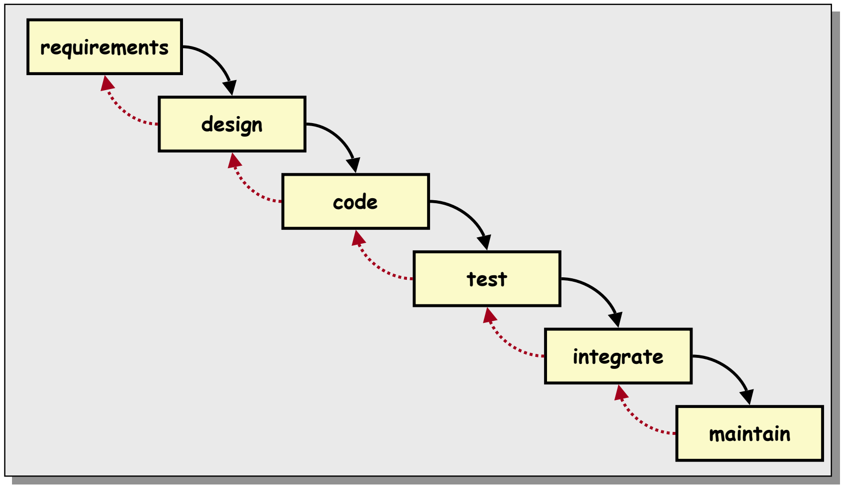
Lecture 4: Software Lifecycles

- **The Software Process**
  - Waterfall model
  - Rapid Prototyping Cycle
  - Phased Models:
    - Incremental Development
    - Evolutionary Development
    - Spiral Model
  - V-model and Systems Engineering
  - The ‘essential’ software process
- **Verification and Validation**

Waterfall Model

Source: *Adapted from Dorfman, 1997, p7*
see also: *van Vliet 1999, p50*



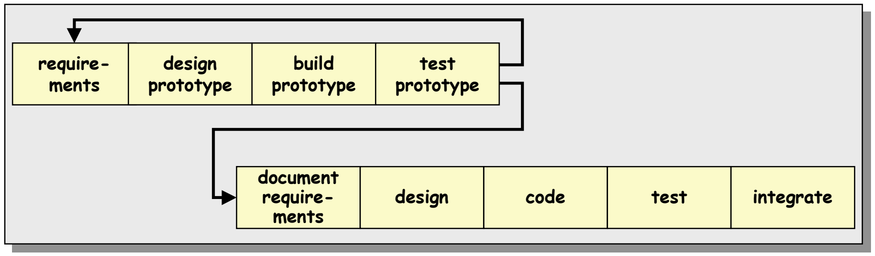
Why not a waterfall?

Source: *Adapted from Blum 1992, pp28-31*
see also: *van Vliet 1999, p50-1*

- **Waterfall model describes a process of stepwise refinement**
  - Based on hardware engineering models
  - Widely used in defense and aerospace industries
- **But software is different:**
  - No fabrication step
    - Program code is just another design level
    - Hence, no ‘commit’ step - software can always be changed…!
  - No body of experience for design analysis (yet)
    - Most analysis (testing) is done on program code
    - Hence, problems not detected until late in the process
  - Waterfall model takes a static view of requirements
    - ignores changing needs
    - Lack of user involvement once specification is written
  - Unrealistic separation of specification from design
  - Doesn’t accommodate prototyping, reuse, etc.

Prototyping lifecycle

Source: *Adapted from van Vliet 1999, p53*

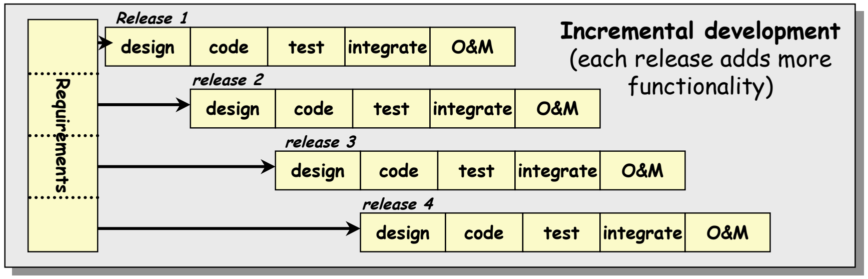


- **Prototyping is used for:**
  - understanding the requirements for the user interface
  - examining feasibility of a proposed design approach
  - exploring system performance issues
- **Problems:**
  - users treat the prototype as the solution
  - a prototype is only a partial specification

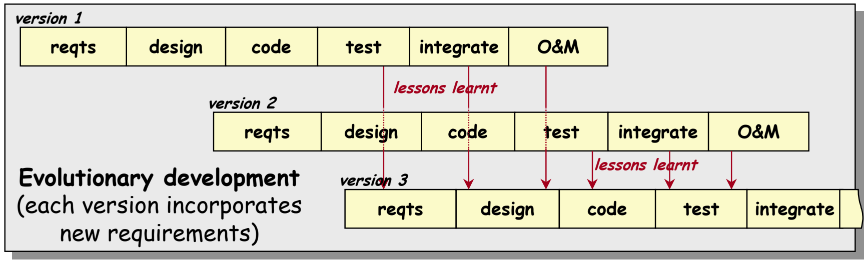
Source: Adapted from Dorfman, 1997, p10

Phased Lifecycle Models

Source: *Adapted from Dorfman, 1997, p10*
see also: *van Vliet 1999, p56*



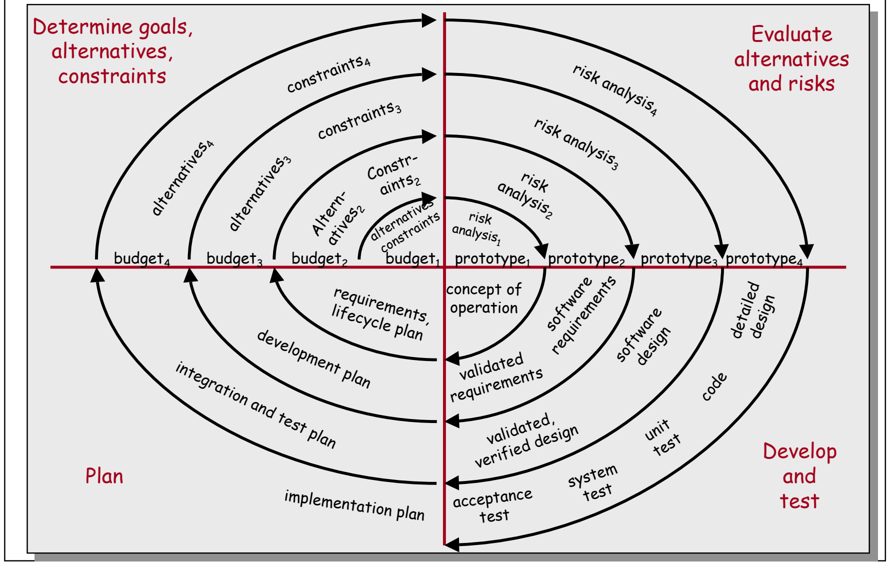
Incremental development
(each release adds more functionality)



Evolutionary development
(each version incorporates new requirements)

The Spiral Model

Source: *Adapted from Pfleeger, 1998, p57*
see also: *van Vliet 1999, p63*

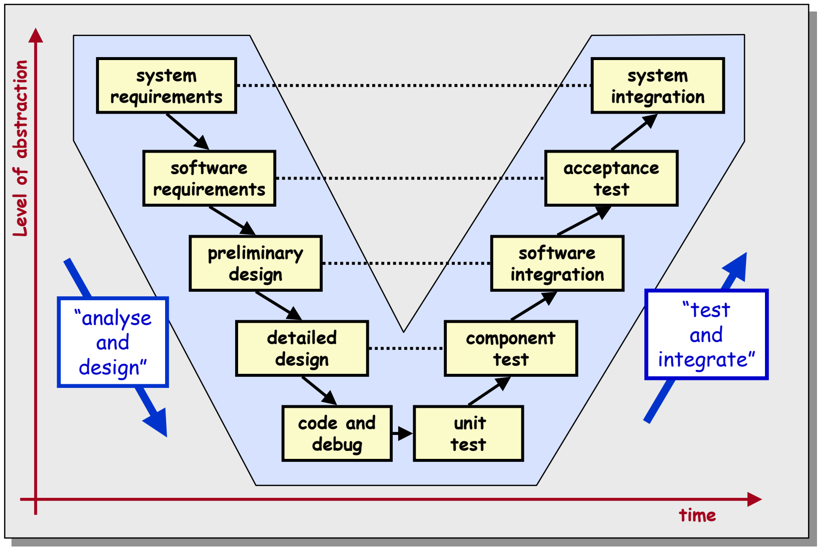


Comments on phased models

- ➜ **Incremental development**
  - ✎ avoids ‘big bang’ implementation
  - ✎ but:
    - ➢ assumes all requirements known up-front
- ➜ **Evolutionary development**
  - ✎ allows for lessons from each version to be incorporated into the next
  - ✎ but…
    - ➢ hard to plan for versions beyond the first;
    - ➢ lessons may be learnt too late
- ➜ **Spiral model**
  - ✎ incorporates prototyping and risk analysis
  - ✎ but…
    - ➢ cannot cope with unforeseen changes (e.g. new business objectives)
    - ➢ not clear how to analyze risk

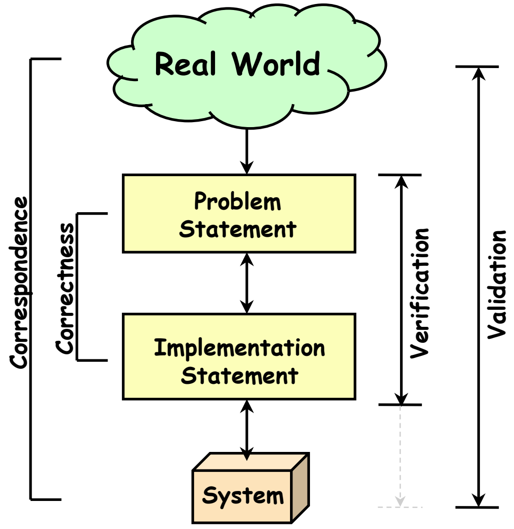
V-Model

Source: *Adapted from Forsberg & Mooz 1997*



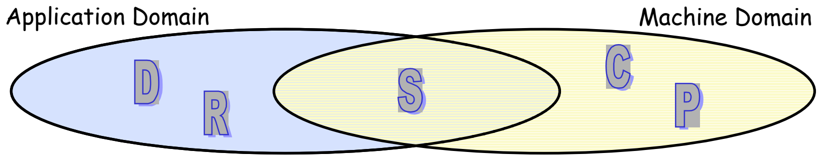
The “essential” software process

Source: *Adapted from Blum, 1992, p32*
see also: *van Vliet p11*



Verification and Validation

Source: *Adapted from Jackson, 1995, p170-171*



- For V&V, we need to worry about:
  - The properties of the computer hardware (C)
  - The properties of the program (P)
  - The properties of the machine in the application domain (the specification, S)
  - The properties of the domain, independent of the machine (D)
  - The requirements for the machine (R)
- Demonstrating that P satisfies R is then a two step process:
  - Do C and P imply S? *(Verification)*
  - Do S and D imply R? *(Validation)*

Validation Example

Source: *Adapted from Jackson, 1995, p172*

- Requirement R:
  - “Reverse thrust shall only be enabled when the aircraft is moving on the runway”
- Domain Properties D:
  - Wheel pulses on if and only if wheels turning
  - Wheels turning if and only if moving on runway
- Specification S:
  - Reverse thrust enabled if and only if wheel pulses on
- S + D imply R
  - But what if the domain model is wrong?

Summary

- Software is different
  - many assumptions from other engineering models don’t apply
  - there is no fabrication step
  - the underlying science of software behaviour is not well developed
  - (software engineering is still an immature discipline)
- Many different views of the software process
  - waterfall model is too rigid (doesn’t allow for change)
  - other models incorporate prototyping, evolution, risk, etc.
  - no lifecycle model is perfect
- Essential process:
  - describe the problem
  - describe the solution
  - verify (does the solution solve the stated problem?)
  - validate (did we solve the right problem?)

References

van Vliet, H. "Software Engineering: Principles and Practice (2nd Edition)" Wiley, 1999.

Chapter 3 provides a very good overview of lifecycle models.

Blum, B. "Software Engineering: A Holistic View". Oxford University Press, 1992.

Dorfman, M. "Requirements Engineering". In Thayer, R. H and Dorfman, M. (eds.) "Software Requirements Engineering, Second Edition". IEEE Computer Society Press, 1997, p7-22

Forsberg, K and Mooz, H. "System Engineering Overview". In Thayer, R. H and Dorfman, M. (eds.) "Software Requirements Engineering, Second Edition". IEEE Computer Society Press, 1997, p44-72

Jackson, M. "Software Requirements & Specifications: A Lexicon of Practice, Principles and Prejudices". Addison-Wesley, 1995.

Pfleeger, S. "Software Engineering: Theory and Practice". Prentice Hall, 1997.