SWE 261P:
Software Testing and Debugging

Professor James A. Jones
Department of Informatics
http://www.ics.uci.edu/~jajones

Administrative Stuff

- Lectures: Tuesdays
  4:00PM–6:50PM

- Course Exam: Tuesday, Mar. 12

  Office Hours: Immediately following class, or otherwise by appointment

Schedule

- Schedule is posted on the website
- Will likely change throughout the quarter.

Date	Content	Assignment Due
Week 1, Tues. Jan. 9	Course Introduction, Testing Fundamentals	**Assigned:** • **Participation:** Preliminary Course Survey: Due Friday (Jan. 12) night at midnight
Week 2, Tues. Jan. 16	Testing Principles, JUnit,Exploratory Testing, Acceptance Testing	**Assigned:** • **Participation:** Sign up for your project groups and software systems. Groups can be 1, 2, or 3 students large.: Due Tuesday, Jan 23 by 4pm
Week 3, Tues. Jan. 23	Functional Testing, Partitioning, Equivalence Partitioning, Boundary Testing, Combinatorial Testing	**Assigned:** • **Project: Introduction, Set up, Partitioning**
Week 4, Tues. Jan. 30	Parameterized Testing in JUnit, Functional Models, Finite State Machines	**Assigned:** • **Project: Functional Models and Finite State Machines**
Week 5, Tues. Feb. 6	Static Analysis, Control Flow Analysis, Structural Testing, Instrumentation, Code Coverage	**Assigned:** • **Project: Structural (White Box) Testing**
Week 6, Tues. Feb. 13	Test Driven Development (TDD), Behavior Driven Development (BDD), Continuous Integration, GUI Testing	**Assigned:** • **Project: Continuous Integration** • **Participation: BDD** ◦ Read "Introducing BDD" by Dan North
Week 7, Tues. Feb. 20	Mocking, Testable Design	**Assigned:** • **Project: Testable Design, Mocking**
Week 8, Tues. Feb. 27	Code Review, Static Analysis Tools, Mutation Testing, Debugging	**Assigned:** • **Project Presentation: Sign up for your presentation time slot** • **Project: Static Analyzers, Mutation Testing**
Week 9, Tues. Mar. 5	Project Report Presentations.	**Assigned:** • **Project: Final Project Report**
Week 10, Tues. Mar. 12	Exam	

Administrative Stuff

- Website: Canvas
- Class Files (Slides, Handouts, Assignments): Canvas
- Submission: Canvas
- Email Mailing List: Canvas

Materials

- No text book required
- However, a good supplemental (and optional) resource is “Software Testing and Analysis”, Pezzè and Young
- Laptop
- Slides will be posted before or after class
- I’ll also link a number of free online resources

Acknowledgements

Course materials being used from

- Rosenblum's course on Validation and Verification
- Pezzè and Young's testing and analysis slides
- Amman and Offutt's software testing materials
- Harrold's program analysis course
- Richardson's software testing and analysis
- Mauricio Aniche and Arie van Deursen's automated software testing course

Attendance

- You are responsible for material that is distributed during class.
- If you miss class, please arrange beforehand with a friend to get notes/handouts for you.
- If you know you are going to miss something important, contact the instructor (me) and/or the TA beforehand. It's much easier to accommodate planned absences
- You are responsible for all material taught in this course.

Announcements

- All announcements will be sent out through Canvas

- When emailing me, please include “SWE261P” in the subject line

Me

James A. Jones — “Jim”

- Professor of Information and Computer Science
- Department of Informatics
- Office: ISEB 2450
- Email: jajones@uci.edu

Teaching Assistants

- Hang Du (hdu5@uci.edu)
    - Office Hour: TBA
- Yi-Hung Chou (yihungc1@uci.edu)
    - Office Hour: TBA

Topics We Will Cover

(Tentative)

- Testing Fundamentals
- Combinatorial Testing
- Structural Testing
- Regression Testing
- Testing Driven Development
- Testing and Profiling
- Testing Processes
- Debugging
- Continuous Integration
- BDD
- Static Analysis
- Dynamic Analysis

Course Structure

- In-class:
  - Lectures
  - Group discussions
  - Practicums
  - Course exam
- Outside class:
  - Homework assignments will comprise the overall Course Project that will require using the techniques taught in class

Grading

- Class participation (10%)
- Project (40%)
- Project Presentation (20%)
- Exam (30%)

Project

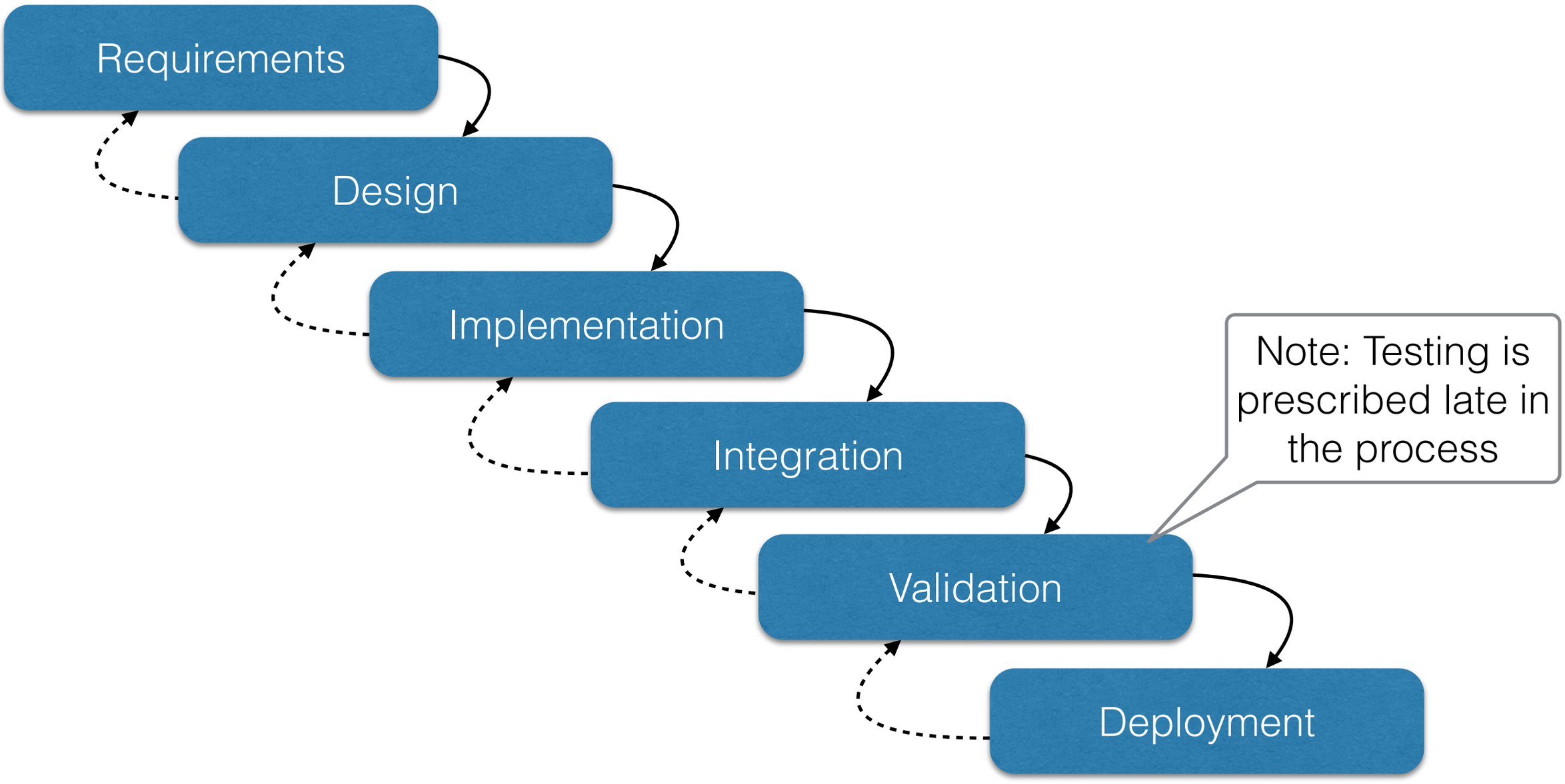
- Choose a ***Java*** software system
  - At least 15K LOC
  - At least 100 classes
  - Not developed by you: was developed by others and is used by thousands of people. Publicly available, open source.
  - Must be unique in class: each group has their own program — no two groups may share the same system.
  - Must be recognizable, well-used, popular project
  - Look for projects that already have test cases
  - Look for projects that have some sort of user interface (GUI, command line, etc.) and is not only a library.

Exam

- Last day of class (week 10)
- Will cover the topics that we cover throughout the course
- The slides will be the best study guide for the exam

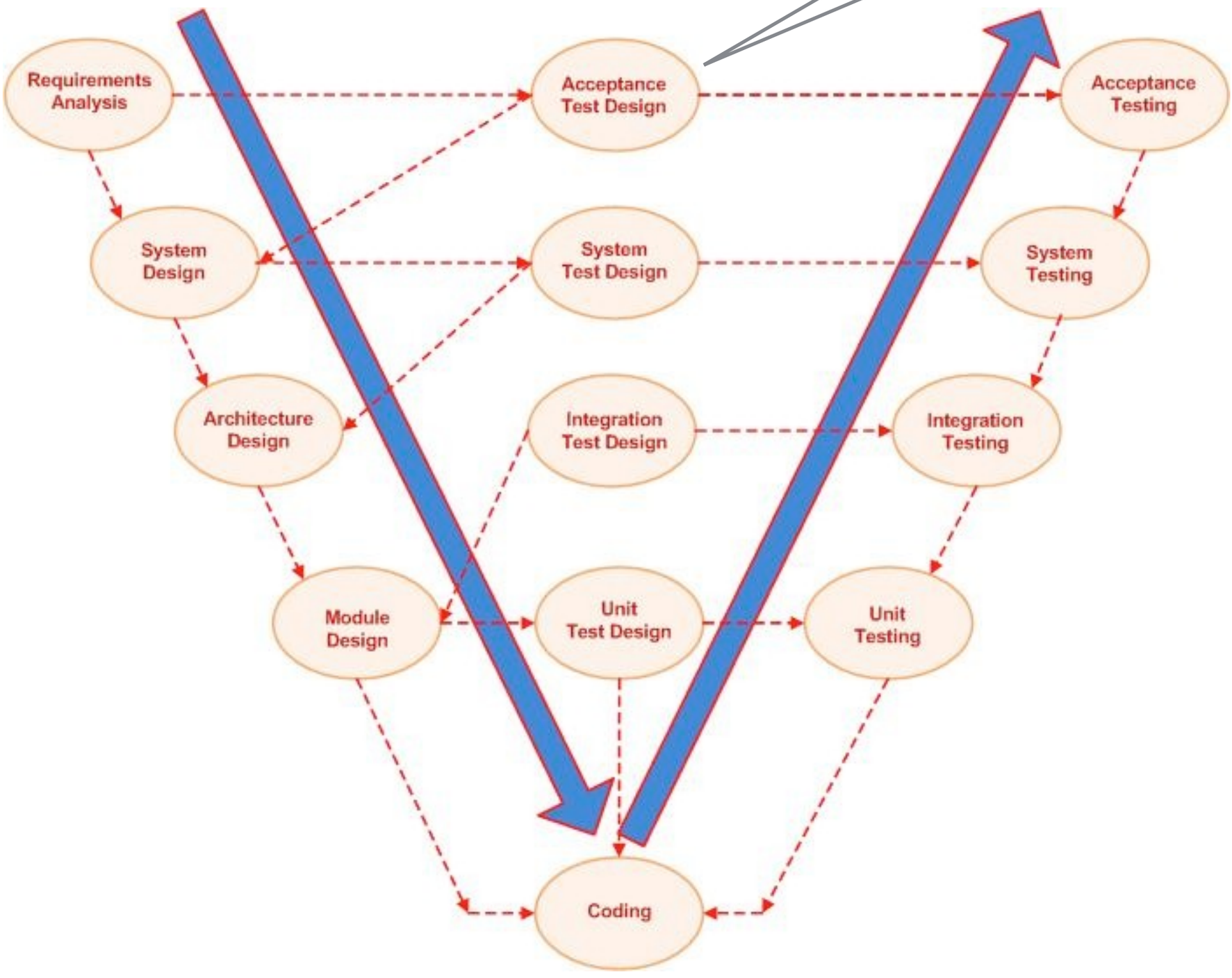
Testing Fundamentals

Waterfall Model (Royce, 1970)

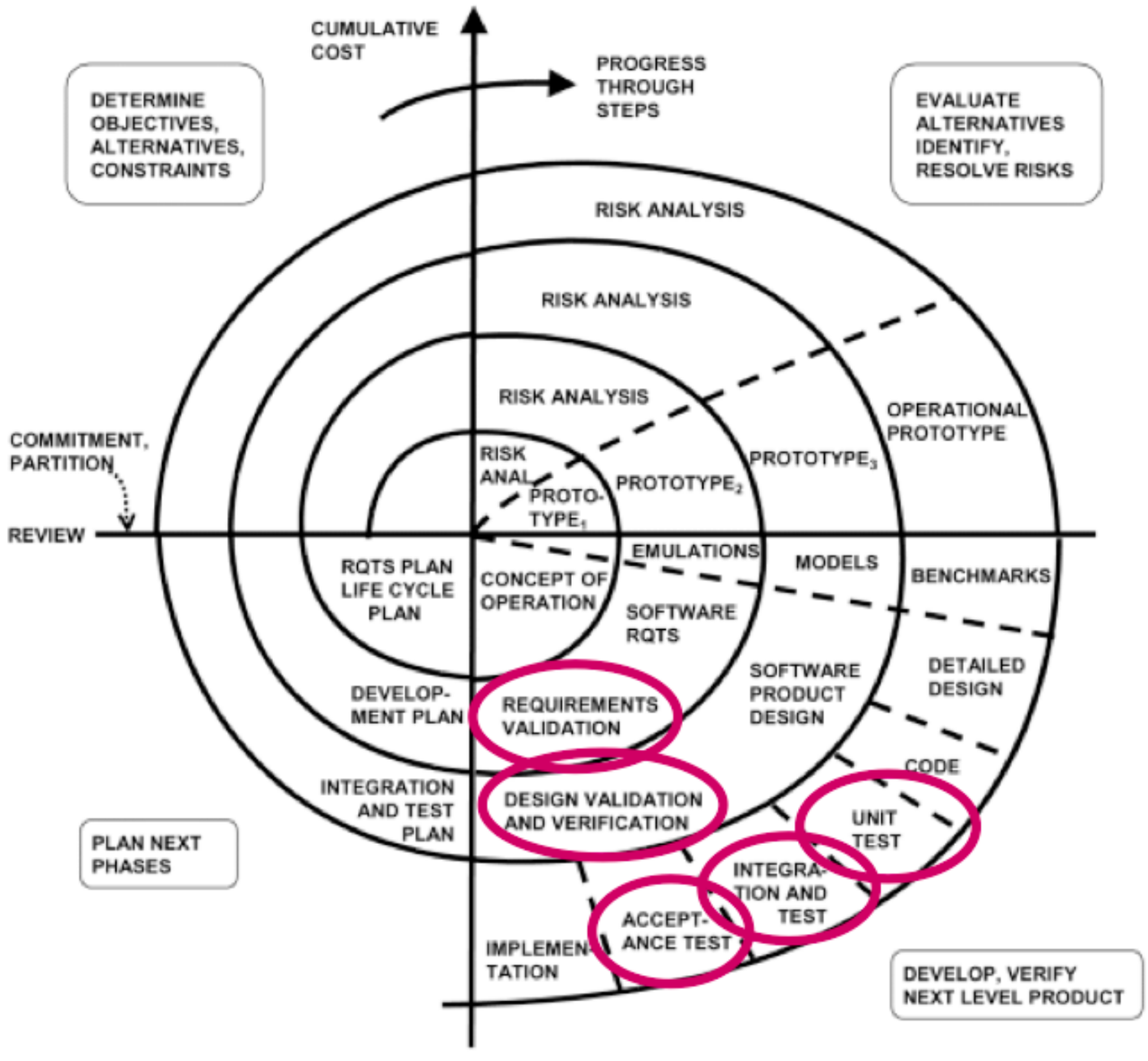


V-model

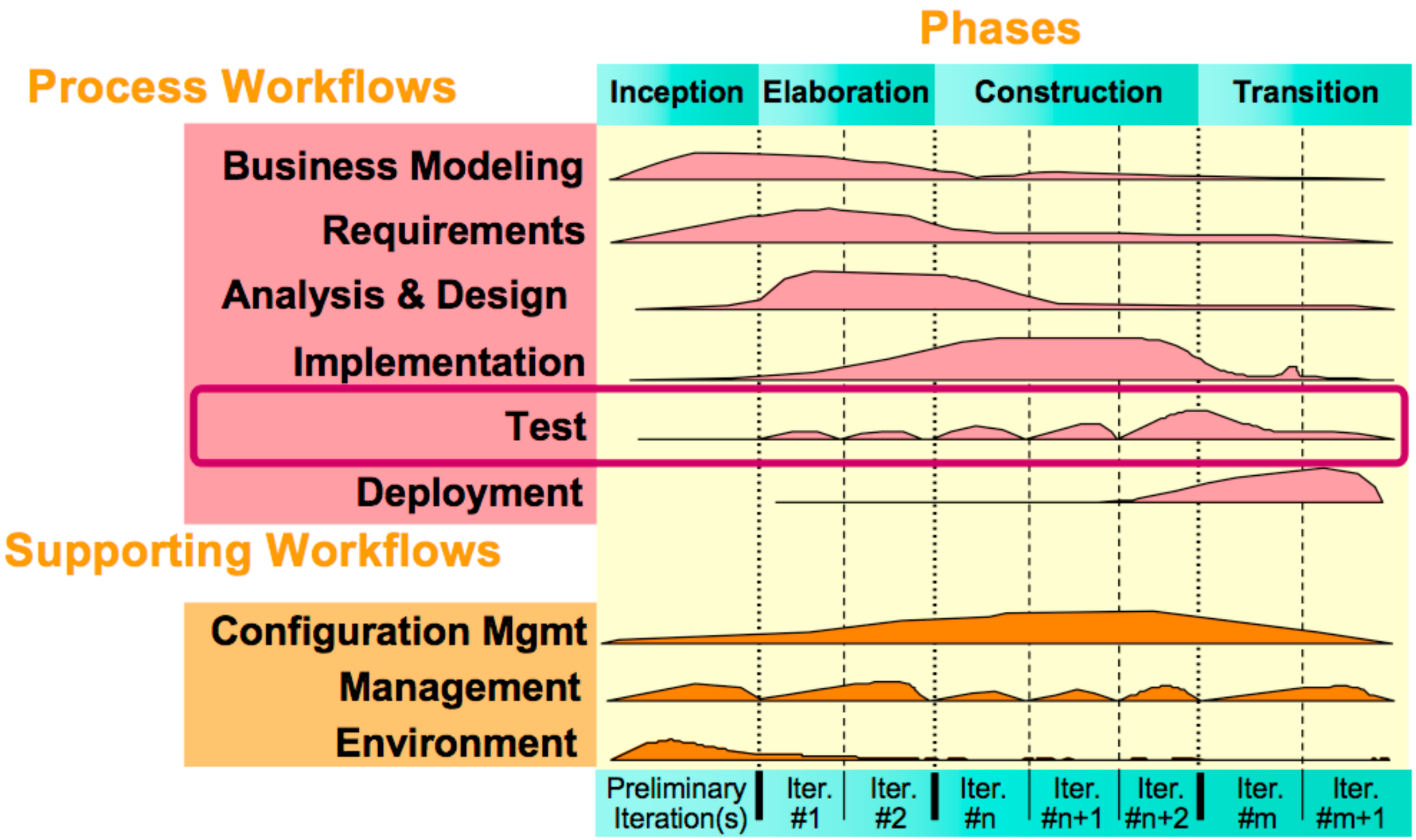
Note: Test design is incorporated earlier in the process



Spiral Model (Boehm, 1988)



Unified Software Development Process (Jacobson, 1999)



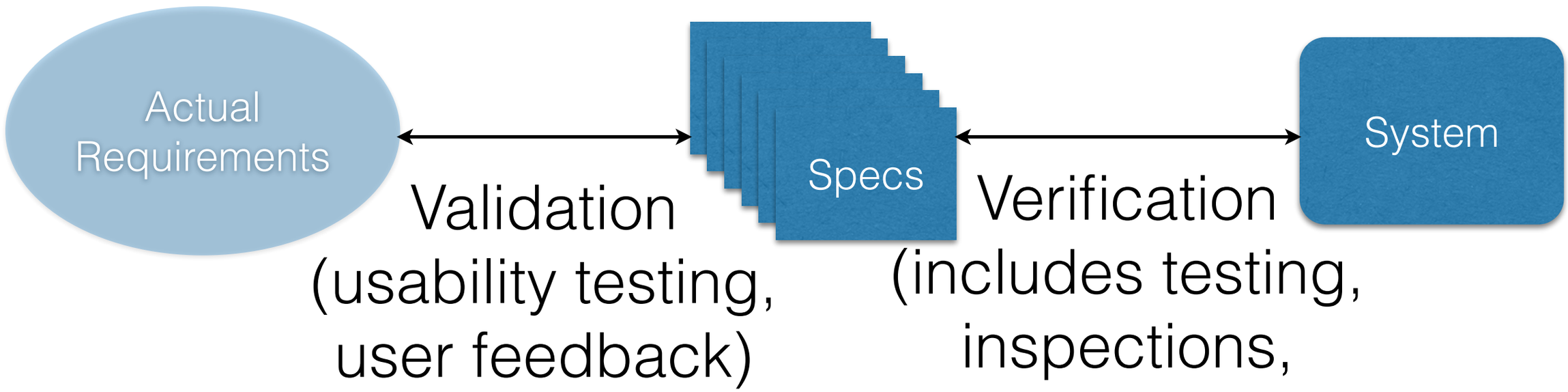
Lesson: Quality Assurance activities actually start very early or at the very beginning of a project (in one form or another), and as the field of software engineering matures, there is greater recognition that QA is more important earlier and throughout the development process.

Fundamentals

- Validation and Verification (“V&V”)

we talk about both

- Verification: “Are we building the machine right?”
- Validation: “Are we building the right machine?”



Terminology

- ***Test Case***: A defined set of input values (and possibly a defined starting state) that cause a program to take some defined action, with an expected output
- ***Test Suite***: A collection of test cases
- ***Test Oracle***: A mechanism for determining whether the actual behavior of a test case execution matches the expected behavior

actual correctness

A Famous (or Infamous) Quote

> "Testing can only prove the presence of bugs, not their absence." – Edsger W. Dijkstra

- An oft-repeated disparagement of testing that ignored the many problems of his favored alternative (formal proofs of correctness)
- But, essence of this quote is true

"Testing can only prove the presence of bugs, not their absence." – Edsger W. Dijkstra

find test cases is difficult

- Essence of this quote is true
  - Testing allows only a sampling of an enormously large program input space
  - The difficulty for the tester is to construct *effective* samples
    - Reveal faults
    - Reveal performance bottlenecks
    - Demonstrate reliability, usability, ...

1.hiring many engineers to solve the same problem seperately, and check their output;
2. Divide problem into many small problems
3.does cursh

Testing Oracles and Non-testable Programs

- Weyuker observed that many programs are "non-testable," in the sense that it is nearly impossible to construct an effective oracle for them
- Many numerical algorithms
  - Example: Multiplication of two large matrices containing large values
    - Must somehow compute result independently to verify
    - But, that independent computation may be just as faulty
- Many large distributed real-time programs
  - Example: Strategic Defense Initiative (SDI)

Oracles and Reliability Testing

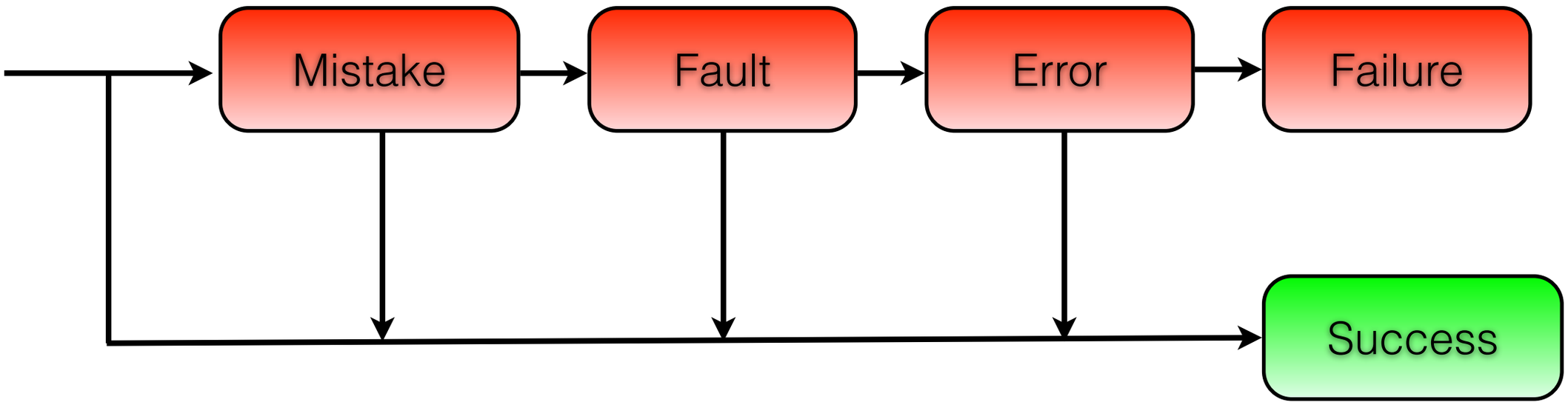
- Reliability testing gets around some of the problems of non-testable programs by applying statistical reasoning to a testing activity
  - Reliability: The probability of failure-free operation over some stated period of time — with "failure" defined quite coarsely (e.g., no crash)
  - Can be *estimated* through testing, to a level of precision that depends on how much testing was performed (more testing => more precision)

Terminology

- ***Mistake***: A human action that produces an incorrect result
- ***Fault***: (same as "bug") An anomaly in the source code of a program that *may* lead to an error
- ***Error***: The runtime effect of executing a fault, which causes a deviation from correct behavior and *may* result in a failure
- ***Failure***: The manifestation of an error

incorrect codes

IEEE Standard Glossary of Software Engineering Terminology. IEEE Std. 610.12-1990


Mistake
Fault
Error
Failure
Success

Fault vs. Error vs. Failure Example

```
 void rotateLeft(int* array, int
size) {
    int i;
    for (i=0; i<size; i++) {
        array[i] = array[i+1];
    }
}
```

C program taking an array of integers and rotating the values one position to the left, with wraparound

Test case 1

array input	size	array output
	0	

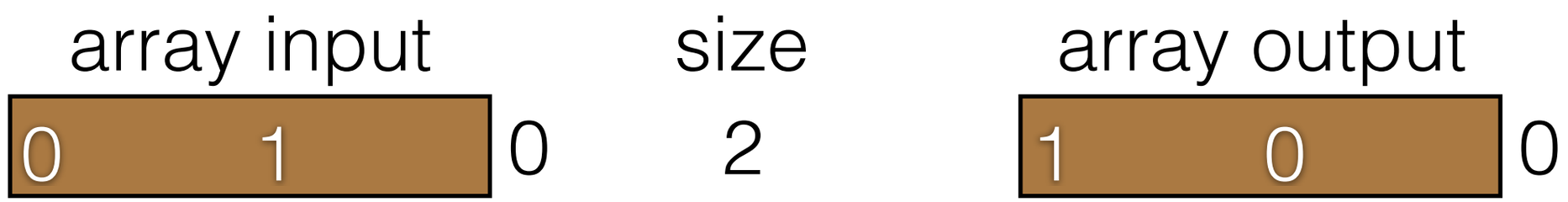
No error, no failure

Fault vs. Error vs. Failure Example

```
void rotateLeft(int* array, int size) {
    int i;
    for (i=0; i<size; i++) {
        array[i] = array[i+1];
    }
}
```

C program taking an array of integers and rotating the values one position to the left, with wraparound

Test case 2



Error, but no Failure

- The loop accesses memory outside of the array
- But the output array is coincidentally correct

Fault vs. Error vs. Failure Example

```
void rotateLeft(int* array, int size) {
    int i;
    for (i=0; i<size; i++) {
        array[i] = array[i+1];
    }
}
```

C program taking an array of integers and rotating the values one position to the left, with wraparound

Test case 3

Failure!

- The output array is incorrect

Fault vs. Error vs. Failure

```
 void rotateLeft(int* array, int
size) {
    int i;
    for (i=0; i<size; i++) {
        array[i] = array[i+1];
    }
}
```

But, what exactly <u>is</u> “the fault”?

- Depends greatly on one’s point of view
  - There are potentially many faults here
    - The loop indexes array outside its bounds
    - The loop never moves array[0] to another position
    - The loop never saves array[0] for later wraparound
  - There are also many possible fixes
    - The fix actually determines what “the fault” was!

Terminology (redux)

- Mistake, Fault, Bug, Error, Failure
-

Terminology (redux)

- Mistake, Fault, Bug, Error, Failure
- Human action, Incorrect code, Incorrect code, deviation of behavior at runtime, externally observable deviation of behavior

Terminology (redux)

- Mistake, Fault, Bug, Error, Failure
- Human action, Incorrect code, Incorrect code, deviation of behavior at runtime, externally observable deviation of behavior *from expected behavior*

Terminology

- ***Test Effectiveness***: The extent to which testing reveals faults or achieves other objectives
- ***Test Plan***: A document describing the scope, approach, resources, and schedule of intended testing activity
- ***Testing versus Debugging***: Testing reveals faults, while debugging is used to remove faults

Assignment

Complete the survey in Canvas by Friday night (Jan. 12). You can find it in the Quizzes section. It is not “graded” — that is, there are no right or wrong answers. It is anonymous — I can see who took it and who did not, but I cannot see who said what. It is simply for me to get a sense for at what level I should teach this course. I’ll count participation in the survey toward your participation in the course.

I will present the aggregated results of the survey in class next week.