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

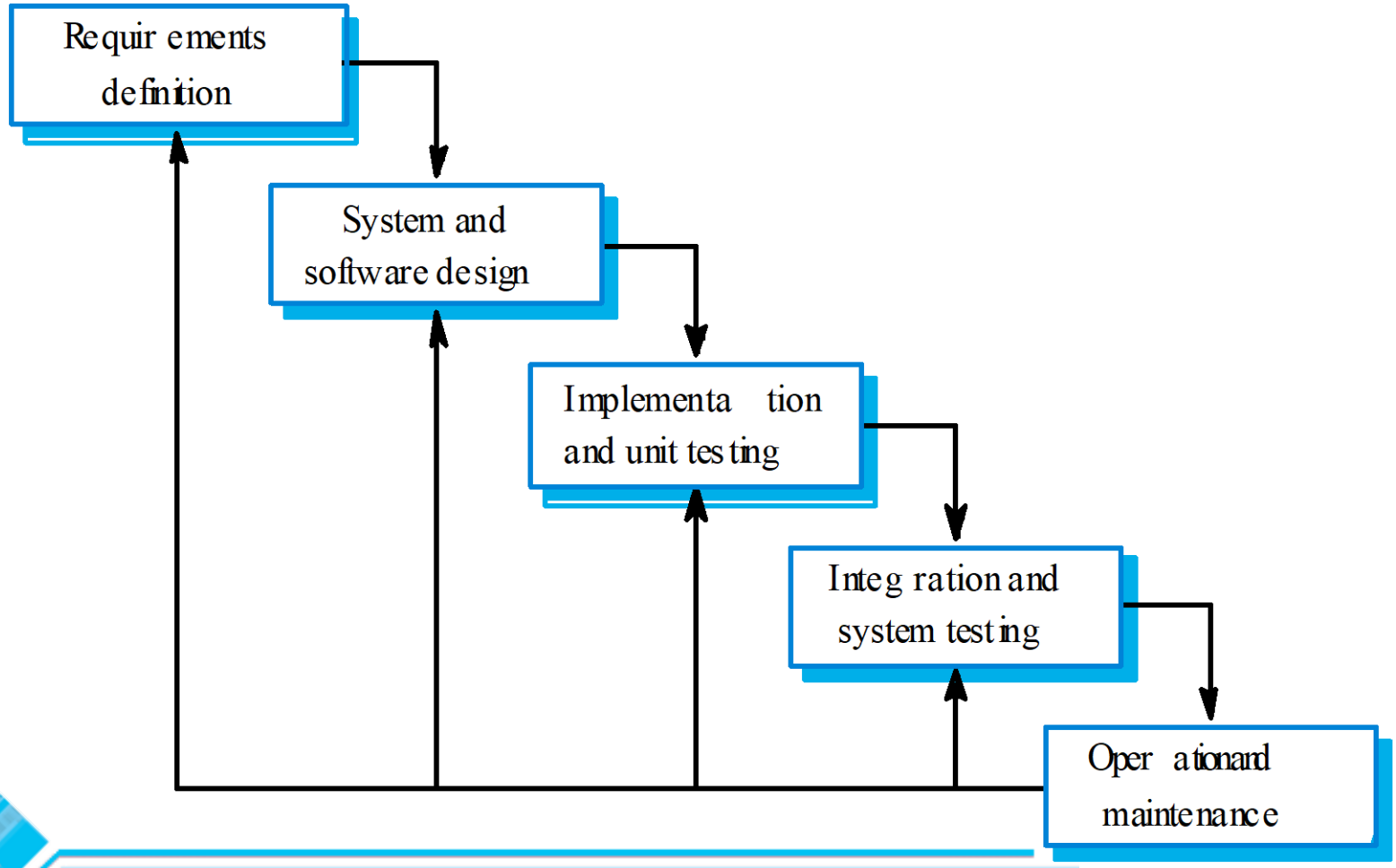
2. Generic software process models

- 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

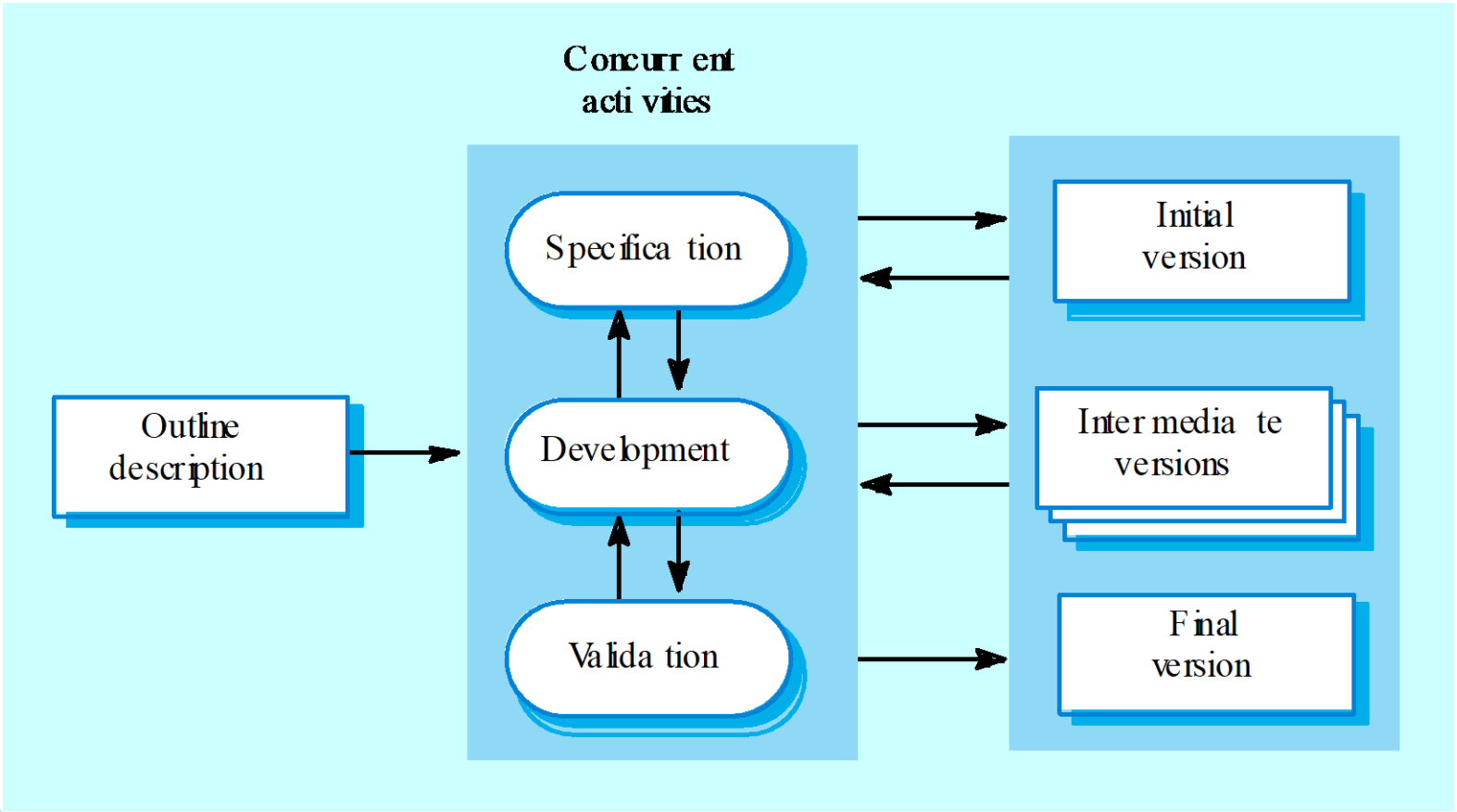
- **Develop an initial implementation prototype**
- **Client test drive …**  **feed back**
- **Refine prototype**

❑ 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

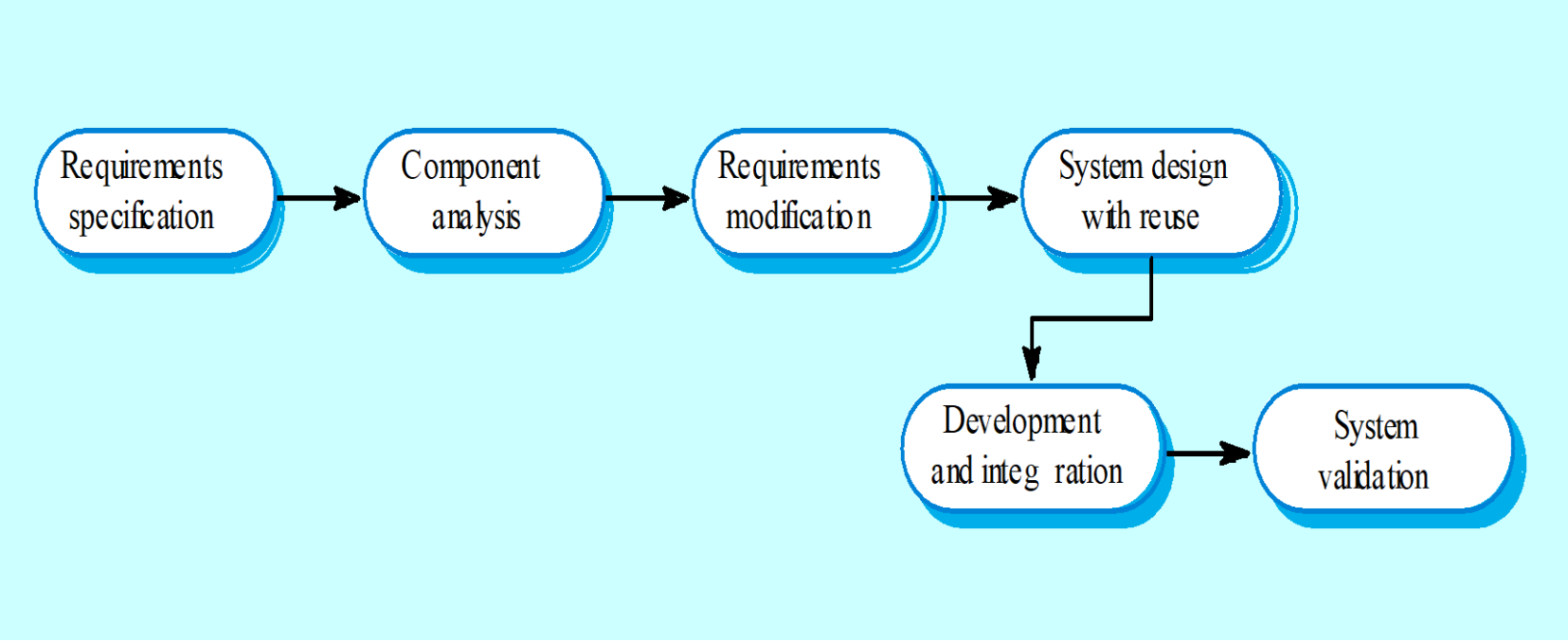
Applicability

- 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

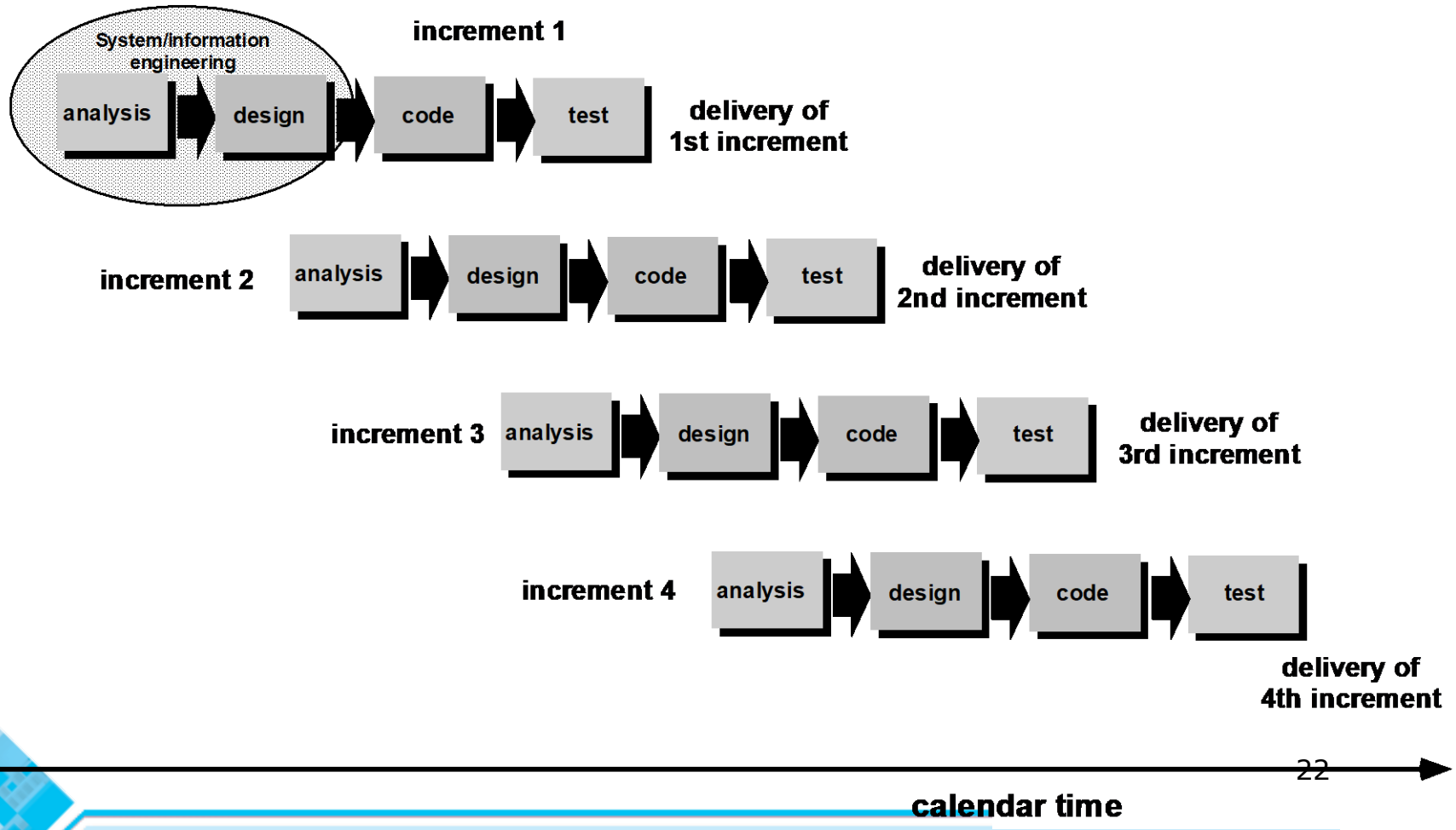
- **Incremental development**

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

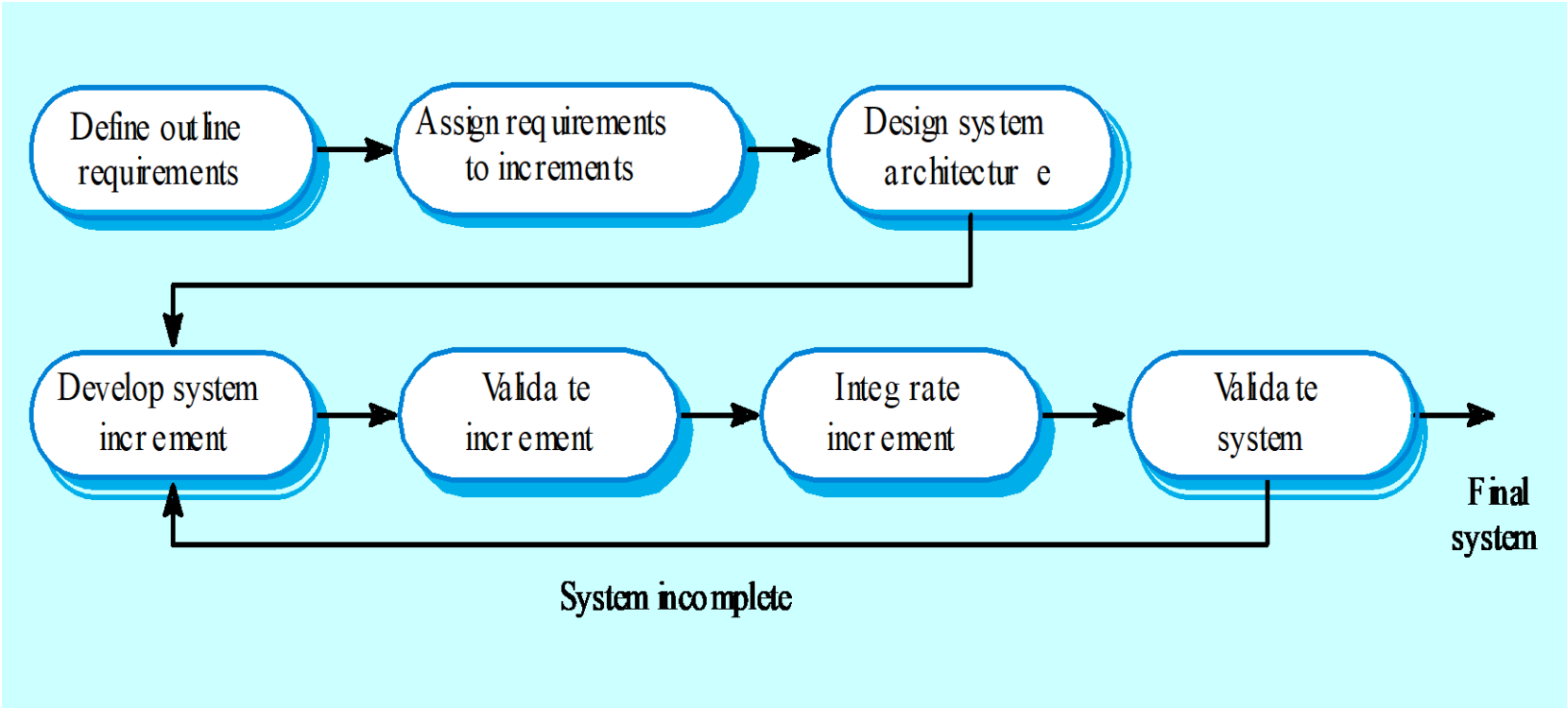
Incremental delivery

- 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)**

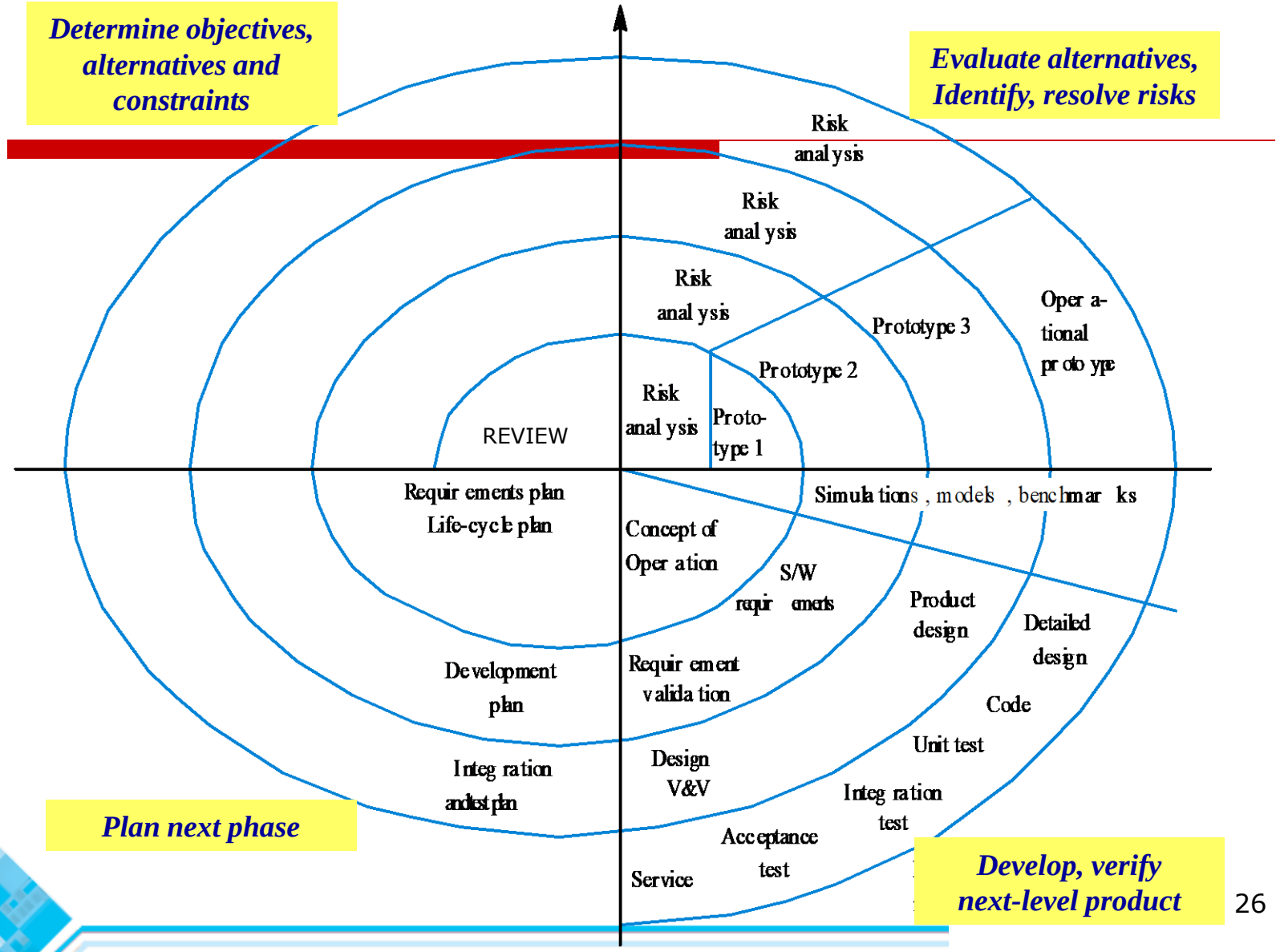
- Process is represented as a spiral rather than as a sequence of activities with backtracking.

- 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:

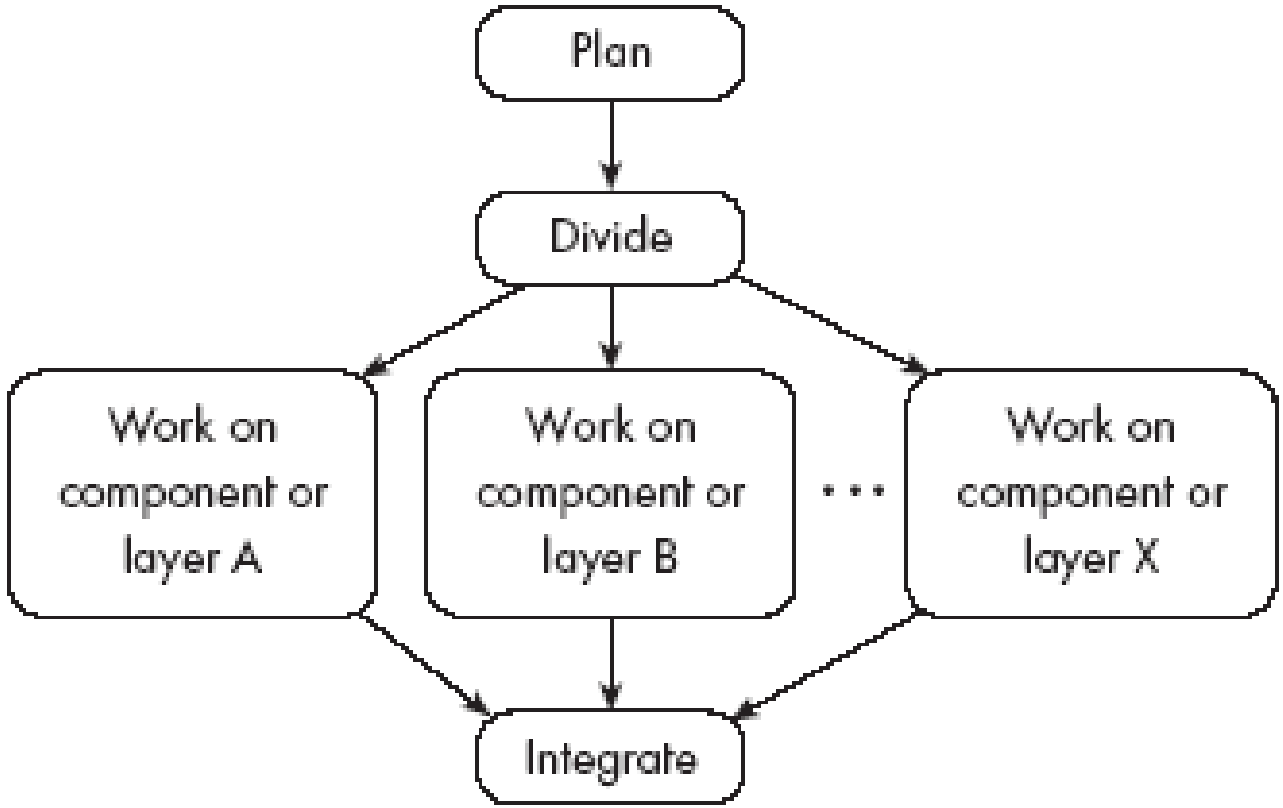
- Objective setting
  - Specific objectives for the phase are identified.
- Risk assessment and reduction
  - Risks are assessed and activities put in place to reduce the key risks. For example if there is a risk that the requirement. are inappropriate, a prototype system may be developed.
- Development 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.

Agile Software Development

- Agile methods
- Plan-driven and agile development

Rapid software development

- Rapid development and delivery is now often the most important requirement for software systems
  - Businesses operate in a fast –changing requirement and it is practically impossible to produce a set of stable software requirements
  - Software has to evolve quickly to reflect changing business needs.
- Rapid software development
  - Specification, design and implementation are inter-leaved
  - System is developed as a series of versions with stakeholders involved in version evaluation
  - User interfaces are often developed using graphical toolset.

Agile methods

- Dissatisfaction with the overheads involved in software design methods of the 1980s and 1990s led to the creation of agile methods. These methods:
  - Focus on the code rather than the design
  - Are based on an iterative approach to software development
  - Are intended to deliver working software quickly and evolve this quickly to meet changing requirements.
- The aim of agile methods is to reduce overheads in the software process (e.g. by limiting documentation) and to be able to respond quickly to changing requirements without excessive rework.

The principles of agile methods

Principle	Description
Customer involvement	Customers should be closely involved throughout the development process. Their role is provide and prioritize new system requirements and to evaluate the iterations of the system.
Incremental delivery	The software is developed in increments with the customer specifying the requirements to be included in each increment.
People not process	The skills of the development team should be recognized and exploited. Team members should be left to develop their own ways of working without prescriptive processes.
Embrace change	Expect the system requirements to change and so design the system to accommodate these changes.
Maintain simplicity	Focus on simplicity in both the software being developed and in the development process. Wherever possible, actively work to eliminate complexity from the system.

Agile method applicability

- Product development where a software company is developing a small or medium-sized product for sale.
- Custom system development within an organization, where there is a clear commitment from the customer to become involved in the development process and where there are not a lot of external rules and regulations that affect the software.
- Because of their focus on small, tightly-integrated teams, there are problems in scaling agile methods to large systems.

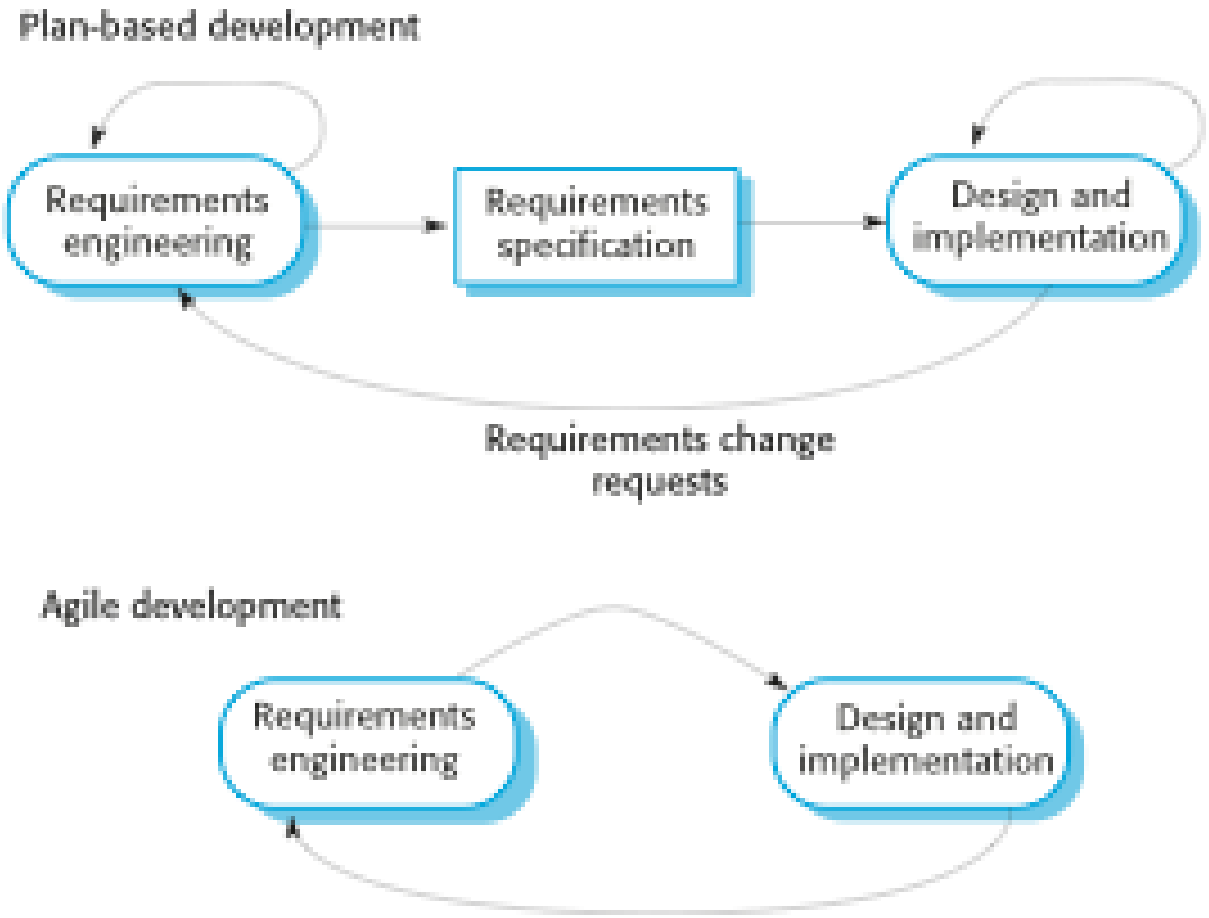
Problems with agile methods

- It can be difficult to keep the interest of customers who are involved in the process.
- Team members may be unsuited to the intense involvement that characterises agile methods.
- Prioritising changes can be difficult where there are multiple stakeholders.
- Maintaining simplicity requires extra work.
- Contracts may be a problem as with other approaches to iterative development.

Plan-driven and agile development

- Plan-driven development
  - A plan-driven approach to software engineering is based around separate development stages with the outputs to be produced at each of these stages planned in advance.
  - Not necessarily waterfall model – plan-driven, incremental development is possible
  - Iteration occurs within activities.
- Agile development
  - Specification, design, implementation and testing are inter-leaved and the outputs from the development process are decided through a process of negotiation during the software development process.

Plan-driven and agile specification



Key points

- Agile methods are incremental development methods that focus on rapid development, frequent releases of the software, reducing process overheads and producing high-quality code. They involve the customer directly in the development process.
- The decision on whether to use an agile or a plan-driven approach to development should depend on the type of software being developed, the capabilities of the development team and the culture of the company developing the system.

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

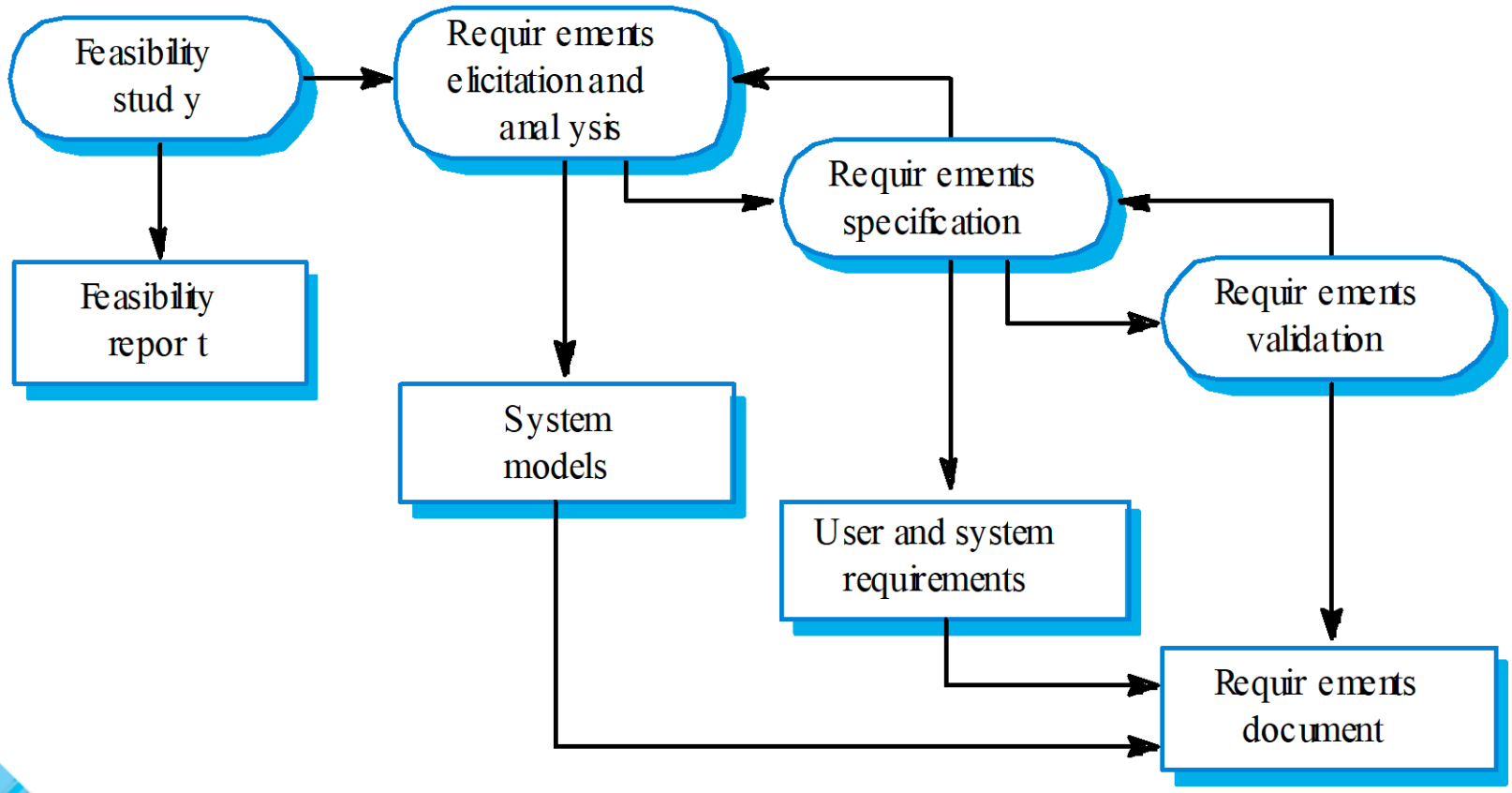
4. Requirements validation: ***this activity checks the requirements for:.***

- 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