Software Engineering – CSC 343

Chapter 2

Software Processes

Objectives

- **To introduce software process models**
- **To describe three generic process models and when they may be used**
- **To describe outline process models for:**
  - requirements engineering
  - software development
  - testing and evolution

Topics covered

- Software process models
- Process iteration
- Process activities
- Computer-aided software engineering

1. Introduction

- A structured set of activities required to develop a software system
  - Specification;
  - Design;
  - Testing/Validation;
  - Evolution.

1. Introduction

- A software process model:
  - is an abstract representation of a process
  - it presents a description of a process from some particular perspective.
- Many organization still rely on ad-hoc processes
  - no use of sw processes methods
  - no use of best practice in sw industry

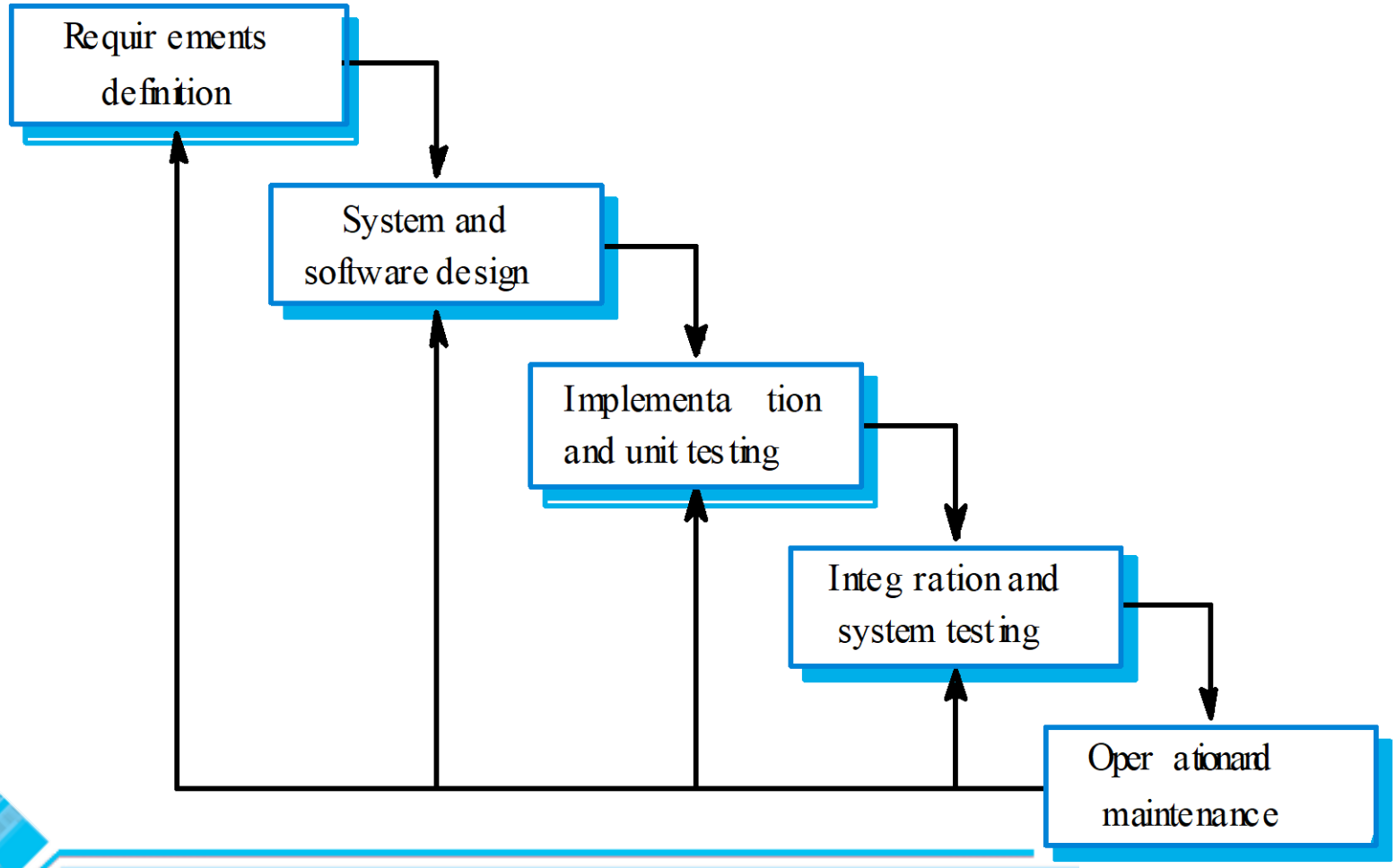
2. Generic software process models

- The waterfall model
  - Separate and distinct phases of specification and development: Requirements, design, implementation, testing, …
  - No evolution process, only development
  - Widely used & practical
  - Recommended when requirements *are well known and stable at start*
- Evolutionary development
  - Specification and development are interleaved
  - Develop rapidly & refine with client
  - Widely used & practical
  - Recommended when requirements *are not well known at start*

Generic software process models

- Reuse-based (Component-based) development
  - The system is *assembled* from existing components
    »Components already developed within the organization
    »COTS “Commercial of the shelf ” components
  - Integrating rather than developing
  - Allows rapid development
  - Gaining more place
  - Future trend

Waterfall model



Waterfall model

- The classic way of looking at S.E. that accounts for the importance of requirements, design and quality assurance.
  - The model suggests that software engineers should work in a series of stages.
  - Before completing each stage, they should perform quality assurance (verification and validation).
  - The waterfall model also recognizes, to a limited extent, that you sometimes have to step back to earlier stages.

Limitations of the waterfall model

- The model implies that you should attempt to complete a given stage before moving on to the next stage
  - Does not account for the fact that requirements constantly change.
  - It also means that customers can not use anything until the entire system is complete.
- The model makes no allowances for prototyping.
- It implies that you can get the requirements right by simply writing them down and reviewing them.
- The model implies that once the product is finished, everything else is maintenance.

Limitations of the waterfall model

- Drawback: the difficulty of accommodating change after the process is underway
- Inflexible partitioning of the project into distinct stages
- Inflexible: to respond to dynamic business environment leading to requirements changes
- Appropriate when the requirements are *well-understood and stable*

Evolutionary development

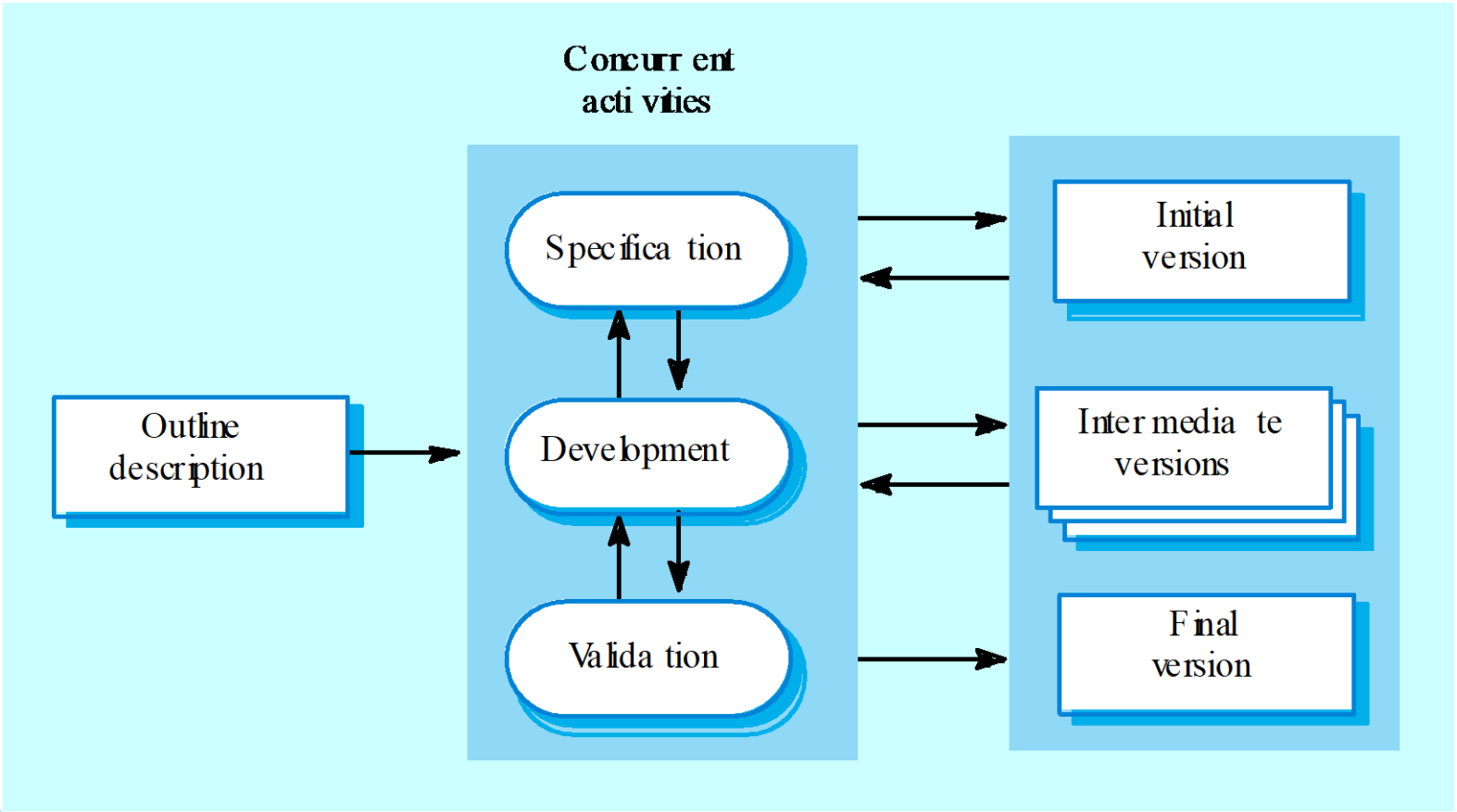
- **Develop an initial implementation prototype**
- **Client test drive …**  **feed back**
- **Refine prototype**

❑ 2 types of Evolutionary development

Exploratory development

Throw-away prototyping

Evolutionary development



Evolutionary development

2 types of Evolutionary development

- Exploratory development
  - Objective is to work with customers, explore their requirements and to evolve a final system from an initial outline specification.
  - Should start with *well-understood* requirements and add new features as proposed by the customer.
- Throw-away prototyping
  - Objective is to understand the system requirements and outline abetter definition of requirements.
  - Should start with poorly understood requirements to clarify what is really needed.

Evolutionary development

Problems

- Lack of process visibility at client management level (less regular reports/documentation … the system is changing continuously)
- Systems are often poorly structured
- Special skills (e.g. in languages/tools for rapid prototyping) may be required

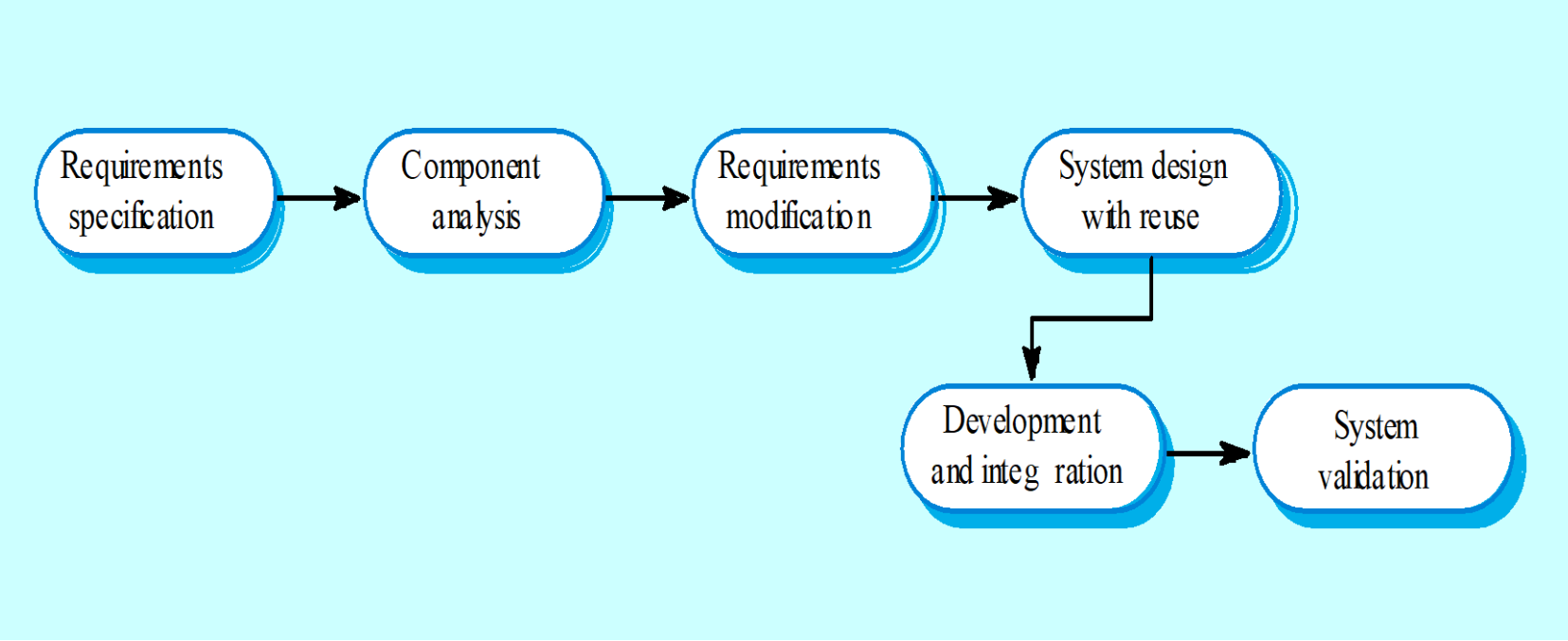
Applicability

- For small or medium-size interactive systems
- For parts of large systems (e.g. the user interface)
- For short-lifetime systems

Component-based 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.
- This approach is becoming increasingly used as component standards have emerged.

Reuse-oriented development



3. Process iteration

- Change is inevitable in all large sw projects. As new technologies, designs and implementation change.
- The process activities are regularly repeated as the system is reworked in response to change requests.
- Iteration can be applied to any of the generic process models.
- Iterative process models present the sw as a cycle of activities.
- The advantage of this approach is that it avoids premature commitments to a specification or design.

Process iteration

- Two (related) approaches:
  - Incremental delivery: the software specification, design and implementation are broken into a series of increments that are each developed in turn.
  - Spiral development: the development of the system spirals outwards from an initial outline through to the final developed system.

Incremental delivery

Software process models - Comparison

- **Waterfall model**

  Requirements should be well defined **at start and committed to**

- **Evolutionary model**

  Requirements & design decisions may be delayed: Poor structure difficult to maintain

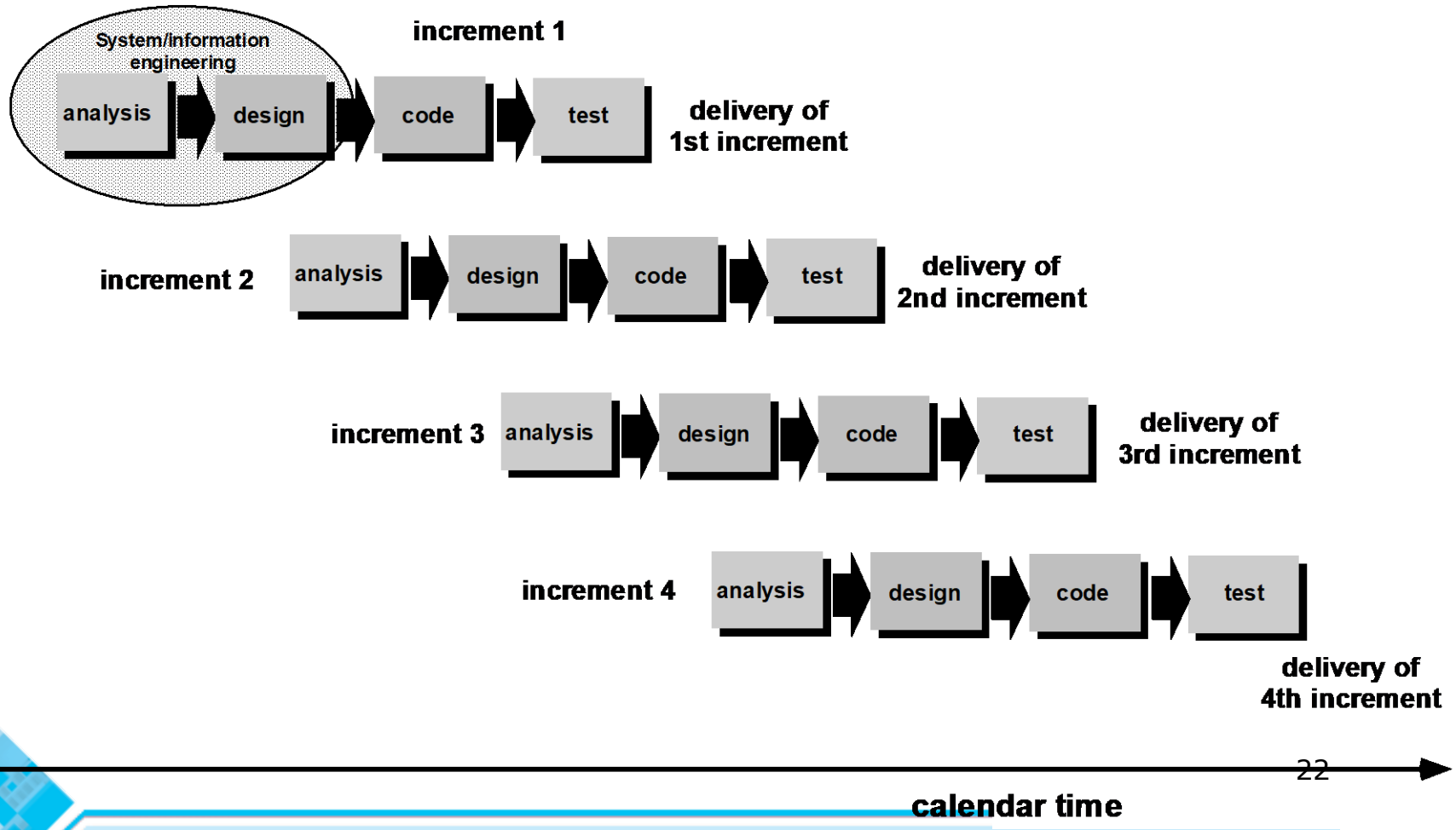
- **Incremental development**

  - Is an in-between approach that combines the advantages of these models.
  - Incremental ***prioritized delivery of modules***
  - ***Hybrid*** of Waterfall and Evolutionary

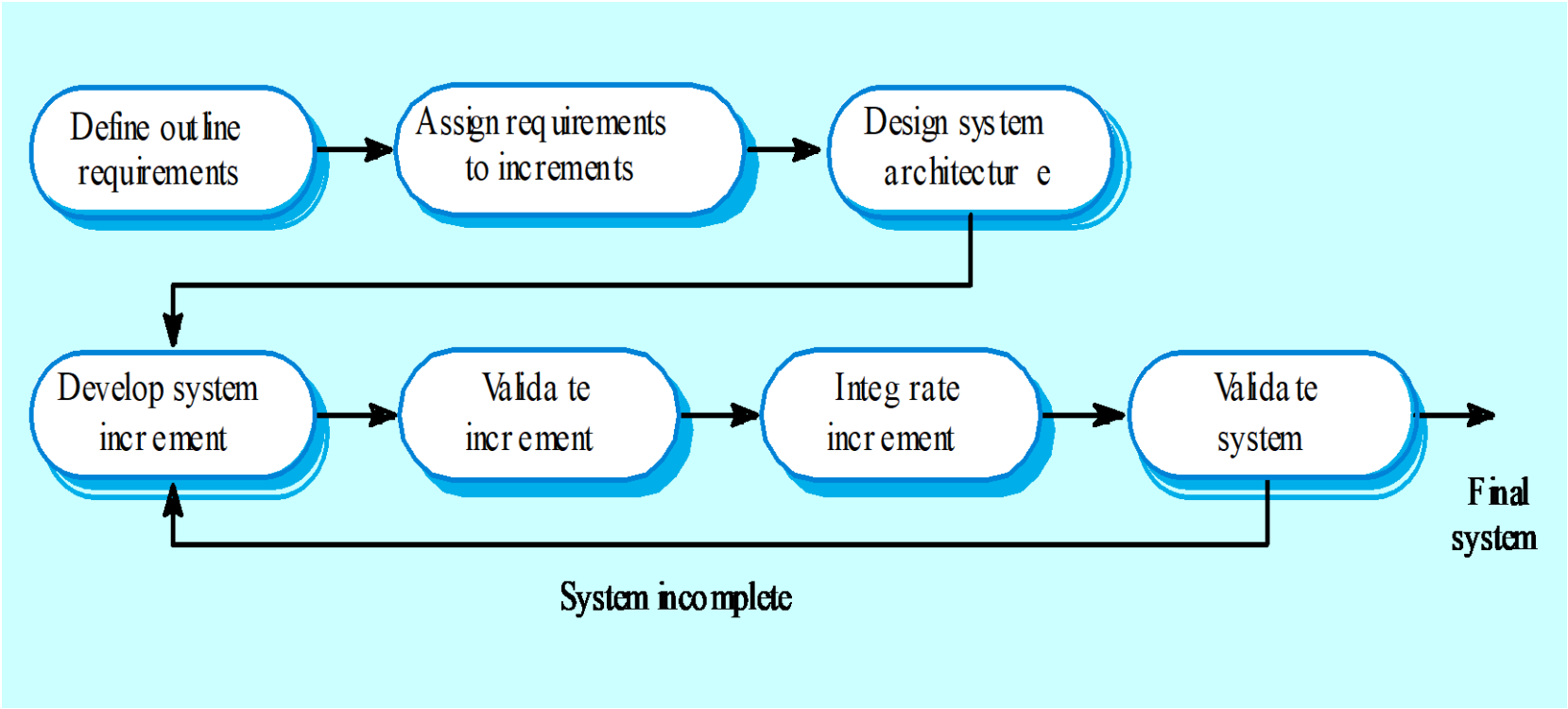
Incremental delivery

- 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 delivery



Incremental development



Incremental development 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.

Spiral development

- Best features of waterfall & prototyping models

  + **Risk Analysis (missed in other models)**

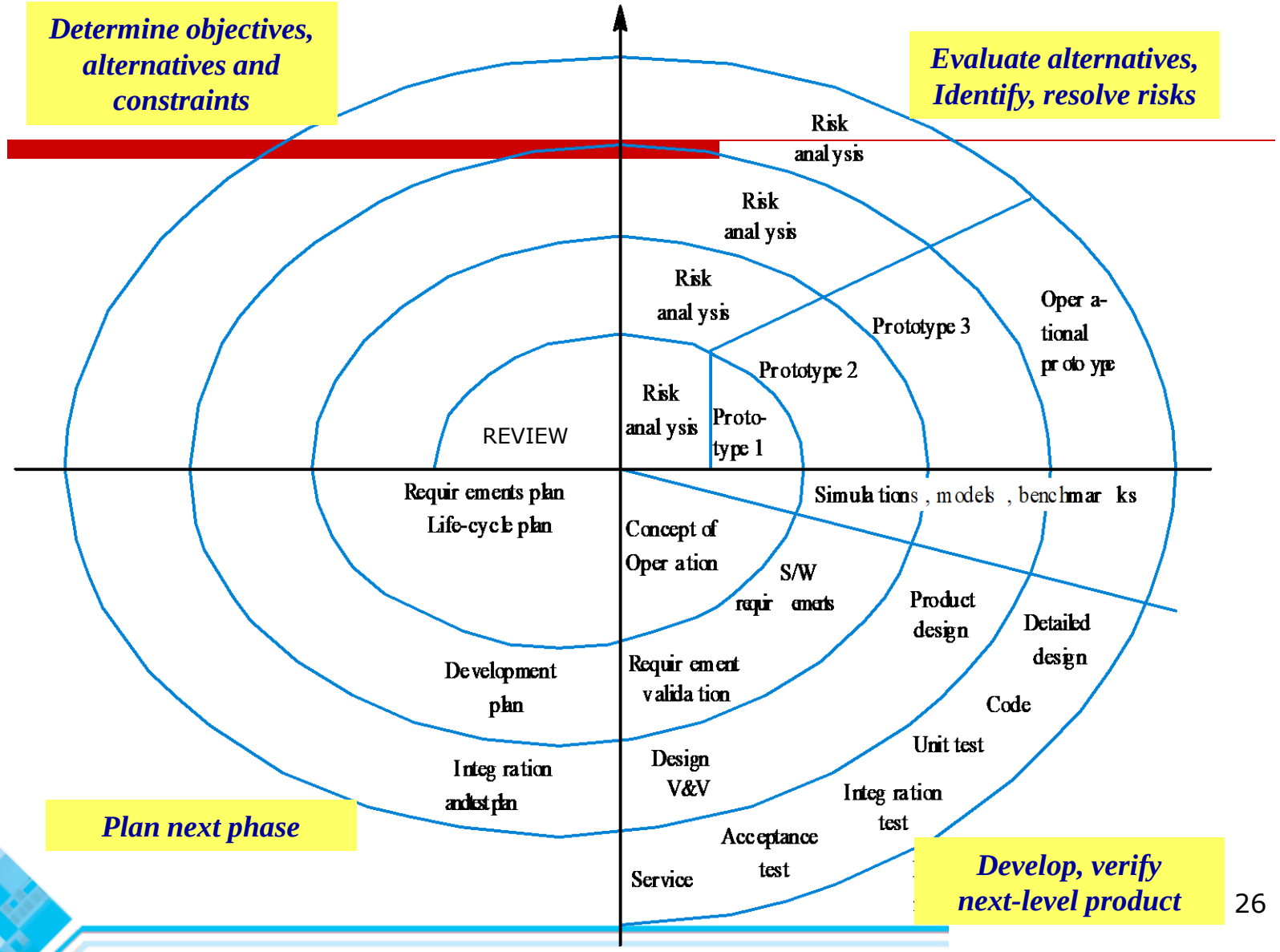
- Process is represented as a spiral rather than as a sequence of activities with backtracking.

- Each loop in the spiral represents a phase in the process.

- Risks are explicitly assessed and resolved throughout the process.

Informally, risk simply means something that can go wrong.

Spiral model of the software process



Spiral development

- It explicitly embraces prototyping and an *iterative* approach to software development.
  - Start by developing a small prototype.
  - Followed by a mini-waterfall process, primarily to gather requirements.
  - Then, the first prototype is reviewed.
  - In subsequent loops, the project team performs further requirements, design, implementation and review.
  - The first thing to do before embarking on each new loop is risk analysis.
  - Maintenance is simply a type of on-going development.

Spiral model: 4 sectors

Each loop in the spiral is split into four sectors:

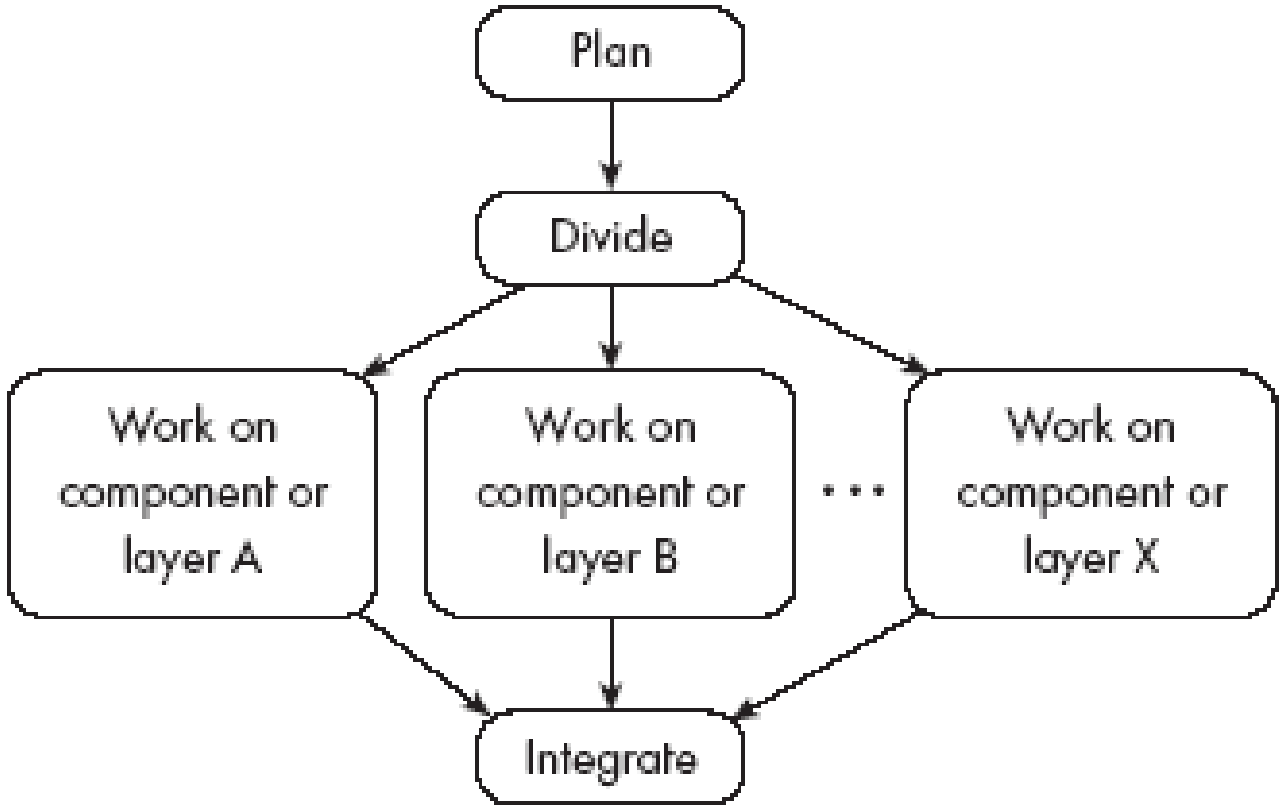
- Objective setting
  - Specific objectives for the phase are identified.
- Risk assessment and reduction
  - Risks are assessed and activities put in place to reduce the key risks. For example if there is a risk that the requirement. are inappropriate, a prototype system may be developed.
- Development and validation
  - A development model for the system is chosen which can be any of the generic models.
- Planning
  - Review with client
  - Plan next phase of the spiral if further loop is needed

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 concurrent engineering model



The concurrent engineering model

- It explicitly accounts for the divide and conquer principle.
  - Each team works on its own component, typically following a spiral or evolutionary approach.
  - There has to be some initial planning, and periodic integration.

4. Process Activities

- Software specification
- Software design and implementation
- Software validation
- Software evolution

Software specification

Requirements engineering process

- **The process of establishing**
  - What services are required (Functional requirements) for the system
  - Identifying the constraints on the system's operation and development (Non-functional requirements)

- **Requirements engineering process**

1. Feasibility study: ***An estimate is made of whether the identified user needs may be satisfied using current software and hardware technologies.***

- Alternatives & Quick cost/benefit analysis
- Feasibility: Technical, Financial, Human, Time schedule
- Deliverables: Feasibility report

2. Requirements elicitation and analysis: Facts finding

- Interviews, JAD "Joint Application Development", Questionnaires, Document inspection, Observation
- Deliverables: System models (Diagrams)

Software specification

Requirements engineering process

- **Requirements engineering process**

3. Requirements specification: ***the activity of translating the information gathered during the analysis activity into a document that defines a set of requirements.***

- User level: abstract specification
- System level: detailed specification
- Deliverables: User and system requirements

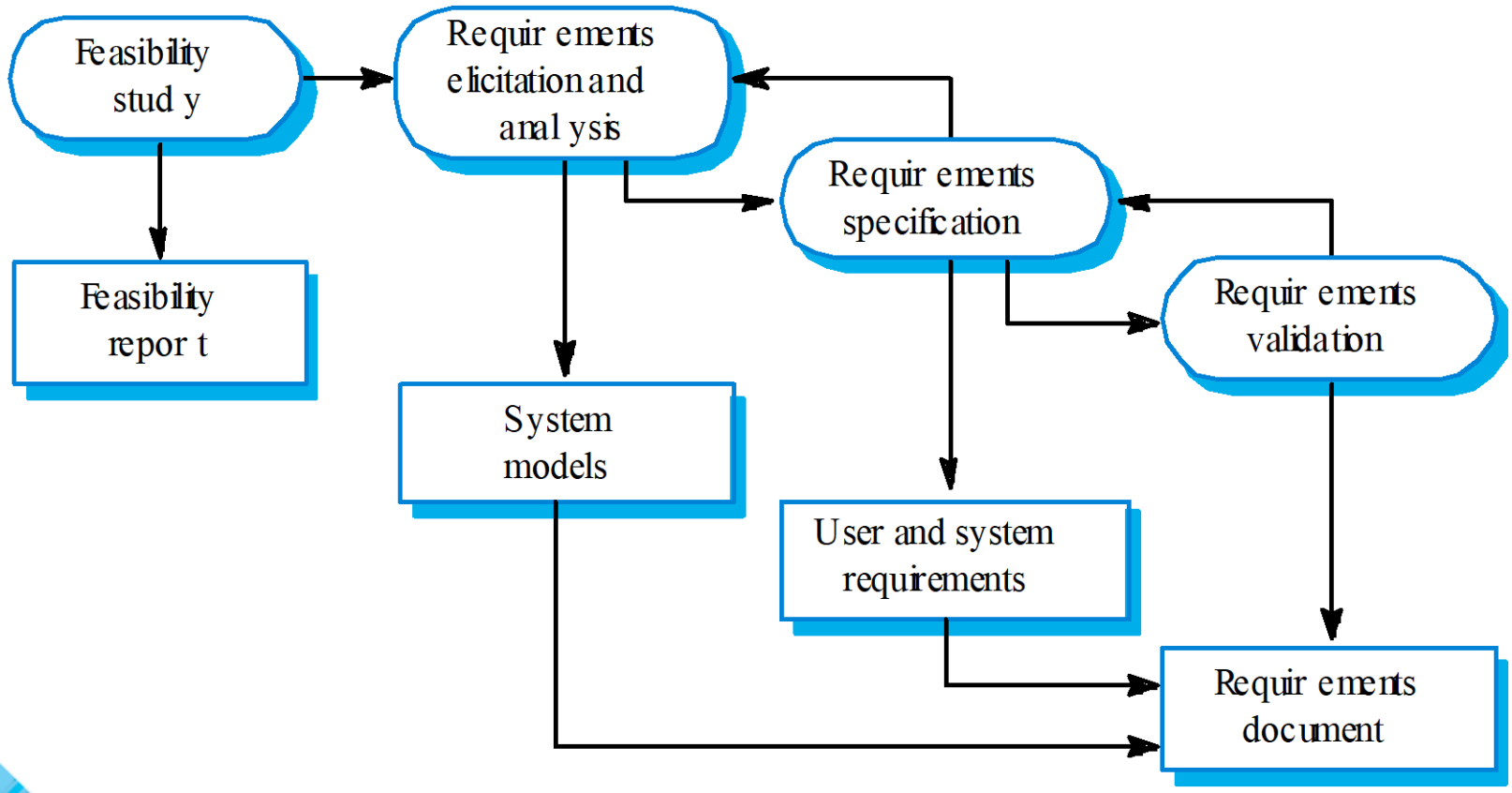
4. Requirements validation: ***this activity checks the requirements for:.***

- Completeness
- Consistency
- Realism
- Deliverables: Updated requirements

Global Deliverables of the Requirements Engineering Process :
System Requirements Specification document

Software specification

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.**

Design process activities

- Architectural design
- Abstract specification
- Interface design
- Component design
- Data structure design
- Algorithm design

Design Process Activities

1. Architectural design
   - Subsystems/relationships, block diagram
   - Deliverables: System architecture
2. Abstract specification for each subsystem
   - Deliverables: **For each sub-system, an abstract specification of its services and constraints under which it must operate is produced**
3. System/subsystems Interface design
   - With other subsystems of the sys
   - With external systems (Bank, GOSI, …) *General Organization for Social Insurance*
   - Deliverables: Interface specs for each subsystem in relation to other subsystems or external systems

Design Process Activities

4. Component design
   - Services are allocated to components
   - Components interfaces are designed
     - » Interfaces with other components of the system
     - » Interfaces with external systems
     - » GUI
     - » Input
     - » Output
   - Deliverables: Component specs

Design Process Activities

5. Data structure (Database) design
   - Detailed design of data structure to be implemented (design or implementation activity)
   - Deliverables: Data structure specs

6. Algorithm design
   - Detailed design of algorithm for services to be implemented (design or implementation activity)
   - Deliverables: Algorithm specs

The software design process