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Acquisition, Development and Implementation of Information Systems

Learning Objectives

- To understand the modern business systems and business process design;
- To conceptualize a systematic approach to SDLC and review its phase wise activities, methods, tools, controls etc.;
- To understand the software procurement, RFP process, Evaluation of IT proposals etc.;
- To analyze the current system in view of understanding requirements;
- To compare different SDLC models and to be able select the most appropriate model for a particular project;
- To conceptualize the generic phases and associated activities of SDLC;
- To understand the importance of testing, implementation and maintenance; and
- To know the auditor's role in SDLC;

Task Statements

- To demonstrate business process modeling;
- To select the system development method best suited for a project;
- To calculate the ROI for given projects;
- To organize the procurement as well as development of information systems, in case of particular business needs;
- To undertake feasibility study of the IS projects; and
- To manage the acquisition of hardware, software and other necessary infrastructure for establishing the requisite operating infrastructure.

Knowledge Statements

- To know the business process modeling;
- To know the key consideration, while going for system development;
- To know various methods by which a system development can be undertaken;
- To know advantages and disadvantages of various system development models;
- To know different phases of SDLC and their related concepts; and
- To know the auditor's role in SDLC.

5.1 Introduction

Information systems play a vital role in the success of any functional system today. It may be reckoned as the symbiosis of IT hardware and software, in today's super highways of information infrastructure. Information systems serve many different purposes. Its functions may include the processing of business transactions to provide information needed to decide recurring issues, assisting senior officials with strategy formulations, and linking office information and corporate data etc. Technology has developed at a rapid pace but the most important aspect of any system is human know-how and the use of ideas to harness the computers so that it performs the required tasks. This process is essentially 'what system development is all about'. To be of any use, a computer-based information system must function properly, be easy to use and suit the organization for which it has been designed. If a system helps people to work more effectively and efficiently then deployment would be justified.

In the business context today, information systems are inevitable. Its deployment may be triggered by acquisition of already functional ready-to-use systems or by the development of customised solutions using requisite IT infrastructure, environment and support. System acquisition efforts are put in place due to many reasons, but primarily due to availability of such systems on affordable prices subject to satisfactory solution to the requisite tasks and functionalities. Another pressing need may be caused by stress in existing system. That is, the present system is not able to meet the requirements of system stakeholders and particularly, of its users. This makes it necessary to change/modify the system. To change or to modify depends on the intensity of stress. There are situations, which can be managed by slight modifications, but there may be situations, which may need complete overhaul. Secondly, case entity goes for system change. For example: Increased competition, pressure on profits, customer satisfaction being few reasons, which have forced many corporate to go for better systems. Many of them have shifted from traditional accounting packages to Enterprise Resource Planning Software.

Moreover, opportunity may be another reason for acquisition i.e. if management sees that there is scope for capitalising on a new business opportunity / venture, then management goes for system acquisition. Many companies implement new software's to capitalise in such opportunity. Effort for system development requires an understanding of the business process of the entity. In business, systems development refers to the process of examining a business situation in the prevailing context with the intent of improving it through better procedures and methods. The breaking point shall be business process design, in view of the feasibility of automation using affordable technical artefacts and to meet the goals.

5.2 Business Process Design

Business process design means structuring or restructuring the tasks, functionalities and activities for improvising a business system. Business Process Design is a critical step to understand the requirements of the system. Business Process Design needs a lot of intellectual capability from team of developers doing the same. Business process design involves a sequence of the steps described briefly in the following sections.

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5.2.1 Present Process Documentation

In this step, the present business process is analyzed and documented. The key deliverable of this step includes the well-defined short-comings of the present processes and the overall business requirements. This step includes the following activities:

- Understanding the business and the objectives for which it exists;
- Documenting the existing business processes; and
- Analysis of the documented processes.

5.2.2 Proposed Process Documentation

This step is to design the new process requirements for the system. The design is based on the new system requirements and the changes proposed. The activities include the following:

- Understanding of the business processes necessary to achieve the business objectives;
- Designing the new processes; and
- Documentation of the new process, preferably using of CASE tools.

5.2.3 Implementation of New Process

This step is to implement largely the new as well as modified processes at the entity. The critical activities may include the following:

- Validating the new process;
- Implementing the new process; and
- Testing the new process.

It has been mentioned that system development effort is triggered in two basic situations, first due to stress and second due to opportunity. Business Process Design is largely based on nature of system i.e. whether it is typically integrated, automatic and manual. The idea of business process design has different implications when the same is being designed for integrated, automatic or manual system. Each nature of system needs a special design consideration, which may be understood by looking at the following case descriptions.

To understand these aforementioned facts in a more practical way, some case studies are given as follows:

Case 1: Manual Billing System: The billing clerk checks the price list of products before s/he bills the same to customer. S/he checks the approved price list of the products as is applicable on the date of billing, checks for discounts and bills the products to customer. In the above process, the key issue being that the billing clerk needs to possess, applicable and authorized price list with him. Business Process Design shall need to address the following critical issues:

- Availability of approved price lists with billing clerk.
- How it shall be ensured that the billing has been done on applicable rates only?
- How the approval is accorded to price lists?

- Whether the price list updating process is pre-defined or need based?
- How exceptions to listed price shall be documented?
- How the exceptions shall be submitted to management?

Case 2: Automatic Billing System: In this system, every bill is generated through system. System has in its database of approved price list. As soon as, the billing clerk selects the product from product lists, the system automatically picks up the price, as it is already available in data base. There is no option available with billing clerk to modify price at the time of billing. The key processes that need to be controlled include, ensuring the system price list is the approved price list. Business Process Design shall need to address the following issues:

- Availability of approved price lists in system.
- How it shall be ensured that the price lists in system cannot be modified?
- How the approval is accorded to price lists?
- Whether the price list updating process is pre-defined or need based?
- How the said price lists are updated in system?
- How the correctness of updates is validated?
- How exceptions, where the billed price is different from price in system authorized?
- How the exceptions to price reported to management?
- Does system provide a separate report for the same?

Case 3: Integrated Systems: Integrated system means a system, which has been tightly interfaced with the business processes of the entity. This shall require greater intellectual inputs to the process of business process modeling. The key issue to be addressed being the interface between the business process and the business objective. The issue to be addressed in addition to those discussed above shall include following:

- How the business objective change is built into business process change?
- How the business processes shall be documented?

Business Process Modeling is an important step for the process of system development. This step is important and critical for success of better system development. A off shoot of this process is the term Business Process Re-engineering. The key difference being, that in Business Process Re-engineering, the existing processes are fundamentally redefined rather than new processes being created, in the light of accommodating new environmental developments.

5.3 System Development

In business, systems development refers to the process of examining a business situation with the intent of improving it through better procedures and methods. System development can generally be thought of as having two major components described briefly as follows:

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- **System Analysis** is the process of gathering and interpreting facts, diagnosing problems, and using the information to recommend improvements to the system.
- **System Design** is the process of planning and structuring a new business system or one to replace or complement an existing system.

But before planning can be done, one must thoroughly understand the old system and determine how computers can be used to make its operation more effective.

Example: Consider stockroom operations of a clothing store. What measures can be taken to control its inventory and gain access to more up-to-date information about stock levels and reordering in a better way.

Solution: The Stores Manager asks a System Analyst to organize the stockroom operations. Before an analyst can design a system to capture data, update files and produce reports, s/he needs to know more about the following:

- How does the store currently operates?
- What forms are being used to store information manually, such as requisitions, purchase orders and invoices etc.?
- What reports are being produced and how they are being used, etc?

To proceed, an analyst seeks information about lists of reorder notices, outstanding purchase orders, records of stock on hand, and other reports. S/he tries to understand how the existing system works and more specifically what the flow of information through the system looks like and assesses as carefully as possible, what the future need of the system will be and what changes should be considered to meet these needs. S/he may recommend alternatives for improving the situation, which then management decides to accept or reject. The plan includes all system design features, file specifications, operating procedures, and design features, and equipment and personnel requirements. The system design is like the blue print for a building, it specifies all the features that should be there in the finished product.

5.3.1 Achieving System Development Objectives

Achieving the objectives of the system development is essential but many times, such objectives are not achieved as desired. An analysis on 'why organizations fail to achieve their systems development objectives' reveals bottlenecks. Some of the most notable ones are described briefly as follows:

- (i) **User Related Issues:** It refers to those issues where user/customer is reckoned as the primary agent. Some of the aspects with regard to this problem are mentioned as follows:
 - **Shifting User Needs:** User requirements for IT are constantly changing. As these changes accelerate, there will be more requests for Information systems development and more development projects. When these changes occur during a development process, the development team faces the challenge of developing systems whose very purpose might change since the development process began.
 - **Resistance to Change:** People have a natural tendency to resist change, and information systems development projects signal changes - often radical - in the

workplace. When personnel perceive that the project will result in personnel cutbacks, threatened personnel will dig in their heels, and the development project is doomed to failure.

- **Lack of Users' Participation:** Users must participate in the development efforts to define their requirements, feel ownership for project success, and work to resolve development problems. User participation also helps to reduce user resistance to change.
 - **Inadequate Testing and User Training:** New systems must be tested before installation to determine that they operate correctly. Users must be trained to effectively utilize the new system.
- (ii) **Developer Related Issues:** It refers to the issues and challenges with regard to the developers. Some of the critical bottlenecks are mentioned as follows:
- **Lack of Standard Project Management and System Development Methodologies:** Some organizations do not formalize their project management and system development methodologies, thereby making it very difficult to consistently complete projects on time or within budget.
 - **Overworked or Under-Trained Development Staff:** In many cases, system developers often lack sufficient educational background and requisite state of the art skills. Furthermore, many companies do a little to help their development personnel stay technically sound, and more so a training plan and training budget do not exist.
- (iii) **Management Related Issues:** It refers to the bottlenecks with regard to organizational set up, administrative and overall management to accomplish the system development goals. Some of such bottlenecks are mentioned as follows:
- **Lack of Senior Management Support and Involvement:** Developers and users of information systems watch senior management to determine 'which systems development projects are important' and act accordingly by shifting their efforts away from any project, which is not receiving management attention. In addition, management can see that adequate resources, as well as budgetary control over use of those resources, are dedicated to the project.
 - **Development of Strategic Systems:** Because strategic decision making is unstructured, the requirements, specifications, and objectives for such development projects are difficult to define.
- (iv) **New Technologies:** When an organization tries to create a competitive advantage by applying advance technologies, it generally finds that attaining system development objectives is more difficult because personnel are not as familiar with the technology.

In order to overcome these aforementioned issues, organizations must execute a well-planned systems development process efficiently and effectively. Accordingly, a sound system development team is inevitable.

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5.3.2 System Development Team

Several people in the organization are responsible for systems development. In large systems, the worth of a particular project is typically decided by a top management level steering committee. Such committee usually consists of a group of key users of Information Systems services, those act as a review body for Information Systems plans and applications development. The steering committee ensures that ongoing systems development activities are consistently aimed at satisfying the information requirements of managers and users within the organization. A project management team generally consists of both computer professionals and key users. System analysts are subsequently assigned to determine user requirements, design the system and assist in development and implementation activities. In any organization, systems designers take a lead role during the design, development and implementation stages. In end-user developed systems, the end-user is ultimately responsible for the system. Generally, the end-user seeks guidance from information centre personnel while developing the system.

5.3.3 Accountants' Involvement in Development Work

Most accountants are uniquely qualified to participate in systems development because they may be among the few people in an organization, who can combine knowledge of IT, business, accounting, and internal control, as well as behavior and communications, to ensure that new systems meet the needs of the user and possess adequate internal controls. They have specialized skills - such as accounting and auditing - that can be applied to the development project. For example, an accountant might perform the analysis of a proposed system's costs and benefits.

An accountant can help in various related aspects during system development; some of them are as follows:

(i) Return on Investment (referred as ROI): This defines the return, an entity shall earn on a particular investment i.e. capital expenditure. This financial data is a prime consideration for any capital expenditure entity decides to incur. The important data required for this analysis being the cost of project, the expected revenue/benefit for a given period. The analysis ideally needs to be done before the start of the development efforts for better decision making by management. For this analysis following data needs to be generated.

(a) Cost: This includes estimates for typical costs involved in the development, which are given as follows:

- *Development Costs:* Development Costs for a computer based information system include costs of the system development process, like salaries of developers.
- *Operating Costs:* Operating Costs of a computer based information system including hardware/software rental or depreciation charges; salaries of computer operators and other data processing personnel, who will operate the new system.
- *Intangible Costs:* Intangible Cost that cannot be easily measured. For example, the development of a new system may disrupt the activities of an organization and cause a loss of employee productivity or morale.

(b) **Benefits:** The benefits, which result from developing new or improved information systems that can be subdivided into tangible and intangible benefits. A post implementation analysis is also done to see how the system development effort has benefitted an organization. For example: A large oil company in public sector, few years back implemented an ERP system at a total cost of ₹ 100 crores. The calculated benefits from the project were ₹ 40 crores per annum. Above data gives an actual ROI of 40%, which is tremendous for any business. Same also tells the payback period is around 2.5 years.

(ii) **Computing Cost of IT Implementation and Cost Benefit Analysis:** For analysis of ROI, accountants need the costs and returns from the system development efforts. For correct generation of data, proper accounting needs to be done. Accountants shall be the person to whom management shall look for the purpose.

(iii) **Skills expected from an Accountant:** An accountant, being an expert in accounting field must possess skills to understand the system development efforts and nuances of the same. S/he is expected to have various key skills, including understanding of the business objectives, expert book keeper, and understanding of system development efforts etc.

5.4 Systems Development Methodology

A **System Development Methodology** is a formalized, standardized, well-organized and documented set of activities used to manage a system development project. It refers to the framework that is used to structure, plan and control the process of developing an information system. Each of the available methodologies is best suited to specific kinds of projects, based on various technical, organizational, project and team considerations. The methodology is characterized by the following:

- The project is divided into a number of identifiable processes, and each process has a starting point and an ending point. Each process comprises several activities, one or more deliverables, and several management control points. The division of the project into these small, manageable steps facilitates both project planning and project control.
- Specific reports and other documentation, called Deliverables must be produced periodically during system development to make development personnel accountable for faithful execution of system development tasks.
- Users, managers, and auditors are required to participate in the project, which generally provide approvals, often called signoffs, at pre-established management control points. Signoffs signify approval of the development process and the system being developed.
- The system must be tested thoroughly prior to implementation to ensure that it meets users' needs as well as requisite functionalities.
- A training plan is developed for those who will operate and use the new system.
- Formal program change controls are established to preclude unauthorized changes to computer programs.
- A post-implementation review of all developed systems must be performed to assess the effectiveness and efficiency of the new system and of the development process.

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Since organizations vary significantly in the way they automate their business procedures, and each new type of system usually differs from others, several different system development approaches are often used within an organization. All these approaches are not mutually exclusive, which means that it is possible to perform some prototyping while applying the traditional approach. These approaches are established as models and include Waterfall - Linear framework type, Prototyping-Iterative framework type, Incremental - Combination of linear and iterative framework type, Spiral - Combination linear and iterative framework type, Rapid Application Development (RAD) : Iterative Framework Type, and Agile Methodologies models; described one by one in the following sections:

5.4.1 Waterfall Model

The waterfall approach is a traditional development approach in which each phase is carried in sequence or linear fashion. These phases include requirements analysis, specifications and design requirements, coding, final testing, and release. In this traditional approach of system development, activities are performed in sequence. Fig. 5.4.1 shows examples of the tasks performed during each phase of the traditional approach. When the traditional approach is applied, an activity is undertaken only when the prior step is fully completed.

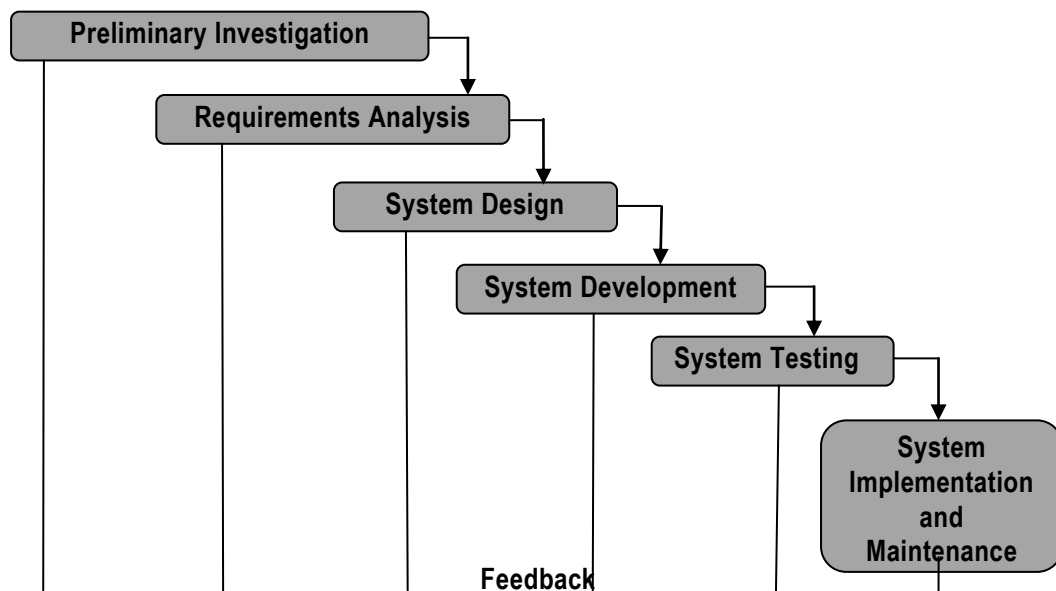


Fig. 5.4.1: Waterfall Approach

The characterizing features of this model have influenced the development community in big way. Some of the key characteristics are the following:

- Project is divided into sequential phases, with some overlap and splash back acceptable between phases.
- Emphasis is on planning, time schedules, target dates, budgets and implementation of an entire system at one time.

- Tight control is maintained over the life of the project through the use of extensive written documentation, as well as through formal reviews and approval/signoff by the user and information technology management occurring at the end of most phases before beginning the next phase.
- (a) **Strengths:** The fundamental strength of the waterfall model has made it quite popular and handy among the fraternity. Major strengths are given as follows:
 - It is ideal for supporting less experienced project teams and project managers or project teams, whose composition fluctuates.
 - The orderly sequence of development steps and design reviews help to ensure the quality, reliability, adequacy and maintainability of the developed software.
 - Progress of system development is measurable.
 - It enables to conserve resources.
- (b) **Weaknesses:** Though it is highly useful model, it suffers from various weaknesses too. Experts and practitioners identify a number of weaknesses including the following:
 - It is criticized to be inflexible, slow, costly, and cumbersome due to significant structure and tight controls.
 - Project progresses forward, with only slight movement backward.
 - There is a little to iterate, which may be essential in situations.
 - It depends upon early identification and specification of requirements, even if the users may not be able to clearly define 'what they need early in the project'.
 - Requirement inconsistencies, missing system components and unexpected development needs are often discovered during design and coding.
 - Problems are often not discovered until system testing.
 - System performance cannot be tested until the system is almost fully coded, and under capacity may be difficult to correct.
 - It is difficult to respond to changes, which may occur later in the life cycle, and if undertaken it proves costly and are thus discouraged.
 - It leads to excessive documentation, whose updation to assure integrity is an uphill task and often time-consuming.
 - Written specifications are often difficult for users to read and thoroughly appreciate.
 - It promotes the gap between users and developers with clear vision of responsibility.

5.4.2 The Prototyping Model

The traditional approach sometimes may take years to analyze, design and implement a system. More so, many a times we know a little about the system until and unless we go through its working phases, which are not available. In order to avoid such bottlenecks and overcome the issues, organizations are increasingly using prototyping techniques to develop

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smaller systems such as DSS, MIS and Expert systems. The goal of prototyping approach is to develop a small or pilot version called a prototype of part or all of a system. A prototype is a usable system or system component that is built quickly and at a lesser cost, and with the intention of modifying/replicating/expanding or even replacing it by a full-scale and fully operational system. As users work with the prototype, they learn about the system criticalities and make suggestions about the ways to manage it. These suggestions are then incorporated to improve the prototype, which is also used and evaluated. Finally, when a prototype is developed that satisfies all user requirements, either it is refined and turned into the final system or it is scrapped. If it is scrapped, the knowledge gained from building the prototype is used to develop the real system.

Prototyping can be viewed as a series of four steps, symbolically depicted in Fig. 5.4.2 wherein Implementation and Maintenance phases followed by full-blown developments take place once the prototype model is tested and found to be meet uses' requirements. The generic phases of this model are explained as follows:

- **Identify Information System Requirements:** In traditional approach, the system requirements are to be identified before the development process starts. However, under prototype approach, the design team needs only fundamental system requirements to build the initial prototype, the process of determining them can be less formal and time-consuming than when performing traditional systems analysis.
- **Develop the Initial Prototype:** The designers create an initial base model and give little or no consideration to internal controls, but instead emphasize system characteristics such as simplicity, flexibility, and ease of use. These characteristics enable users to interact with tentative versions of data entry display screens, menus, input prompts, and source documents. The users also need to be able to respond to system prompts, make inquiries of the information system, judge response times of the system, and issue commands.
- **Test and Revise:** After finishing the initial prototype, the designers first demonstrate the model to users and then give it to them to experiment and ask users to record their likes and dislikes about the system and recommend changes. Using this feedback, the design team modifies the prototype as necessary and then resubmits the revised model to system users for reevaluation. Thus iterative process of modification and reevaluation continues until the users are satisfied.

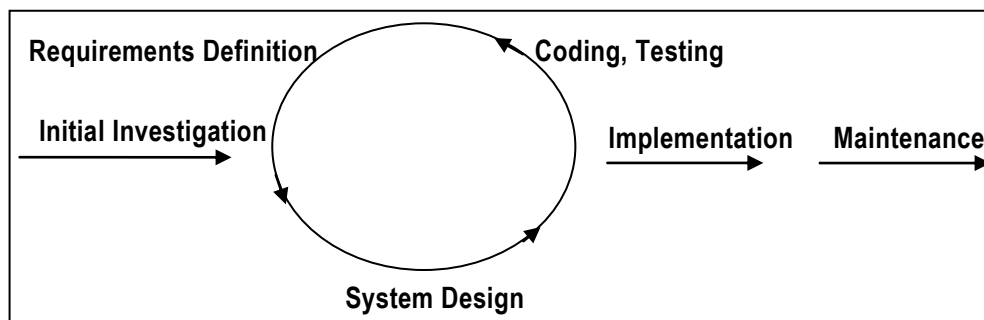


Fig. 5.4.2: Prototyping Model

- **Obtain User Signoff of the Approved Prototype:** Users formally approve the final version of the prototype, which commits them to the current design and establishes a contractual obligation about what the system will, and will not, do or provide. Prototyping is not commonly used for developing traditional applications such as accounts receivable, accounts payable, payroll, or inventory management, where the inputs, processing, and outputs are well known and clearly defined.
- (a) **Strengths:** Some of its strengths identified by the experts and practitioners include the following:
 - It improves both user participation in system development and communication among project stakeholders.
 - It is especially useful for resolving unclear objectives; developing and validating user requirements; experimenting with or comparing various design solutions, or investigating both performance and the human computer interface.
 - Potential exists for exploiting knowledge gained in an early iteration as later iterations are developed.
 - It helps to easily identify, confusing or difficult functions and missing functionality.
 - It enables to generate specifications for a production application.
 - It encourages innovation and flexible designs.
 - It provides for quick implementation of an incomplete, but functional, application.
 - It typically results in a better definition of these users' needs and requirements than does the traditional systems development approach.
 - A very short time period is normally required to develop and start experimenting with a prototype. This short time period allows system users to immediately evaluate proposed system changes.
 - Since system users experiment with each version of the prototype through an interactive process, errors are hopefully detected and eliminated early in the developmental process. As a result, the information system ultimately implemented should be more reliable and less costly to develop than when the traditional systems development approach is employed.
- (b) **Weaknesses:** Some of the weaknesses identified by the experts and practitioners include the following:
 - Approval process and control are not strict.
 - Incomplete or inadequate problem analysis may occur whereby only the most obvious and superficial needs will be addressed, resulting in current inefficient practices being easily built into the new system.
 - Requirements may frequently change significantly.
 - Identification of non-functional elements is difficult to document.

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- Designers may prototype too quickly, without sufficient upfront user needs analysis, resulting in an inflexible design with narrow focus that limits future system potential.
- Prototype may not have sufficient checks and balances incorporated.
- Prototyping can only be successful if the system users are willing to devote significant time in experimenting with the prototype and provide the system developers with change suggestions. The users may not be able or willing to spend the amount of time required under the prototyping approach.
- The interactive process of prototyping causes the prototype to be experimented with quite extensively. Because of this, the system developers are frequently tempted to minimize the testing and documentation process of the ultimately approved information system. Inadequate testing can make the approved system error-prone, and inadequate documentation makes this system difficult to maintain.
- Prototyping may cause behavioral problems with system users. These problems include dissatisfaction by users if system developers are unable to meet all user demands for improvements as well as dissatisfaction and impatience by users when they have to go through too many interactions of the prototype.

In spite of above listed weaknesses, to some extent, systems analysis and development has been greatly improved by the introduction of prototyping. Prototyping enables the user to take an active part in the systems design, with the analyst acting in an advisory role. Prototyping makes use of the expertise of both the user and the analyst, thus ensuring better analysis and design, and prototyping is a crucial tool in that process.

5.4.3 The Incremental Model

The Incremental model is a method of software development where the model is designed, implemented and tested incrementally (a little more is added each time) until the product is finished. The product is defined as finished when it satisfies all of its requirements. This model combines the elements of the waterfall model with the iterative philosophy of prototyping. It is pictorially depicted in Fig. 5.4.3.

The product is decomposed into a number of components, each of which are designed and built separately (termed as builds). Each component is delivered to the client when it is complete. This allows partial utilization of product and avoids a long development time. It also creates a large initial capital outlay with the subsequent long wait avoided. This model of development also helps to ease the traumatic effect of introducing completely new system all at once. A few pertinent features are listed as follows:

- A series of mini-waterfalls are performed, where all phases of the waterfall development model are completed for a small part of the system, before proceeding to the next increment.
- Overall requirements are defined before proceeding to evolutionary, mini – Waterfall development of individual increments of the system.

- The initial software concept, requirement analysis, and design of architecture and system core are defined using the Waterfall approach, followed by iterative Prototyping, which culminates in installation of the final prototype (i.e. Working system).

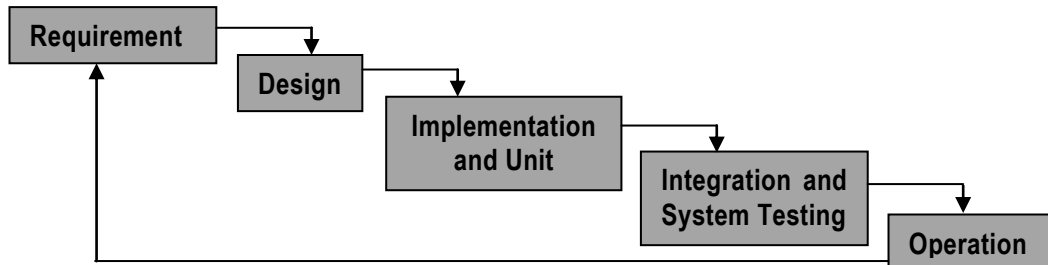


Fig. 5.4.3: Incremental Model

- (a) **Strengths:** Some of its strengths identified by the experts and practitioners include the following:
- Potential exists for exploiting knowledge gained in an early increment as later increments are developed.
 - Moderate control is maintained over the life of the project through the use of written documentation and the formal review and approval/signoff by the user and information technology management at designated major milestones.
 - Stakeholders can be given concrete evidence of project status throughout the life cycle.
 - It is more flexible and less costly to change scope and requirements.
 - It helps to mitigate integration and architectural risks earlier in the project.
 - It allows the delivery of a series of implementations that are gradually more complete and can go into production more quickly as incremental releases.
 - Gradual implementation provides the ability to monitor the effect of incremental changes, isolated issues and make adjustments before the organization is negatively impacted.
- (b) **Weaknesses:** Some of the weaknesses identified by the experts and practitioners include the following:
- When utilizing a series of mini-waterfalls for a small part of the system before moving onto the next increment, there is usually a lack of overall consideration of the business problem and technical requirements for the overall system.
 - Each phase of an iteration is rigid and do not overlap each other.
 - Problems may arise pertaining to system architecture because not all requirements are gathered up front for the entire software life cycle.
 - Since some modules will be completed much earlier than others, well-defined interfaces are required.
 - It is difficult to demonstrate early success to management.

5.4.4 Spiral Model

The Spiral model is a software development process combining elements of both design and prototyping-in-stages. It tries to combine advantages of top-down and bottom-up concepts. It combines the features of the prototyping model and the waterfall model (given in Fig. 5.4.4). The spiral model is intended for large, expensive and complicated projects. Game development is a main area where the spiral model is used and needed, that is because of the size and the constantly shifting goals of those large projects. A list of pertinent characterizing features includes the following:

- The new system requirements are defined in as much detail as possible. This usually involves interviewing a number of users representing all the external or internal users and other aspects of the existing system.
- A preliminary design is created for the new system. This phase is the most important part of "Spiral Model" in which all possible alternatives that can help in developing a cost effective project are analyzed and strategies are decided to use them. This phase has been added specially in order to identify and resolve all the possible risks in the project development. If risks indicate any kind of uncertainty in requirements, prototyping may be used to proceed with the available data and find out possible solution in order to deal with the potential changes in the requirements.
- A first prototype of the new system is constructed from the preliminary design. This is usually a scaled-down system, and represents an approximation of the characteristics of the final product.
- A second prototype is evolved by a fourfold procedure by evaluating the first prototype in terms of its strengths, weaknesses, and risks; defining the requirements of the second prototype; planning and designing the second prototype; and constructing and testing the second prototype.

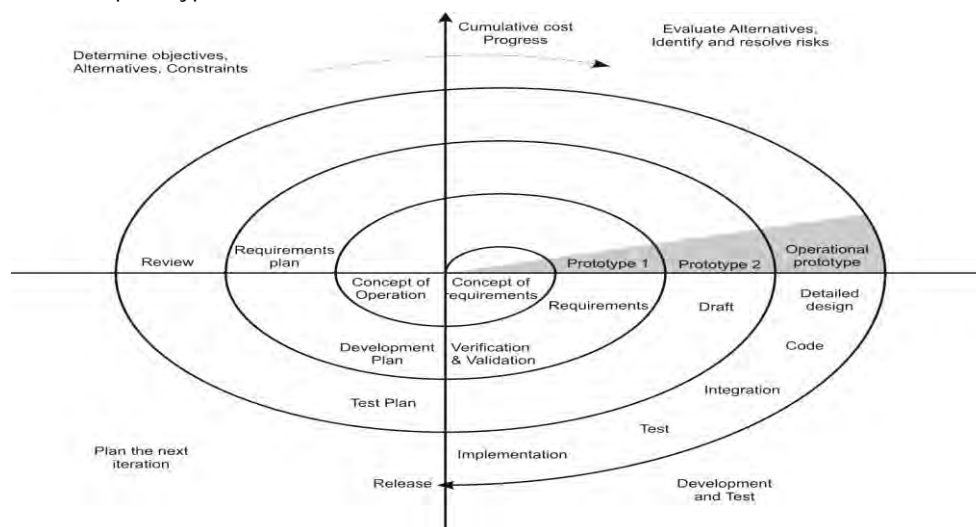


Fig. 5.4.4: Spiral Model

- (a) **Strengths:** Some of its strengths identified by the experts and practitioners include the following:
- It enhances the risk avoidance.
 - It is useful in helping for optimal development of a given software iteration based on project risk.
 - It can incorporate Waterfall, Prototyping, and Incremental methodologies as special cases in the framework, and provide guidance as to which combination of these models best fits a given software iteration, based upon the type of project risk. For example, a project with low risk of not meeting user requirements but high risk of missing budget or schedule targets would essentially follow a linear Waterfall approach for a given software iteration. Conversely, if the risk factors were reversed, the Spiral methodology could yield an iterative prototyping approach.
- (b) **Weaknesses:** Some of the weaknesses identified by the experts and practitioners include the following:
- It is challenging to determine the exact composition of development methodologies to use for each iteration around the Spiral.
 - It may prove highly customized to each project, and thus is quite complex and limits reusability.
 - A skilled and experienced project manager is required to determine how to apply it to any given project.
 - No established controls exist for moving from one cycle to another cycle. Without controls, each cycle may generate more work for the next cycle.
 - There are no firm deadlines, cycles continue with no clear termination condition leading to, inherent risk of not meeting budget or schedule.

5.4.5 Rapid Application Development (RAD) Model

Rapid Application Development (RAD) refers to a type of software development methodology; which uses minimal planning in favor of rapid prototyping. The planning of software developed using RAD is interleaved with writing the software itself. The lack of extensive pre-planning generally allows software to be written much faster, and makes it easier to change requirements. Key features include the following:

- Key objective is fast development and delivery of a high quality system at a relatively low investment cost,
- Attempts to reduce inherent project risk by breaking a project into smaller segments and providing more ease-of-change during the development process.
- Aims to produce high quality systems quickly, primarily through the use of iterative Prototyping (at any stage of development), active user involvement, and computerized development tools. Graphical User Interface (GUI) builders, Computer Aided Software Engineering (CASE) tools, Database Management Systems (DBMS), Fourth generation programming languages, Code generators and object-oriented techniques etc.

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- Key emphasis is on fulfilling the business need while technological or engineering excellence is of lesser importance.
 - Project control involves prioritizing development and defining delivery deadlines or “timeboxes.” If the project starts to slip, emphasis is on reducing requirements to fit the timebox, not in increasing the deadline.
 - Generally includes Joint Application Development (JAD), where users are intensely involved in system design, either through consensus building in structured workshops, or through electronically facilitated interaction.
 - Active user involvement is imperative.
 - Iteratively produces production software, as opposed to a throwaway prototype.
 - Produces documentation necessary to facilitate future development and maintenance.
 - Standard systems analysis and design techniques can be fitted into this framework.
- (a) **Strengths:** Some of the strengths identified by the experts and practitioners include the following:
- The operational version of an application is available much earlier than with Waterfall, Incremental, or Spiral frameworks.
 - Because RAD produces systems more quickly and to a business focus, this approach tends to produce systems at lower cost.
 - Quick initial reviews are possible.
 - Constant integration isolates problems and encourages customer feedback.
 - It holds a great level of commitment from stakeholders, both business and technical, than Waterfall, Incremental, or spiral frameworks. Users are seen as gaining more of a sense of ownership of a system, while developer are seen as gaining more satisfaction from producing successful systems quickly.
 - It concentrates on essential system elements from user viewpoint.
 - It provides for the ability to rapidly change system design as demanded by users.
 - It leads to a tighter fit between user requirements and system specifications.
- (b) **Weaknesses:** Some of the weaknesses identified by the experts and practitioners include the following:
- Fast speed and lower cost may affect adversely the system quality.
 - The project may end up with more requirements than needed (gold-plating).
 - Potential for feature creep where more and more features are added to the system over the course of development.
 - It may lead to inconsistent designs within and across systems.
 - It may call for violation of programming standards related to inconsistent naming conventions and inconsistent documentation,
 - It may call for lack of attention to later system administration needs built into

system.

- Formal reviews and audits are more difficult to implement than for a complete system.
- Tendency for difficult problems to be pushed to the future to demonstrate early success to management.
- Since some modules will be completed much earlier than others, well-defined interfaces are required.

5.4.6 Agile Model

This is an organized set of software development methodologies based on the *iterative and incremental* development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery; time boxed iterative approach and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development life cycle. Agile Manifesto is based on following 12 features:

- Customer satisfaction by rapid delivery of useful software;
- Welcome changing requirements, even late in development;
- Working software is delivered frequently (weeks rather than months);
- Working software is the principal measure of progress;
- Sustainable development, able to maintain a constant pace;
- Close, daily co-operation between business people and developers;
- Face-to-face conversation is the best form of communication (co-location);
- Projects are built around motivated individuals, who should be trusted;
- Continuous attention to technical excellence and good design;
- Simplicity;
- Self-organizing teams; and
- Regular adaptation to changing circumstances.

(a) **Strengths:** Some of the strengths identified by the experts and practitioners include the following:

- Agile methodology has the concept of an adaptive team, which enables to respond to the changing requirements.
- The team does not have to invest time and efforts and finally find that by the time they delivered the product, the requirement of the customer has changed.
- Face to face communication and continuous inputs from customer representative leaves a little space for guesswork.
- The documentation is crisp and to the point to save time.

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- The end result is generally the high quality software in least possible time duration and satisfied customer.
- (b) **Weaknesses:** Some of the weaknesses identified by the experts and practitioners include the following:
- In case of some software deliverables, especially the large ones, it is difficult to assess the efforts required at the beginning of the software development life cycle.
 - There is lack of emphasis on necessary designing and documentation.
 - Agile increases potential threats to business continuity and knowledge transfer. By nature, Agile projects are extremely light on documentation because the team focuses on verbal communication with the customer rather than on documents or manuals.
 - Agile requires more re-work and due to the lack of long-term planning and the lightweight approach to architecture, re-work is often required on Agile projects when the various components of the software are combined and forced to interact.
 - The project can easily get taken off track if the customer representative is not clear about the final outcome.
 - Agile lacks the attention to outside integration.

5.5 System Development Life Cycle (SDLC)

The System Development Life Cycle provides system designers and developers to follow a sequence of activities. It consists of a generic sequence of steps or phases in which each phase of the SDLC uses the results of the previous one. The SDLC is document driven, which means that at crucial stages, the processes documentation is produced. A phase of the SDLC is not complete until the appropriate documentation or artifact is produced. These are sometimes referred to as logical phase deliverables. A deliverable may be a substantial written document, a software artifact, a system test plan or even a physical object such as a new piece of technology that has been ordered and delivered. This feature of the SDLC is critical to the successful management of an IS project.

The SDLC can also be viewed from a more process oriented perspective. This emphasizes the parallel nature of some of the activities and presents activities such as system maintenance as an alternative to a complete re-design of an existing system. The advantages of this system are given as follows:

- Better planning and control by project managers;
- Compliance to prescribed standards ensuring better quality;
- Documentation that SDLC stresses on is an important measure of communication and control; and
- The phases are important milestones and help the project manager and the user for review and signoff.

From the perspective of the IS Audit, the following are the possible advantages:

- The IS auditor can have clear understanding of various phases of the SDLC on the basis of the detailed documentation created during each phase of the SDLC.
- The IS Auditor on the basis of his/her examination, can state in his/her report about the compliance by the IS management of the procedures, if any, set by the management.
- The IS Auditor, if has a technical knowledge and ability of different areas of SDLC, can be a guide during the various phases of SDLC.
- The IS auditor can provide an evaluation of the methods and techniques used through the various development phases of the SDLC.

Some of the shortcomings and anticipated risks associated with the SDLC are as follows:

- The development team may find it cumbersome.
- The users may find that the end product is not visible for a long time.
- The rigidity of the approach may prolong the duration of many projects.
- It may not be suitable for small and medium sized projects.

The process of system development starts when management or sometimes system development personnel realize that a particular business system needs improvement. The System Development Life Cycle method can be thought as a set of activities that analysts, designers and users carry out to develop and implement an information system. In most of the business situations, these activities are closely related, usually inseparable and even the order of the steps in these activities may be difficult to determine. Different parts of a project can be in various phases at the same time, with some components undergoing analysis while others are at advanced design stages. Table 5.5.1 describes the activities of all the phases involved in the System Development Life Cycle.

Table 5.5.1: System Development Life Cycle

PHASE	PHASE NAME	NATURE OF ACTIVITY
1.	Preliminary Investigation	Determining and evaluating the strategic feasibility of the system and ensure that the solution fits the business strategy.
2.	Systems Requirements Analysis	Analyzing the typical system requirements, in view of its functionalities, deliverables etc.
3.	Systems Design	Designing the system in terms of user interface, data storage and data processing functions on the basis of the requirement phase by developing the system flowcharts, system and data flow diagrams, screens and reports.
4.	Systems Acquisition	Acquisition of Operating infrastructure including hardware, software and services.
5.	Systems Development	Developing the system as per the system designed in view

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		of its adequate implementation to lead to fulfillment of requirements to the satisfaction of all the stakeholders.
6.	Systems Testing	Requisite testing to ensure the valid and reliable implementations.
7.	Systems Implementation	Operationalization of the developed system for the acceptance by management and user before migration of the system to the live environment and data conversion from legacy system to the new system.
8.	Post Implementation Review and Maintenance	Continuous evaluation of the system as it functions in the live environment and its updation / maintenance.

5.5.1 Preliminary Investigation

It is predominantly aimed to determine and analyze the strategic benefits in implementing the system through evaluation and quantification of - productivity gains; future cost avoidance; cost savings, and Intangible benefits like improvement in morale of employees. The deliverable of the preliminary investigation includes a report including feasibility study observations.

A preliminary investigation is normally initiated by some sort of system request. The steps involved in the preliminary investigation phase are Identification of Problem, Identification of objectives, Delineation of scope, and Feasibility Study. Thereby, it largely enables the requirements engineer to tackle the issues and Feasibility Study for the following:

- Determine whether the solution is as per the business strategy;
- Determine whether the existing system can rectify the situation without a major modification;
- Define the time frame for which the solution is required;
- Determine the approximate cost to develop the system; and
- Determine whether the vendor product offers a solution to the problem.

(i) Identification of Problem: The first step in an application development is to define the problem clearly and precisely, which is done only after the critical study of the existing system and several rounds of discussions with the user group. Then its prevalence within the organization has to be assessed. A problem that has a considerable impact on the organization is likely to receive immediate management attention. User involvement will also be high, if they are convinced that the proposed solution will resolve the problem.

For instance, personnel in a functional area may feel that an existing system is outdated or a manager might want access to specific new information that s/he claims will lead to better decisions. Shifting business requirements, changing organizational environments, and evolving information technology may render systems ineffective or inefficient. Whatever may be the reason, managers and users may feel compelled to submit a request for a new system to the IS department. If the need seems genuine, a system analyst is assigned to perform

preliminary investigation who submits all proposals to the steering committee for evaluation to identify those projects that are most beneficial to the organization.

Thus, it can be concluded that the purpose of the preliminary investigation is to evaluate the project request feasibility. It is neither a designed study nor it includes the collection of details to completely describe the business system. Rather it relates to collection of information that permits committee members to evaluate the merits of the project request and make an informed judgment about the feasibility of the proposed project.

The analyst working on the preliminary investigation should accomplish the following objectives:

- Clarify and understand the project request;
- Determine the size of the project;
- Determine the technical and operational feasibility of alternative approaches;
- Assess costs and benefits of alternative approaches; and
- Report findings to the management with recommendation outlining the acceptance or rejection of the proposal.

(ii) Identification of Objectives: After the identification of the problem, it is easy to work out and precisely specify the objectives of the proposed solution. For instance, inability to provide a convenient reservation system, for a large number of intending passengers was the problem of the Railways. So, one of the objectives was 'to introduce a system wherein intending passengers could book a ticket from source to destination, faster than in real-time'.

(iii) Delineation of Scope: The scope of a solution defines its typical boundaries. It should be clear and comprehensible to the user management stating the extent and 'what will be addressed by the solution and what will not'. Often, the scope becomes a contentious issue between development and user organizations. Hence, outlining the scope in the beginning is essential and proves quite handy. The typical scope determination may be performed on the following dimensions:

- **Functionality Requirements:** What functionalities will be delivered through the solution?
- **Data to be Processed:** What data is required to achieve these functionalities?
- **Control Requirements:** What are the control requirements for this application?
- **Performance Requirements:** What level of response time, execution time and throughput is required?
- **Constraints:** What are the conditions the input data has to conform to? For example, what is the maximum number of characters that a name can have in a database?
- **Interfaces:** Is there any special hardware/software that the application has to interface with? For example-Payroll application may have to capture from the attendance monitoring system that the company has already installed. Then the solution developer has to understand the format of data, frequency mode of data transfer and other aspects of the software.

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- **Reliability requirements:** Reliability of an application is measured by its ability to remain uncorrupted in the face of inadvertent / deliberate misuse and probability of failure-free operations. The reliability required for an application depends on its criticality and the user profile.

Moreover, while eliciting information to delineate the scope, few aspects needs to be kept in mind:

- Different users may represent the problem and required solution in different ways. The system developer should elicit the need from the initiator of the project alternately called champion or executive sponsor of the project, addressing his concerns should be the basis of the scope.
- While the initiator of the project may be a member of the senior management, the actual users may be from the operating levels in an organization. An understanding of their profile helps in designing appropriate user interface features.
- While presenting the proposed solution for a problem, the development organization has to clearly quantify the economic benefits to the user organization. The information required has to be gathered at this stage. For example, when a system is proposed for Road tax collection, data on the extent of collection and defaults is required to quantify benefits that will result to the Transport Department.
- It is also necessary to understand the impact of the solution on the organization- its structure, roles and responsibilities. Solutions, which have a wide impact, are likely to be met with greater resistance. ERP implementation in organizations is a classic example of change management requirement. Organizations that have not been able to handle it may have a very poor ERP implementation record with disastrous consequences.
- While economic benefit is a critical consideration when deciding on a solution, there are several other factors that have to be given weightage too. These factors are to be considered from the perspective of the user management and resolved. For example, in a security system, how foolproof it is, may be a critical factor like the economic benefits that entail.

Two primary methods with the help of which the scope of the project can be analyzed are given as follows:

- **Reviewing Internal Documents:** The analysts conducting the investigation first try to learn about the organization involved in, or affected by, the project. For example, to review an inventory system proposal, an analyst may try to know how does the inventory department operates and who are the managers and supervisors. Analysts can usually learn these details by examining organization charts and studying written operating procedures.
- **Conducting Interviews:** Written documents tell the analyst how the systems should operate, but they may not include enough details to allow a decision to be made about the merits of a systems proposal, nor do they present users' views about current operations. To learn these details, analysts use interviews. Interviews allow analysts to know more about the nature of the project request and the reasons for submitting it.

Usually, preliminary investigation interviews involve only management and supervisory personnel.

(iv) Feasibility Study: After possible solution options are identified, project feasibility i.e. the likelihood that these systems will be useful for the organization is determined. A feasibility study is carried out by the system analysts, which refers to a process of evaluating alternative systems through cost/benefit analysis so that the most feasible and desirable system can be selected for development. The Feasibility Study of a system is evaluated under following dimensions described briefly as follows:

- **Technical:** Is the technology needed available?
- **Financial:** Is the solution viable financially?
- **Economic:** Return on Investment?
- **Schedule/Time:** Can the system be delivered on time?
- **Resources:** Are human resources reluctant for the solution?
- **Operational:** How will the solution work?
- **Behavioral:** Is the solution going to bring any adverse effect on quality of work life?
- **Legal:** Is the solution valid in legal terms?

The detailed description of each dimension is given as follows:

(a) **Technical Feasibility:** It may try to answer, whether implementation of the project viable using current technology? It is concerned with issues pertaining to hardware and software. Essentially, an analyst ascertains whether the proposed system is feasible with existing or expected computer hardware and software technology. The technical issues usually raised during the feasibility stage of investigation include the following:

- Does the necessary technology exist to do what is suggested (and can it be acquired)?
- Does the proposed equipment have the technical capacity to hold the data required to use the new system?
- Can the proposed application be implemented with existing technology?
- Will the proposed system provide adequate responses to inquiries, regardless of the number or location of users?
- Can the system be expanded if developed?
- Are there technical guarantees of accuracy, reliability, ease of access, and data security?

Some of the technical issues to be considered are given in the Table 5.5.2 below.

Table 5.5.2: Technical Issues

Design Considerations		Design Alternatives
Communications	Channel	Point to point, multidrop, or line sharing

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configuration	
Communications Channel	Telephone lines, coaxial cable, fiber optics, microwave, or satellite
Communications network	Centralized, decentralized, distributed, or local area
Computer programs	Independent vendor or in-house
Data storage medium	Tape, floppy disk, hard disk, or hard copy
Data storage structure	Files or database
File organization and access	Direct access or sequential files
Input medium	Keying, OCR, MICR, POS, EDI, or voice recognition
Operations	In-house or outsourcing
Output frequency	Instantaneous, hourly, daily, weekly, or monthly
Output medium	CRT, hard copy, voice, or turn-around document
Output scheduling	Pre-determined times or on demand
Printed output	Pre-printed forms or system-generated forms
Processor	Micro, mini, or mainframe
Transaction processing	Batch or online
Update frequency	Instantaneous, hourly, daily, weekly, or monthly

- (b) **Financial Feasibility:** The solution proposed may be prohibitively costly for the user organization. For example, Monitoring the stock through VSAT network connecting multiple locations may be acceptable for an organization with high turnover. But this may not be a viable solution for smaller ones.
- (c) **Economic Feasibility:** It includes an evaluation of all the incremental costs and benefits expected if the proposed system is implemented. After problems or opportunities are identified, the analysts must determine the scale of response needed to meet the user's requests for a new system as well as the approximate amount of time and money that will be required in the effort. The financial and economic questions raised by analysts during the preliminary investigation are for the purpose of estimating the following:
- The cost of conducting a full systems investigation;
 - The cost of hardware and software for the class of applications being considered;
 - The benefits in the form of reduced costs or fewer costly errors; and
 - The cost if nothing changes (i.e. the proposed system is not developed).

After possible solution options are identified, an analyst should make a primary estimate of each solution's costs and benefits.

- (d) **Schedule or Time Feasibility:** Schedule feasibility involves the design team's estimating how long it will take a new or revised system to become operational and communicating this information to the steering committee. For example, if a design team projects that it will take 16 months for a particular system design to become fully functional, the steering committee may reject the proposal in favor of a simpler alternative that the company can implement in a shorter time frame.
- (e) **Resources Feasibility:** This focuses on human resources. Implementing sophisticated software solutions becomes difficult at specific locations because of the reluctance of skilled personnel to move to such locations.
- (f) **Operational Feasibility:** It is concerned with ascertaining the views of workers, employees, customers and suppliers about the use of computer facility. A system can be highly feasible in all respects except the operational and fails miserably because of human problems. Some of the questions, which help in testing the operational feasibility of a project, may include the following:
- Is there sufficient support for the system from management and from users?
 - Are current business methods acceptable to users?
 - Have the users been involved in planning and development of the project?
 - Will the proposed system cause harm? Will it produce poorer results in any respect or area? Will loss of control result in any areas? Will accessibility of information be lost?
 - Will individual performance be poorer after implementation than before?
- This analysis may involve a subjective assessment of the political and managerial environment in which the system is to be implemented. In general, the greater the requirements for change in the user environment in which the system will be installed, greater is the risk of implementation failure.
- (g) **Behavioral Feasibility:** It refers to the systems, which is to be designed to process data and produce the desired outputs. However, if the data input for the system is not readily available or collectable, then the system may not be successful.
- (h) **Legal Feasibility:** Legal feasibility is largely concerned with whether there will be any conflict between a newly proposed system and the organization's legal obligations. Any system, which is liable to violate the local legal requirements, should also be rejected. For example, a revised system should comply with all applicable statutes about financial and statutory reporting requirements, as well as the company's contractual obligations.
- (v) **Reporting Results to Management:** After the analyst articulates the problem, defines the same along with its scope, s/he provides one or more solution alternatives and estimates the cost and benefits of each alternative and reports these results to the management. The report should be accompanied by a short covering letter of intent that summarizes the results and makes the recommendation regarding further procedures. From the analyst's report, management should determine what to do next. Not all projects submitted for evaluation and review may get accepted. Requests that fail to pass feasibility test are not pursued further

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unless they are reworked and resubmitted as new proposals. In some cases, only a part of the project is actually unworkable and the steering committee may decide to combine the workable part of the project with another feasible proposal. In certain other cases, primary investigation produces new information to suggest that improvements in management and supervision, and not the development of information systems are the actual solutions to the reported problems.

(vi) Internal Control Aspects: Management implements proper internal control to ensure business objectives. As defined in section 217(2AA), Companies Act, 1956, Directors are responsible to have proper internal control for a company. In terms of system development, controls need to be well in place during the development of system. In systems, it is not possible to put in place controls post development. A better understanding of controls during planning and effective implementation of those controls shall help to achieve the above stated objectives.

For validating control aspects in system, entity may have an internal audit team. Few large software developers engage outside experts for the same. To check controls internally or through external auditor depends on size and nature of entities of the business. The same is also dependent upon management's attitude. Review by external consultant is more independent. External consultant may bring his/her expertise to entity. The flip side is that external consultant may be costly; secrecy is also a fact to consider. However, the key control queries regarding various aspects at this stage may include the following:

- Whether problem definition is proper?
- Whether all feasibility studies have been properly done?
- Whether results of feasibility studies have been documented?
- Whether management report submitted reflects the outcome of feasibility studies done?

5.5.2 System Requirements Analysis

This phase includes a thorough and detailed understanding of the current system, identifies the areas that need modification to solve the problem, the determination of user/managerial requirements and to have fair idea about various systems development tools. The following objectives are performed in this phase in order to generate the deliverable, Systems Requirements Specification (SRS):

- To identify and consult the stake owners to determine their expectations and resolve their conflicts;
- To analyze requirements to detect and correct conflicts and determine priorities;
- To gather data or find facts using tools like - interviewing, research/document collection, questionnaires, observation;
- To verify that the requirements are complete, consistent, unambiguous, verifiable, modifiable, testable and traceable;
- To model activities such as developing models to document Data Flow Diagrams, E-R Diagrams; and

- To document activities such as interview, questionnaires, reports etc. and development of a system (data) dictionary to document the modeling activities.

In order to accomplish the aforementioned objectives, a series of steps are taken. Such steps result in process, assuring appropriate systems requirements analysis. A generic set of process are described as follows:

(i) Fact Finding: Every system is built to meet some set of needs, for example, the need of the organization for lower operational costs, better information for managers, smooth operations for users or better levels of services to customers. To assess these needs, the analysts often interact extensively with people, who will be benefited from the system in order to determine 'what are their actual requirements'. Various fact-finding techniques/tools are used by the system analyst for determining these needs/requirements are briefly discussed below:

- **Documents:** Document means manuals, input forms, output forms, diagrams of how the current system works, organization charts showing hierarchy of users and manager responsibilities, job descriptions for the people, who work with the current system, procedure manuals, program codes for the applications associated with the current system, etc. Documents are a very good source of information about user needs and the current system.
- **Questionnaires:** Users and managers are asked to complete questionnaire about the information systems when the traditional system development approach is chosen. The main strength of questionnaires is that a large amount of data can be collected through a variety of users quickly. Also, if the questionnaire is skillfully drafted, responses can be analyzed rapidly with the help of a computer.
- **Interviews:** Users and managers may also be interviewed to extract information in depth. The data gathered through interviews often provide system developers with a larger picture of the problems and opportunities. Interviews also give analyst the opportunity to observe and record first-hand user reaction and to probe for further information.
- **Observation:** In general and particularly in prototyping approaches, observation plays a central role in requirement analysis. Only by observing how users react to prototypes of a new system, the system can be successfully developed.

(ii) Analysis of the Present System: Detailed investigation of the present system involves collecting, organizing and evaluating facts about the system and the environment in which it operates. There should be enough information assembled so that a qualified person can understand the present system without visiting any of the operating departments. Survey of existing methods, procedures, data flow, outputs, files, input and internal controls that should be intensive in order to fully understand the present system and its related problems. The following areas should be studied in depth:

- **Reviewing Historical Aspects:** A brief history of the organization is a logical starting point for an analysis of the present system. The historical facts enable to identify the major turning points and milestones that have influenced its growth. A review of annual reports and organization charts can identify the growth of management levels as well as the development of various functional areas and departments. The system analyst should investigate 'what system changes have occurred in the past including operations' that have been successful or unsuccessful with computer equipment and techniques.

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- **Analyzing Inputs:** A detailed analysis of present inputs is important since they are basic to the manipulation of data. Source documents are used to capture the originating data for any type of system. The system analyst should be aware of various sources from where the data are initially captured, keeping in view the fact that outputs for one area may serve as an input for another area. The system analyst must understand the nature of each form, 'what is contained in it', 'who prepared it', 'from where the form is initiated', 'where it is completed', the distribution of the form and other similar considerations. If the analyst investigates these questions thoroughly, s/he will be able to determine how these inputs fit into the framework of the present system.
- **Reviewing Data Files:** The analyst should investigate the data files maintained by each department, noting their number and size, where they are located, who uses them and the number of times per given time interval, these are used. Information on common data files and their size will be an important factor, which will influence the new information system. This information may be contained in the systems and procedures manuals. The system analyst should also review all on-line and off-line files, which are maintained in the organization as it will reveal information about data that are not contained in any outputs. The related cost of retrieving and processing the data is another important factor that should be considered by the systems analyst.
- **Reviewing Methods, Procedures and Data Communications:** Methods and procedures transform input data into useful output. A method is defined as a way of doing something; a procedure is a series of logical steps by which a job is accomplished. A procedure review is an intensive survey of the methods by which each job is accomplished, the equipment utilized and the actual location of the operations. Its basic objective is to eliminate unnecessary tasks or to perceive improvement opportunities in the present information system. A system analyst also needs to review and understand the present data communications used by the organization. S/he must review the types of data communication equipment including data interface, data links, modems, dial-up and leased lines and multiplexers. The system analyst must understand how the data-communications network is used in the present system so as to identify the need to revamp the network when the new system is installed.
- **Analyzing Outputs:** The outputs or reports should be scrutinized carefully by the system analysts in order to determine 'how well they will meet the organization's needs. The analysts must understand what information is needed and why, who needs it and when and where it is needed. Additional questions concerning the sequence of the data, how often the form reporting is used, how long is it kept on file, etc. must be investigated. Often, many reports are a carry-over from earlier days and have little relevance to current operations. Attempts should be made to eliminate all such reports in the new system.
- **Reviewing Internal Controls:** A detailed investigation of the present information system is not complete until internal control mechanism is reviewed. Locating the control points helps the analyst to visualize the essential parts and framework of a system. An examination of the present system of internal controls may indicate weaknesses that should be removed in the new system. The adoption of advanced methods, procedures and equipments might allow much greater control over the data.

- **Modeling the Existing System:** As the logic of inputs, methods, procedures, data files, data communications, reports, internal controls and other important items are reviewed and analyzed in a top down manner; the processes must be properly documented. The flow charting and diagramming of present information not only organizes the facts, but also helps to disclose gaps and duplication in the data gathered. It allows a thorough comprehension of the numerous details and related problems in the present operation.
- **Undertaking Overall Analysis of the Existing system:** Based upon the aforesaid investigation of the present information system, the final phase of the detailed investigation includes the analysis of the present work volume; the current personnel requirements; the present costs-benefits of each of these must be investigated thoroughly.

(iii) System Analysis of Proposed Systems: After a thorough analysis of each functional area of the present information system, the proposed system specifications must be clearly defined, which are determined from the desired objectives set forth at the first stage of the study. Likewise, consideration should be given to the strengths and short comings of the present system. The required systems specifications should be in conformity with the project's objectives articulated and in accordance with the following:

- Outputs are produced with great emphasis on timely managerial reports that utilize the management by exception' principle.
- Databases are maintained with great accent on online processing capabilities.
- Input data is prepared directly from original source documents for processing by the computer system.
- Methods and procedures that show the relationship of inputs and outputs to the database, utilize data communications as, when and where deemed appropriate.
- Work volumes and timings are carefully considered for present and future periods including peak periods.

The starting point for compiling these specifications is output. After outputs have been determined, it is possible to infer what inputs, database, methods, procedures and data communications must be employed. The output-to-input process is recommended since outputs are related directly to the objectives of the organization. The future workload of the system must be defined for inputs, database and outputs in terms of average and peak loads, cycles and trends.

(iv) System Development Tools: Many tools and techniques have been developed to improve current information systems and to develop new ones. Such tools help end users and systems analysts primarily for the following:

- To conceptualize, clarify, document and communicate the activities and resources involved in the organization and its information systems;
- To analyze present business operations, management decision making and information processing activities of the organization; and
- To propose and design new or improved information systems to solve business problems or pursue business opportunities that have been identified.

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Many systems development tools take the form of diagrams and other graphic representations. The major tools used for system development specification or representations can be classified into four categories based on the systems features. These are described briefly as follows:

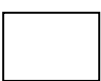


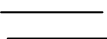
- **System Components and Flows:** These tools help the system analysts to document the data flow among the major resources and activities of an information system. System flow charts are typically used to show the flow of data media as they are processed by the hardware devices and manual activities. A data flow diagram uses a few simple symbols to illustrate the flow of data among external entities (such as people or organizations etc.), processing activities and data storage elements. A system component matrix provides a matrix framework to document the resources used, the activities performed and the information produced by an information system.
- **User Interface:** Designing the interface between end users and the computer system is a major consideration of a system analyst while designing the new system. Layout forms and screens are used to construct the formats and contents of input/output media and methods. Dialogue flow diagrams analyze the flow of dialogue between computers and people. It documents the flows among different display screens generated by alternative end user responses to menus and prompts.
- **Data Attributes and Relationships:** The data resources in information system are defined, catalogued and designed by this category of tools. A Data Dictionary catalogs the description of the attributes (characteristics) of all data elements and their relationships to each other as well as to external systems. Entity-relationship diagrams are used to document the number and type of relationship among the entities in a system. File layout forms document the type, size and names of the data elements in a system. Grid charts help in identifying the use of each type of data element in input/output or storage media of a system.
- **Detailed System Processes:** These tools are used to help the programmer to develop detailed procedures and processes required in the design of a computer program. Decision trees and decision tables use a network or tabular form to document the complex conditional logic involved in choosing among the information processing alternatives in a system. Structure charts document the purpose, structure and hierarchical relationships of the modules in a program.

It is clear from the foregoing description that a number of CASE tools are in use for typical representation, specifications and system modeling. A set of the prominent tools have been already mentioned categorically and some are being described in detail as follows:

- (a) **Structured English:** Structured English, also known as Program Design Language (PDL), is the use of the English language with the syntax of structured programming. Thus, Structured English aims at getting the benefits of both the programming logic and natural language. Program logic that helps to attain precision and natural language that helps in getting the convenience of spoken languages. A better structured, universal and precise tool is referred to as pseudo code.

- (b) **Flowcharts:** Flowcharting is a pictorial representation technique that can be used by analysts to represent the inputs, outputs and processes of a business process. It is a common type of chart that represents an algorithm or process showing the steps as boxes of various kinds, and their order by connecting these with arrows. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.
- (c) **Data Flow Diagrams:** A Data Flow Diagram uses few simple symbols to illustrate the flow of data among external entities (such as people or organizations, etc.), processing activities and data storage elements. A DFD is composed of four basic elements: Data Sources and Destinations, Data Flows, Transformation processes, and Data stores shown in Table 5.5.3. These four symbols are combined to show how data are processed.

Table 5.5.3: Data Flow Diagram Symbols

Symbol	Name	Explanation
	Data Sources and destinations	The people and organizations that send data to and receive data from the system are represented by square boxes called Data destinations or Data Sinks.
	Data flows	The flow of data into or out of a process is represented by curved or straight lines with arrows.
	Transformation process	The processes that transform data from inputs to outputs are represented by circles, often referred to as bubbles.
	Data stores	The storage of data is represented by two horizontal lines.

- (d) **Decision Tree:** A Decision Tree or tree diagram is a support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. Decision tree is commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal and to calculate conditional probabilities.
- (e) **Decision Table:** A Decision Table is a table, which may accompany a flowchart, defining the possible contingencies that may be considered within the program and the appropriate course of action for each contingency. Decision tables are necessitated by the fact that branches of the flowchart multiply at each diamond (comparison symbol) and may easily run into scores and even hundreds. If, therefore, the programmer attempts to draw a flowchart directly, s/he is liable to miss some of the branches. The four parts of the decision table are given as follows:
- **Condition Stub** – This comprehensively lists the comparisons or conditions;
 - **Action Stub** – This comprehensively lists the actions to be taken along various program branches;

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- **Condition entries** – This list in its various columns the possible permutations of answer to the questions in the conditions stub); and
 - **Action entries** – This lists in its columns corresponding to the condition entries the actions contingent upon the set of answers to questions of that column.
- (f) **CASE Tools:** The data flow diagram and system flow charts that users review are commonly generated by systems developers using the on-screen drawing modules found in CASE (Computer-Aided-Software Engineering) software packages. CASE refers to the automation of anything that humans do to develop systems and support virtually all phases of traditional system development process. For example, these packages can be used to create complete and internally consistent requirements specifications with graphic generators and specifications languages.
- An ideal CASE system would have an integrated set of tools and features to perform all aspects in the life cycle. Some of the features that various CASE products possess are - Repository / Data Dictionary; Computer aided Diagramming Tools; Word Processing; Screen and Report generator; Prototyping; Project Management; Code Generation; and Reverse Engineering.
- (g) **System Components Matrix:** A System Component Matrix provides a matrix framework to document the resources used, the activities performed and the information produced by an information system. It can be used as an information system framework for both systems analysis and system design and views the information system as a matrix of components that highlights how the basic activities of input, processing, output, storage and controls are accomplished in an information system, and how the use of hardware, software and people resources can convert data resources into information products. Table 5.5.4 illustrates the use of a system component matrix to document the basic components of a sales processing and analysis system in an organization.

Table 5.5.4: A System Component Matrix

Information system Activities	Hardware Resources		Software Resources		People Resources		Data Resources	Information Products
	Machines	Media	Programs	Procedures	Specialists	Users		
Input	POS Terminals	Bar tags, Mag Stripe Cards	Data Entry program	Data Entry procedures		Sales clerks customers	Customer data, product data	Data entry displays
Processing	Mainframe Computer		Sales processing program, sales analysis program	Sales transaction procedures	Computer operators	Sales clerks managers	Customer inventory and sales databases	Processing status displays
Output	POS Terminals, Management Workstations	Paper reports and receipts	Report generator program, Graphic program	Output use and distribution procedures		Sales clerks managers, customers		Sales receipts, sales analysis reports and displays
Storage	Magnetic Drives	Disk Magnetic disk packs	Database management system program		Computer operators		Customer, inventory and sales databases	
Control	POS terminals, Management workstations	Paper documents and control reports	Performance monitor program, security monitor program	Correction procedures	Computer operators control clerks	Sales clerks managers customers	Customer, inventory and sales database	Data entry display, sales receipts, Error display and signals

- (h) **Data Dictionary:** A data dictionary contains descriptive information about the data items in the files of a business information system. Thus, a data dictionary is a computer file about data. Each computer record of a data dictionary contains information about a single data item used in a business information system. This information may include - the identity of the source document(s) used to create the data item; the names of the computer files that store the data item; the names of the computer programs that modify the data item; the identity of the computer programs or individuals permitted to access the data item for the purpose of file maintenance, upkeep, or inquiry; the identity of the computer programs or individuals not permitted to access the data item etc.

As new data fields are added to the record structure of a business file, information about each new data item is used to create a new record in the data dictionary. Similarly, when new computer programs are created that access data items in existing files, the data dictionary is updated to indicate the data items the new programs access. Finally, when data fields are deleted from the structure of file records, their corresponding records in the data dictionary are dropped.

Fig. 5.5.5 shows a sample record from a generic data dictionary, which is basically a file about data. Each file record contains information about one data field used in other files or metadata of the system.

Name of data field	File in which stored	Source document	Size in bytes	Type
Inventory quantity on hand	Inventory master file	Form number ABC 123	4	Numeric




Fig. 5.5.5: Example of Data Dictionary

Accountants and auditors can also make good use of a data dictionary. For example, a data dictionary can help to establish an audit trail because it can identify the input sources of data items, the computer programs that modify particular data items, and the managerial reports on which the data items are output. When an accountant participates in the design of a new system, a data dictionary can also be used to plan the flow of transaction data through the system.

- (i) **User Interface Layout and Forms:** Several type layout forms for both soft and hard copy are used to model input/output components of an automated information system. Some of the prominent and inevitable ones are described briefly as follows:
- **Layout form and Screen Generator:** These are for printed report used to format or “paint” the desired layouts and contact without having to enter complex formatting information. Fig. 5.5.6 shows a Layout screen for the design of a customer order report.
 - **Menu Generator:** Menu generator outlines the functions, which the system is aimed to accomplish. Menu may be linked to other submenus that will enable the user to understand how the screens and sub-screens will be used for data entry or inquiry.

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- **Report Generator:** Report generator has capacity of performing similar functions as found in screen generators. In addition, it can also indicate totals, paging, sequencing and control breaks in creating samples of the desired report.
- **Code Generator:** Code generator allows the analyst to generate modular units of source code from the high level specifications provided by the system analyst and play significant role in systems development process.

Customer Order Report				
Date MM/DD/YY				
Order Number	9999			
Customer Name	XXXXXXXXXXXXXXXXXXXXXXXXXX			
Catalog Number	Available	Location	Cost	Stock Level
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
XXXXXXXXXXXXXX	X	XXXXXXX	999.99	99999
	3 Exit	1.8 Column	8 Repeat	10 Field

Fig. 5.5.6: Layout screen for the design of a display for a customer order report

(v) **Systems Specification:** At the end of the analysis phase, the systems analyst prepares a document called **Systems Requirement Specifications (SRS)**. A well documented SRS may normally contains the following sections:

- **Introduction:** Goals, Objectives, software context, Scope and Environment of the computer-based system.
- **Information Description:** Problem description; Information content, flow and structure; Hardware, software, human interfaces for external system elements and internal software functions.
- **Functional Description:** Diagrammatic representation of functions; Processing narrative for each function; Interplay among functions; Design constraints.
- **Behavioral Description:** Response to external events and internal controls.
- **Validation Criteria:** Classes of tests to be performed to validate functions, performance and constraints.
- **Appendices:** Data flow/Object Diagrams; Tabular Data; Detailed description of algorithms charts, graphs and other such material.
- **SRS Review:** The development team makes a presentation and then hands over the SRS document to be reviewed by the user or customer. The review reflects the development team's understanding of the existing processes. Only, after ensuring that

the document represents existing processes accurately, the user should sign the document. This is a technical requirement of the contract between users and development team/organization.

(vi) Roles Involved in SDLC: A variety of tasks during the SDLC are performed by special teams/committees/individuals based on requisite expertise as well as skills. Some of the generic roles are described as follows:

(a) Steering Committee: It is a special high power committee of experts to accord approvals for go-ahead and implementations. Some of the functions of Steering Committee are given as follows:

- To provide overall directions and ensures appropriate representation of affected parties;
- To be responsible for all cost and timetables;
- To conduct a regular review of progress of the project in the meetings of steering committee, which may involve co-ordination and advisory functions; and
- To undertake corrective actions like rescheduling, re-staffing, change in the project objectives and need for redesigning.

(b) Project Manager: A project manager is normally responsible for more than one project and liaising with the client or the affected functions. S/he is responsible for delivery of the project deliverables within the time/budget and periodically reviews the progress of the project with the project leader and his/her team.

(c) Project Leader: The project leader is dedicated to a project, who has to ensure its completion and fulfillment of objectives. S/he reviews the project status more frequently than a Project Manager and the entire project team reports to him/her.

(d) Systems Analyst / Business Analyst: The systems analysts' main responsibility is to conduct interviews with users and understand their requirements. S/he is a link between the users and the designers/programmers, who convert the users' requirements in the system requirements and plays a pivotal role in the Requirements analysis and Design phase.

(e) Module Leader/Team Leader: A project is divided into several manageable modules, and the development responsibility for each module is assigned to Module Leaders. For example, while developing a financial accounting application – Treasury, Accounts payable, Accounts receivable can be identified as separate modules and can be assigned to different module leaders. Module leaders are responsible for the delivery of tested modules within the stipulated time and cost.

(f) Programmer/Developers: Programmers is a mason of the software industry, who converts design into programs by coding using programming language. Apart from developing the application in a programming language, they also test the program for debugging activity to assure correctness and reliability

(g) Database Administrator: The data in a database environment has to be maintained by a specialist in database administration so as to support the application program. The DBA

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handles multiple projects; ensures the integrity and security of information stored in the database and also helps the application development team in database performance issues. Inclusion of new data elements has to be done only with the approval of the database administrator.

- (h) **Quality Assurance:** This team sets the standards for development, and checks compliance with these standards by project teams on a periodic basis. Any quality assurance person, who has participated in the development process, shall not be viewed as 'independent' to carry out quality audits.
 - (i) **Testers:** Testers are a junior level quality assurance personnel attached to a project, who test programs and subprograms as per the plan given by the module / project leaders and prepare test reports.
 - (j) **Domain Specialist:** Whenever a project team has to develop an application in a field that's new to them, they take the help of a domain specialist. For example, if a team undertakes application development in Insurance, about which they have little knowledge, they may seek the assistance of an Insurance expert at different stages. This makes it easier to anticipate or interpret user needs. A domain specialist need not have knowledge of software systems.
 - (k) **IS Auditor:** As a member of the team, IS Auditor ensures that the application development also focuses on the control perspective. S/he should be involved at the Design Phase and the final Testing Phase to ensure the existence and the operations of the Controls in the new software.
- (vii) **Internal Controls:** Requirements phase is the most important phases of SDLC. The issue of controls is very important here also. Some of the key control aspects at this stage may be taken care by the following queries:
- Whether present system analysis has been properly done?
 - Whether appropriate domain, were expert was engaged?
 - Whether all user requirements of proposed system have been considered?
 - Whether SRS document has been properly made and vetted by Users, Domain Experts, System Analysts?

5.5.3 System Designing

After the completion of requirements analysis for a system, systems designing activity takes place for the most feasible and optimal alternative, which is selected by management. The objective is to design an Information System that best satisfies the users/managerial requirements. It describes the parts of the system and their interaction. It sets out how the system shall be implemented using the chosen hardware, software and network facilities. It also specifies the program and the database specifications and the security plans and further specifies the change control mechanism to prevent uncontrolled entry of new requirements.

The key and generic design phase activities include describing inputs and outputs such as screen design and reports; determining the processing steps and computation rules for the

new solution; determining data file or database system file design; preparing the program specifications for the various types of requirements or information criteria defined; and Internal/external controls.

Design phase documents/deliverables include a 'blueprint' for the design with the necessary specifications for the hardware, software, people and data resources. System design involves first logical design and then physical construction of a system. The logical design of an information system is like an engineering blueprint; it shows major features of the system and 'how they are related to one another'. Physical construction, the activity following logical design, produces program software, files and a working system. Design specifications guides the programmers about 'what the system should do and how to implement'. The programmers, in turn, write the programs that accept input from users, process data, produce the reports, and store data in the files.

Once the detailed design is completed, the design is then distributed to the system developers for coding. The design phase activities includes Architectural Design; Design of the Data / Information Flow; Design of the Database; Design of the User-interface; Physical Design; and Design and acquisition of the hardware/system software platform', which are described briefly as follows:

- (a) **Architectural Design:** Architectural design deals with the organization of applications in terms of hierarchy of modules and sub-modules. At this stage, we identify major modules; functions and scope of each module; interface features of each module; modules that each module can call directly or indirectly and Data received from / sent to / modified in other modules. The architectural design is made with the help of a tool called Functional Decomposition, which can be used to represent hierarchies as shown in Fig. 5.5.7. It has three elements – Module, Connection, and Couple.

The module is represented by a box and connection between them by arrows. Couple is data element that moves from one module to another and is shown by an arrow with circular tail.

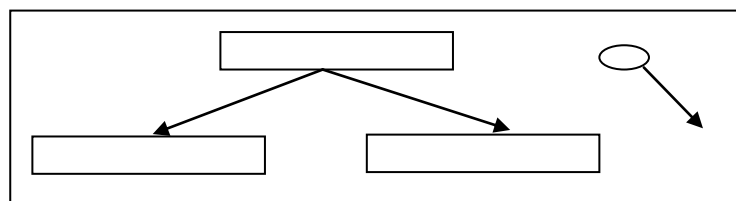


Fig. 5.5.7: Functional Decomposition Tool

- (b) **Design of Data/Information flow:** The design of the data and information flow is a major step in the conceptual design of the new system. In designing the data / information flow for the proposed system, the inputs that are required are - existing data / information flows, problems with the present system, and objective of the new system. All these have been identified in the analysis phase and documented in Software Requirements Specification (SRS).
- (c) **Design of Database:** Design of the database involves determining its scope ranging from local to global structure. The scope is decided on the basis of interdependence

among organizational units. The design of the database involves four major activities, which are shown in Table 5.5.5.

Table 5.5.5: Major Activities in Database Designing

Design Activity	Explanation
Conceptual Modeling	These describe the application domain via entities/objects, attributes of these entities/objects and static and dynamic constraints on these entities/objects, their attributes, and their relationships.
Data Modeling	Conceptual Models need to be translated into data models so that they can be accessed and manipulated by both high-level and low-level programming languages.
Storage Structure Design	Decisions must be made on how to linearize and partition the data structure so that it can be stored on some device. For example- tuples (row) in a relational data model must be assigned to records, and relationships among records might be established via symbolic pointer addresses.
Physical Layout Design	Decisions must be made on how to distribute the storage structure across specific storage media and locations for example, the cylinders, tracks, and sectors on a disk and the computers in a LAN or WAN.

- (d) **User Interface Design:** It involves determining the ways in which users will interact with a system. The points that need to be considered while designing the user interface are - source documents to capture raw data, hard-copy output reports, screen layouts for dedicated source-document input, inquiry screens for database interrogation, graphic and color displays, and requirements for special input/output device.

One of the most important feature of an information system for users is the output, it generates. Designing computer output should proceed in an organized, well thought out manner. The right output must be developed while ensuring that each output element is designed so that users will find the system easy to use effectively.

Input design consists of developing specifications and procedures for data preparation, developing steps, which are necessary to put transactions data into a usable form for processing, and data-entry, i.e., the activity of putting the data into the computer for processing. The output from an information system should accomplish one or more of the following objectives including to convey information about past activities, current status or projections of the future, signal important events, opportunities, problems or warnings, trigger an action, and confirmation of an action.

Important factors in Input/Output design are listed in Table 5.5.6, which should be considered by the system analyst while designing user input/ output forms.

Table 5.5.6: Factors affecting Input / Output Form Designs

Characteristic	Definition	Input Design	Output Design
Content	Refers to the actual pieces of data to be gathered to produce the required output to be provided to users.	The analyst is required to consider the types of data that are needed to be gathered to generate the desired user outputs. New documents for collecting such information may be designed.	The contents of a weekly output report to a sales manager might consist of sales person's name, sales calls made by each sales person during the week, and the amount of each product sold by each salesperson to each major client category.
Timeliness	Timeliness refers to when users need outputs, which may be required on a regular, periodic basis - perhaps daily, weekly, monthly, at the of quarter or annually.	Data needs to be inputted to computer in time because outputs cannot be produced until certain inputs are available. Hence, a plan must be established regarding when different types of inputs will enter the system.	A sales manager, may be requiring a weekly sales report. Other users, such as airline agents, require both real-time information and rapid response times in order to render better client service.
Format	Input format refers to the manner in which data are physically arranged. Output format refers to the arrangement referring to data output on a printed report or in a display screen.	After the data contents and media requirements are determined, input formats are designed on the basis of few constraints like - the type and length of each data field as well as any other special characteristics (number decimal places etc.).	Format of information reports for the users should be so devised that it assists in decision-making, identifying and solving problems, planning and initiating corrective action and searching.

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Media	Input-output medium refers to the physical device used for input, storage or output.	This includes the choice of input media and subsequently the devices on which to enter the data. Various user input alternatives may include display workstations, magnetic tapes, magnetic disks, keyboards, optical character recognition, pen-based computers and voice input etc. A suitable medium may be selected depending on the application to be computerized.	A variety of output media are available in the market these days which include paper, video display, microfilm, magnetic tape/disk and voice output.
Form	Form refers to the way the information is inputted in the input form and the content is presented to users in various output forms - quantitative, non-quantitative, text, graphics, video and audio.	Forms are pre-printed papers that require people to fill in responses in a standardized way. Forms elicit and capture information required by organizational members that often will be input to the computer. Through this process, forms often serve as source documents for the data entry personnel.	The form of the output should be decided keeping in view the requirements for the concerned user. For example - Information on distribution channels may be more understandable to the concerned manager if it is presented in the form of a map, with dots representing individual outlets for stores.
Input Volume/ Output Volume	Input volume refers to the amount of data that has to be entered in the	In some decision-support systems and many real-time processing systems, input volume is light.	It is better to use high-speed printer or a rapid-retrieval display unit, which are fast and

	<p>computer system at any one time. The amount of data output required at any one time is known as output volume.</p>	<p>In batch-oriented transaction processing systems, input volume could be heavy which involves thousands of records that are handled by a centralized data entry department using key-to-tape or key-to-disk systems.</p>	<p>frequently used output devices in case the volume is heavy.</p>
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- (e) **Physical Design:** For the physical design, the logical design is transformed into units, which in turn can be decomposed further into implementation units such as programs and modules. During physical design, the primary concern of the auditor is effectiveness and efficiency issues. The auditor should seek evidence that designers follow some type of structured approach like CASE tools to access their relative performance via simulations when they undertake physical design. Some of the issues addressed here are type of hardware for client application and server application, Operating systems to be used, type of networking, processing – batch – online, real – time; frequency of input, output; and month-end cycles / periodical processing.

Some of the generic design principles being applied to develop the design of typical information systems include the following:

- There is a tendency to develop merely one design and consider it the final product. However, the recommended procedure is to design two or three alternatives and choose the best one on pre-specified criteria.
- The design should be based on the analysis.
- The software functions designed should be directly relevant to business activities.
- The design should follow standards laid down. For instance, the user interface should have consistent color scheme, menu structure, location of error message and the like.
- The design should be modular, with high cohesion and low coupling.

Moreover, a module is a manageable unit containing data and instructions to perform a well-defined task. Interaction among modules is based on well-defined interfaces. Modularity is measured by two parameters: Cohesion and Coupling. Cohesion refers to the manner in which elements within a module are linked and interacting. Coupling is a measure of the interconnection between modules. It refers to the number and complexity of connections between 'calling' and 'called' modules.

- (f) **System's Operating Platform:** In some cases, the new system requires an operating platform including hardware, network and system software not currently available in an

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organization. For example – a DSS might require high-quality graphics output not supported by the existing hardware and software. The new hardware/system software platform required to support the application system will then have to be designed for requisite provisions. If different hardware and software are not able to communicate with each, subsequent changes will have to be made and resources expanded in trying to make the hardware and software compatible to each other. Auditors should be concerned about the extent to which modularity and generality are preserved in the design of the hardware/system software platform.

(g) Internal Design Controls: From internal control point of view, this phase is also an important phase as all internal controls are placed in system during this phase. The key control aspects at this stage include the following:

- Whether management reports of stage I and stage II, were referred by System Designer?
- Whether all control aspects have been properly covered?
- Whether controls put in place in system, appear in the documentation done at this stage?
- Whether a separate review of design document has been done by internal auditor?

5.5.4 System Acquisition

After a system is designed either partially or fully, the next phase of the systems development starts, which relates to the acquisition of operating infrastructure including hardware, software and services. Such acquisitions are highly technical and cannot be taken easily and for granted. Thereby, technical specifications, standards etc. come to rescue.

(a) Acquisition Standards: Management should establish acquisition standards that address the security and reliability issues as per current state-of-the art development standards. Acquisition standards should focus on the following:

- Ensuring security, reliability, and functionality already built into a product;
- Ensuring managers complete appropriate vendor, contract, and licensing reviews and acquiring products compatible with existing systems;
- Invitations-to-tender soliciting bids from vendors when acquiring hardware or integrated systems of hardware and software;
- Request-for-proposals soliciting bids when acquiring off-the-shelf or third-party developed software; and
- Establishing acquisition standards to ensure functional, security, and operational requirements to be accurately identified and clearly detailed in request-for-proposals.

(b) Acquiring Systems Components from Vendors: At the end of the design phase, the organization gets a reasonable idea of the types of hardware, software and services, it needs for the system being developed. Acquiring the appropriate hardware and software is critical for the success of the whole project. The organization can discover new hardware and software developments in various ways. Management also decides whether the hardware is to be

purchased, leased from a third party or to be rented. A sub-committee of experts under the steering committee, referred to as 'System Acquisition Committee' is constituted. The sub-committee is mandated to ensure timely and effective completion of this stage.

The next aspect is call for Request For Proposal (RFP) from vendors. This stage is one of the most critical phases for system acquisition; as well defined RFP leads to better acquisition. RFP, means asking vendors to submit proposals for the requirements mentioned. RFP process is the initiation of final stages for implementation. The requirements analysis and design phase have been completed, before starting of this phase. The following considerations are valid for both acquisition of hardware and software:

- **Vendor Selection:** This step is a critical step for success of process of acquisition of systems. It is necessary to remember that vendor selection is to be done prior to sending RFP. The result of this process is that 'RFP are sent only to selected vendors'. For vendor selection, following things are kept in mind including the background and location advantage of the vendor, the financial stability of vendor, the market feedback of vendor performance, in terms of price, services etc.
- **Geographical Location of Vendor:** The issue to look for whether the vendor has local support persons. Otherwise, the proposals submitted by vendor not as per RFP requirements need to be rejected, with no further discussion on such rejected proposals. This stage may be referred to as 'technical validation', that is to check the proposals submitted by vendors, are technically complying with RFP requirements.
- **Presentation by Selected Vendors:** All vendors, whose proposals are accepted after "technical validation", are allowed to make presentation to the System Acquisition Team. The team evaluates the vendor's proposals by using techniques.
- **Evaluation of Users Feedback:** The best way to understand the vendor systems is to analyze the feedback from present users. Present users can provide valuable feedback on system, operations, problems, vendor response to support calls.

Besides these, some specific considerations for hardware and software acquisition are described as follows:

- The benchmark tests to be done for proposed machine. For hardware's, there are specified standard benchmark tests defined based on the nature of hardware. These need to be applied to proposed equipment.
- Software considerations that can be current applications programs or new programs that have been designed to represent planned processing needs.
- The benchmarking problems are oriented towards testing whether a computer offered by the vendor meets the requirements of the job on hand of the buyer.
- The benchmarking problems would then comprise long jobs, short jobs, printing jobs, disk jobs, mathematical problems, input and output loads etc., in proportion typical of the job mix.
- If the job is truly represented by the selected benchmarking problems, then this approach can provide a realistic and tangible basis for comparing all vendors' proposals.

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- Tests should enable buyer to effectively evaluate cross performance of various systems in terms of hardware performance (CPU and input/output units), compiler language and operating system capabilities, diagnostic messages, ability to deal with certain types of data structures and effectiveness of software utilities.
- Benchmarking problems, however, suffer from a couple of disadvantages. It takes considerable time and efforts to select problems representative of the job mix which itself must be precisely defined. It also requires the existence of operational hardware, software and services of systems. Nevertheless, this approach is very popular because it can test the functioning of vendors' proposal. The manager can extrapolate in the light of the results of benchmarking problems, the performance of the vendors' proposals on the entire job mix.

(c) Other Acquisition Aspects and Practices: On addition to the above, there are several other acquisition aspects and practices also, which are given as follows:

(i) Hardware Acquisition: In case of procuring such machinery as machine tools, transportation equipment, air conditioning equipment, etc., the management can normally rely on the time tested selection techniques and the objective selection criteria can be delegated to the technical specialist. The management depends upon the vendor for support services, systems design, education and training etc., and expansion of computer installation for almost an indefinite period; therefore, this is not just buying the machine and paying the vendor for it but it amounts to an enduring alliance with the supplier.

(ii) Software Acquisition: Once user output and input designs are finalized, the nature of the application software requirements must be assessed by the systems analyst. This determination helps the systems development team to decide 'what type of application software products is needed' and consequently, the degree of processing that the system needs to handle. This helps the system developers in deciding about the nature of the systems software and computer hardware that will be most suitable for generating the desired outputs, and also the functions and capabilities that the application software must possess. At this stage, the system developers must determine whether the application software should be created in-house or acquired from a vendor.

(iii) Contracts, Software Licenses and Copyright Violations: Contracts between an organization and a software vendor should clearly describe the rights and responsibilities of the parties to the contract. The contracts should be in writing with sufficient detail to provide assurances for performance, source code accessibility, software and data security, and other important issues. Software license is a license that grants usage permission to do things with computer software. The usual goal is to authorize activities, which are prohibited by default by copyright law, patent law, trademark law and any other intellectual property rights. The reason for the license, essentially is that virtually all intellectual property laws were enacted to encourage disclosure of the intellectual property. Copyright laws protect proprietary as well as open-source software. The use of unlicensed software or violations of a licensing agreement expose organizations to possible litigation.

(iv) Validation of Vendors' proposals: The contracts and software licensing process consists of evaluating and ranking the proposals submitted by vendors and is quite difficult,

expensive and time consuming, but in any case it has to be gone through. This problem is made difficult by the fact that vendors would be offering a variety of configurations. The following factors have to be considered towards rigorous evaluation.

- The Performance capability of each proposed System in Relation to its Costs;
- The Costs and Benefits of each proposed system;
- The Maintainability of each proposed system;
- The Compatibility of each proposed system with Existing Systems; and
- Vendor Support.

(v) Methods of Validating the proposal: Large organizations would naturally tend to adopt a sophisticated and objective approach to validate the vendor’s proposal. Some of the validation methods are given as follows:

- **Checklists:** It is the most simple and a subjective method for validation and evaluation. The various criteria are put in check list in the form of suitable questions against which the responses of the various vendors are validated. For example, Support Service Checklists may have parameters like Performance; System development, Maintenance, Conversion, Training, Back-up, Proximity, Hardware and Software.
- **Point-Scoring Analysis:** Point-scoring analysis provides an objective means of selecting a final system. There are no absolute rules in the selection process, only guidelines for matching user needs with software capabilities. Thus, even for a small business, the evaluators must consider such issues as the company’s data processing needs, its in-house computer skills, vendor reputations, software costs, and so forth. Table 5.5.7 illustrates a Point Scoring Analysis list.

Table 5.5.7: Point Scoring Analysis List

Software Evaluation Criteria	Possible points	Vendor A	Vendor B	Vendor C
Does the software meet all mandatory specifications?	10	7	9	6
Will program modifications, if any, be minimal to meet company needs?	10	8	9	7
Does the software contain adequate controls?	10	9	9	8
Is the performance (speed, accuracy, reliability, etc.) adequate?	10	7	9	6
Are other users satisfied with the software?	8	6	7	5
Is the software user-friendly?	10	7	8	6
Can the software be demonstrated and test-driven?	9	8	8	7
Does the software have an adequate warranty?	8	6	7	6

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Is the software flexible and easily maintained?	8	5	7	5
Is online inquiry of files and records possible?	10	8	9	7
Will the vendor keep the software up to date?	10	8	8	7
Totals	123	94	106	85

- **Public Evaluation Reports:** Several consultancy as well as independent agencies compare and contrast the hardware and software performance for various manufacturers and publish their reports in this regard. This method has been frequently and usefully employed by several buyers in the past. For those criteria, however, where published reports are not available, reports would have to be made to other methods of validation. This method is particularly useful where the buying staff has inadequate knowledge of facts.
- **Benchmarking Problems related Vendor's Solutions:** Benchmarking problems related to vendors' proposals are accomplished by sample programs that represent at least a part of the buyer's primary work load and include considerations and can be current applications that have been designed to represent planned processing needs. That is, benchmarking problems are oriented towards testing whether a solution offered by the vendor meets the requirements of the job on hand of the buyer.
- **Testing Problems:** Test problems disregard the actual job mix and are devised to test the true capabilities of the hardware, software or system. For example, test problems may be developed to evaluate the time required to translate the source code (program in an assembly or a high level language) into the object code (machine language), response time for two or more jobs in multi-programming environment, overhead requirements of the operating system in executing a user program, length of time required to execute an instruction, etc. The results, achieved by the machine can be compared and price performance judgment can be made. It must be borne in mind, however that various capabilities to be tested would have to be assigned relative weight-age.

5.5.5 System Development : Programming Techniques and Languages

This phase is supposed to convert the design specifications into a functional system under the planned operating system environments. Application programs are written, tested and documented, conduct system testing. Finally it results into a fully functional and documented system. A good coded application and programs should have the following characteristics:

- **Reliability:** It refers to the consistency with which a program operates over a period of time. However, poor setting of parameters and hard coding of some data, subsequently could result in the failure of a program after some time.
- **Robustness:** It refers to the applications' strength to uphold its operations in adverse situations by taking into account all possible inputs and outputs of a program in case of least likely situations.

- **Accuracy:** It refers not only to 'what program is supposed to do', but should also take care of 'what it should not do'. The second part becomes more challenging for quality control personnel and auditors.
- **Efficiency:** It refers to the performance per unit cost with respect to relevant parameters and it should not be unduly affected with the increase in input values.
- **Usability:** It refers to a user-friendly interface and easy-to-understand internal/external documentation.
- **Readability:** It refers to the ease of maintenance of program even in the absence of the program developer.

Other related aspects of this phase are given as follows:

- (a) **Program Coding Standards:** The logic of the program outlined in the flowcharts is converted into program statements or instructions at this stage. For each language, there are specific rules concerning format and syntax. Syntax means vocabulary, punctuation and grammatical rules available in the language manuals that the programmer has to follow strictly and pedantically. Different programmers may write a program using different sets of instructions but each giving the same results. Therefore, the coding standards are defined, which serves as a method of communication between teams, amongst the team members and users, thus working as a good control. Coding standards minimize the system development setbacks due to programmer turnover. Coding standards provide simplicity, interoperability, compatibility, efficient utilization of resources and least processing time.
- (b) **Programming Language:** Application programs are coded in the form of statements or instructions and the same is converted by the compiler to object code for the computer to understand and execute. The programming languages commonly used are given as follows :
- High level general purpose programming languages such as COBOL and C ;
 - Object oriented languages such as C++, JAVA etc.;
 - Scripting language such as JavaScript, VBScript; and
 - Decision Support or Logic Programming languages such as LISP and PROLOG.

The choice of a programming language may depend on various pertinent parameters. In general, language selection may be made on the basis of application area; algorithmic complexity; environment in which software has to be executed; performance consideration; data structure complexity; knowledge of software development staff; and capability of in-house staff for maintenance.

- (c) **Program Debugging:** Debugging is the most primitive form of testing activity, which refers to correcting programming language syntax and diagnostic errors so that the program compiles cleanly. A clean compile means that the program can be successfully converted from the source code written by the programmer into machine language instructions. Debugging can be a tedious task consisting of following four steps:

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- Giving input the source program to the compiler,
 - Letting the compiler to find errors in the program,
 - Correcting lines of code that are erroneous, and
 - Resubmitting the corrected source program as input to the compiler.
- (d) **Testing the Programs:** A careful and thorough testing of each program is imperative to the successful installation of any system. The programmer should plan the testing to be performed, including testing of all the possible exceptions. The test plan should require the execution of all standard processing logic based on chosen testing strategy/techniques. The program test plan should be discussed with the project manager and/or system users. A log of test results and all conditions successfully tested should be kept. The log will prove invaluable in finding the faults and debugging.
- (e) **Program Documentation:** The writing of narrative procedures and instructions for people, who will use software is done throughout the program life cycle. Managers and users should carefully review both internal and external documentation in order to ensure that the software and system behave as the documentation indicates. If they do not, documentation should be revised. User documentation should also be reviewed for understandability i.e. the documentation should be prepared in such a way that the user can clearly understand the instructions.
- (f) **Program Maintenance:** The requirements of business data processing applications are subject to periodic change. This calls for modification of various programs. There are usually separate categories of programmers called maintenance programmers, who are entrusted with this task.

5.5.6 System Testing

Testing is a process used to identify the correctness, completeness and quality of developed computer software. Testing should systematically uncover different classes of errors in a minimum amount of time with a minimum amount of efforts. The data collected through testing can also provide an indication of the software's reliability and quality. However, testing cannot show the absence of defect, it can only show that software defects are present. Different levels/facets of Testing are described as follows.

(i) **Unit Testing:** In computer programming, unit testing is a software verification and validation method in which a programmer tests if individual units of source code are fit for use. A unit is the smallest testable part of an application, which may be an individual program, function, procedure, etc. or may belong to a base/super class, abstract class or derived/child class. Unit tests are typically written and run by software developers to ensure that code meets its design and behaves as intended. The goal of unit testing is to isolate each component of the program and show that they are correct. A unit test provides a strict, written contract that the piece of code must satisfy.

There are five categories of tests that a programmer typically performs on a program unit. Such typical tests are described as follows:

- **Functional Tests:** Functional Tests check 'whether programs do, what they are supposed to do or not'. The test plan specifies operating conditions, input values, and expected results, and as per this plan, programmer checks by inputting the values to see whether the actual result and expected result match.
- **Performance Tests:** Performance Tests should be designed to verify the response time, the execution time, the throughput, primary and secondary memory utilization and the traffic rates on data channels and communication links.
- **Stress Tests:** Stress testing is a form of testing that is used to determine the stability of a given system or entity. It involves testing beyond normal operational capacity, often to a breaking point, in order to observe the results. These tests are designed to overload a program in various ways. The purpose of a stress test is to determine the limitations of the program. For example, during a sort operation, the available memory can be reduced to find out whether the program is able to handle the situation.
- **Structural Tests:** Structural Tests are concerned with examining the internal processing logic of a software system. For example, if a function is responsible for tax calculation, the verification of the logic is a structural test.
- **Parallel Tests:** In Parallel Tests, the same test data is used in the new and old system and the output results are then compared.

In terms of techniques, Unit Testing is classified as Static Analysis Testing and Dynamic Testing. Such typical testing techniques are elaborated as follows:

- (a) **Static Testing:** Static Analysis Tests are conducted on source programs and do not normally require executions in operating conditions. Typical static analysis techniques include the following:
- **Desk Check:** This is done by the programmer him/herself. S/he checks for logical syntax errors, and deviation from coding standards.
 - **Structured Walk Through:** The application developer leads other programmers to scan through the text of the program and explanation to uncover errors.
 - **Code Inspection:** The program is reviewed by a formal committee. Review is done with formal checklists.
- (b) **Dynamic Analysis Testing:** Such testing is normally conducted through execution of programs in operating conditions. Typical techniques for dynamic testing and analysis include the following:
- **Black Box Testing:** Black Box Testing takes an external perspective of the test object, to derive test cases. These tests can be functional or non-functional, though usually functional. The test designer selects typical inputs including simple, extreme, valid and invalid input-cases and executes to uncover errors. There is no knowledge of the test object's internal structure.

This method of test design is applicable to all levels of software testing i.e. unit, integration, functional testing, system and acceptance. The higher the level, hence

the bigger and more complex the box, the more one is forced to use black box testing to simplify. While this method can uncover unimplemented parts of the specification, one cannot be sure that all existent paths are tested. If a module performs a function, which is not supposed to, the black box test does not identify it.

- **White Box Testing:** It uses an internal perspective of the system to design test cases based on internal structure. It requires programming skills to identify all paths through the software. The tester chooses test case inputs to exercise paths through the code and determines the appropriate outputs. Since the tests are based on the actual implementation, if the implementation changes, the tests probably will need to change, too. It is applicable at the unit, integration and system levels of the testing process, it is typically applied to the unit. While it normally tests paths within a unit, it can also test paths between units during integration, and between subsystems during a system level test. After obtaining a clear picture of the internal workings of a product, tests can be conducted to ensure that the internal operation of the product conforms to specifications and all the internal components are adequately exercised.
- **Gray Box Testing:** It is a software testing technique that uses a combination of black box testing and white box testing. In gray box testing, the tester applies a limited number of test cases to the internal workings of the software under test. In the remaining part of the gray box testing, one takes a black box approach in applying inputs to the software under test and observing the outputs.

(ii) Integration Testing: Integration testing is an activity of software testing in which individual software modules are combined and tested as a group. It occurs after unit testing and before system testing with an objective to evaluate the validity of connection of two or more components that pass information from one area to another. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for system testing. This is carried out in the following two manners:

- **Bottom-up Integration:** It is the traditional strategy used to integrate the components of a software system into a functioning whole. It consists of unit testing, followed by sub-system testing, and then testing of the entire system. Bottom-up testing is easy to implement as at the time of module testing, tested subordinate modules are available. The disadvantage, however is that testing of major decision / control points is deferred to a later period.
- **Top-down Integration:** It starts with the main routine, and stubs are substituted, for the modules directly subordinate to the main module. An incomplete portion of a program code that is put under a function in order to allow the function and the program to be compiled and tested, is referred to as a stub. A stub does not go into the details of implementing details of the function or the program being executed.

Once the main module testing is complete, stubs are substituted with real modules one by one, and these modules are tested with stubs. This process continues till the atomic

modules are reached. Since decision-making processes are likely to occur in the higher levels of program hierarchy, the top-down strategy emphasizes on major control decision points encountered in the earlier stages of a process and detects any error in these processes. The difficulty arises in the top-down method, because the high-level modules are tested, not with real outputs from subordinate modules, but from stubs.

(iii) Regression Testing: Each time a new module is added or any modification made in the software, it changes. New data flow paths are established, new I/O may occur and new control logic is invoked. These changes may cause problems with functions that previously worked flawlessly. In the context of the integration testing, the regression tests ensure that changes or corrections have not introduced new faults. The data used for the regression tests should be the same as the data used in the original test.

(iv) System Testing: It is a process in which software and other system elements are tested as a whole. System testing begins either when the software as a whole is operational or when the well-defined subsets of the software's functionality have been implemented. The purpose of system testing is to ensure that the new or modified system functions properly. These test procedures are often performed in a non-production test environment. The types of testing that might be carried out are as follows:

- **Recovery Testing:** This is the activity of testing 'how well the application is able to recover from crashes, hardware failures and other similar problems'. Recovery testing is the forced failure of the software in a variety of ways to verify that recovery is liable to be properly performed, in actual failures.
- **Security Testing:** This is the process to determine that an Information System protects data and maintains functionality as intended or not. The six basic security concepts that need to be covered by security testing are – confidentiality, integrity, availability authentication, authorization, and non-repudiation. This testing technique also ensures the existence and proper execution of access controls in the new system.
- **Stress or Volume Testing:** Stress testing is a form of testing that is used to determine the stability of a given system or entity. It involves testing beyond normal operational capacity, often to a breaking point, in order to observe the results. Stress testing may be performed by testing the application with large quantity of data during peak hours to test its performance.
- **Performance Testing:** In the computer industry, software performance testing is used to determine the speed or effectiveness of a computer, network, software program or device. This testing technique compares the new system's performance with that of similar systems using well defined benchmarks.

(v) Final Acceptance Testing: It is conducted when the system is just ready for implementation. During this testing, it is ensured that the new system satisfies the quality standards adopted by the business and the system satisfies the users. Thus, the final acceptance testing has two major parts:

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- **Quality Assurance Testing:** It ensures that the new system satisfies the prescribed quality standards and the development process is as per the organization's quality assurance policy, methodology and prescriptions.
- **User Acceptance Testing:** It ensures that the functional aspects expected by the users have been well addressed in the new system. There are two types of the user acceptance testing described as follows:
 - **Alpha Testing:** This is the first stage, often performed by the users within the organization by the developers, to improve and ensure the quality/functionalities as per users satisfaction.
 - **Beta Testing:** This is the second stage, generally performed after the deployment of the system. It is performed by the external users, during the real life execution of the project. It normally involves sending the product outside the development environment for real world exposure and receives feedback for analysis and modifications, if any.

Internal Testing Controls: There are several controls that can be exercised internally to assure the testing phase quality and efficiency. Though it varies from one organization to another, some of the generic key control aspects appear to be addressed by the responses to following queries:

- Whether the test-suite prepared by the testers includes the actual business scenarios?
- Whether test data used covers all possible aspects of system?
- Whether CASE tools like 'Test Data Generators' have been used?
- Whether test results have been documented?
- Whether tests have been performed in their correct order?
- Whether modifications needed based on test results have been done?
- Whether modifications made have been properly authorized and documented?

5.5.7 System Implementation

In order to finally deploy or implement the new system in the real operating environment, several activities are undertaken. In terms of the output of the phase, a fully functional as well as documented system is a prerequisite. Moreover, many other issues including defect removal, maintenances, reengineering etc. may also be in place to assure the desirable quality control of the system in its true operational environment. Some of the generic key activities involved in System Implementation include the following:

- Conversion of data to the new system files;
- Training of end users;
- Completion of user documentation;
- System changeover; and
- Evaluation of the system a regular intervals.

The process of ensuring that the information system is operational and then allowing users to take over its operation for use and evaluation is called Systems Implementation. Implementation includes all those activities that take place to convert from the old system to the new. The new system may be totally new, replacing an existing manual or automatic system or it may be a major modification in an existing system. Some of the generic activities involved in system implementation stage are described briefly as follows:

(i) Equipment Installation: The hardware required to support the new system is selected prior to the implementation phase. The necessary hardware should be ordered in time to allow for installation and testing of equipment during the implementation phase. An installation checklist should be developed at this time with operating advice from the vendor and system development team. In those installations, where people are experienced in the installation of the same or similar equipment, adequate time should be scheduled to allow completion of the following activities:

- **Site Preparation:** An appropriate location/ambiance as prescribed and the typical equipment must be available to provide an operating environment for the equipment that will meet the vendor's temperature, humidity and dust control specifications etc.
 - **Installation of New Hardware / Software:** The equipment must be physically installed by the manufacturer, connected to the power source and wired to communication lines, if required. If the new system interfaces with the other systems or is distributed across multiple software platforms, some final commissioning tests of the operating environment may be desirable to prove end to end connectivity.
 - **Equipment Checkout:** The equipment must be turned on for testing under normal operating conditions. Though the routine 'diagnostic tests' should be run by the vendor, the implementation in-house team should devise and run extensive tests of its own to ensure that equipment functionalities in actual working conditions.
- (ii) Training Personnel:** A system can succeed or fail depending on the way it is operated and used. Therefore, the quality of training received by the personnel involved with the system in various capacities helps or hinders the successful implementation of information system. Thus, training is a major component of systems implementation. When a new system is acquired, which often involves new hardware and software, both users and computer professionals generally need some type of training. Often, this is imparted through classes, which are organized by vendor, and through hands-on learning techniques. Such training structure should be highly formalized and be based business process executions with actual data.
- (iii) System Change-Over Strategies:** Conversion or changeover is the process of changing over or shifting over from the old system (may be the manual system) to the new system. It requires careful planning to establish the basic approach to be used in the actual changeover, as it may put many resources/assets/operations at risk. The Four types of popular implementation strategies are described as follows:
- **Direct Implementation / Abrupt Change-Over:** This is achieved through an abrupt takeover – an all or no approach. With this strategy, the changeover is done in one

operation, completely replacing the old system in one go. Fig 5.5.8 (i) depicts Direct Implementation, which usually takes place on a set date, often after a break in production or a holiday period so that time can be used to get the hardware and software for the new system installed without causing too much disruption.

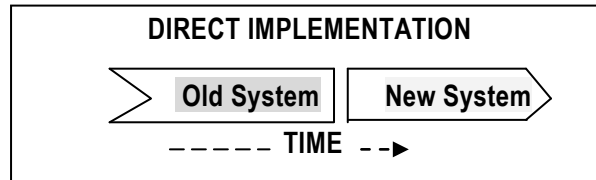


Fig. 5.5.8 (i): Direct Changeover

- **Phased Changeover:** With this strategy, implementation can be staged with conversion to the new system taking place gradually. For example, some new files may be converted and used by employees whilst other files continue to be used on the old system i.e. the new is brought in stages (phases). If a phase is successful then the next phase is started, eventually leading to the final phase when the new system fully replaces the old one as shown in Fig. 5.5.8(ii).

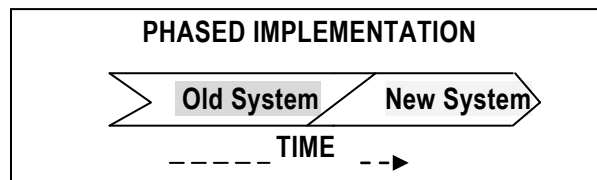


Fig. 5.5.8 (ii): Phased Changeover

- **Pilot Changeover:** With this strategy, the new system replaces the old one in one operation but only on a small scale. Any errors can be rectified or further beneficial changes can be introduced and replicated throughout the whole system in good time with the least disruption. For example - it might be tried out in one branch of the company or in one location. If successful then the pilot is extended until it eventually replaces the old system completely. Fig. 5.5.8 (iii) depicts Pilot Implementation.

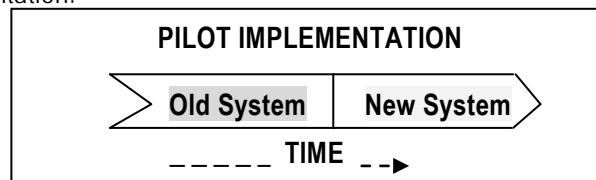


Fig. 5.5.8 (iii): Pilot Changeover

- **Parallel Changeover:** This is considered the most secure method with both systems running in parallel over an introductory period. The old system remains fully operational while the new systems come online. With this strategy, the old and the new system are both used alongside each other, both being able to operate independently. If all goes well, the old system is stopped and new system carries on as the only system. Fig. 5.5.8 (iv) shows parallel implementation.

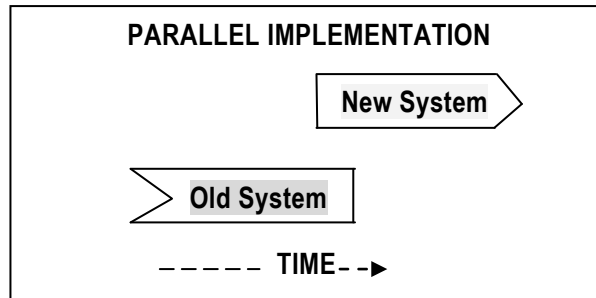


Fig. 5.5.8 (iv): Parallel Changeover

- (iv) Such requisite changeover or Conversion includes all those activities, which must be completed to successfully convert from the previous system to the new information system. Fundamentally these technical activities can be classified as follows:
- **Procedure Conversion:** Operating procedures should be carefully completed with sufficient-enough documentation for the new system. It applies to both computer-operations and functional area operations. Before any parallel or conversion activities can start, operating procedures must be clearly spelled out for personnel in the functional areas undergoing changes. Information on input, data files, methods, procedures, output, and internal control must be presented in clear, concise and understandable terms for the average reader. Written operating procedures must be supplemented by oral communication during the training sessions on the system change.
 - **File Conversion:** Because large files of information must be converted from one medium to another, this phase should be started long before programming and testing are completed. The cost and related problems of file conversion are significant whether they involve on-line files (common database) or off-line files. In order for the conversion to be as accurate as possible, file conversion programs must be thoroughly tested. Adequate control, such as record counts and control totals, should be required output of the conversion program. The existing computer files should be kept for a period of time until sufficient files are accumulated for back up. This is necessary in case, the files must be reconstructed from scratch after a "bug" is discovered later in the conversion routine.
 - **System conversion:** After on-line and off-line files have been converted and the reliability of the new system has been confirmed for a functional area, daily processing can be shifted from the existing information system to the new one. All transactions initiated after this time are processed on the new system. System development team members should be present to assist and to answer any questions that might develop. Consideration should be given to operating the old system for some more time to permit checking, matching and balancing the total results of both systems.
 - **Scheduling Personnel and Equipment:** Scheduling data processing operations of a new information system for the first time is a difficult task for the system manager.

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As users become more familiar with the new system, the job becomes more routine. Schedules should be set up by the system manager in conjunction with departmental managers of operational units serviced by the equipment. The master schedule for next period/month should provide sufficient computer time to handle all required processing.

5.5.8 Post Implementation Review and Systems Maintenance

In order to assess, review and assure the complete working solution, a number of activities may be planned. As no phase may be assured to be perfect, errors are liable to occur. Therefore, a well-formalized review must be undertaken including some of the systems maintenance activities, such as adding new data elements, modifying reports, adding new reports; and changing calculations. As the deliverable of this phase, a well written document stating observations, modifications, controls, scope of further improvements etc. may be prepared. Such aspects may also be availed in the form of responses to following queries:

- Could further training or coaching improve the degree of benefit being generated?
- Are there further functional improvements or changes that would deliver greater benefit?
- Are specific improvements required in procedures, documentation, support, etc.?
- What learning points are there for future projects?

(i) Post Implementation Review: A Post Implementation Review answers the question "Did we achieve what we set out to do in business terms?" Some of the purposes served a Post Implementation Review ascertains the degree of success from the project, in particular, the extent to which it met its objectives, delivered planned levels of benefit, and addressed the specific requirements as originally defined.

It examines the efficacy of all elements of the working business solution to see if further improvements can be made to optimize the benefit delivered. A Post-Implementation Review should be scheduled some time after the solution has been deployed. Typical periods range from 6 weeks to 6 months, depending on the type of solution and its environment. There are two basic dimensions of Information system that should be evaluated. The first dimension is concerned with whether the newly developed system is operating properly. The other dimension is concerned with whether the user is satisfied with the information system with regard to the reports supplied by it. Typical evaluations include the following:

- **Development Evaluation:** Evaluation of the development process is primarily concerned with whether the system was developed on schedule and within budget. It requires schedules and budgets to be established in advance and that record of actual performance and cost be maintained. However, it may be noted that very few information systems have been developed on schedule and within budget. In fact, many information systems are developed without clearly defined schedules or budgets. Due to the uncertainty and mystique associated with system development, they are not subjected to traditional management control procedures.
- **Operational Evaluation:** The evaluation of the information system's operation pertains to whether the hardware, software and personnel are capable to perform their duties. It

tries to answer the questions related to functional aspects of the system. Such an evaluation is relatively straightforward if evaluation criteria are established in advance. For example, if the systems analyst lays down the criterion that a system, which is capable of supporting one hundred terminals should give response time of less than two seconds, evaluation of this aspect of system operation can be done easily after the system becomes operational.

- **Information Evaluation:** An information system should also be evaluated in terms of information it provides or generates. This aspect of system evaluation is difficult and it cannot be conducted in a quantitative manner, as is the case with development and operational evaluations. The objective of an information system is to provide information to a considerable extent to support the organizational decision system. Therefore, the extent to which information provided by the system is supportive to decision making is the area of concern in evaluating the system.

(ii) System Maintenance: Maintaining the system is an important aspect of SDLC. As key personnel change positions in the organization, new changes will be implemented, which will require system updates at regular intervals. Most of the information systems require at least some modification after development. The need for modification arises from a failure to anticipate/capture all the requirements during system analysis/design and/or from changing organizational requirements. Maintenance can be categorized in the following ways:

- **Scheduled Maintenance:** Scheduled maintenance is anticipated and can be planned for operational continuity and avoidance of anticipated risks. For example, the implementation of a new inventory coding scheme can be planned in advance, security checks may be promulgated etc.
- **Rescue Maintenance:** Rescue maintenance refers to previously undetected malfunctions that were not anticipated but require immediate troubleshooting solution. A system that is properly developed and tested should have few occasions of rescue maintenance.
- **Corrective Maintenance:** Corrective maintenance deals with fixing bugs in the code or defects found during the executions. A defect can result from design errors, logic errors coding errors, data processing and system performance errors. The need for corrective maintenance is usually initiated by bug reports drawn up by the end users. Examples of corrective maintenance include correcting a failure to test for all possible conditions or a failure to process the last record in a file.
- **Adaptive Maintenance:** Adaptive maintenance consists of adapting software to changes in the environment, such as the hardware or the operating system. The term environment in this context refers to the totality of all conditions and influences, which act from outside upon the system, for example, business rule, government policies, work patterns, software and hardware operating platforms. The need for adaptive maintenance can only be recognized by monitoring the environment.
- **Perfective Maintenance:** Perfective maintenance mainly deals with accommodating to the new or changed user requirements and concerns functional enhancements to the

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system and activities to increase the system's performance or to enhance its user interface.

- **Preventive Maintenance:** Preventive maintenance concerns with the activities aimed at increasing the system's maintainability, such as updating documentation, adding comments, and improving the modular structure of the system. The long-term effect of corrective, adaptive and perfective changes increases the system's complexity. As a large program is continuously changed, its complexity, which reflects deteriorating structure, increases unless work is done to maintain or reduce it. This work is known as preventive change.

5.6 Operation Manuals

It is typical user's guide, also commonly known as Operations Manual. Moreover, it may be a technical communication document intended to give assistance to people using a particular system. It is usually written by technical writers, although user guides are written by programmers, product or project managers, or other technical staff, particularly in smaller companies. These are most commonly associated with electronic goods, computer hardware and software. The section of an operation manual will include the following:

- A cover page, a title page and copyright page;
- A preface, containing details of related documents and information on how to navigate the user guide;
- A contents page;
- A guide on how to use at least the main functions of the system;
- A troubleshooting section detailing possible errors or problems that may occur, along with how to fix them;
- A FAQ (Frequently Asked Questions);
- Where to find further help, and contact details;
- A glossary and, for larger documents, an index.

Sample format of generic operations manual could be as shown in Table 5.6.1:

Table 5.6.1: Sample Format of Operations Manual

1.0 General Information	3.0 Run Description
1.1 System Overview	3.1 Run Inventory
1.2 Project References	3.2 Run Description
1.3 Authorized Use Permission	*3.2.x [Run Identifier]
1.4 Points of Contact	3.2.x.1 Run Interrupt Checkpoints
1.4.1 Information	3.2.x.2 Set-Up and Diagnostic Procedures
1.4.2 Coordination	3.2.x.3 Error Messages
1.4.3 Help Desk	3.2.x.4 Restart / Recovery Procedures
1.5 Organization of the Manual	* Each run should be under a separate header. Generate new sections and
1.6 Acronyms and Abbreviations	
2.0 System Operations Overview	

<p>2.1 System Operations</p> <p>2.2 Software Inventory</p> <p>2.3 Information Inventory</p> <p> 2.3.1 Resource Inventory</p> <p> 2.3.2 Report Inventory</p> <p>2.4 Operational Inventory</p> <p>2.5 Processing Overview</p> <p> 2.5.1 System Restrictions</p> <p> 2.5.2 Waivers of Operational Standards</p> <p> 2.5.3 Interfaces with Other Systems</p> <p>2.6 Communications Overview</p> <p>2.7 Security</p>	<p>subsections as necessary for each run from 3.2.1 through 3.2.x.</p>
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5.7 Auditors’ Role in SDLC

The audit of systems under development can have three main objectives. It is primarily aimed to provide an opinion on the efficiency, effectiveness, and economy of project management. An auditor’s role is to assess the extent to which the system being developed provides for adequate audit trails and controls to ensure the integrity of data processed and stored; and the effectiveness of controls being enacted for the management of the system’s operation.

In order to achieve these goals, an auditor has to attend project and steering committee meetings and examine project control documentation and conducting interviews. This is to ensure ‘what project control standards are to be complied with, (such as a formal systems development process) and determining the extent to which compliance is being achieved. For addressing the second objective, the auditor can examine system documentation such as functional specifications to arrive at an opinion on controls. The auditor’s opinion will be based on the degree to which the system satisfies the general control objectives that any information system should meet. A list of such objectives should be provided to the auditor. The auditor should provide a list of the standard controls, over such operational concerns as response time, CPU usage, and random access space availability that the auditor has used as assessment criteria.

An Auditor may adapt a rating system such as on a scale of 1 to 10 in order to give rating to the various phases of SDLC. While rating a Feasibility Study, an auditor can review Feasibility Study Report and different work products of this study phase. An interview with personnel, who have conducted this feasibility study, can be conducted. Depending on the content and quality of the Feasibility Study report and interviews, an auditor can arrive at a rating between 1 to 10 (10 being best). After deriving such a rating for all the phases, the auditor can form his/her overall opinion about the SDLC phases.

Moreover, in order to audit technical work products (such as database design or physical design), auditor may opt to include a technical experts to seek his/her opinion on the technical aspects of SDLC. However, auditor will have to give control objectives, directives and in general, validate the opinion expressed by technical experts. Some of the control considerations for an auditor include the following:

- Documented policy and procedures;

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- Established Project team with all infrastructure and facilities ;
- Developers/ IT managers are trained on the procedures ;
- Appropriate approvals are being taken at identified mile-stones;
- Development is carried over as per standards, functional specifications;
- Separate test environment for development/ test/ production / test plans;
- Design norms and naming conventions are as per standards and are adhered to;
- Business owners testing and approval before system going live;
- Version control on programs;
- Source Code is properly secured;
- Adequate audit trails are provided in system; and
- Appropriateness of methodologies selected.

Further, Post-Implementation Review is performed to determine whether the system adequately meets earlier identified business requirements and needs (in feasibility studies or Requirements Specifications). Auditors should be able to determine if the expected benefits of the new system are realized and whether users are satisfied with the new system. In post implementation review, auditors need to review which of the SDLC phases have not met desired objectives and whether any corrective actions were taken. If there are differences between expectations and actual results, auditors need to determine the reasons for the same. Such discrepancies may be due to incomplete user requirements or any other shortcoming. Such reasons can help auditors to evaluate the current situation and offer guidelines for future projects.

In order to formalize the auditors' role and practices, a master checklist may be prepared. Such checklists may prove handy and highly beneficial to ensure an appropriate acquisition and / or development of information systems including software, and to maintain the information systems in an appropriate manner. The following sample checklist may be used by the IS Auditors for this purpose:

S. No.	Checkpoints	Status
1.	Whether information system acquisition and / or development policy and procedure documented?	
2.	Whether system acquisition and / or development policy and procedure approved by the management?	
3.	Whether the policy and procedure cover the following: <ul style="list-style-type: none">• Problems faced in the existing system and need for replacement• Functionality of new IS• Security needs• Regulatory compliance• Acceptance Criteria	

	<ul style="list-style-type: none"> • Proposed roles and responsibilities • Transition/ Migration to new IS • Interfaces with legacy systems • Post implementation review • Maintenance arrangements. 	
4.	Whether policy and procedure documents are communicated / available to the respective users?	
5.	Whether policy and procedure documents are reviewed and updated at regular intervals?	
6.	Whether the organization has evaluated requirement and functionalities of proposed IS? <i>(Verify the requirements analysis conducted at three levels viz. process level, application level and organization level. Verify the site visit reports and other customer references obtained with respect to functionalities of proposed IS).</i>	
7.	Whether the organization carried out feasibility study in respect of the following <ul style="list-style-type: none"> • Financial feasibility • Operational feasibility • Technical feasibility 	
8.	Whether the selection of vendor and acquisition terms considers the following: <ul style="list-style-type: none"> • Evaluation of alternative vendors • Specification on service levels and deliverables • Penalty for delays • Escrow mechanism for Source codes • Customization • Upgrades • Regulatory Compliance • Support and maintenance. 	
9.	Whether the organization has identified and assigned roles in development activities to appropriate stakeholders? <i>(Verify the assigned roles should be on “need to know” and “need to basis”. and duties of developers and operators are segregated).</i>	
10.	Whether the organization has a separate development, test and production environments?	
11.	Whether the IS developed plan is prepared and approved by the management?	

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	<p>(Verify that IS development plan to include:</p> <ul style="list-style-type: none"> • Input data elements, • Validations controls viz. Field/ Transactions/ File with appropriate error reporting • Process workflow • data classifications with security are in place, viz. Read only for users, Read/ Write for authorized persons • Output). 	
12.	<p>Whether the testing of IS includes:</p> <ul style="list-style-type: none"> • Confirms the compliance to functional requirements • Confirms the compatibility with IS infrastructure • Identifies bugs and errors and addresses them by analyzing root causes <p>Escalating functionality issues at appropriate levels.</p>	
13.	<p>Whether the adequate documentation for:</p> <ul style="list-style-type: none"> • Preserving test results for future reference • Preparation of manuals like systems manual, installation manual, user manual • Obtaining user sign off / acceptance 	
14.	<p>Whether the implementation covers the following?</p> <ul style="list-style-type: none"> • User Departments' involvement and their role • User Training • Acceptance Testing • Role of Vendor and period of Support • Required IS Infrastructure plan • Risk involved and actions required to mitigate the risks • Migration plan 	
15.	<p>If the development activities are outsourced, are the outsourcing activities evaluated based on the following practices:</p> <ul style="list-style-type: none"> • What is the objective behind Outsourcing? • What are the in-house capabilities in performing the job? • What is the economic viability? • What are the in-house infrastructure deficiencies and the time factor involved? • What are the Risks and security concerns? • What are the outsourcing arrangement and fall back method? • What are arrangements for obtaining the source code for the software? 	

	<ul style="list-style-type: none">• Reviewing the capability and quality of software development activities by visit to vendor's premises?• Review of progress of IS development at periodic intervals.	
16.	Whether the organization carried out a post implementation review of new IS?	
17.	Whether a process exists for measuring vendors' performance against the agreed service levels?	
18.	Whether the post implementation review results are documented?	

5.8 Summary

The objective of the chapter is to describe the key issues for the system development process. The core issues dealt in the chapter include the RFP process and its evaluation. Chapter also helps to understand the concepts of ROI in terms of investments made in systems. Afterwards, the chapter discusses various methods of developments. It establishes a link between the need of business and the methods adopted to develop the system. It elaborates various advantages and disadvantages of system development.

The chapter explains the key considerations for selecting the method of development. Other methods for the development e.g. Waterfall, Prototyping, Incremental, Spiral, Rapid Application Development (RAD) and Agile Methodologies have also been discussed. Once a method of development has been selected, the chapter elaborates the steps within each method development. It lists various teams and functions at each stage of system development. Detailed discussion on the System Development Life Cycle (SDLC) is also provided in the chapter. Accordingly, various stages for development of system development life cycle have been discussed. In addition, CASE tools used during development of the system including flowchart, data flow diagram have also been discussed.