Principles of software testing

Testing identifies the presence of defects

not possible to demonstrate absence of defects, only their presence

Exhaustive testing is impossible

possible only in trivial cases

Reduce the number of tests designed/executed to make process economically viable

Choosing which tests to design and execute; *risk management*

Early testing

test early in the development cycle

Costs increase; design -1, coding -10,…
final product 1,000

Defect clustering

defects are clustered (aggregated) according to identical criteria (similar error repeated, group of components designed in the same period of time, defective off-the –shelf component)…

Pesticide paradox

a lack of efficiency of tests when used over a period of time; re-execution of identical tests

Tests are changed over time, variation in test data, order of execution of tests…

Testing is context dependent

safety-critical systems tested differently than most e-commerce systems

Test effort influenced by available time and resources

Software Quality

Software Quality (ISO 9126)

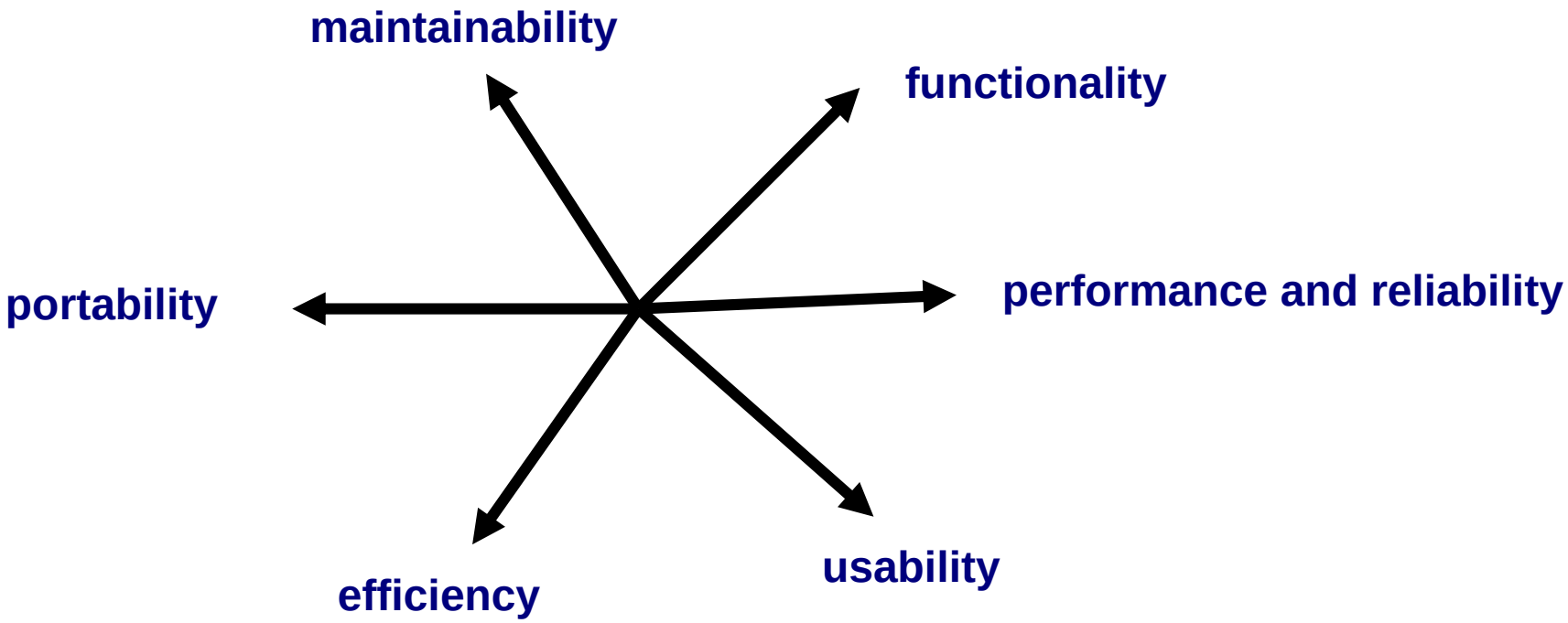
ISO – International Standardization Organization
(quality management system)

http://en.wikipedia.org/wiki/ISO_9126

hierarchical framework for quality definition
(characteristics and sub-characteristics)

Software Quality (ISO 9126)

***multifaceted* and *hierarchical* concept**



Software Quality (ISO-9126)

Functionality

EXISTENCE OF SET OF FUNCTIONS AND THEIR SPECIFIED PROPERTIES

suitability

accuracy

interoperability

security

Performance and Reliability

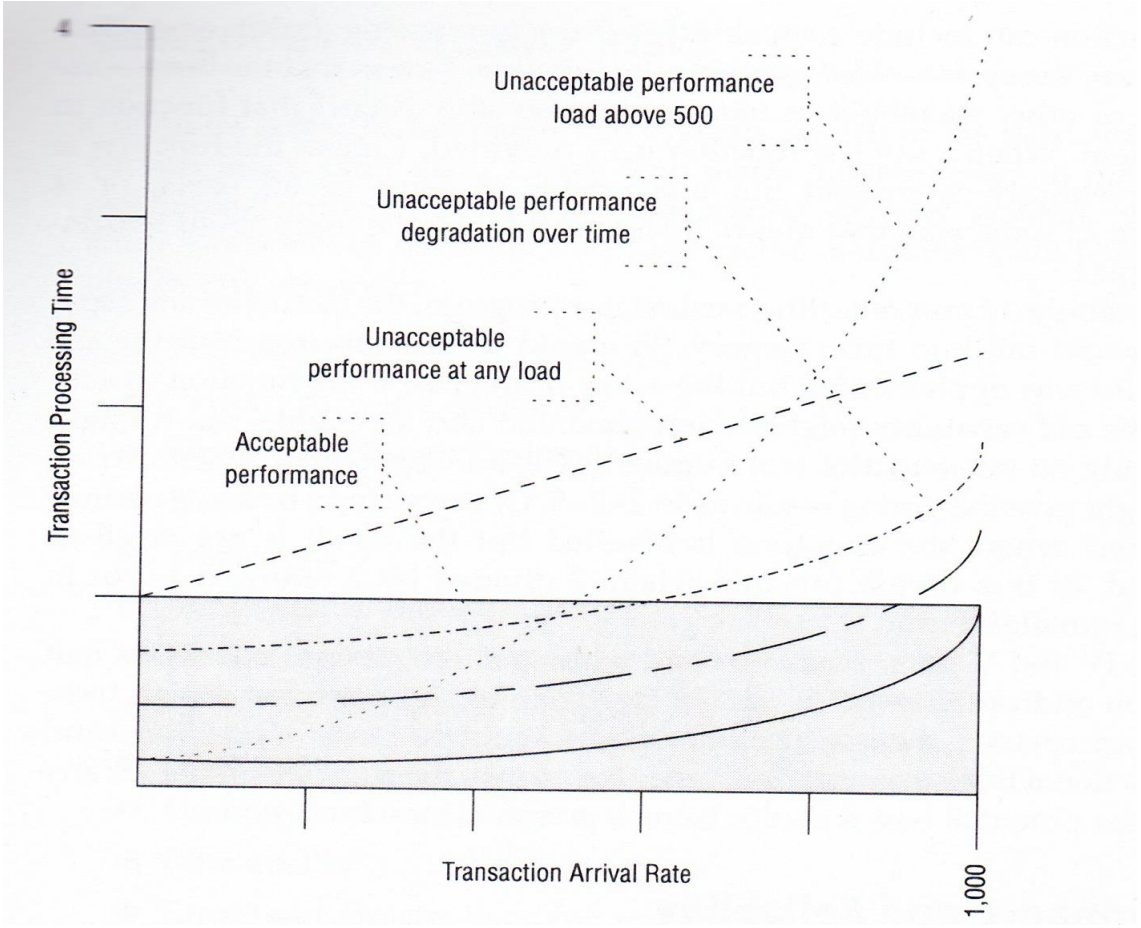
SOFTWARE MAINTAINS ITS LEVEL OF PERFORMANCE UNDER STATED CONDITIONS AND FOR A STATED PERIOD OF TIME

maturity

fault tolerance

recoverability

Software Quality (ISO-9126)



Software Quality (ISO-9126)

Efficiency — ***LEVEL OF PERFORMANCE AND AMOUNT OF RESOURCES USED***

- *time behavior*
- *resource behavior*

Maintainability — ***EFFORT NEEDED TO MAKE SPECIFIED MODIFICATIONS***

- *analyzability*
- *changeability*
- *stability*
- *testability*

Software Quality (ISO-9126)

Usability — ***ABILITY OF SOFTWARE CONCERNING THE EFFORT NEEDED FOR USE, ASSESSMENT OF USE (by a stated or implied set of users)***

understandability
learnability
operability

Portability — ***ABILITY OF SOFTWARE TO BE TRANSFERRED FROM ONE ENVIRONMENT TO ANOTHER***

adaptability
Instability
Conformance
replaceability

McCall model for software quality factors

Product operation factors

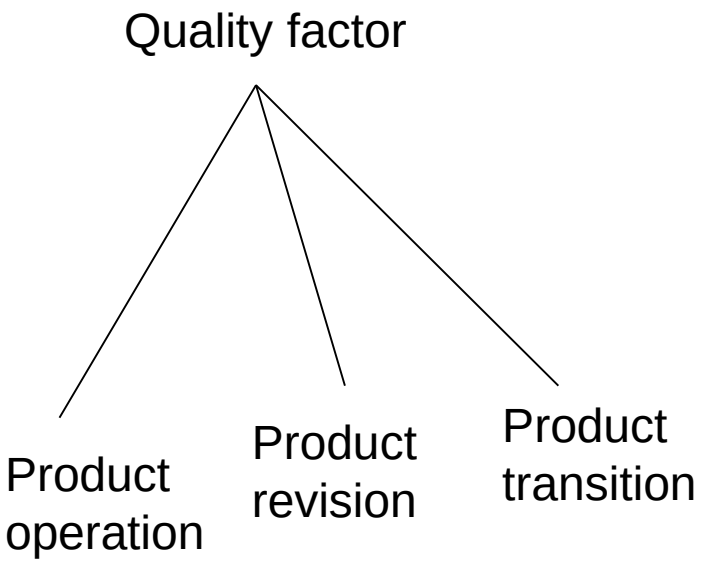
- Correctness
- Reliability
- Efficiency
- Integrity
- Usability

Product revision factors

- Maintainability
- Flexibility
- Testability

Product transition factors

- Portability
- Reusability
- Interoperability



McCall model for software quality factors (1)

Product operation factors

Correctness: required accuracy of the output, completeness of output, Up-to-dateness, response time

Reliability: deals with failure to provide service, failure rate, system downtown (%), maximum recovery time

Efficiency: hardware/software resources required

Integrity: deals with software system security

Usability: operation usability and training usability

McCall model for software quality factors (2)

Product revision factors

Maintainability: determines efforts needed by maintenance personnel to identify reasons of a software failure and completing correction.

Flexibility: capabilities and effort to support adaptive maintenance

Testability: deals with testing process of a software system and its operation

McCall model for software quality factors (3)

Product transition factors

Portability: relates to adaptation of system to other environments (hardware, operating system, etc.)

Reusability: use in future projects

Interoperability: requirement on creating interfdaces with other software systems or equipment firmware

Informal Quality Risk Analysis

Quality Risk Analysis Table

Risk category	Technical risk	Business risk	Priority	Testing tracking
Risk 1				
Risk 2				
Risk n				

Technical level of risk: likelihood that a fault might exist
assessment: system architect, designer, senior programmers

Business level of risk: impact of a given fault might have on the users, customers, and other stakeholders

Rating business and technical risks on some fixed scale:

1. very high, 2- high, 3. medium 4. low 5. very low

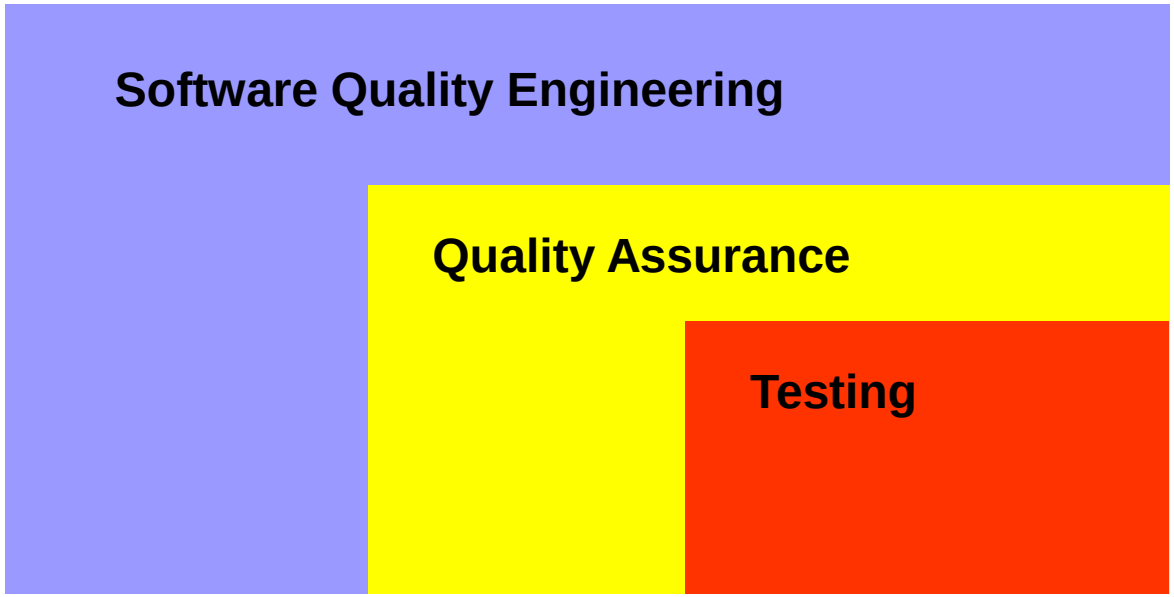
Alternative Frameworks

Different application domains – adoption of quality frameworks based upon specific business and market environments

CUPRIMDS @ IBM

capability
usability
performance
reliability
installation
maintenance
documentation
service

Software Quality Engineering, Quality Assurance, and Testing: A hierarchy



Quality assurance: testing, inspection, formal verification, defect prevention, fault tolerance

Errors, faults, failures

IEEE Standard 610.12 (1990)

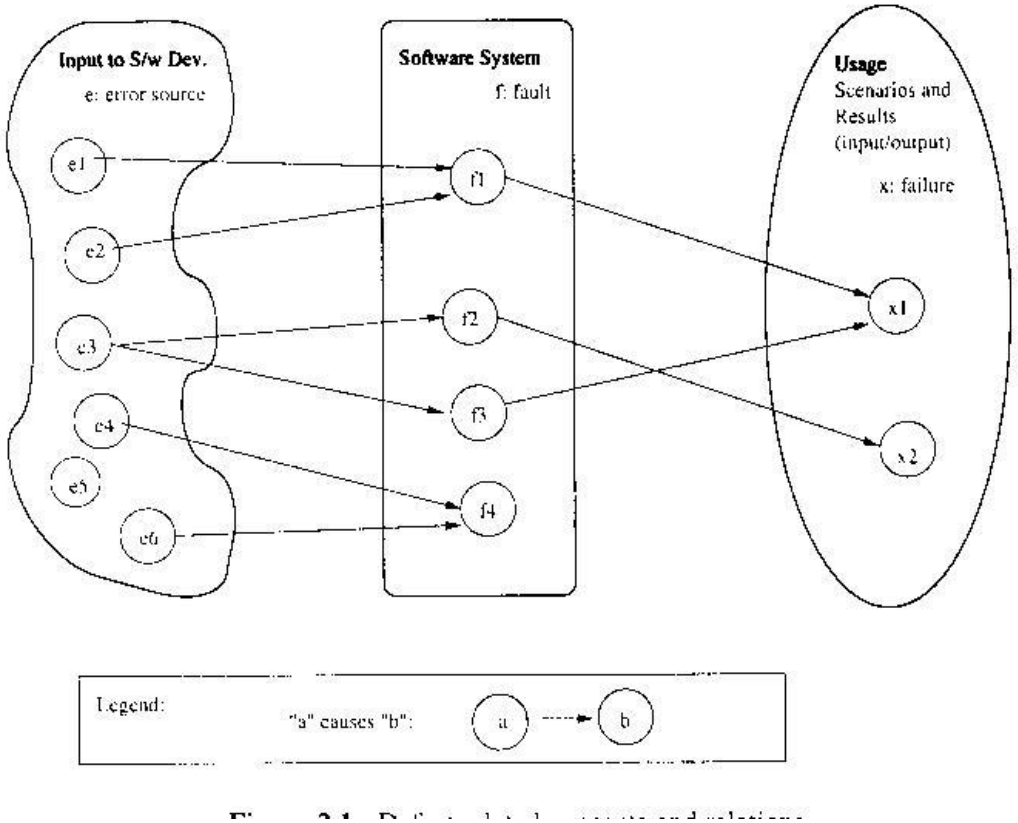
Failure – the inability of system to perform its required functions within specified performance requirements

Fault – an incorrect step, process, or data definition in a computer program

Error – a human action that produces an incorrect result

Defects = {errors, faults, failures}

Errors, faults, failures: relationships



Errors → faults → failures

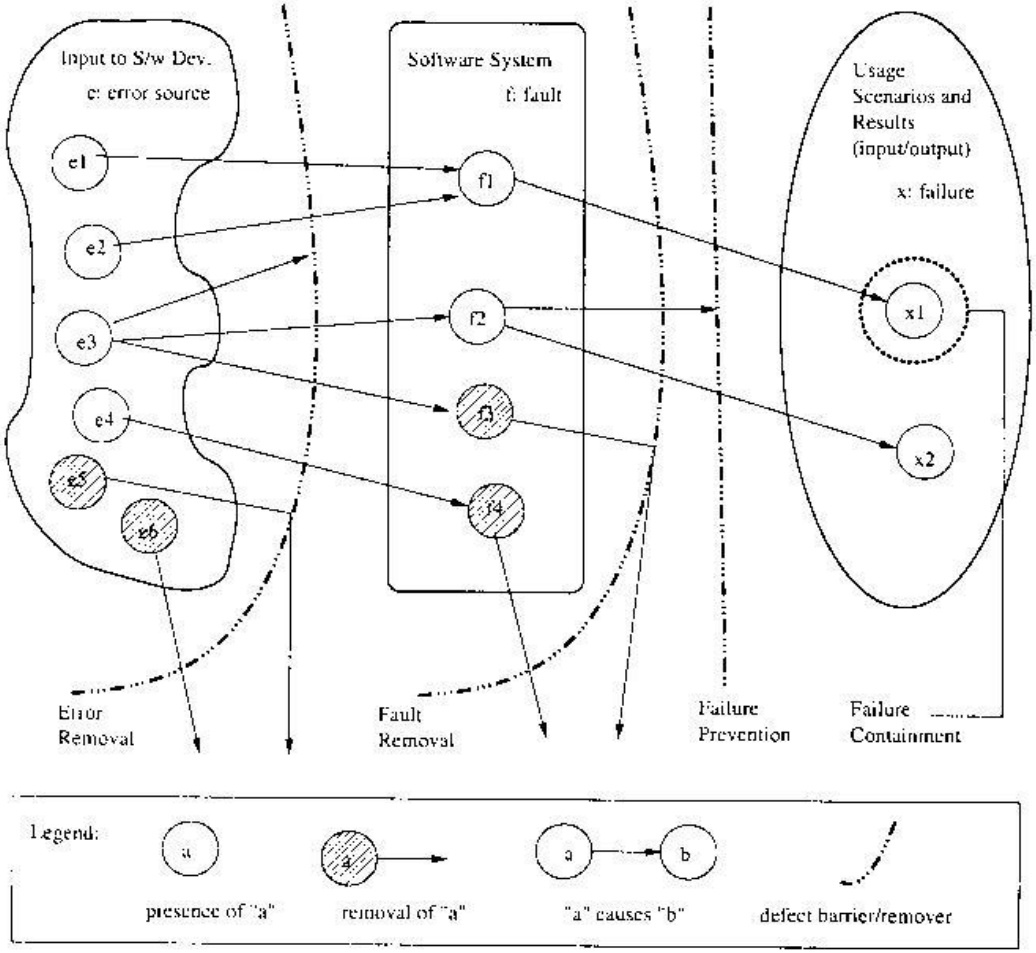
Character of relationships: one-to-one, one-to-many…

Bugs, debugging…

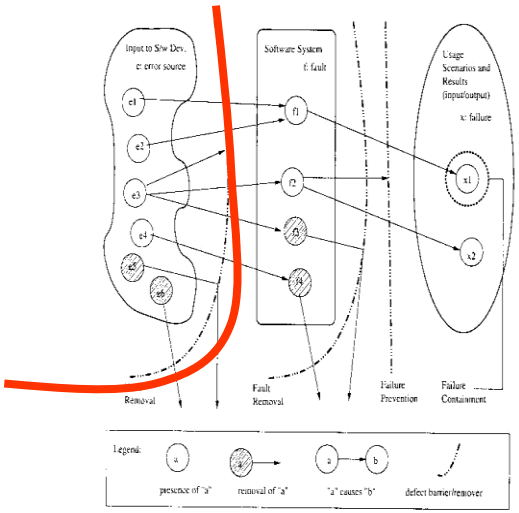
Bugs --?? Not recommended

Debugging → defect detection and removal

Software quality assurance: Main ways of dealing with defects



Software quality assurance: Main lines of defence



Defect prevention: **error source elimination; education, training, formal specification and verification, selection of and application of appropriate technologies**

Software errors- causes (1)

Definition of requirements

Client-developer communication failures

Deliberate deviations from software requirements

Logical design errors

Coding errors

Software errors- causes (2)

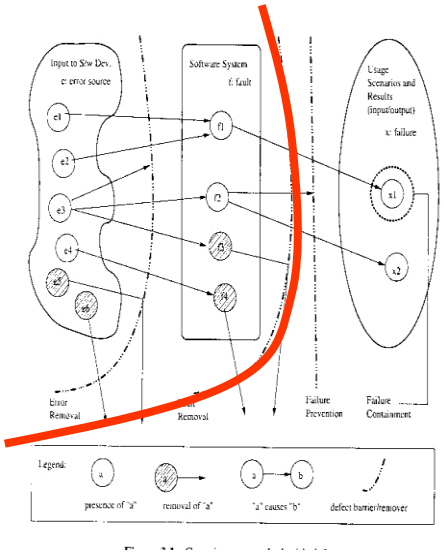
Noncompliance with documentation and coding instructions

Shortcomings of the testing process

User interface and procedure errors

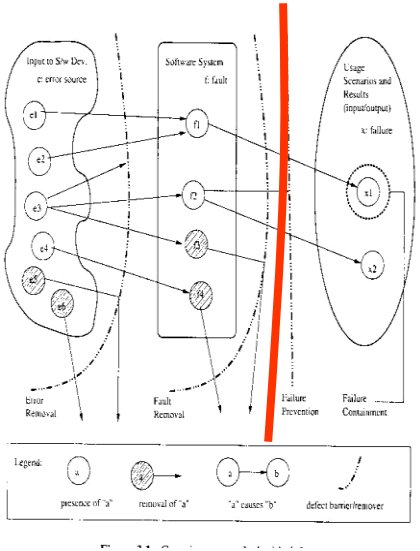
Documentation errors

Software quality assurance: Main lines of defence



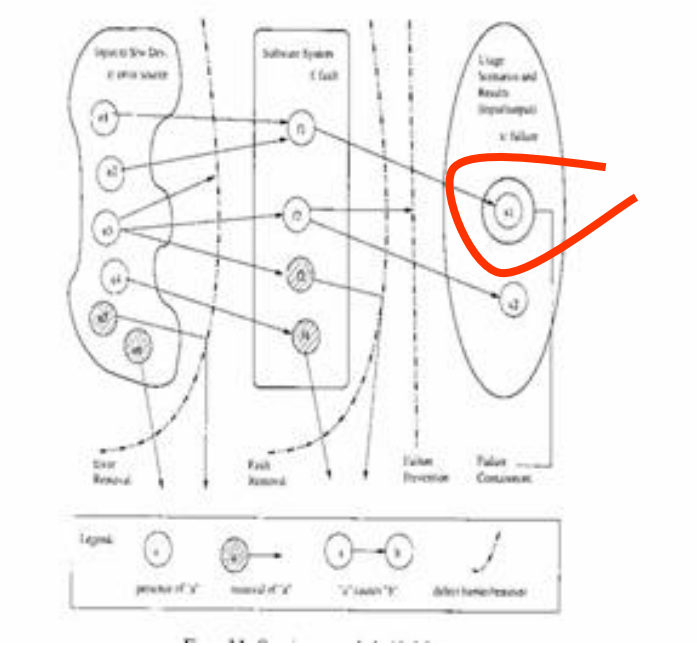
Defect or fault removal： **inspection and testing**

Software quality assurance: Main lines of defence



Failure prevention : **fault tolerance, failure prevention, failure impact minimization [recovery blocks, N-version programming..]**

Software quality assurance: Main lines of defence



Defect containment : failure impact minimization

Verification and Validation (V & V) Perspective

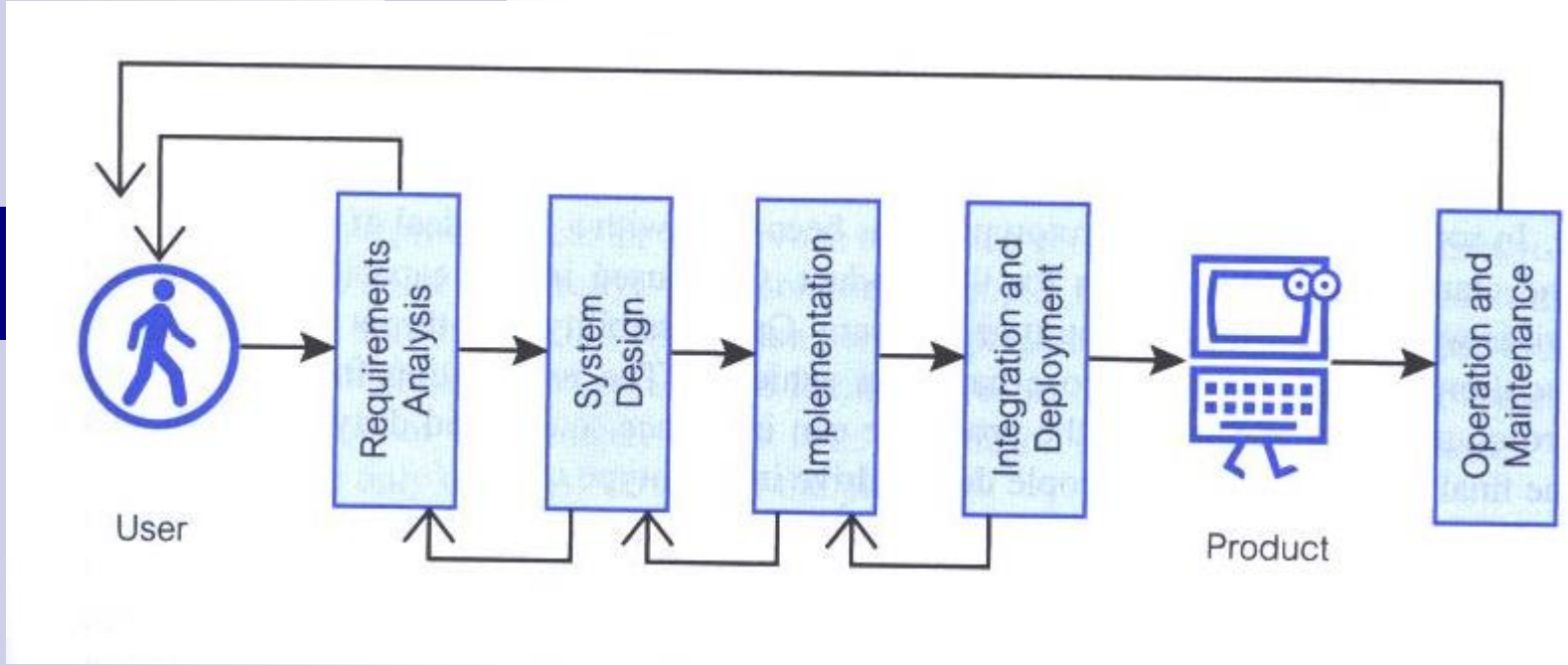
Validation: checks the conformance to the quality expectations of customers

deals directly with users and requirements

e.g., product specifications need to be validated through inspections and reviews

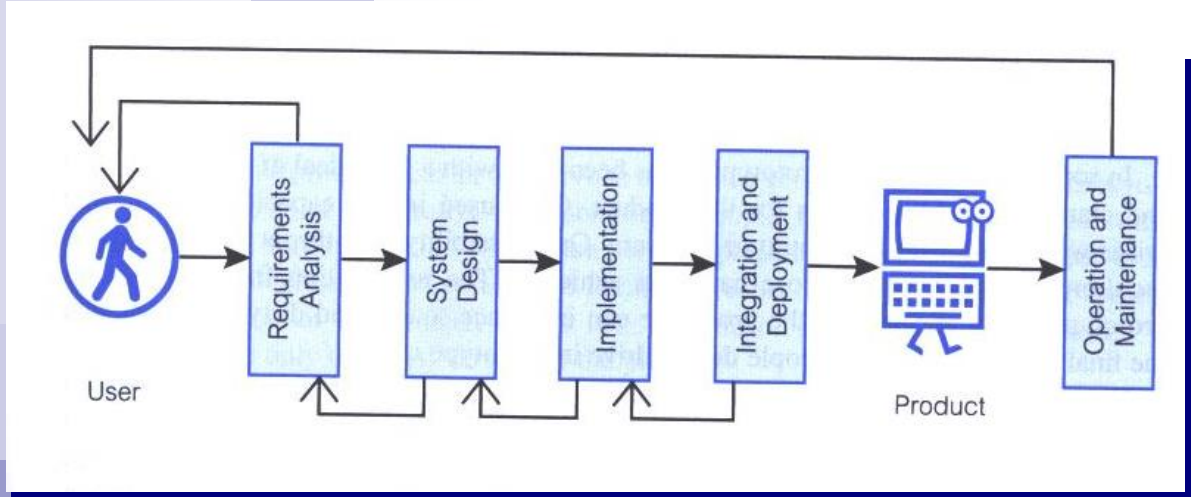
Verification: deals with internal product specifications

Waterfall lifecycle



1970s
Large projects
Monolithic structure aimed at a single delivery
Linear sequence of phases
User involved only in early stages of requirements analysis

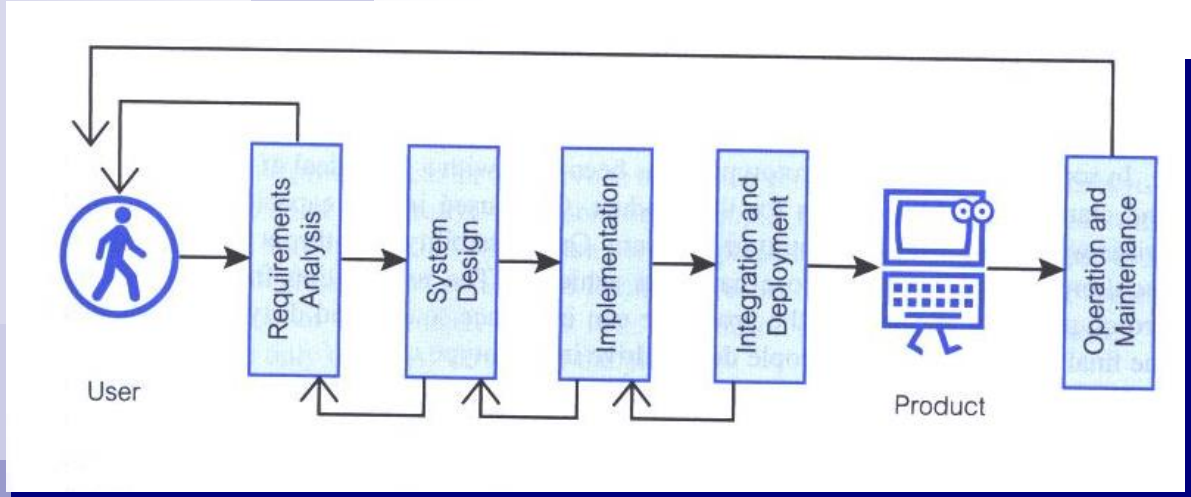
Waterfall lifecycle



Advantages:

- enforces disciplined approach to software development.
- defines milestones in a clear manner
- facilitates project management
- produces complete documentation

Waterfall lifecycle

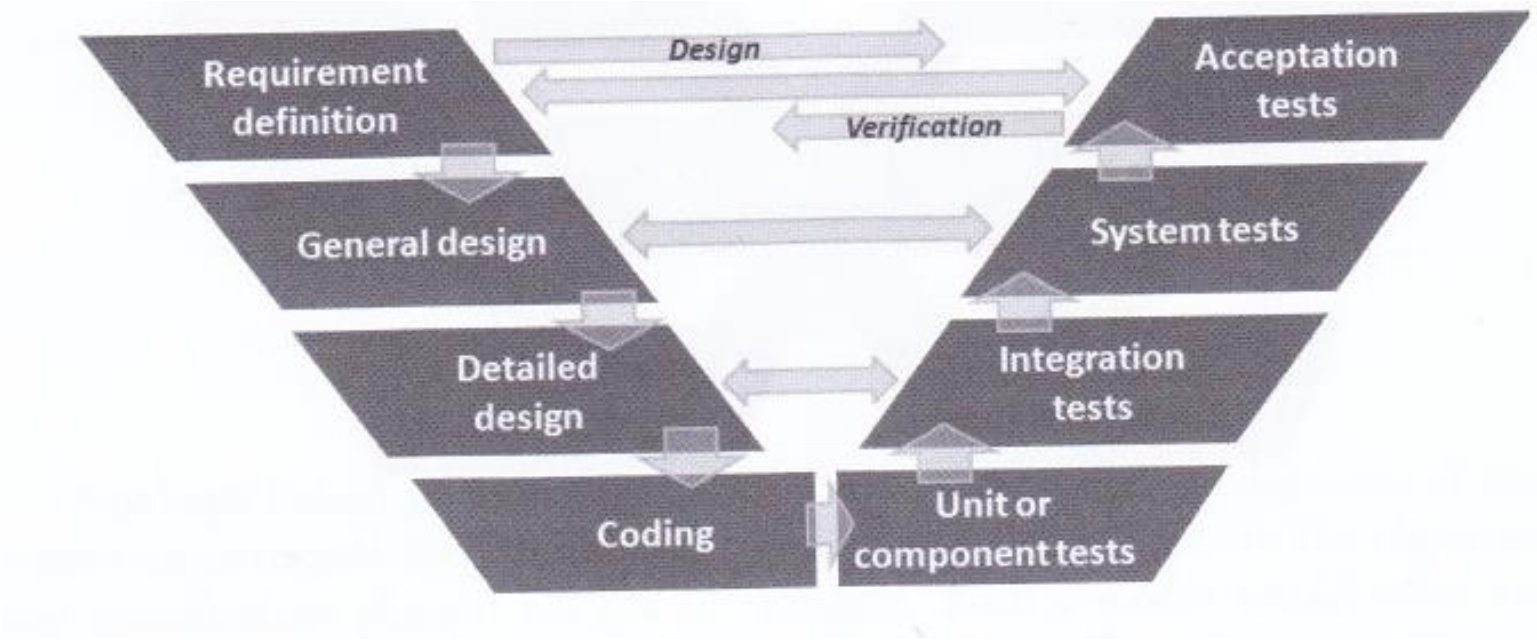


Disadvantages:

- monolithic approach – may take a lot of time to final product
- freezing the results of each phase (against principles of software engineering)
- project planning realized in early stages of the lifecycle

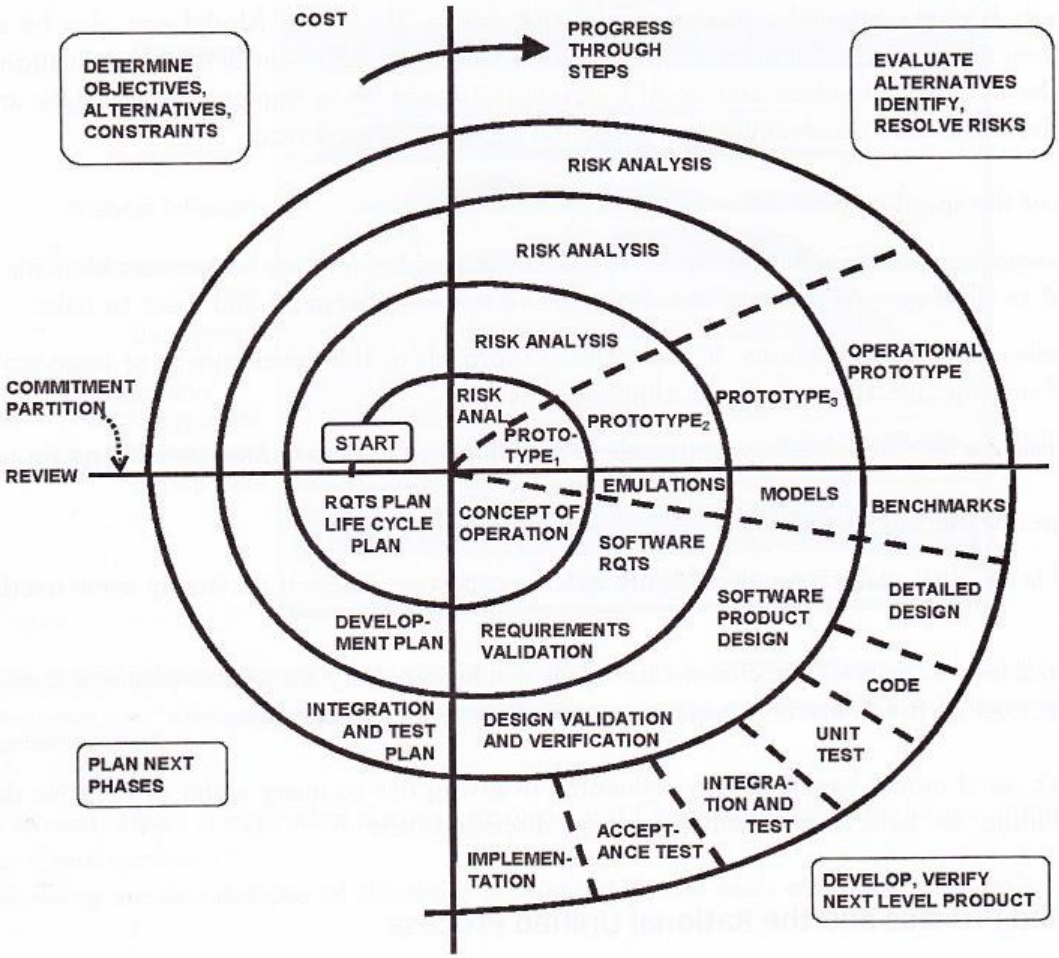
V model

V model links design activity to a test activity of the same level (main advantage of the model)



Spiral model (Boehm, 1988)

Risk-driven process with incremental deliverables



Spiral model (Boehm, 1988)

1. Identification of critical objectives and constraints of the product
2. Evaluation of project and process alternatives for achieving the objectives
3. Identification of risks
4. Cost effective resolution of a subset of risks
5. Development of project deliverables (requirements, design, implementation, testing)
6. Planning for next and future cycles
7. Stakeholders review of iteration deliverables

Spiral model: advantages and disadvantages

Advantages:

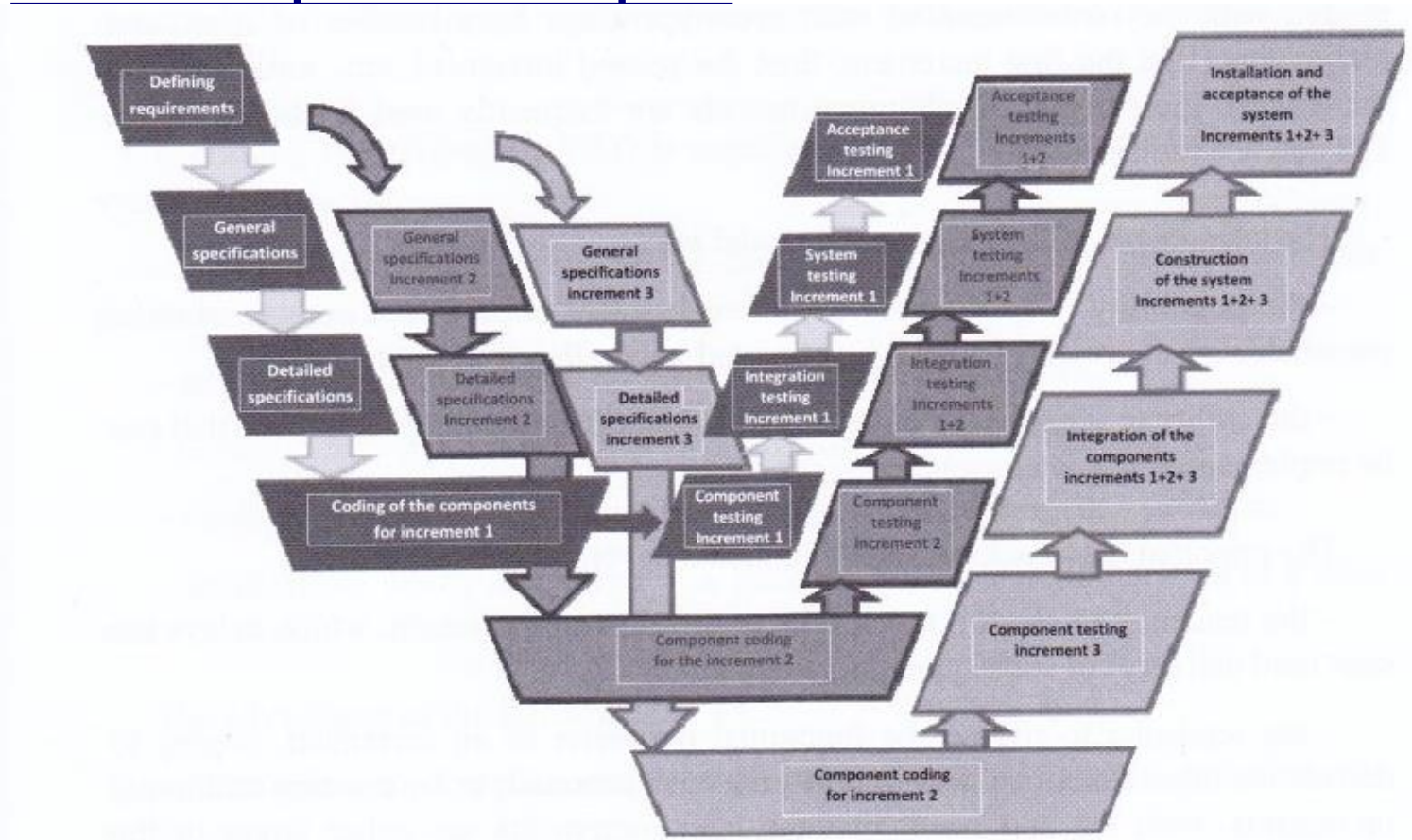
- Risk is managed early and throughout the process
- Software evolves as the project progresses; unattainable alternatives are eliminated early
- Planning is built into the process

Disadvantages:

- Complicated to use
- May be overkill for small projects

Incremental model

- the design of an initial collection of components (functionalities) to which additional components are added until development is complete



Incremental model: advantages and drawbacks

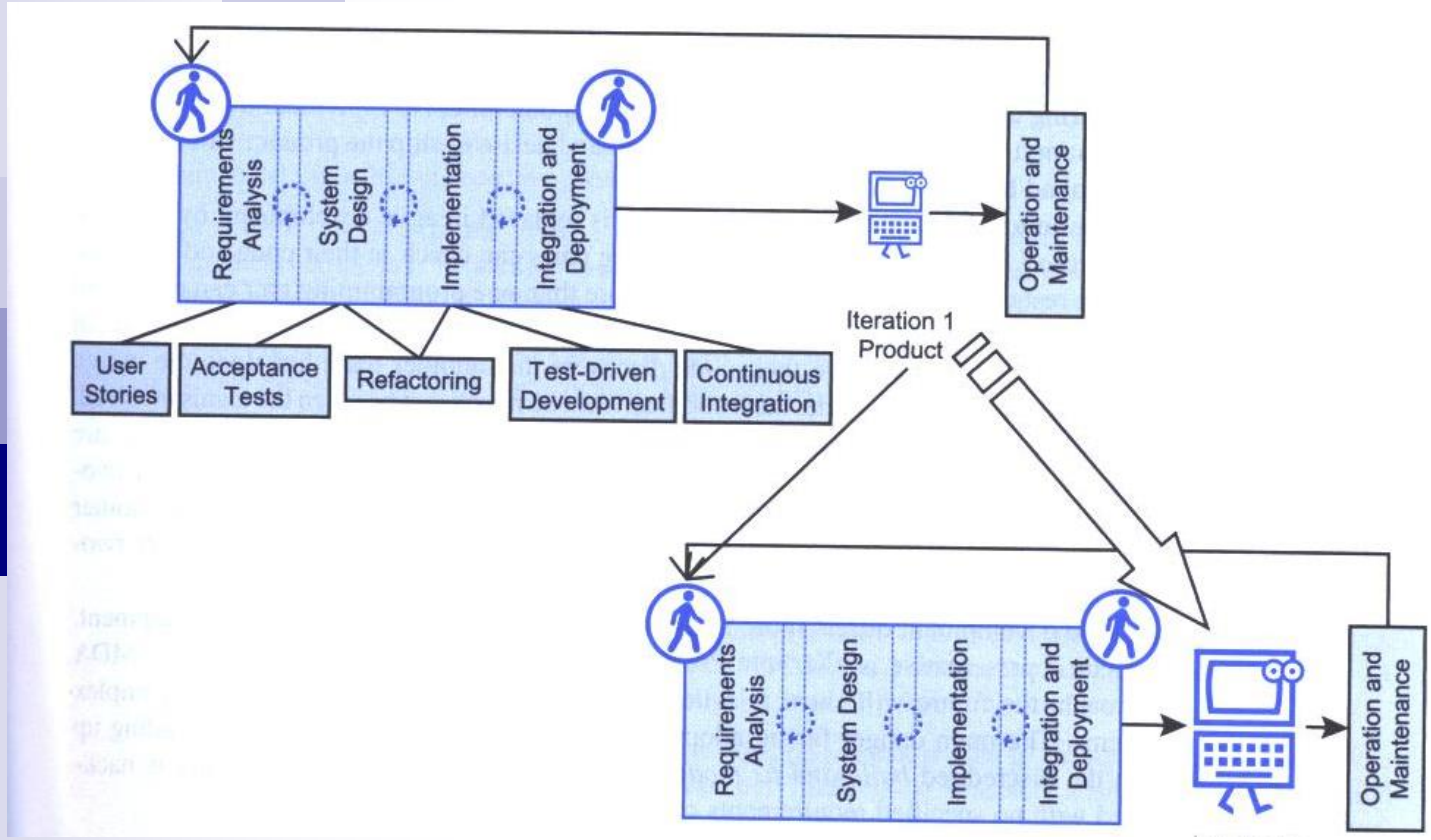
Advantages:

- Large development effort is split into a number of reasonably sized projects
- Identification of important critical components and those that can be implemented at later stage

Disadvantages:

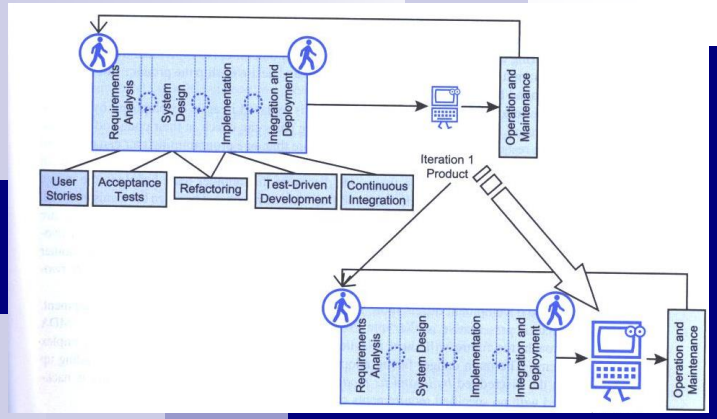
- The tendency to use too much time to develop an increment
- The tendency to reduce the functional perimeter of an increment, hoping to deliver the other functionalities in subsequent increments; later increments larger or the finished product delayed

Agile lifecycle (2001)



Agile Alliance (2001)- a new approach to software development

Agile lifecycle (2001)



Manifesto of Agile Alliance (2001)

1. **Individuals and interactions over processes and tools**
2. **Working software over comprehensive documentation**
3. **Customer collaboration over contract negotiations**
4. **Responding to change over following a plan**

Agile lifecycle (2001)

Software development is a creative activity that depends on people and team collaboration

In agile development, customers work closely with the development team

Pair programming, collective ownership, continuous integration and short cycles (2 week cycle-minor delivery, 6 week cycle- major delivery)

Agile model: advantages and disadvantages

Advantages:

- The project always has demonstrable results
- Developers tend to be well motivated
- Customers are able to provide/refine requirements (based on the evolving product)

Disadvantages:

- Questionable in case of large applications
- Documentation problematic

Development models: comparative analysis

Aspect	**Waterfall**	**V-model**	**Incremental**	**Spiral**	**Agile**
Clear implementation for management	y	y	y	y	n
All requirements necessary before start	y	y	n/y	n	n
Ease of resources allocation	y	y	y	y	n
Quick availability of running software	n	n	y	y	y
Risk and cost control via prototyping	n	n	y	y	y

Testing: people and management

Organizational activities

People's skills

Models

vertical model: organized around a product; one or more teams perform all different types of testing

horizontal model: mainly in large organizations; testing team performs one type of testing for many products