test specialist – Building a Testing Group-The Structure of Testing Group- .The Technical Training Program

4.1 PEOPLE AND ORGANIZATIONAL ISSUE IN TESTING

People and Organizational Issues in Testing

Common people issues:

1. Perceptions and misconceptions about testing,
2. Comparison between testing and development functions,
3. Providing career path for testing professionals,
4. The role of the ecosystem and a call for action,

Perception and Misconception about Testing

- ✓ Testing is not technically challenging
- ✓ Testing does not provide me a career path or growth
- ✓ I am put in testing – what is wrong with me?
- ✓ These folks are my adversaries.
- ✓ Testing is what I can do in the end if I get the time
- ✓ There is no sense of ownership in testing
- ✓ Testing is only destructive

"Testing Is Not Technically Challenging"

- ❖ Where these come from the fallacy in the statements and what can be given as arguments to counter these perceptions, it is important that these misconceptions and perceptions are cleared upfront to build a successful and motivated testing team **" Testing is not technically challenging"**
- ❖ If we are conducting interviews to hire people for performing testing functions we will generally observe a very bipolar behavior among the candidates.
- ❖ There will be the first set of people-usually a minority – who will approach testing with tremendous pride commitment and enjoyment.
- ❖ The send set unfortunately, a majority will be those who get in to testing is not technically challenging.
- ❖ One of the arguments given is "if I look at development functions, I acquire a proficiency in a given programming language and that is considered valuable.
- ❖ On the other hand testing is simply a routine and repetitive job that does not require any special skills.

❖ This argument may have been true about twenty years ago when most of the testing was manual and the products were somewhat simplistic.
❖ Testing stream bears a remarkable parallel to the development job functions.

Table 4.1: Similarities in the testing and development functions

Functions in development projects	Corresponding functions in testing projects	Similarity
Requirements specifications	Test specification	Both require a thorough understanding of the domain sometimes testing function require an even more holistic understanding of the entire system from the users perspective
Design	Test design	Test design carrier with it all the attributes of product design in term s of architecting the test system, considering reuse, Formulating standards and so on
Development/coding	Test script development	Involves using the test development and test automation tools.
Testing	Making the test operational	This would involve well-knit team work between the development and testing teams to ensure that the correct captured.
Maintenance	Test maintenance	Keeping the tests [regression, test, functional tests, and so on] with changes from maintenance.

❖ Requires a holistic understanding of the entire product rather than just a single module.
❖ Requires thorough understanding of the multiple domain
❖ Specialization in language
❖ Use of tools
❖ Opportunities for conceptualization and out-of the box thinking.
❖ Significant investment are made in testing today-sometimes a lot more than in development
❖ There is testing in all development and development in all testing.
❖ An internal test tool today could very well be one of those expensive test automation tools of tomorrow.

Testing Does Not Provide Me a Career Path or Growth
- ❖ A number of organizations have career paths defined for people in the development and other software engineering functions but when it comes to testing functions, the career paths are not clearly laid out.
- ❖ In fact even the job titles are given as "development engineer"
- ❖ 'Senior Development Engineer ' and so on from a project life cycle point of view, developers seem to have natural progression into being a designer, a business analyst, and a domain expert. There is also scope for being a respected "architect"
- ❖ Testing is not a devil and development is not an angel, opportunities abound equally in testing and development.

Comparison between Testing and Development Functions
- ❖ The perceptions and misconceptions have some significant differences between testing and development functions. The differences are the testing is often a crunch time function generally more "elasticity" is allowed in projects in earlier phase.
- ❖ Testing functions are arguably the most difficult one to staff Testing functions usually carry more external dependencies than development functions. In the area s like categorizing defects the test engineer is expected to get involved in formulation, being closest to reality.

Providing Career Paths for Testing Professions
- ❖ The career progression that a testing professional may look forward to and the competencies he or she needs to acquire as he or she makes this progression.
- ❖ When people look for a career path in testing [or for that matter in any chosen profession] some of the areas of progression.
  - ✓ Technical challenge
  - ✓ Learning opportunities
  - ✓ Increasing responsibilities and authority
  - ✓ Increasing independence
  - ✓ Ability to have a significant influence on an organization s success
  - ✓ Rewards and recognition
- ❖ The progression for typical test engineer from a functional point of view .A typical test engineer's career may begin by executing certain manual or automated test.
- ❖ One possible progression for testing professionals that takes in to account the three stages of growth. An individual starts his testing career as fresh engineer, during this time; most of the role he plays is in the following stages

The role of the ecosystem and a call for action - Role of Education System
- ❖ There are formal core courses on programming but only a few universities offer core courses on software training.
- ❖ Consider some of these facts about what prevails in most universities.
- ❖ The right values can only be more effectively caught by the students than be taught by the teachers.
- ❖ There are lab courses for various development tools but non or very few for common testing tools.

- ❖ Even during courses like operating systems and databases, the emphasis on exercises and practical work is only on programming aspects, not on appropriately testing the built product.
- ❖ Most projects done as a part of the curriculum never ask for test plan nor look at testing effectiveness.
- ❖ Most courses, and projects reward individual performance and present very little opportunity for team work, which is so essential for the success of development and test engineers.
- ❖ Real-life scenarios like constant church of changes and the impact of such changes on quality of the product and the demands placed on testing and quality assurance methods are seldom emphasized.

Role of Senior Management
- ❖ Fairness to and recognition of testing professional should not only be done but should be seen to be done.
- ❖ The senior management of organizations plays a vital role in the development of test professionals.
- ❖ Some of the concrete steps they can take to achieve this are as follows
  - ✓ Ensuring a fair distribution of appropriately talented people in the testing.
  - ✓ Not allowing development engineers to look down upon test engineers.
  - ✓ Encouraging and consciously ensuring that there is active job rotation among development, testing and support functions.
  - ✓ Demonstrating equity in recognition and reward schemes to the top performers in all the functions, including testing.
  - ✓ Nurturing talent in test professionals by providing them opportunities to further their knowledge and skills.

Role of the Community
- ❖ As members of test community do you have pride and sense of equality? Remember authority is taken not given.
- ❖ Regardless of whatever the senior management or academia do, the success of the testing community starts from within. There are a few things that the members of the testing community, the testing professionals should do in order to showcase and promote the testing profession . Testers should start with a sense of pride in their job and the realization of their role in a more holistic way, in the bigger picture of the entire product.
- ❖ Testers should themselves see a career in testing rather than view testing as a stop gap arrangement or a means to get into development functions.

4.2 ORGANIZATION STRUCTURES FOR TESTING TEAMS

- ✓ Dimension of organization structures.
- ✓ Structures in single product companies.
- ✓ Structures for multi- product companies.
- ✓ Effect of globalization and geographically distributed teams on product testing.
- ✓ Testing services organizations.
- ✓ Success factors for testing organizations.

Dimension of Organization Structures
- ❖ Organization structures directly relate to some of the people issues. The study of organization structures is important from the point of view of effectiveness because as appropriately designed organization structure can provide accountability to results.
- ❖ This accountability can promote better team work among the different constituents and create better focus in work.
- ❖ Organization classified into two categories:
  - ✓ product organization
  - ✓ services organization

- ❖ **Product organizations** produce software products and have a "womb to tomb" responsibility for the entire project.
- ❖ **Service organizations** do not have complete product responsibility. In the testing context, they are external organizations that provide testing services to other organizations that require them.
- ❖ **Product or service organizations** that are involved in testing cab be either single-site or multi-site.
- ❖ In a single-site team, all members are located at one place while in a multi-site team, the team is scattered across multiple locations.

Structures in Single Product Companies
- ❖ Product companies in general have high level organization structure.
- ❖ The CTO s office sets the high-level technology directions for the company. A business unit is in charge of each product that the company produces. A product business unit is organized in to a product management group and a product delivery group.
- ❖ The product management group has the responsibility of merging the CTO s direction with specific market needs to come out with a product road map. The product delivery group is responsible for delivering the product and handles both development and testing functions.

Testing Team Structure For Single-Product Companies
- ❖ Most product companies start with a single product. The product delivery team members distribute their time among multiple tasks and often wear multiple hats.
- ❖ All engineers report into the project manager who is in charge of the entire project, with every little distinction between testing function and development function. Very thin line separating the development team and "testing team".
- ❖ There is very little management hierarchy and people playing the roles of "manager", "leads" and so on actually are also engineers who are expected to act as individual contributors as well.
  - Exploits the rear-loading nature of testing activities.
  - Enables engineers to gain experience in all aspects of life cycle
  - Is amenable to the fact that the organization mostly has only mostly informal process.
- ❖ Some defects may be detected early. Accountability for testing and quality reduces. Developers do not in general like testing and hence the effectiveness of testing suffers.
- ❖ Schedule pressures generally compromise testing. Developers may not be able to carry out the different type of tests.

Component-Wise Testing Teams

- ❖ Even if a company produces only one product, the product is made up of a number of components that fit together as a whole.
- ❖ The structure of each of the component teams can be either a coalesced development-testing team or a team with distinct responsibilities for testing and development.
- ❖ An informal mix-and-match of the different organization structures for the different components, with a central authority to ensure overall quality will be more effective.

Structure For Multi-Product Companies

- ❖ When a company becomes successful as single-product company, it may decide to diversify in to other products. In such a case, each of the product is considered as a separate business unit, responsible for all activities of a product.
- ❖ The organization of a test team in multi-product companies is dictated largely by the following factors.
- ❖ How tightly coupled the products are in terms of technology. Dependence among various products.
- ❖ How synchronous are the release cycles of products. Customer base for each product and similarity among customer bases for various products.
- ❖ Based on the above factors, there are several options available for organizing testing teams for a multi-product company.
- ❖ A central "test think-tank/brain trust" team, which formulates the test strategy for the organization.
- ❖ One test team for all the products.
- ❖ Different test team for each product [or related product]
- ❖ Different test teams for different types of tests.
- ❖ A hybrid of all the above models.

Testing Teams Are Part Of CTO Office

- ❖ Testability of a product is as important as its development. Hence, it makes sense to assign the same level of importance to testing as to development.
- ❖ One way to accomplish this is to have a testing team report directly to the CTO as appear to the design and development teams.
- ❖ The advantages that this model brings to the table are as follows:
  - Developing a product architecture that is testable or suitable for testing.
  - Development and tests.
  - Testing team will have better product and technology skills.
  - The testing team can get a clear understanding of what design and architecture are built for and plan their tests.
  - The CTO s team can evolve a consistent, cost-effective strategy for test automation.
  - As the architecture and testing responsibilities are with the same person, that is the CTO, the end-to-end objectives of architectures such as performance, load condition, availability requirements, and so on.

❖ This model, where in testing role reports to CTO and has high visibility will motivate them to have a good target to aim for. In order to be effective
❖ The team should be small in number.
❖ It should be a team of equals or at most very few hierarchies. It should have organization with wide representation
❖ It should have decision-making and enforcing authority and not just be a recommending committee.

4.3   TESTING SERVICES

Business Need for Testing Services:

❖ It is common to find testing activities outsourced to external companies who specialize in testing and provide testing services
❖ There are several business drivers for this model of testing as a service
- Testing is becoming increasingly diverse and a very specialized function
- The variety and complexity of the test automation tools further increase the challenge in testing
- The testing as a process is becoming better defined
- A product development organization which has expertise in setting up and running an effective testing function
- An outsourced organization can offer location advantages
- An outsourced organization can provide lost advantages

Typical Roles And Responsibilities Of Testing Services Organization

❖ A testing Services organization is made up of a number of accounts, with each account being responsible for a major customer
❖ The account manager serves the following functions:
- Is the single point of contact between the customer and the testing services organization for all matters and is also the point of escalation
- Developers support with the customer and is responsible for ensuring that current projects are delivered as promised and for getting new business from the customer
- Participants in all strategic communication between the customer and the testing services
- Acts as proxy for the customer within the testing services organization
❖ The testing services team organizes its account team as a near-site team and remote team. The near – site team is usually a small team. It is placed at or near the customer location.
❖ This team serves the following functions:
- Be appoint of direct first point of contact for the customer for tactical or urgent issues
- Act as a stop-gap to represent the remote team, in the event or emergencies like travel embargo infrastructure unavailability etc.
- It also serves to increase the rapport between the customer's operational team and the testing services team.

❖ The remote team manager manages the entire remote team and can have a peer- to –peer relationship with the near-site team or have the near-site team reporting to him or her.

Challenges And Issues In Testing Services Organizations

❖ All testing organizations face certain common challenges. In the case of a testing services organization to which testing is outsourced, some of these challenges are exuberated, primarily because of the arm's length distance from the development team.

4.4   TEST PLANNING

A Plan Is A Document That Provides A Framework Or Approach For Achieving A Set Of Goals.

❖ Test plans tend to be more technically oriented.
❖ A software project plan that may contain a test plan as well will often refer to business goals. Test planning is an essential practice for any organization that wishes to develop a test process that is repeatable and manageable. Pursuing the maturity goals embedded in the TMM structure is not a necessary precondition for initiating a test-planning process.
❖ A test process improvement effort does provide a good framework for adopting this essential practice. Test planning should begin early in the software lifecycle, although for many organizations whose test processes are immature this practice is not yet in place.
❖ A plan also contains milestones.
❖ Milestones are tangible events that are expected to occur at a certain time in the project's lifetime. Managers use them to determine project status. Tracking the actual occurrence of the milestone events allows a manager to determine if the project is progressing as planned. Finally, a plan should assess the risks involved in carrying out the project.
❖ The planner usually includes the following essential high-level items.
- Overall test objectives.
- What to test (scope of the tests).
- Who will test
- How to test.
- When to test.
- When to stop testing.

❖ Test plans can be organized in several ways depending on organizational policy. There is often a hierarchy of plans that includes several levels of quality assurance and test plans. At the top of the plan hierarchy there may be a software quality assurance plan. This plan gives an overview of all verification and validation activities for the project, as well as details related to other quality issues such as audits, standards, configuration control, and supplier control.
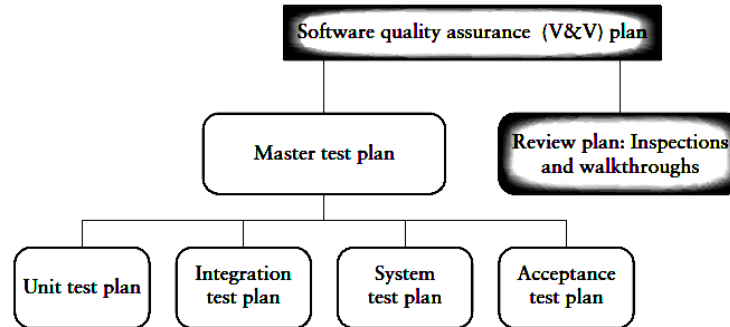
Figure 4.1: Hierarchy of test plan

❖ The persons responsible for developing test plans depend on the type of plan under development. Usually staff from one or more groups cooperates in test plan development.
❖ The type and organization of the test plan, the test plan hierarchy, and who is responsible for development should be specified in organizational standards or software quality assurance documents.

4.5   TEST PLAN COMPONENT

Test Plan Identifier
❖ Each test plan should have a unique identifier so that it can be associated with a specific project and become a part of the project history. The project history and all project-related items should be stored in a project database or come under the control of a configuration management system.

Introduction
❖ In this section the test planner gives an overall description of the project, the software system being developed or maintained, and the software items and/or features to be tested. It is useful to include a high-level description of testing goals and the testing approaches to be used.

Items to Be Tested
❖ This is a listing of the entities to be tested and should include names, identifiers, and version/revision numbers for each entity.
❖ The items listed could include procedures, classes, modules, libraries, subsystems, and systems. References to the appropriate documents where these items and their behaviors are described such as requirements and design documents, and the user manual should be included in this component of the test plan.
❖ These references support the tester with traceability tasks.

Features to Be Tested
❖ In this component of the test plan the tester gives another view of the entities to be tested by describing them in terms of the features they encompass. Features may be described as distinguishing characteristics of a software component or system.

Approach
- ❖ This section of the test plan provides broad coverage of the issues to be addressed when testing the target software. Testing activities are described. The level of descriptive detail should be sufficient so that the major testing tasks and task durations can be identified.

Item Pass/Fail Criteria
- ❖ Given a test item and a test case, the tester must have a set of criteria to decide on whether the test has been passed or failed upon execution.
- ❖ The master test plan should provide a general description of these criteria. In the test design specification section more specific details are given for each item or group of items under test with that specification.

Suspension and Resumption Criteria
- ❖ In this section of the test plan, criteria to suspend and resume testing are described. In the simplest of cases testing is suspended at the end of a working day and resumed the following morning. For some test items this condition may not apply and additional details need to be provided by the test planner.

Test Deliverables
- ❖ Execution-based testing has a set of deliverables that includes the test plan along with its associated test design specifications, test procedures, and test cases. The latter describe the actual test inputs and expected outputs.

Testing Tasks
- ❖ In this section the test planner should identify all testing-related tasks and their dependencies. Using a Work Breakdown Structure (WBS) is useful here. A Work Breakdown Structure is a hierarchical or treelike representation of all the tasks that are required to complete a project.

The Testing Environment
- ❖ Here the test planner describes the software and hardware needs for the testing effort. The planner must also indicate any laboratory space containing the equipment that needs to be reserved.

Responsibilities
- ❖ The staff who will be responsible for test-related tasks should be identified. This includes personnel who will be:
  - Transmitting the software-under-test;
  - Developing test design specifications, and test cases;
  - Executing the tests and recording results;
  - Tracking and monitoring the test efforts;
  - Checking results;
  - Interacting with developers;
  - Managing and providing equipment;
  - Developing the test harnesses; and Interacting with the users/customers.

Staffing and Training Needs

❖ The test planner should describe the staff and the skill levels needed to carry out test-related responsibilities such as those listed in the section above. Any special training required to perform a task should be noted.

Scheduling

❖ Task durations should be established and recorded with the aid of a task networking tool. Test milestones should be established, recorded, and scheduled.

Risks and Contingencies

❖ Every testing effort has risks associated with it. Testing software with a high degree of criticality, complexity, or a tight delivery deadline all impose risks that may have negative impacts on project goals. These risks should be identified, evaluated in terms of their probability of occurrence, prioritized, and contingency plans should be developed that can be activated if the risk occurs.

Testing Costs

❖ The IEEE standard for test plan documentation does not include a separate cost component in its specification of a test plan. This is the usual case for many test plans since very often test costs are allocated in the overall project management plan. Test costs that should included in the plan are:

- Costs of planning and designing the tests;
- Costs of acquiring the hardware and software necessary for the tests;
- Costs to support the test environment;
- Costs of executing the tests;
- Costs of recording and analyzing test results;
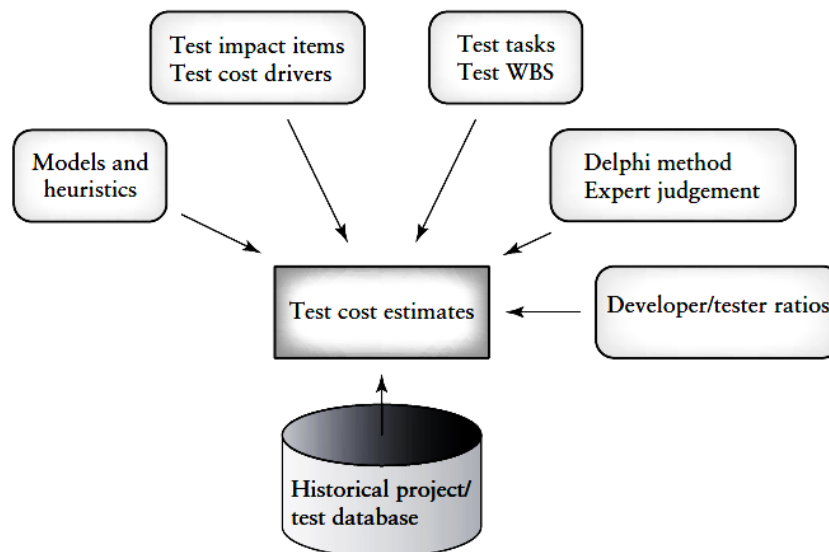- Tear-down costs to restore the environment.

Figure 4.2: Approaches to Test Cost Estimation

❖ A cost driver can be described as a process or product factor that has an impact on overall project costs. A cost driver includes,

- Product attributes such as the required level of reliability;
- Hardware attributes such as memory constraints;
- Personnel attributes such as experience level;
- Project attributes such as use of tools and methods;

4.6   TEST PLAN ATTACHMENTS

❖ The following components of the test plan contain this detailed information. These documents are generally attached to the test plan.

Test Design Specification

❖ The IEEE standard for software test documentation describes a test design specification as a test deliverable that specifies the requirements of the test approach.

❖ To develop test design specifications many documents such as the requirements, design documents, and user manual are useful.

❖ For requirements-based test, developing a requirements traceability matrix is valuable. This helps to insure all requirements are covered by tests, and connects the requirements to the tests.

❖ The test planner should be sure to list any related documents that may also contain some of this material.

- Test Design Specification Identifier
- Features to Be Tested.
- Approach Refinements
- Test Case Identification
- Pass/Fail Criteria

Test Case Specification

❖ This series of documents attached to the test plan defines the test cases required to execute the test items named in the associated test design specification.

❖ Much attention should be placed on developing a quality set of test case specifications. Each test case must be specified correctly so that time is not wasted in analyzing the results of an erroneous test.

❖ Careful design and referencing to the appropriate test design specification is important to support testing in the current project and for reuse in future projects.

- Test Case Specification Identifier
- Test Items
- Input Specifications
- Output Specifications
- Special Environmental Needs
- Special Procedural Requirements
- Interface Dependencies

Test Procedure Specification

- ❖ A procedure in general is a sequence of steps required to carry out a specific task.
- ❖ In this attachment to the test plan the planner specifies the steps required to execute a set of test cases.
- ❖ Another way of describing the test procedure specification is that it specifies the steps necessary to analyze a software item in order to evaluate a set of features.
- ❖ Reference to documents where parts of these components are described must be provided.

  - • Test Procedure Specification Identifier
  - • Purpose
  - • Specific Requirements
  - • Procedure Steps

Procedure Steps

- ❖ **Setup**: to prepare for execution of the procedure;
- ❖ **Start**: to begin execution of the procedure;
- ❖ **Proceed**: to continue the execution of the procedure;
- ❖ **Measure**: to describe how test measurements related to outputs willbe made;
- ❖ **Shut down**: to describe actions needed to suspend the test when unexpectedevents occur;
- ❖ **Restart**: to describe restart points and actions needed to restart theprocedure from these points;
- ❖ **Stop**: to describe actions needed to bring the procedure to an orderlyhalt;
- ❖ **Wrap up**: to describe actions necessary to restore the environment;
- ❖ **Contingencies**: plans for handling anomalous events if they occurduring execution of this procedure.

4.7   LOCATING TEST ITEMS

- ❖ Suppose a tester is ready to run tests on an item on the date described in the test plan.She needs to be able to locate the item and have knowledge of its current status.
- ❖ This is the function of the Test Item Transmittal Report.
- ❖ This document is not a component of the test plan, but is necessary to locate and track the items that are submitted for test.
- ❖ Each Test Item Transmittal Report has a unique identifier. It should contain the following information for each item that is tracked,

  - • Version/revision number of the item;
  - • Location of the item;
  - • Persons responsible for the item (e.g., the developer);
  - • References to item documentation and the test plan it is related to;
  - • Status of the item;
  - • Approvals—space for signatures of staff who approve the transmittal.

4.8   TEST MANAGEMENT

Choice of Standards:

- ❖ Standards compromise an important part of planning in any organization standards are of two types:

    1. **External standards**
    2. **Internal standards**

        - **External standards** are standards that a product should comply with are externally visible and are usually stipulated by external consortia.
        - **Internal standards** are standards formulated by attesting organization to bring in consistency and predictability.
- ❖ Some of the internal standards include:
    - Naming and storage conventions for test artifacts
    - Document standards
    - Test coding standards
    - Test reporting standards

Naming and storage conventions for test artifacts

- ❖ Easy identification of the product functionality that a set of tests are intended for
- ❖ Reverse mapping be identify the functionality corresponding to a given set of tests
- ❖ Every test artifacts have to be named appropriately and meaningfully. Such naming conventions should enable:

Documentation standards

- ❖ Internal documentation of test scripts are similar to internal documentation of program code and should include the following:
    - Appropriate header level comments at the beginning of a file that outlines the functions to be served by the test
    - Sufficient in-line comments, spread throughout the file, explaining the functions served by the various parts of a test script
    - Up-to-date change history information, recording all the changes made to the test file.

Test coding standards

- ❖ Test coding standards go one level deeper into the tests and enforce standards on how the tests however are written. The standards may:
    - Enforce the right type of initialization and clean-up that the test should do to make the results independent of other tests
    - Encourage reusability of test artifacts
    - Provide standard interfaces to external entitles like operating system, hardware and so on.

Test reporting standards
- ❖ Since testing is tightly interlinked with product quality, all the stakeholders must get a consistent and timely view of the progress of tests.

Test Infrastructure Management
- ❖ Testing requires a robust infrastructure to be planned upfront. This infrastructure is made up of three essential elements.
  - A test case database (TCDB)
  - A defect repository
  - Configuration Management repository and tool

- ❖ A SCM repository also known as (CM repository) keeps track of change control and version control and version control of all the files/entities that make up a software product.
- ❖ Change control ensures:
- ❖ Changes to test files are made in a controlled fashion and only with proper approvals.
- ❖ Changes made by one test engineer are not accidentally lost or overwritten by other changes.
- ❖ Each change produces a distinct version of the file that is re-creatable at any point of time
  At any point of time, everyone gets access to only the most recent version of the test files

Test People Management
- ❖ People management is an integral part of any project management.
- ❖ It is a difficult chasm for engineers – turned – managers to cross.
- ❖ As an individual contributor, a person relies only on his or her own skills to accomplish an assigned activity
- ❖ The person is not necessarily trained on how to document what need to be done so that it can be accomplished be someone else.
- ❖ People management also requires the ability to hire, motivate, and retain the right people.
- ❖ Project managers often learn these skills in a "sink or swim", mode, being thrown head-on into the task.

Integrating with product release
- ❖ The schedules of testing have to be linked directly to product release.
- ❖ Thus project planning for entire product should be done in a holistic way, encompassing the project plan for testing and development.
- ❖ The following are some of the points to be decided for this planning:
  - Sync points between development and testing as to when different types of testing can commence, for example, when integration testing could start, when system testing could start and so on.
  - Service level agreements between development and testing as to how long it would take for the testing team to complete the testing.
  - Consistent definitions of the various priorities and severities of the defects
  - Communication mechanisms to the documentation group to ensure that the documentation is kept in sync with the product in terms of known defects, work around and so on.

4.9   TEST PROCESS

- ❖ Putting together and base lining a test plan
- ❖ Test case specification
- ❖ Update of traceability matrix
- ❖ Identifying possible candidates for automation
- ❖ Developing and base lining test cases
- ❖ Executing test cases and keeping traceability matrix current
- ❖ Collecting and analysing metrics
- ❖ Preparing test summary report
- ❖ Recommending product release criteria

Putting Together and Base Lining A Test Plan:

- ❖ An organization normally arrives at a template that is to be used across the board. Each testing project puts together a test plan based on the template. Should any changes be required in the template, then such a change is made only after careful deliberations.
- ❖ The test plan is reviewed by a designated set of competent people in the organization.
- ❖ The test plan is base lined into the configuration management repository. From then on, the base lined test plan becomes the basis for running the testing project.
- ❖ Any significant changes in the testing project should thereafter be reflected in the test plan and the changed test plan base lined again in the configuration management repository.

Test Case Specification

- ❖ The testing team designs test case specifications, which then becomes the basis for preparing individual test cases.
- ❖ A test case is nothing but a series of steps executed on a product, using a predefined set of input data, expected to produce a pre-defined set of outputs, in a given environment.
- ❖ Hence a test case specification should clearly identify.
  - The purpose of the test: This lists what feature or part the test is intended for. The test case should follow the naming conventions that are consistent with the feature/module being tested.
  - Items being tested, along with their version/release numbers as appropriate.
  - Environment that needs to be set up for running the test case.
- ❖ This can include the hardware environment setup, supporting software environment set up (for example, setup of the operating system, database and so on). Set up of the product under test (installation of the right version, configuration data initialization and so on).
- ❖ Input data to be used for the test case
- ❖ The expected results that are considered to be "correct results"
- ❖ A step to compare the actual results produced with the expected results. This step should do an "intelligent" comparison of the expected and actual results to highlight any discrepancies.
- ❖ Any relationship between this test and other tests: This can be in the form of dependencies among the tests or the possibility of reuse across the tests.

Update of Traceability Matrix:
- ❖ A requirements traceability matrix ensures that the requirements make it through the subsequent lifecycle phases and do not get orphaned mid-course.
- ❖ In particular, the traceability matrix is a tool to validate that every requirement is tested.
- ❖ A traceability matrix is created during the requirements gathering phase itself by filling up the unique identifier for each requirement.
- ❖ As the project proceeds through the design and coding phases, the unique identifier for design features and the program, file name is entered in the traceability matrix.
- ❖ When a test case specification is complete, the row corresponding to the requirement which is being tested by the test case is updated with the test case specification identifier. This ensures that there is a two-way mapping between requirements and test cases.

Identifying Possible Candidates For Automation:
- ❖ The test case design forms the basis for writing the test cases. Before writing the test cases, a decision should be taken to which tests are to be automated and which should be run manually.
- ❖ Some of the criteria that will be used in deciding which scripts to automate include
  - Repetitive nature of the test.
  - Effort involved in automation.
  - Amount of manual intervention required for the test.
  - Cost of automation tool.

Developing and Base Lining Test Cases:
- ❖ The development of test cases entails transacting the test specification to a form from which the tests can be executed. If a test case is a candidate for automation then this step requires writing test scripts in the automation language.
- ❖ The test cases should also have change history documentation, which specifies
  - What was the change
  - Why the change was necessitated
  - Who made the change
  - When was the change made
  - A brief description of how the change has been implemented
  - Other files affected by the change

Executing Test Cases And Keeping Traceability Matrix Current:
- ❖ The prepared test cases have to be executed at the appropriate times during a project. For example, test cases corresponding to smoke tests may be run on daily basis.
- ❖ As the test cases are executed during a test cycle, the defect repository is updated with
  - Defects from the earlier test cycles that are fixed in the current build.
  - New defects that get uncovered in the current run of the tests.

Collecting and analyzing metrics:
- ❖ When tests are executed, information about test execution gets collected in test logs and other files.

Preparing test summary report:

- ❖ At the completion, of a test cycle a test summary report is produced. This report gives insights to the senior management about the fitness of the product for release.
- ❖ Recommending product release criteria.
- ❖ "While under testing a product could be a risk over testing a product trying to remove "that last defect" could be as much of a risk!"
- ❖ The job of the testing team is to articulate to the senior management and the product test team.
  - What defects the product has;
  - What is the impact/severity f each of the defects
  - What would be the risks of releasing the product with the existing defects.

4.10   REPORTING TEST RESULTS

- ❖ The test plan and its attachments are test-related documents that are prepared prior to test execution. There are additional documents related to testing that are prepared during and after execution of the tests.

Test Log

- ❖ The test log should be prepared by the person executing the tests. It is a diary of the events that take place during the test. It supports the concept of a test as a repeatable experiment. The test log is invaluable for use in defect repair. It gives the developer a snapshot of the events associated with a failure. Retest that follows defect repair is also supported by the test log.
- ❖ The test log is valuable for regression testing that takes place in the development of future releases of a software product, and circumstances where code from a reuse library is to be reused. The test log can have many formats. An organization can design its own format or adopt IEEE recommendations.

Test Log Identifier

- ❖ Each test log should have a unique identifier.

Description

- ❖ In the description section the tester should identify the items being tested, their version/ revision number, and their associated Test Item/Transmittal Report. The environment in which the test is conducted should be described including hardware and operating system details.

Activity and Event Entries

- ❖ The tester should provide dates and names of test log authors for each event and activity. This section should also contain:
  - Execution description
  - Procedure results
  - Environmental information
  - Anomalous events
  - Incident report identifiers

Test Incident Report
- ❖ The tester should record in a test incident report any event that occurs during the execution of the tests that is unexpected, unexplainable, and that requires a follow-up investigation. The IEEE Standard for Software Test Documentation recommends the following sections in the report,
  - Test Incident Report identifier
  - Summary
  - Incident description
  - Impact

Test Summary Report

- ❖ This report is prepared when testing is complete. It is a summary of the results of the testing efforts. It also becomes a part of the project's historical database and provides a basis for lessons learned as applied to future projects. The IEEE test documentation standard describes the following sections for the Test Summary Report,
  - Test Summary Report identifier
  - Variances
  - Comprehensiveness assessment
  - Summary of results
  - Evaluation
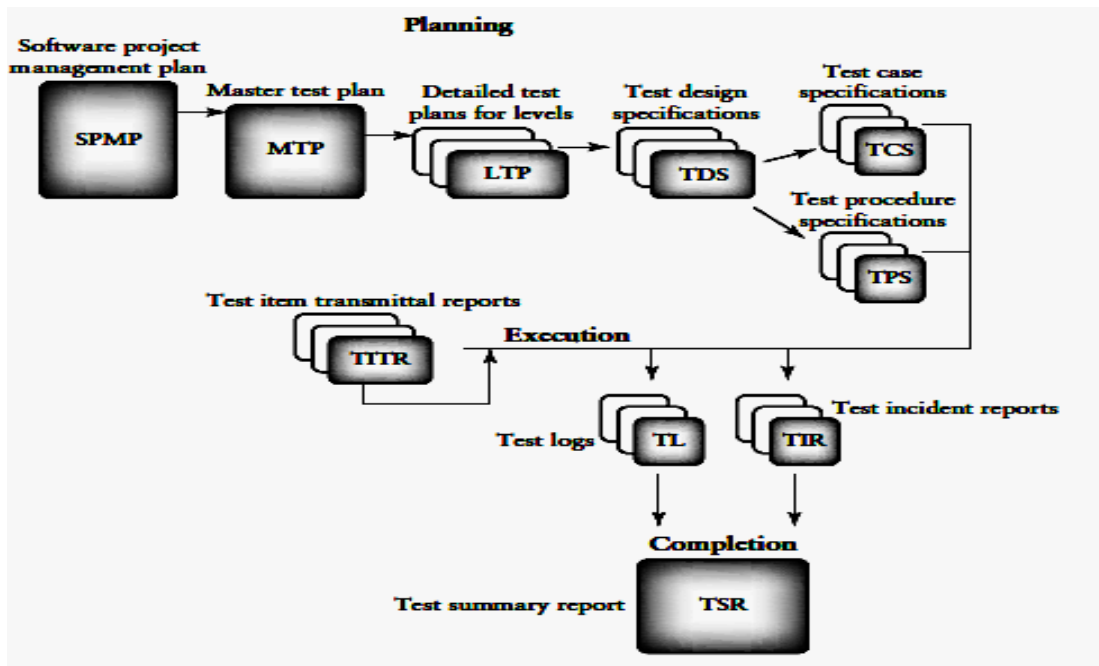 - Summary of activities
  - Approvals

Figure 4.3: Test related documents recommended by IEEE

4.11   INTRODUCING THE TEST SPECIALIST

❖ When an organization has reached TMM level 2 it has accomplished a great deal. Fundamental testing maturity goals have been achieved . There are testing and debugging policies in place , which are available for all project personnel to access . There is management support for these policies . Management ensures they are applied to all projects. Testing for each project is planned. The test plan is prepared in conjunction with the project plan so that project goals can be achieved.

❖ Moving up to TMM level 3 requires further investment of organizational resources in the testing process . One of the maturity goals at TMM level 3 calls for the "Establishment of a test organization."

❖ By supporting a test group an organization acquires leadership in areas that relate to testing and quality issues. There will be staff with the necessary skills and motivation to be responsible for:

- Maintenance and application of test policies;
- Development and application of test-related standards;
- Participating in requirements, design, and code reviews;
- Test planning;
- Test design;
- Test execution;
- Test measurement;
- Test monitoring (tasks, schedules, and costs);
- Defect tracking, and maintaining the defect repository;
- Acquisition of test tools and equipment;
- Identifying and applying new testing techniques, tools, and methodologies;
- Mentoring and training of new test personnel;
- Test reporting.

❖ The staff members of such a group are called test specialists or test engineers . Their primary responsibly is to ensure that testing is effective and productive, and that quality issues are addressed. Testers are not developers , or analysts , although background in these areas is very helpful and necessary. Testers don't repair code. Test specialists need to be educated and trained in testing and quality issues.

4.12 SKILLS NEEDED BY A TEST SPECIALIST

❖ Because of the nature of technical and managerial responsibilities assigned to the tester, many managerial and personal skills are necessary for success in the area of work.

❖ On the personal and managerial level a test specialist must have:

- Organizational, and planning skills;
- The ability to keep track of, and pay attention to, details;
- The determination to discover and solve problems;
- The ability to work with others and be able to resolve conflicts;
- The ability to mentor and train others;
- The ability to work with users and clients;
- Strong written and oral communication skills;

- The ability to work in a variety of environments;
- The ability to think creatively

❖ On the technical level testers need to have:
  - An education that includes an understanding of general software engineering principles, practices, and methodologies;
  - Strong coding skills and an understanding of code structure and behavior;
  - A good understanding of testing principles and practices;
  - A good understanding of basic testing strategies, methods, and techniques;
  - The ability and experience to plan, design, and execute test cases and test procedures on multiple levels (unit, integration, etc.);
  - A knowledge of process issues;
  - Knowledge of how networks, databases, and operating systems are organized and how they work;
  - A knowledge of configuration management;
  - A knowledge of test-related documents and the role each documents plays in the testing process;
  - The ability to define, collect, and analyze test-related measurements;
  - The ability, training, and motivation to work with testing tools and equipment;
  - Knowledge of quality issues.

❖ Testers must have knowledge of both white and black box techniques and methods and the ability to use them to design test cases.
❖ Organizations need to realize that this knowledge is a necessary prerequisite for tool use and test automation.
❖ The list of skills and knowledge requirements needed to be a successful test specialist is long and complex.
❖ Acquiring these skills takes education, training, experience, and motivation. Organizations must be willing to support such staff since they play a valuable role in the organizational structure and have a high impact on the quality of the software delivered.

Tester Requirements   The Tester

Personal and Managerial Skills

Organizational, and planning skills
Track and pay attention to detail
Determination to discover and solve problems
Work with others, resolve conflicts
Mentor and train others
Work with users/clients
Written/oral communication skills
Think creatively

Technical Skills

General software engineering principles and practices
Understanding of testing principles and practices
Understanding of basic testing strategies, and methods
Ability to plan, design, and execute test cases
Knowledge of process issues
Knowledge of networks, databases, and operating systems
Knowledge of configuration management
Knowledge of test-related documents
Ability to define, collect, and analyze test measurements
Ability, training, and motivation to work with testing tools
Knowledge of quality issues

Figure 4.5: Skills needed for Test Specialist

4.13   BUILDING A TESTING GROUP

- ❖ Organizing, staffing, and directing are the major process in managing the testing process. Staffing activities include filling positions, assimilating new personnel, education and training, and staff evaluation.
- ❖ Directing includes providing leadership, building teams, facilitating communication, motivating personnel, resolving conflicts, and delegating authority.
- ❖ Organizing includes selecting organizational structures, creating positions, defining responsibilities, and delegating authority.
- ❖ Hiring staff for the testing group, organizing the testing staff members into teams, motivating the team members, and integrating the team into the overall organizational structure are organizing, staffing, and directing activities your organization will need to perform to build a managed testing process.
- ❖ Establishing a specialized testing group is a major decision for an organization. The steps in the process are summarized in the Figure. To initiate the process, upper management must support the decision to establish a test group and commit resources to the group.
- ❖ When hiring staff to fill test specialist positions, management should have a clear idea of the educational and skill levels required for each testing position and develop formal job descriptions to fill the test group slots. When the job description has been approved and distributed, the interviewing process takes place.
- ❖ Interviews should be structured and of a problem-solving nature. The interviewer should prepare an extensive list of questions to determine the interviewee's technical background as well as his or her personal skills and motivation.
- ❖ Zawacki has developed a general guide for selecting technical staff members that can be used by test managers.
- ❖ Dustin describes the kinds of questions that an interviewer should ask when selecting a test specialist.
- ❖ When the team has been selected and is up and working on projects, the team manager is responsible for keeping the test team positions filled (there are always attrition problems). He must continually evaluate team member performance.
- ❖ Bartol and Martin have written a paper that contains guidelines for evaluation of employees that can be applied to any type of team and organization.
- ❖ They describe four categories for employees based on their performance:

                         (i)   **retain,**
                         (ii)   **likely to retain**
                         (iii)   **likely to release**
                         (iv)   **release**

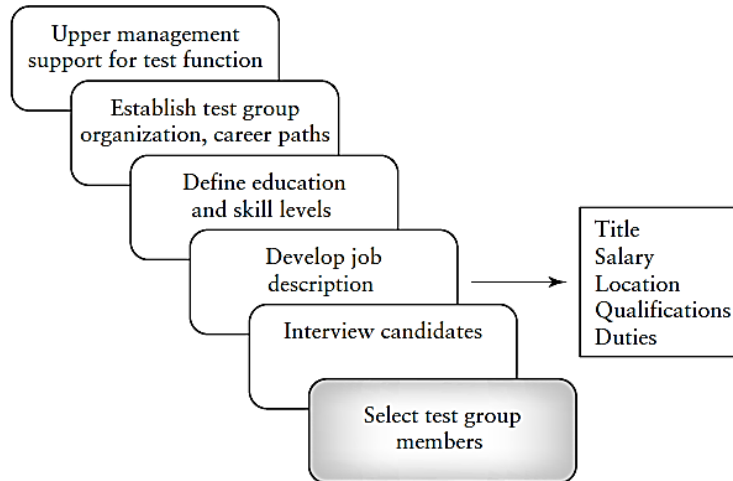- ❖ For each category, appropriate actions need to be taken by the manager to help employee and employer.

Figure 4.6: Steps in forming a test group

Structure of test group

- ❖ It is important for a software organization to have an independent testing group. The group should have a formalized position in the organizational hierarchy.
- ❖ A reporting structure should be established and resources allocated to the group.
- ❖ The group members are assigned to projects throughout the organization where they do their testing work. When the project is completed they return to the test organization for reassignment.
- ❖ They report to a test manager or test director, not a project manager.
- ❖ In such an organization testers are viewed as assets. They have defined career paths to follow which contributes to long-term job satisfaction.
- ❖ Since they can be assigned to a project at its initiation, they can give testing support throughout the software life cycle.
- ❖ There is a test knowledge base of test processes, test procedures, test tools, and test histories (lessons learned). Dedicated staff is responsible for maintaining a test case and test harness library.
- ❖ A test organization is expensive, it is a strategic commitment.
- ❖ Given the complex nature of the software being built, and its impact on society, organizations must realize that a test organization is necessary and that it has many benefits.
- ❖ By investing in a test organization a company has access to a group of specialists who have the responsibilities and motivation to:
  - Maintain testing policy statements;
  - Plan the testing efforts;
  - Monitor and track testing efforts so that they are on time and within budget;
  - Measure process and product attributes;
  - Provide management with independent product and process quality information;
  - Design and execute tests with no duplication of effort;
  - Automate testing;
  - Participate in reviews to insure quality; are meet.

- ❖ The duties of the team members may vary in individual organizations. The following gives a brief description of the duties for each tester that are common to most organizations.

The Test Manager
- ❖ In most organizations with a testing function, the test manager (or test director) is the central person concerned with all aspects of testing and quality issues.
- ❖ The test manager is usually responsible for test policy making, customer interaction, test planning, test documentation, controlling and monitoring of tests, training, test tool acquisition, participation in inspections and walkthroughs, reviewing test work, the test repository, and staffing issues such as hiring, firing, and evaluation of the test team members.

The Test Lead
- ❖ The test lead assists the test manager and works with a team of test engineers on individual projects. He or she may be responsible for duties such as test planning, staff supervision, and status reporting. The test lead also participates in test design, test execution and reporting, technical reviews, customer interaction, and tool training.

The Test Engineer
- ❖ The test engineers design, develop, and execute tests, develop test harnesses, and set up test laboratories and environments. They also give input to test planning and support maintenance of the test and defect repositories.

The Junior Test Engineer
- ❖ The junior test engineers are usually new hires.
- ❖ They gain experience by participating in test design, test execution, and test harness development. They may also be asked to review user manuals and user help facilities defect and maintain the test and defect repositories.

QUESTION BANK
PART-A

People And Organizational Issues In Testing

1. What are the common people issues in testing?
- ❖ Perceptions and misconceptions about testing
- ❖ Comparison between testing and development functions
- ❖ Providing career path for testing professionals
- ❖ The role of the ecosystem and a call for action

Organization Structures For Testing Teams

2. What are the possibilities available for organizing a testing team in multi-product company?
- ❖ A central "test think-tank/brain trust" team, which formulates the test strategy for the organization.
- ❖ One test team for all the products.
- ❖ Different test team for each product [or related product]
- ❖ Different test teams for different types of tests.
- ❖ A hybrid of all the above models.

Testing Services

3. What are the challenges faced by a testing service organization?

All testing organizations face certain common challenges. In the case of a testing services organization to which testing is outsourced, some of these challenges are exuberated, primarily because of the arm's length distance from the development team

Test Planning

4. What is plan?

A plan is a document that provides a framework or approach for achieving a set of goals. Test plans tend to be more technically oriented. However, a software project plan that may contain a test plan as well will often refer to business goals.

5. What is milestone?

Milestones are tangible events that are expected to occur at a certain time in the project's lifetime. Managers use them to determine project status.

6. What is Work Breakdown Structure?

A Work Breakdown Structure is a hierarchical or treelike representation of all the tasks that are required to complete a project.

7. What are the test costs that should be included in the test plan?

- ❖ Costs Of Planning And Designing The Tests;
- ❖ Costs Of Acquiring The Hardware And Software Necessary For The Tests (Includes Development Of The Test Harnesses);
- ❖ Costs To Support The Test Environment;
- ❖ Costs Of Executing The Tests;
- ❖ Costs Of Recording And Analyzing Test Results;
- ❖ Tear-Down Costs To Restore The Environment.

8. What are test cost impact items?

- ❖ The nature of the organization; its testing maturity level, and general maturity.
- ❖ The nature of the software product being developed.
- ❖ The scope of the test requirements.
- ❖ The level of tester ability
- ❖ Knowledge of the project problem domain.
- ❖ The level of tool support.
- ❖ Training requirements

9. Write the various approaches to test cost estimation. [Nov 2012]

- ❖ The COCOMO model and heuristics
- ❖ Use of test cost drivers
- ❖ Test tasks
- ❖ Tester/developer ratios
- ❖ Expert Judgment

Test Plan Components

10. List the various Test Plan components.

- ❖ Test Plan identifier
- ❖ Introduction
- ❖ Items to be tested
- ❖ Features to be tested
- ❖ Pass/Fail criteria
- ❖ Suspension & Resumption criteria
- ❖ Testing tasks
- ❖ Test environment
- ❖ Risks & Contingencies

❖ Testing costs
❖ Approvals

11. Define Suspension & Resumption criteria.

The criteria to suspend and resume testing are described in the simplest of cases testing is suspended at the end of a working day and resumed the following morning.

12. Define the term Pass/ Fail Criteria.

Given a test item and a test case, the tester must have a set of criteria to decide on whether the test has been passed or failed upon execution

13. What are the uses of test design specification?

It is used to identify the features covered by this design and associated tests for the features. The test design specification also has links to the associated test cases and test procedures needed to test the features, and also describes in detail pass/fail criteria for the features. The test design specification helps to organize the tests and provides the connection to the actual test inputs/outputs and test steps.

14. What are the components need to be in test design specification?
❖ Test Design Specification Identifier
❖ Features to Be Tested
❖ Test case Identification
❖ Pass/fail criteria
❖ Test case specifications
❖ Approach refinements

Test Plan Attachments

15. State the need of test plan components. [Nov 2009]

For some systems projects, a hardware test plan and a software test plan will address different techniques and tools as well as different audiences.
However, there are chances that these test plans can get overlapped, hence, a master test plan should be made that addresses the common elements of both the test plans can reduce the amount of redundant documentation.

16. What are the components of test plan? [Nov 2009] [Nov 2014]
❖ Test Design specification
❖ Test case specification
❖ Test procedure specification

17. How will you identify Test case specification? [May 2012]

Each test case specification should be assigned a unique number. It contains:
❖ Test Items
❖ Input Specification
❖ Output Specification
❖ Special environmental needs

Locating Test Items

18. What is the purpose of test transmitted report and test log? [Nov 2012]

Suppose a tester is ready to run on the data described in the test plan. We need to be able to locale the item and have knowledge of its current status. This is the function of the test transmitted report.

The test log should be prepared by the person executing the tests. It is a diary of the events that take place during the test. It supports the concept of a test as a repeatable experiment.

19. List out the information that should be included in test transmittal report.

Each Test Item Transmittal Report has a unique identifier. It should contain the following information for each item that is tracked.

  (i) version/revision number of the item;
  (ii) location of the item;
  (iii) persons responsible for the item (e.g., the developer);
  (iv) references to item documentation and the test plan it is related to;
  (v) status of the item;
  (vi) approvals—space for signatures of staff who approve the transmittal.

Test Management

20. What are the types of standards used for managing the test process?

❖ Internal standards
❖ External standards

Test Process

21. What are activities /processes involved in testing?

❖ Putting together and base lining a test plan
❖ Test case specification
❖ Update of traceability matrix
❖ Identifying possible candidates for automation
❖ Developing and base lining test cases
❖ Executing test cases and keeping traceability matrix current
❖ Collecting and analyzing metrics
❖ Preparing test summary report
❖ Recommending product release criteria

Reporting Test Results

22. What is test log?

The test log is a diary of the events that take place during the test. It supports the concept of a test as a repeatable experiment. It should be prepared by the person executing the tests.

23. What is the use of Test incident Report?

   The tester should record in a test incident report (sometimes called a problem report) any event that occurs during the execution of the tests that is unexpected, unexplainable, and that requires a follow-up investigation.

24. What is Test Summary Report? [Nov 2017]

   Test summary report is prepared when testing is complete. It is a summary of the results of the testing efforts. It also becomes a part of the project's historical database and provides a basis for lessons learned as applied to future projects. When a project post-mortem is conducted, the Test Summary Report can help managers, testers, developers, and SQA staff to evaluate the effectiveness of the testing efforts.

The role of three groups in Test Planning and Policy Development

25. What are the roles of upper management in testing process?
   - ❖ Establishing an organization wide test planning committee with funding.
   - ❖ Ensuring that the testing policy statement and quality standards support test planning with commitment of resources, tools, templates, and training.
   - ❖ Ensuring that the testing policy statement contains a formal mechanism for user input to the test planning process, especially for acceptance and usability testing.
   - ❖ Ensuring that all projects are in compliance with the test planning policy.

26. What are the roles of developers in testing process?
   - ❖ Working with management to develop testing and debugging policies and goals.
   - ❖ Participating in the teams that oversee policy compliance and change management.
   - ❖ Familiarizing themselves with the approved set of testing/debugging goals and policies, keeping up-to-date with revisions, and making suggestions for changes when appropriate.
   - ❖ When developing test plans, setting testing goals for each project at each level of test that reflect organizational testing goals and policies.
   - ❖ Carrying out testing activities that are in compliance with organizational policies.

Introducing The Test Specialist

27. What are the steps in forming the test group?
   - ❖ Upper management support for test function
   - ❖ Establish test group organization, career paths
   - ❖ Define education and skill levels
   - ❖ Develop job description
   - ❖ Interview candidates
   - ❖ Select Test group members

28. What are the roles of test specialist?
   - ❖ Maintenance And Application Of Test Policies
   - ❖ Development And Application Of Test-Related Standards

❖ Participating In Requirements, Design, And Code Reviews
❖ Test Planning
❖ Test Design
❖ Test Execution
❖ Test Measurement
❖ Test Monitoring (Tasks, Schedules, And Costs)
❖ Defect Tracking, And Maintaining The Defect Repository
❖ Acquisition Of Test Tools And Equipment
❖ Identifying And Applying New Testing Techniques, Tools, And Methodologies
❖ Mentoring And Training Of New Test Personnel
❖ Test Reporting.

Skills Needed By A Test Specialist

29. What are the skills needed for tester on personal managerial level?[Nov 2014] [Nov 2016]
❖ Organizational, And Planning Skills;
❖ The Ability To Keep Track Of, And Pay Attention To, Details;
❖ The Determination To Discover And Solve Problems;
❖ The Ability To Work With Others And Be Able To Resolve Conflicts;
❖ The Ability To Mentor And Train Others

30. What are the skills needed for a test specialist?[CS1016-Nov 2014] [Nov 2017]
❖ Strong Coding Skills And An Understanding Of Code Structure And Behaviour
❖ A Good Understanding Of Testing Principles And Practices
❖ A Good Understanding Of Basic Testing Strategies, Methods, And Techniques

Building a Testing Group.

31. Mention the Test team hierarchy.
❖ The Test Manager, The Test Lead, The Test Engineer, The Junior & Test Engineer

32. What is the role of Test Manager?

The test manager (or test director) is the central person concerned with all aspects of testing and quality issues. The test manager is usually responsible for test policy making, customer interaction, test planning, test documentation, controlling and monitoring of tests, training, test tool acquisition, participation in inspections and walkthroughs, reviewing test work, the test repository, and staffing issues such as hiring, firing, and evaluation of the test team members.

33. What is the role of Test Lead?

The test lead assists the test manager and works with a team of test engineers on individual projects. He or she may be responsible for duties such as test planning, staff supervision, and status reporting. The test lead also participates in test design, test execution and reporting, technical reviews, customer interaction, and tool training.

PART B

1. **Explain issues caused by people and organization in software testing. [Nov 2014 – 8M] [Nov 2009-8M]** *[Refer Pg.no:125]*

2. **Briefly discuss the testing team in organizational structures. [Nov 2014-8M]** *[Refer Pg.no:128]*

3. **Explain the role of testing. [Nov 2009- 8 M]** *[Refer Pg.no:131]*

4. **State and discuss the various stages of a test plan [Nov 2009 – 8M]** *[Refer Pg.no:132]*

5. **Explain about test plan components. (Or) What are some of the essential items a tester should include in a test plan? [CS1016-Nov 2014-8M] [Nov 2017-16M]** *[Refer Pg.no:133]*

6. **Describe test related documents that are developed during and after execution based testing. [Nov 2014 – 8M][May 2017]** *[Refer Pg.no:136]*

7. **Write short notes on locating test items. [4M]** *[Refer Pg.no:137]*

8. **Write a short note on test management. [8M]** *[Refer Pg.no:138]*

9. **Explain the testing process in detail. [8M]** *[Refer Pg.no:140]*

10. **Write short notes on test report. [8M]** *[Refer Pg.no:142]*

11. **Briefly discuss the various groups in Test Plan and policy development with their role. [Nov 2014-16M]** *[Refer Pg.no:144]*

12. **Write short note on test specialist. [6M]** *[Refer Pg.no:145]*

13. **Explain the skills needed by attest specialist. [May 2017-16M] [Nov 2017-8M]** *[Refer Pg.no:146]*

14. **How can we build a test group? [Nov 2009 -8M] [Nov 2017-8M]** *[Refer Pg.no:147]*