Software Processes & Process Model

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** – 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 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.

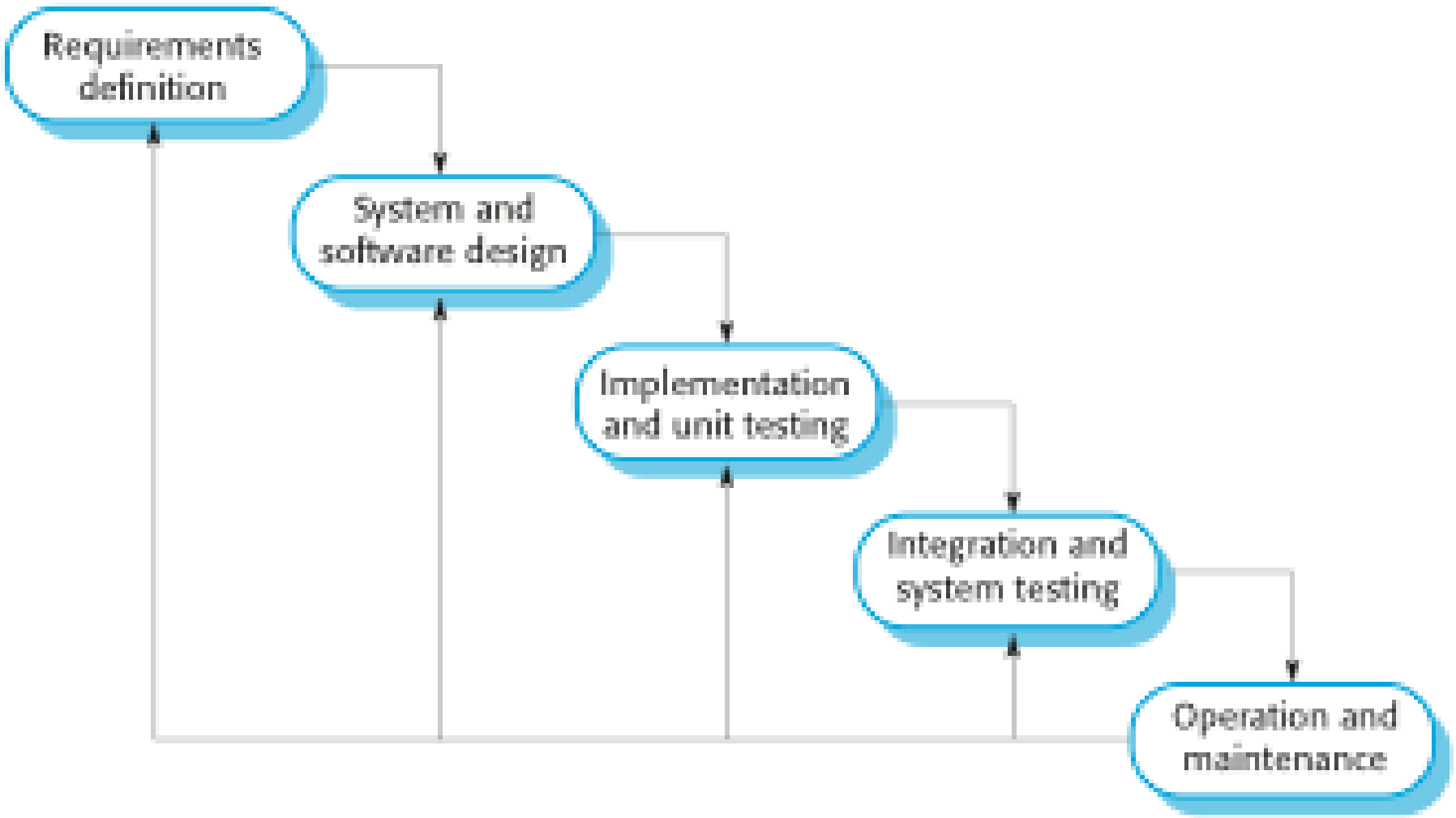
Plan-Driven and Agile Processes

- 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 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.
- Reuse-Oriented Software Engineering
  - The system is assembled from existing 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



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.

Advantages of Waterfall Model:

- This model is simple and easy to understand and use.
- It is easy to manage due to the rigidity of the model – each phase has specific deliverables and a review process.
- In this model phases are processed and completed one at a time. Phases do not overlap.
- Waterfall model works well for smaller projects where requirements are very well understood

Disadvantages of Waterfall Model:

- Once an application is in the testing stage, it is very difficult to go back and change something that was not well-thought out in the concept stage.
- No working software is produced until late during the life cycle.
- High amounts of risk and uncertainty.
- Not a good model for complex and object-oriented projects.
- Poor model for long and ongoing projects.
- Not suitable for the projects where requirements are at a moderate to high risk of changing.

When to Use the Waterfall Model:

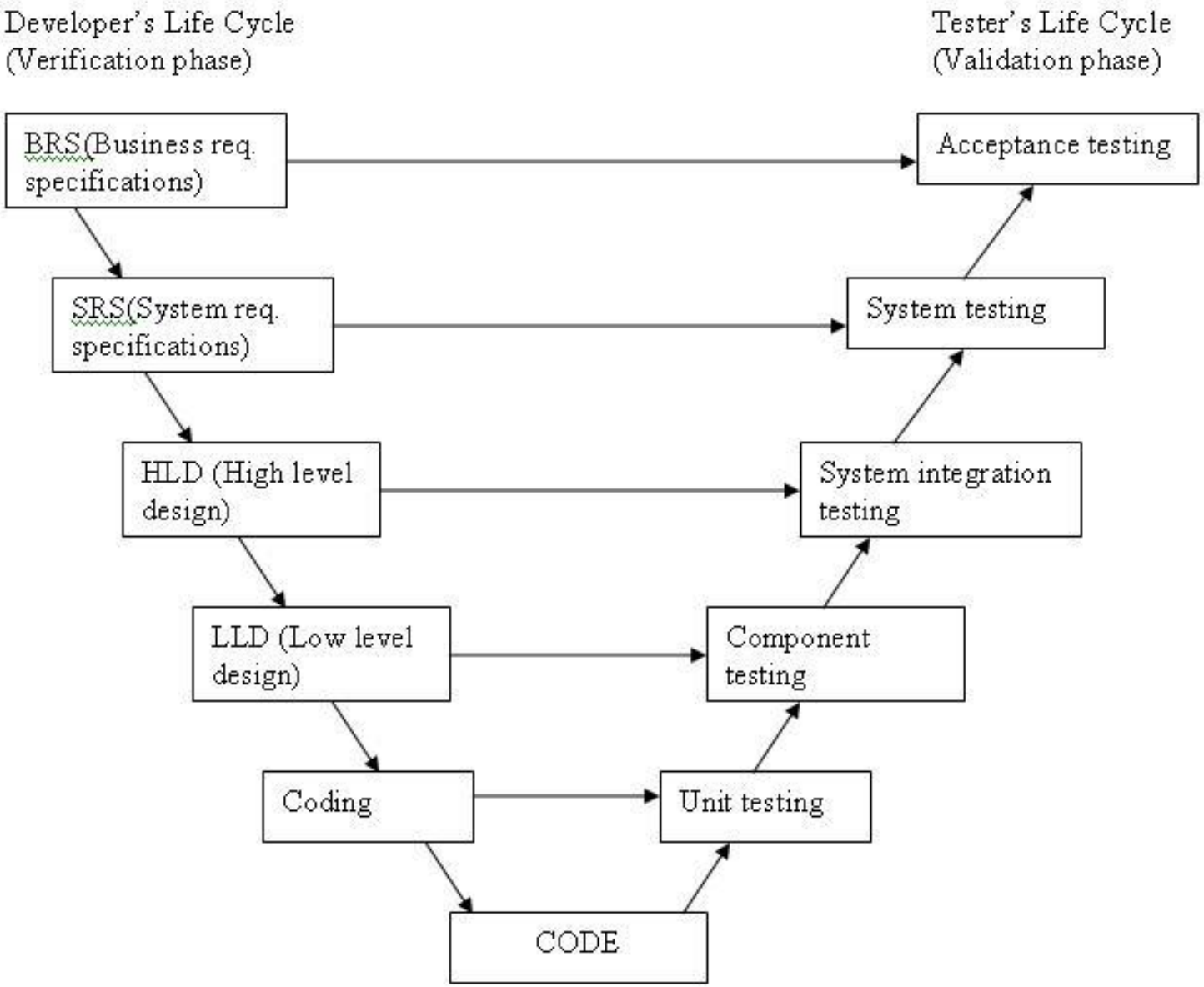
- This model is used only when the requirements are very well known, clear and fixed.
- Product definition is stable.
- Technology is understood.
- There are no ambiguous requirements
- Ample resources with required expertise are available freely
- The project is short.

Very less customer enter action is involved during the development of the product. Once the product is ready then only it can be demoted to the end users. Once the product is developed and if any failure occurs then the cost of fixing such issues are very high, because we need to update everywhere from document till the logic.

V- Model

- V- model means Verification and Validation model. Just like the waterfall model, the V-Shaped life cycle is a sequential path of execution of processes.
- Each phase must be completed before the next phase begins.
- Testing of the product is planned in parallel with a corresponding phase of development in **V-model**.

Diagram of V-model:



The various phases of the V-model are as follows:

- **Requirements** like BRS and SRS begin the life cycle model just like the waterfall model. But, in this model before development is started, a system test plan is created. The test plan focuses on meeting the functionality specified in the requirements gathering.
- **The high-level design (HLD)** phase focuses on system architecture and design. It provide overview of solution, platform, system, product and service/process. An integration test plan is created in this phase as well in order to test the pieces of the software systems ability to work together.
- **The low-level design (LLD)** phase is where the actual software components are designed. It defines the actual logic for each and every component of the system. Class diagram with all the methods and relation between classes comes under LLD. Component tests are created in this phase as well.

The various phases of the V-model are as follows:

- **The implementation** phase is, again, where all coding takes place. Once coding is complete, the path of execution continues up the right side of the V where the test plans developed earlier are now put to use.
- **Coding:** This is at the bottom of the V-Shape model. Module design is converted into code by developers.

Advantages of V-model:

- Simple and easy to use.
- Testing activities like planning, test designing happens well before coding. This saves a lot of time. Hence higher chance of success over the waterfall model.
- Proactive defect tracking – that is defects are found at early stage.
- Avoids the downward flow of the defects.
- Works well for small projects where requirements are easily understood.

Disadvantages and when to use of V-model:

Disadvantages of V-model:

® Very rigid and least flexible.

® Software is developed during the implementation phase, so no early prototypes of the software are produced.

® If any changes happen in midway, then the test documents along with requirement documents has to be updated.

When to use the V-model:

® The V-shaped model should be used for small to medium sized projects where requirements are clearly defined and fixed.

® The V-Shaped model should be chosen when ample technical resources are available with needed technical expertise.

Incremental Development

® In incremental model the whole requirement is divided into various builds. Multiple development cycles take place here, making the life cycle a "multi-waterfall" cycle.

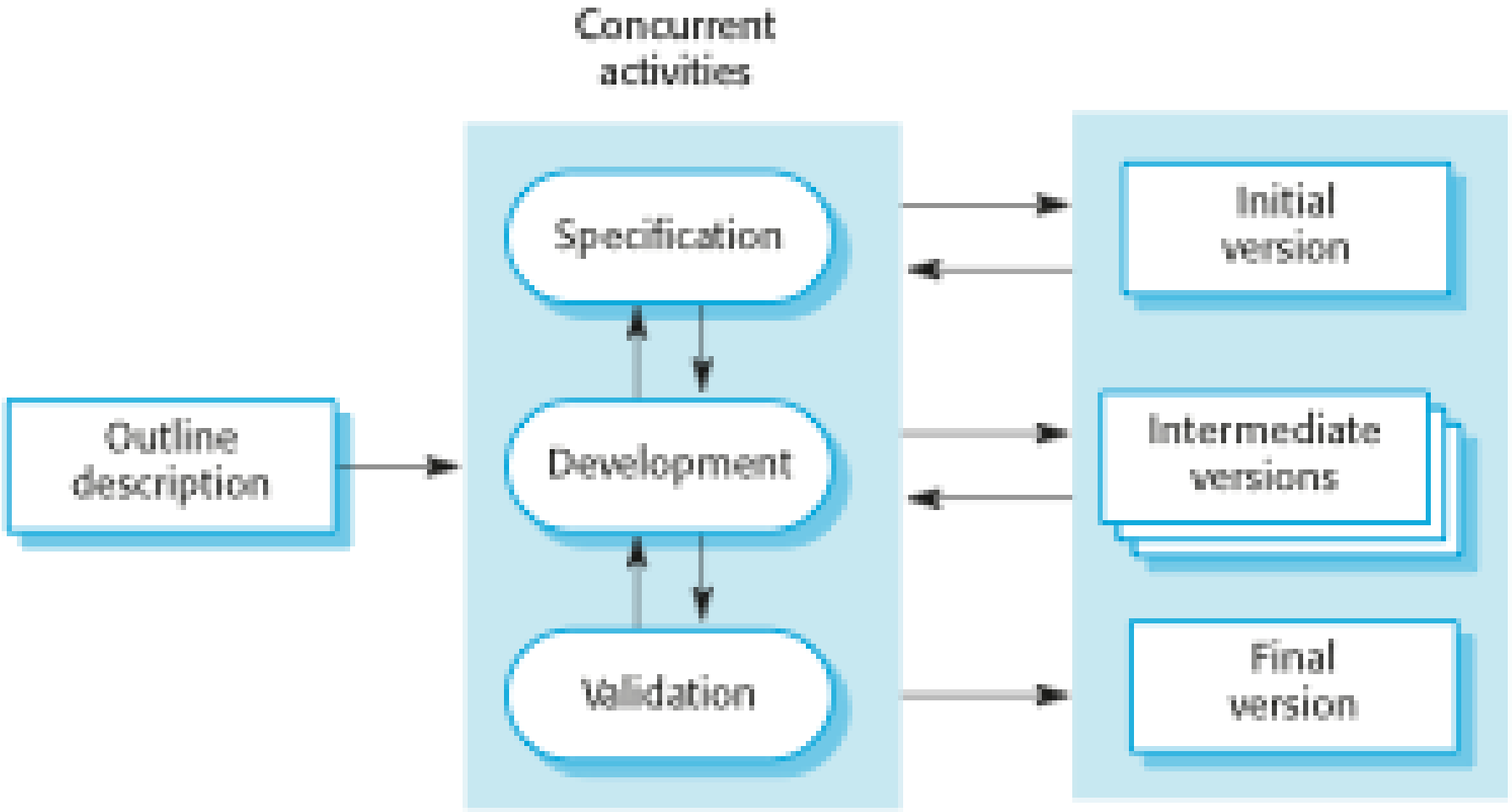
® Cycles are divided up into smaller, more easily managed modules. Each module passes through the requirements, design, implementation and testing phases.

® A working version of software is produced during the first module, so you have working software early on during the software life cycle.

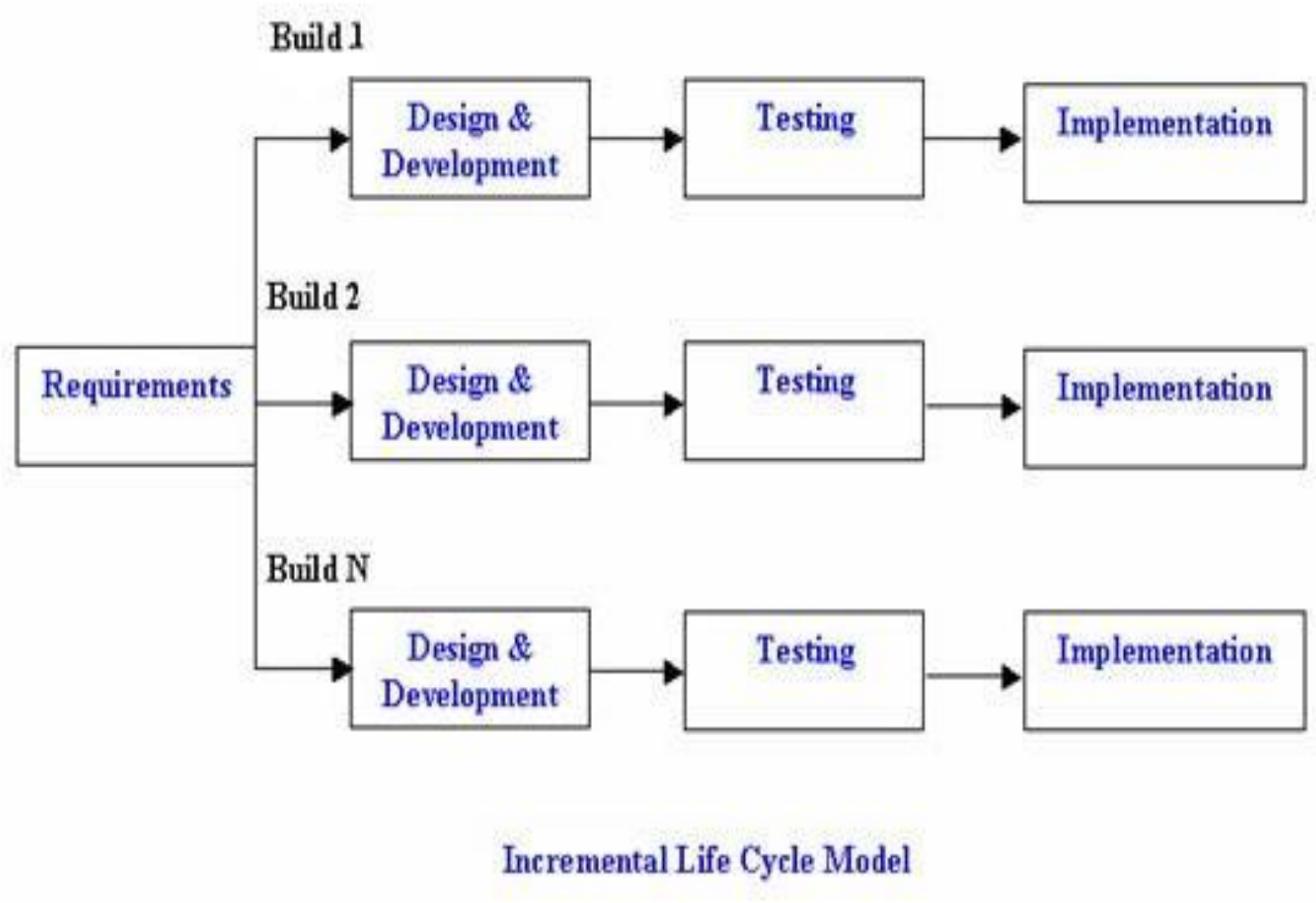
® Each subsequent release of the module adds function to the previous release. The process continues till the complete system is achieved.

✧ For example:

Incremental development



How Does it work



Incremental Life Cycle Model

Advantages of Incremental model:

- ® Generates working software quickly and early during the software life cycle.
- ® This model is more flexible – less costly to change scope and requirements.
- ® It is easier to test and debug during a smaller iteration.
- ® In this model customer can respond to each built.
- ® Lowers initial delivery cost.
- ® Easier to manage risk because risky pieces are identified and handled during it'd iteration.

Disadvantages of Incremental model:

® Needs good planning and design.

® Needs a clear and complete definition of the whole system before it can be broken down and built incrementally.

® Total cost is higher than waterfall.

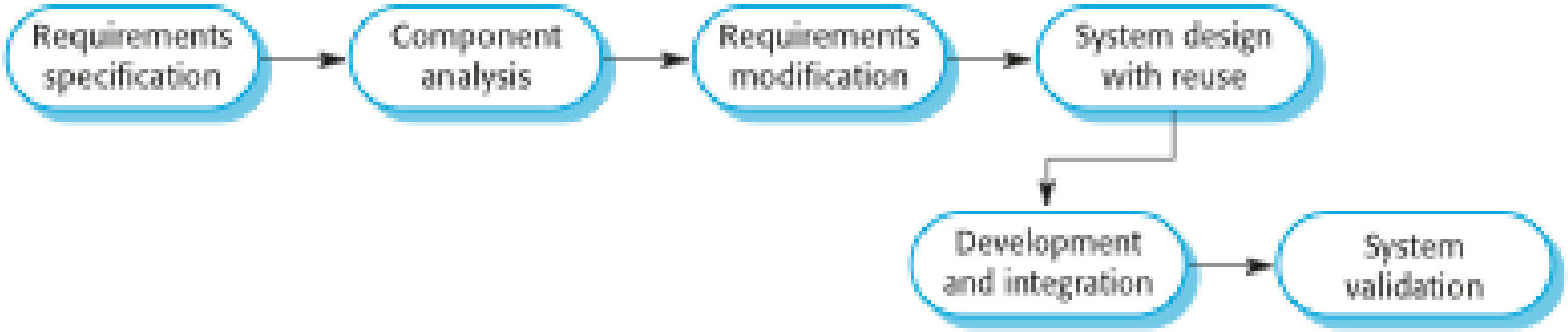
When to use the Incremental model:

®This model can be used when the requirements of the complete system are clearly defined and understood.
®Major requirements must be defined; however, some details can evolve with time.
®There is a need to get a product to the market early.
®A new technology is being used
®Resources with needed skill set are not available
®There are some high risk features and goals.

Reuse-oriented software engineering

- Based on systematic reuse where systems are integrated from existing components or COTS (Commercial-off-the-shelf) systems.
- Process stages
  - Component analysis;
  - Requirements modification;
  - System design with reuse;
  - Development and integration.
- Reuse is now the standard approach for building many types of business system
  - Reuse covered in more depth in Chapter 16.

Reuse-oriented software engineering



Types of software component

- ✧ Web services that are developed according to service standards and which are available for remote invocation.
- ✧ Collections of objects that are developed as a package to be integrated with a component framework such as .NET or J2EE.
- ✧ Stand-alone software systems (COTS) that are configured for use in a particular environment.

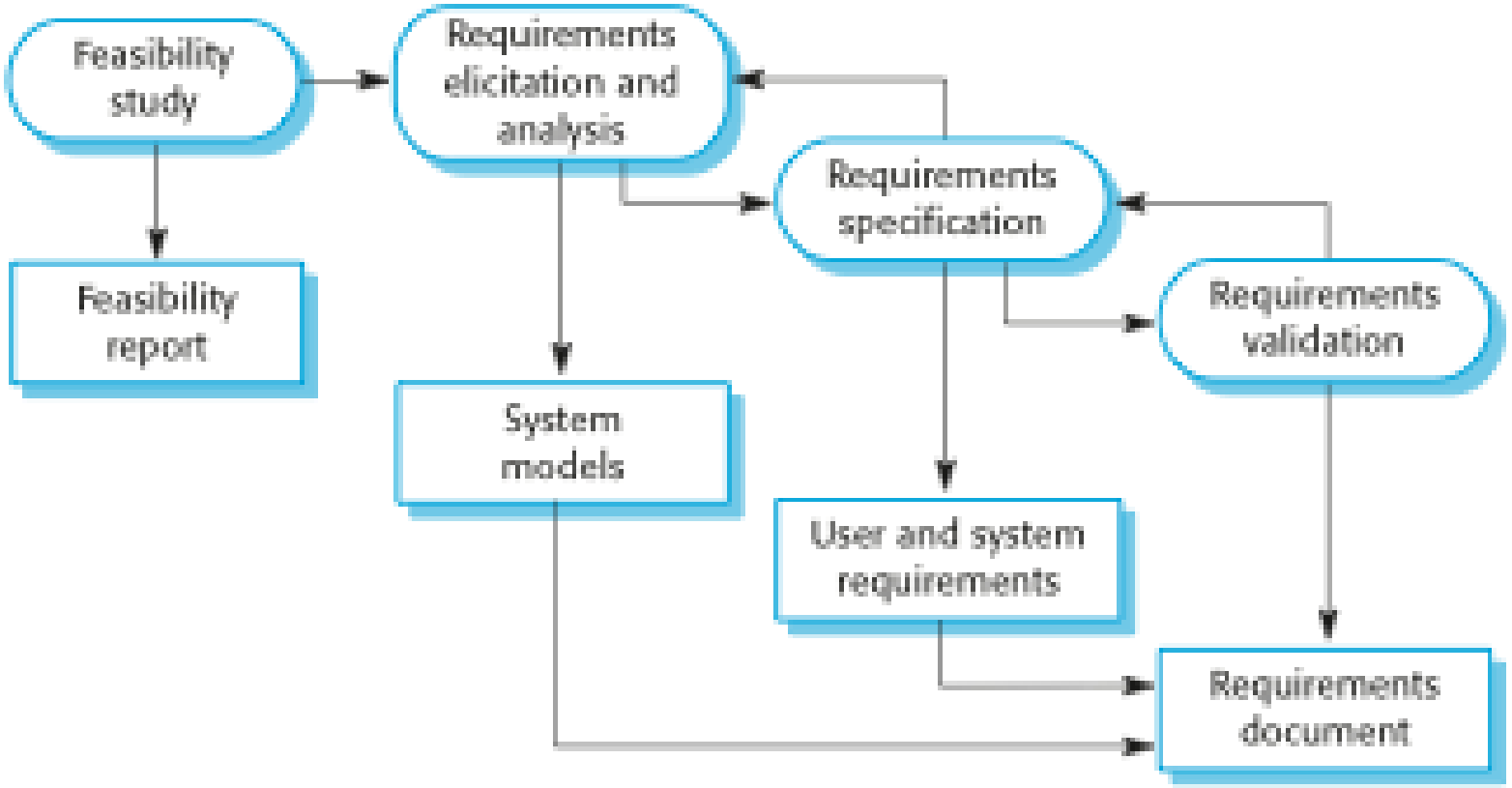
Process activities

- 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. In the waterfall model, they are organized in sequence, whereas in incremental development they are inter-leaved.

Software specification

- ✧ The process of establishing what services are required and the constraints on the system's operation and development.
- ✧ Requirements engineering process
  - Feasibility study
    - Is it technically and financially feasible to build the system?
  - Requirements elicitation and analysis
    - What do the system stakeholders require or expect from the system?
  - Requirements specification
    - Defining the requirements in detail
  - Requirements validation

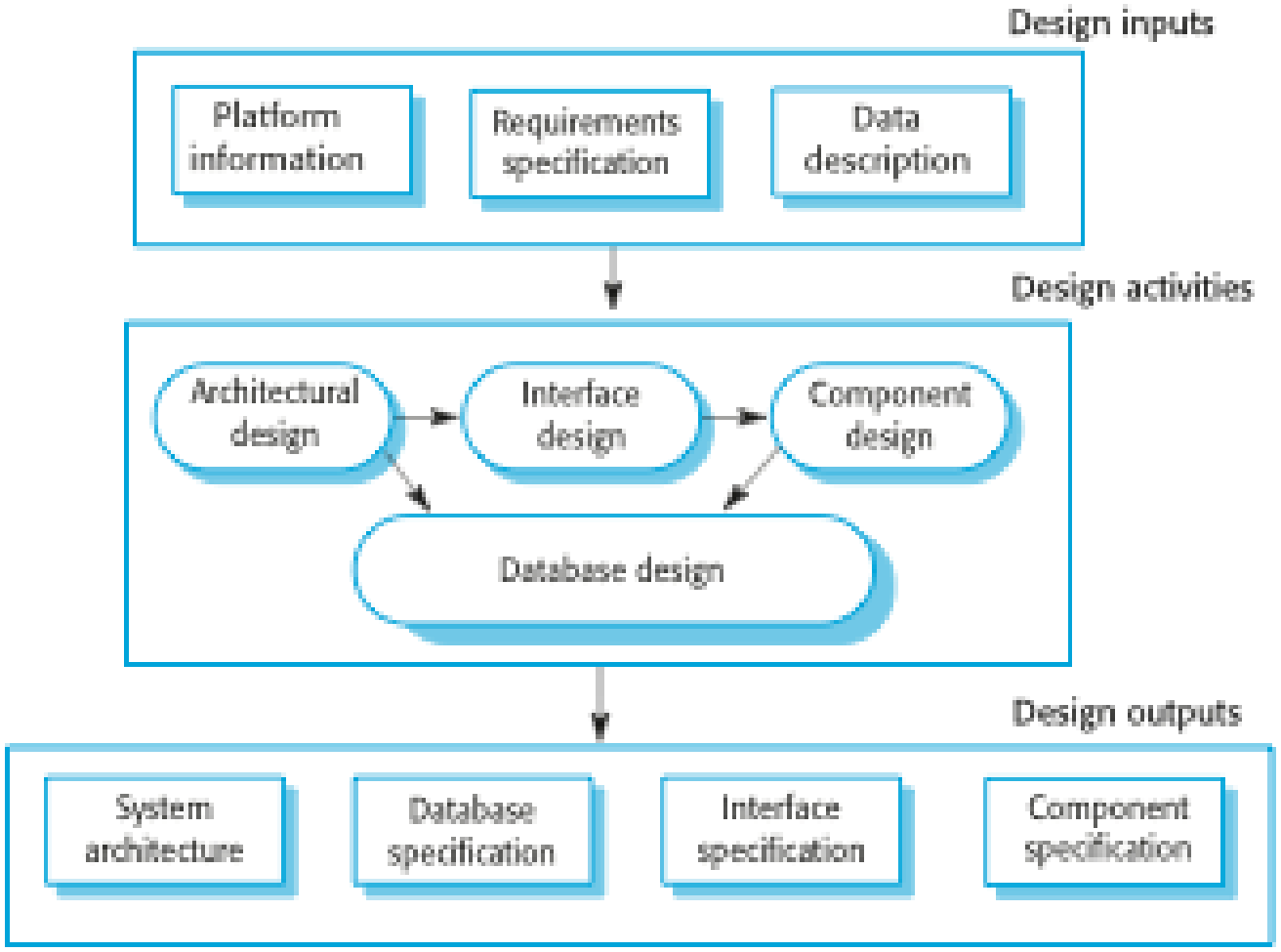
The requirements engineering process



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.

A general model of the design process



Design activities

- *Architectural design*, where you identify the overall structure of the system, the principal components (sometimes called sub-systems or modules), their relationships and how they are distributed.
- *Interface design*, where you define the interfaces between system components.
- *Component design*, where you take each system component and design how it will operate.
- *Database design*, where you design the system data structures and how these are to be represented in a database.

Software validation

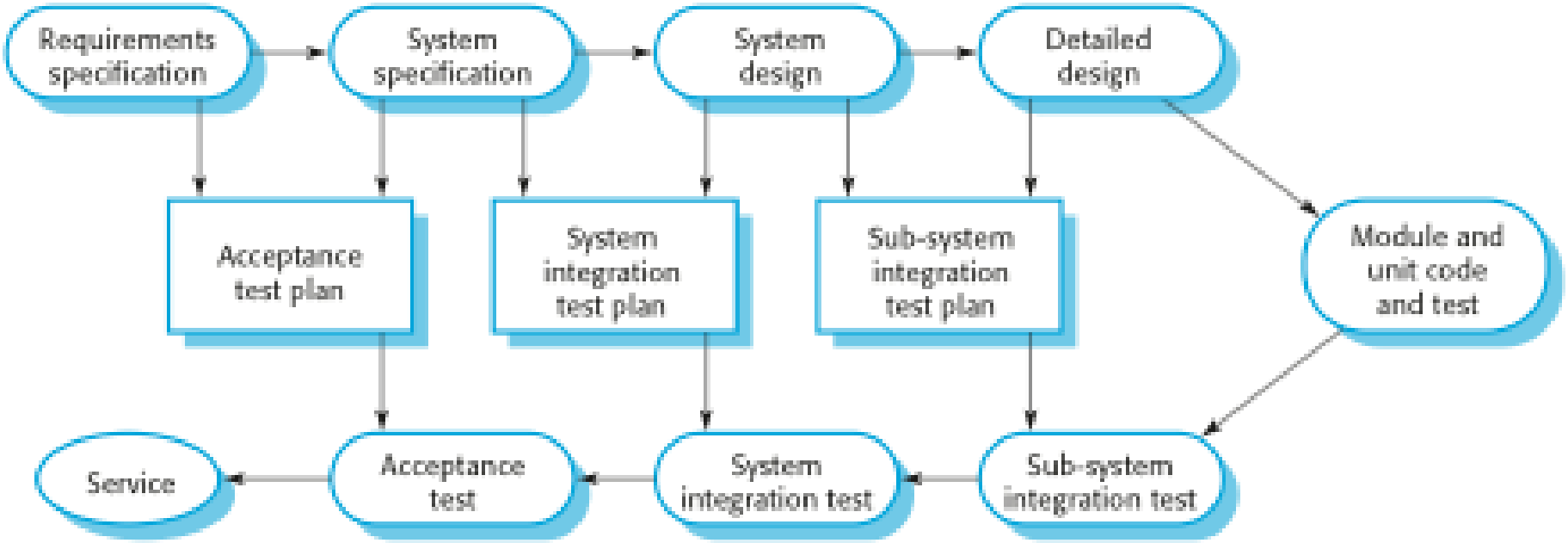
- ✧ Verification and validation (V & V) is intended to show that a system conforms to its specification and meets the requirements of the system customer.
- ✧ Involves checking and review processes and system testing.
- ✧ System testing involves executing the system with test cases that are derived from the specification of the real data to be processed by the system.
- ✧ Testing is the most commonly used V & V activity.

Stages of testing

Testing stages

- ✧ Development or 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 is particularly important.
- ✧ Acceptance testing
  - Testing with customer data to check that the system meets the customer’s needs.

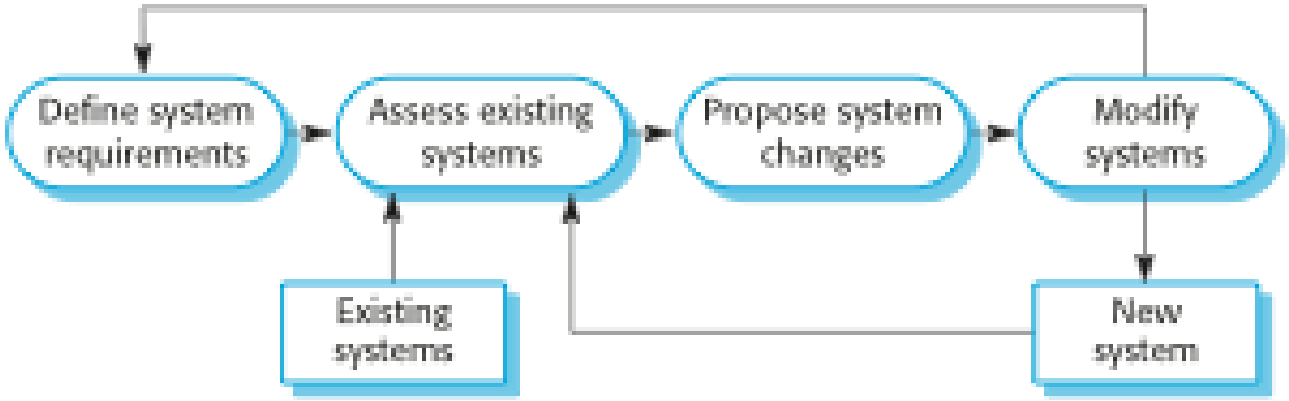
Testing phases in a plan-driven software process



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.

System evolution



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.

Key points

- ✧ Requirements engineering is the process of developing a software specification.
- ✧ 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.

Chapter 2 – Software Processes

Lecture 2

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 avoidance, 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.

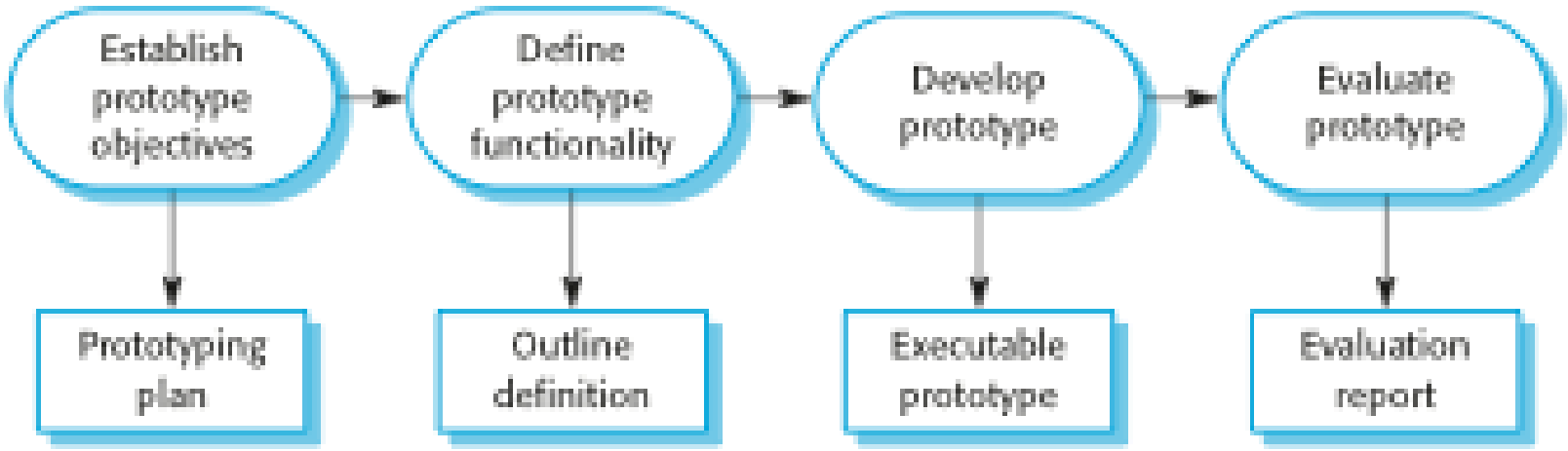
Software prototyping

- 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;
  - In the testing process to run back-to-back tests.

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;
  - Error checking and recovery may not be included in the prototype;
  - 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 organisational 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

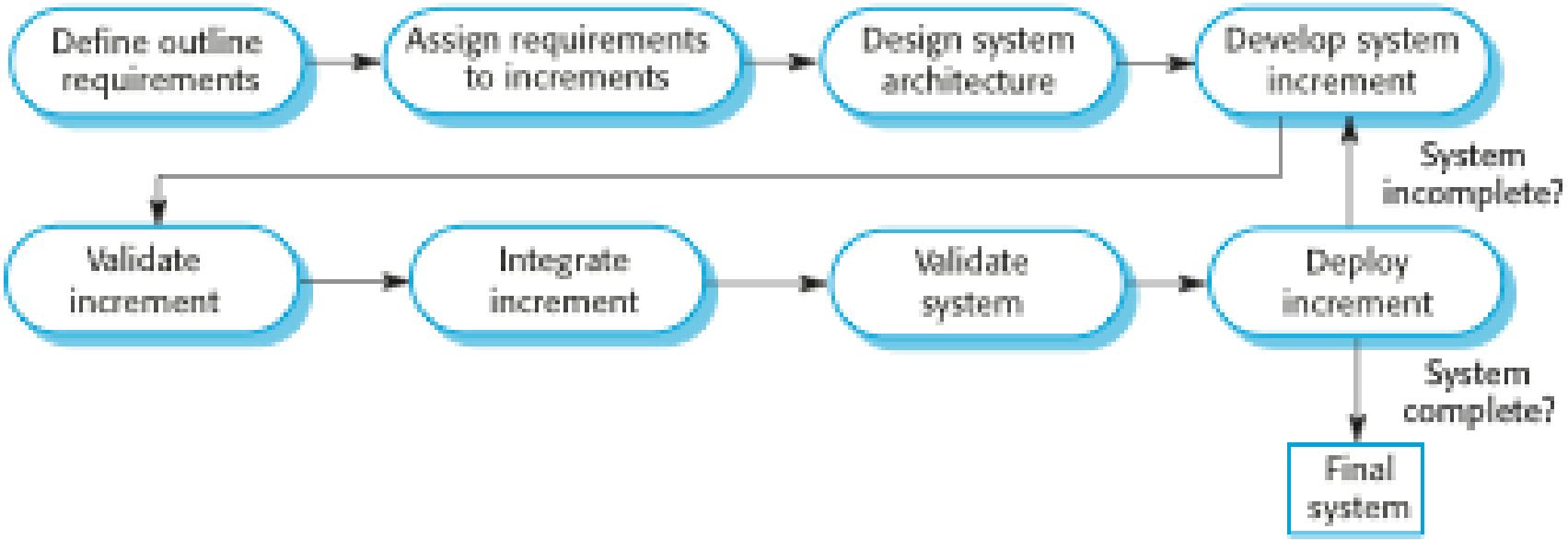
✧ Incremental development

- 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;
- Difficult to implement for replacement systems as increments have less functionality than the system being replaced.

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.

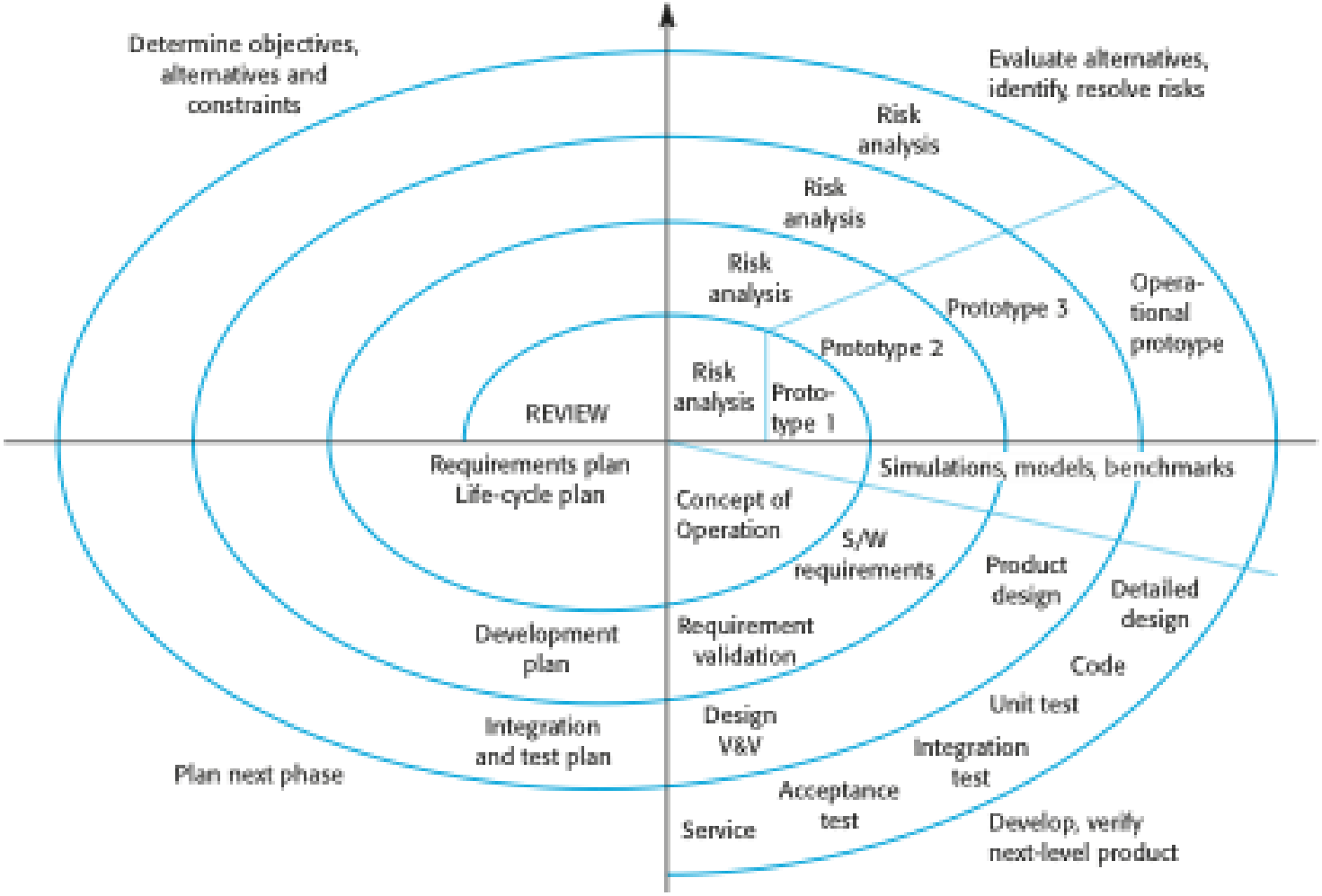
Incremental delivery problems

- 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.

Boehm’s spiral model

- ✧ Process is represented as a spiral rather than as a sequence of activities with backtracking.
- ✧ Each loop in the spiral represents a phase in the process.
- ✧ No fixed phases such as specification or design - loops in the spiral are chosen depending on what is required.
- ✧ Risks are explicitly assessed and resolved throughout the process.

Boehm's spiral model of the software process



Spiral model sectors

- ✧ Objective setting
  - Specific objectives for the phase are identified.
- ✧ Risk assessment and reduction
  - Risks are assessed and activities put in place to reduce the key risks.
- ✧ Development and validation
  - A development model for the system is chosen which can be any of the generic models.
- ✧ Planning
  - The project is reviewed and the next phase of the spiral is planned.

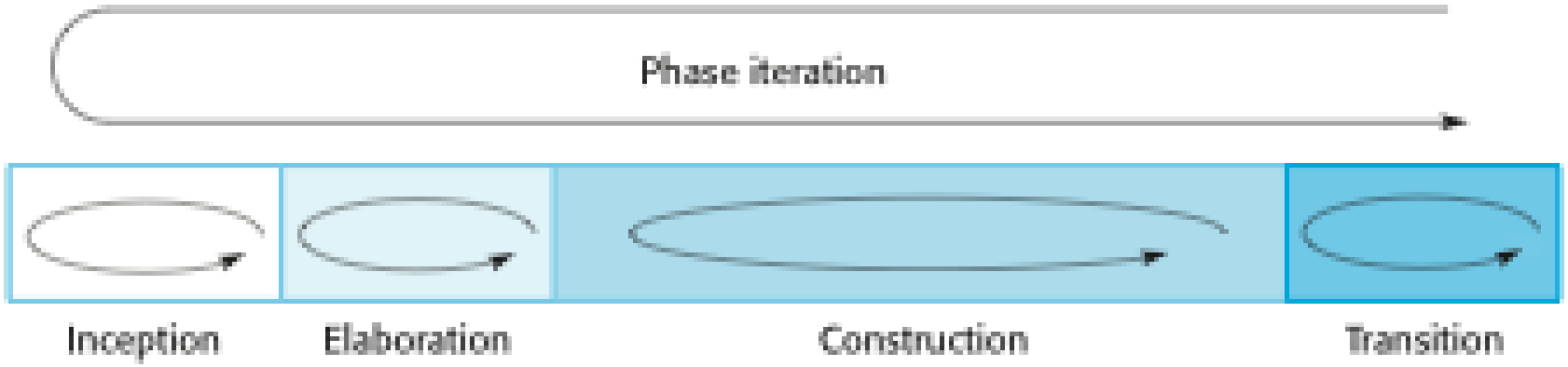
Spiral model usage

- Spiral model has been very influential in helping people think about iteration in software processes and introducing the risk-driven approach to development.
- In practice, however, the model is rarely used as published for practical software development.

The Rational Unified Process

- A modern generic process derived from the work on the UML and associated process.
- Brings together aspects of the 3 generic process models discussed previously.
- Normally described from 3 perspectives
  - A dynamic perspective that shows phases over time;
  - A static perspective that shows process activities;
  - A practive perspective that suggests good practice.

Phases in the Rational Unified Process



RUP phases

- ✧ Inception
  - Establish the business case for the system.
- ✧ Elaboration
  - Develop an understanding of the problem domain and the system architecture.
- ✧ Construction
  - System design, programming and testing.
- ✧ Transition
  - Deploy the system in its operating environment.

RUP iteration

- ✧ In-phase iteration
  - Each phase is iterative with results developed incrementally.
- ✧ Cross-phase iteration
  - As shown by the loop in the RUP model, the whole set of phases may be enacted incrementally.

Static workflows in the Rational Unified Process

Workflow	Description
Business modelling	The business processes are modelled using business use cases.
Requirements	Actors who interact with the system are identified and use cases are developed to model the system requirements.
Analysis and design	A design model is created and documented using architectural models, component models, object models and sequence models.
Implementation	The components in the system are implemented and structured into implementation sub-systems. Automatic code generation from design models helps accelerate this process.

Static workflows in the Rational Unified Process

Workflow	Description
Testing	Testing is an iterative process that is carried out in conjunction with implementation. System testing follows the completion of the implementation.
Deployment	A product release is created, distributed to users and installed in their workplace.
Configuration and change management	This supporting workflow managed changes to the system (see Chapter 25).
Project management	This supporting workflow manages the system development (see Chapters 22 and 23).
Environment	This workflow is concerned with making appropriate software tools available to the software development team.

RUP good practice

- ✧ Develop software iteratively
  - Plan increments based on customer priorities and deliver highest priority increments first.
- ✧ Manage requirements
  - Explicitly document customer requirements and keep track of changes to these requirements.
- ✧ Use component-based architectures
  - Organize the system architecture as a set of reusable components.

RUP good practice

- ✧ Visually model software
  - Use graphical UML models to present static and dynamic views of the software.
- ✧ Verify software quality
  - Ensure that the software meet's organizational quality standards.
- ✧ Control changes to software
  - Manage software changes using a change management system and configuration management tools.

Key points

- ✧ Processes should include activities to cope with change. This may involve a prototyping phase that helps avoid poor decisions on requirements and design.
- ✧ Processes may be structured for iterative development and delivery so that changes may be made without disrupting the system as a whole.
- ✧ The Rational Unified Process is a modern generic process model that is organized into phases (inception, elaboration, construction and transition) but separates activities (requirements, analysis and design, etc.) from these phases.