

Software Engineering

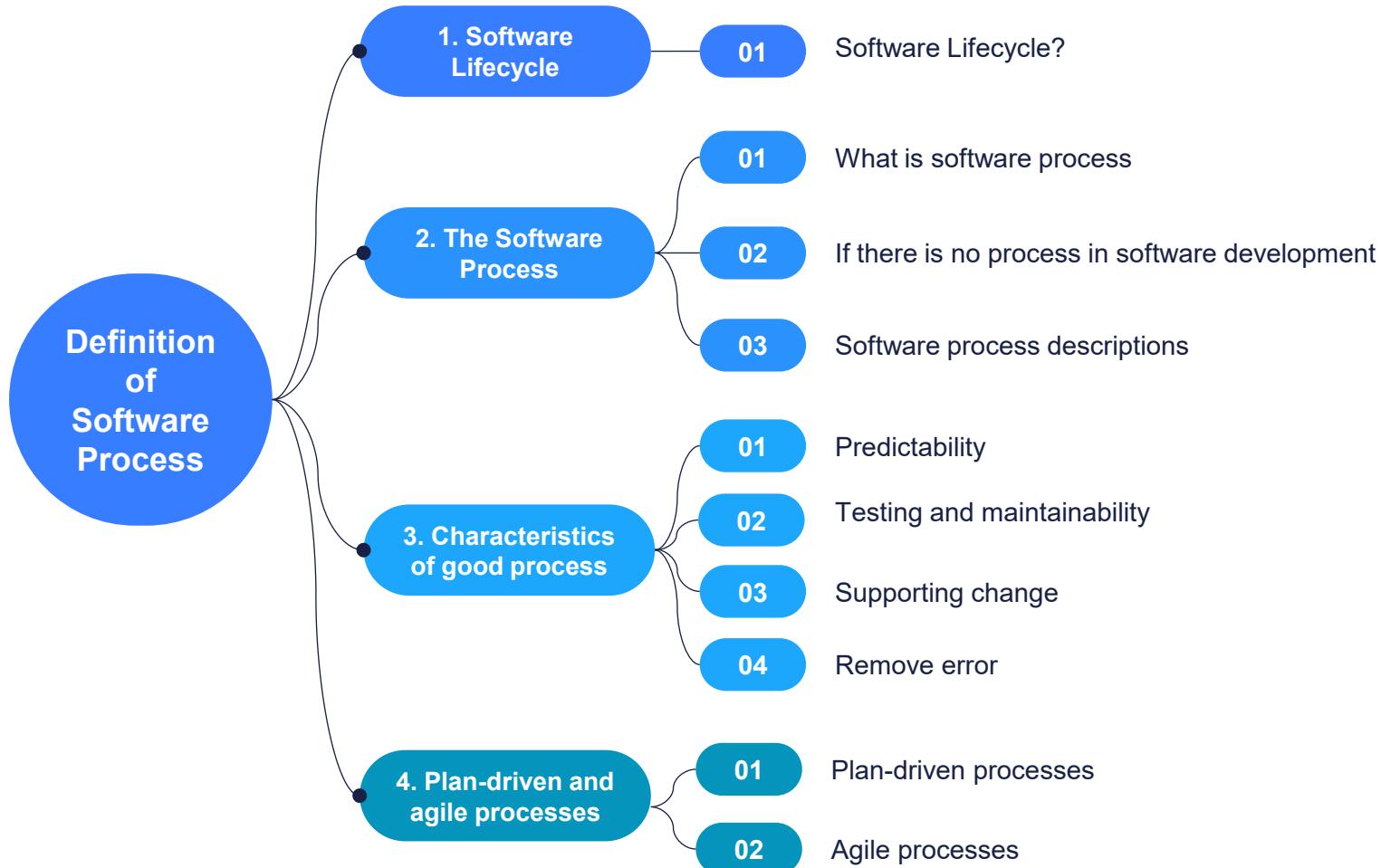
2 – Software Processes

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Topics covered

- 01** Definition of Software process
- 02** Software process models
- 03** Process activities
- 04** Coping with change
- 05** Process improvement

2-1: Definition of Software Process

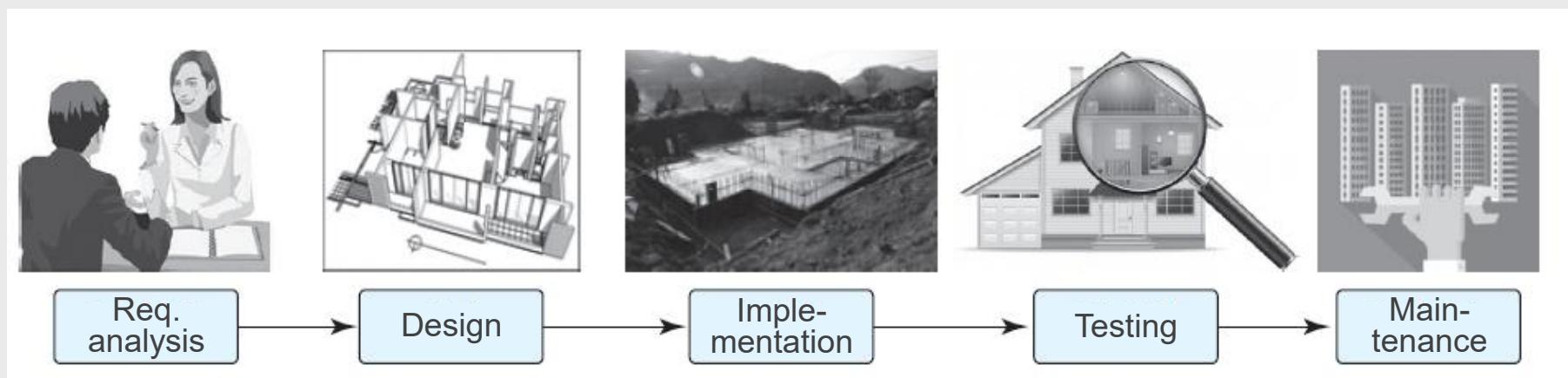


Definition of software process

Software lifecycle

[Software lifecycle]

Technique and management-related works for software development



Source: <All about software engineering>. 생능출판사. 최은만

Definition of software process

The Software process

[What is software process?]

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

[Many different software processes but all involve]

Specification (명세화)

defining what the system should do

Design and implementation (개발)

defining the organization of the system and implementing the system

Validation (검증)

checking that it does what the customer wants

Evolution (진화)

changing the system in response to changing customer needs.

Definition of software process

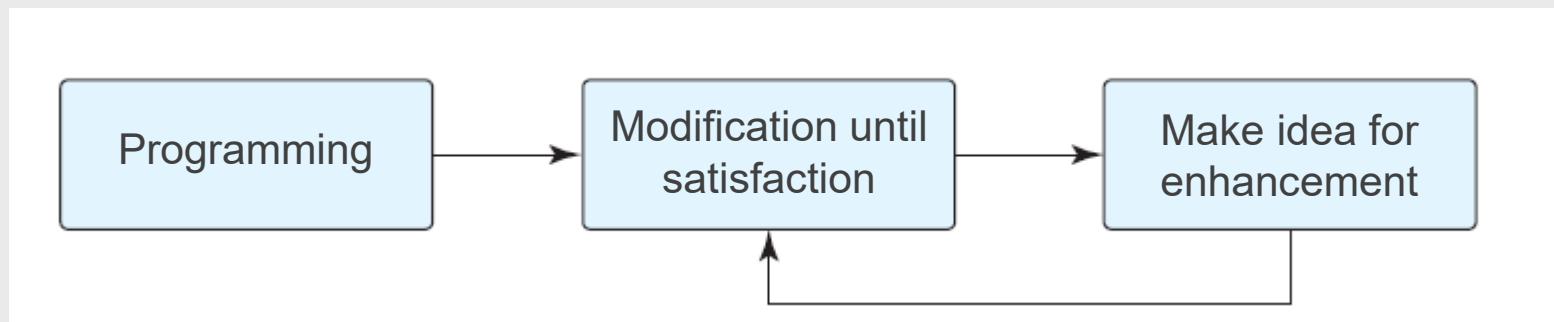
The Software process

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

The Software process

[If there is no process in software development]

- Failing to realize the importance of designing.
- No plans, no work goals
- No awareness of the need for systematic testing work or quality assurance activities
- That called as code-and-fix (주먹구구식 방법)



Source: <All about software engineering>. 생능출판사. 최은만

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]

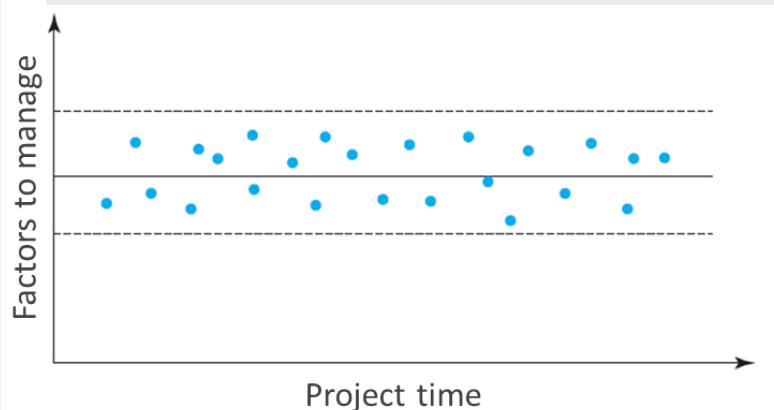
- **Products** (제품) : the outcomes(산출물) of a process activity.
- **Roles** (역할) : reflect the responsibilities of the people involved in the process.
- **Pre- and post-conditions** (사전, 사후조건)
: statements that are true before and after a process activity has been enacted or a product produced.

Definition of software process

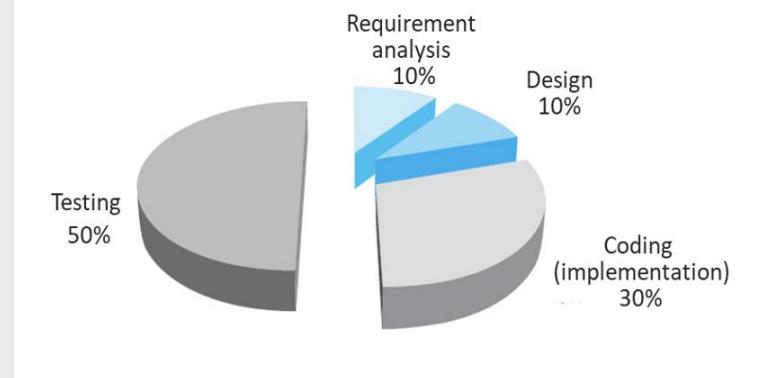
Characteristics of good process

[Characteristics of good process]

Predictability (예측가능성)



Testing and maintainability (테스팅과 유지보수의 용이성)

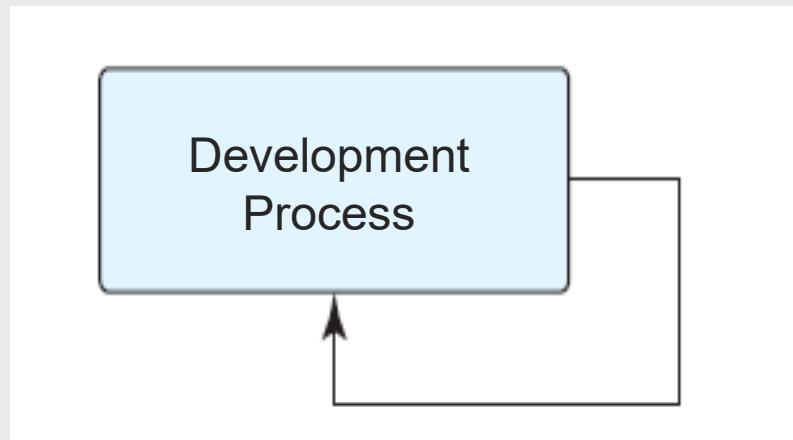


Source: <All about software engineering>. 생능출판사. 최은만

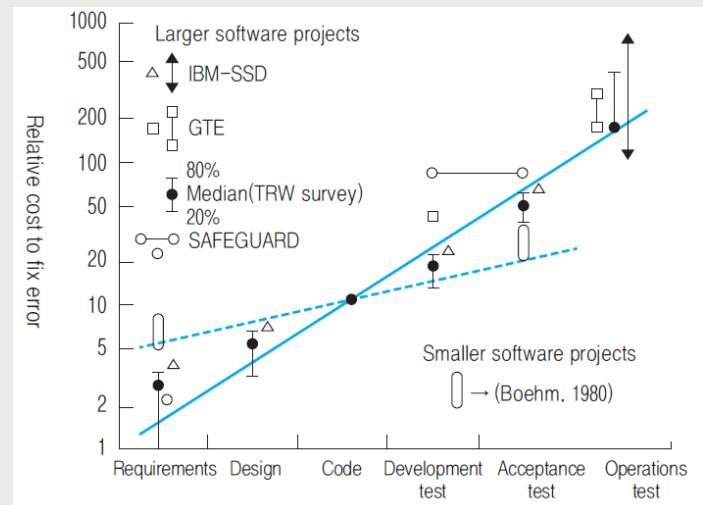
Characteristics of good process

[Characteristics of good process]

Supporting change
(변경 지원)



Remove error
(결함제거)



Source: <All about software engineering>. 생능출판사. 최은만

Plan-driven and agile processes

[Plan-driven processes]

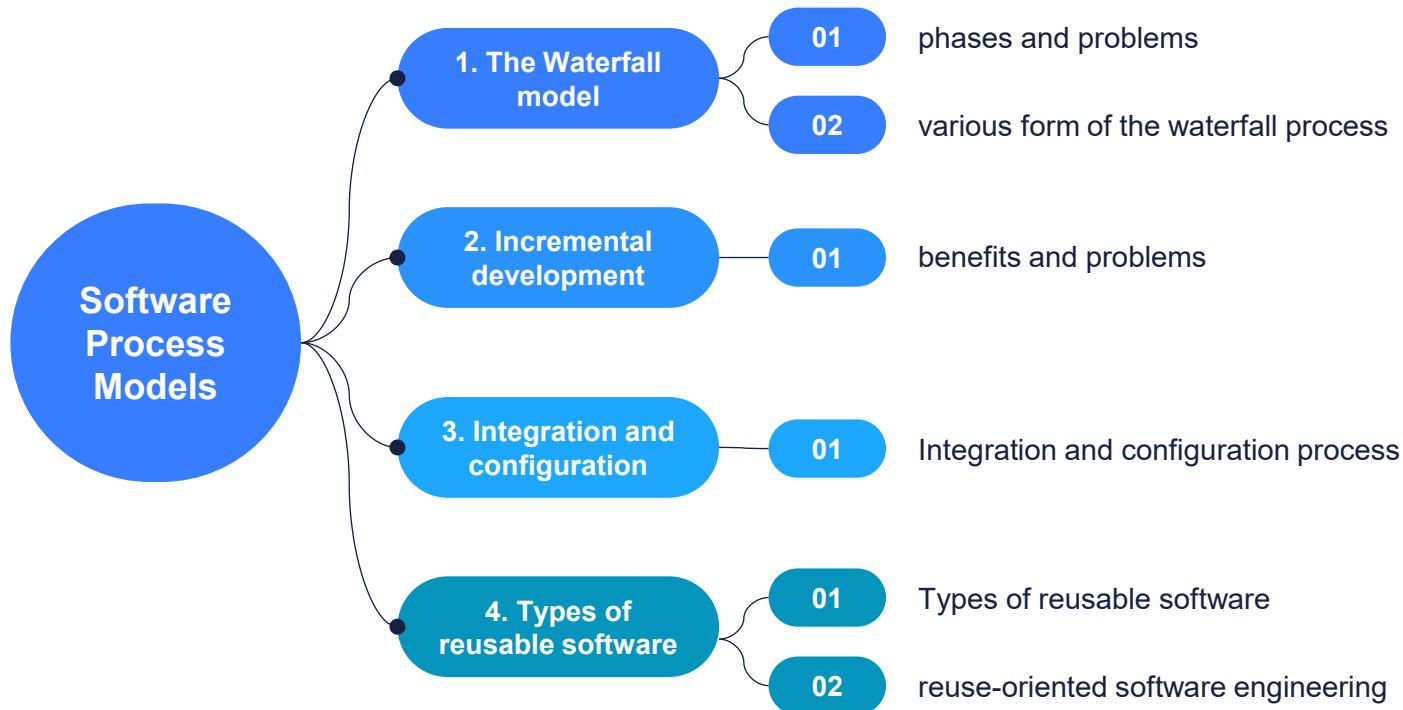
- processes where all of the process activities are planned in advance and progress is measured against this plan.

[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.**

2-2 : 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.

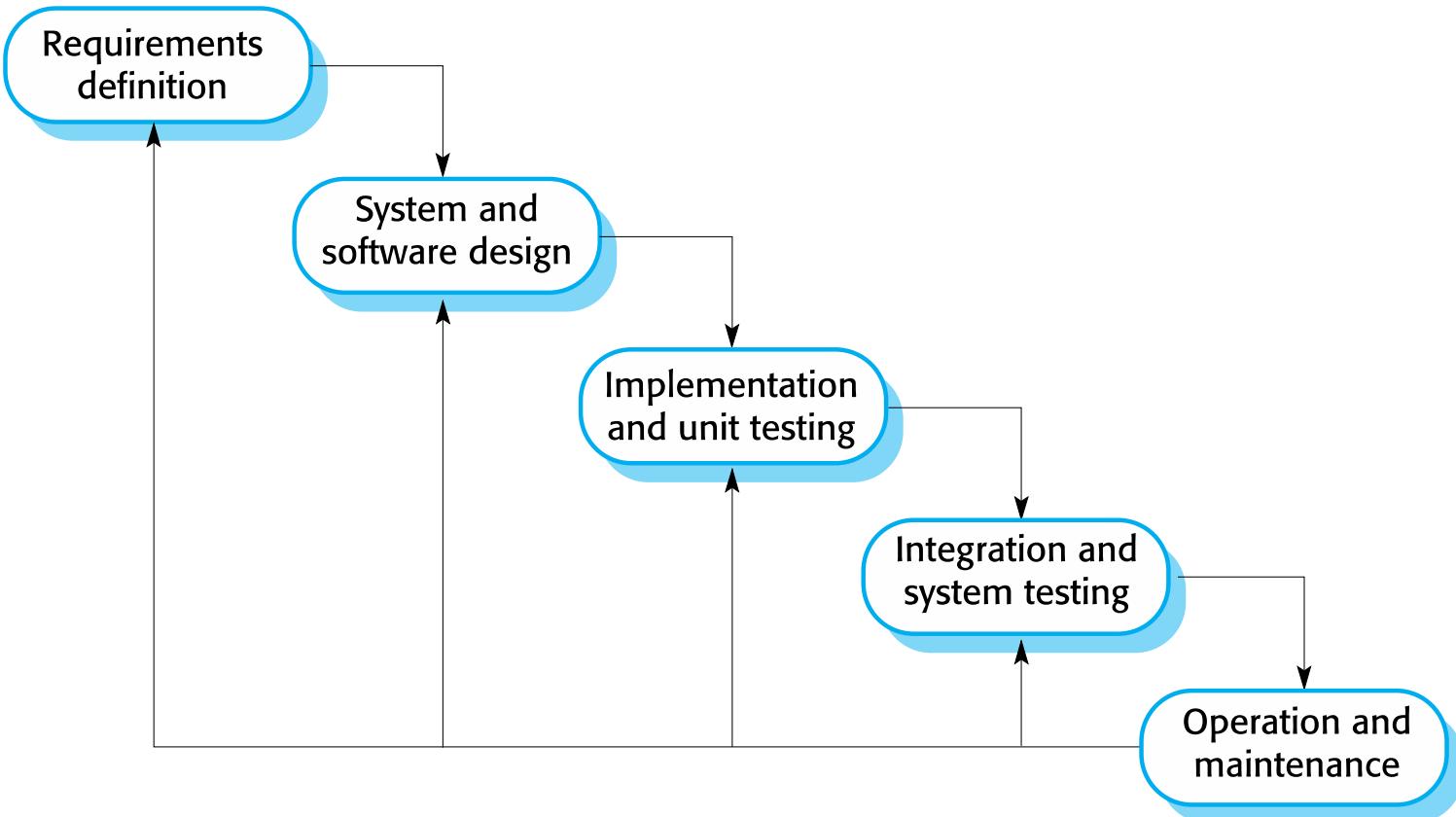
Integration and configuration

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



The 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.

The 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.

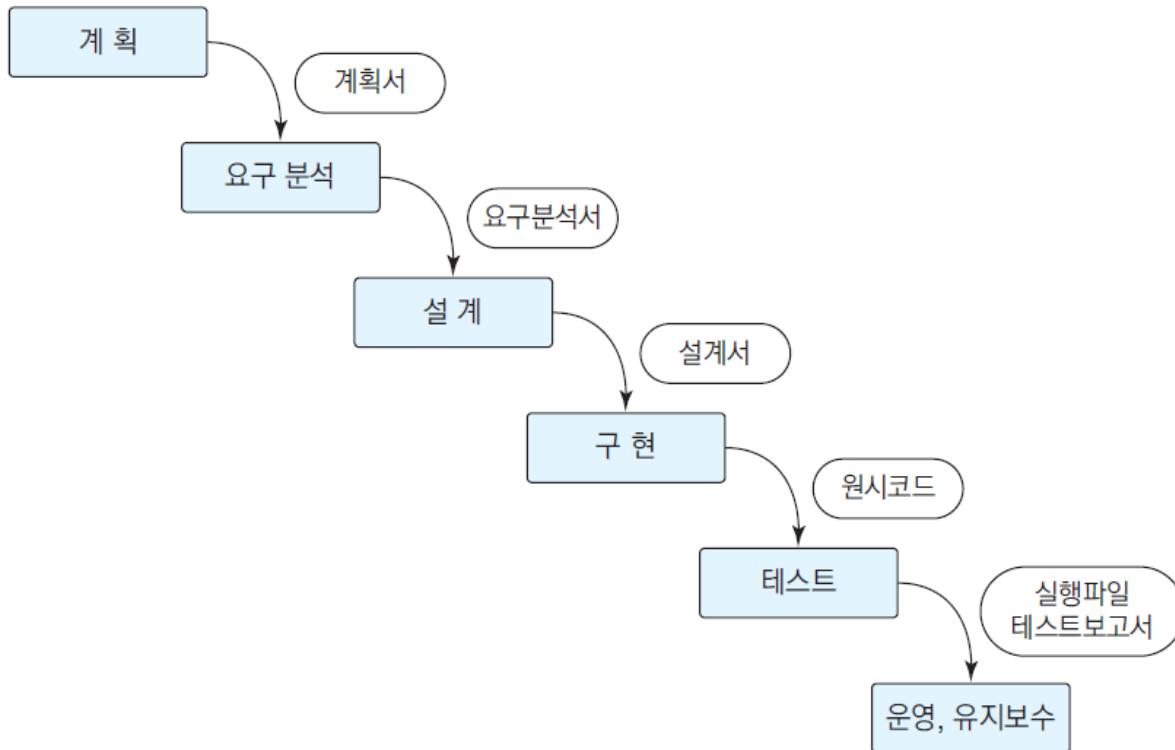
[The waterfall model is mostly used **for large systems engineering projects** where a system is developed at several sites.]

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

Various form of the waterfall process

[General form (as Korean)]

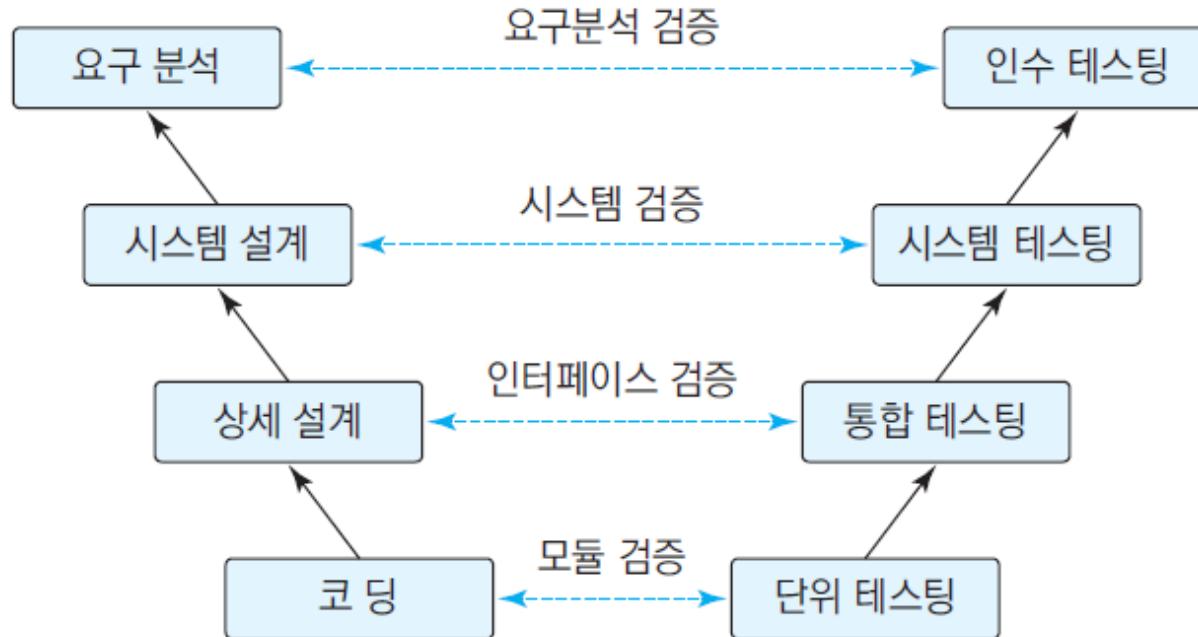
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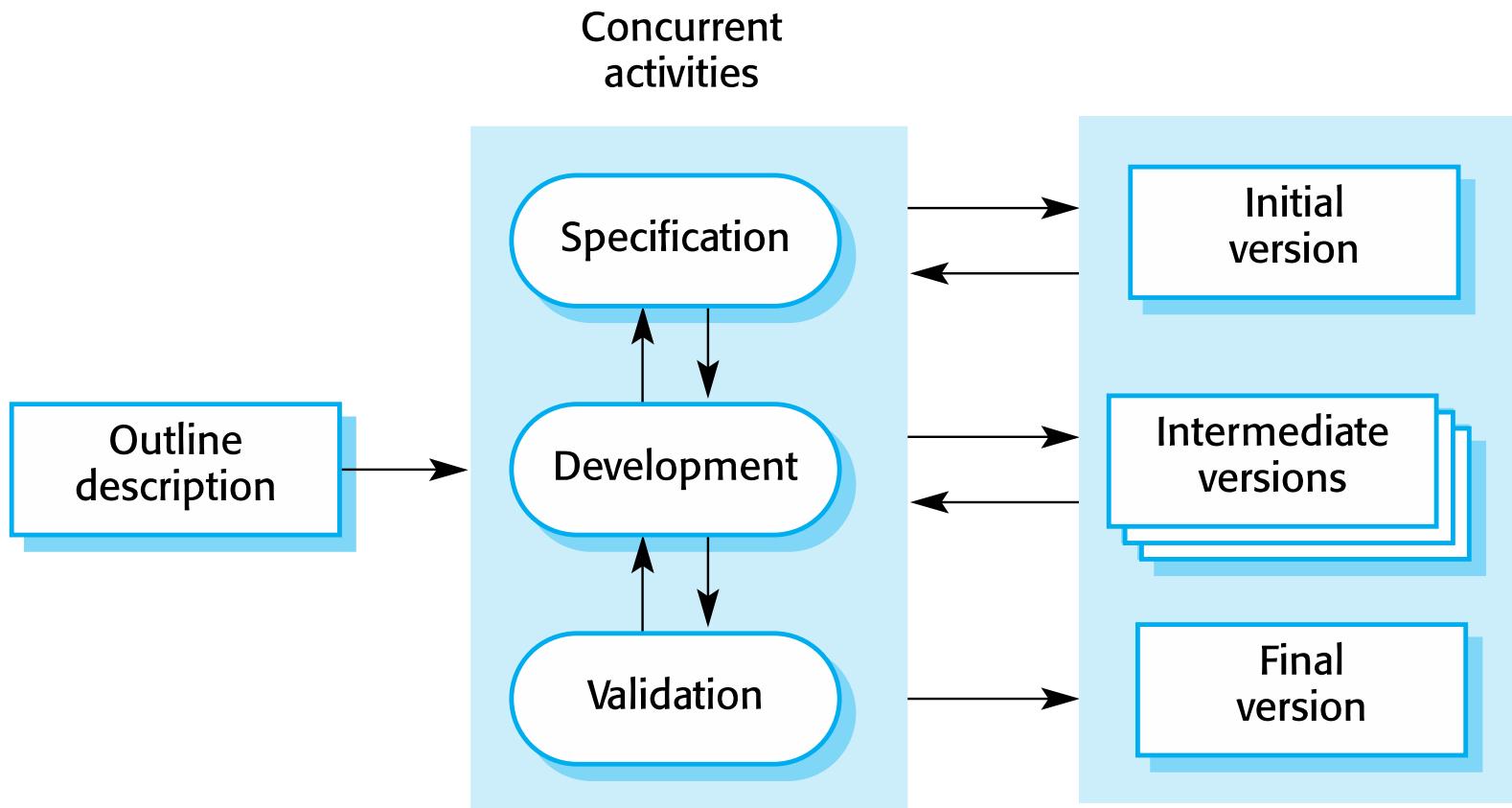
Various form of the waterfall process

[V-model to enhance verification (as Korean)]

Source: <All about software engineering>. 생능출판사. 최은만



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** (가시적이지 못함).
 - 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.

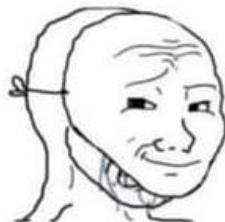
Integration and configuration

Integration and configuration process

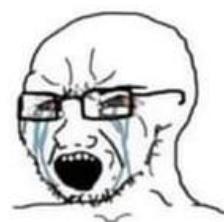
- Based on **software reuse** where systems are integrated from existing components or application systems.
(sometimes called COTS -Commercial-off-the-shelf systems)
- Reused elements may be configured to adapt their behaviour and functionality to a user's requirements.
- **Reuse is now the standard approach** for building many types of business system.

Integration and configuration

DESIGNERS

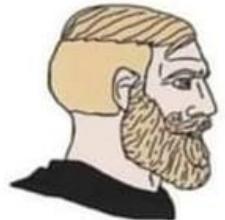


Look, we have similar ideas.



No! You stole my idea.

PROGRAMMERS



Man, I stole your code.



It's not my code.

Github Users



Man, I stole your code.



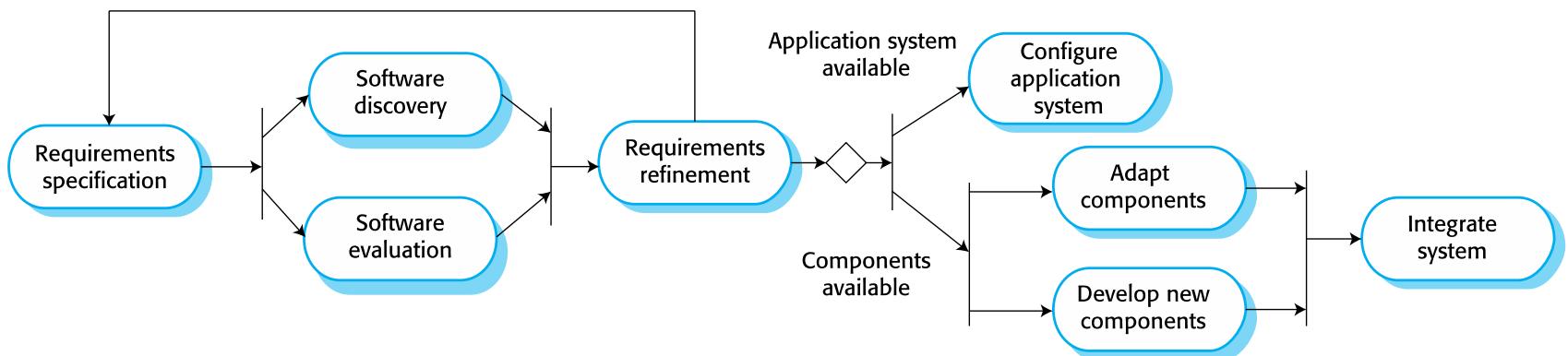
Thanks for the fork

Types of reusable software

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



Reuse-oriented software engineering

[Key process of reuse-oriented SE]

Requirements specification

propose initial requirement

Software discovery and evaluation

based on overview of requirements,
discover component and system that provides required features

Requirements refinement

refine requirements using
the discovered components or system.

Application system configuration

COTS application system may used
if the COTS satisfy the requirements

Component adaptation and integration

develop components if there are suitable COTS

Reuse-oriented software engineering

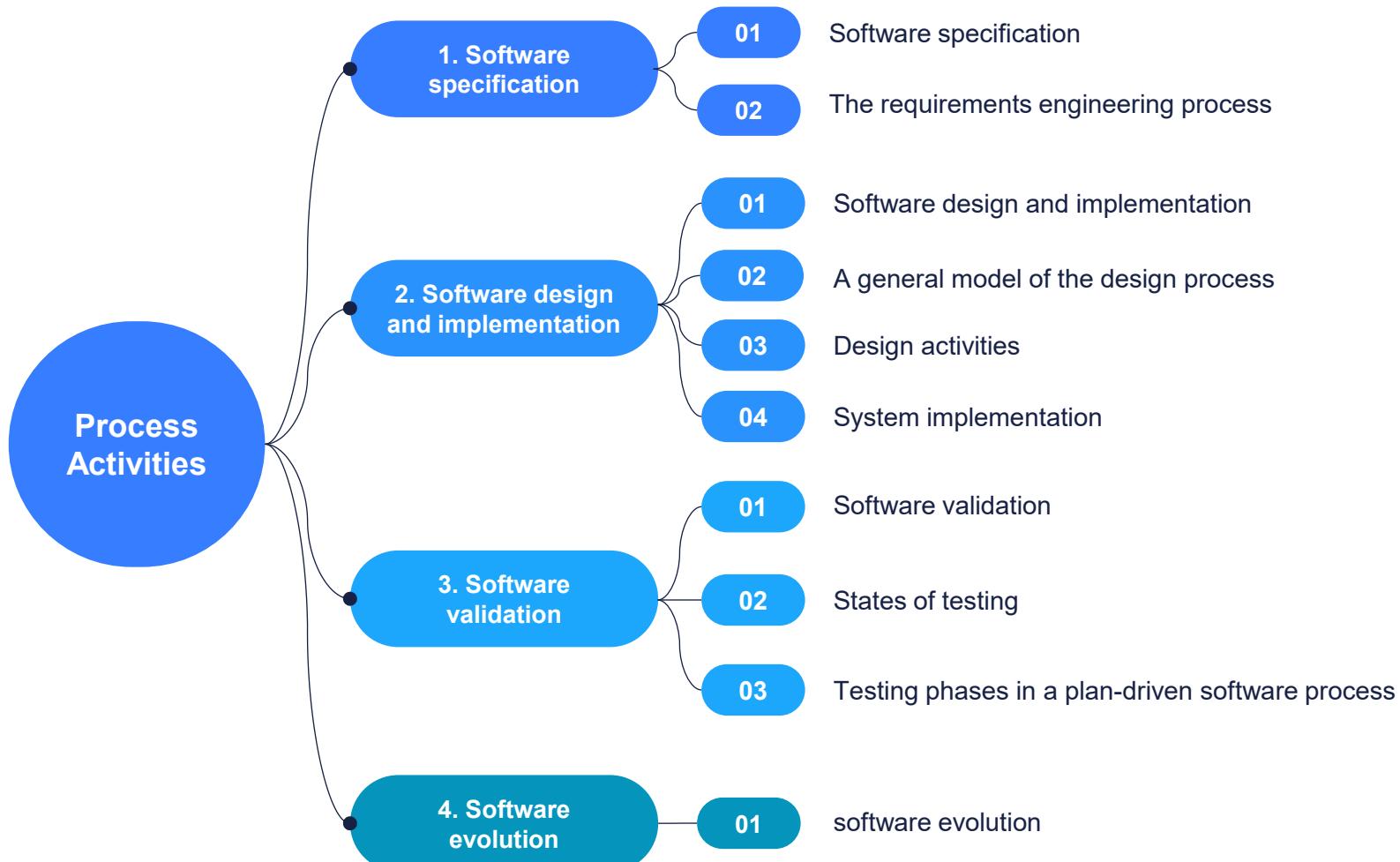
[Advantages]

- **Reduced costs and risks** as less software is developed from scratch
- **Faster delivery** and **deployment** of system

[Disadvantages]

- Requirements compromises are inevitable so system may **not meet real needs of users**
- **Loss of control** over evolution of reused system elements

2-3 : 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
1) specification, 2) development, 3) validation and 4) 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.

Software specification

[Software specification?]

- The process of establishing what services are required
- The process of establishing what 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

Process activities

Software specification



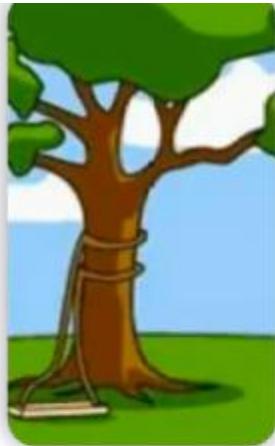
How the customer explained it



How to project leader understood it



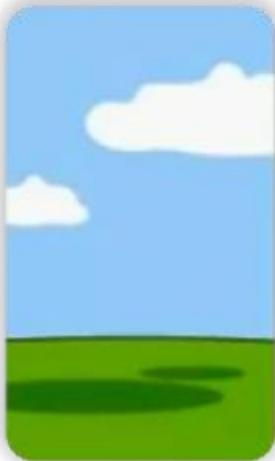
How the engineer designed it



How the programmer wrote it



How the sales executive described it



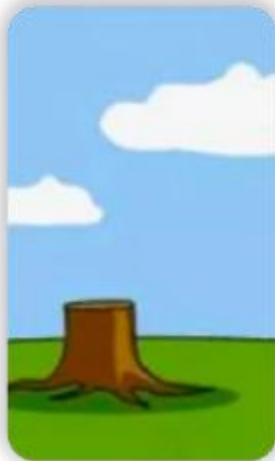
How the project was documented



What operations installed



How the customer was billed



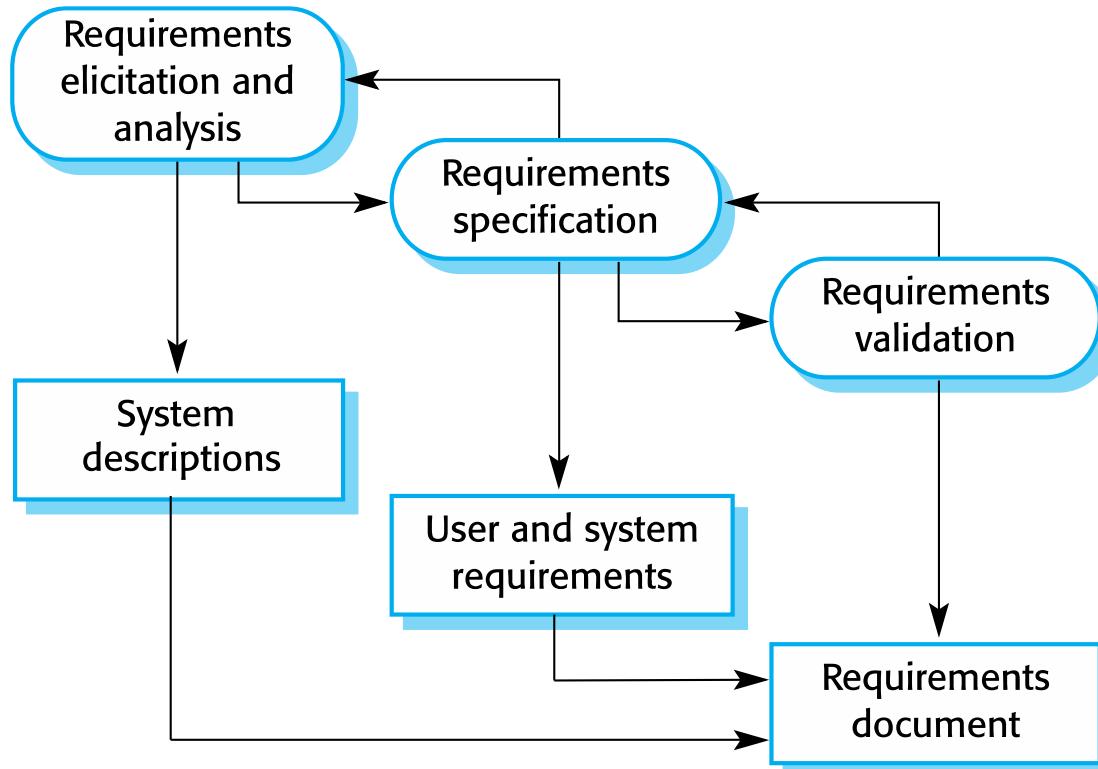
How the helpdesk supported it



What the customer really needed

Software specification

[The requirements engineering process]



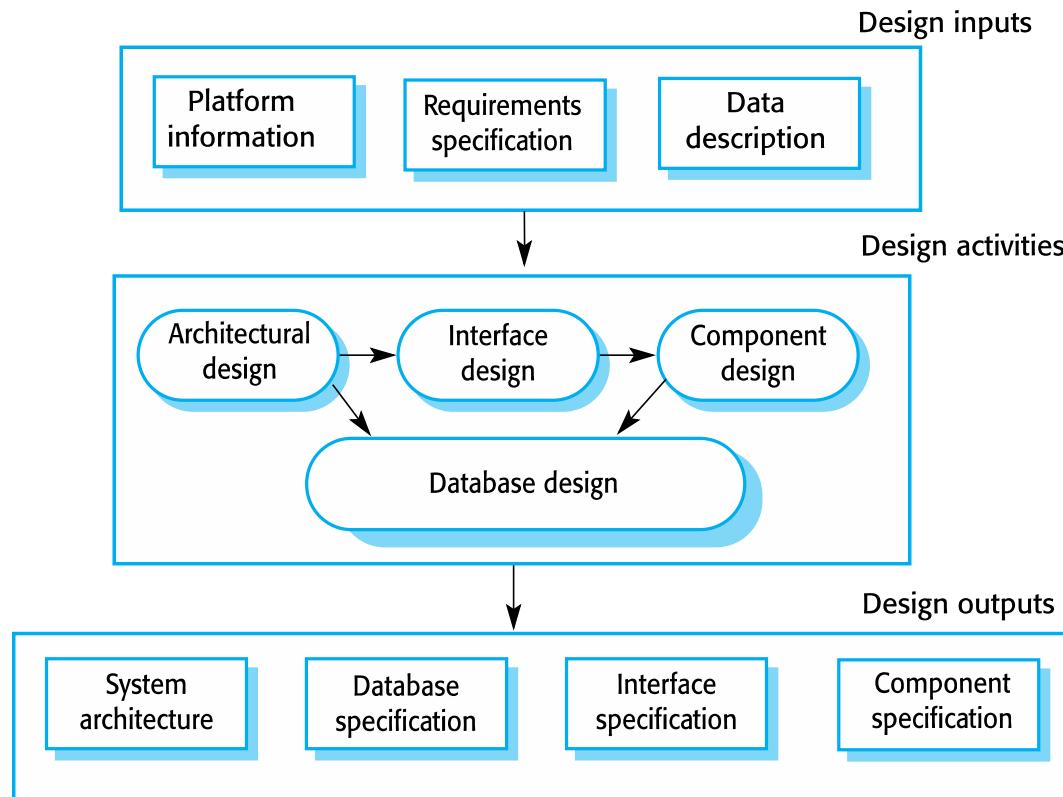
Software design and implementation

[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.

Software design and implementation

[A general model of the design process]



Software design and implementation

[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.

Software design and implementation

[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.

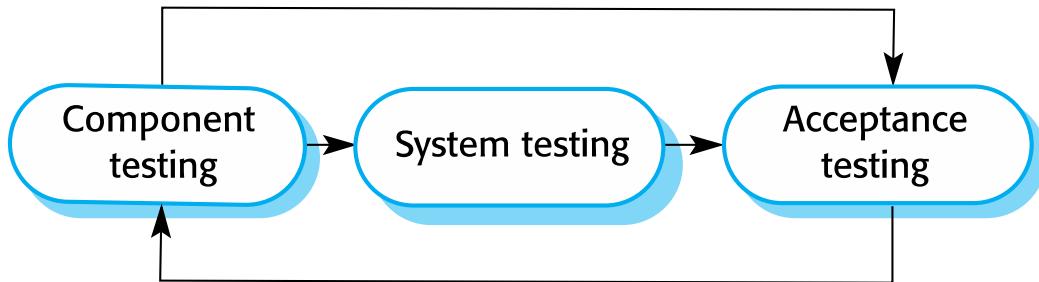
Software validation

[Software validation]

- Verification and validation (V & V, 검증 및 확인)
 - intended to show that a **system conforms to its specification**
 - **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**.

Software validation

[States of testing]



Component testing

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

System testing

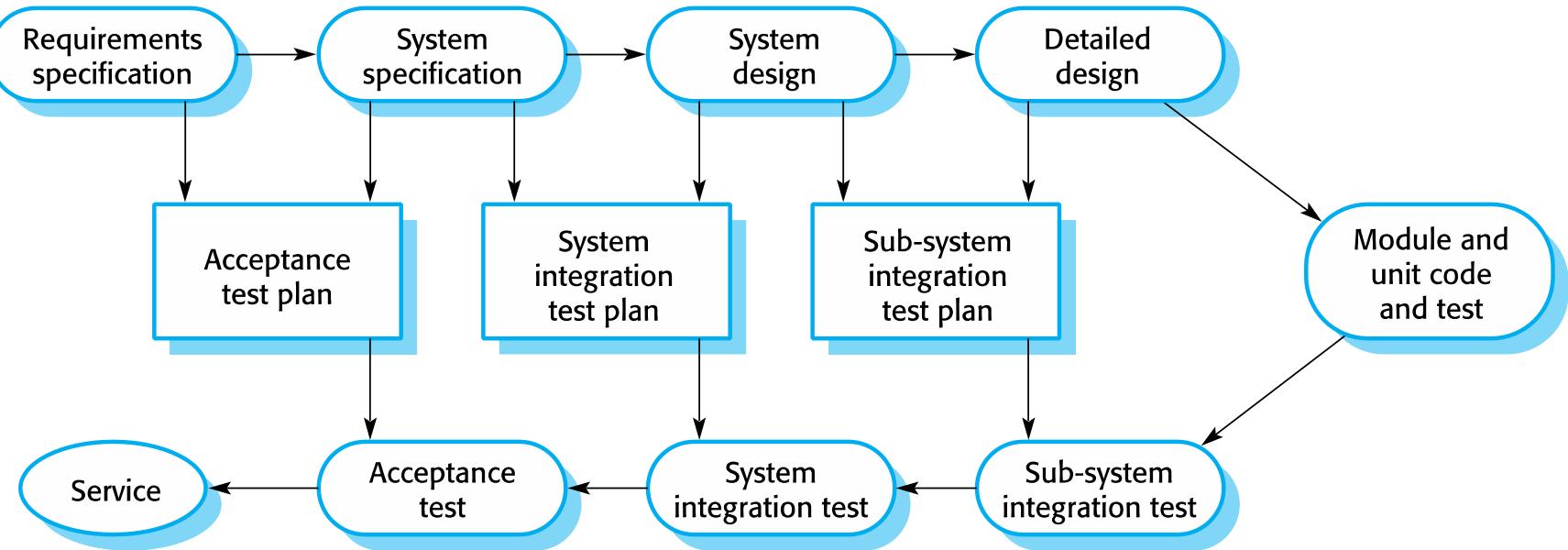
- : Testing of the system as a whole.
- : Testing of emergent properties is particularly important.

Customer testing

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

Software validation

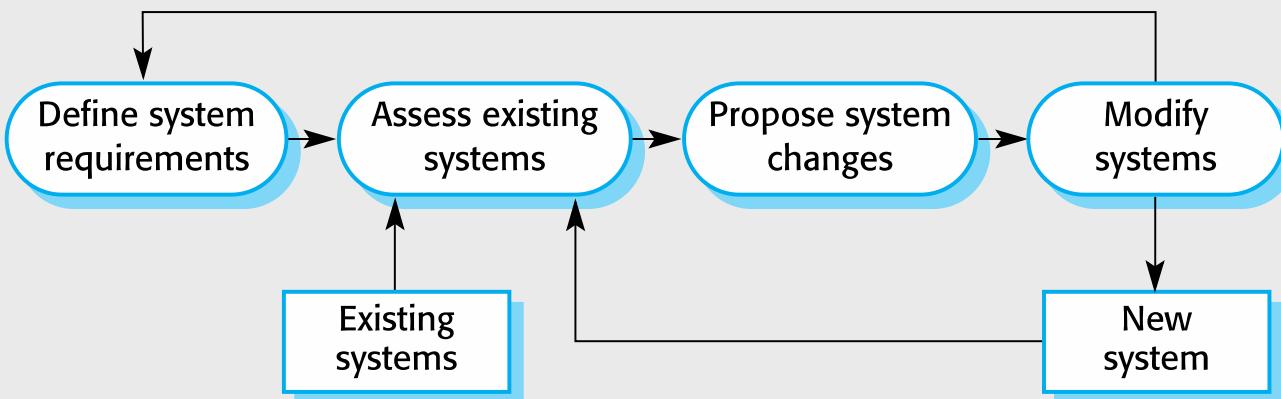
[Testing phases in a plan-driven software process (V-model)]



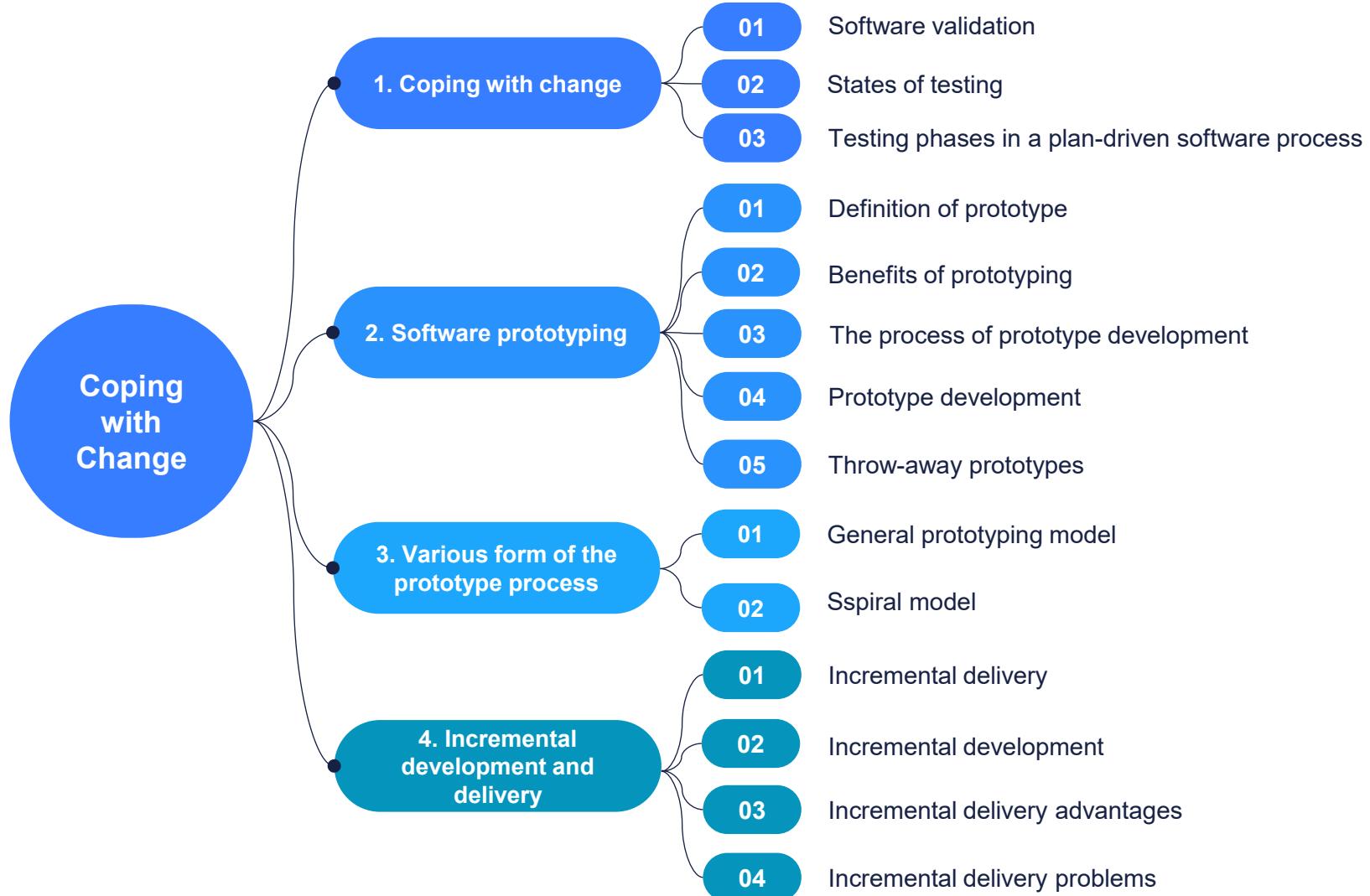
Software evolution

[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.



2-4 : Coping with change



Coping with change : 변경 처리

- ✧ 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

Coping with change

[Reducing the costs of rework]

Change anticipation (변경 예측)

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 (변경 허용)

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 been altered to incorporate the change.

Coping with change

[Coping with changing requirements]

- **System prototyping**

- 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**

- System increments are delivered to the customer for **comment and experimentation**.
- This supports both change avoidance and change tolerance.

Software prototyping

Definition of prototype

- 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.

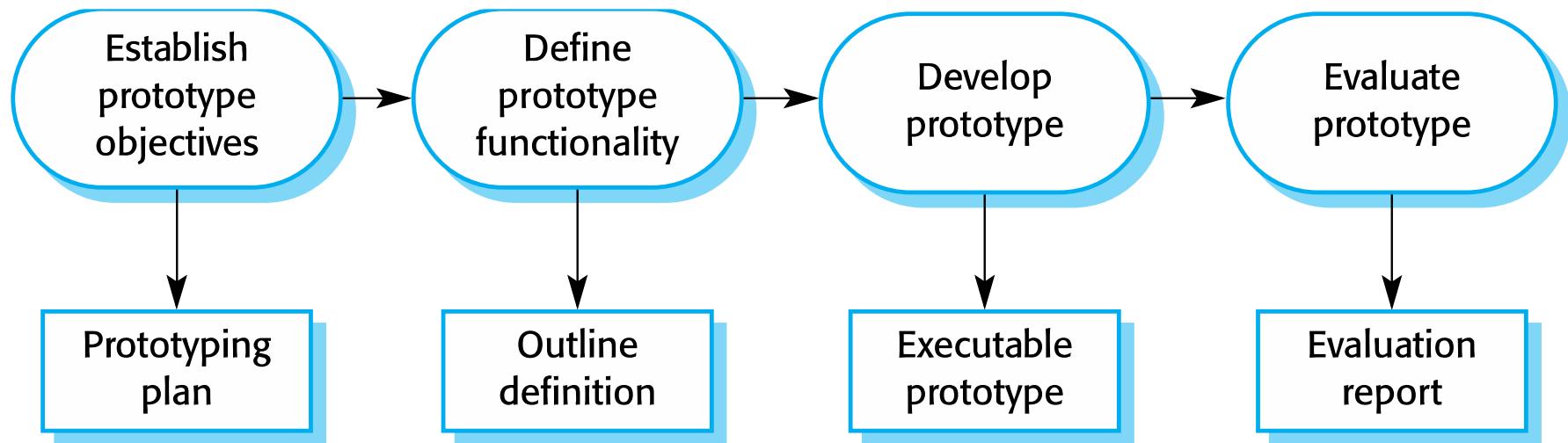
Software prototyping

[Benefits of prototyping]

- Improved system **usability**.
- A closer match to users' **real needs**.
- Improved **design quality**.
- Improved **Maintainability**.
- **Reduced** development **effort**.

Software prototyping

[The process of prototype development]



Software prototyping

[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

Software prototyping

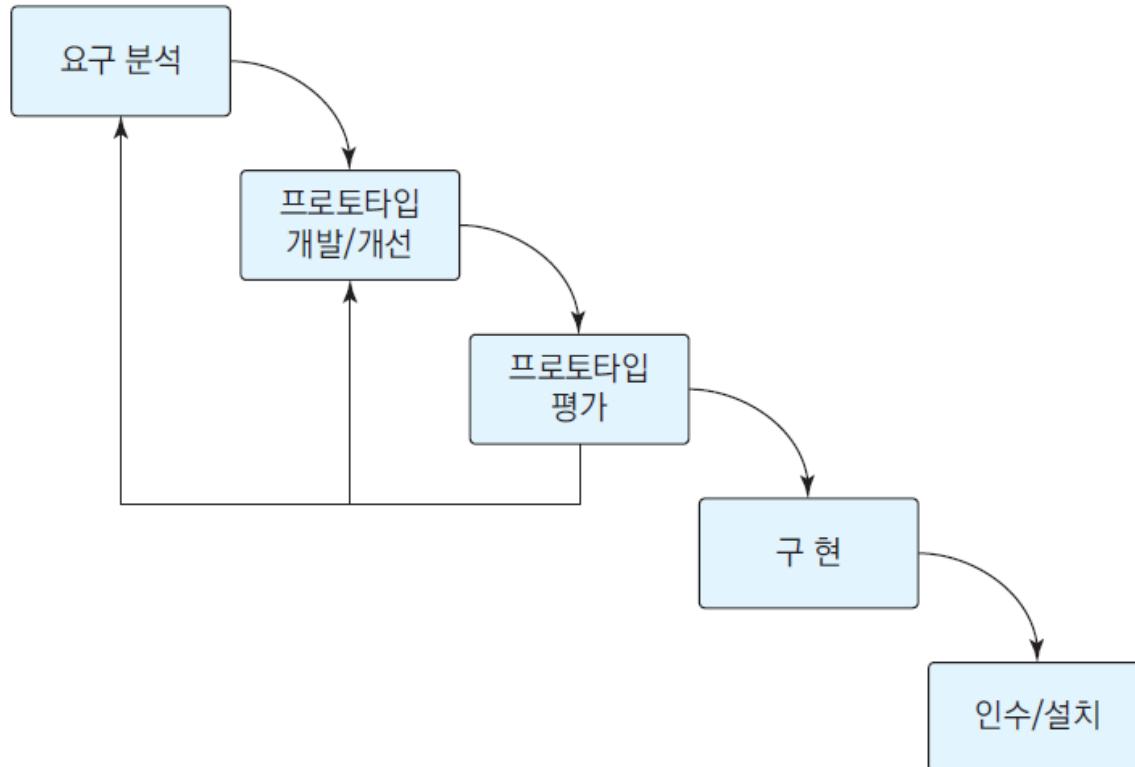
[Throw-away prototypes]

- 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.

Various form of the prototype process

[General prototyping model (as Korean)]

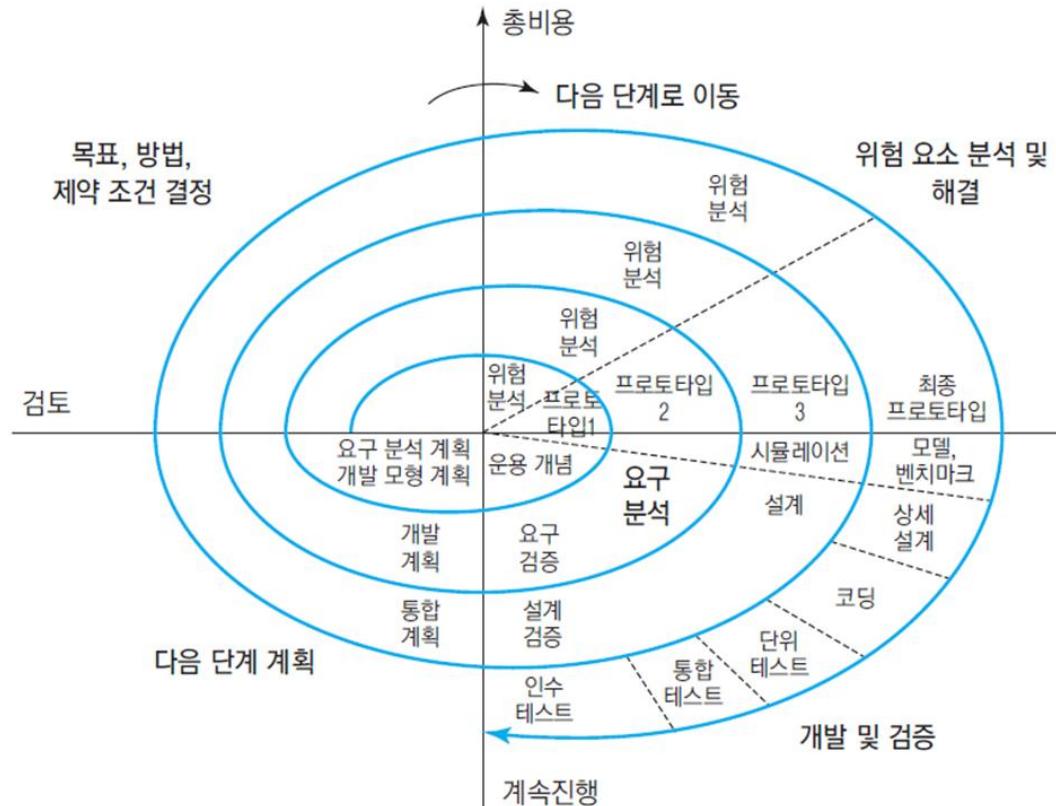
Source: <All about software engineering>. 생능출판사. 최은만



Various form of the prototype process

[Spiral model (as Korean)]

Source: <All about software engineering>. 생능출판사. 최은만



Incremental delivery

[Incremental delivery (단계적 인수)]

- 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

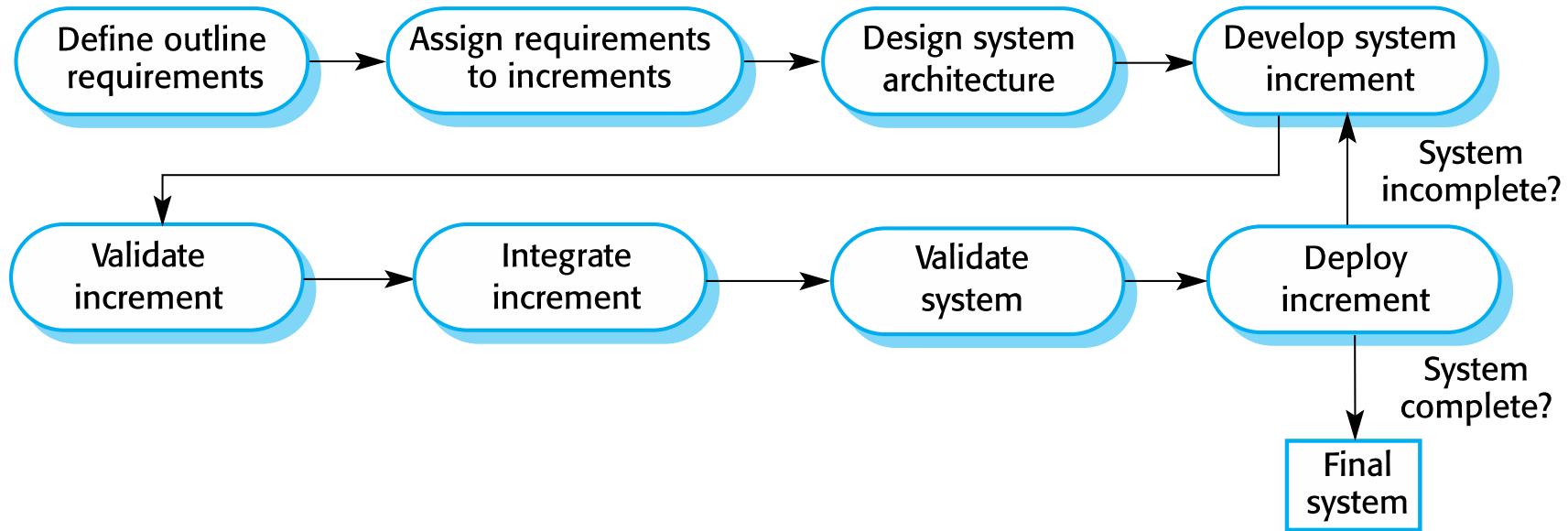
[Incremental development]

- **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 development and delivery



Incremental development and 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 development and delivery

[Incremental delivery problems]

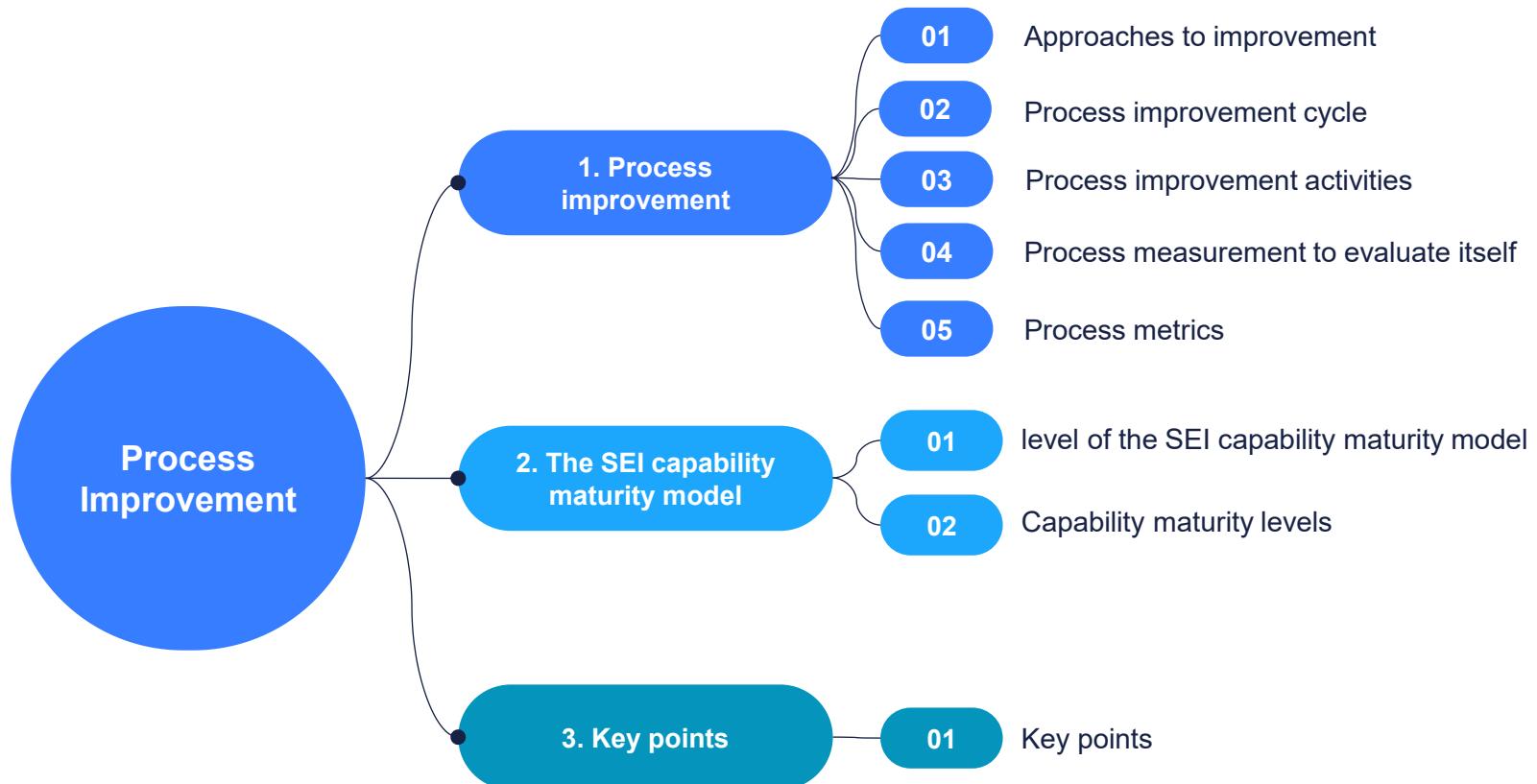
Most systems require a set of basic facilities that are used by different parts of the system.

- 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.

2-5 : Process Improvement



Process improvement : 프로세스 개선

- 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.

Process improvement

[Approaches to improvement]

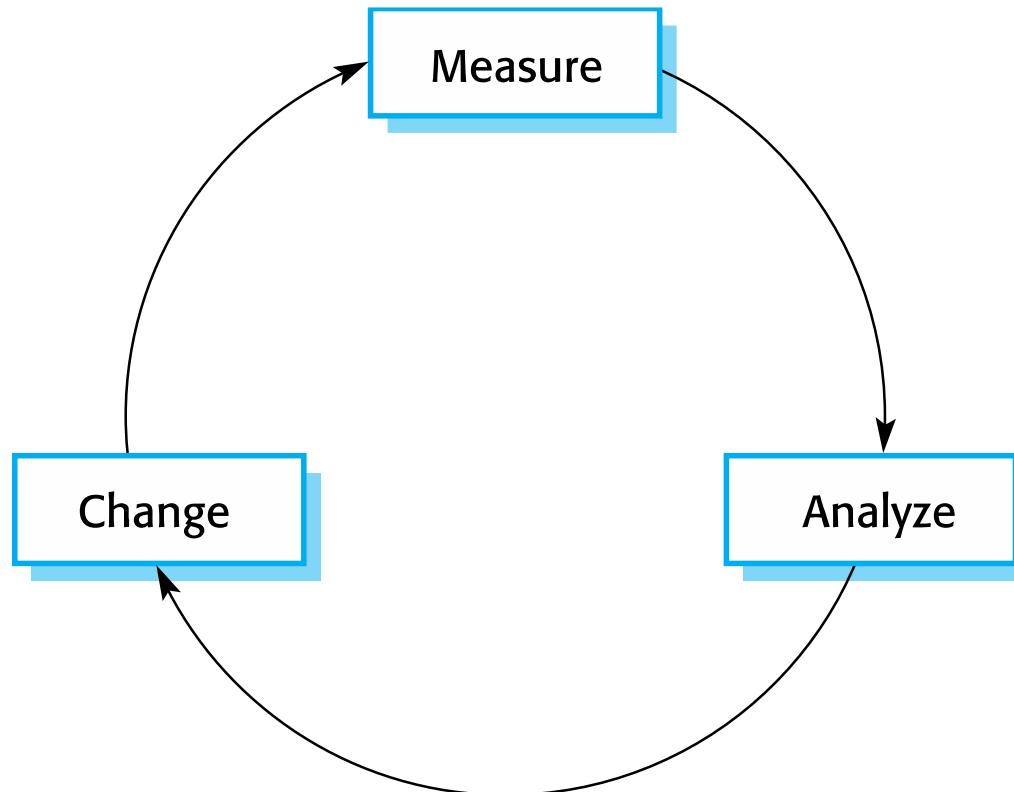
The process maturity approach

- which focuses on **improving process and project management**
- **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

- 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.

Process improvement cycle



Process improvement activites

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 improvement

[Process measurement to evaluate itself]

- 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 improvement

[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.

The SEI capability maturity model

[Level of 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

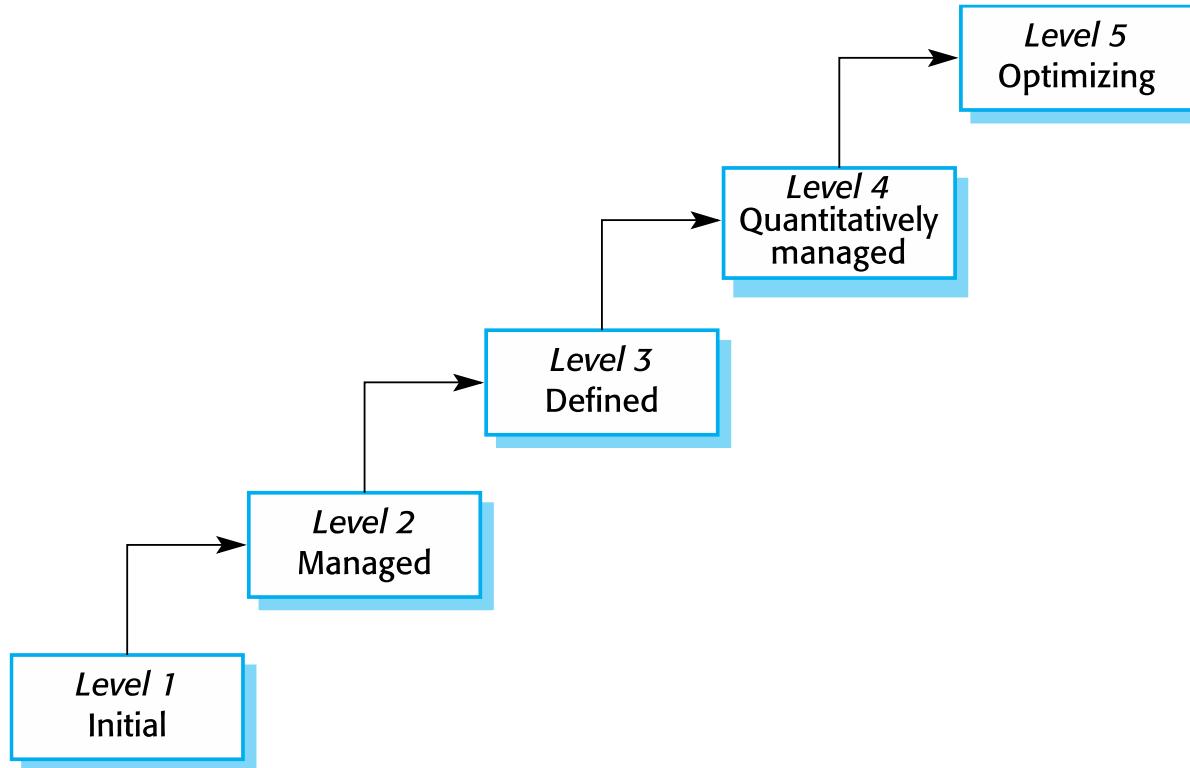
Quality management strategies defined and used

Optimising

Process improvement strategies defined and used

The SEI capability maturity model

[Capability maturity levels]



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.