UNIT- I

Software and Software Engineering: The Nature of Software, The Unique Nature of WebApps, Software Engineering, The Software Process, Software Engineering Practice, Software Myths
Process Models: A Generic Process Model, Process Assessment and Improvement, Prescriptive Process Models, Specialized Process Models, The Unified Process, Personal and Team Process Models, Process Technology, Product and Process.
Agile Development: Agility, Agility and the Cost of Change, Agile Process, Extreme Programming, Other Agile Process Models

Software and Software Engineering

- Software engineering stands for the term is made of **two** words, S**oftware** and E**ngineering.**
- **Software** is more than just a program code. A program is an executable code, which serves some computational purpose. Software is considered to be collection of executable programming code, associated libraries and documentations. Software, when made for a specific requirement is called **software product.**
- **Engineering** on the other hand, is all about developing products, using well-defined, scientific principles and methods.
- **Software engineering** is an engineering branch associated with development of software product using welldefined scientific principles, methods and procedures. The outcome of software engineering is an efficient and reliable software product.

Definitions

IEEE defines software engineering as:
(1) The application of a systematic, disciplined, quantifiable approach to the development, operation and maintenance of software; that is, the application of engineering to software.
(2) The study of approaches as in the above statement.
Fritz Bauer, a German computer scientist, defines software engineering as:
Software engineering is the establishment and use of sound engineering principles in order to obtain economically software that is reliable and work efficiently on real machines.

1.1 THE NATURE OF SOFTWARE

Software takes Dual role of Software. It is a **Product** and at the same time a **Vehicle for delivering a product**. Software delivers the most important product of our time is called **information**

1.1.1 Defining Software

Software is defined as

1. **Instructions** : Programs that when executed provide desired function, features, and performance
2. **Data structures** : Enable the programs to adequately manipulate information
3. **Documents**: Descriptive information in both hard copy and virtual forms that describes the operation and use of the programs.

Characteristics of software

Software has characteristics that are considerably different than those of hardware:

1) Software is developed or engineered, it is not manufactured in the Classical Sense.

Although some similarities exist between software development and hardware manufacture, the two activities are fundamentally different. In both the activities, high quality is achieved through good design, but the manufacturing phase for hardware can introduce quality problems that are nonexistent

or easily corrected for software. Both the activities are dependent on people, but the relationship between people is totally varying. These two activities require the construction of a "**product**" but the approaches are different. Software costs are concentrated in engineering which means that software projects cannot be managed as if they were manufacturing.

2) Software doesn't "Wear Out"

The following figure shows the relationship between failure rate and time. Consider the failure rate as a function of time for hardware. The relationship is called **the bathtub curve**, indicates that hardware exhibits relatively high failure rates early in its life, defects are corrected and the failure rate drops to a steady-state level for some period of time. As time passes, however, the failure rate rises again as hardware components suffer from the cumulative effects of dust, vibration, abuse, temperature extremes, and many other environmental maladies. So, stated simply, the hardware begins to wear out. Software is not susceptible to the environmental maladies that cause **hardware to wear out**

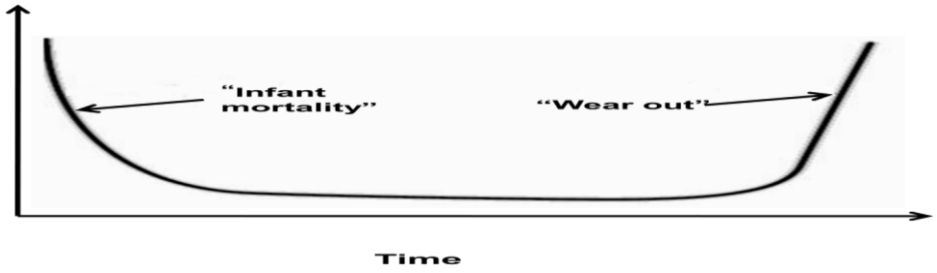

Fig: FAILURE CURVE FOR HARDWARE

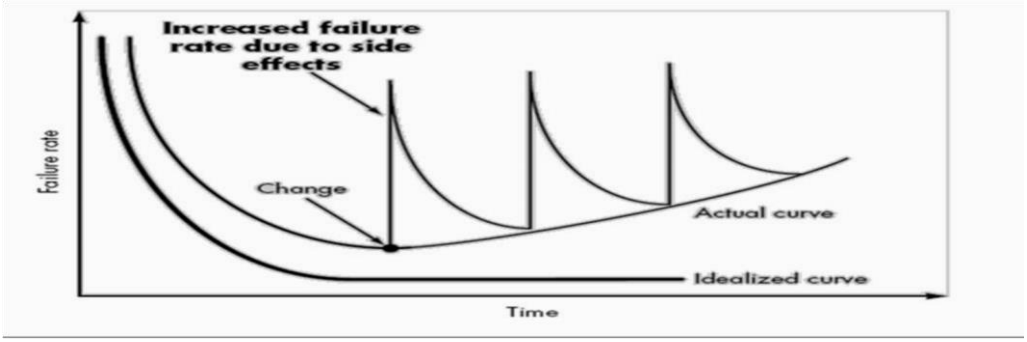

Fig: FAILURE CURVE FOR SOFTWARE

3) Although the industry is moving toward component-based construction, most software continues to be custom built

A software component should be designed and implemented so that it can be reused in many different programs. Modern reusable components encapsulate both data and the processing that is applied to the data, enabling the software engineer to create new applications from reusable parts

1.1.2 Software Application Domains

Seven Broad Categories of software are challenges for software engineers:

(a) System software: A collection of programs written to service other programs. Some system software (e.g., compilers, editors, and file management utilities)

(b)Application software: **S**tand-alone programs that solve a specific business need. Application software is used to control business functions in real time (e.g., point-of-sale transaction processing, real-time manufacturing process control).

(c)Engineering/scientific software: It has been characterized by "number crunching" algorithms. Applications range from astronomy to volcanology, from automotive stress analysis to space shuttle orbital dynamics, and from molecular biology to automated manufacturing.

(d) Embedded software: It resides within a product or system and is used to implement and control features and functions for the end user and for the system itself. Embedded software can perform limited and esoteric functions (e.g., key pad control for a microwave oven) or provide significant function and control capability (e.g., digital functions in an automobile such as fuel control, dashboard displays, and braking systems).

(e) Product-line software: Designed to provide a specific capability for use by many different customers. Productline software can focus on a limited and esoteric marketplace (e.g., inventory control products) or address mass consumer markets (e.g., word processing, spreadsheets, computer graphics, multimedia, entertainment, database management, and personal and business financial applications).

(f) Web applications: These Applications called "WebApps," this network-centric software category spans a wide array of applications. In their simplest form, WebApps can be little more than a set of linked hypertext files that present information using text and limited graphics.

(g) Artificial intelligence software: These makes use of non numerical algorithms to solve complex problems that are not amenable to computation or straightforward analysis. Applications within this area include robotics, expert systems, pattern recognition (image and voice), artificial neural networks, theorem proving, and game playing.

New Software Challenges

- **Open-world computing** : Creating software to allow machines of all sizes to communicate with each other across vast networks (Distributed computing—wireless networks)
- **Net sourcing** : Architecting simple and sophisticated applications that benefit targeted end-user markets worldwide (the Web as a computing engine)
- **Open Source** : Distributing source code for computing applications so customers can make local
  modifications easily and reliably ("free" source code open to the computing community)

1.1.3 Legacy Software

- Legacy software is older programs that are developed decades ago.
- The quality of legacy software is poor because it has inextensible design, convoluted code, poor and nonexistent documentation, test cases and results that are not achieved.

As time passes legacy systems evolve due to following reasons:

- The software must be adapted to meet the needs of new computing environment or technology.
- The software must be enhanced to implement new business requirements.
- The software must be extended to make it interoperable with more modern systems or database
- The software must be re-architected to make it viable within a network environment.

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1.2 UNIQUE NATURE OF WEB APPS

In the early days of the World Wide Web, websites consisted of little more than a set of linked hypertext files that presented information using text and limited graphics. As time passed, the augmentation of HTML by development tools (e.g., XML, Java) enabled Web engineers to provide computing capability along with informational content. *Web-based systems and applications* (*WebApps*) were born. Today, WebApps have evolved into sophisticated computing tools that not only provide stand-alone function to the end user, but also have been integrated with corporate databases and business applications.

WebApps are one of a number of distinct software categories. Web-based systems and applications "involve a mixture between print publishing and software development, between marketing and computing, between internal communications and external relations, and between art and technology." The following attributes are encountered in the vast majority of WebApps.

- **Network intensiveness.** A WebApp resides on a network and must serve the needs of a diverse community of clients. The network may enable worldwide access and communication (i.e., the Internet) or more limited access and communication (e.g., a corporate Intranet).
- **Concurrency.** A large number of users may access the WebApp at one time. In many cases, the patterns of usage among end users will vary greatly.
- **Unpredictable load.** The number of users of the WebApp may vary by orders of magnitude from day to day.
  One hundred users may show up on Monday; 10,000 may use the system on Thursday.
- **Performance.** If a WebApp user must wait too long, he or she may decide to go elsewhere.
- **Availability.** Although expectation of 100 percent availability is un reasonable, users of popular WebApps often demand access on a 24/7/365 basis
- **Data driven.** The primary function of many WebApps is to use hypermedia to present text, graphics, audio, and video content to the end user. In addition, WebApps are commonly used to access information that exists on databases that are not an integral part of the Web-based environment (e.g., e-commerce or financial applications).
- **Content sensitive.** The quality and aesthetic nature of content remains an important determinant of the quality of a WebApp.
- **Continuous evolution.** Unlike conventional application software that evolves over a series of planned, chronologically spaced releases, Web applications evolve continuously.
- **Immediacy.** Although *immediacy*—the compelling need to get software to market quickly—is a characteristic of many application domains, WebApps often exhibit a time-to-market that can be a matter of a few days or weeks.
- **Security.** Because WebApps are available via network access, it is difficult, if not impossible, to limit the population of end users who may access the application. In order to protect sensitive content and provide secure modes
- **Aesthetics**. An undeniable part of the appeal of a WebApp is its look and feel. When an application has been designed to market or sell products or ideas, aesthetics may have as much to do with success as technical design.

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1.3 SOFTWARE ENGINEERING - A LAYERED TECHNOLOGY

In order to build software that is ready to meet the challenges of the twenty-first century, you must recognize a few simple realities

- **Problem should be understood before software solution is developed**
- **Design is a pivotal Software Engineering activity**
- **Software should exhibit high quality**
- **Software should be maintainable**

These simple realities lead to one conclusion. Software in all of its forms and across all of its application domains should be **engineered**.

Software Engineering by Fritz Bauer defined as:
Software engineering is the establishment and use of sound engineering principles in order to obtain economically software that is reliable and works efficiently on real machines.

IEEE has developed a more comprehensive definition as:

1) Software engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software. 2) The study approaches as in (1)

Software Engineering is a **layered technology**. Software Engineering encompasses a **Process, Methods** for managing and engineering software and **tools**.

The following Figure represents **Software engineering Layers**

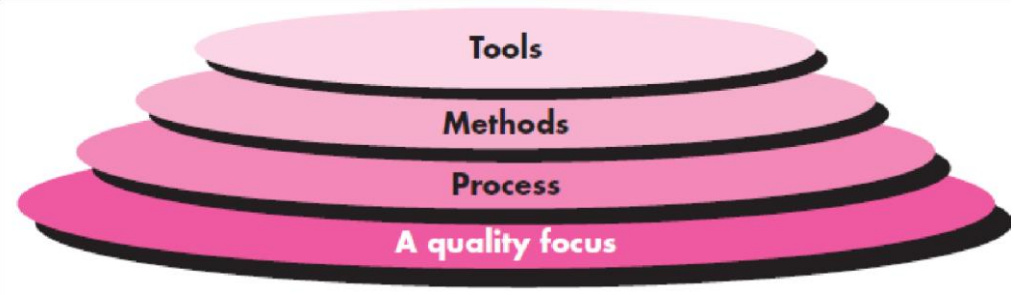

Fig: Software Engineering-A layered technology

Software engineering is a layered technology. Referring to above Figure, any engineering approach must rest on an organizational commitment to **quality**.

The bedrock that supports software engineering is a **quality focus**.

The foundation for software engineering is the ***process* layer**. The software engineering process is the glue that holds the technology layers together and enables rational and timely development of computer software. **Process** defines a **framework** that must be established for effective delivery of software engineering technology.

Software engineering ***methods*** provide the technical **how-to's** for building software. **Methods** encompass a broad array of tasks that include communication, requirements analysis, design modeling, program construction, testing, and support.

Software engineering ***tools*** provide **automated or semi automated** support for the process and the methods. When tools are integrated so that information created by one tool can be used by another, a system for the support of software development, called *computer-aided software engineering*, is established.

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1.4 THE SOFTWARE PROCESS

A ***process*** is a collection of **activities, actions, and tasks** that are performed when some work product is to be created. An ***activity*** strives to achieve a broad objective (e.g., communication with stakeholders) and is applied regardless of the application domain, size of the project, complexity of the effort, or degree of rigor with which software engineering is to be applied.

An ***action*** encompasses a set of tasks that produce a major work product (e.g., an architectural design model).

A ***task*** focuses on a small, but well-defined objective (e.g., conducting a unit test) that produces a tangible outcome. A ***process framework*** establishes the foundation for a complete software engineering process by identifying a small number of ***framework activities*** that are applicable to all software projects, regardless of their size or complexity. In addition, the process framework encompasses a set of ***umbrella activities*** that are applicable across the entire software process.

A generic process framework for software engineering encompasses **five** activities:

- **Communication.** Before any technical work can commence, it is critically important to communicate and collaborate with the customer. The intent is to understand stakeholders objectives for the project and to gather requirements that help define software features and functions.
- **Planning.** Any complicated journey can be simplified if a map exists. A software project is a complicated journey, and the planning activity creates a "map" that helps guide the team as it makes the journey. The map—called a *software project plan*—defines the software engineering work by describing the technical tasks to be conducted, the risks that are likely, the resources that will be required, the work products to be produced, and a work schedule.
- **Modeling.** Creation of models to help developers and customers understand the requires and software design
- **Construction.** This activity combines code generation and the testing that is required to uncover errors in the code.

- **Deployment.** The software is delivered to the customer who evaluates the delivered product and provides feedback based on the evaluation.

These **five** generic framework activities can be used during the development of small, simple programs, the creation of large Web applications, and for the engineering of large, complex computer-based systems.

Software engineering process framework activities are complemented by a number of U**mbrella Activities**. In general, **umbrella activities** are applied throughout a software project and help a software team manage and control progress, quality, change, and risk. Typical umbrella activities include:

- **Software project tracking and control**—allows the software team to assess progress against the project plan and take any necessary action to maintain the schedule.
- **Risk management**—assesses risks that may affect the outcome of the project or the quality of the product.
- **Software quality assurance**—defines and conducts the activities required to ensure software quality.
- **Technical reviews**—assesses software engineering work products in an effort to uncover and remove errors before they are propagated to the next activity.
- **Measurement**—defines and collects process, project, and product measures that assist the team in delivering software that meets stakeholders needs; can be used in conjunction with all other framework and umbrella activities.
- **Software configuration management**—manages the effects of change throughout the software process.
- **Reusability management**—defines criteria for work product reuse and establishes mechanisms to achieve reusable components.
- **Work product preparation and production**—encompasses the activities required to create work products such as models, documents, logs, forms, and lists.

Attributes for Comparing Process Models

- Overall flow and level of interdependencies among tasks
- Degree to which work tasks are defined within each framework activity
- Degree to which work products are identified and required
- Manner in which quality assurance activities are applied
- Manner in which project tracking and control activities are applied
- Overall degree of detail and rigor of process description
- Degree to which stakeholders are involved in the project
- Level of autonomy given to project team
- Degree to which team organization and roles are prescribed

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1.5 Software Engineering Practice

A generic software process model composed of a set of activities that establish a framework for software engineering practice. Generic framework activities—communication, planning, modeling, construction, and deployment—and umbrella activities establish a skeleton architecture for software engineering work.

1.5.1 The Essence of Practice

The essence of software engineering practice:

1. *Understand the problem* (communication and analysis).
2. *Plan a solution* (modeling and software design).
3. *Carry out the plan* (code generation).
4. *Examine the result for accuracy* (testing and quality assurance).

Understand the problem. It's sometimes difficult to admit, but most of us suffer from hubris when we're presented with a problem. We listen for a few seconds and then think, *Oh yeah, I understand,*

let's get on with solving this thing. Unfortunately, understanding isn't always that easy. It's worth spending a little time answering a few simple questions:

- *Who has a stake in the solution to the problem?* That is, who are the stakeholders?
- *What are the unknowns?* What data, functions, and features are required to properly solve the problem?
- *Can the problem be compartmentalized?* Is it possible to represent smaller problems that may be easier to understand?
- *Can the problem be represented graphically?* Can an analysis model be created?

Plan the solution. Now you understand the problem (or so you think) and you can't wait to begin coding. Before you do, slow down just a bit and do a little design:

- *Have you seen similar problems before?* Are there patterns that are recognizable in a potential solution? Is there existing software that implements the data, functions, and features that are required?
- *Has a similar problem been solved?* If so, are elements of the solution reusable?
- *Can sub problems be defined?* If so, are solutions readily apparent for the sub problems?
- *Can you represent a solution in a manner that leads to effective implementation?* Can a design model be created?

Carry out the plan. The design you've created serves as a road map for the system you want to build. There may be unexpected detours, and it's possible that you'll discover an even better route as you go, but the "plan" will allow you to proceed without getting lost.

- *Does the solution conform to the plan?* Is source code traceable to the design model?
- *Is each component part of the solution provably correct?* Have the design and code been reviewed, or better, have correctness proofs been applied to the algorithm?

Examine the result. You can't be sure that your solution is perfect, but you can be sure that you've designed a sufficient number of tests to uncover as many errors as possible.

- *Is it possible to test each component part of the solution?* Has a reasonable testing strategy been implemented?
- *Does the solution produce results that conform to the data, functions, and features that are required?* Has the software been validated against all stakeholder requirements?

1.5.2 Software General Principles

The dictionary defines the word *principle* as "an important underlying law or assumption required in a system of thought."

David Hooker has proposed **seven** principles that focus on software Engineering practice.

The First Principle: *The Reason It All Exists*

A software system exists for one reason: *to provide value to its users*.

The Second Principle: KISS (Keep It Simple, Stupid!)

Software design is not a haphazard process. There are many factors to consider in any design effort. *All design should be as simple as possible, but no simpler*. **The Third Principle: Maintain the Vision**

A clear vision is essential to the success of a software project. Without one, a project almost unfailingly ends up being
"of two [or more] minds" about itself.

The Fourth Principle: What You Produce, Others Will Consume

Always specify, design, and implement knowing someone else will have to understand what you are doing. **The Fifth Principle: Be Open to the Future**

A system with a long lifetime has more value. *Never design yourself into a corner*. *Before beginning a software project, be sure the software has a business purpose and that users perceive value in it.*

The Sixth Principle: Plan Ahead for Reuse

Reuse saves time and effort. *Planning ahead for reuse reduces the cost and increases the value of both the reusable components and the systems into which they are incorporated*.

The Seventh principle: Think!

Placing clear, complete thought before action almost always produces better results. When you think about something, you are more likely to do it right.

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1.6 SOFTWARE MYTHS

Software Myths- beliefs about software and the process used to build it - can be traced to the earliest days of computing. Myths have a number of attributes that have made them insidious. For instance, myths appear to be reasonable statements of fact, they have an intuitive feel, and they are often promulgated by experienced practitioners who "know the score"

Management Myths:

Managers with software responsibility, like managers in most disciplines, are often under pressure to maintain budgets, keep schedules from slipping, and improve quality. Like a drowning person who grasps at a straw, a software manager often grasps at belief in a software myth.

Myth1: *We already have a book that's full of standards and procedures for building software. Won't that provide my people with everything they need to know?*

Reality:

- The book of standards may very well exist, but is it used?
- Are software practitioners aware of its existence?
- Does it reflect modern software engineering practice?
- Is it complete?
- Is it adaptable?
- Is it streamlined to improve time to delivery while still maintaining a focus on Quality? In many cases, the answer to these entire question is NO.

Myth2: *If we get behind schedule, we can add more programmers and catch up*
Reality: Software development is not a mechanistic process like manufacturing. "Adding people to a late software project makes it later." At first, this statement may seem counterintuitive. However, as new people are added, people who were working must spend time educating the newcomers, thereby reducing the amount of time spent on productive development effort

Myth3: *If we decide to outsource the software project to a third party, I can just relax and let that firm build it.* **Reality:** If an organization does not understand how to manage and control software project internally, it will invariably struggle when it out sources software project.

Customer Myths:

A customer who requests computer software may be a person at the next desk, a technical group down the hall, the marketing /sales department, or an outside company that has requested software under contract. In many cases, the customer believes myths about software because software managers and practitioners do little to correct misinformation. Myths led to false expectations and ultimately, dissatisfaction with the developers.

Myth1: *A general statement of objectives is sufficient to begin writing programs - we can fill in details later.* **Reality:** Although a comprehensive and stable statement of requirements is not always possible, an ambiguous statement of objectives is a recipe for disaster. Unambiguous requirements are developed only through effective and continuous communication between customer and developer.

Myth2: *Project requirements continually change, but change can be easily accommodated because software is flexible.* **Reality:** It's true that software requirement change, but the impact of change varies with the time at which it is introduced. When requirement changes are requested early, cost impact is relatively small. However, as time passes, cost impact grows rapidly – resources have been committed, a design framework has been established, and change can cause upheaval that requires additional resources and major design modification.

Practitioner's Myths:

Myths that are still believed by software practitioners have been fostered by 50 years of programming culture. During the early days of software, programming was viewed as an art form. Old ways and attitudes die hard.

Myth1: *Once we write the program and get it to work, our job is done.*
Reality: Someone once said that "the sooner you begin 'writing code', the longer it'll take you to get done." Industry data indicate that between 60 and 80 percent of all effort expended on software will be expended after it is delivered to the customer for the first time.

Myth2: *Until I get the program "running" I have no way of assessing its quality.*
Reality: One of the most effective software quality assurance mechanisms can be applied from the inception of a project—the *formal technical review*. Software reviews are a "quality filter" that have been found to be more effective than testing for finding certain classes of software defects.

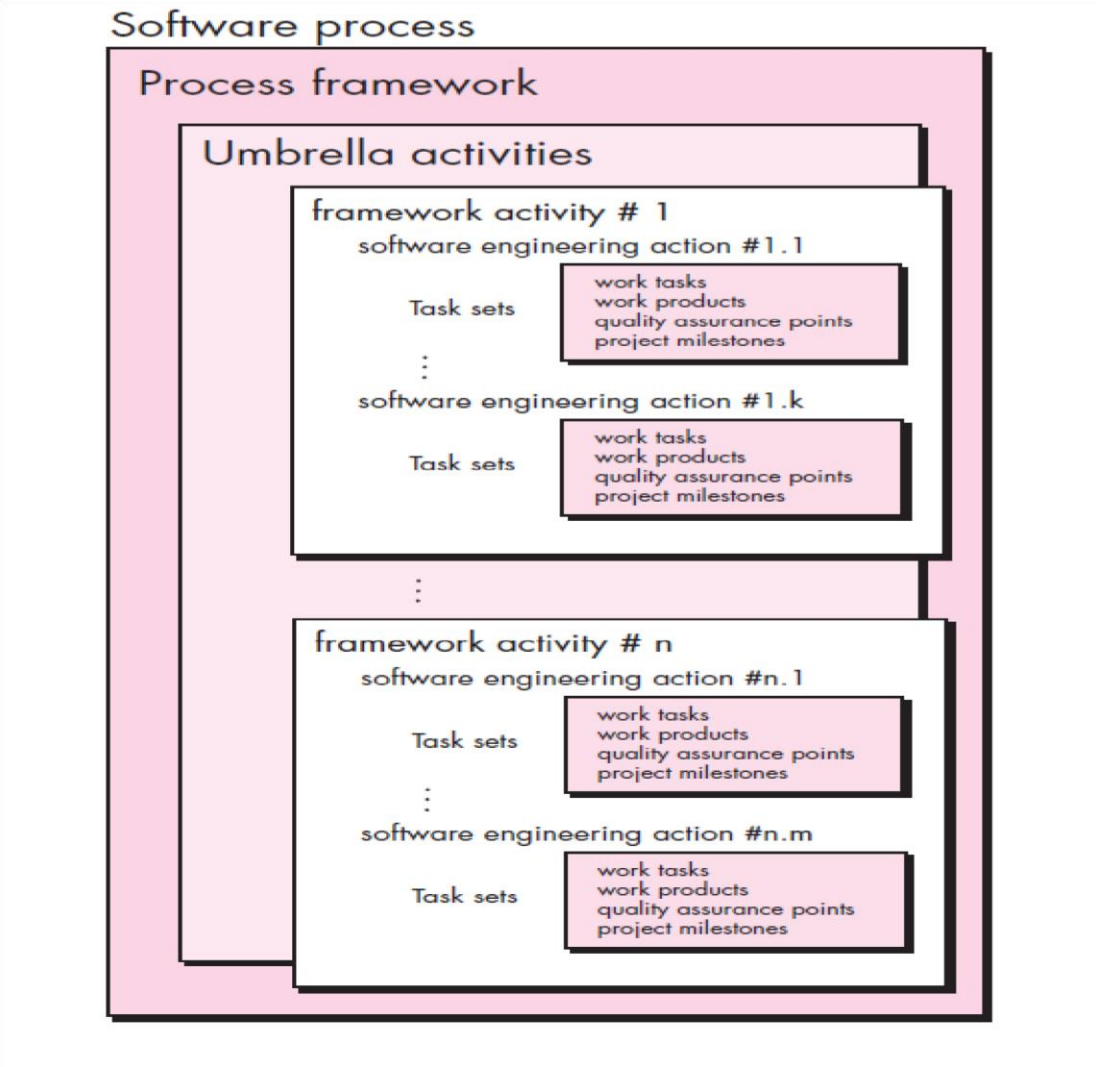
Myth3: *The only deliverable work product for a successful project is the working program.*
Reality: A working program is only one part of a *software configuration* that includes many elements. Documentation provides a foundation for successful engineering and, more important, guidance for software support.

Myth4: *Software engineering will make us create voluminous and unnecessary documentation and will invariably slow us down.*
Reality: Software engineering is not about creating documents. It is about creating quality. Better quality leads to reduced rework. And reduced rework results in faster delivery times. Many software professionals recognize the fallacy of the myths just described. Regrettably, habitual attitudes and methods foster poor management and technical practices, even when reality dictates a better approach. Recognition of software realities is the first step toward formulation of practical solutions for software engineering.

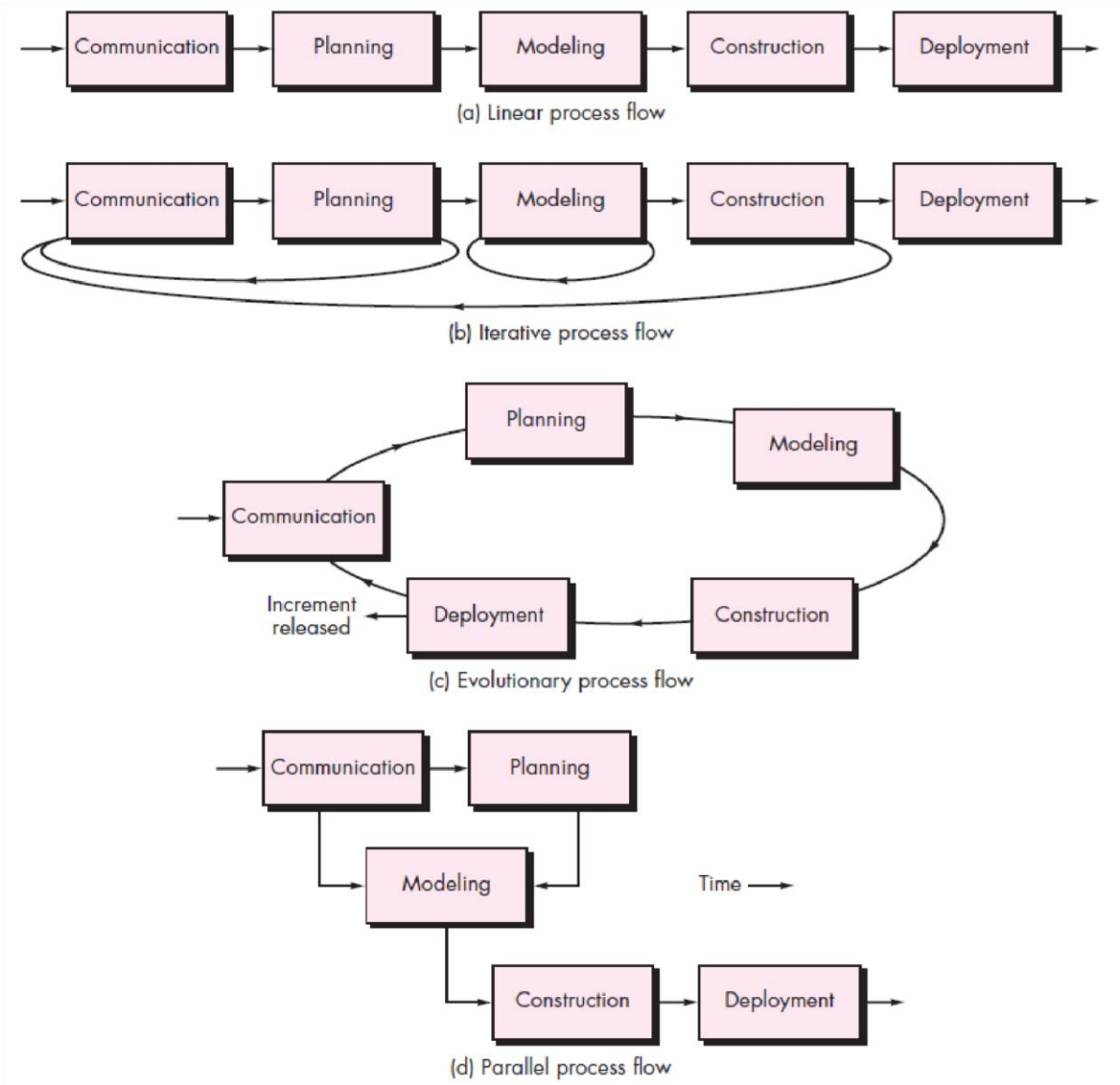
PROCESS MODELS

1.7 A GENERIC PROCESS MODEL

The software process is represented schematically in following figure. Each framework activity is populated by a set of software engineering actions. Each software engineering action is defined by a *task set* that identifies the work tasks that are to be completed, the work products that will be produced, the quality assurance points that will be required, and the milestones that will be used to indicate progress.



- A generic process framework defines **five** framework activities—**communication, planning, modeling, construction,** and **deployment.**
- In addition, a set of umbrella activities **project tracking and control, risk management, quality assurance, configuration management, technical reviews, and others** are applied throughout the process.
- This aspect is called ***process flow.*** It describes how the framework activities and the actions and tasks that occur within each framework activity are organized with respect to sequence and time.
- A generic process framework for software engineering
- A ***linear process flow*** executes each of the **five** framework activities in sequence, beginning with communication and culminating with deployment.
- An ***iterative process flow*** repeats one or more of the activities before proceeding to the next.
- An ***evolutionary process flow*** executes the activities in a "circular" manner. Each circuit through the five activities leads to a more complete version of the software.
- A ***parallel process flow*** executes one or more activities in parallel with other activities (e.g., modeling for one aspect of the software might be executed in parallel with construction of another aspect of the software).



1.7.1 Process Patterns

A ***process pattern*** describes a process-related problem that is encountered during software engineering work, identifies the environment in which the problem has been encountered, and suggests one or more proven solutions to the problem. Stated in more general terms, a process pattern provides you with a template —**a consistent method for describing problem solutions within the context of the software process**.

Patterns can be defined at any level of abstraction. a pattern might be used to describe a **problem (and solution)** associated with a complete **process model** (e.g., prototyping). In other situations, patterns can be used to describe a problem (and solution) associated with a **framework activity** (e.g., **planning**) or an **action** within a framework activity (e.g., project estimating).

Ambler has proposed a template for describing a process pattern:

(a) Pattern Name. The pattern is given a meaningful name describing it within the context of the software process **(b)Forces.** The environment in which the pattern is encountered and the issues that make the problem visible and may affect its solution.

(c)Type. The pattern type is specified. Ambler suggests **three** types:

1. ***Stage pattern***—defines a problem associated with a framework activity for the process. Since a framework activity encompasses multiple actions and work tasks, a stage pattern incorporates multiple task patterns (see the following) that are relevant to the stage

(framework activity). An example of a stage pattern might be **Establishing Communication.** This pattern would incorporate the task pattern **Requirements Gathering** and others.

2. ***Task pattern***—defines a problem associated with a software engineering action or work task and relevant to successful software engineering practice (e.g., Requirements Gathering is a task pattern).
3. ***Phase pattern***—define the sequence of framework activities that occurs within the process, even when the overall flow of activities is iterative in nature. An example of a phase pattern might be **Spiral Model** or **Prototyping.**

(d) Initial context. Describes the conditions under which the pattern applies. Prior to the initiation of the pattern:

(1) What organizational or team-related activities have already occurred?
(2) What is the entry state for the process?
(3) What software engineering information or project information already exists?

(e) Problem. The specific problem to be solved by the pattern.

(f) Solution. Describes how to implement the pattern successfully. It also describes how software engineering information or project information that is available before the initiation of the pattern is transformed as a consequence of the successful execution of the pattern.

(g) Resulting Context. Describes the conditions that will result once the pattern has been successfully implemented.

Upon completion of the pattern:

(1) What organizational or team-related activities must have occurred?
(2) What is the exit state for the process?
(3) What software engineering information or project information has been developed?

(h) Related Patterns. Provide a list of all process patterns that are directly related to this one. This may be represented as a hierarchy or in some other diagrammatic form.

(i) Known Uses and Examples. Indicate the specific instances in which the pattern is applicable.

Process patterns provide an effective mechanism for addressing problems associated with any software process. The patterns enable you to develop a hierarchical process description that begins at a high level of abstraction (a phase pattern).

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********** **1.8 PROCESS ASSESSMENT AND IMPROVEMENT**

Assessment attempts to understand the current state of the software process with the intent of improving it. A number of different approaches to **software process assessment and improvement** have been proposed over the past few decades.

Standard CMMI Assessment Method for Process Improvement (SCAMPI)—provides a **five** step process assessment model that incorporates **five** phases: **initiating, diagnosing, establishing, acting, and learning.** The SCAMPI method uses the SEI CMMI as the basis for assessment.

CMM-Based Appraisal for Internal Process Improvement (CBA IPI)— provides a diagnostic technique for assessing the relative maturity of a software organization; uses the SEI CMM as the basis for the assessment.

SPICE (ISO/IEC15504)—a standard that defines a set of requirements for software process assessment. The intent of the standard is to assist organizations in developing an objective evaluation of the efficacy of any defined software process.

ISO 9001:2000 for Software—a generic standard that applies to any organization that wants to improve the overall quality of the products, systems, or services that it provides. Therefore, the standard is directly applicable to software organizations and companies.

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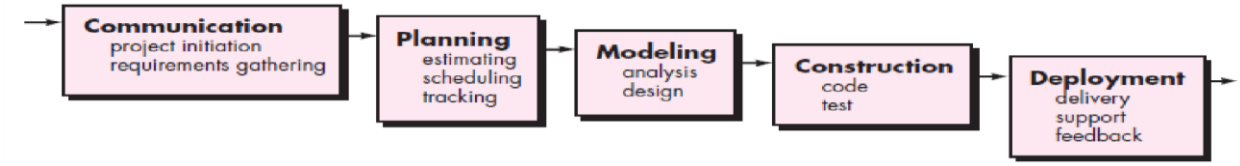
********** **1.9 PRESCRIPTIVE PROCESS MODELS**

Prescriptive process models were originally proposed to bring order to the chaos of software development. Prescriptive process models define a prescribed set of process elements and a predictable process work flow. "prescriptive" because they prescribe a set of process elements—framework activities, software engineering actions, tasks, work products, quality assurance, and change control mechanisms for each project.

1.9.1 The Waterfall Model

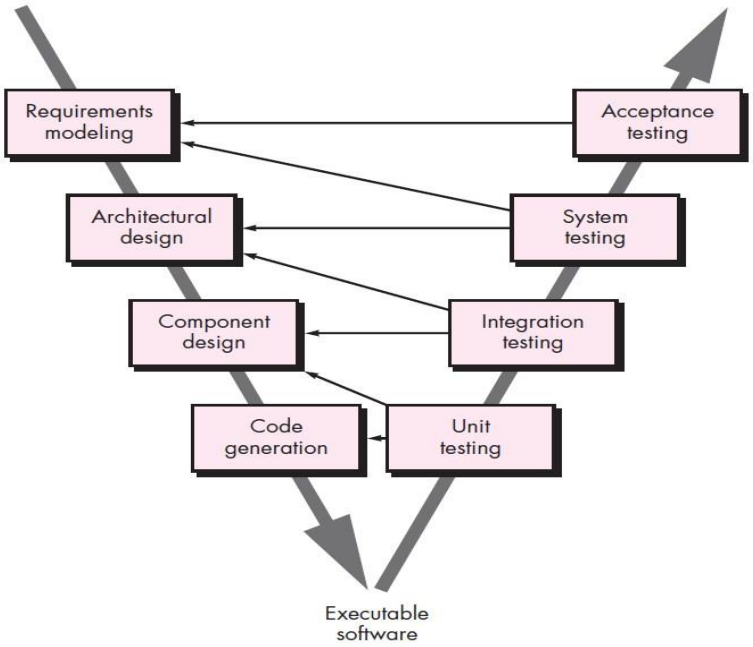
The ***waterfall model***, sometimes called the ***classic life cycle***, suggests a systematic, sequential approach to software development that begins with customer specification of requirements and progresses through **planning, modeling, construction, and deployment**.



The waterfall model

A variation in the representation of the waterfall mod el is called the ***V-model.*** Represented in following figure. The V model depicts the relationship of quality assurance actions to the actions associated with communication, modeling, and early construction activities

The V-model



As a software team moves down the left side of the **V**, basic problem requirements are refined into progressively more detailed and technical representations of the problem and its solution. Once code has been generated, the team moves up the right side of the **V**, essentially performing a series of tests that validate each of the models created as the team moved down the left side. The V-model provides a way of visualizing how verification and validation actions are applied to earlier engineering work.

The waterfall model is the oldest paradigm for software engineering. The problems that are sometimes encountered when the waterfall model is applied are:

1. Real projects rarely follow the sequential flow that the model proposes. Although the linear model can accommodate iteration, it does so indirectly. As a result, changes can cause confusion as the project team proceeds.
2. It is often difficult for the customer to state all requirements explicitly. The waterfall model requires this and has difficulty accommodating the natural uncertainty that exists at the beginning of many projects.
3. The customer must have patience. A working version of the program(s) will not be available until late in the project time span.

This model is suitable when ever limited number of new development efforts and when requirements are well defined and reasonably stable.

1.9.2 Incremental Process Models

The incremental model delivers a series of releases, called increments, that provide progressively more functionality for the customer as each increment is delivered.

The *incremental* model combines elements of linear and parallel process flows discussed in Section 1.7. The incremental model applies linear sequences in a staggered fashion as calendar time progresses. Each linear sequence produces deliverable "increments" of the software in a manner that is similar to the increments produced by an evolutionary process flow.

For example, word-processing software developed using the incremental paradigm might deliver basic file management, editing, and document production functions in the first increment; more sophisticated editing and document production capabilities in the second increment; spelling and grammar checking in the third increment; and advanced page layout capability in the fourth increment. When an incremental model is used, the first increment is often a *core product.* That is, basic requirements are addressed but many supplementary features remain undelivered. The core product is used by the customer. As a result of use and/or evaluation, a plan is developed for the next increment. The plan addresses the modification of the core product to better meet the needs of the customer and the delivery of additional features and functionality. This process is repeated following the delivery of each increment, until the complete product is produced.

Incremental development is particularly useful when **staffing is unavailable** for a complete implementation by the business deadline that has been established for the project. Early increments can be implemented with fewer people. If the core product is well received, then additional staff (if required) can be added to implement the next increment. In addition, increments can be planned to manage technical risks.

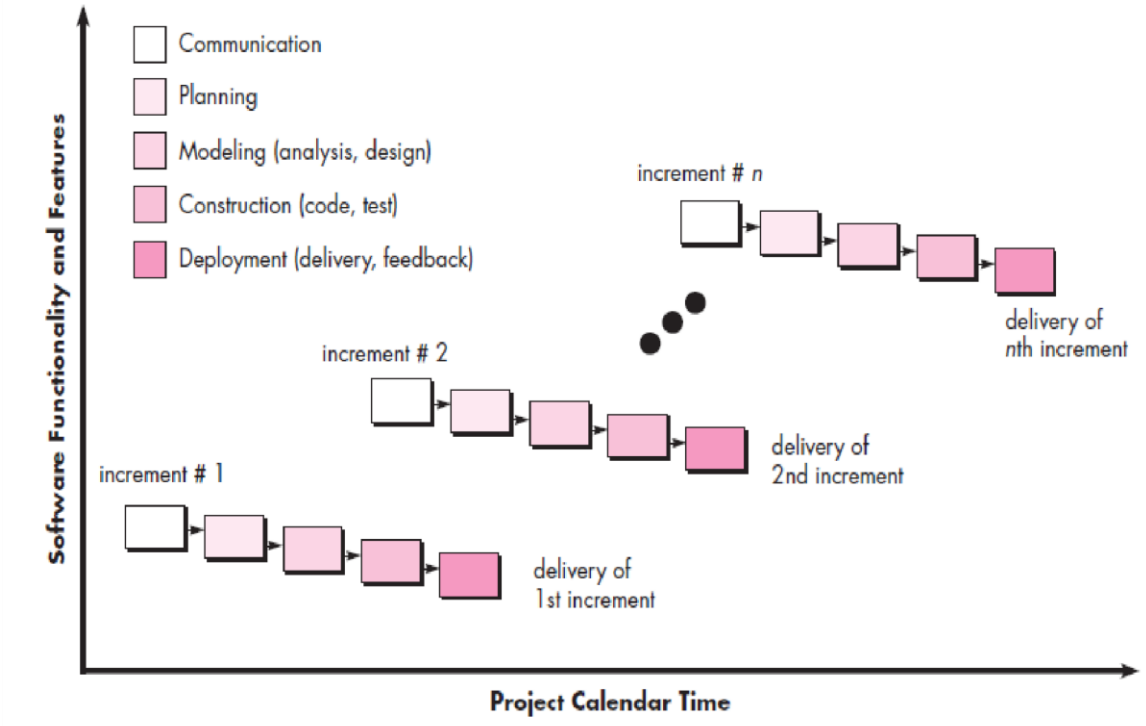


Fig : Incremental Model

1.9.3 Evolutionary Process Models

Evolutionary models are **iterative**. They are characterized in a manner that enables you to develop increasingly more complete versions of the software with each iteration. There are **two** common evolutionary process models. **Prototyping Model :** Often, a customer defines a set of general objectives for software, but does not identify detailed requirements for functions and features. In other cases, the developer may be unsure of the efficiency of an algorithm, the adaptability of an operating

system, or the form that human-machine interaction should take. In these, and many other situations, a ***prototyping paradigm*** may offer the best approach.

Although prototyping can be used as a stand-alone process model, it is more commonly used as a technique that can be implemented within the context of any one of the process models.

The prototyping paradigm begins with **communication**. You meet with other stakeholders to define the overall objectives for the software, identify whatever requirements are known, and outline areas where further definition is mandatory. A prototyping iteration is planned **quickly**, and **modeling** (in the form of a "quick design") occurs. A **quick design** focuses on a representation of those aspects of the software that will be visible to end users.

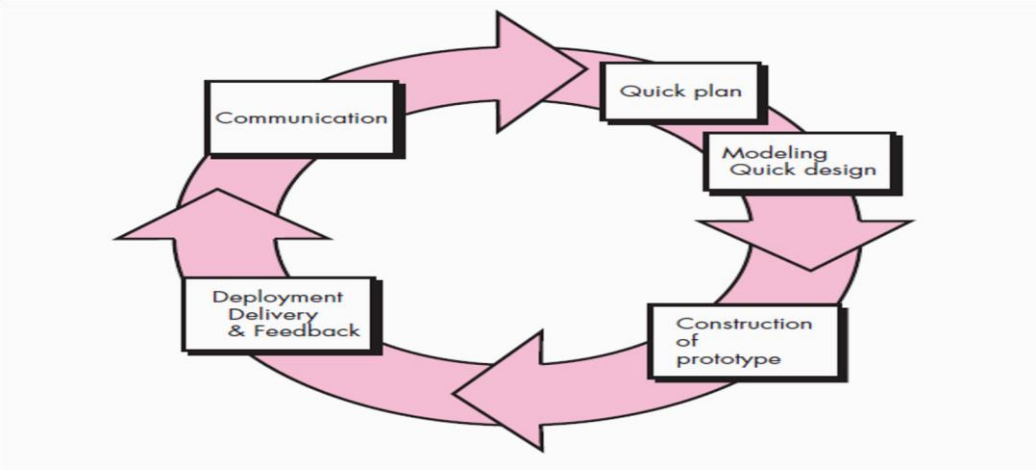


Fig : prototyping paradigm

The quick design leads to the **construction of a prototype**. The prototype is deployed and evaluated by stakeholders, who provide feedback that is used to further refine requirements. Iteration occurs as the prototype is tuned to satisfy the needs of various stakeholders, while at the same time enabling you to better understand what needs to be done.

The prototype serves as a mechanism for identifying software requirements. If a working prototype is to be built, you can make use of existing program fragments or apply tools that enable working programs to be generated quickly. The prototype can serve as **"the first system**." Prototyping can be **problematic** for the following reasons:

1. Stakeholders see what appears to be a working version of the software, unaware that the prototype is held together haphazardly, unaware that in the rush to get it working you haven't considered overall software quality or long-term maintainability.
2. As a software engineer, you often make implementation compromises in order to get a prototype working quickly. An inappropriate operating system or programming language may be used simply because it is available and known; an inefficient algorithm may be implemented simply to demonstrate capability.

Although problems can occur, prototyping can be an **effective paradigm** for software engineering.

The Spiral Model : Originally proposed by **Barry Boehm**, the spiral model is an evolutionary software process model that couples the iterative nature of prototyping with the controlled and systematic aspects of the waterfall model. It provides the potential for rapid development of increasingly more complete versions of the software. Boehm describes the model in the following manner.

The spiral development model is a **risk-driven process model** generator that is used to **guide multistakeholder concurrent engineering** of software intensive systems. It has **two** main distinguishing features. One is a ***cyclic approach*** for incrementally growing a system's degree of definition and implementation while decreasing its degree of risk. The other is a set of ***anchor point milestones*** for ensuring stakeholder commitment to feasible and mutually satisfactory system solutions. Using the spiral model, software is developed in a series of evolutionary releases. During early iterations, the release might be a model or prototype. During later iterations, increasingly more complete versions of the engineered system are produced.

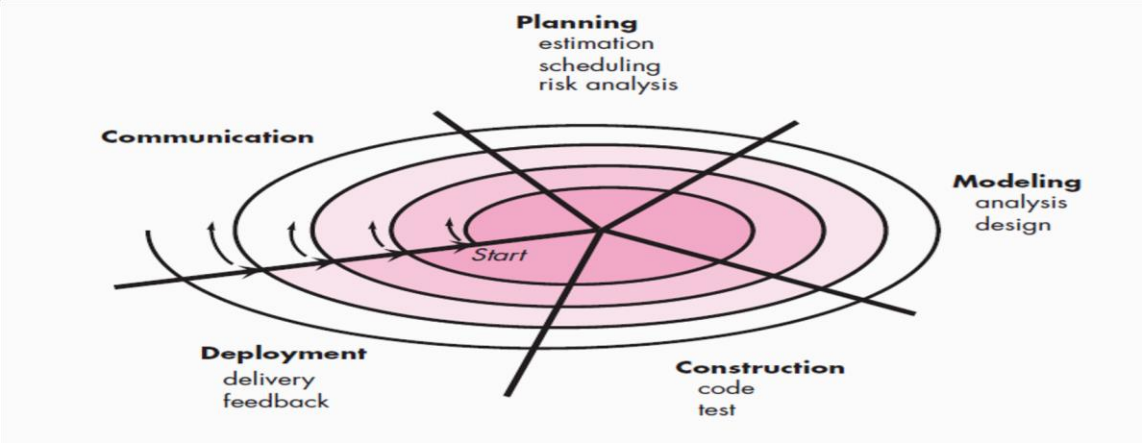


Fig : The Spiral Model

A spiral model is divided into a set of **framework activities** defined by the software engineering team. As this evolutionary process begins, the software team performs activities that are implied by a circuit around the spiral in a **clockwise** direction, beginning at the **center**. Risk is considered as each revolution is made. ***Anchor point milestones*** are a combination of work products and conditions that are attained along the path of the spiral are noted for each evolutionary pass.

The first circuit around the spiral might result in the development of a **product** specification; subsequent passes around the spiral might be used to develop a **prototype** and then progressively more sophisticated versions of the software. Each pass through the planning region results in adjustments to the project plan.

The spiral model can be adapted to apply throughout the life of the computer software. Therefore, the first circuit around the spiral might represent a "**concept development project**" that starts at the core of the spiral and continues for multiple iterations until concept development is complete. The new product will evolve through a number of iterations around the spiral. Later, a circuit around the spiral might be used to represent a "**product enhancement project.".** The spiral model is a **realistic approach** to the development of **large-scale systems** and software. Because software evolves as the process progresses, the developer and customer better understand and react to risks at each evolutionary level. It maintains the systematic stepwise approach suggested by the classic life cycle but incorporates it into an iterative framework that more realistically reflects the real world.

1.9.4 Concurrent Models

The concurrent development model, sometimes called **concurrent engineering**, allows a software team to represent iterative and concurrent elements of any of the process models. The concurrent model is often more appropriate for product engineering projects where different engineering teams are involved.

These models provide a schematic representation of one software engineering activity within the **modeling** activity using a concurrent modeling approach. The activity **modeling** may be in any one of the states noted at any given time. Similarly, other activities, actions, or tasks (e.g., **communication** or **construction**) can be represented in an analogous manner.

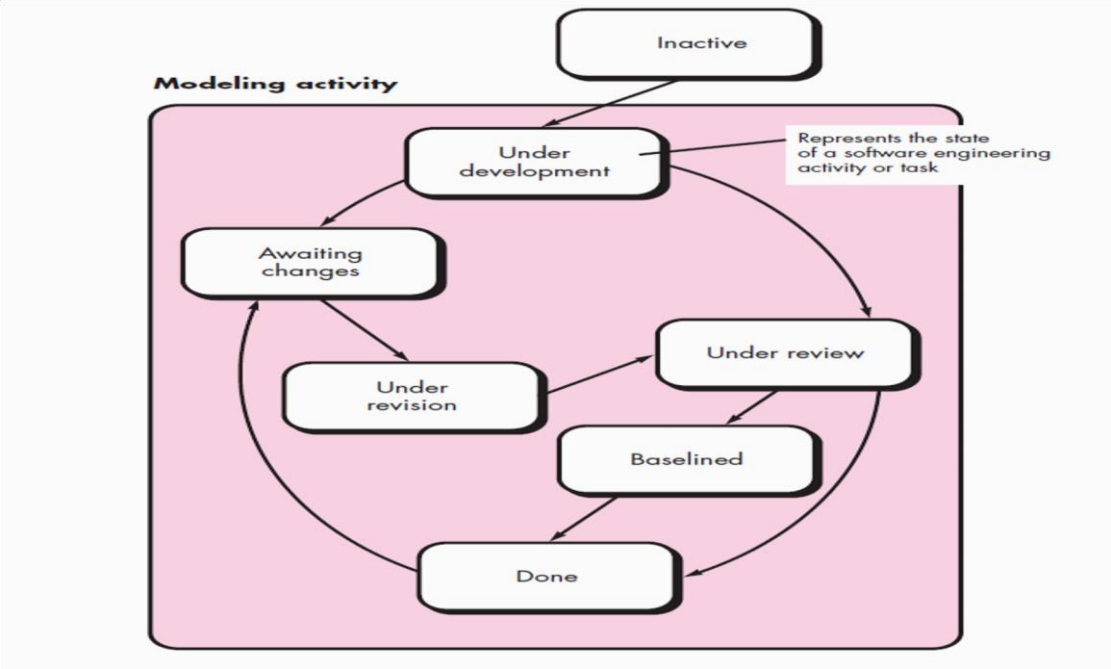


Fig : Concurrent development model

All software engineering activities exist concurrently but reside in different states. Concurrent modeling defines a series of events that will trigger transitions from state to state for each of the software engineering activities, actions, or tasks. This generates the event *analysis model correction*, which will trigger the requirements analysis action from the **done** state into the **awaiting changes** state.

Concurrent modeling is applicable to all types of software development and provides an accurate picture of the current state of a project. Each activity, action, or task on the network exists simultaneously with other activities, actions, or tasks. Events generated at one point in the process network trigger transitions among the states.

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1.10 SPECIALIZED PROCESS MODELS

Specialized process models take on many of the characteristics of one or more of the traditional models presented in the preceding sections. However, these models tend to be applied when a specialized or narrowly defined software engineering approach is chosen.

1.10.1 Component-Based Development

The *component-based development model* incorporates many of the characteristics of the spiral model. It is evolutionary in nature, demanding an iterative approach to the creation of software. However, the component-based development model constructs applications from **prepackaged** software components.

Modeling and construction activities begin with the identification of **candidate components.** These components can be designed as either conventional software modules or object-oriented classes or packages of classes. Regardless of the technology that is used to create the components, the component-based development model incorporates the following steps

1. Available component-based products are researched and evaluated for the application domain in question.
2. Component integration issues are considered.
3. A software architecture is designed to accommodate the components.
4. Components are integrated into the architecture.
5. Comprehensive testing is conducted to ensure proper functionality.

The component-based development model leads to software reuse, and reusability provides software engineers with a number of measurable benefits.

1.10.2 The Formal Methods Model

The *formal methods model* encompasses a set of activities that leads to formal mathematical specification of computer software. Formal methods enable you to specify, develop, and verify a computer-based system by applying a rigorous, mathematical notation. A variation on this approach, called ***clean room software engineering***.

When formal methods are used during development, they provide a mechanism for eliminating many of the problems that are difficult to overcome using other software engineering paradigms. **Ambiguity, incompleteness, and inconsistency** can be discovered and corrected more easily, but through the application of mathematical analysis.

When formal methods are used during design, they serve as a basis for program verification and therefore enable you to discover and correct errors that might otherwise go undetected. Although not a mainstream approach, the formal methods model offers the promise of **defect-free software**. **Draw Backs**:

- The development of formal models is currently quite time consuming and expensive. • Because few software developers have the necessary background to apply formal methods, extensive training is required.
- It is difficult to use the models as a communication mechanism for Technically unsophisticated customers.

1.10.3 Aspect-Oriented Software Development

A OSD defines "aspects" that express customer concerns that cut across multiple system functions, features, and information. When concerns cut across multiple system functions, features, and information, they are often referred to as ***crosscutting concerns***. ***Aspectual requirements*** define those crosscutting concerns that have an impact across the software architecture.

Aspect-oriented software development (AOSD), often referred to as *aspect-oriented programming* (AOP), is a relatively new software engineering paradigm that provides a process and methodological approach for **defining, specifying, designing, and constructing *aspects***."

Grundy provides further discussion of aspects in the context of what he calls *aspect-oriented component engineering* (AOCE):

> AOCE uses a concept of horizontal slices through vertically-decomposed software components, called

"**aspects**," to characterize cross-cutting functional and non-functional properties of components.

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1.11 THE UNIFIED PROCESS

Unified process (UP) is an architecture-centric, use-case driven, iterative and incremental development process. UP is also referred to as the **unified software development process**.

The Unified Process is an attempt to draw on the best features and characteristics of traditional software process models, but characterize them in a way that implements many of the best principles of **agile software development.** The Unified Process recognizes the importance of **customer communication** and streamlined methods for describing the customer's view of a system. It emphasizes the important role of software architecture and "helps the architect focus on the right goals, such as understandability, reliance to future changes, and reuse" . It suggests a process flow that is iterative and incremental, providing the evolutionary feel that is essential in modern software development.

1.11.1 A Brief History

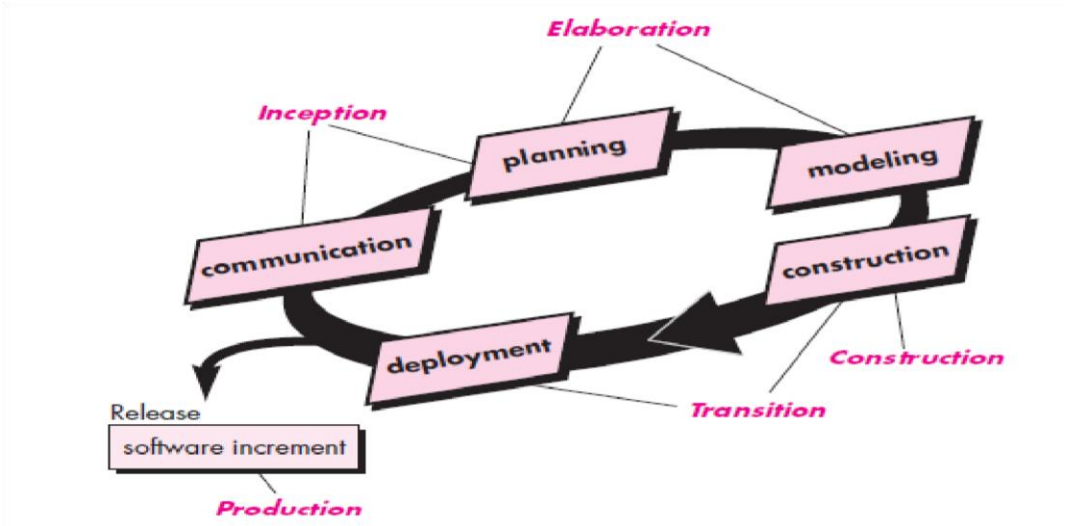
During the early 1990s James Rumbaugh, Grady Booch, and Ivar Jacobson began working on a "unified method" that would combine the best features of each of their individual object-oriented analysis and design methods and adopt additional features proposed by other experts in object-oriented modeling.

The result was **UML—a *unified modeling language*** that contains a robust notation for the modeling and development of object-oriented systems. They developed the ***Unified Process***, a framework for object-oriented software engineering using **UML**.

1.11.2 Phases of the Unified Process

This process divides the development process into **five** phases:

- Inception
- Elaboration
- Conception
- Transition
- Production



The ***inception phase*** of the UP encompasses both customer communication and planning activities. By collaborating with stakeholders, business requirements for the software are identified; a rough architecture for the system is proposed; and a plan for the iterative, incremental nature of the ensuing project is developed.

The ***elaboration phase*** encompasses the communication and modeling activities of the generic process model. Elaboration refines and expands the preliminary use cases that were developed as part of the inception phase and expands the architectural representation to include **five different views** of the software—***the use case model, the requirements model, the design model, the implementation model, and the deployment model***. Elaboration creates an
"**executable architectural baseline**" that represents a "**first cut**" executable system.

The ***construction phase*** of the UP is identical to the construction activity defined for the generic software process. Using the architectural model as input, the construction phase develops or acquires the software components that will make each use case operational for end users. To accomplish this, requirements and design models that were started during the elaboration phase are completed to reflect the final version of the software increment. All necessary and required features and functions for the software increment (i.e., the release) are then implemented in **source code**.

The ***transition phase*** of the UP encompasses the latter stages of the generic construction activity and the first part of the generic deployment (delivery and feedback) activity. Software is given to end users for **beta testing and user feedback** reports both defects and necessary changes. At the conclusion of the transition phase, the software increment becomes a usable software release.

The ***production phase*** of the UP coincides with the deployment activity of the generic process. During this phase, the ongoing use of the software is monitored, support for the operating environment (infrastructure) is provided, and defect reports and requests for changes are submitted and evaluated. It is likely that at the same time the construction, transition, and production phases are being conducted, work may have already begun on the next software increment. This means that the **five UP phases** do not occur in a sequence, but rather with staggered concurrency.

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1.12 PERSONAL AND TEAM PROCESS MODELS

The best software process is one that is close to the people who will be doing the work. Watts Humphrey proposed two process models. Models - "P**ersonal Software Process (PSP)**" and "**Team Software Process (TSP)**." Both require hard work, training, and coordination, but both are achievable.

1.12.1 Personal Software Process (PSP)

The ***Personal Software Process*** **(PSP)** emphasizes personal measurement of both the work product that is produced and the resultant quality of the work product. In addition **PSP** makes the practitioner responsible for project planning and empowers the practitioner to control the quality of all software work products that are developed. The **PSP** model defines **five** framework activities:

- **Planning.** This activity isolates requirements and develops both size and resource estimates. In addition, defects estimate (the number of defects projected for the work) is made. All metrics are recorded on worksheets or templates. Finally, development tasks are identified and a project schedule is created.
- **High-level design.** External specifications for each component to be constructed are developed and a component design is created. Prototypes are built when uncertainty exists. All issues are recorded and tracked.
- **High-level design review.** Formal verification methods are applied to uncover errors in the design. Metrics are maintained for all important tasks and work results.
- **Development.** The component-level design is refined and reviewed. Code is generated, reviewed, compiled, and tested. Metrics are maintained for all important tasks and work results.
- **Postmortem.** Using the measures and metrics collected, the effectiveness of the process is determined. Measures and metrics should provide guidance for modifying the process to improve its effectiveness.

PSP stresses the need to identify errors early and, just as important, to understand the types of errors that you are likely to make. PSP represents a disciplined, metrics-based approach to software engineering that may lead to culture shock for many practitioners.

1.12.2 Team Software Process (TSP)

Watts Humphrey extended the lessons learned from the introduction of PSP and proposed a ***Team Software Process*** **(TSP).** The goal of TSP is to build a "**self directed**" project team that organizes itself to produce high-quality software.

Humphrey defines the following objectives for TSP:

- Build self-directed teams that plan and track their work, establish goals, and own their processes and plans. These can be pure software teams or integrated product teams (IPTs) of 3 to about 20 engineers.
- Show managers how to coach and motivate their teams and how to help them sustain peak performance.
- Accelerate software process improvement by making CMM23 Level 5 behavior normal and expected.
- Provide improvement guidance to high-maturity organizations.
- Facilitate university teaching of industrial-grade team skills.

A self-directed team has a consistent understanding of its overall goals and objectives; defines roles and responsibilities for each team member; tracks quantitative project data (about productivity and quality); identifies a team process that is appropriate for the project and a strategy for implementing the process; defines local standards that are applicable to the team's software engineering work; continually assesses risk and reacts to it; and tracks, manages, and reports project status.

TSP defines the following framework activities: **project launch, high-level design, implementation, integration and test,** and **postmortem.** TSP makes use of a wide variety of scripts, forms, and standards that serve to guide team members in their work. "Scripts" define specific process activities (i.e., project launch, design, implementation, integration and system testing, postmortem) and

other more detailed work functions (e.g., development planning, requirements development, software configuration management, unit test) that are part of the team process.

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1.13 PROCESS TECHNOLOGY

Process technology tools allow a software organization to build an automated model of the process framework, task sets, and umbrella activities. The model, normally represented as a network, can then be analyzed to determine typical workflow and examine alternative process structures that might lead to reduced development time or cost.

Once an acceptable process has been created, other process technology tools can be used to allocate, monitor, and even control all software engineering activities, actions, and tasks defined as part of the process model. Each member of a software team can use such tools to develop a checklist of work tasks to be performed, work products to be produced, and quality assurance activities to be conducted. The process technology tool can also be used to coordinate the use of other software engineering tools that are appropriate for a particular work task.

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1.14 PRODUCT AND PROCESS

The **Product** is ***what*** **we're** actually building. What's our solution to the problem at hand? Half of engineering is making sure you're building the right product and have the ability to actually build it. For software engineers, that means coming up with a software solution and being able to code it up properly.

The hidden side of engineering is the **Process**, which means *how* we're actually building our product. Products don't just result from a single all-night coding session -- we need to make sure we're following a process that lets us create that Product in the most efficient and effective way possible.

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******** AGILE DEVELOPMENT

1.15 WHAT IS AGILITY?

Agile is a software development methodology to build software incrementally using short iterations of 1 to 4 weeks so that the development process is aligned with the changing business needs.

An agile team is a nimble team able to appropriately respond to changes. Change is what software development is very much about. Changes in the software being built, changes to the team members, changes because of new technology, changes of all kinds that may have an impact on the product they build or the project that creates the product. Support for changes should be built-in everything we do in software, something we embrace because it is the heart and soul of software. An agile team recognizes that software is developed by individuals working in teams and that the skills of these people, their ability to collaborate is at the core for the success of the project.

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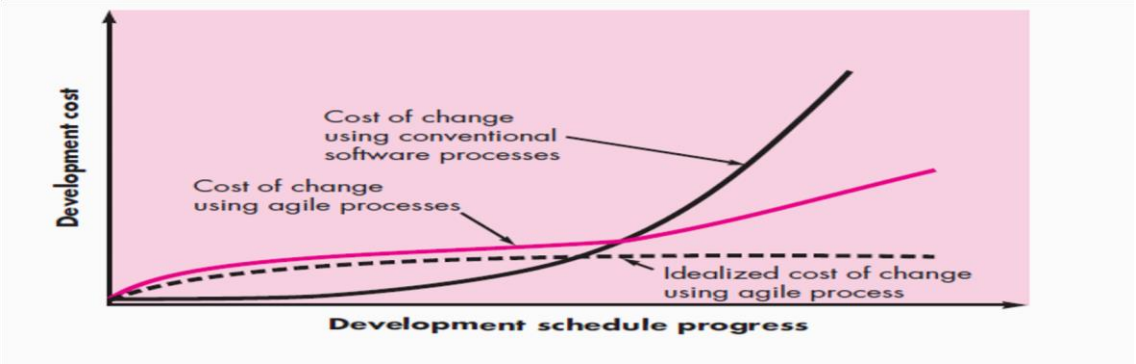
1.16 AGILITY AND THE COST OF CHANGE

An agile process reduces the cost of change because software is released in increments and change can be better controlled within an increment.

Agility argue that a well-designed agile process “flattens” the cost of change curve shown in following figure, allowing a software team to accommodate changes late in a software project without dramatic cost and time impact. When incremental delivery is coupled with other agile practices such as continuous unit testing and pair programming, the cost of making a change is attenuated. Although debate about the degree to which the cost curve flattens is ongoing, there is evidence to suggest that a significant reduction in the cost of change can be achieved.



1.17AGILE PROCESS

Any agile software process is characterized in a manner that addresses a number of key assumptions about the majority of software projects:

1. It is difficult to predict in advance which software requirements will persist and which will change. It is equally difficult to predict how customer priorities will change as the project proceeds.
2. For many types of software, design and construction are interleaved. That is, both activities should be performed in tandem so that design models are proven as they are created. It is difficult to predict how much design is necessary before construction is used to prove the design. **3.** Analysis, design, construction, and testing are not as predictable

1.17.1 Agility Principles

Agility principles for those who want to achieve agility:

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is faceto-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self– organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior

accordingly.

1.17.2 Human Factors

Agile development focuses on the talents and skills of individuals, molding the process to specific people and teams."

The key point in this statement is that *the process molds to the needs of the people and team*

- **Competence.** In an agile development context, "competence" encompasses innate talent, specific softwarerelated skills, and overall knowledge of the process that the team has chosen to apply. Skill and knowledge of process can and should be taught to all people who serve as agile team members.

- **Common focus.** Although members of the agile team may perform different tasks and bring different skills to the project, all should be focused on one goal—to deliver a working software increment to the customer within the time promised. To achieve this goal, the team will also focus on continual adaptations (small and large) that will make the process fit the needs of the team.
- **Collaboration.** Software engineering (regardless of process) is about assessing, analyzing, and using information that is communicated to the software team; creating information that will help all stakeholders understand the work of the team; and building information (computer software and relevant databases) that provides business value for the customer. To accomplish these tasks, team members must collaborate—with one another and all other stakeholders.
- **Decision-making ability.** Any good software team (including agile teams) must be allowed the freedom to control its own destiny. This implies that the team is given autonomy—decision-making authority for both technical and project issues.
- **Fuzzy problem-solving ability.** Software managers must recognize that the agile team will continually have

to deal with ambiguity and will continually be buffeted by change.

- **Mutual trust and respect.** The agile team must become what DeMarco and Lister call a "jelled" team. A jelled team exhibits the trust and respect that are necessary to make them "so strongly knit that the whole is greater than the sum of the parts."
- **Self-organization.** In the context of agile development, self-organization implies **three** things:

(1) the agile team organizes itself for the work to be done,
(2) the team organizes the process to best accommodate its local environment,
(3) the team organizes the work schedule to best achieve delivery of the software increment. Self-organization has a number of technical benefits, but more importantly, it serves to improve collaboration and boost team morale.

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1.18 EXTREME PROGRAMMING (XP)

Extreme Programming **(XP),** the most widely used approach to agile software development, emphasizes business results first and takes an incremental, get-something-started approach to building the product, using continual testing and revision.

1.18.1 XP Values

Beck defines a set of **five** *values* that establish a foundation for all work performed as part of XP—**communication, simplicity, feedback, courage, and respect**. Each of these values is used as a driver for specific XP **activities, actions, and tasks**.

In order to achieve effective ***communication*** between software engineers and other stakeholders, XP emphasizes close, yet informal collaboration between customers and developers, the establishment of effective metaphors3 for communicating important concepts, continuous feedback, and the avoidance of voluminous documentation as a communication medium.

To achieve ***simplicity***, XP restricts developers to design only for immediate needs, rather than consider future needs. The intent is to create a simple design that can be easily implemented in code). If the design must be improved, it can be *refactored* at a later time.

Feedback is derived from three sources: the implemented software itself, the customer, and other software team members. By designing and implementing an effective testing strategy the software provides the agile team with feedback. XP makes use of the ***unit test*** as its primary testing tactic. As each class is developed, the team develops a unit test to exercise each operation according to its specified functionality.

Beck argues that strict adherence to certain XP practices demands ***courage.*** A better word might be ***discipline***. An agile XP team must have the discipline (courage) to design for today, recognizing that future requirements may change dramatically, thereby demanding substantial rework of the design and implemented code.

By following each of these values, the agile team inculcates ***respect*** among it members, between other stakeholders and team members, and indirectly, for the software itself. As they achieve successful delivery of software increments, the team develops growing respect for the XP process.

1.18.2 The XP Process

Extreme Programming uses an object-oriented approach as its preferred development paradigm and encompasses a set of rules and practices that occur within the context of four framework activities: planning, design, coding, and testing. Following figure illustrates the XP process and notes some of the key ideas and tasks that are associated with each framework activity.

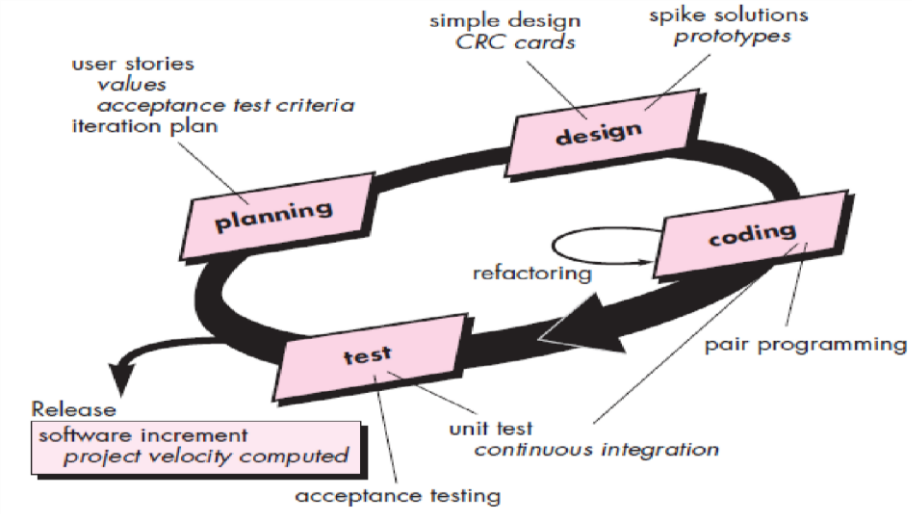

Fig : The Extreme Programming process

Key XP activities are

- **Planning.** The planning activity (also called *the planning game*) begins with *listening*—a requirements gathering activity that enables the technical members of the XP team to understand the business context for the software and to get a broad feel for required output and major features and functionality.
- **Design.** XP design rigorously follows the KIS (keep it simple) principle. A simple design is always preferred over a more complex representation. In addition, the design provides implementation guidance for a story as it is written—nothing less, nothing more. The design of extra functionality If a difficult design problem is encountered as part of the design of a story, XP recommends the immediate creation of an operational prototype of that portion of the design. Called a ***spike solution***, the design prototype is implemented and evaluated. XP encourages ***refactoring***—a construction technique that is also a method for design optimization.

  Fowler describes r**efactoring** in the following manner: Refactoring is the process of changing a software system in such a way that it does not alter the external behavior of the code yet improves the internal structure. It is a disciplined way to clean up code [that minimizes the chances of introducing bugs].
- **Coding.** After stories are developed and preliminary design work is done, the team does *not* move to code, but rather develops a series of unit tests that will exercise each of the stories that is to be included in the current release Once the code is complete, it can be unit-tested immediately, thereby providing instantaneous feedback to the developers.

  A key concept during the coding activity is *pair programming*. XP recommends that two people work together at one computer workstation to create code for a story. This provides a mechanism for real time problem solving (two heads are often better than one) and real-time quality assurance.
- **Testing.** The creation of unit tests before coding commences is a key element of the XP approach. The unit tests that are created should be implemented using a framework that enables them to be automated. This encourages a regression testing strategy whenever code is modified. As the individual unit tests are organized into a "universal testing suite" integration and validation testing of the system can occur on a daily basis. This provides the XP team with a continual indication of progress and also can raise warning flags early if things go awry. Wells states: "Fixing small

problems every few hours takes less time than fixing huge problems just before the deadline." XP ***acceptance tests***, also called ***customer tests***, are specified by the customer and focus on overall system features and functionality that are visible and reviewable by the customer. Acceptance tests are derived from user stories that have been implemented as part of a software release.

1.18.3 Industrial XP

Joshua Kerievsky describes *Industrial Extreme Programming* (IXP) in the following manner: "IXP is an organic evolution of XP. It is imbued with XP's minimalist, customer-centric, test-driven spirit. IXP differs most from the original XP in its greater inclusion of management, its expanded role for customers, and its upgraded technical practices." IXP incorporates six new practices that are designed to help ensure that an XP project works successfully for significant projects within a large organization.

- **Readiness assessment.** Prior to the initiation of an IXP project, the organization should conduct a *readiness assessment.* The assessment ascertains whether (1) an appropriate development environment exists to support IXP, (2) the team will be populated by the proper set of stakeholders, (3) the organization has a distinct quality program and supports continuous improvement, (4) the organizational culture will support the new values of an agile team, and (5) the broader project community will be populated appropriately.
- **Project community.** Classic XP suggests that the right people be used to populate the agile team to ensure success. The implication is that people on the team must be well-trained, adaptable and skilled, and have the proper temperament to contribute to a self-organizing team. When XP is to be applied for a significant project in a large organization, the concept of the "team" should morph into that of a *community.* A community may have a technologist and customers who are central to the success of a project as well as many other stakeholders (e.g., legal staff, quality auditors, manufacturing or sales types) who "are often at the periphery of an IXP project yet they may play important roles on the project". In IXP, the community members and their roles should be explicitly defined and mechanisms for communication and coordination between community members should be established.
- **Project chartering.** The IXP team assesses the project itself to determine whether an appropriate business justification for the project exists and whether the project will further the overall goals and objectives of the organization. Chartering also examines the context of the project to determine how it complements, extends, or replaces existing systems or processes.
- **Test-driven management.** An IXP project requires measurable criteria for assessing the state of the project and the progress that has been made to date. Test-driven management establishes a series of measurable
  "destinations" and then defines mechanisms for determining whether or not these destinations have been reached.
- **Retrospectives.** An IXP team conducts a specialized technical review after a software increment is delivered.
  Called a *retrospective,* the review examines "issues, events, and lessons-learned" across a software increment and/or the entire software release. The intent is to improve the IXP process.
- **Continuous learning.** Because learning is a vital part of continuous process improvement, members of the XP team are encouraged (and possibly, incented) to learn new methods and techniques that can lead to a higher quality product.

1.18.4 XP Debate

All new process models and methods spur worthwhile discussion and in some instances heated debate. Among the issues that continue to trouble some critics of XP are:

- ***Requirements volatility***. Because the customer is an active member of the XP team, changes to requirements are requested informally. As a consequence, the scope of the project can change and earlier work may have to be modified to accommodate current needs. Proponents argue that this happens regardless of the process that is applied and that XP provides mechanisms for controlling scope creep.
- ***Conflicting customer needs***. Many projects have multiple customers, each with his own set of needs. In XP, the team itself is tasked with assimilating the needs of different customers, a job that may be beyond their scope of authority.

• ***Requirements are expressed informally***. User stories and acceptance tests are the only explicit manifestation of requirements in XP. Critics argue that a more formal model or specification is often needed to ensure that omissions, inconsistencies, and errors are uncovered before the system is built. Proponents counter that the changing nature of requirements makes such models and specification obsolete almost as soon as they are developed.

• ***Lack of formal design***. XP deemphasizes the need for architectural design and in many instances, suggests that design of all kinds should be relatively informal. Critics argue that when complex systems are built, design must be emphasized to ensure that the overall structure of the software will exhibit quality and maintainability. XP proponents suggest that the incremental nature of the XP process limits complexity (simplicity is a core value) and therefore reduces the need for extensive design.

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1.19 OTHER AGILE PROCESS MODELS

Other agile process models have been proposed and are in use across the industry. Among the most common are:

- Adaptive Software Development (ASD)
- Scrum
- Dynamic Systems Development Method (DSDM)
- Crystal
- Feature Drive Development (FDD)
- Lean Software Development (LSD)
- Agile Modeling (AM)
- Agile Unified Process (AUP)

1.19.1Adaptive Software Development (ASD)

Adaptive Software Development (ASD) has been proposed by Jim Highsmith as a technique for building complex software and systems. The philosophical underpinnings of ASD focus on human collaboration and team selforganization. High smith argues that an agile, adaptive development approach based on collaboration is "as much a source of *order* in our complex interactions as discipline and engineering." He defines an ASD "life cycle" that incorporates three phases, speculation, collaboration, and learning.

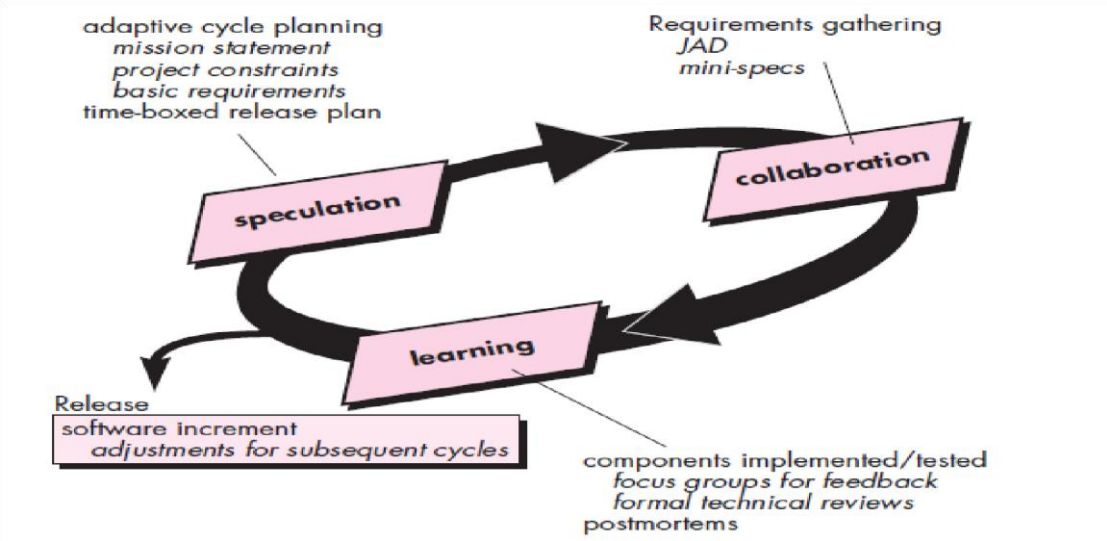


Fig : Adaptive software development

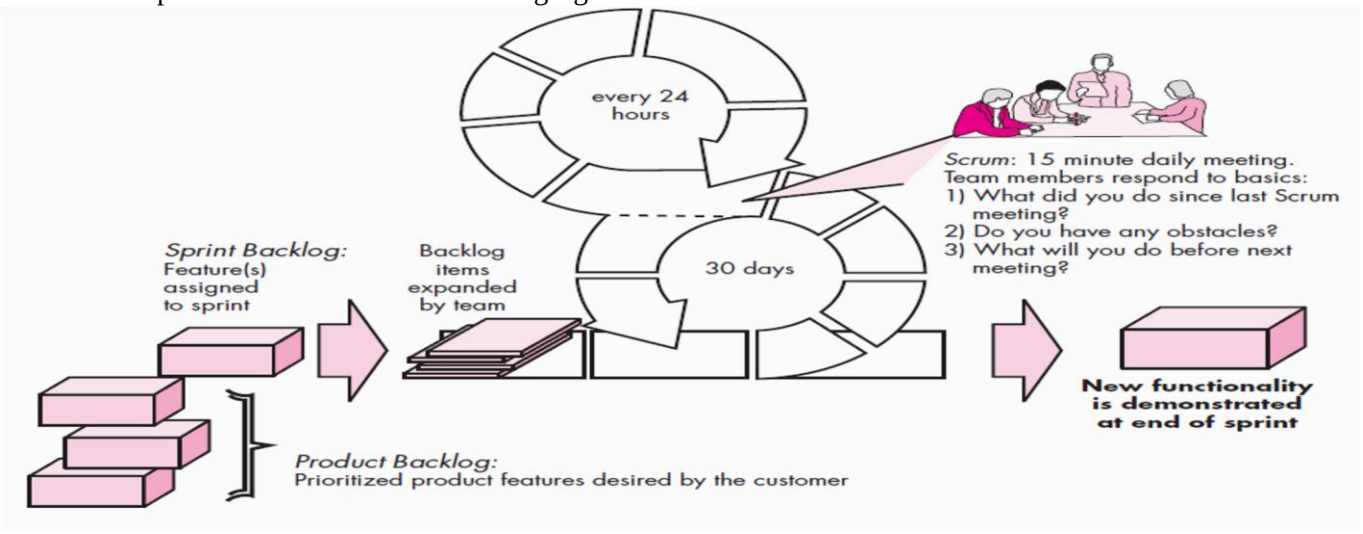
During ***speculation***, the project is initiated and ***adaptive cycle planning*** is conducted. Adaptive cycle planning uses project initiation information—the customer's mission statement, project

constraints (e.g., delivery dates or user descriptions), and basic requirements—to define the set of release cycles (software increments) that will be required for the project.

Motivated people use ***collaboration*** in a way that multiplies their talent and creative output beyond their absolute numbers. This approach is a recurring theme in all agile methods. But collaboration is not easy. It encompasses communication and teamwork, but it also emphasizes individualism, because individual creativity plays an important role in collaborative thinking. It is, above all, a matter of trust. People working together must trust one another to (1) criticize without animosity, (2) assist without resentment, (3) work as hard as or harder than they do, (4) have the skill set to contribute to the work at hand, and (5) communicate problems or concerns in a way that leads to effective action. As members of an ASD team begin to develop the components that are part of an adaptive cycle, the emphasis is on **"learning**" as much as it is on progress toward a completed cycle. ASD teams learn in **three** ways: **focus groups, technical reviews , and project postmortems**.

1.19.2 Scrum

Scrum is an agile software development method that was conceived by Jeff Sutherland and his development team in the early 1990s. Scrum principles are consistent with the agile manifesto and are used to guide development activities within a process that incorporates the following framework activities: requirements, analysis, design, evolution, and delivery. Within each framework activity, work tasks occur within a process pattern called a ***sprint.*** The work conducted within a sprint is adapted to the problem at hand and is defined and often modified in real time by the Scrum team. The overall flow of the Scrum process is illustrated in following figure



Scrum emphasizes the use of a set of software process patterns that have proven effective for projects with tight timelines, changing requirements, and business criticality. Each of these process patterns defines a set of development actions:

- ***Backlog***—a prioritized list of project requirements or features that provide business value for the customer. Items can be added to the backlog at any time. The product manager assesses the backlog and updates priorities as required.
- ***Sprints***—consist of work units that are required to achieve a requirement defined in the backlog that must be fit into a predefined time-box (typically 30 days). Changes (e.g., backlog work items) are not introduced during the sprint. Hence, the sprint allows team members to work in a short-term, but stable environment.
- ***Scrum meetings***—are short (typically 15 minutes) meetings held daily by the Scrum team. Three key questions are asked and answered by all team members ○ What did you do since the last team meeting? ○ What obstacles are you encountering?
  ○ What do you plan to accomplish by the next team meeting?

A team leader, called a ***Scrum master***, leads the meeting and assesses the responses from each person. The Scrum meeting helps the team to uncover potential problems as early as possible. Also, these daily meetings lead to "**knowledge socialization**"

- ***Demos***—deliver the software increment to the customer so that functionality that has been implemented can be demonstrated and evaluated by the customer. It is important to note that the demo may not contain all planned functionality, but rather those functions that can be delivered within the time-box that was established.

1.19.3 Dynamic Systems Development Method (DSDM)

The *Dynamic Systems Development Method* (DSDM) is an agile software development approach that "provides a framework for building and maintaining systems which meet tight time constraints through the use of incremental prototyping in a controlled project environment" The DSDM philosophy is borrowed from a modified version of the **Pareto principle—80 percent of an application can be delivered in 20 percent of the time.** It would take to deliver the complete (100 percent) application. DSDM is an iterative software process in which each iteration follows the 80 percent rule. That is, only enough work is required for each increment to facilitate movement to the next increment. The remaining detail can be completed later when more business requirements are known or changes have been requested and accommodated.

The *DSDM life cycle* that defines **three** different iterative cycles, preceded by **two** additional life cycle activities:

- ***Feasibility study***—establishes the basic business requirements and constraints associated with the application to be built and then assesses whether the application is a viable candidate for the DSDM process
- ***Business study***—establishes the functional and information requirements that will allow the application to provide business value; also, defines the basic application architecture and identifies the maintainability requirements for the application.
- ***Functional model iteration***—produces a set of incremental prototypes that demonstrate functionality for the customer.
- ***Design and build iteration***—revisits prototypes built during ***functional model iteration*** to ensure that each has been engineered in a manner that will enable it to provide operational business value for end users. In some cases, *functional model iteration* and *design and build iteration* occur concurrently.
- ***Implementation***—places the latest software increment into the operational environment. It should be noted that (1) the increment may not be 100 percent complete or (2) changes may be requested as the increment is put into place. In either case, DSDM development work continues by returning to the functional model iteration activity.

1.19.4 Crystal

Alistair Cockburn and Jim Highsmith created the *Crystal family of agile methods* in order to achieve a software development approach that puts a premium on "maneuverability" during what Cockburn characterizes as "a resource limited, cooperative game of invention and communication, with a primary goal of delivering useful, working software and a secondary goal of setting up for the next game"

The Crystal family is actually a set of example agile processes that have been proven effective for different types of projects. The intent is to allow agile teams to select the member of the crystal family that is most appropriate for their project and environment.

1.19.5 Feature Driven Development (FDD)

Feature Driven Development (FDD) was originally conceived by Peter Coad and his colleagues as a practical process model for object-oriented software engineering. Stephen Palmer and John Felsing have extended and improved

Coad's work, describing an adaptive, agile process that can be applied to moderately sized and larger software projects.

Like other agile approaches, FDD adopts a philosophy that (1) emphasizes collaboration among people on an FDD team; (2) manages problem and project complexity using feature-based decomposition followed by the integration of software increments, and (3) communication of technical detail using verbal, graphical, and text-based means.

FDD emphasizes software quality assurance activities by encouraging an incremental development strategy, the use of design and code inspections, the application of software quality assurance audits, the collection of metrics, and the use of patterns (for analysis, design, and construction).

In the context of FDD, a *feature* "is a client-valued function that can be implemented in two weeks or less" The emphasis on the definition of features provides the following benefits:

- Because features are small blocks of deliverable functionality, users can describe them more easily; understand how they relate to one another more readily; and better review them for ambiguity, error, or omissions.
- Features can be organized into a hierarchical business-related grouping.
- Since a feature is the FDD deliverable software increment, the team develops operational features every two weeks.
- Because features are small, their design and code representations are easier to inspect effectively.
- Project planning, scheduling, and tracking are driven by the feature hierarchy, rather than an arbitrarily adopted software engineering task set.

Coad and his colleagues suggest the following template for defining a feature:

<action> the **<result>** **<by for of to>** a(n) **<object>**

where an **<object>** is "a person, place, or thing

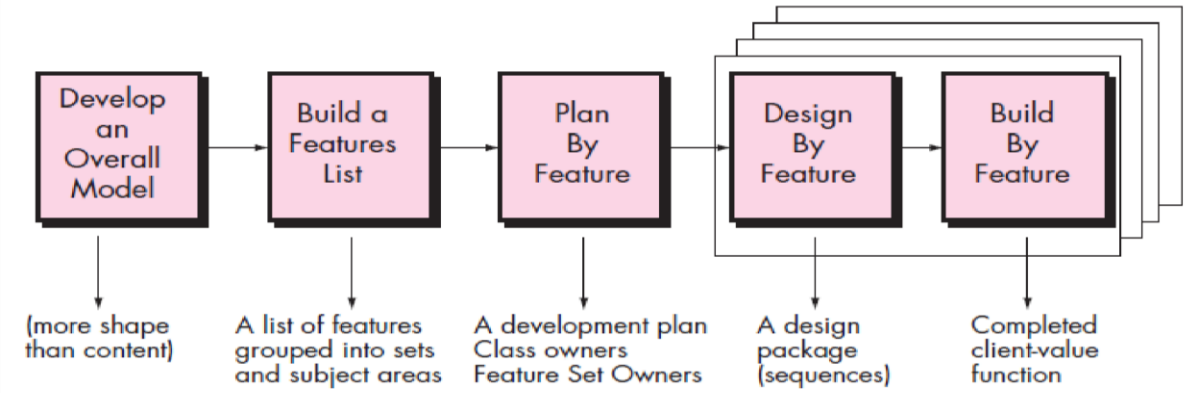


Fig : Feature Driven Development (FDD)

FDD provides greater emphasis on project management guidelines and techniques than many other agile methods. FDD defines **six** milestones during the design and implementation of a feature: "**design walkthrough, design, design inspection, code, code inspection, promote to build**"

1.19.6 Lean Software Development (LSD)

Lean Software Development (LSD) has adapted the principles of lean manufacturing to the world of software engineering. The lean principles that inspire the LSD process can be summarized as ***eliminate waste, build quality in, create knowledge, defer commitment, deliver fast, respect people,*** **and** ***optimize the whole***. Each of these principles can be adapted to the software process.

1.19.7 Agile Modeling (AM)

Agile Modeling (AM) is a practice-based methodology for effective modeling and documentation of softwarebased systems. Simply put, Agile Modeling (AM) is a collection of values, principles, and practices for modeling software that can be applied on a software development project in an effective and light-weight manner. Agile models are more effective than traditional models because they are just barely good, they don't have to be perfect.

Agile modeling adopts all of the values that are consistent with the agile manifesto. The agile modeling philosophy recognizes that an agile team must have the courage to make decisions that may cause it to reject a design and refactor. The team must also have the humility to recognize that technologists do not have all the answers and that business experts and other stakeholders should be respected and embraced.

Agile Modeling suggests a wide array of "core" and "supplementary" modeling principles, those that make AM unique are :

- **Model with a purpose.** A developer who uses AM should have a specific goal in mind before creating the model. Once the goal for the model is identified, the type of notation to be used and level of detail required will be more obvious.
- **Use multiple models.** There are many different models and notations that can be used to describe software. Only a small subset is essential for most projects. AM suggests that to provide needed insight, each model should present a different aspect of the system and only those models that provide value to their intended audience should be used.
- **Travel light.** As software engineering work proceeds, keep only those models that will provide long-term value and jettison the rest. Every work product that is kept must be maintained as changes occur. This represents work that slows the team down. Ambler notes that "Every time you decide to keep a model you trade-off agility for the convenience of having that information available to your team in an abstract manner
- **Content is more important than representation.** Modeling should impart information to its intended audience. A syntactically perfect model that imparts little useful content is not as valuable as a model with flawed notation that nevertheless provides valuable content for its audience.
- **Know the models and the tools you use to create them.** Understand the strengths and weaknesses of each model and the tools that are used to create it.
- **Adapt locally.** The modeling approach should be adapted to the needs of the agile team.

1.19.8 Agile Unified Process (AUP) The ***Agile Unified Process*** (AUP) adopts a "serial in the large" and "iterative in the small" philosophy for building computer-based systems. By adopting the classic UP phased activities—*inception, elaboration, construction,* and *transition*—AUP provides a serial overlay that enables a team to visualize the overall process flow for a software project. However, within each of the activities, the team iterates to achieve agility and to deliver meaningful software increments to end users as rapidly as possible. Each AUP iteration addresses the following activities.

- ***Modeling***. UML representations of the business and problem domains are created.
- ***Implementation.*** Models are translated into source code.
- ***Testing***. Like XP, the team designs and executes a series of tests to uncover errors and ensure that the source code meets its requirements.
- ***Deployment.*** Like the generic process activity deployment in this context focuses on the delivery of a software increment and the acquisition of feedback from end users.
- ***Configuration and project management.*** In the context of AUP, configuration management addresses change management, risk management, and the control of any persistent work products that are produced by the team. Project management tracks and controls the progress of the team and coordinates team activities.
- ***Environment management.*** Environment management coordinates a process infrastructure that includes standards, tools, and other support technology available to the team.