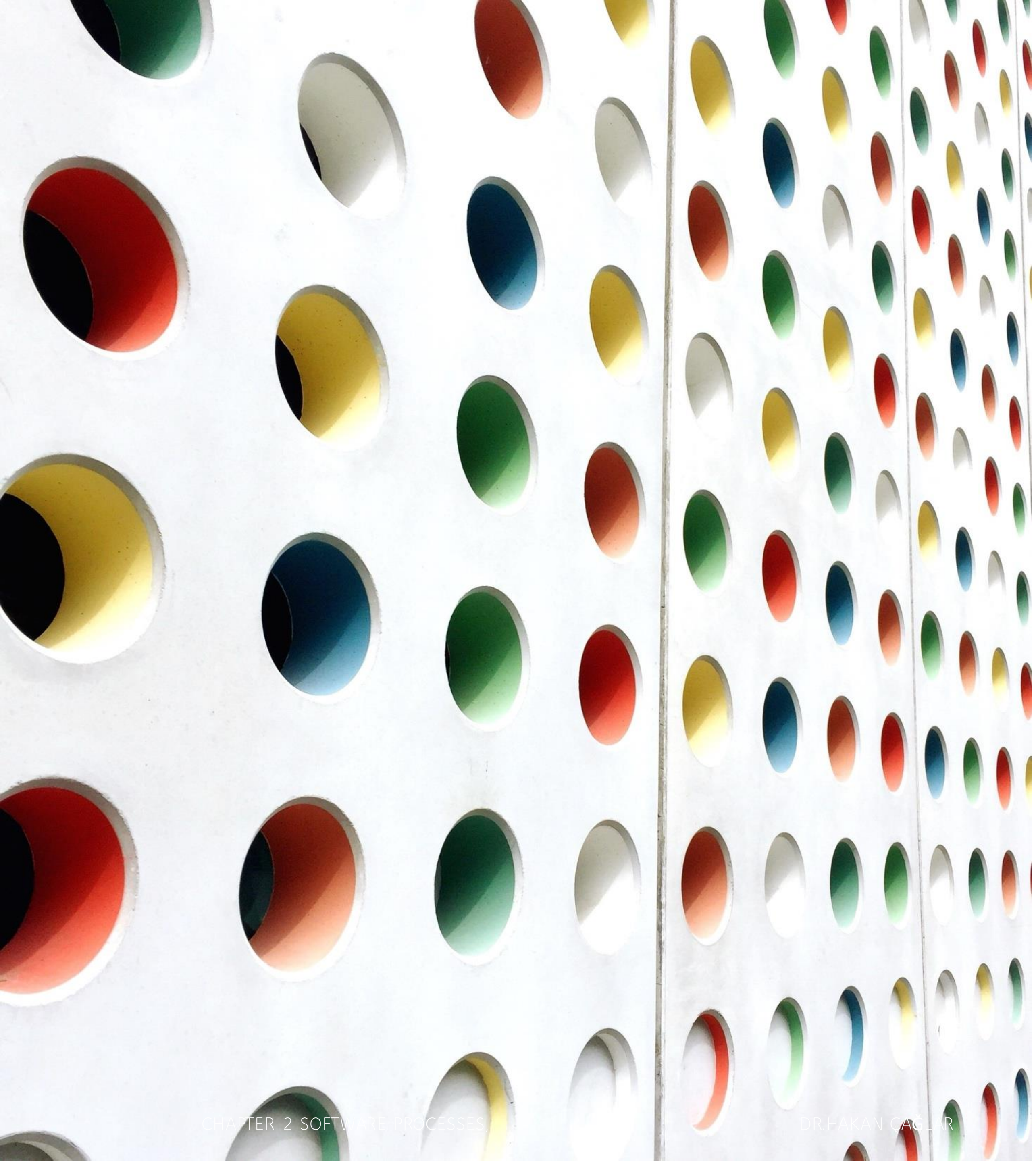


Software Processes

Prof.Dr Hakan Çağlar

Chapter 2 – Software Processes

Topics covered

- Software process models
- Process activities
- Coping with change
- Process improvement

The software process

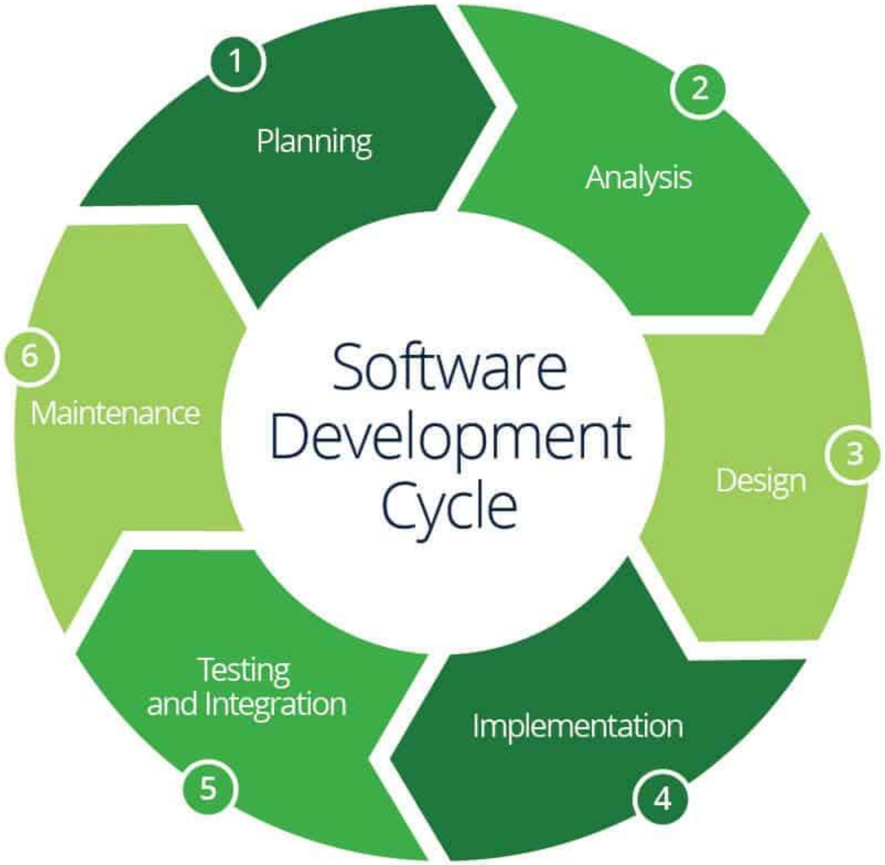
A structured set of activities required to develop a software system.

Many different software processes but all involve:

- Specification – defining what the system should do;
- Design and implementation – defining the organization of the system and implementing the system;
- Validation & Verification – checking that it does what the customer wants;
- Evolution – changing the system in response to changing customer needs.

A software process model is an abstract representation of a process. It presents a description of a process from some particular perspective.

Software development cycle



Software process descriptions

When we describe and discuss processes, we usually talk about the activities in these processes such as specifying a data model, designing a user interface, etc. and the ordering of these activities.

Process descriptions may also include:

- Products, which are the outcomes of a process activity;
- Roles, which reflect the responsibilities of the people involved in the process;
- Pre- and post-conditions, which are statements that are true before and after a process activity has been enacted or a product produced.

Plan-driven and agile processes

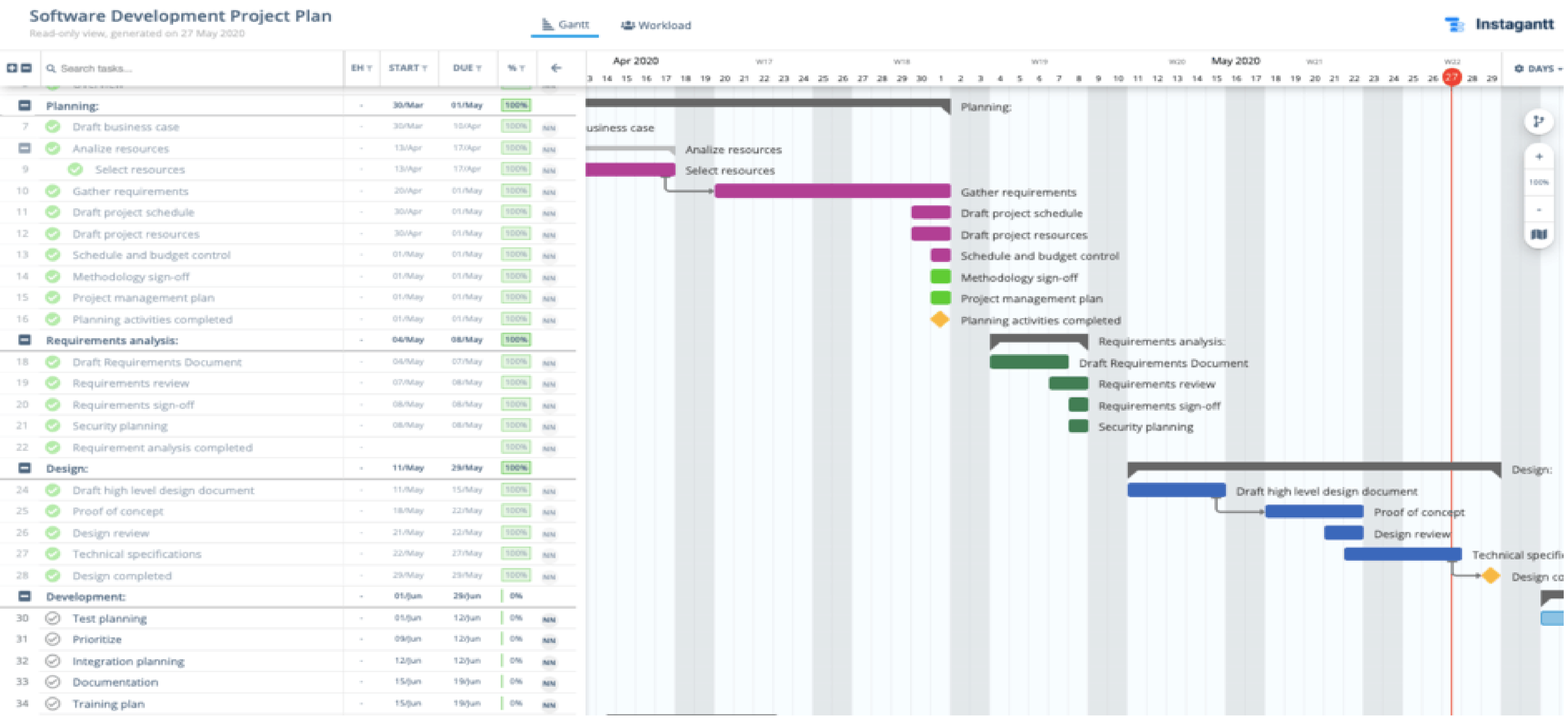
Plan-driven processes are processes where all of the process activities are planned in advance and progress is measured against this plan.

In agile processes, planning is incremental and it is easier to change the process to reflect changing customer requirements.

In practice, most practical processes include elements of both plan-driven and agile approaches.

There are no right or wrong software processes.

Software project planning



Software Development Project Plan

Read-only view, generated on 27 May 2020

	Search tasks...	EH	START	DUE	%	
	Planning:	-	30/Mar	01/May	100%	
7	Draft business case	-	30/Mar	10/Apr	100%	NN
	Analize resources	-	13/Apr	17/Apr	100%	NN
9	Select resources	-	13/Apr	17/Apr	100%	NN
10	Gather requirements	-	20/Apr	01/May	100%	NN
11	Draft project schedule	-	30/Apr	01/May	100%	NN
12	Draft project resources	-	30/Apr	01/May	100%	NN
13	Schedule and budget control	-	01/May	01/May	100%	NN
14	Methodology sign-off	-	01/May	01/May	100%	NN
15	Project management plan	-	01/May	01/May	100%	NN
16	Planning activities completed	-	01/May	01/May	100%	NN
	Requirements analysis:	-	04/May	08/May	100%	
18	Draft Requirements Document	-	04/May	07/May	100%	NN
19	Requirements review	-	07/May	08/May	100%	NN
20	Requirements sign-off	-	08/May	08/May	100%	NN
21	Security planning	-	08/May	08/May	100%	NN
22	Requirement analysis completed	-			100%	NN
	Design:	-	11/May	29/May	100%	
24	Draft high level design document	-	11/May	15/May	100%	NN
25	Proof of concept	-	18/May	22/May	100%	NN
26	Design review	-	21/May	22/May	100%	NN
27	Technical specifications	-	22/May	27/May	100%	NN
28	Design completed	-	29/May	29/May	100%	NN
	Development:	-	01/Jun	29/Jun	0%	
30	Test planning	-	01/Jun	12/Jun	0%	NN
31	Prioritize	-	09/Jun	12/Jun	0%	NN
32	Integration planning	-	12/Jun	12/Jun	0%	NN
33	Documentation	-	15/Jun	19/Jun	0%	NN
34	Training plan	-	15/Jun	19/Jun	0%	NN

Software process models

Software process models

The waterfall model

- Plan-driven model. Separate and distinct phases of specification and development.

Incremental development

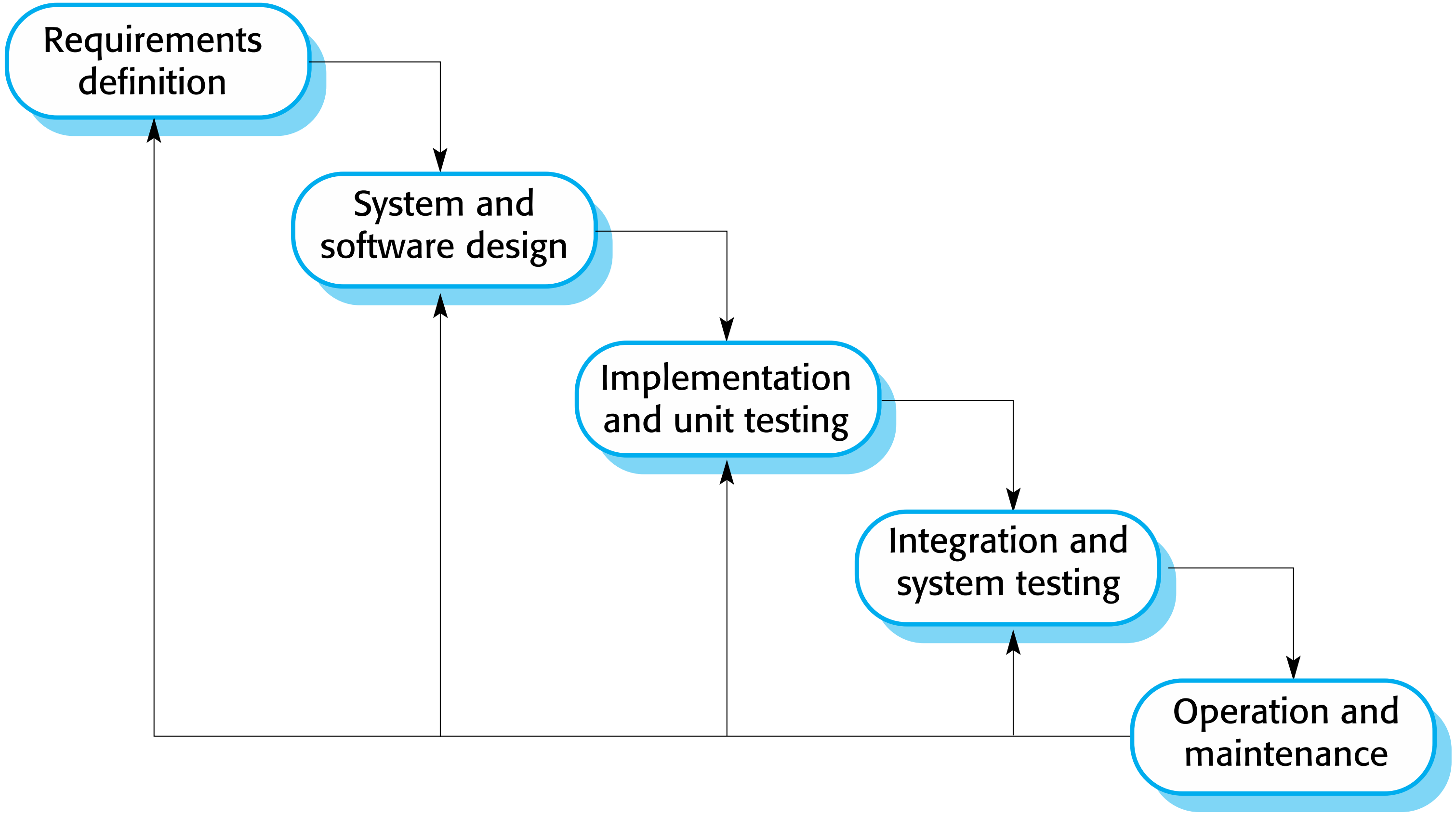
- Specification, development and validation are interleaved. May be plan-driven or agile.

Integration and configuration

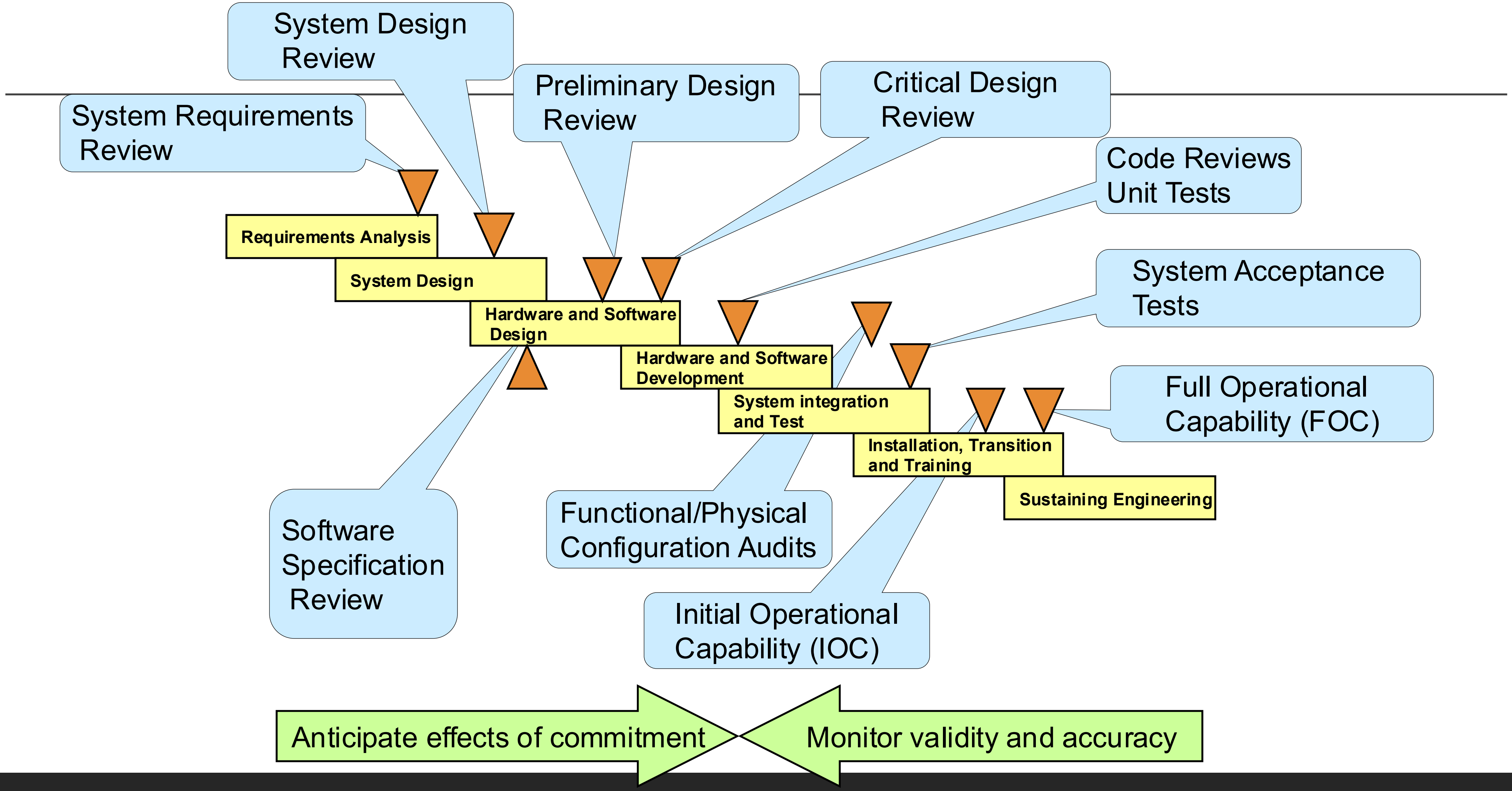
- The system is assembled from existing configurable components. May be plan-driven or agile.

In practice, most large systems are developed using a process that incorporates elements from all of these models.

The waterfall model


Requirements definition
System and software design
Implementation and unit testing
Integration and system testing
Operation and maintenance

Systems Development Activities and Milestones


System Design Review
System Requirements Review
Preliminary Design Review
Critical Design Review
Code Reviews Unit Tests
System Acceptance Tests
Full Operational Capability (FOC)
Requirements Analysis
System Design
Hardware and Software Design
Hardware and Software Development
System integration and Test
Installation, Transition and Training
Sustaining Engineering
Software Specification Review
Functional/Physical Configuration Audits
Initial Operational Capability (IOC)
Anticipate effects of commitment
Monitor validity and accuracy

e-Business System Requirements
Functional Requirements:

RF.1: The system shall allow users to register, log in, and log out using a secure authentication mechanism (log in/password).

RF.2:The system shall allow users to update personal information such as name, address, password, and contact details.

RF.3: The system shall display a catalog of products organized by categories, allowing users to view product details and availability.

RF.4: The system shall allow users to search for products by name, category, or keyword and apply filters such as price range, brand, and rating.

RF.5: The system shall allow user to add, update, or remove products from a shopping cart and view a summary of their selected items.

RF.6: The system shall allow administrators to add, edit, delete, and categorize products, including uploading images and setting prices and stock levels.

RF.7: The system shall allow users to view their past orders and current order status (e.g., pending, shipped, delivered).

RF.8: The system shall allow users to leave reviews and ratings for products they have purchased.

RF.9: The system shall process payments through supported payment methods (e.g., credit card, PayPal, bank transfer) using a secure payment gateway.

RF.10: The system shall provide an AI-based product recommendation engine that suggests relevant products based on user behavior and preferences.

RF.11: The system shall offer 24/7 AI-driven chatbot assistance to help users with product inquiries, order tracking, and FAQs.

RF.12: The system shall use AI algorithms to adjust prices dynamically based on demand, stock levels, and user segments.

RF.13: The system may utilize AI models to detect and flag potentially fraudulent transactions in real-time.

RF.14: The system may use AI to generate and send personalized email promotions based on user activity and preferences.

Actors:

- **User:** Any customer who uses the platform to browse, purchase, and interact with products.
- **Administrator:** Manages the product catalog and possibly oversees system functions.
- **Payment Gateway:** External system used for processing payments.
- **AI System:** Internal subsystem handling recommendations, dynamic pricing, fraud detection, etc.
- **Chatbot:** An automated assistant that handles support and FAQs.

ReqID vs Use Case(s) & Actor

RF.1	Register, Login, Logout	User
RF.2	Update Personal Info	User
RF.3	View Product Catalog, View Product Details	User
RF.4	Search Products, Apply Filters	User
RF.5	Add to Cart, Update Cart, Remove from Cart, View Cart Summary	User
RF.6	Add Product, Edit Product, Delete Product, Categorize Product, Upload Product Image, Set Price, Set Stock	Admin
RF.7	View Order History, Track Order Status	User

RF.8	Leave Review, Rate Product.	User
RF.9	Make Payment.	User & Payment Gateway
RF.10	Get Product Recommendations.	User & AI Engine
RF.11	Interact with Chatbot	User & Chatbot
RF.12	Apply Dynamic Pricing.	User & AI Engine
RF.13	Detect Fraudulent Transactions	AI Engine
RF.14	Send Personalized Promotions	User & AI Engine

Waterfall model phases

There are separate identified phases in the waterfall model:

- Requirements analysis and definition
- System and software design
- Implementation and unit testing
- Integration and system testing
- Operation and maintenance

The main drawback of the waterfall model is the difficulty of accommodating change after the process is underway. In principle, a phase has to be complete before moving onto the next phase.

Waterfall model problems

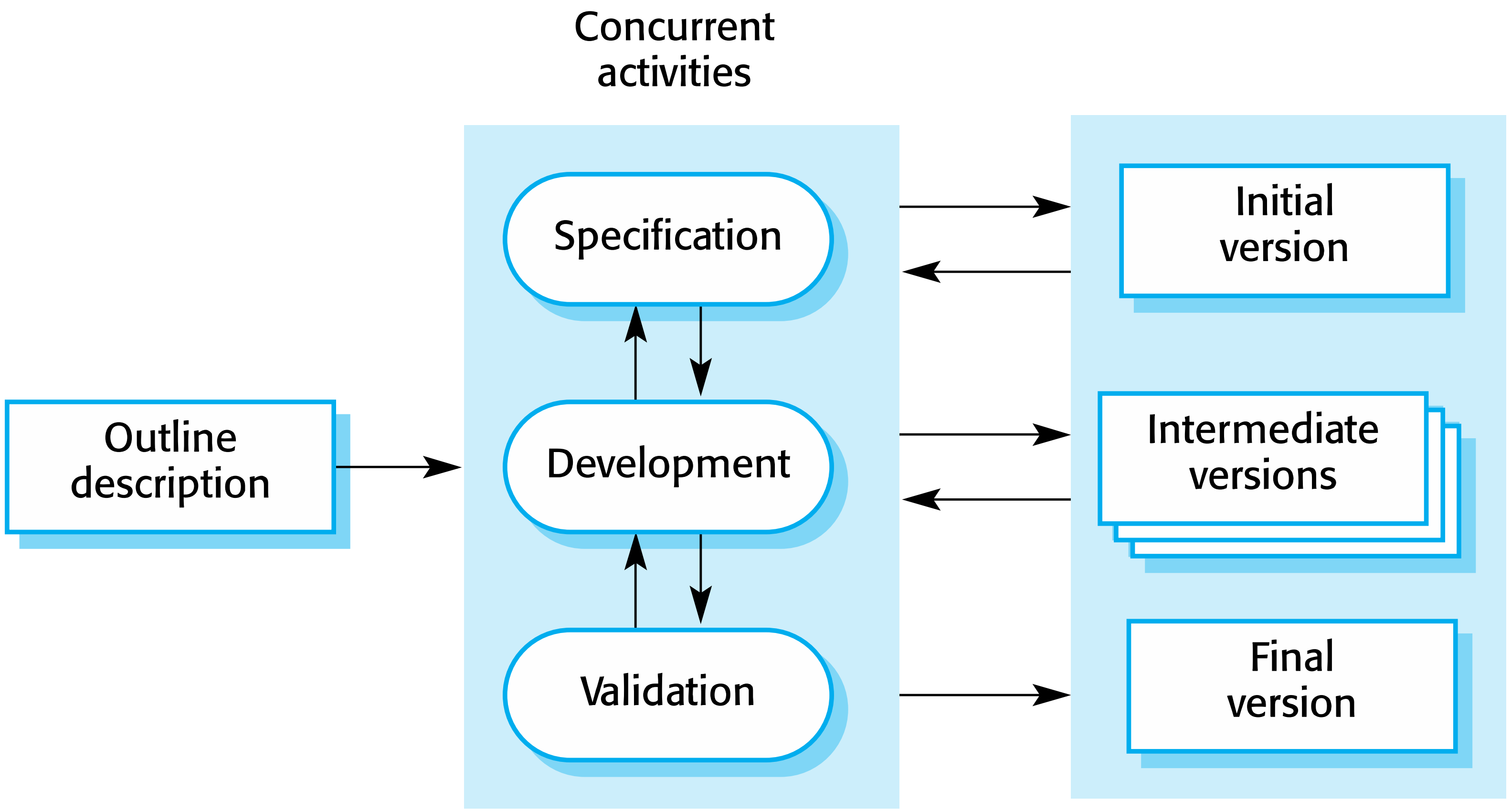
Inflexible partitioning of the project into distinct stages makes it difficult to respond to changing customer requirements.

- Therefore, this model is only appropriate when the requirements are well-understood and changes will be fairly limited during the design process.
- Few business systems have stable requirements.

The waterfall model is mostly used for large systems engineering projects where a system is developed at several sites.

- In those circumstances, the plan-driven nature of the waterfall model helps coordinate the work.

Incremental development



Incremental development benefits

The cost of accommodating changing customer requirements is reduced.

- The amount of analysis and documentation that has to be redone is much less than is required with the waterfall model.

It is easier to get customer feedback on the development work that has been done.

- Customers can comment on demonstrations of the software and see how much has been implemented.

More rapid delivery and deployment of useful software to the customer is possible.

- Customers are able to use and gain value from the software earlier than is not possible with a waterfall process.

Incremental development problems

The process is not visible.

- Managers need regular deliverables to measure progress. If systems are developed quickly, it is not cost-effective to produce documents that reflect every version of the system.

System structure tends to degrade as new increments are added.

- Unless time and money is spent on refactoring to improve the software, regular change tends to corrupt its structure. Incorporating further software changes becomes increasingly difficult and costly.

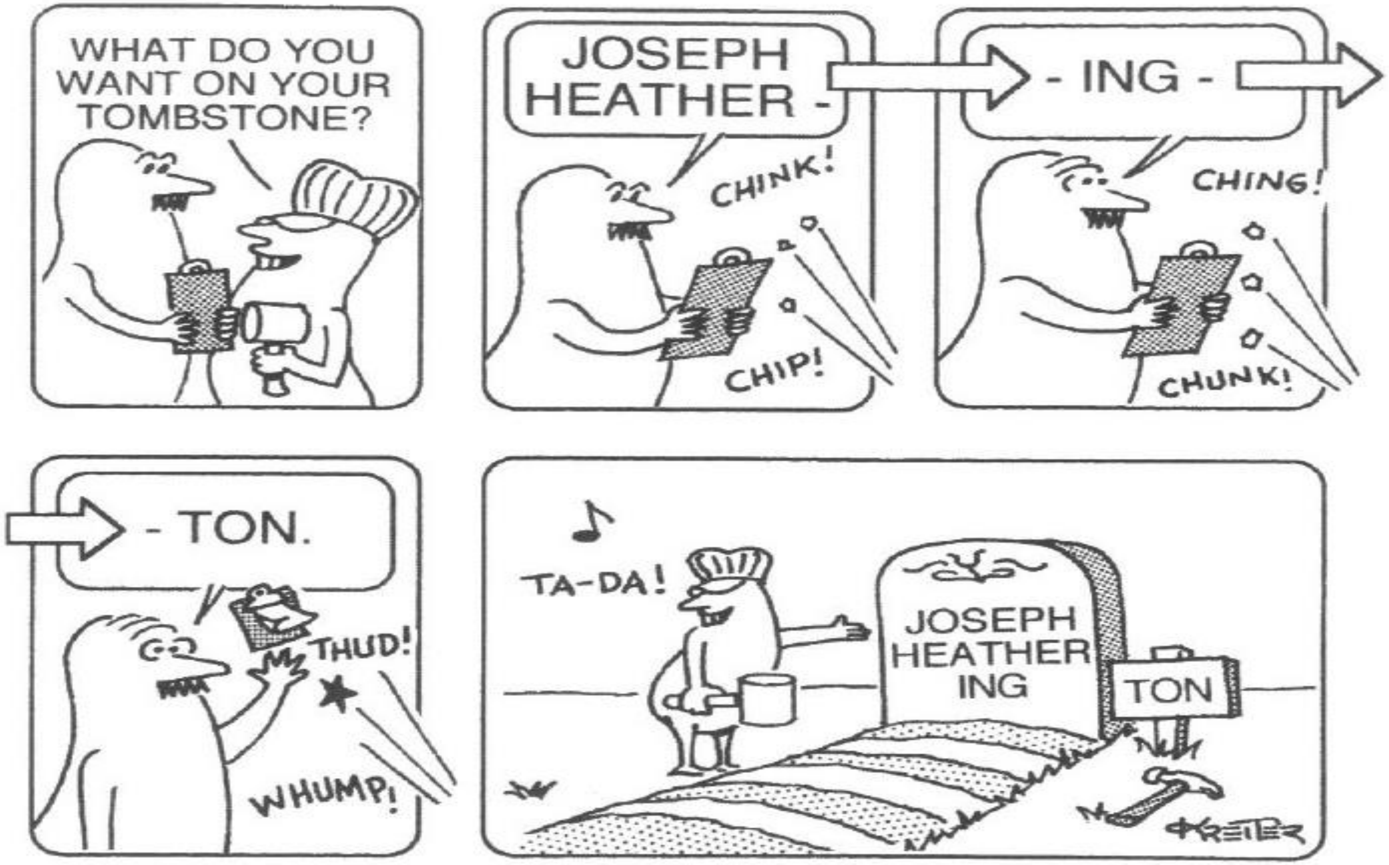
Integration and configuration

Based on software reuse where systems are integrated from existing components or application systems (sometimes called COTS - Commercial-off-the-shelf systems).

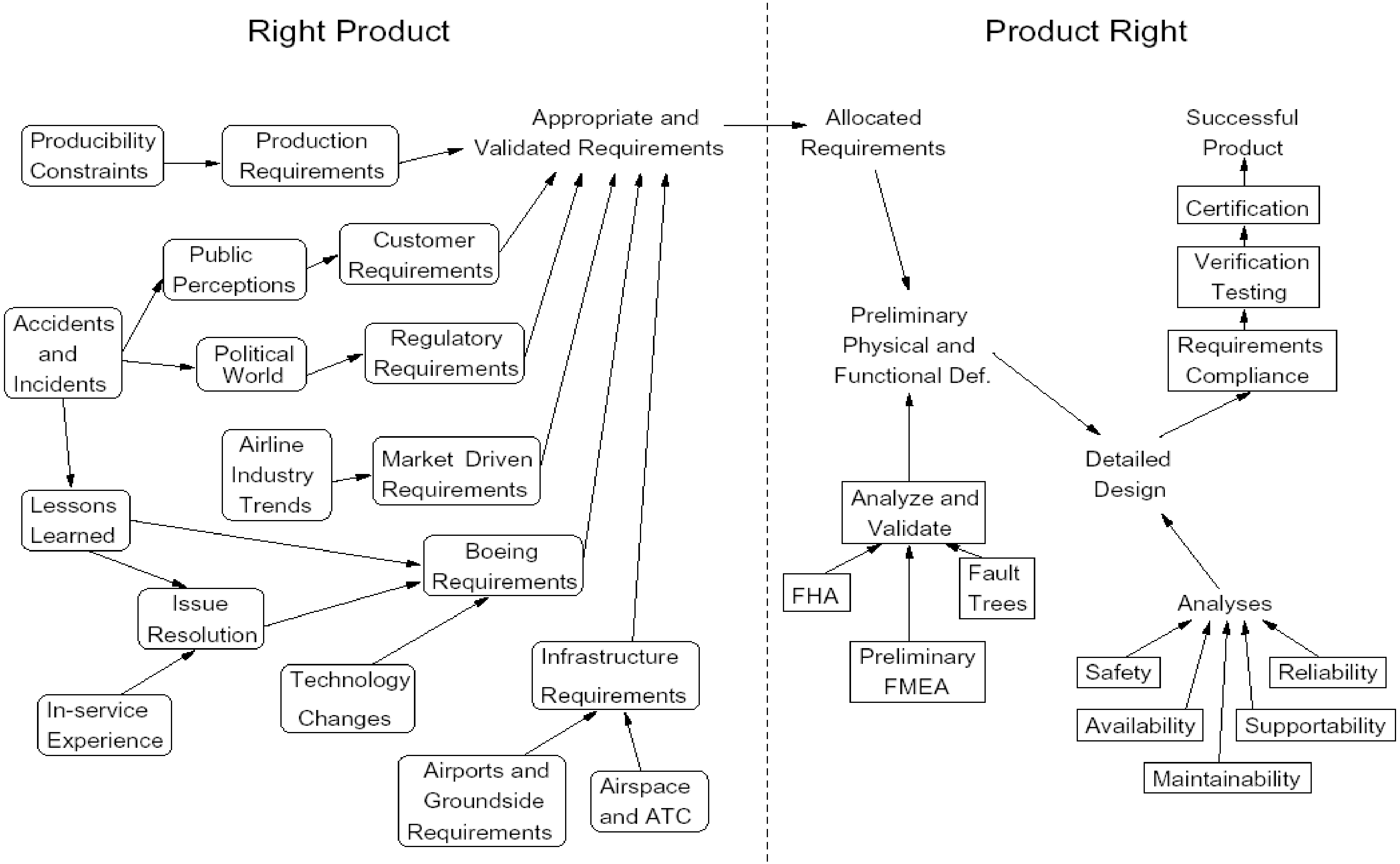
Reused elements may be configured to adapt their behaviour and functionality to a user’s requirements

Reuse is now the standard approach for building many types of business system (ERP SAP, Oracle etc.)

Risks and Problems With Requirements

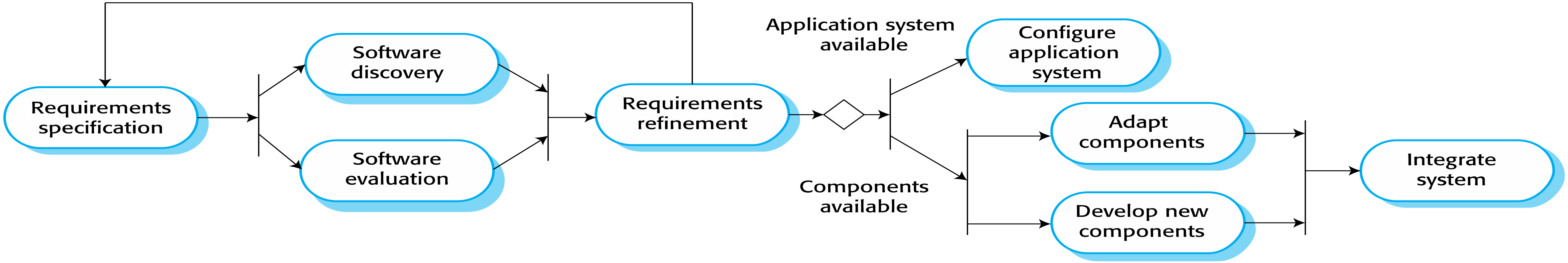


May be expensive to make changes after they have been aggreed.



Boeing Airplane Requirement process

Reuse-oriented software engineering



Key process stages

- Requirements specification
- Software discovery and evaluation
- Requirements refinement
- Application system configuration
- Component adaptation and integration

Advantages and disadvantages

Reduced costs and risks as less software is developed from scratch

Faster delivery and deployment of system

But requirements compromises are inevitable so system may not meet real needs of users

Loss of control over evolution of reused system elements

Process activities

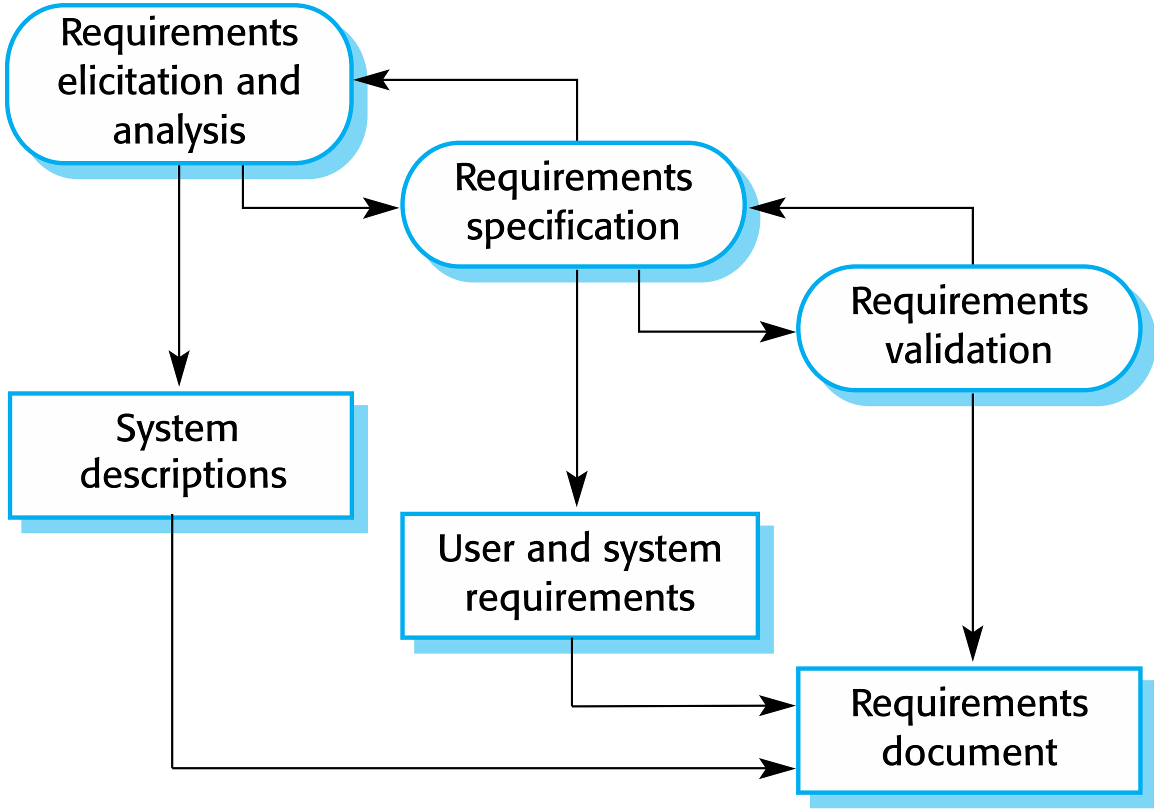
Process activities

Real software processes are inter-leaved sequences of technical, collaborative and managerial activities with the overall goal of specifying, designing, implementing and testing a software system.

The four basic process activities of specification, development, validation and evolution are organized differently in different development processes.

For example, in the waterfall model, they are organized in sequence, whereas in incremental development they are interleaved.

The requirements engineering process


Requirements elicitation and analysis
Requirements specification
Requirements validation
System descriptions
User and system requirements
Requirements document

Software specification

The process of establishing what services are required and the constraints on the system’s operation and development.

Requirements engineering process

- Requirements elicitation and analysis
  - What do the system stakeholders require or expect from the system?
- Requirements specification
  - Defining the requirements in detail
- Requirements validation
  - Checking the validity of the requirements

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Software design and implementation

The process of converting the system specification into an executable system.

Software design

- Design a software structure that realises the specification;

Implementation

- Translate this structure into an executable program;

The activities of design and implementation are closely related and may be inter-leaved.

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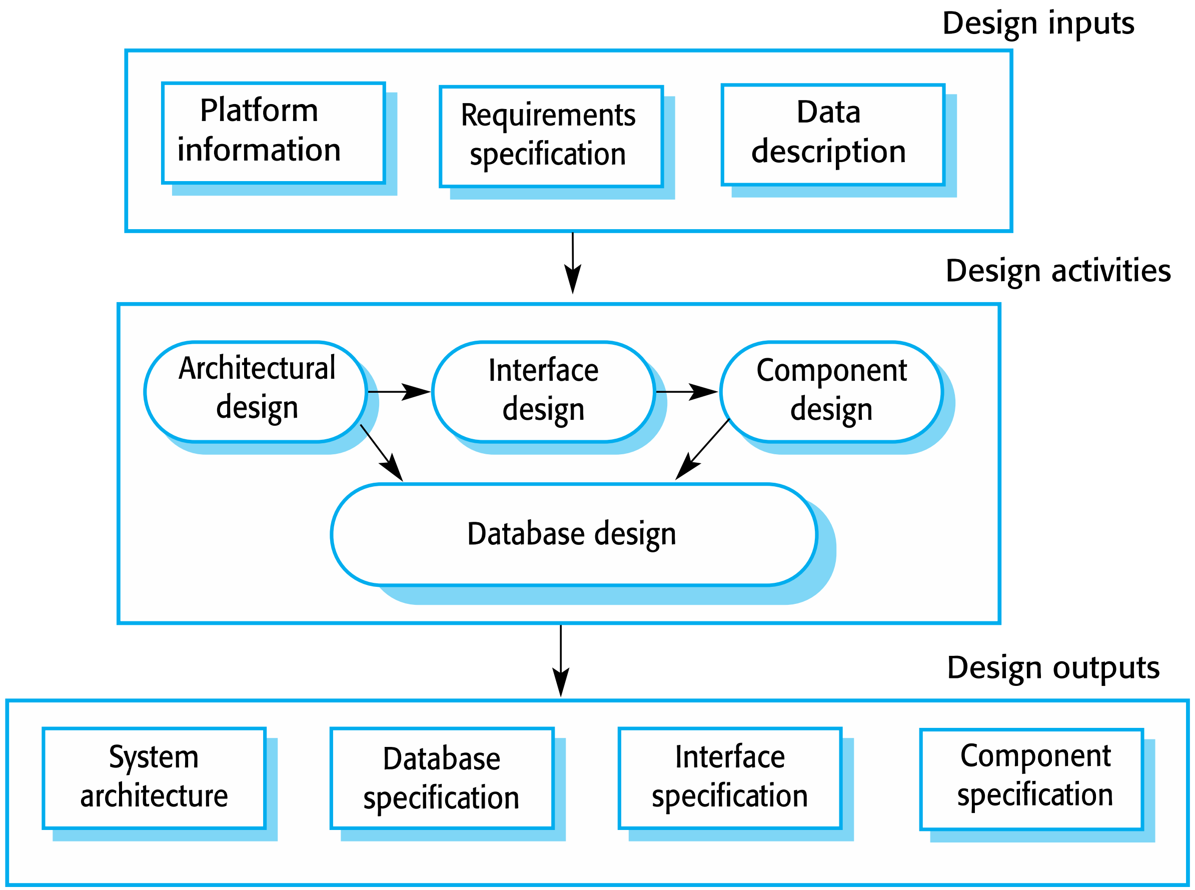
A general model of the design process



Design activities

Architectural design, where you identify the overall structure of the system, the principal components (subsystems or modules), their relationships and how they are distributed.

Database design, where you design the system data structures and how these are to be represented in a database.

Interface design, where you define the interfaces between system components. Internal & external interfaces.

Component selection and design, where you search for reusable components. If unavailable, you design how it will operate.

System implementation

The software is implemented either by developing a program or programs or by configuring an application system.

Design and implementation are interleaved activities for most types of software system.

Programming is an individual activity with no standard process.

Debugging is the activity of finding program faults and correcting these faults.

Software validation

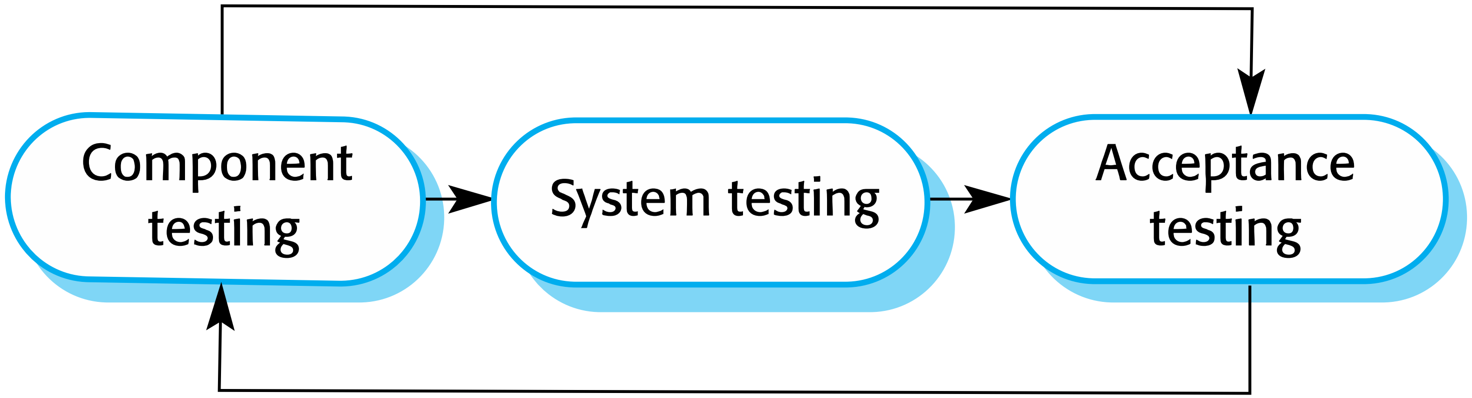
Verification and validation (V&V) is intended to show that a system conforms to its specification and meets the requirements of the system customer.

Involves checking and review processes and system testing.

System testing involves executing the system with test cases that are derived from the specification of the test data to be processed by the system.

Testing is the most commonly used V & V activity.

Stages of testing



Testing stages

Component testing

- Individual components are tested independently;
- Components may be functions or objects or coherent groupings of these entities.

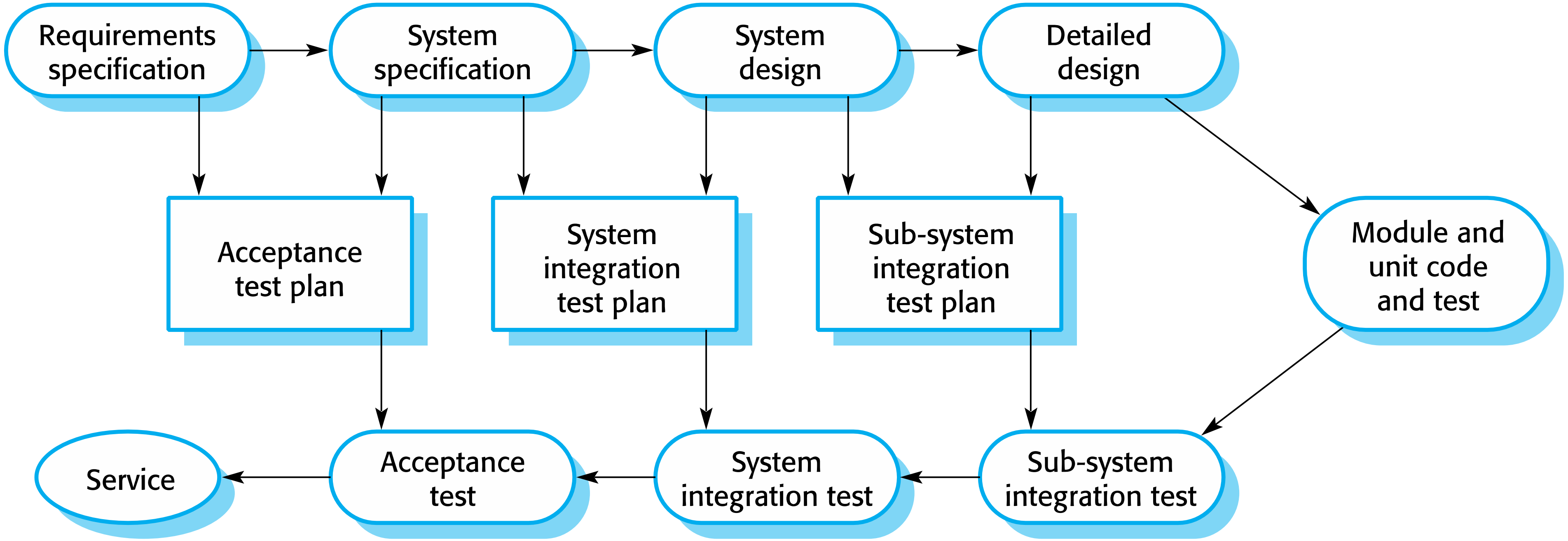
System testing

- Testing of the system as a whole. Testing of emergent properties (exceptional cases) is particularly important.

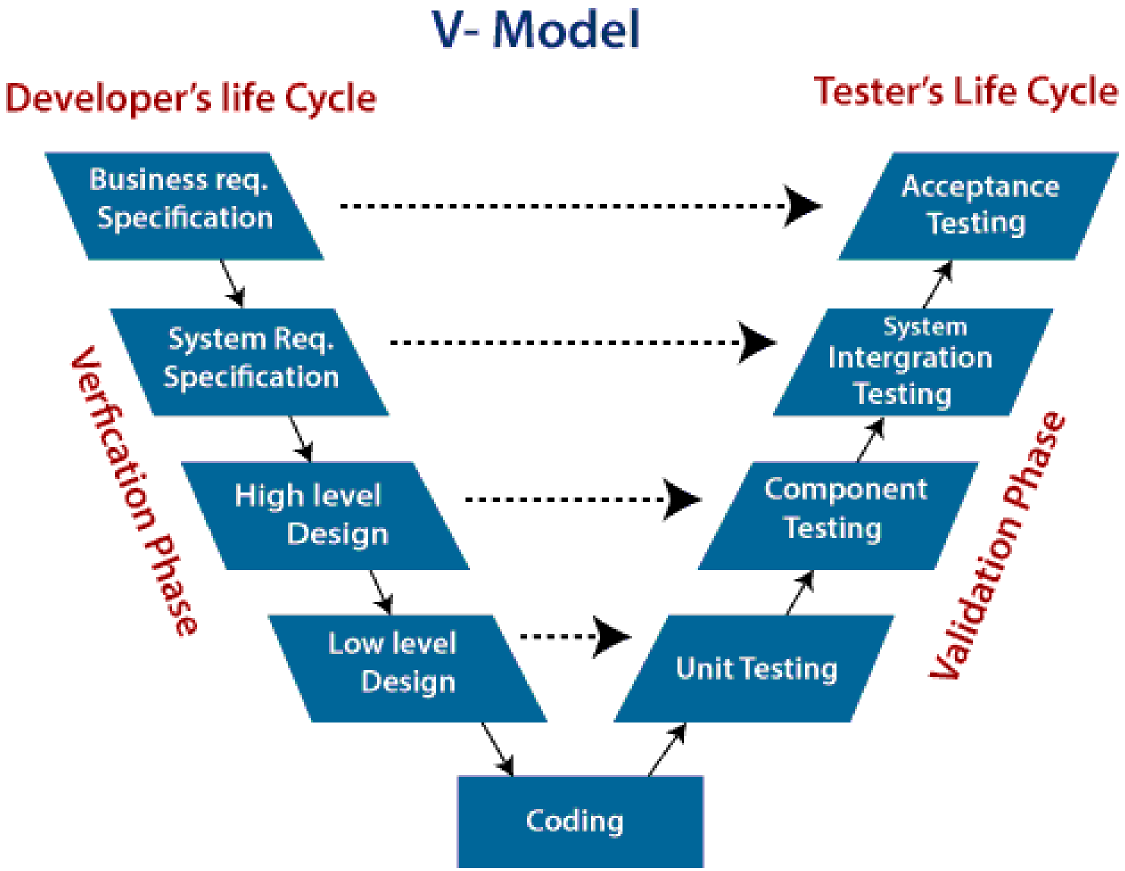
Customer testing (Acceptance testing)

- Testing with customer data to check that the system meets the customer’s needs.

Testing phases plan-driven software process (V-model)


Requirements specification
System specification
System design
Detailed design
Acceptance test plan
System integration test plan
Sub-system integration test plan
Module and unit code and test
Service
Acceptance test
System integration test
Sub-system integration test

V-Model


V- Model
Developer's life Cycle
Tester's Life Cycle
Business req. Specification
System Req. Specification
High level Design
Low level Design
Coding
Unit Testing
Component Testing
System Intergration Testing
Acceptance Testing
Verfication Phase
Validation Phase

Software evolution

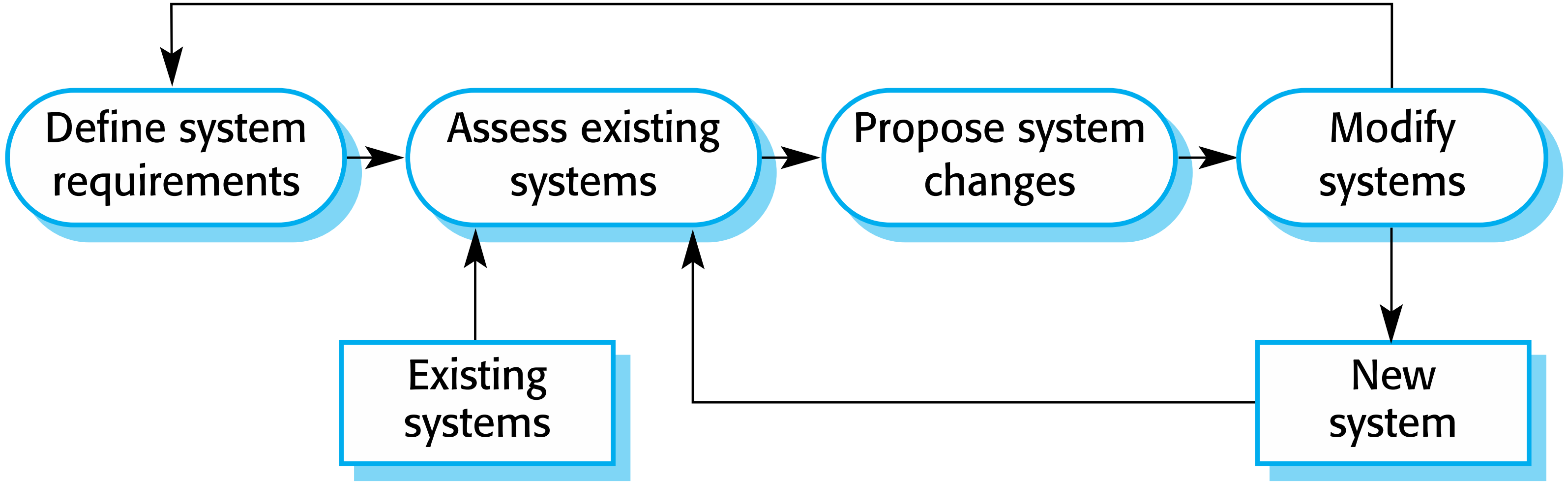
Software is inherently flexible and can change.

As requirements change through changing business circumstances, the software that supports the business must also evolve and change.

Although there has been a demarcation between development and evolution (maintenance) this is increasingly irrelevant as fewer and fewer systems are completely new.

Software life cycle is about 10 - 20 years.

System evolution



Coping with change

Coping with change

Change is inevitable in all large software projects.

- Business changes lead to new and changed system requirements
- New technologies open up new possibilities for improving implementations
- Changing platforms require application changes

Change leads to rework so the costs of change include both rework (e.g. re-analysing requirements) as well as the costs of implementing new functionality

Reducing the costs of rework

Change anticipation, where the software process includes activities that can anticipate possible changes before significant rework is required.

- For example, a prototype system may be developed to show some key features of the system to customers.

Change tolerance, where the process is designed so that changes can be accommodated at relatively low cost.

- This normally involves some form of incremental development. Proposed changes may be implemented in increments that have not yet been developed. If this is impossible, then only a single increment (a small part of the system) may have be altered to incorporate the change.

Coping with changing requirements

System prototyping, where a version of the system or part of the system is developed quickly to check the customer’s requirements and the feasibility of design decisions.

Incremental delivery, where system increments are delivered to the customer for comment and experimentation. This supports both change avoidance and change tolerance.

Software prototyping

A prototype is an initial version of a system used to demonstrate concepts and try out design options.

A prototype can be used in:

- The requirements engineering process to help with requirements elicitation and validation;
- In design processes to explore options and develop a UI design;

Benefits of prototyping

Improved system usability.

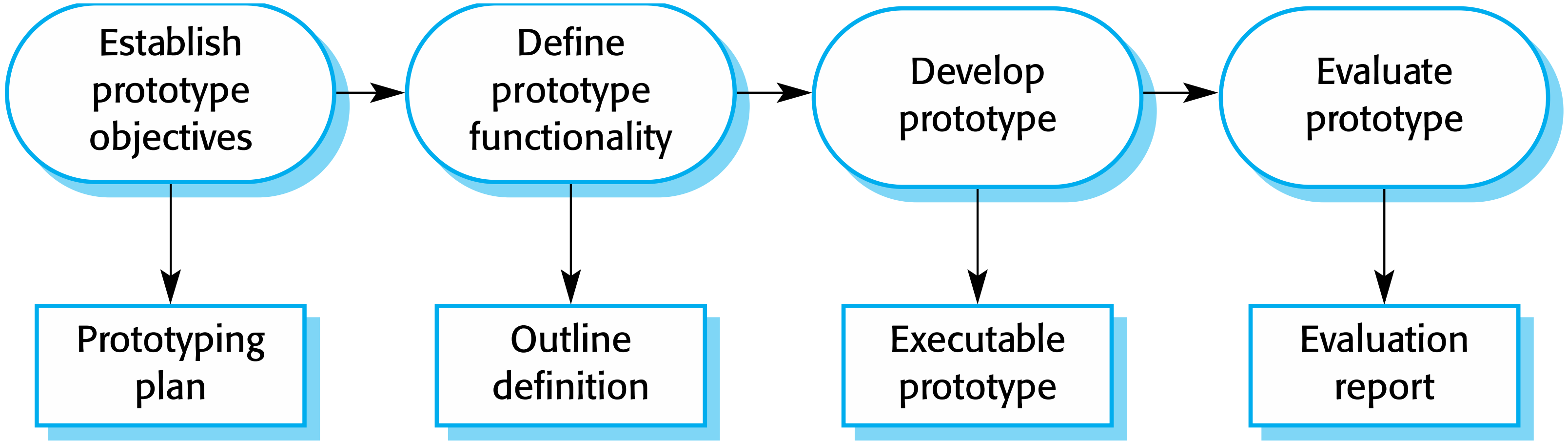
A closer match to users’ real needs.

Improved design quality.

Improved maintainability.

Reduced development effort.

The process of prototype development



Prototype development

May be based on rapid prototyping languages or tools

May involve leaving out functionality

- Prototype should focus on areas of the product that are not well-understood;
- Focus on functional rather than non-functional requirements such as reliability and security

Throw-away prototypes

Prototypes should be discarded after development as they are not a good basis for a production system:

- It may be impossible to tune the system to meet non-functional requirements;
- Prototypes are normally undocumented;
- The prototype structure is usually degraded through rapid change;
- The prototype probably will not meet normal organizational quality standards.

Incremental delivery

Rather than deliver the system as a single delivery, the development and delivery is broken down into increments with each increment delivering part of the required functionality.

User requirements are prioritised and the highest priority requirements are included in early increments.

Once the development of an increment is started, the requirements are frozen though requirements for later increments can continue to evolve.

Incremental development and delivery

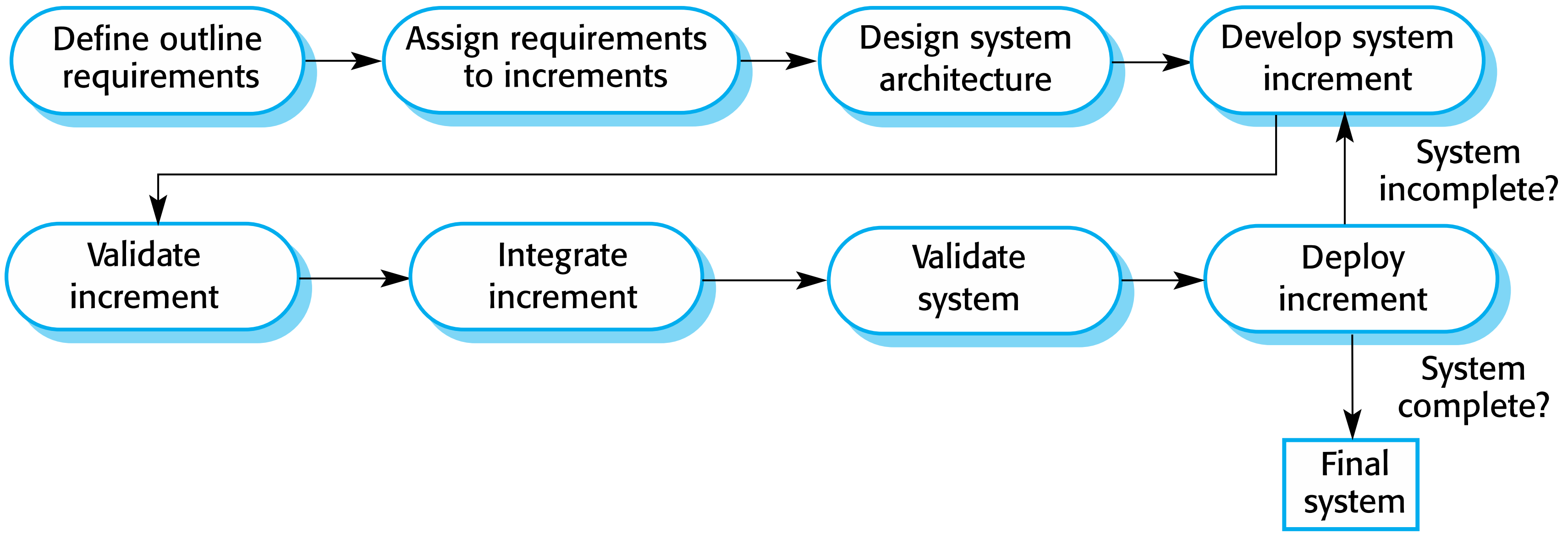
Incremental development

- Develop the system in increments and evaluate each increment before proceeding to the development of the next increment;
- Normal approach used in agile methods;
- Evaluation done by user/customer proxy.

Incremental delivery

- Deploy an increment for use by end-users;
- More realistic evaluation about practical use of software;

Incremental delivery



Incremental delivery advantages

Customer value can be delivered with each increment so system functionality is available earlier.

Early increments act as a prototype to help elicit requirements for later increments.

Lower risk of overall project failure.

The highest priority system services tend to receive the most testing.

Incremental delivery problems

Most systems require a set of basic facilities that are used by different parts of the system.

- As requirements are not defined in detail until an increment is to be implemented, it can be hard to identify common facilities that are needed by all increments.

The essence of iterative processes is that the specification is developed in conjunction with the software.

- However, this conflicts with the procurement model of many organizations, where the complete system specification is part of the system development contract.

Process improvement

Process improvement

Many software companies have turned to software process improvement as a way of enhancing the quality of their software, reducing costs or accelerating their development processes.

Process improvement means understanding existing processes and changing these processes to increase product quality and/or reduce costs and development time.

Approaches to improvement

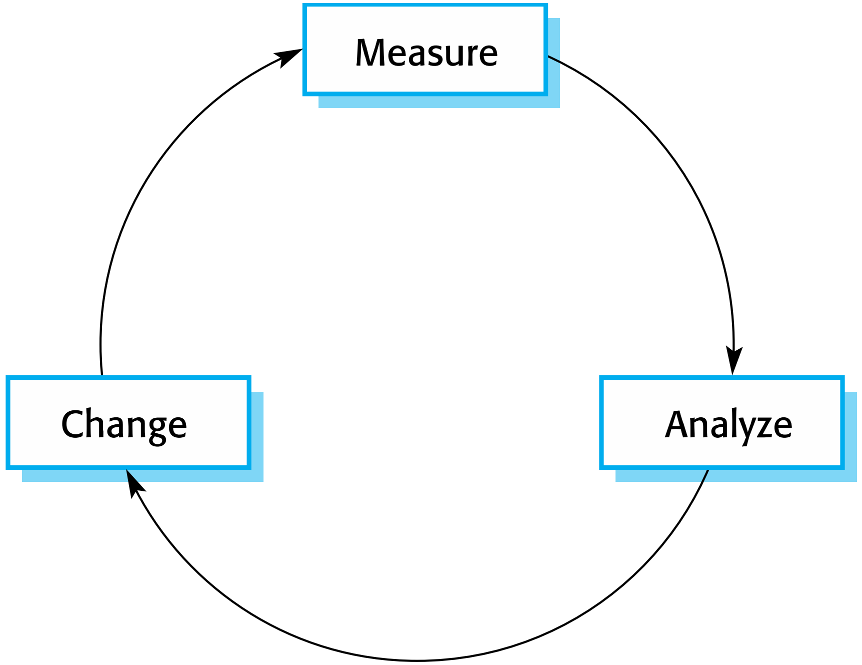
The process maturity approach, which focuses on improving process and project management and introducing good software engineering practice.

- The level of process maturity reflects the extent to which good technical and management practice has been adopted in organizational software development processes.

The agile approach, which focuses on iterative development and the reduction of overheads in the software process.

- The primary characteristics of agile methods are rapid delivery of functionality and responsiveness to changing customer requirements.

The process improvement cycle



Process improvement activities

Process measurement

- You measure one or more attributes of the software process or product. These measurements forms a baseline that helps you decide if process improvements have been effective.

Process analysis

- The current process is assessed, and process weaknesses and bottlenecks are identified. Process models (sometimes called process maps) that describe the process may be developed.

Process change

- Process changes are proposed to address some of the identified process weaknesses. These are introduced and the cycle resumes to collect data about the effectiveness of the changes.

Process measurement

Wherever possible, quantitative process data should be collected

- However, where organisations do not have clearly defined process standards this is very difficult as you don’t know what to measure. A process may have to be defined before any measurement is possible.

Process measurements should be used to assess process improvements

- But this does not mean that measurements should drive the improvements. The improvement driver should be the organizational objectives.

Process metrics

Time taken for process activities to be completed

- E.g. Calendar time or effort to complete an activity or process.

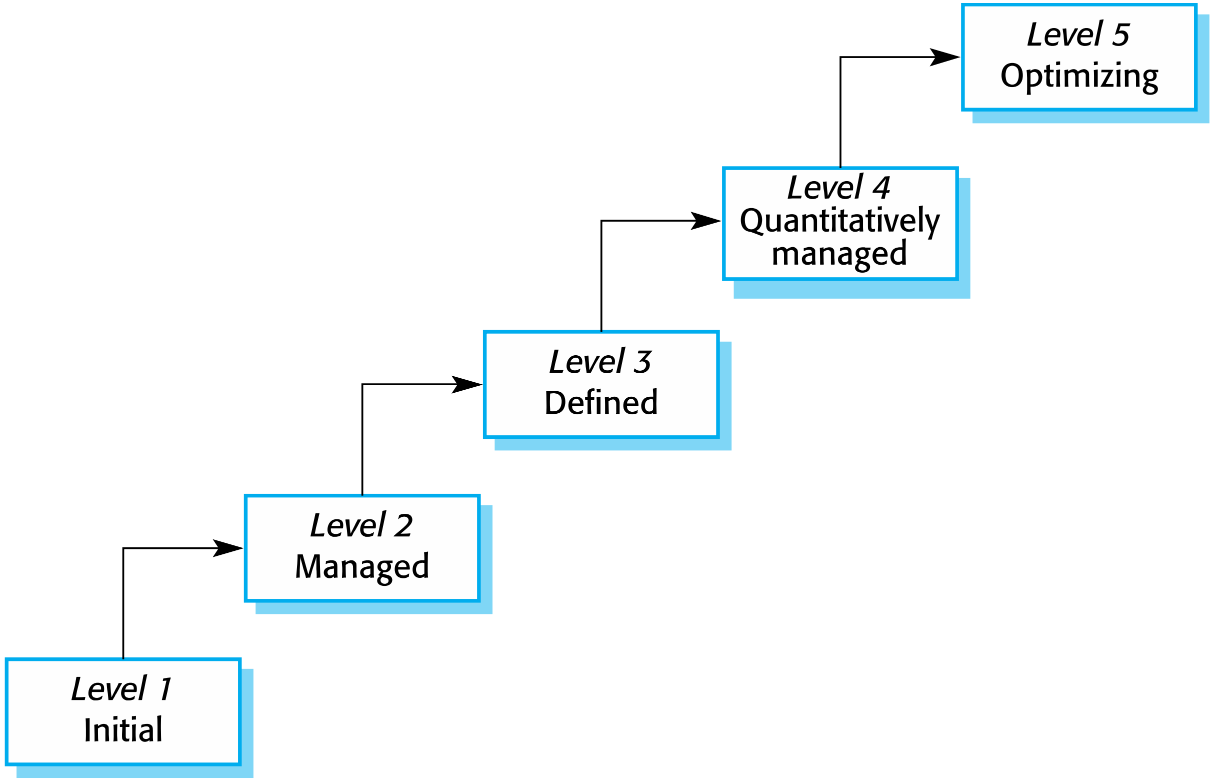
Resources required for processes or activities

- E.g. Total effort in person-days.

Number of occurrences of a particular event

- E.g. Number of defects discovered.

Capability maturity levels



The SEI capability maturity model

Initial

- Essentially uncontrolled

Repeatable

- Product management procedures defined and used

Defined

- Process management procedures and strategies defined and used

Managed

- Quality management strategies defined and used

Optimising

- Process improvement strategies defined and used

Key points

Software processes are the activities involved in producing a software system. Software process models are abstract representations of these processes.

General process models describe the organization of software processes.

- Examples of these general models include the ‘waterfall’ model, incremental development, and reuse-oriented development.

Requirements engineering is the process of developing a software specification.

Key points

Design and implementation processes are concerned with transforming a requirements specification into an executable software system.

Software validation is the process of checking that the system conforms to its specification and that it meets the real needs of the users of the system.

Software evolution takes place when you change existing software systems to meet new requirements. The software must evolve to remain useful.

Processes should include activities such as prototyping and incremental delivery to cope with change.

Key points

Processes may be structured for iterative development and delivery so that changes may be made without disrupting the system as a whole.

The principal approaches to process improvement are agile approaches, geared to reducing process overheads, and maturity-based approaches based on better process management and the use of good software engineering practice.

The SEI process maturity framework identifies maturity levels that essentially correspond to the use of good software engineering practice.