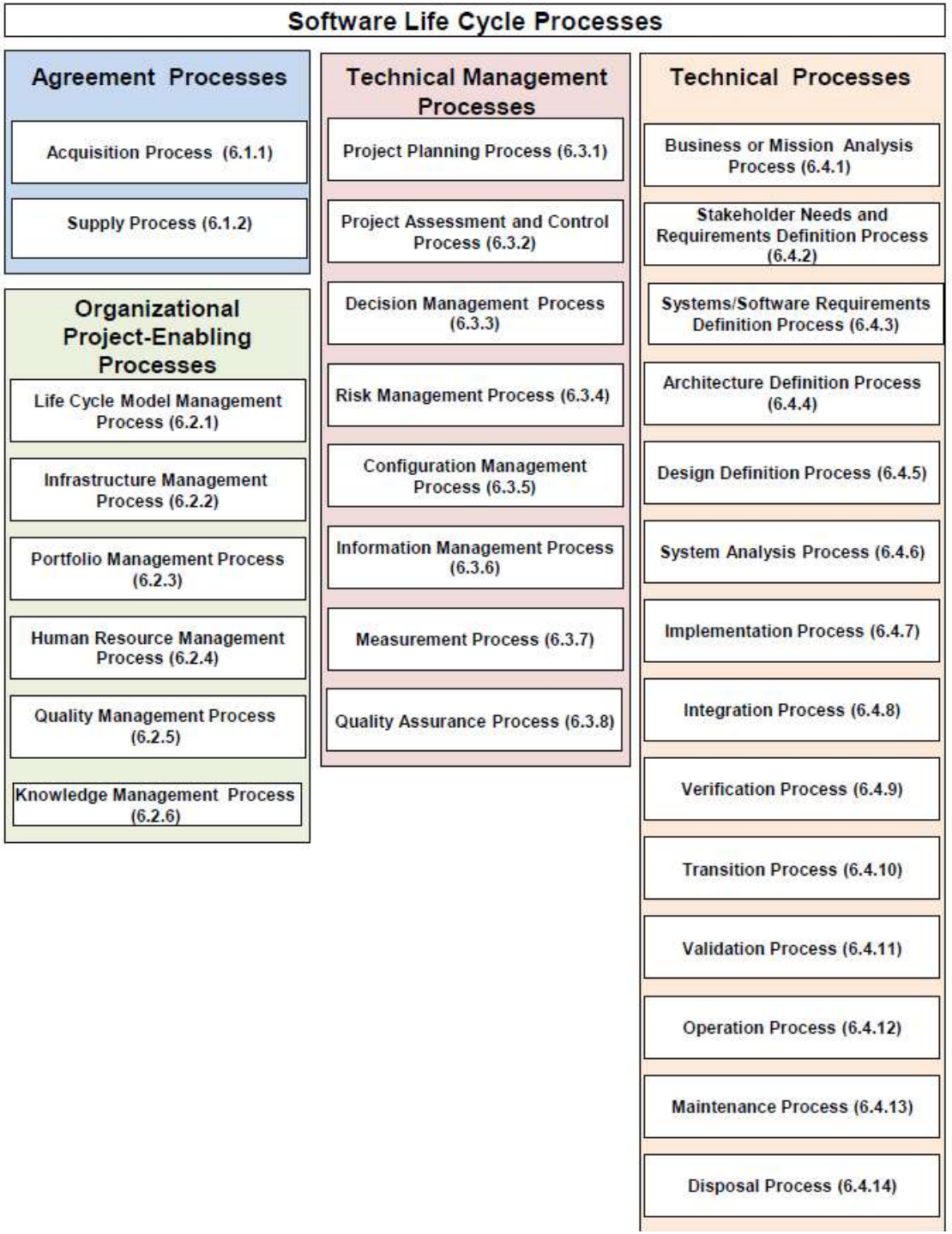
Unit 2 – Software Processes
Topics covered

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

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.

ISO/IEC/IEEE 12207-2017: Software Life Cycle Processes



Software Engineering, Ian Somme
10th Edition, Pearson Education.

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:
  - **Work/Final 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.
  - **Operation Procedure**: a set of written instructions that describes the step-by-step process taken to properly perform a spefific activity

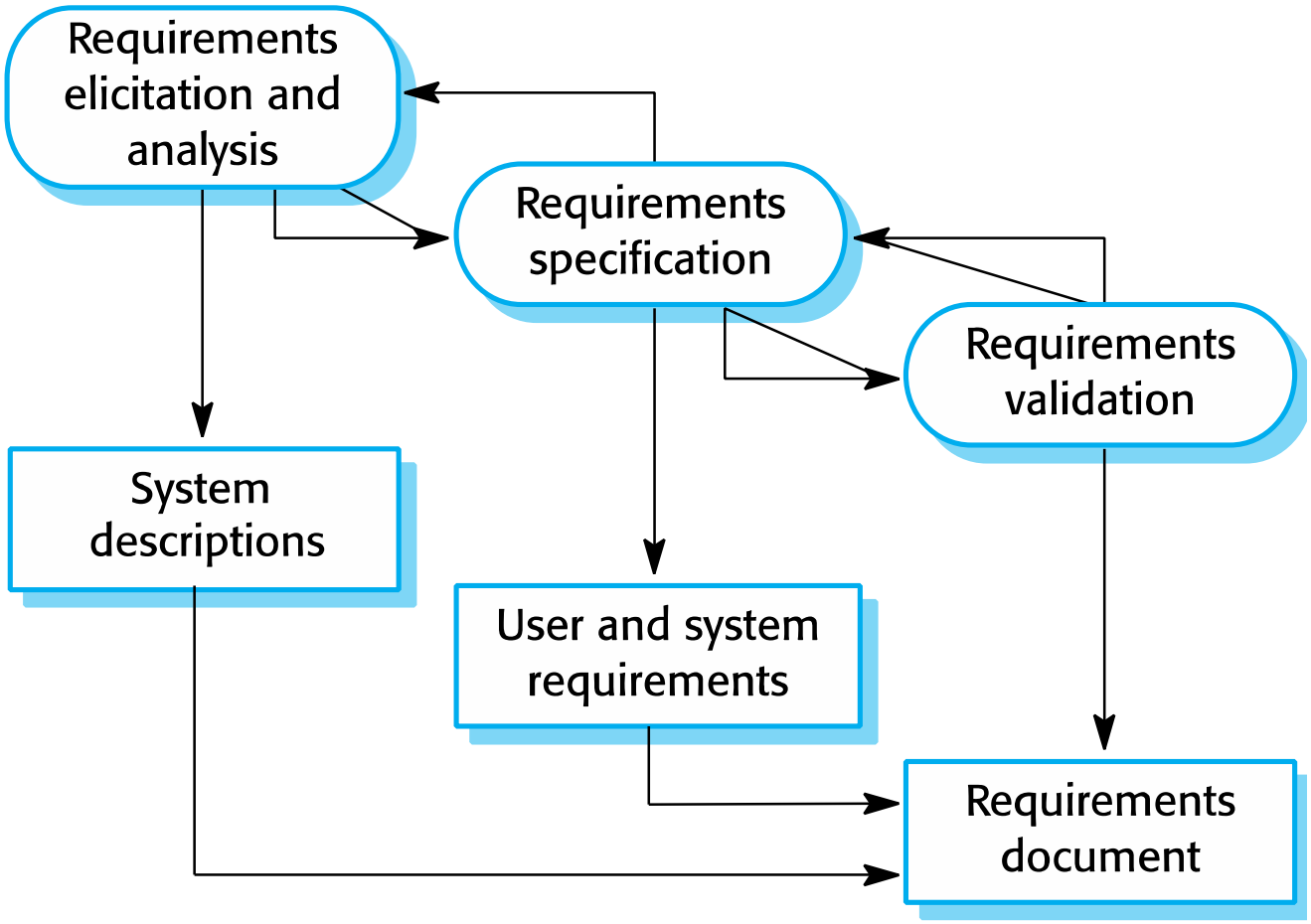
Plan-driven and agile processes

- **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.

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



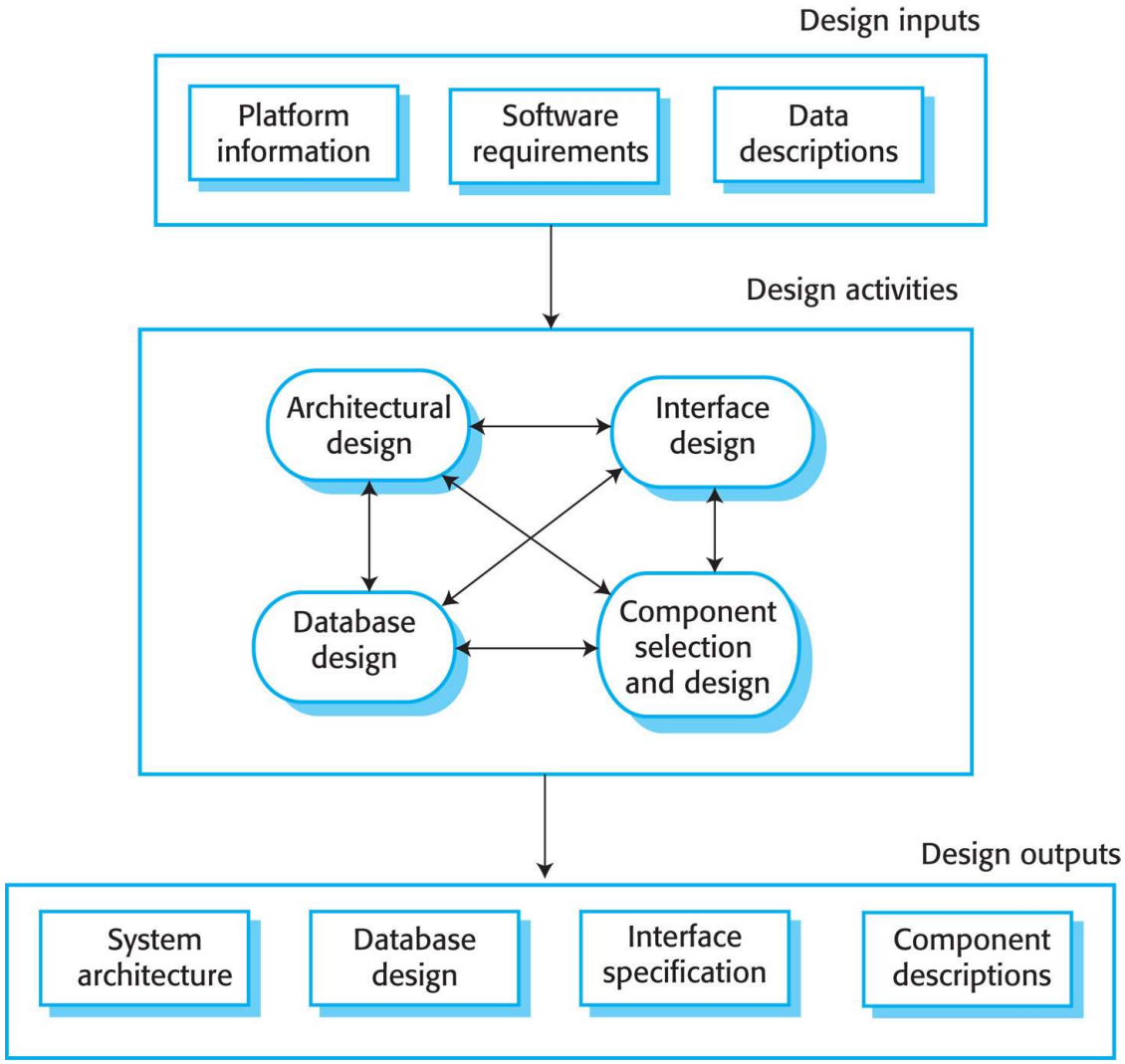
Software specification

- 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

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

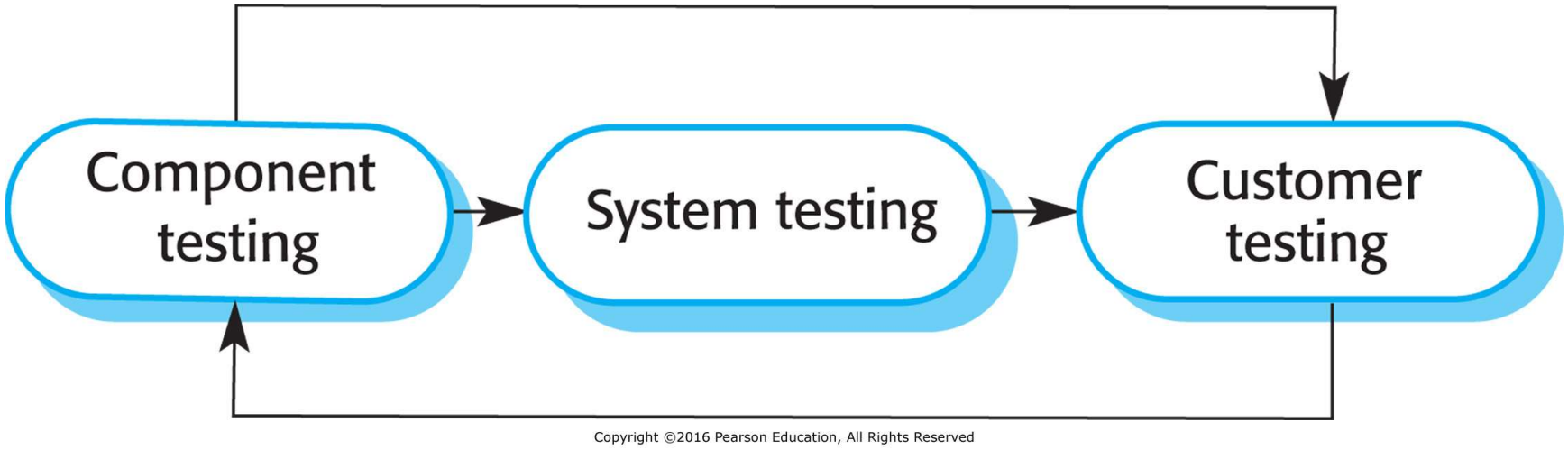
System implementation

- 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 real data to be processed by the system.
- ***Testing*** is the most commonly used ***V & V activity***.

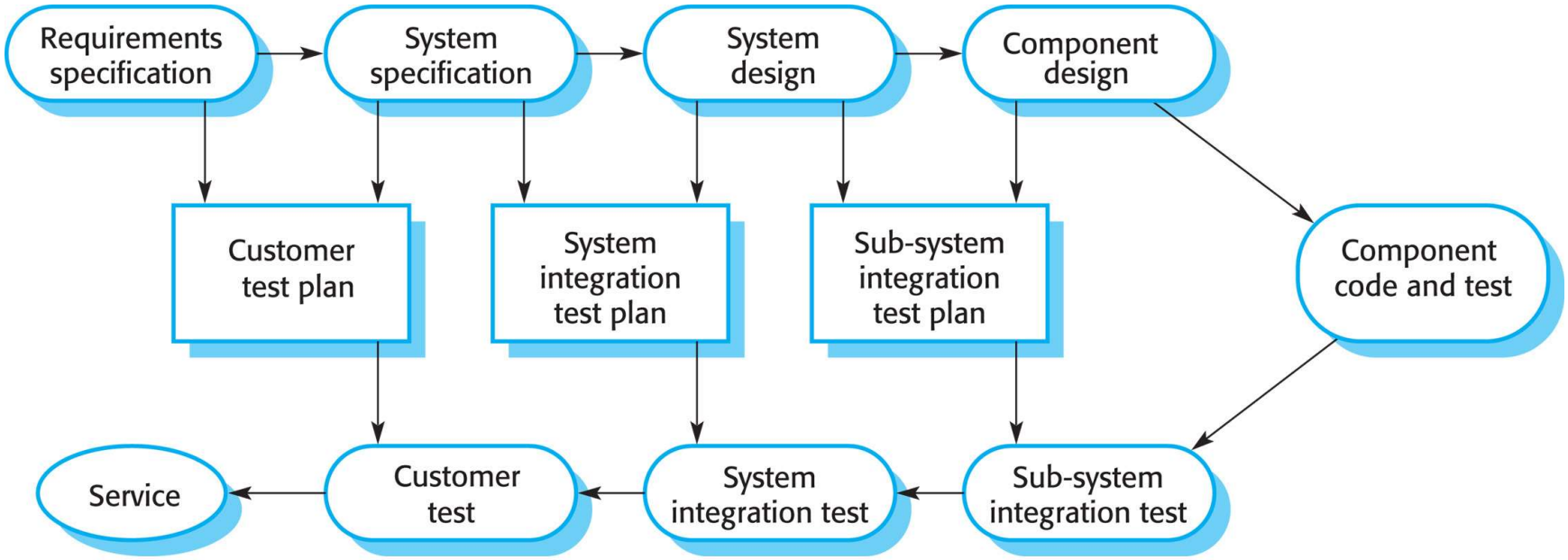
Stages of testing



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 is particularly important.
- ***Customer testing***
  - Testing with customer data to check that the system meets the customer's needs.

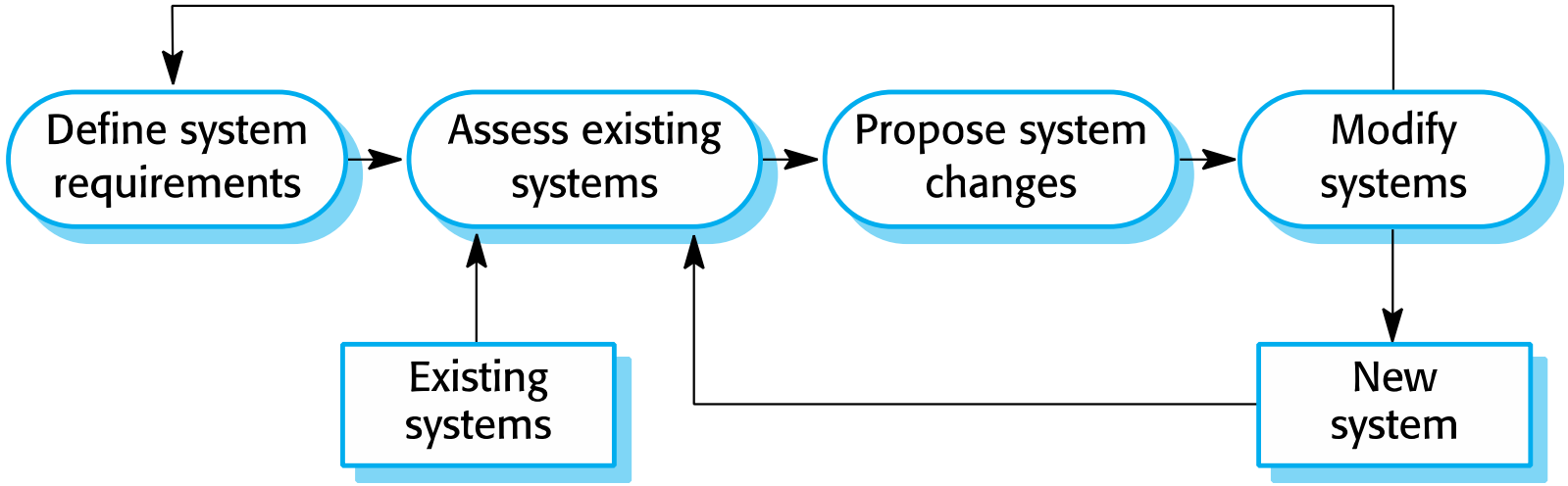
Testing phases in a plan-driven software process (V-model)



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.

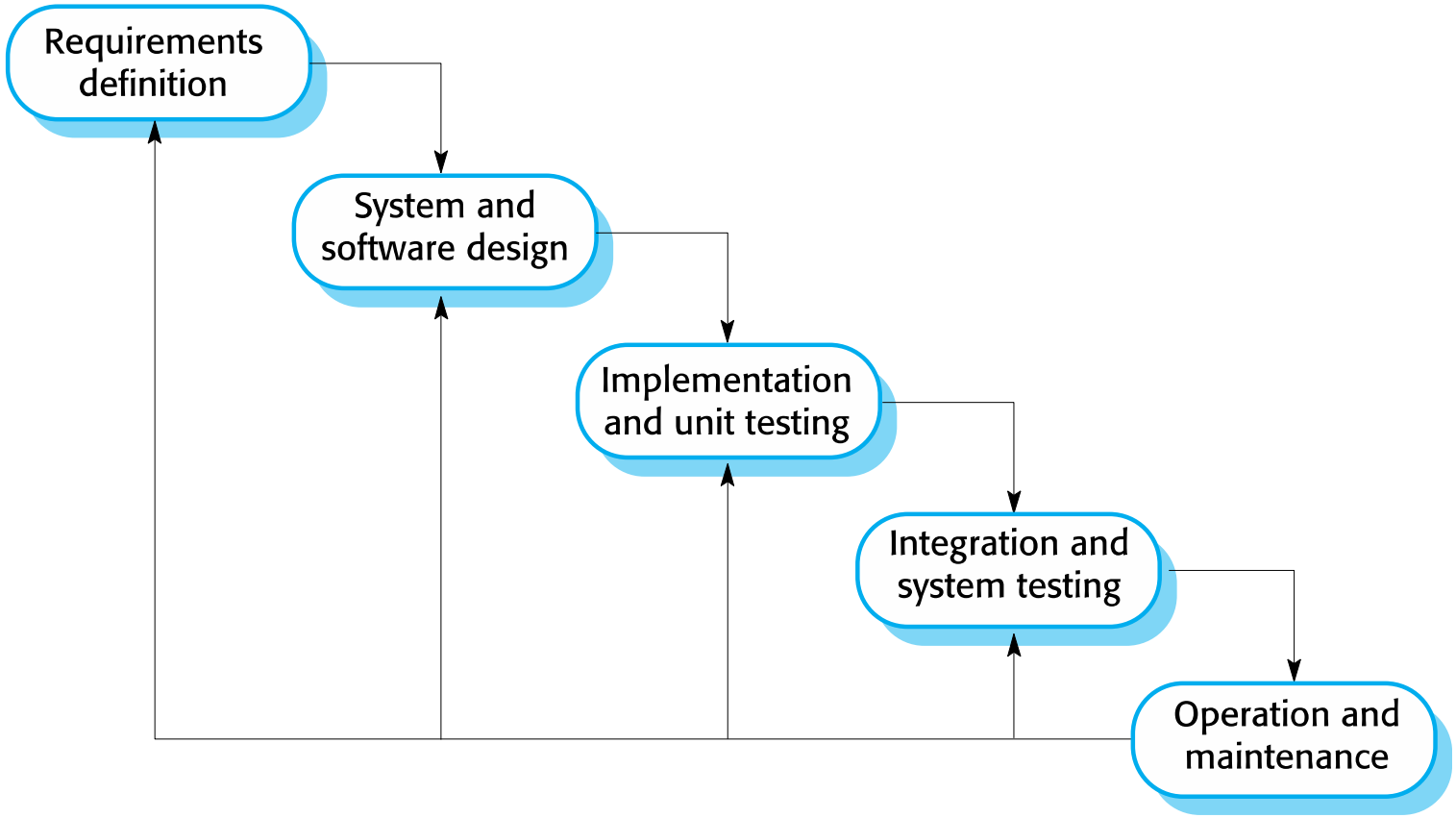
System evolution



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



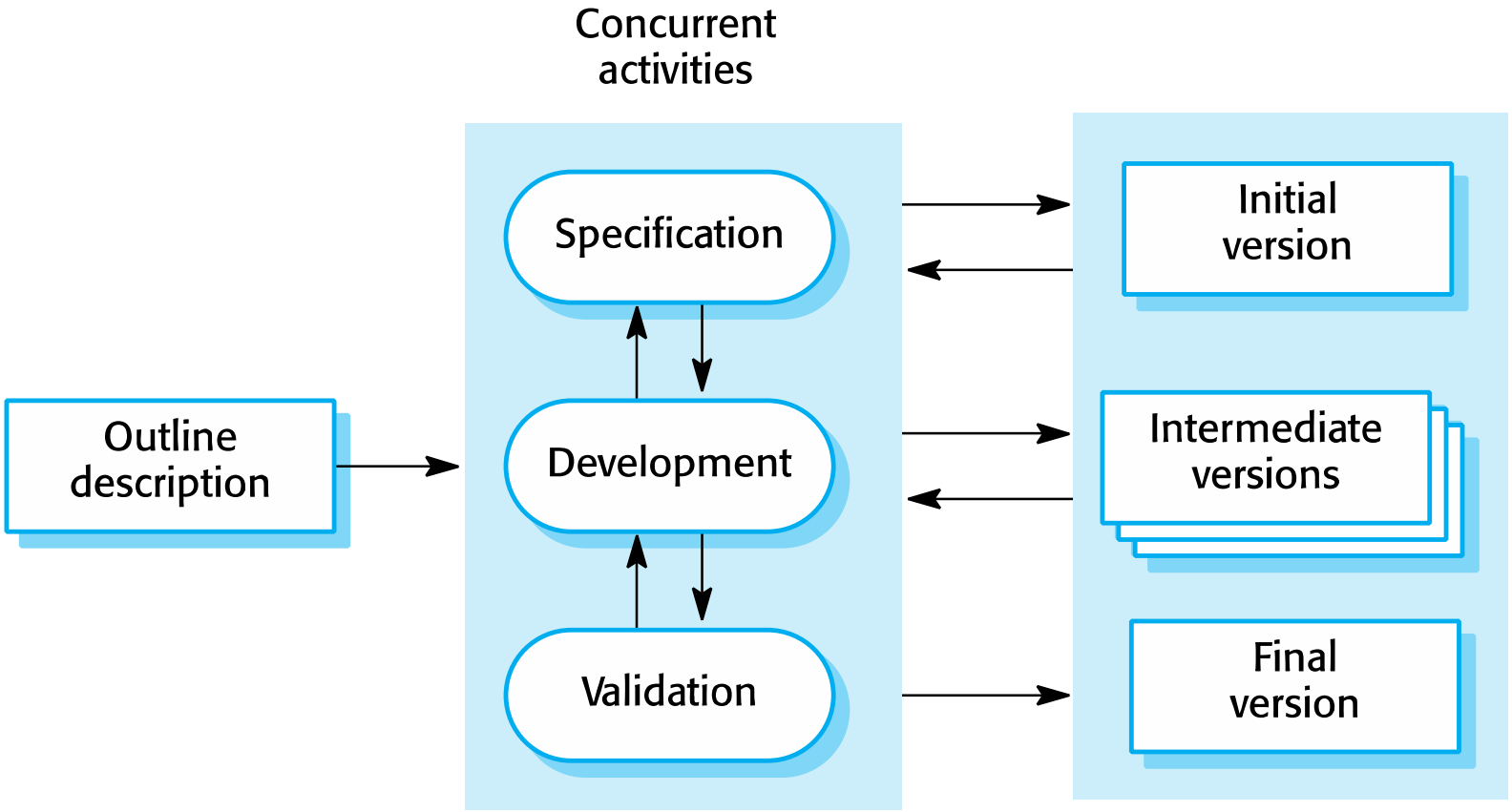
Waterfall model phases

- 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 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.

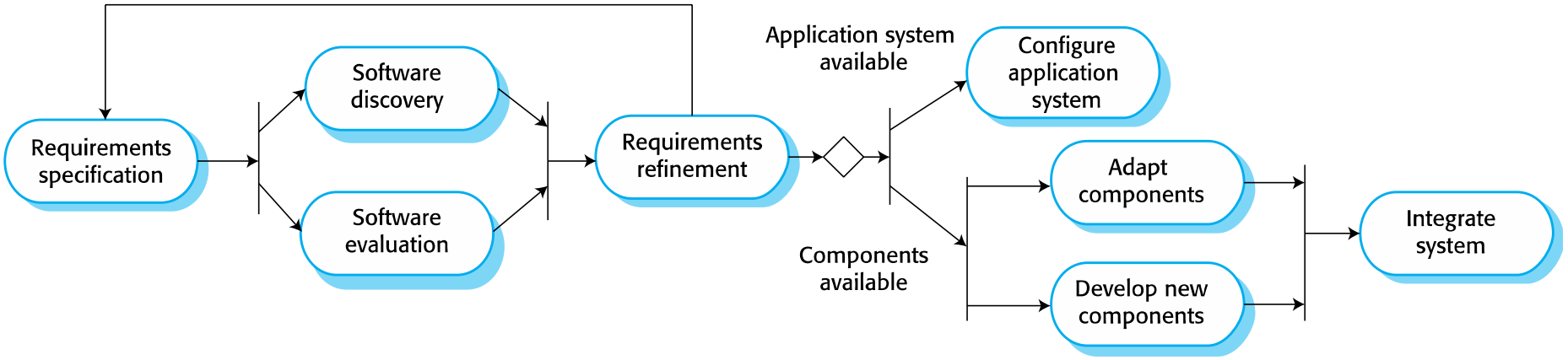
Integration and configuration

- 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
  - Reuse covered in more depth in Chapter 15.

Types of reusable software

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

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

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

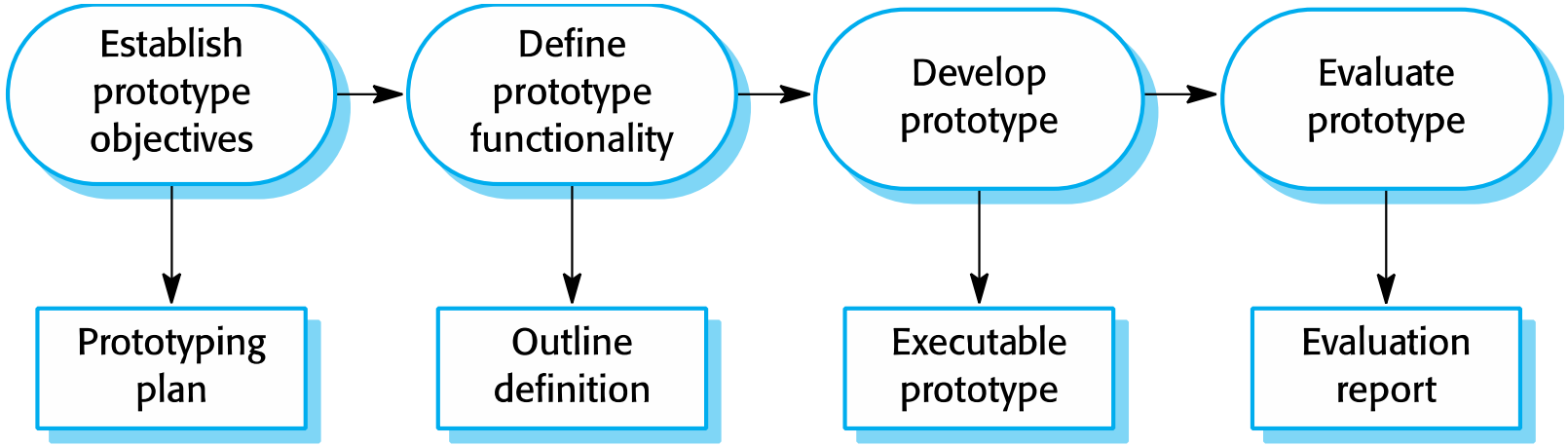
Software prototyping

- 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;
  - 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

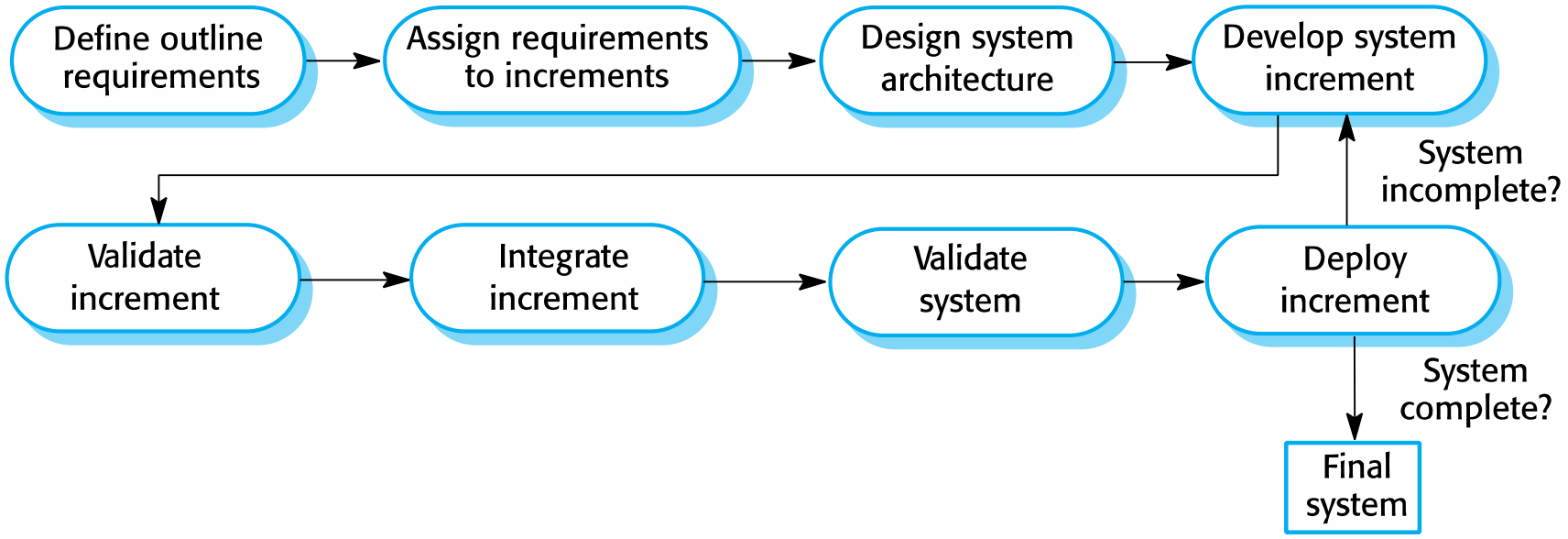
✧ Incremental development

- 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.

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.