



 POLITECNICO DI MILANO

Dipartimento di  
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Planning and Managing Software Projects 2014-15  
Session 16

# Integration and Testing

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- This slides are largely based on Prof. John Musser class notes on “Principles of Software Project Management”
- Original slides are available at <http://www.projectreference.com/>
- Reuse and republish permission was granted

- Software Quality Assurance
- Integration
- Test planning
- Types of testing
- Test metrics
- Test Environments

# Validation vs. Verification

- Validation
  - Are we building the right product?
- Verification
  - Are we building the product right?
  
- Unit, integration, system, regression, compatibility, load&stress testing are verification
- Acceptance and external testing are validation

- Traceability
  - Ability to track relationship between work products
  - Ex: how well do requirements/design/test cases match
  
- Formal Reviews
  - Conducted at the end of each lifecycle phase
  - Potential deliverables:
    - Software Requirement Review (SRR)
    - Critical Design Review (CDR)

# If 99.9% Were Good Enough

- 9,703 checks would be deducted from the wrong bank accounts each hour
- 27,800 pieces of mail would be lost per hour
- 3,000,000 incorrect drug prescriptions per year
- 8,605 commercial aircraft takeoffs would annually result in crashes

Futrell, Shafer, Shafer, "Quality Software Project Management", 2002

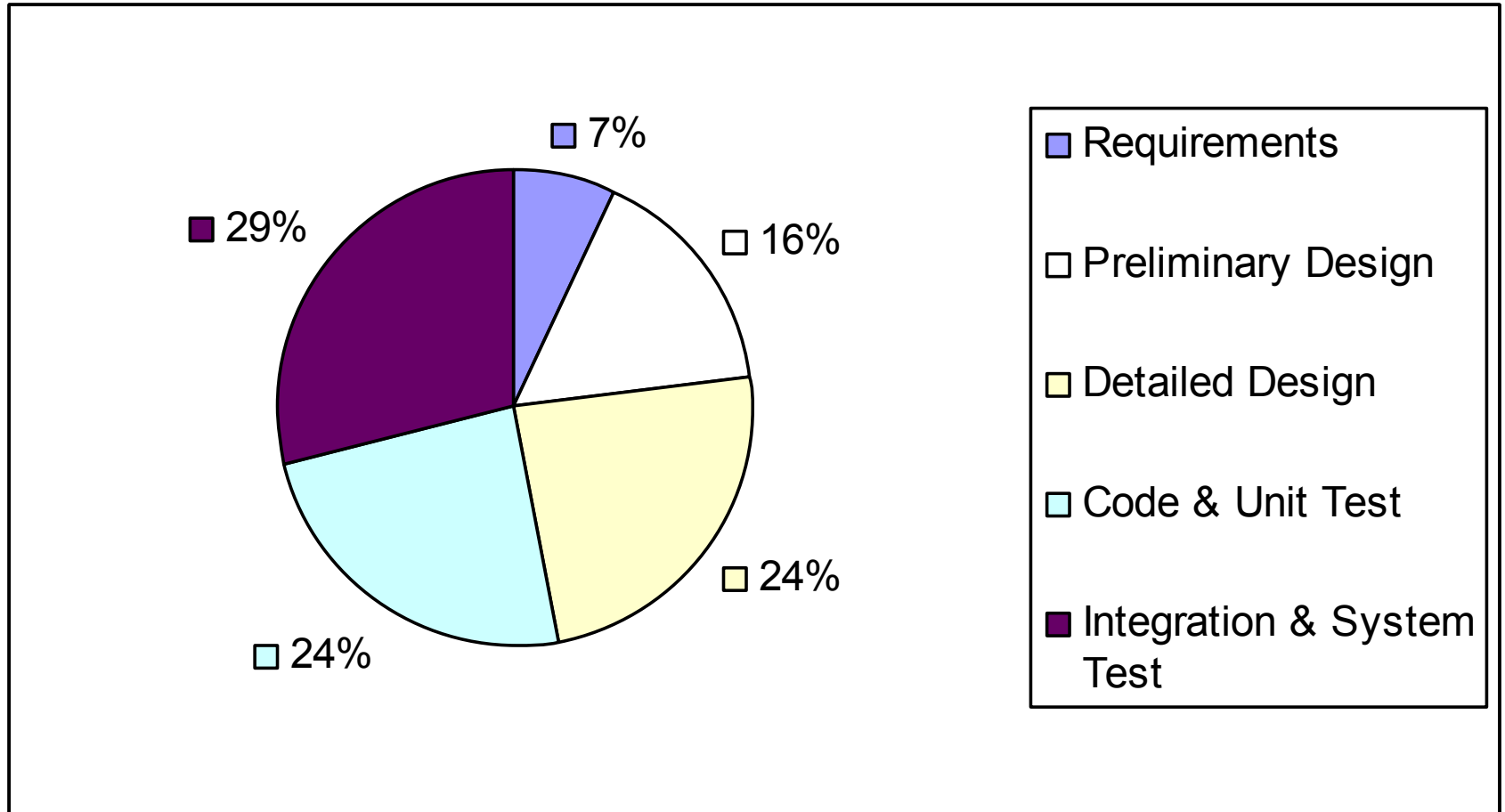
- Faulty Soviet early warning system nearly causes WWIII (1983)
  - 5 ballistic missiles or a bug?
- The AT&T network collapse (1990)
  - an error in a single line of code that had been added during a highly complex software upgrade
- The explosion of the Ariane 5 (1996)
  - Overflow error caused by a conversion from 64 to 16 bit format
- Mars Climate Observer metric problem (1998)
  - A sub-contractor used imperial units, rather than the metric units
- More...

<https://www.google.com/search?q=software+disaster>

- QA or SQA (Software Quality Assurance)
- Good QA comes from good process
- When does SQA begin?
  - during requirements!
- Most of SQA takes place in the integration and testing phase
- QA is your best window into the project



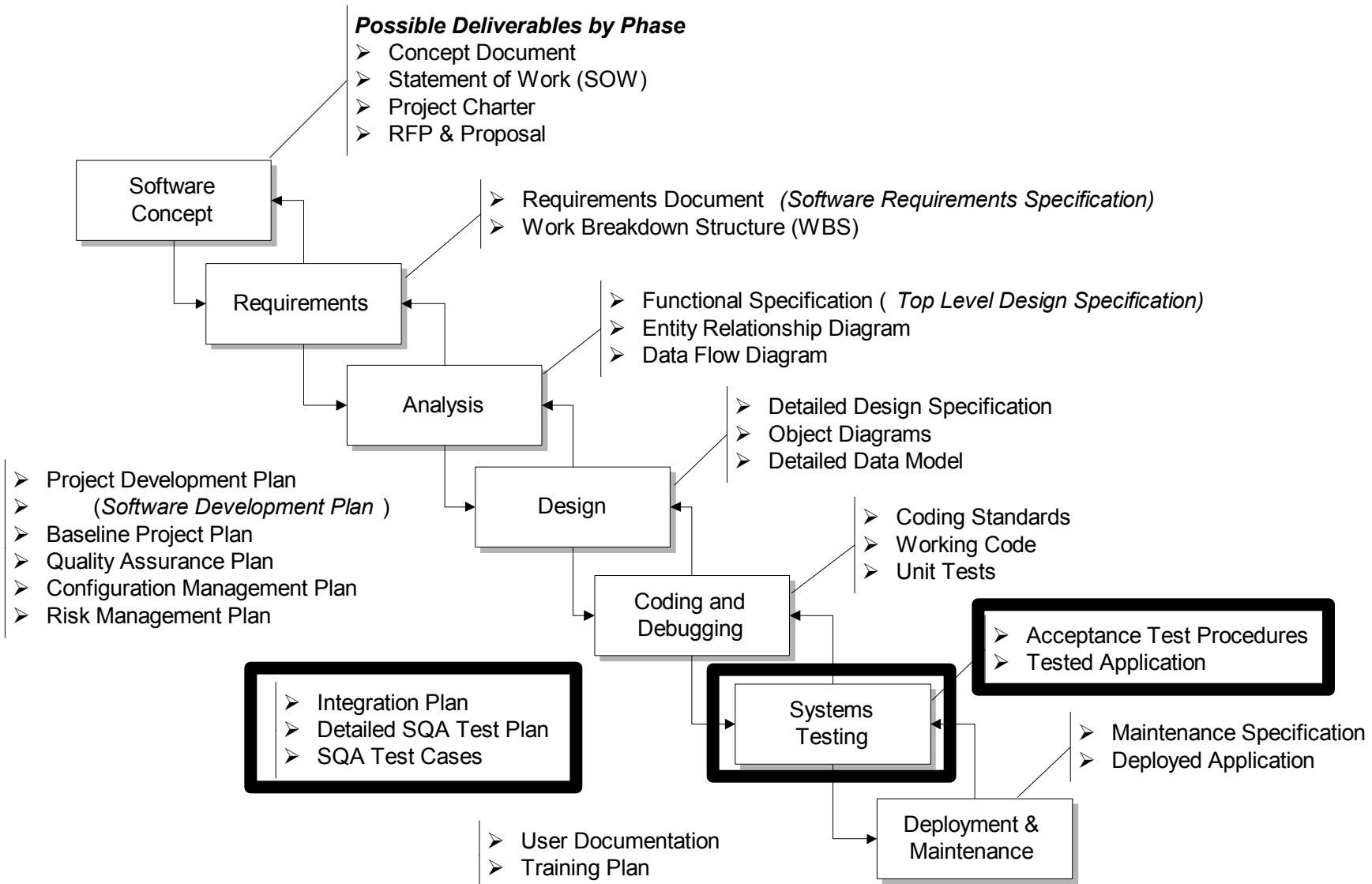
# Software Quality Assurance Development Costs



- QA Manager
  - Hires QA team; creates test plans; selects tools; manages team
  - Salary: \$50-80K/yr, \$50-100/hr
- Test Developer/Test Engineer
  - Performs functional tests; develops automated scripts
  - Salary: \$35-70K/yr, \$40-100/hr
- System Administrator
  - Supports QA functions but not official QA team member
- Copy Editor/Documentation Writer
  - Supports QA; also not part of official team

# Software Quality Assurance

## When and What?



- Development/Integration/Testing
  - Most common place for schedule & activity overlap
- Sometimes Integration/Testing thought of as one phase
- Progressively aggregates functionality
- QA team works in parallel with development team

- Top Down
  - Core or overarching system(s) implemented 1st
  - Combined into minimal “shell” system
  - “Stubs” are used to fill-out incomplete sections
    - Eventually replaced by actual modules
  
- Bottom Up
  - Starts with individual modules and builds-up
  - Individual units (after unit testing) are combined into sub-systems
  - Sub-systems are combined into the whole

- Who does integration testing?
  - Can be either development and/or QA team
- Staffing and budget are at peak
- “Crunch mode” [1]
- Issues
  - Pressure
  - Delivery date nears
  - Unexpected failures (bugs)
  - Motivation issues
  - User acceptance conflicts

[ 1 ] <http://www.urbandictionary.com/define.php?term=crunch+mode>

# Test Plans (SQAP)

- Software Quality Assurance Plan
  - Should be complete near end of requirements
- See example
  - [http://energy.gov/sites/prod/files/cioprod/documents/csr\\_sqa\\_plan.pdf](http://energy.gov/sites/prod/files/cioprod/documents/csr_sqa_plan.pdf)
  - Even use the IEEE 730 standard for Software Quality Assurance Processes

- Purpose
- Reference documents
- Management
- Documentation
- Standards, practices, conventions, metrics
  - Quality measures
  - Testing practices



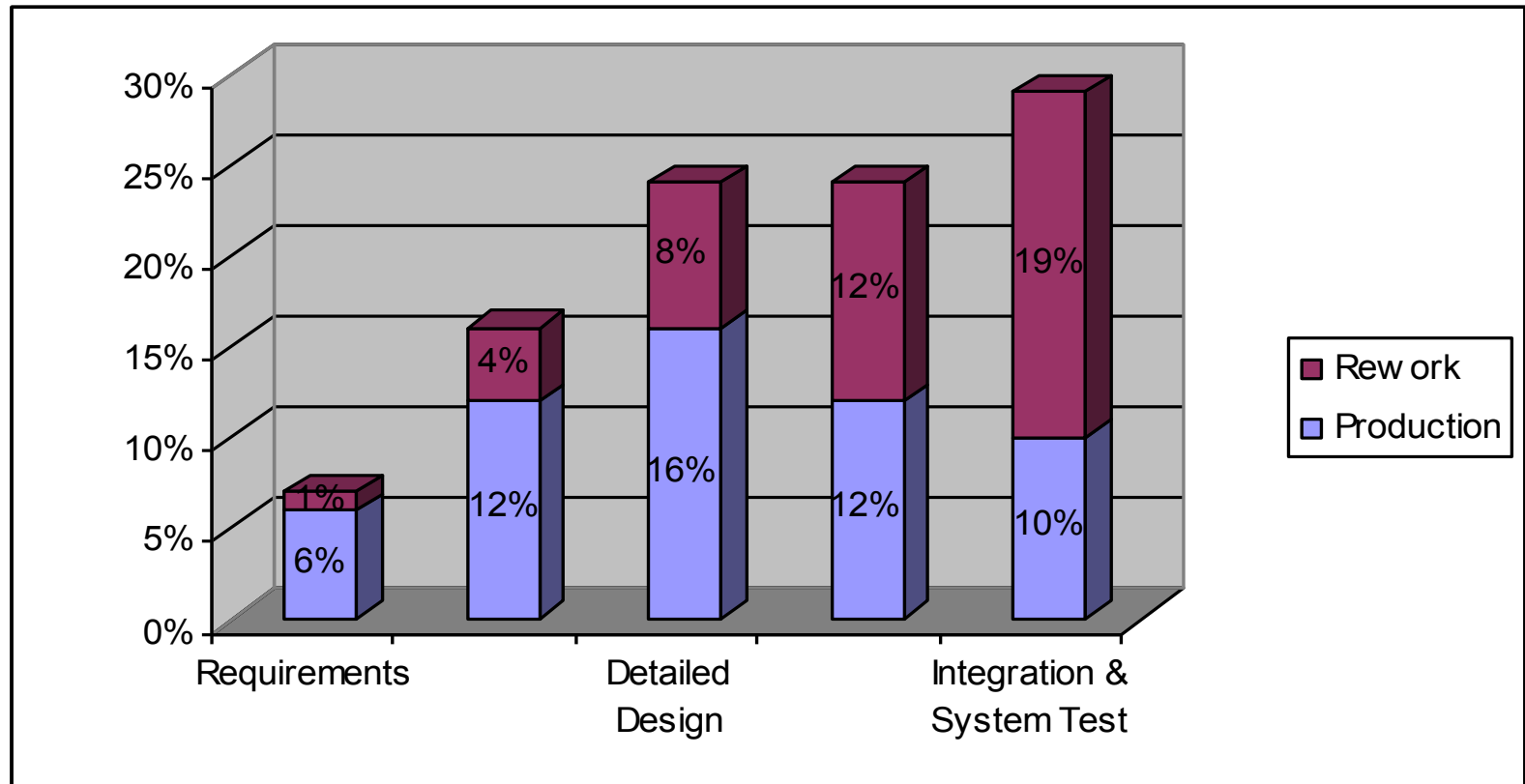
- Reviews and Audits
  - Process and specific reviews
    - Requirements Review (SRR)
    - Test Plan Review
    - Code reviews
    - Post-mortem review
- Risk Management
  - Tie-in QA to overall risk mgmt. Plan
- Problem Reporting and Corrective Action
- Tools, Techniques, Methodologies
- Records Collection and Retention

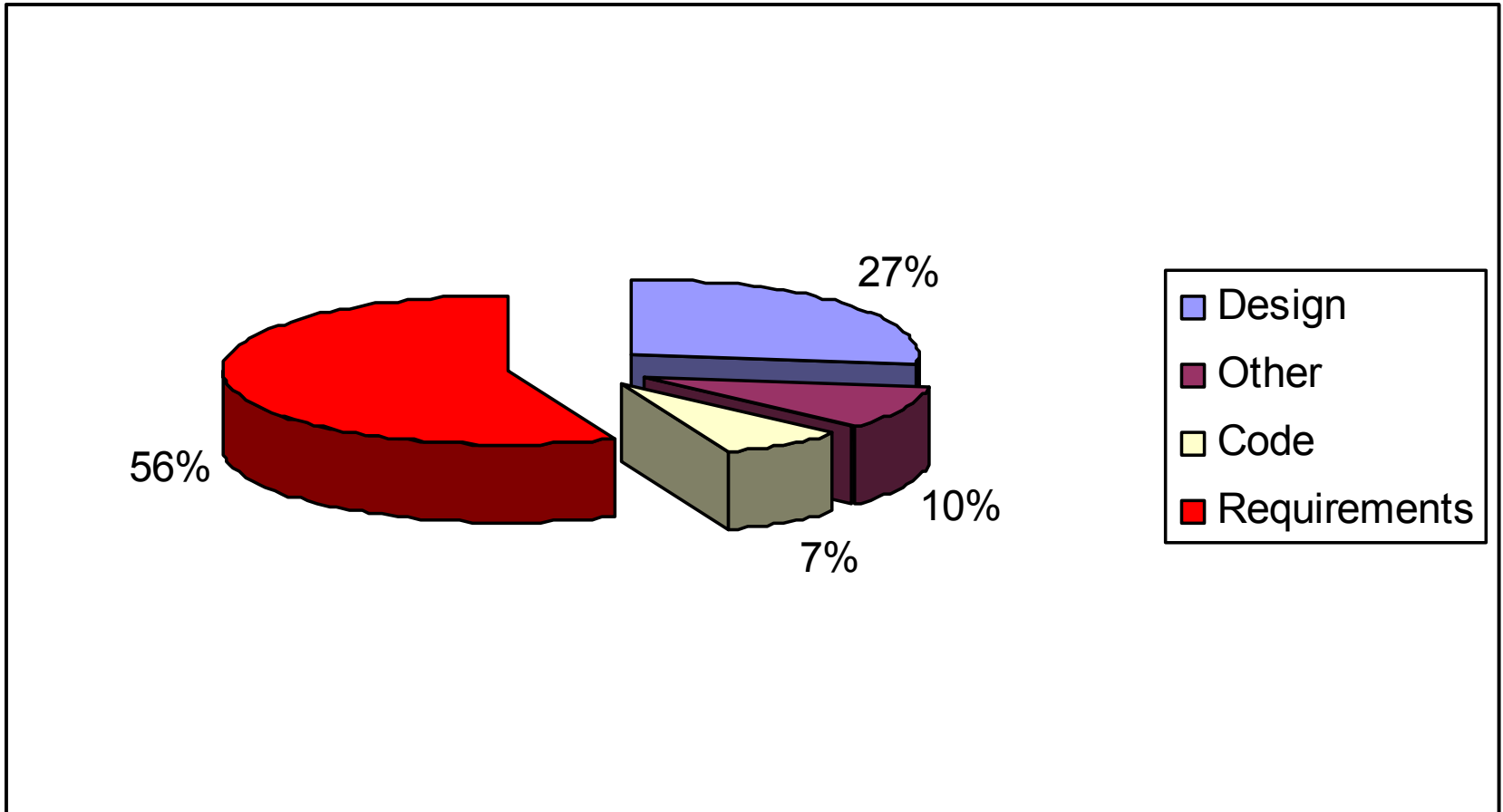
- Exercising computer program with predetermined inputs
- Comparing the actual results against the expected results
- Testing is a form of sampling
- Cannot absolutely prove absence of defects
- All software has bugs. Period.
- Testing is not debugging.

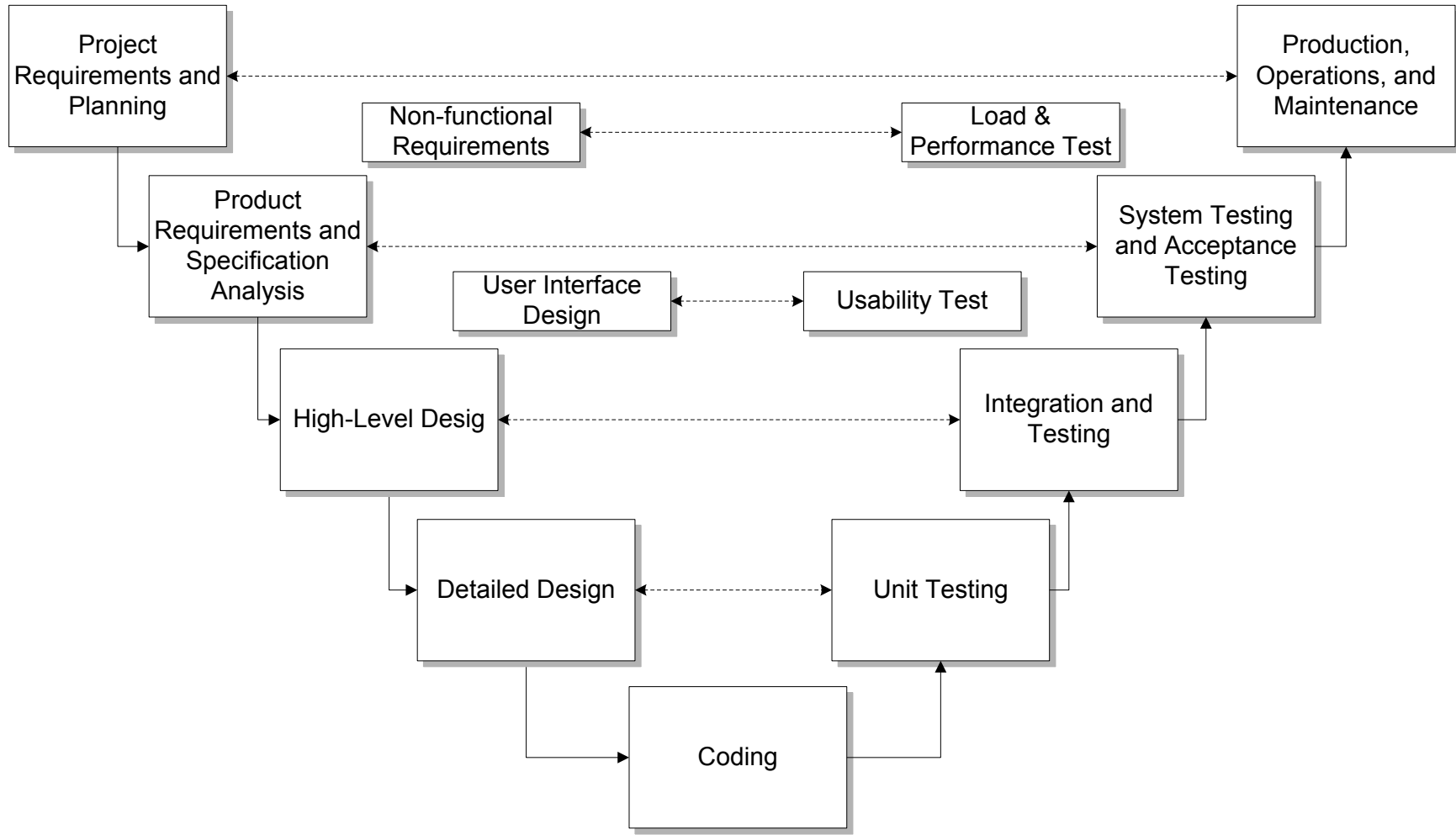
- Key elements of a test plan
- May include scripts, data, checklists
- May map to a Requirements Coverage Matrix
  - A traceability tool
  - See [http://en.wikipedia.org/wiki/Traceability\\_matrix](http://en.wikipedia.org/wiki/Traceability_matrix)
    - Example in next slide

Requirement Identifiers	Reqs Tested	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1	REQ1
		UC 1.1	UC 1.2	UC 1.3	UC 2.1	UC 2.2	UC 2.3.1	UC 2.3.2	UC 2.3.3	UC 2.4	UC 3.1	UC 3.2	TECH 1.1	TECH 1.2	TECH 1.3
<b>Test Cases</b>	321	3	2	3	1	1	1	1	1	1	2	3	1	1	1
Tested Implicitly	77														
1.1.1	1	x													
1.1.2	2		x	x											
1.1.3	2	x											x		
1.1.4	1			x											
1.1.5	2	x												x	
1.1.6	1		x												
1.1.7	1			x											
1.2.1	2				x		x								
1.2.2	2					x		x							
1.2.3	2								x	x					
1.3.1	1										x				
1.3.2	1										x				
1.3.3	1											x			
1.3.4	1											x			
1.3.5	1											x			
etc...															
5.6.2	1														x

- Software equivalent of “scrap” in manufacturing







- Unit Testing
- Integration Testing
- System Testing
- User Acceptance Testing



- When do you stop?
- Rarely are all defects “closed” by release
- Shoot for all Critical/High/Medium defects
- This also happen in over industries
  - e.g., Adverse drug reactions
- Often, occurs when time runs out
- Final Sign-off (see also UAT) by:
  - customers, engineering, product mgmt.,

## Black-Box Testing

- Functional Testing
- Program is a “black-box”
  - Not concerned with how it works but what it does
  - Focus on inputs & outputs
- Test cases are based on SRS (specs)

- Accounts for the structure of the program
- Coverage
  - Statements executed
  - Paths followed through the code

# Unit Testing

- a.k.a. Module Testing
- Type of white-box testing
  - Sometimes treated black-box
- Who does Unit Testing?
  - Developers
  - Unit tests are written in code
    - Same language as the module
    - a.k.a. “Test drivers”
- When do Unit Testing?
  - Ongoing during development
  - As individual modules are completed

# Unit Testing

- Individual tests can be grouped
  - “Test Suites”
  
- JUnit
  - Part of the XP methodology
  - “Test-first programming”

# Integration Testing

- Testing interfaces between components
- First step after Unit Testing
- Components may work alone but fail when put together
- Defect may exist in one module but manifest in another
- Black-box tests

# System Testing

- Testing the complete system
- A type of black-box testing

# User Acceptance Testing

- Last milestone in testing phase
- Ultimate customer test & sign-off
- Sometimes synonymous with beta tests
- Customer is satisfied software meets their requirements
- Based on “Acceptance Criteria”
  - Conditions the software must meet for customer to accept the system
  - Ideally defined before contract is signed
  - Use quantifiable, measurable conditions



# Regression Testing

- Re-running of tests after fixes or changes are made to software or the environment
- EX: QA finds defect, developer fixes, QA runs regression test to verify
- Automated tools very helpful for this

# Compatibility Testing

- Testing against other “platforms”
  - Ex: Testing against multiple browsers
  - Does it work under Netscape/IE, Windows/Mac
  
- Test repeatability and self-evidence
  - “Acid test” from the California Gold Rush
    - See [http://en.wikipedia.org/wiki/Acid\\_test\\_\(gold\)](http://en.wikipedia.org/wiki/Acid_test_(gold))
  - Acid tests for browsers compatibility to Web Standards
    - [http://en.wikipedia.org/wiki/Template:Acid\\_tests](http://en.wikipedia.org/wiki/Template:Acid_tests)
  - Be aware of
    - Quick and obvious vs. complete and fair

# External Testing 1/3

- Alpha 1st, Beta 2nd
- Testing by users outside the organization
  - Typically done by users
- Alpha release
  - Given to very limited user set
  - Product is not feature-complete
- During later portions of test phase
- Beta release
  - Customer testing and evaluation
  - Most important feature
  - Preferably after software stabilizes

- Value of Beta Testing
  - Testing in the real world
  - Getting a software assessment
  - Marketing
  - Augmenting you staff
- Do not determine features based on it
  - Too late!
- Beta testers must be “recruited”
  - From: Existing base, marketing, tech support, site
- Requires the role of “Beta Manager”
- All this must be scheduled by PM

- Release Candidate (RC)
  - To be sent to manufacturing if testing successful
- Release to Manufacturing (RTM)
  - Production release formally sent to manufacturing
- Aim for a “stabilization period” before each of these milestones
  - Team focus on quality, integration, stability

# Static Testing

- Reviews
  - Most artifacts can be reviewed
  - Proposal, contract, schedule, requirements, code, data model, test plans
- Peer Reviews
  - Methodical examination of software work products by peers to identify defects and necessary changes
  - Goal: remove defects early and efficiently
  - Planned by PM, performed in meetings, documented

- Human testers = inefficient
- Pros
  - Lowers overall cost of testing
  - Tools can run unattended
  - Tools run through ‘suites’ faster than people
  - Great for regression and compatibility tests
  - Tests create a body of knowledge
  - Can reduce QA staff size
- Cons
  - But not everything can be automated
  - Learning curve or expertise in tools
  - Cost of high-end tools \$5-80K (low-end are still cheap)

# Load & Stress Testing 1/2

- Push system beyond capacity limits
- Often done via automated scripts
  - By the QA team
  - Near end of functional tests
- Can show
  - Hidden functional issues
  - Maximum system capacity
  - Unacceptable data or service loss
  - Determine if “Performance Requirements” met
    - Remember, these are part of “non-functional” requirements



- Metrics
  - Minimal acceptable response time
  - Minimal acceptable number of concurrent users
  - Minimal acceptable downtime
  
- Vendors: High-End
  - LoadRunner by HP
    - <http://www8.hp.com/us/en/software-solutions/loadrunner-load-testing/>
  - Empirix
    - <http://www.empirix.com/>

- Source: Athens Consulting Group

<b>Bad</b>	<b>Good</b>
Must support 500 users	Must support 500 simultaneous users
10 second response time	[Average Maximum 90th percentile] response time must be X seconds
Must handle 1M hits per day	Must handle peak load of 28 page requests per second

- Unique factors
  - Distributed (N-tiers, can be many)
  - Very high availability needs
  - Uses public network (Internet)
  - Large number of platforms (browsers + OS)
  
- 5 causes of most site failures
  - Internal network performance
  - External network performance
  - Hardware performance
  - Unforeseeable traffic spikes
  - Web application performance

- Commercial Tools: Load Test & Site Management
  - Mercury Interactive (acquired by HP in 2006)
    - SiteScope  
<http://www8.hp.com/us/en/software-solutions/sitescope-application-monitoring/>
    - AppPulse Active  
<http://www8.hp.com/us/en/software-solutions/apppulse-active-web-cloud-monitoring>
- Commercial Subscription Services
  - Keynote Systems
    - <http://www.keynote.com/>
- Monitoring Tools
  - [http://en.wikipedia.org/wiki/Website\\_monitoring](http://en.wikipedia.org/wiki/Website_monitoring)
- Availability: More “Nines” = More \$’s
  - Must balance QA & availability costs vs. benefits

- Installation Testing
  - Very important if not a Web-based system
  - Can lead to high support costs and customer dissatisfaction
  
- Usability Testing
  - Verification of user satisfaction
    - Navigability
    - User-friendliness
    - Ability to accomplish primary tasks

- Load: Max. acceptable response time, min. # of simultaneous users
- Disaster: Max. allowable downtime
- Compatibility: Min/Max. browsers & OS's supported
- Usability: Min. approval rating from focus groups
- Functional: Requirements coverage; 100% pass rate for automated test suites

- These are very important to the PM
- Number of outstanding defects
  - Ranked by severity
    - Critical, High, Medium, Low
    - Showstoppers
- Opened vs. closed

# Defect Tracking

- Get tools to do this for you
  - Bugzilla - <http://www.bugzilla.org/>
  - TestTrack Pro - <http://www.seapine.com/ttpro.html>
  - Some good ones are free or low-cost
- Make sure all necessary team members have access (meaning nearly all)
- Have regular ‘defect review meetings’
  - Can be weekly early in test, daily in crunch
- Who can enter defects into the tracking system?
  - Lots of people: QA staff, developers, analysts, managers, (sometimes) users, PM



- Fields
  - State: open, closed, pending
  - Date created, updated, closed
  - Description of problem
  - Release/version number
  - Person submitting
  - Priority: low, medium, high, critical
  - Comments: by QA, developer, other

- Open Rates
  - How many new bugs over a period of time
- Close Rates
  - How many closed over that same period
  - Ex: 10 bugs/day
- Change Rate
  - Number of times the same issue updated
- Fix Failed Counts
  - Fixes that didn't really fix (still open)
  - One measure of “vibration” in project

- Microsoft Study
  - 10-20/KLOC during test
  - 0.5/KLOC after release

- You need to test somewhere. Where?
- Typically separate hardware/network environment(s)

- Development
- Testing
- Staging (optional)
- Production

# Typical Hardware Environments

- Development
  - Where programmers work
  - Unit tests happen here
- Testing
  - For integration, system, and regression testing
- Staging
  - For burn-in and load testing
- Production
  - Final deployment environment(s)

- Pareto Analysis
  - The 80-20 rule
    - 80% of defects from 20% of code
  - Identifying the problem modules
- Phase Containment
  - Testing at the end of each phase
  - Prevent problems moving phase-to-phase
- Burn-in or soak testing
  - Allowing system to run “longer” period of time
  - Variation of stress testing

- “Code Freeze”
  - When developers stop writing new code and only do bug fixes
  - Occurs at a varying point in integration/testing
- Tester-to-Coder Ratio
  - It depends
  - Often 1:3 or 1:4
  - QA staff size grows: QA Mgr and/or lead early



- Deadlines
  - FINAL version 22.6.2015
- Content
  - Requirements for your project as SCRUM user stories
  - 4-5 would do
  - Make them as independent as you can
  - Attach a business value and an effort/cost estimation to each of them
  - Remember! Implementing 2-3 of them should be enough to deliver a shippable product
- Submission procedures as for previous homeworks

# Questions?