Software development processes: from the waterfall to the Unified Process

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The Waterfall Model

Requirements → Design → Implementation → Verification → Maintenance

Image from Wikipedia
Pros, cons and history of the waterfall

+ better than no process at all – makes clear that requirements must be analysed, software must be tested, etc.
– inflexible and unrealistic – in practice, you cannot follow it: e.g., verification will show up problems with requirements capture.
– slow and expensive – in an attempt to avoid problems later, end up “gold plating” early phases, e.g., designing something elaborate enough to support the requirements you suspect you’ve missed, so that functionality for them can be added in coding without revisiting Requirements.

Introduced by Winston W. Royce in a 1970 paper as an obviously flawed idea!
Domains of use for waterfall-like models

**embedded systems**: Software must work with specific hardware; Can’t change software functionality later.

**safety critical systems**: Safety and security analysis of whole system is needed up front before implementation.

**some very large systems**: Allows for independent development of subsystems.
Spiral model


1. Determine objectives
2. Identify and resolve risks
3. Development and Test
4. Plan the next iteration
5. Release

- Cumulative cost
- Progress
- Requirements plan
- Concept of operation
- Concept of requirements
- Prototype 1
- Prototype 2
- Operational prototype
- Detailed design
- Code
- Integration
- Test
- Implementation
- Verification & Validation
- Development plan
- Test plan
- Verification & Validation
- Draft

Review
Spiral model

Successive loops involve more advanced activities:
- checking feasibility,
- gathering requirements,
- design development,
- integration and test.

Phases of single loop:

1. **Objective setting**: plans drawn up, risks identified.
2. **Risk assessment and reduction**: Consider alternatives. E.g. go for prototype to analyse uncertain requirement.
3. **Development and validation**:
4. **Planning**: Project reviewed and decisions made about continuing

A key innovation is prominent role of *risk*. 
Steps towards the Unified Process

- 1987-1995: Jacobson founded Objectory ("Object factory"). Use cases promoted as driver of development.
- 1998: (Rational) Unified Process

Unified process: the public domain, generic ideas
Rational unified process: more detailed, commercial. Now IBM.
Lots of variants, e.g. OpenUP, EnterpriseUP...
Characteristics of UP

- Mitigate major risks early
- Business needs drive application requirements
- Understand user requirements
- Improve quality
- Tailor the process
- Early user access
- Increase reuse
- Extensibility
- Get early feedback

(controlled iterative Use-Case Driven Architecture Centric Tailorable)

(adapted from Rational slide)
UP phases

One cycle consists of phases:

- **Inception** ends with commitment from the project sponsor to go ahead: business case for the project and its basic feasibility and scope known.
- **Elaboration** ends with
  - basic architecture of the system in place,
  - a plan for construction agreed,
  - all significant risks identified,
  - major risks understood enough not to be too worried.
- **Construction** (definitely iterative) ends with a beta-release system.
- **Transition** is the process of introducing the system to its users.

Iteration:

- process for one product will have several cycles
- each instance of a phase might have several iterations
UP phases: risk management

(adapted from Rational slide)
Workflows: 9 activities

6 Engineering workflows:

- Business modelling
- Requirements
- Analysis and design
- Implementation
- Test
- Deployment

3 Supporting workflows:

- Configuration and change management
- Project management
- Environment (e.g. process and tools)
Workflows used in phases

(adapted from Rational slide)
UP best practices

Six fundamental best practices:

2. Manage requirements. Explicit documentation, analyze impact before adopting.
3. Use component-based architectures. Promote systematic reuse.
4. Visually model software. UML...
5. Verify software quality. Testing, checking coding standards...
6. Control change to software. Configuration management...
Watts Humphrey, A discipline for software engineering (1995) p9:
“The following is the approach taken by the PSP:

▶ Identify those large-system software methods and practices that can be used by individuals.
▶ Define the subset of those methods and practices that can be applied while developing small programs.
▶ Structure those methods and practices so they can be gradually introduced.
▶ Provide exercises suitable for practising these methods in an educational setting.”
PSP provides a ladder of gradually more sophisticated practices. Explicit phases of development, e.g. separate design from coding. Lots of forms to fill in, e.g. time recording log, defect recording log. Aim is to provide numerical data adequate for identifying weak areas and tracking improvements, in process and in own skills.

More info: http://www.sei.cmu.edu/tsp/
Tool support: http://www.processdash.com/
Where does PSP fit in?

PSP is a relatively high ceremony process, aimed at individuals and small projects. It’s often used as a training process by people who expect to end up using a high ceremony process – such as UP – on large projects.

TSP, Team Software Process, is an intermediate.

Agile processes such as Extreme Programming take a very different approach – owing partly to deep philosophical differences, partly to different context assumptions. Next lecture.

A process maturity model such as CMMI (from SEI) can be used to help choose how to improve a software development process so as to fit the actual needs of the organisation.
Suggested: Browse the web to learn more about the processes mentioned:

- Waterfall
- Spiral
- (Rational) Unified Process
- Personal Software Process
- Capability Maturity Model

Suggested: Sommerville Ch 2 (9th and 10th Ed) and linked pages