Introduction To Software Testing

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What is testing?

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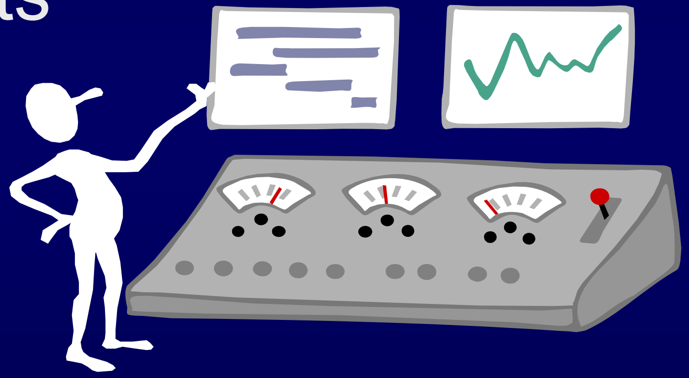
Testing

Testing:

- to check the quality (functionality, reliability, performance, …) of an (software) object

  -by performing experiments

  -in a controlled way



- In avg. 10-20 errors per 1000 LOC
- 30-50 % of development time and cost in embedded software

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Costs of Poor Quality

- Increased time to find and fix problems
- Increased time-to-market
- Increased cost to distribute modifications
- Increased customer support
- Product liability
- Failure in the market placeb

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Testing Objectives

- To identify as many errors as possible
- To bring the software to an acceptable level of quality
- To determine risk of release

Risk

- *Make best possible use of resources by identifying and prioritizing quality aspects and subsystems*
  - Higher risk ⇒ more testing
  - No risk ⇒ no testing
- Risk = chance of failure × damage

➢Use frequency
➢Chance of error being present
  ➢Complexity
  ➢New tools/techniques
  ➢Inexperienced developers

➢Cost of repair
➢Loss of market share
➢Legal claim

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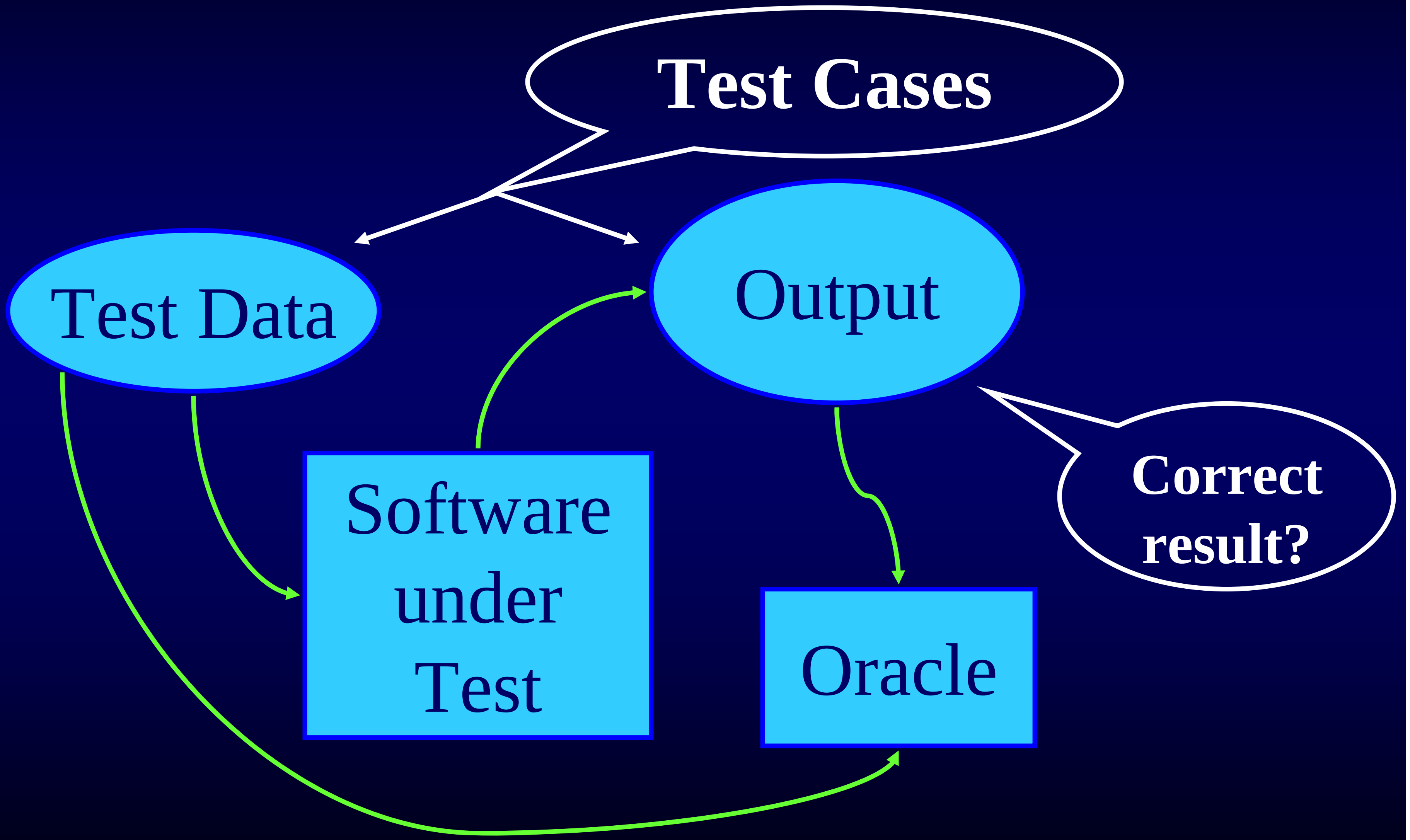
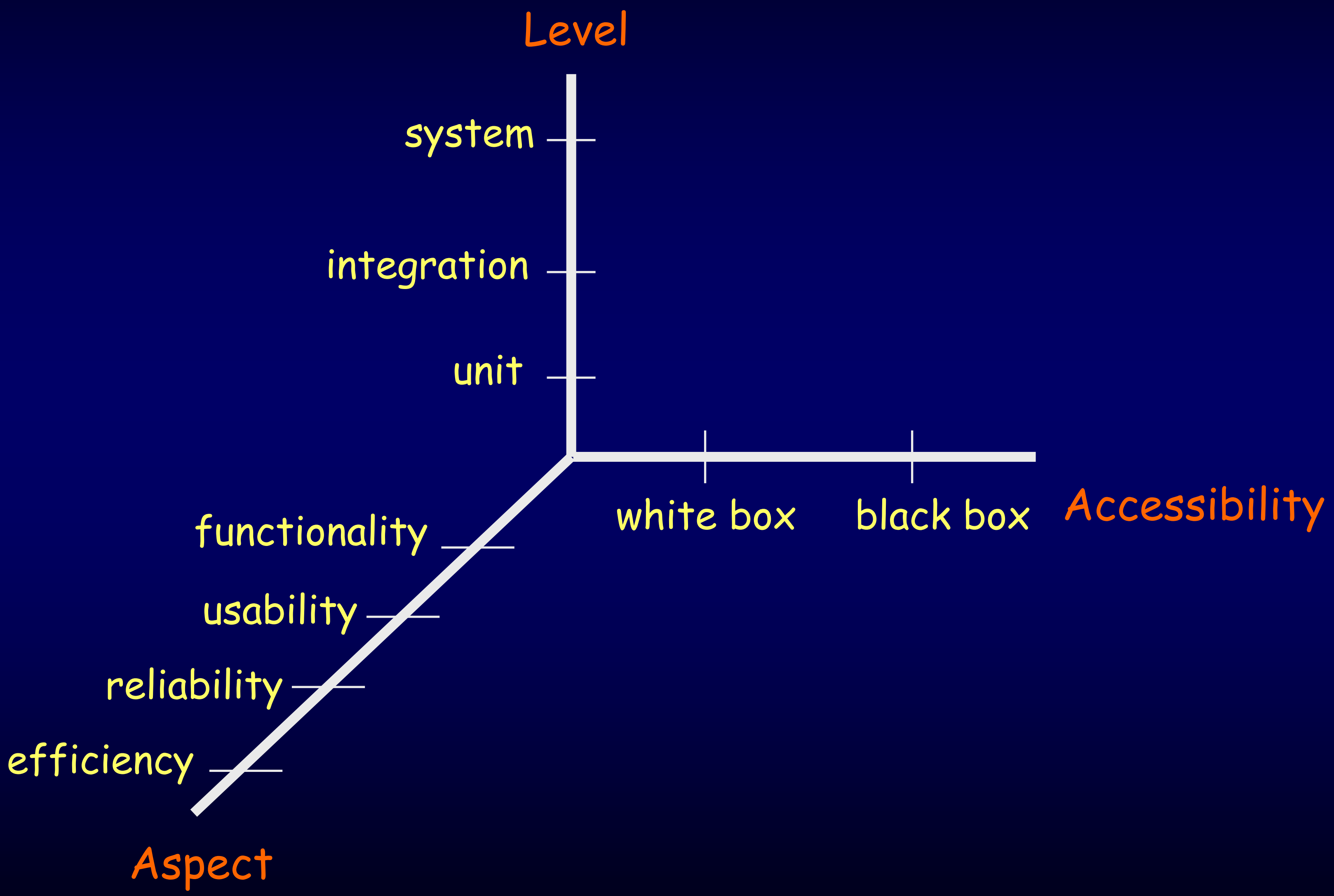
Testing

- Dynamic testing is the process of executing a program or system with the intent of finding error
(Glenford Meyers' definition)
- Static testing is any activity that aims at finding defects by inspecting, reviewing, walking through, and analyzing any static component of the software (code, documents, and models)
- Debugging is an ad hoc activity performed by individual developers to find and remove bugs from a program.
- Testing is a *planned* activity

What is a Test?



Types of Testing



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Quality-Characteristics (ISO-9126)

- Functionality $\Rightarrow$ functional testing
  - Suitability, accuracy, security, compliance, interoperability
- Reliability $\Rightarrow$ reliability testing
  - maturity, fault tolerance, recoverability
- Usability $\Rightarrow$ usability testing
  - understandability, learnability, operability
- Efficiency $\Rightarrow$ performance testing
  - time behaviour, resource utilization
- Maintainability $\Rightarrow$ maintainability testing ??
  - Analysability, changeability, stability, testability
- Portability $\Rightarrow$ portability testing ?
  - Adaptability, installability, conformance, replacability

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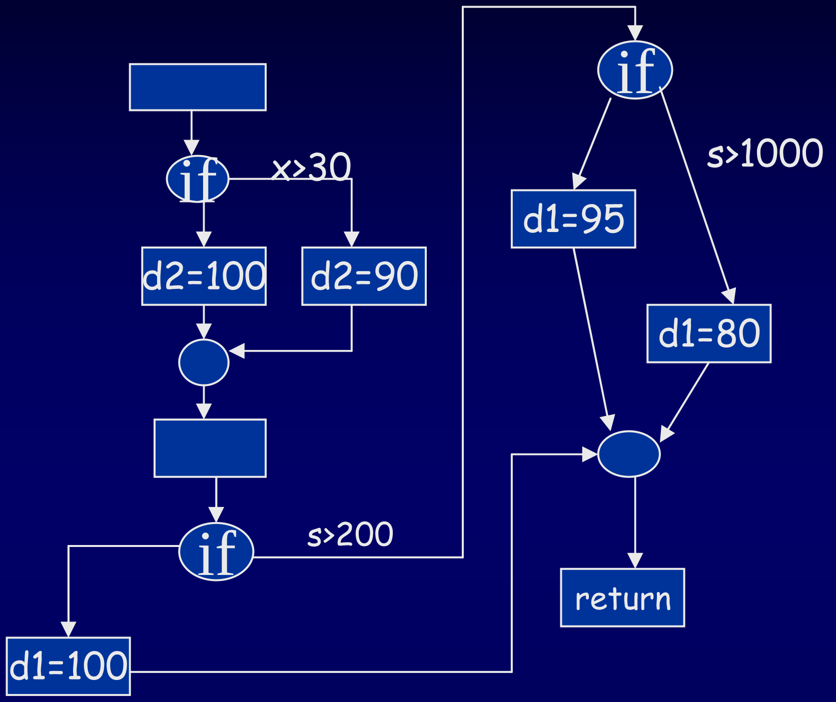
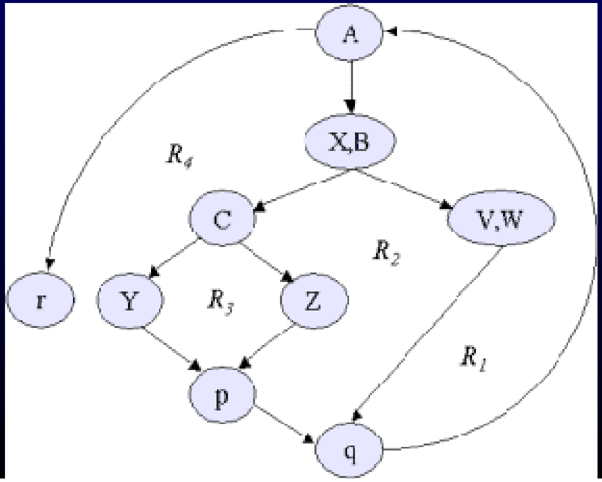
Whitebox Example

```
int invoice (int x, int y) {
  int d1, d2, s;
  if (x<=30) d2=100;
  else d2=90;
  s=5*x + 10 *y;
  if (s<=200) d1=100;
  else if (s<=1000) d1 = 95;
          else d1 = 80;
  return (s*d1*d2/10000);
}
```



Test Cases

Test Data	Expected Output
X=5 Y=5	75
X=31 Y=10	229.5
X=30 Y=100	977.5



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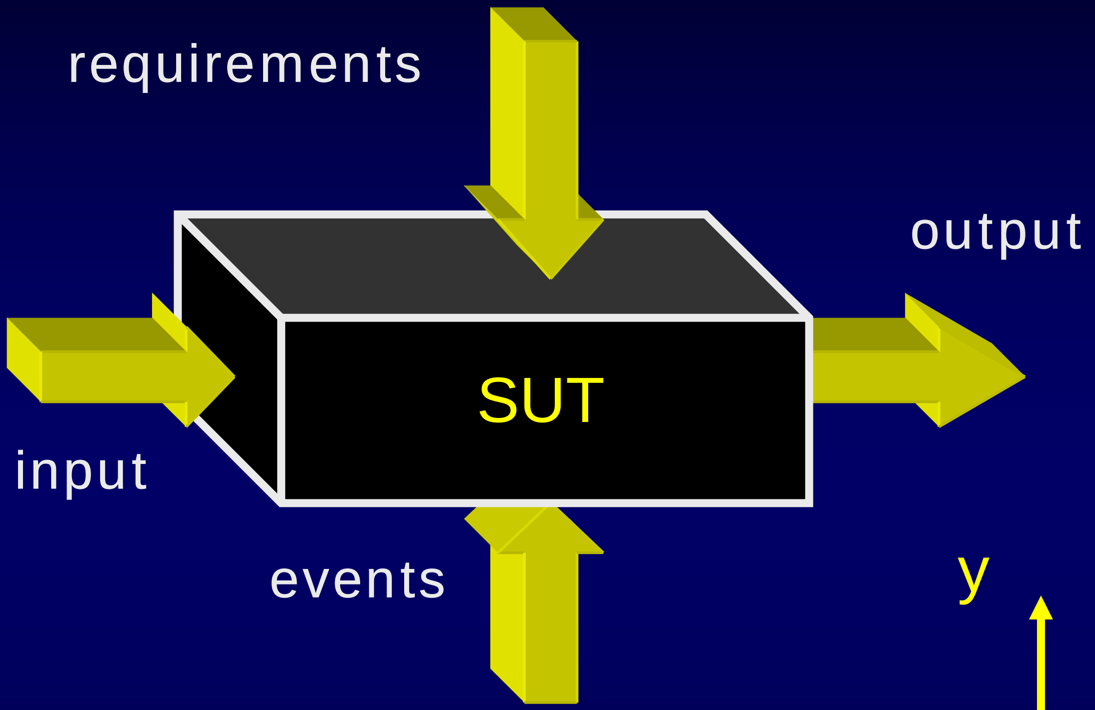
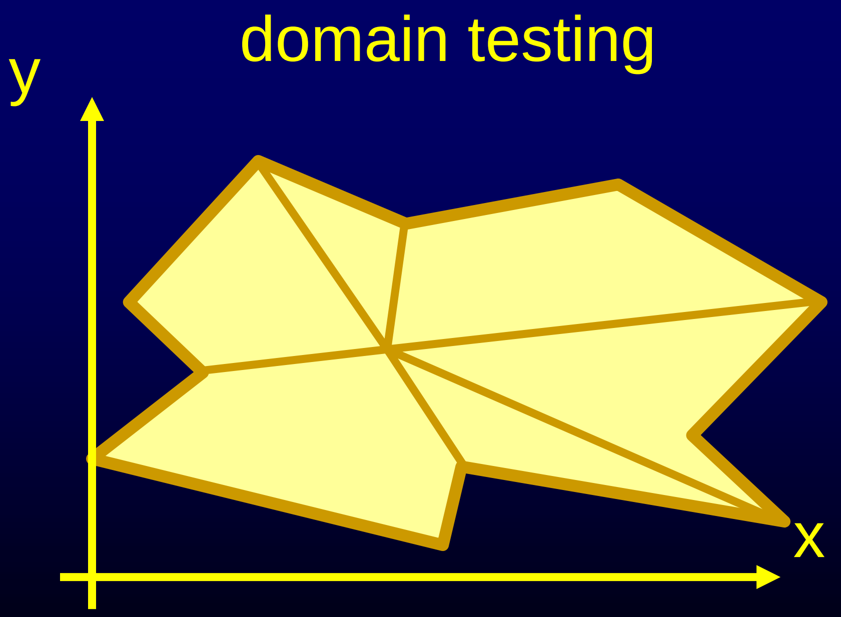
Black box testing





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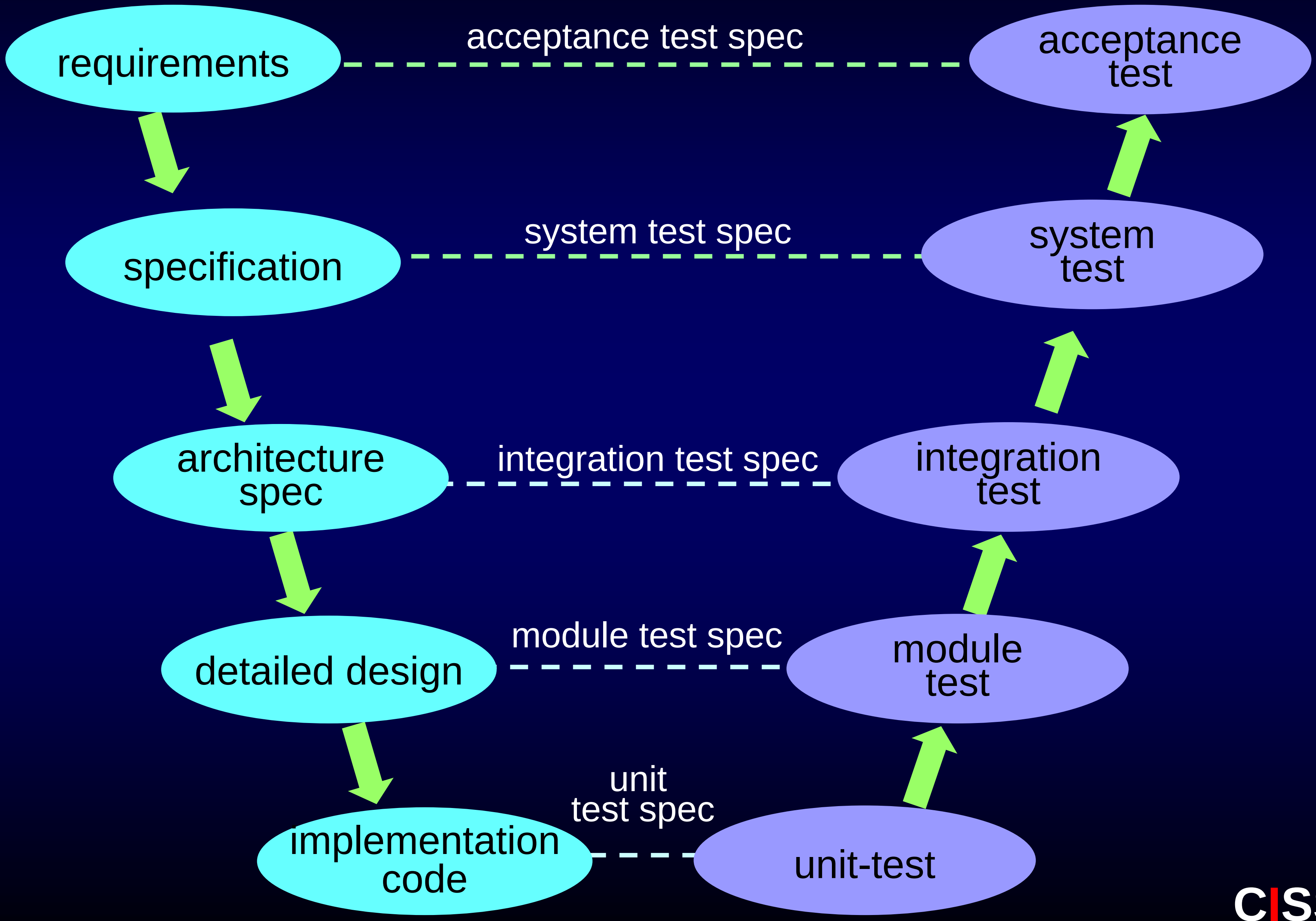
V - Model



requirements
acceptance test spec
acceptance test
specification
system test spec
system test
architecture spec
integration test spec
integration test
detailed design
module test spec
module test
implementation code
unit test spec
unit-test

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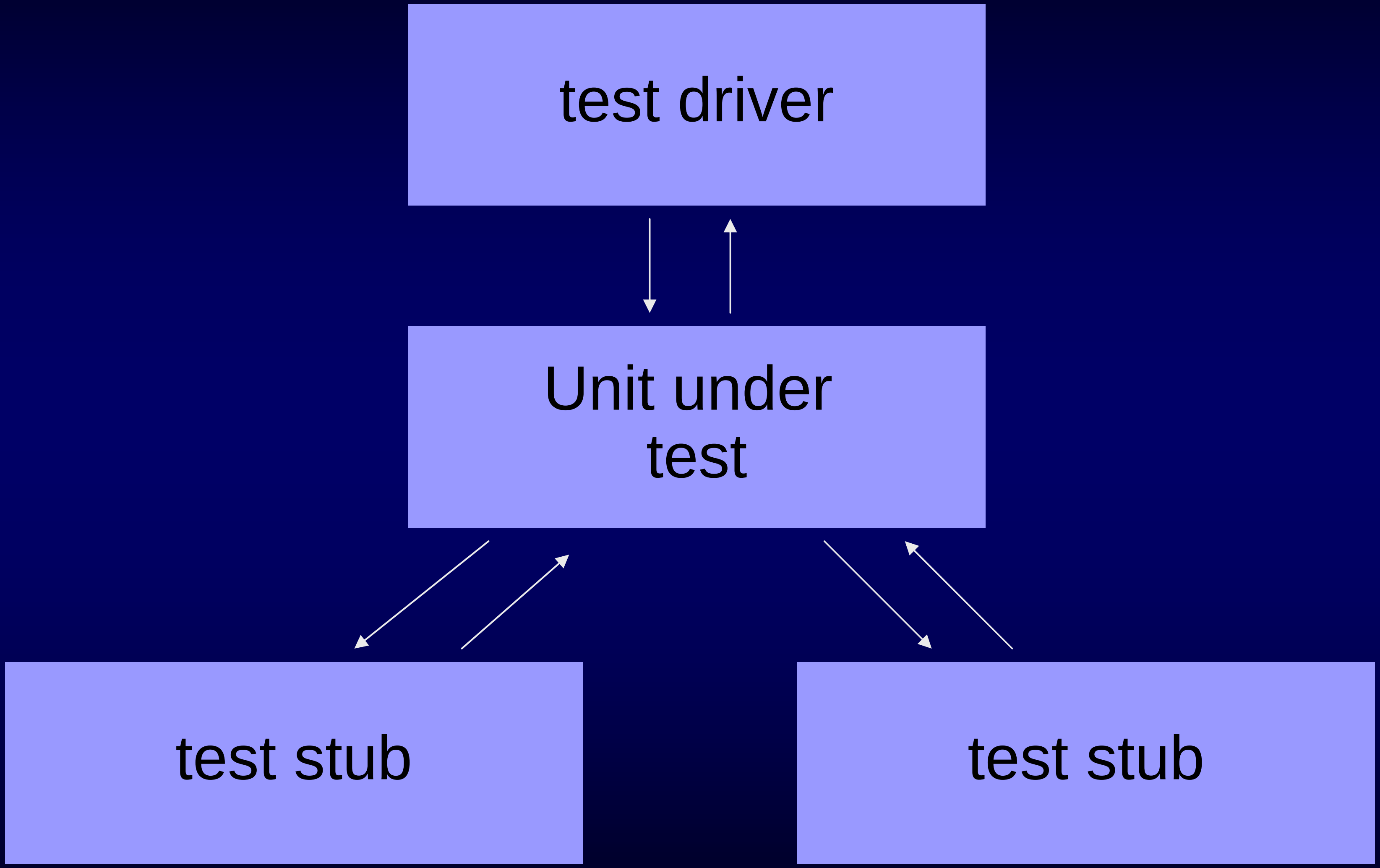
Unit Test



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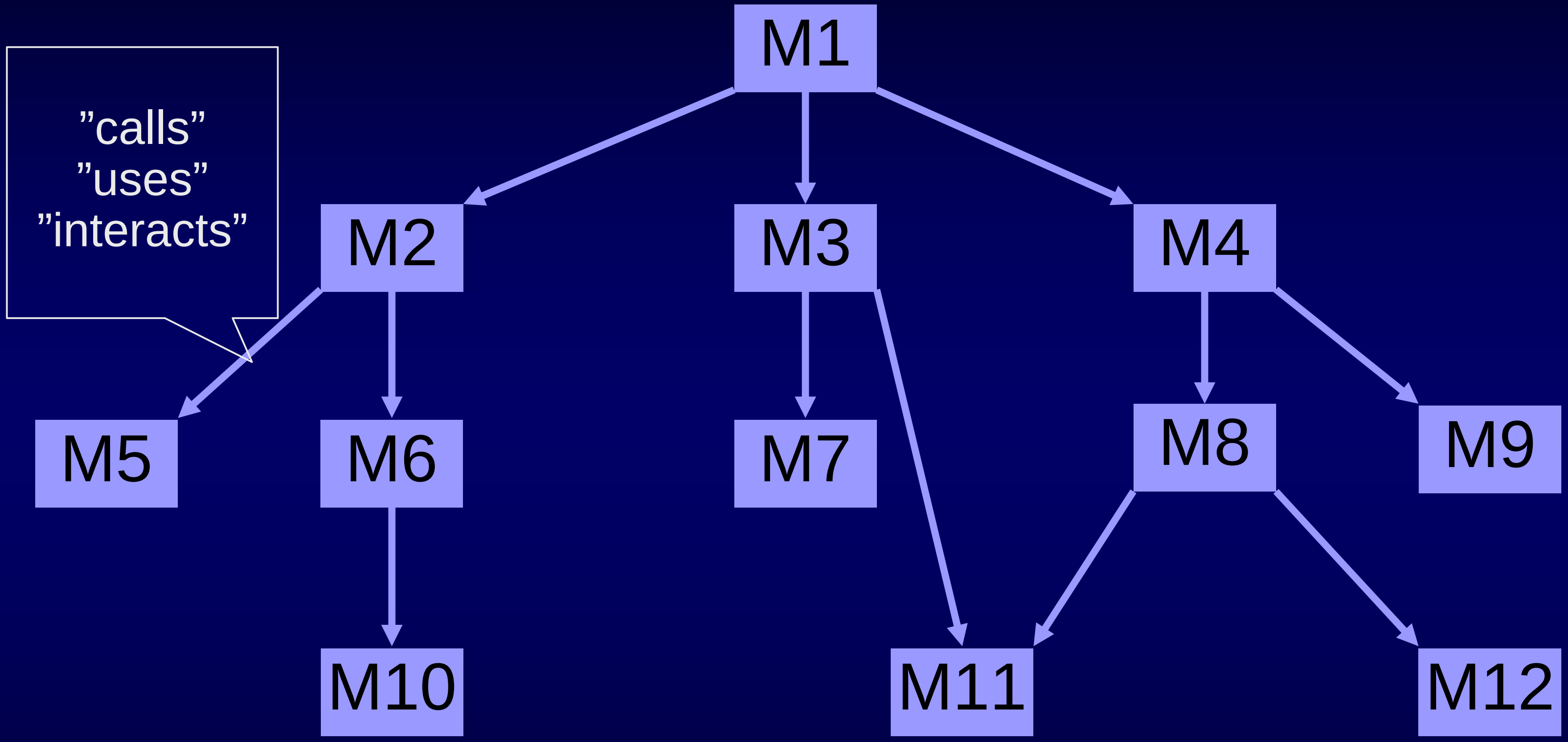
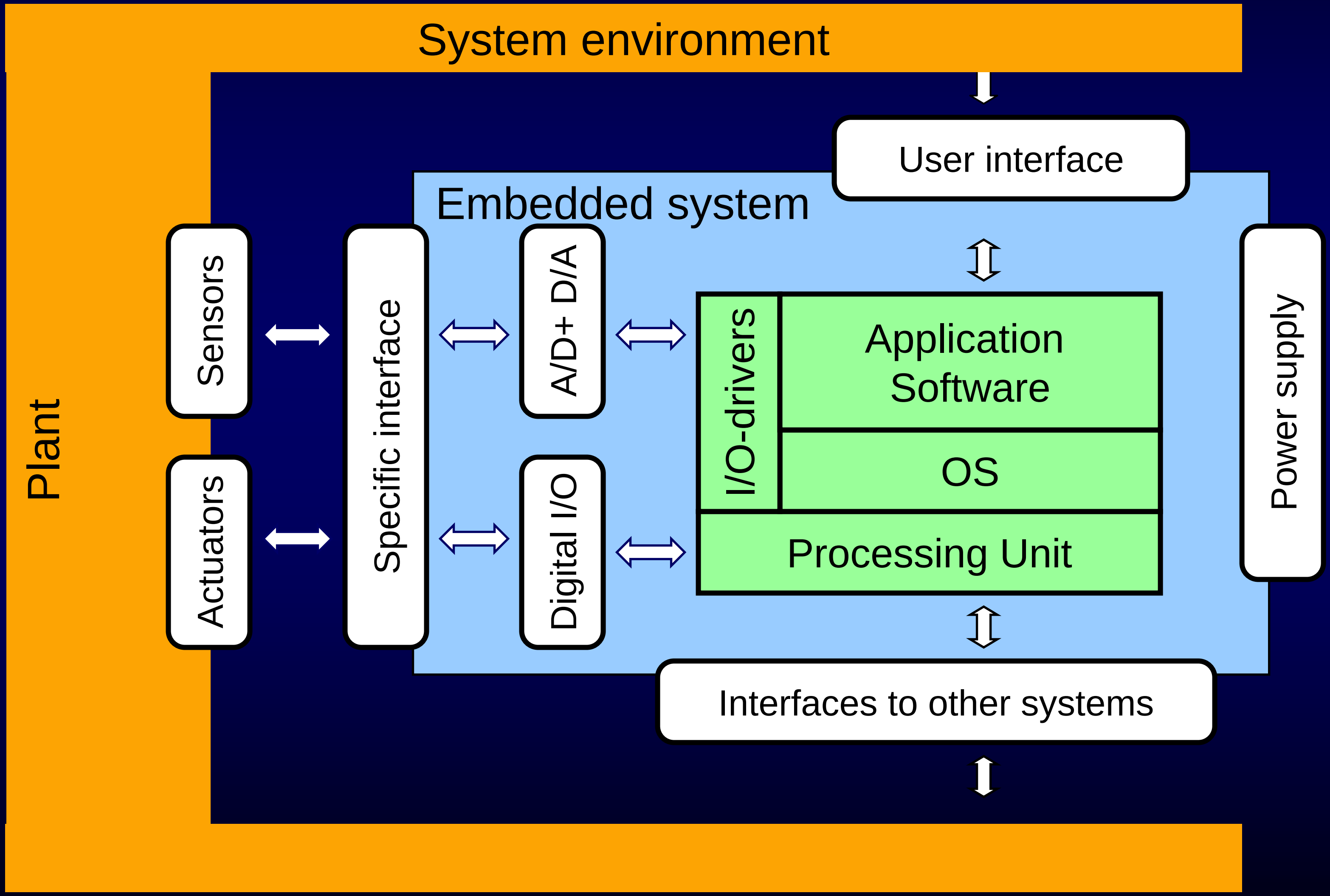
Integration Test



Generic Embedded System



System test

- 2*CRTG (4 channels) 2 * 200 k€

Test Equipment

- Complete Type Approval Test System (3 M€)

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A Self-Assessment Test [Myers]

- "A program reads three integer values. The three values are interpreted as representing the lengths of the sides of a triangle. The program prints a message that states whether the triangle is scalene, isosceles, or equilateral."

- *Write a set of test cases to test this program*

A Self-Assessment Test [Myers]

Test cases for:

1. valid scalene triangle ?
2. valid equilateral triangle ?
3. valid isosceles triangle ?
4. 3 permutations of previous ?
5. side = 0 ?
6. negative side ?
7. one side is sum of others ?
8. 3 permutations of previous ?
9. one side larger than sum of others ?
10. 3 permutations of previous ?
11. all sides = 0 ?
12. non-integer input ?
13. wrong number of values ?
14. for each test case: is expected output specified ?
15. check behaviour after output was produced ?

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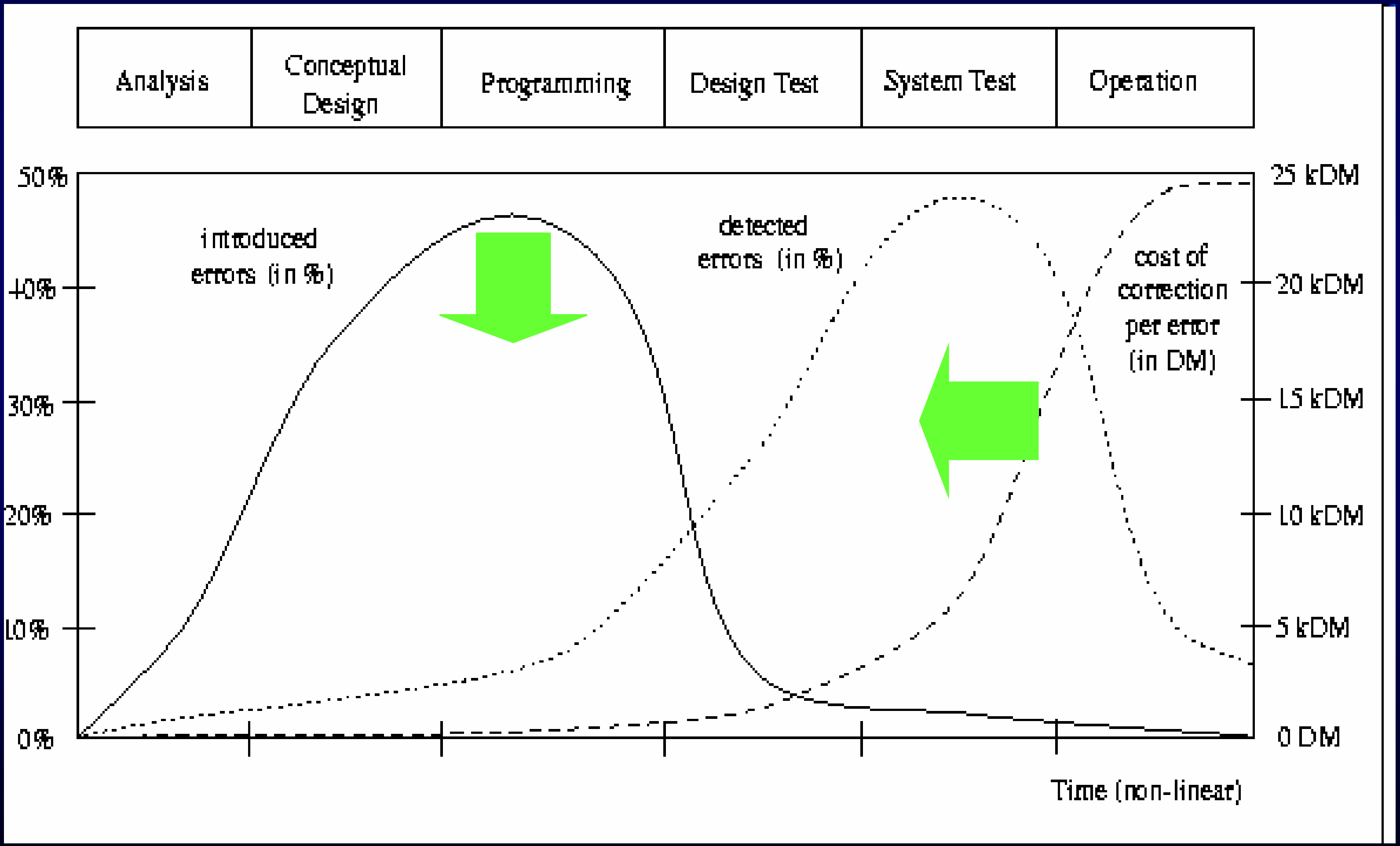
Challenges: Introducing, Detecting and repairing Errors *Liggesmeyer 98*



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Challenges of Testing

- Infinity of testing:
  - too many possible input combinations -- infinite breadth
  - too many possible input sequences -- infinite depth
  - too many invalid and unexpected inputs
- Exhaustive testing never possible:
  - when to stop testing ?
  - how to invent effective and efficient test cases with high probability of detecting errors ?
- Optimization problem of testing yield and invested effort
  - usually stop when time is over ......
- What is an effective method to measure coverage ?

Challenges of Testing

- Many operating environments and contexts
  - Impact of platform capabilities – OS, HW, Remote systems
  - Typical and rare use patterns
  - Implicit requirements
  - Domain knowledge
- How can software fail ?
  - Typical programming errors
  - Typical wrongly implemented features
  - Exceptional cases
  - No realistic reliability models for software
- How to translate in to effective tests?

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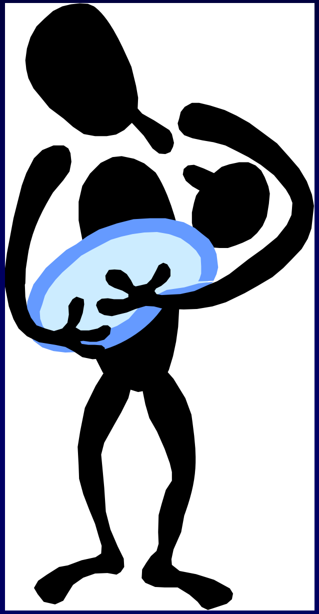
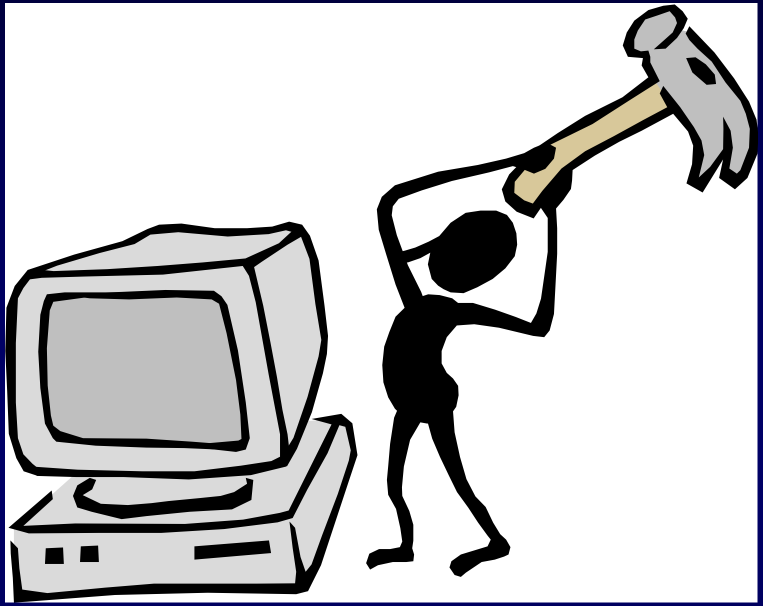
Challenges of Testing

- Regression testing:
  - very important
  - very boring and expensive
  - must be automated
- Test oracle problem
  - Bad specification or no specification at all
  - Requirements change
  - Requirements elucidation is a process

Challenges: Who Should Test?





- Developer
  - Understands the system
  - But, will test gently
  - And, is driven by deadlines

- Independent tester
  - Must learn system
  - But, will attempt to break it
  - And, is driven by “quality”

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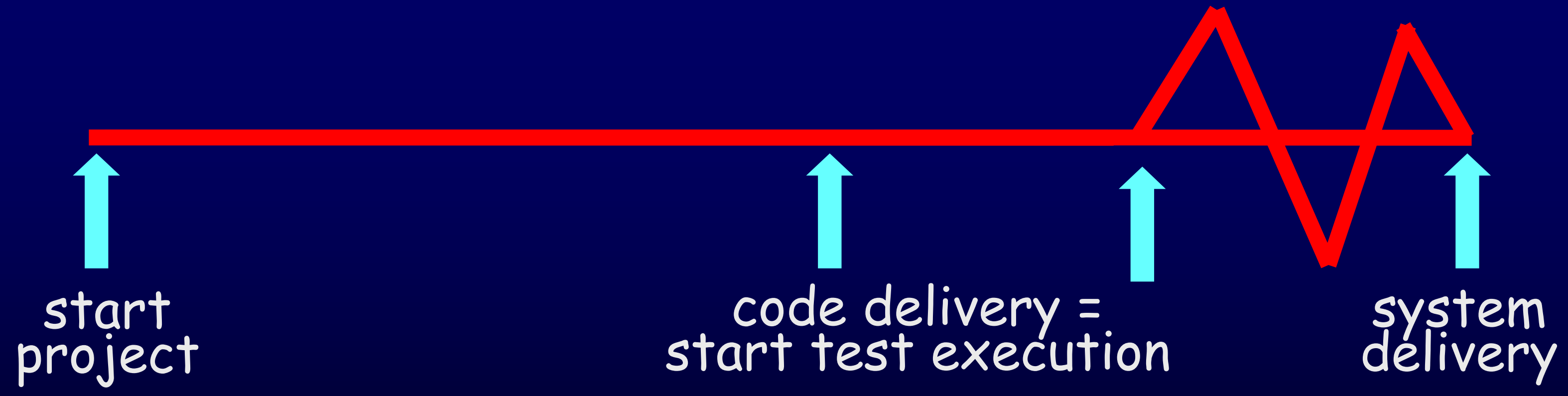
Challenges of Testing

Moving implementation deadlines

...... but fixed delivery deadlines



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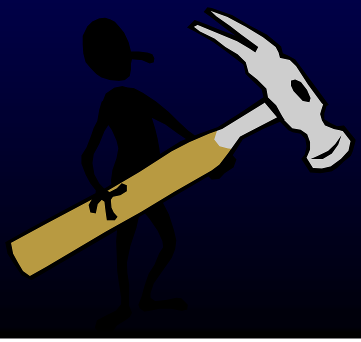
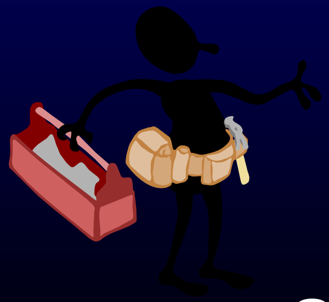
Challenges of Testing

- Lack of appropriate tools
  - Diversified fields
  - Experts dispersed, but also doesn't talk across application domain.
  - Tools are specialized, sells in low volume
  - Tools are expensive,
  - Tools are immature
  - No money available for test tools





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Challenges of Testing

- New embedded systems
  - more functionality
  - increasingly advanced
  - faster time-to-market
  - higher quality
- Testing
  - more to be tested
  - more complicated
  - in less time
  - more thorough

- skilled developers and testers
- advanced testing tools and techniques
- well organized
- using solid development method

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Summary

Some Testing Principles

- Testing starts during the requirements phase
- The programmer shall not be the (only) tester
- A test case specifies the test inputs
  and the expected outputs
- Test cases shall also cover invalid and unexpected inputs
- Test cases shall test that the program does what it should do
  and that it does not do what it should not do
- Test cases shall be recorded for reuse
- A test is successful when it detects an error
  (but the project manager thinks differently !)
- No risk, no test

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END

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