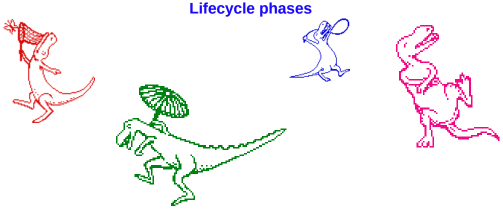
III. Software Lifecycles

Software processes and lifecycles
Relative costs of lifecycle phases
Examples of lifecycles and processes
Process maturity scale
Information system development lifecycle
Lifecycle phases



The Software System Lifecycle

- A **software process** is a partially ordered collection of actions, carried out by one or more software engineers, software users, or other software systems in order to accomplish a (software engineering) task..
- The **software system lifecycle** is a software process by which a software system is developed, tested, installed and maintained throughout its useful history.
- The concept of software lifecycle is a useful project management tool. A lifecycle consists of **phases**, each of which is a software process.
- Think of lifecycles as coarse-grain software processes. There is a lot of work on fine-grain software processes, such as fixing a bug, extending a module, testing a module, etc.

We focus here on
information system development lifecycles

The Software Lifecycle

- For large software systems, involving >10K lines of code (LOC), the breakdown of costs between different phases is as follows:

Requirements Analysis	5%
Design	10%
Programming-in-the-small	15%
Integration	10%
Maintenance and Evolution	60%

- The breakdown of costs per phase for small software systems (<5K LOC) has as follows:

Specification	10%
Decomposition	20%
Coding	20%
Optimization	15%
Testing	25%
Validation	10%

Systems analysis and design more important than coding!

What is Described by a Lifecycle?

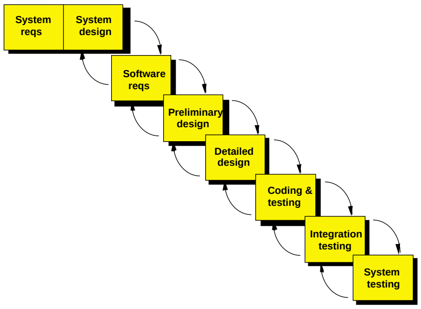
- The lifecycle describes the temporal, causal and I/O relationships between different lifecycle phases
- The lifecycle concept includes the concept of feedback (returning to a previous phase) as well as moving forward to the next phase
- In the past, the lifecycle concept was applied to the management of complex systems that had some sort of physical hardware as their end product, e.g., missiles, communication networks, spacecraft, etc.
- However, for hardware systems there is a tangible end product that can be measured and observed,...

It is not as easy to measure and observe
the results of information systems analysis and design

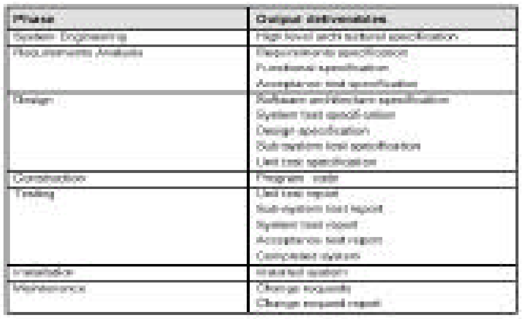
Lifecycle Models

- History of lifecycle models
  - Stage-wise (Benington, 1956)
  - Waterfall (Royce, 1970)
  - Transformational, automatic (Balzer, 1973; Balzer, Cheatham and Turner, 1983)
  - Evolutionary (Basili & Turner, 1975)
  - Transformational, specification to implementation (Lehman, Stenning and Turski, 1984)
  - Spiral (Boehm, 1986)
- Benefits of lifecycle models
  - Process awareness and understanding
  - Order of global activities
  - Improvement in product quality
  - Reduction of software costs
- Deficiencies of lifecycle models
  - Too coarse-grained -- they hide important process detail

The Waterfall Lifecycle Model



Waterfall Life Cycle Deliverables

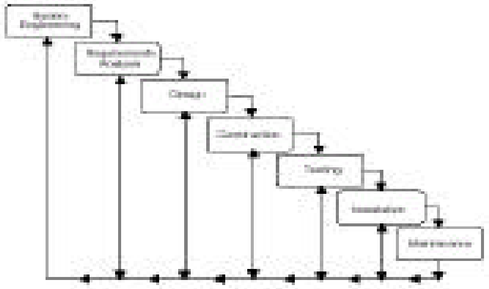


Phase	Output deliverables
System Engineering	High-level architectural specification
Requirements Analysis	Requirements specification Functional specification Acceptance test specification
Design	Software architecture specification System test specification Design specification Sub-system test specification Unit test specification
Construction	Program code
Testing	Unit test report Sub-system test report System test report Acceptance test report Completed system
Installation	Installed system
Maintenance	Change requests Change request report

Criticisms of the Waterfall Life Cycle Model

- Advantages
  - ✓The tasks of a step may be assigned to a specialized team;
  - ✓The progress of the project can be evaluated at the end of each phase and an assessment made as to whether the project should proceed;
- Criticisms
  - ✓Inflexible partitioning of the project into distinct steps -- real projects rarely follow it!
  - ✓Iterations are inevitable;
  - ✓It may take too long;
  - ✓Difficult to respond to changing customer requirements.
- Generally, this lifecycle model is appropriate when the requirements for a given system are well-understood.

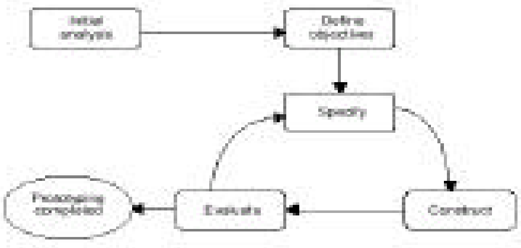
The Waterfall Life Cycle with Iteration



Prototyping

- Built something quickly to explore some aspect of the systems requirements
- The prototype is not intended as the final working system; among other things, it may be incomplete. less resilient (ex. poor performance) than a production system.
- In building a prototype, the objective is to investigate user requirements, in particular:
  - ✓ What data should be presented and what data should be captured;
  - ✓To investigate suitable forms of interfaces;
- Also to determine whether a particular implementation platform is appropriate, as well as the efficacy of a language, DBMS or communication infrastructure.

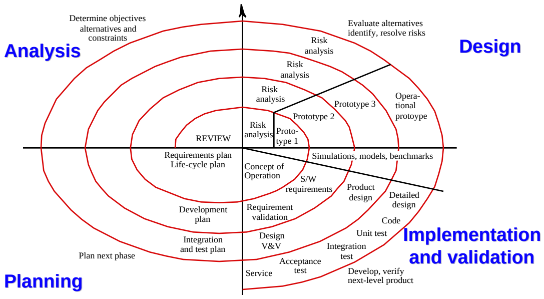
Prototyping



Evaluation of Prototyping

- Advantages
  - ✓Early demonstrations of system functionality help identify any misunderstandings between developer and client;
  - ✓Helps identify missing client requirements;
  - ✓Problems with user interfaces can be identified;
  - ✓Early testing of feasibility and usefulness of the system (partially)
- Problems
  - ✓The client may not understand the extra effort needed to produce a working production system;
  - ✓May divert attention from functional to solely interface issues;
  - ✓Requires significant user involvement;
  - ✓Managing the prototyping life cycle is not easy;
- Applicability
  - ✓For small or medium-size interactive systems
  - ✓For parts of large systems (e.g. user interfaces)
  - ✓For short-lifetime systems.

The Spiral Lifecycle Model



Software Processes: Fixing a Bug

Step 1: Problem identification

/* During testing, a problem is identified */

- A problem report is created, including problem identification, responsible personnel etc.
- Responsible personnel is notified

Step 2: Problem analysis

- Perform problem description evaluation, evaluation of software component etc.
- Propose solutions and describe technical and operational implications

Step 3: Cost analysis

- Project manager decides whether to use cost analysis routine
- If so, perform cost analysis to determine impact in work-months

Step 4: Schedule analysis...

Step 5: Perform change process...

Step 6: Close problem report...

Software Process Programming

A Testing process

```
Function AllFunctionsnsOK(executable,tests);
  declare executable executableCode,
             tests testSet,
             result derivedResult;
  /* executableCode etc are types, undefined here */
  All-fn-OK := true;
  For case := 1 to #tests do
       derive(executable, tests[case].input, result)
       if ~resultOK(result, testcase[case].output)
            then All-fn-OK := false; exit;
  end loop;
end All-Fn-Perf-OK
```

This only works for highly structured or automated processes

[Osterweil87]

Software Process Maturity

Level	Characteristic	Key challenges	Result
5 optimizing	improvement feedback into process	maintain organization at optimizing level	Productivity & quality
4 managed	process defined quantitatively and measured	changing technology; problem prevention	
3 defined	process defined and institutionalized	process measurement and analysis	
2 repeatable	intuitive process, dependent on individuals	training, process focus	
1 initial	ad hoc/chaotic	project and configuration management	risk

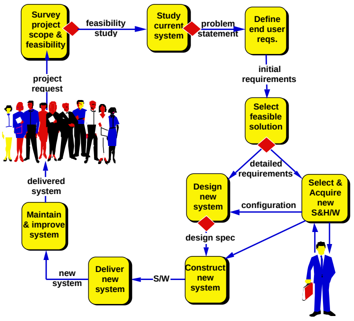
Software Process Maturity: Field Study (early '90s)

Level	USA (167 cases)	Japan (196 cases)	Result
5 optimizing	0%	0.5%	Productivity & quality
4 managed	0%	0%	
3 defined	1%	0.5%	
2 repeatable	13%	1%	
1 initial	86%	98%	risk

Information System Development Phases

- We focus now on the development part of the software lifecycle.
- There are many ways to divide up an information system development into phases
- For this course, we identify four major phases: **feasibility study**, **requirements analysis**, **system design** and **implementation**.
- All activities associated with each phase must be performed, managed and documented.
- **Development support** -- tools and methodologies that support the performance, management and documentation of all four phases

The Information System Lifecycle Phases



Who Are the Players ("Stakeholders")?

- **Management** -- for initiation, approval, control, possibly as users
- **End-users** (persons who actually use the system on a day-to-day basis) -- they provide input during requirements definition and testing, participate in committees and final system evaluation
- **Developers** (analysts and programmers)
  Analysts -- serve as project leaders, perform information analysis, create system requirements and design
  Programmers -- program, test, document, maintain
- **System support group** -- they are responsible for system maintenance
- **Database administrator** -- responsible for design and control of one or more databases
- **Program librarian** -- keeps track of all program files, documentation
- **Steering committee** -- oversees project to ensure that objectives have been met

Phase I: The Feasibility Study Phase

Deciding What to Do:

☞ Confirm that a problem exists

☞ Carry out a study to determine if a system can be developed to solve the problem (2 days - 4 weeks)

- A feasibility study looks at the problem at a high level (only takes into account few details)
- The study provides cost and savings estimates for the proposed solution.
- The feasibility study is reviewed by the customer (usually through a manager) and if the review is positive, then a more detailed requirements study is undertaken.

Phase II: The Requirements Analysis Phase

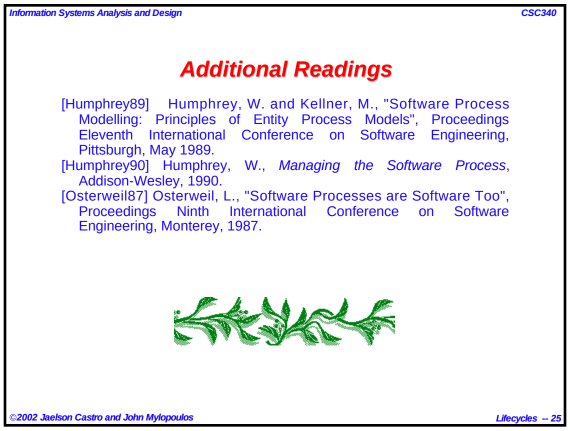
- **Study** existing procedures and computerized information systems in detail and document them.
- **Define** goals to be achieved by the new system
- **Propose** alternate (possibly several) business processes that might better fit organizational goals and objectives. Discuss these with the customer and get feedback on what is the most desirable alternative.
- **Define** the boundaries of the information system to be built as part of the collection of business processes.
- **Define** non-functional requirements on the proposed system, including input/output requirements, response requirements, file requirements, etc. Collect statistics on volumes, amounts of data handled by the system.

Phase III: The Design Phase

- Specify an architecture and a detailed design for the proposed information system
- Ideal system specified first, meeting all functional requirements, then modified to meet non-functional requirements and other constraints
- Resources allocated for hardware equipment, personnel tasks and programming tasks
- Technical specifications are prepared for: system architecture (components, system interfaces to existing systems), processing logic (how does the system do what it is supposed to?), database design (what information does the system handle?), input/output (what do the users see?), platform requirements (on what systems does the system run?) and manual procedures (how do people use the system?)

Phase IV: The Implementation Phase (Not Covered in this Course)

- The system is implemented on the basis of the design specification.
- Programming of the system is carried out
- Testing of the system, both as individual parts and as a whole, are conducted (acceptance test)
- Equipment is acquired and installed
- Procedures, system manuals, software specifications and documentation are completed
- Staff is trained



Additional Readings

[Humphrey89] Humphrey, W. and Kellner, M., "Software Process Modelling: Principles of Entity Process Models", Proceedings Eleventh International Conference on Software Engineering, Pittsburgh, May 1989.

[Humphrey90] Humphrey, W., *Managing the Software Process*, Addison-Wesley, 1990.

[Osterweil87] Osterweil, L., "Software Processes are Software Too", Proceedings Ninth International Conference on Software Engineering, Monterey, 1987.