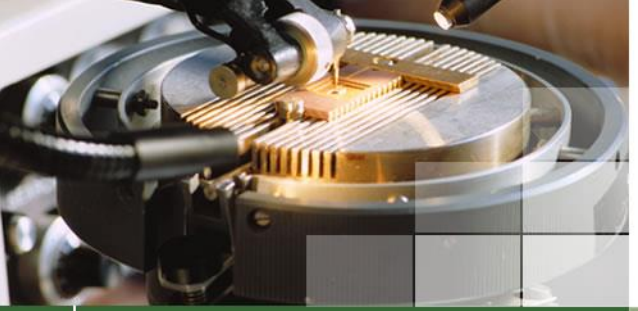


POLITECNICO DI MILANO

Dipartimento di
Elettronica e Informazione

Planning and Managing Software Projects 2012-13

Class 17

Integration and Testing

Emanuele Della Valle

http://emanueledellavalle.org

Credits

- 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

Today

- 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

Software Quality

- 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

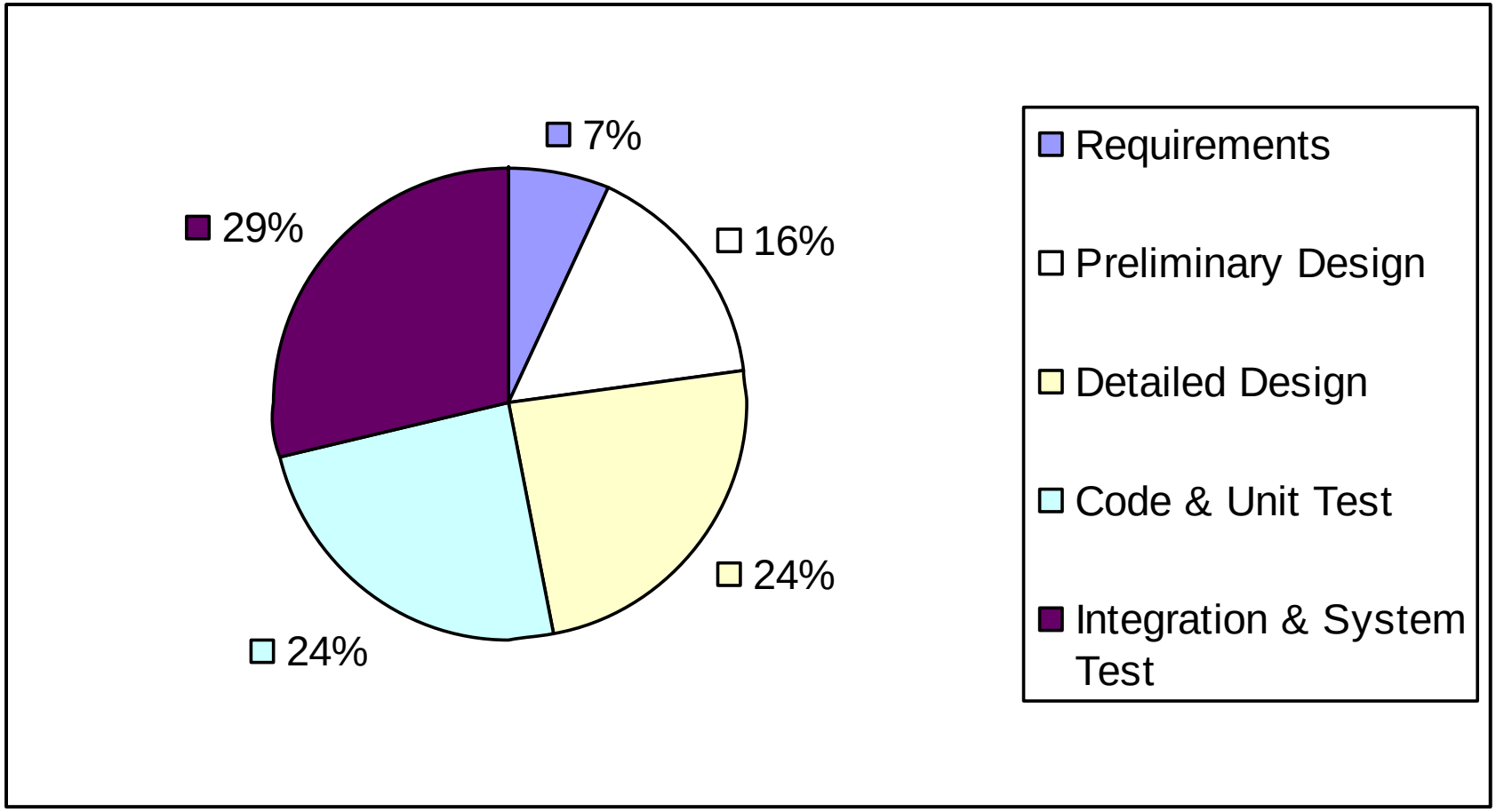
- 9,703 checks would be deducted from the wrong bank accounts each hour
- 27,800 pieces of mail would be lost per hour
- 3,000,000 incorrect drug prescriptions per year
- 8,605 commercial aircraft takeoffs would annually result in crashes

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

Quality Assurance

- 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

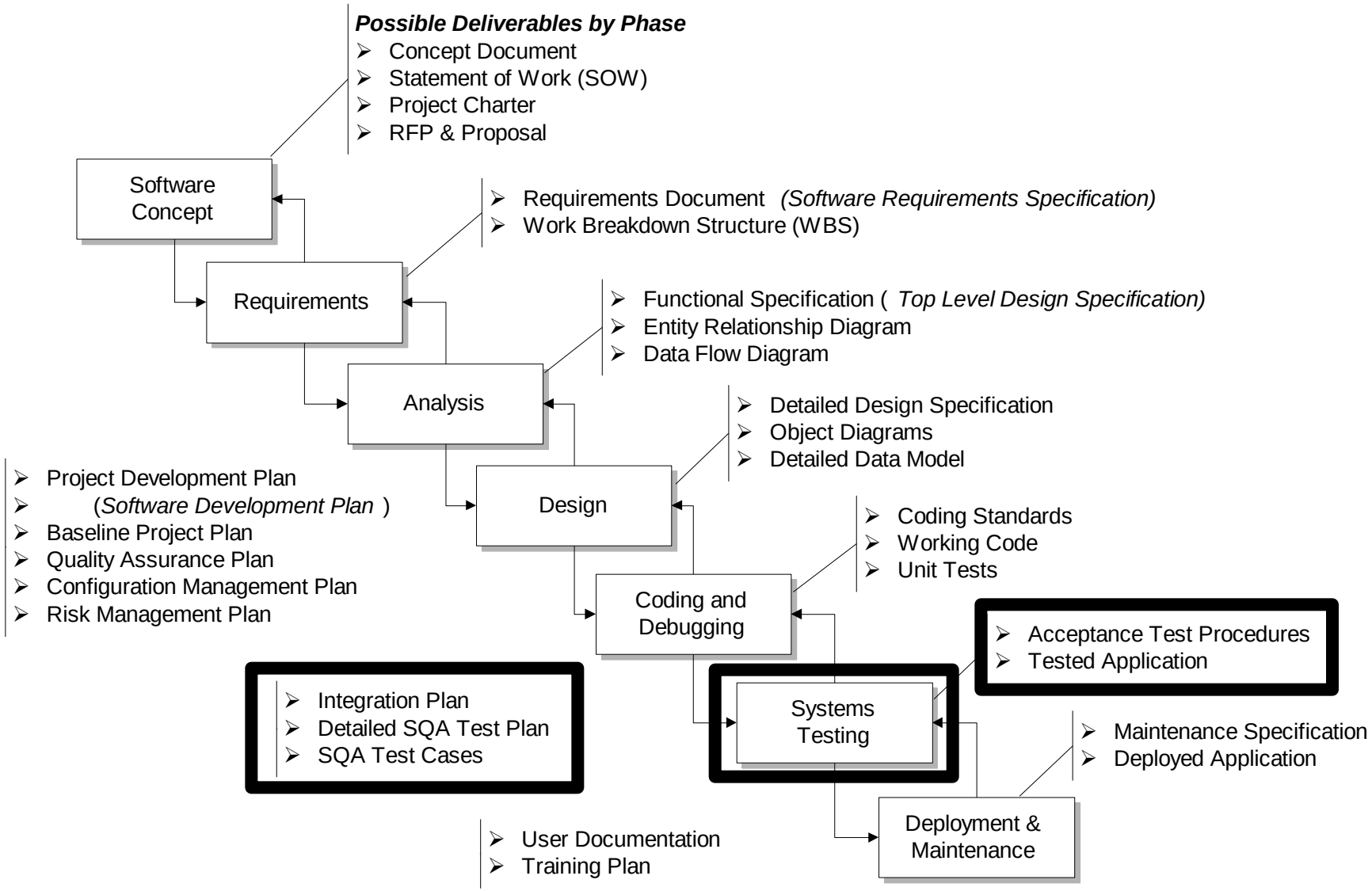
Development Costs



QA Roles

- 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

When and What?



Integration & Testing

- 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

Integration Approaches

- 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

Characteristics and Issues

- 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 (by MIT for NASA)
  - http://acis.mit.edu/acis/sqap/sqap.r1.html

Standard sections 1/2

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

Standard sections 2/2

- 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

Testing

- 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.

Test Cases

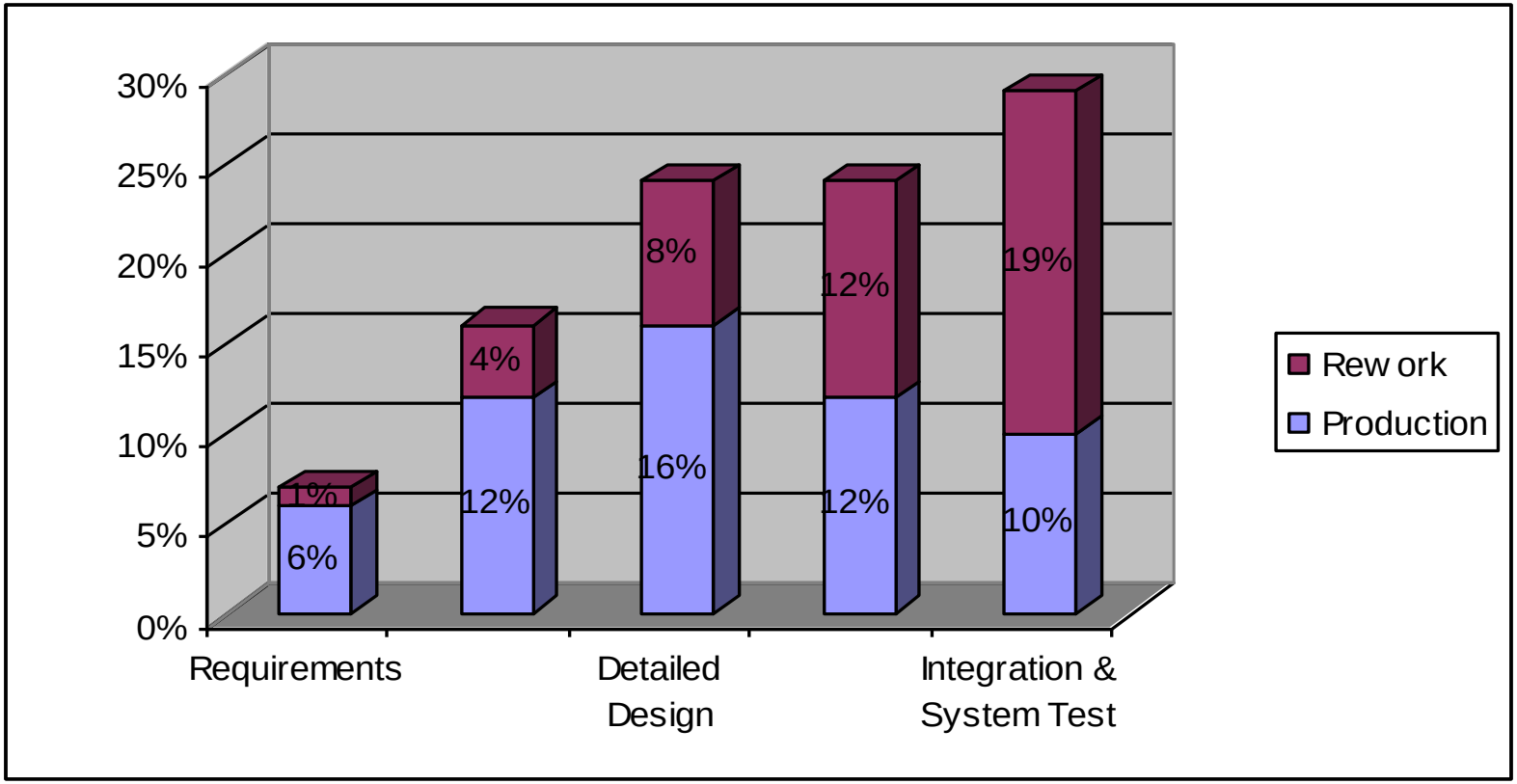
- Key elements of a test plan
- May include scripts, data, checklists
- May map to a Requirements Coverage Matrix
  - A traceability tool
  - See http://en.wikipedia.org/wiki/Traceability_matrix
    - Example in next slide

Test Cases - Sample traceability matrix

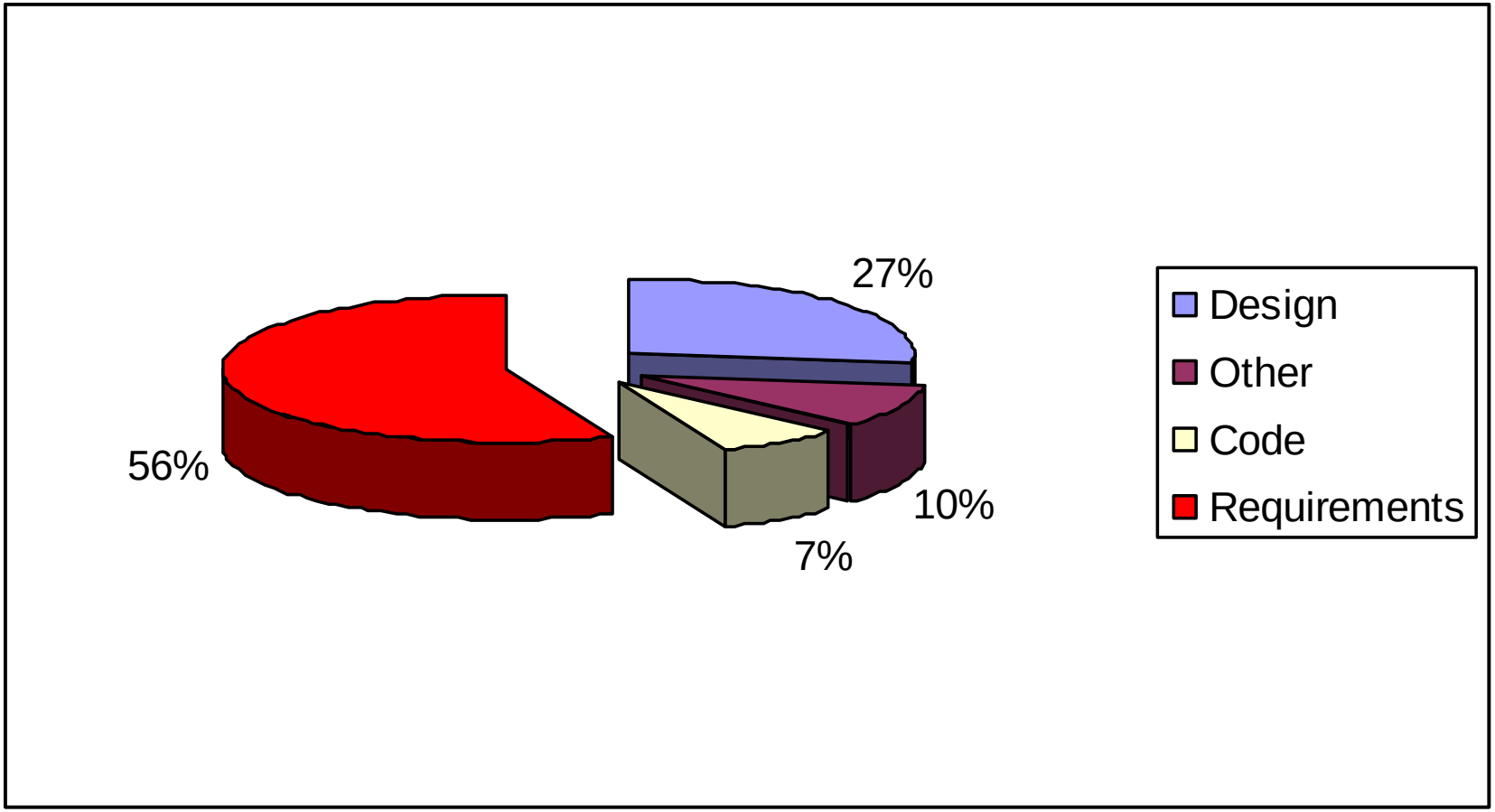
Requirement Identifiers	Reqs Tested	REQ1 UC 1.1	REQ1 UC 1.2	REQ1 UC 1.3	REQ1 UC 2.1	REQ1 UC 2.2	REQ1 UC 2.3.1	REQ1 UC 2.3.2	REQ1 UC 2.3.3	REQ1 UC 2.4	REQ1 UC 3.1	REQ1 UC 3.2	REQ1 TECH 1.1	REQ1 TECH 1.2	REQ1 TECH 1.3
Test Cases	321	3	2	3	1	1	1	1	1	1	2	3	1	1	1
Tested Implicitly	77														
1.1.1	1	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

Rework

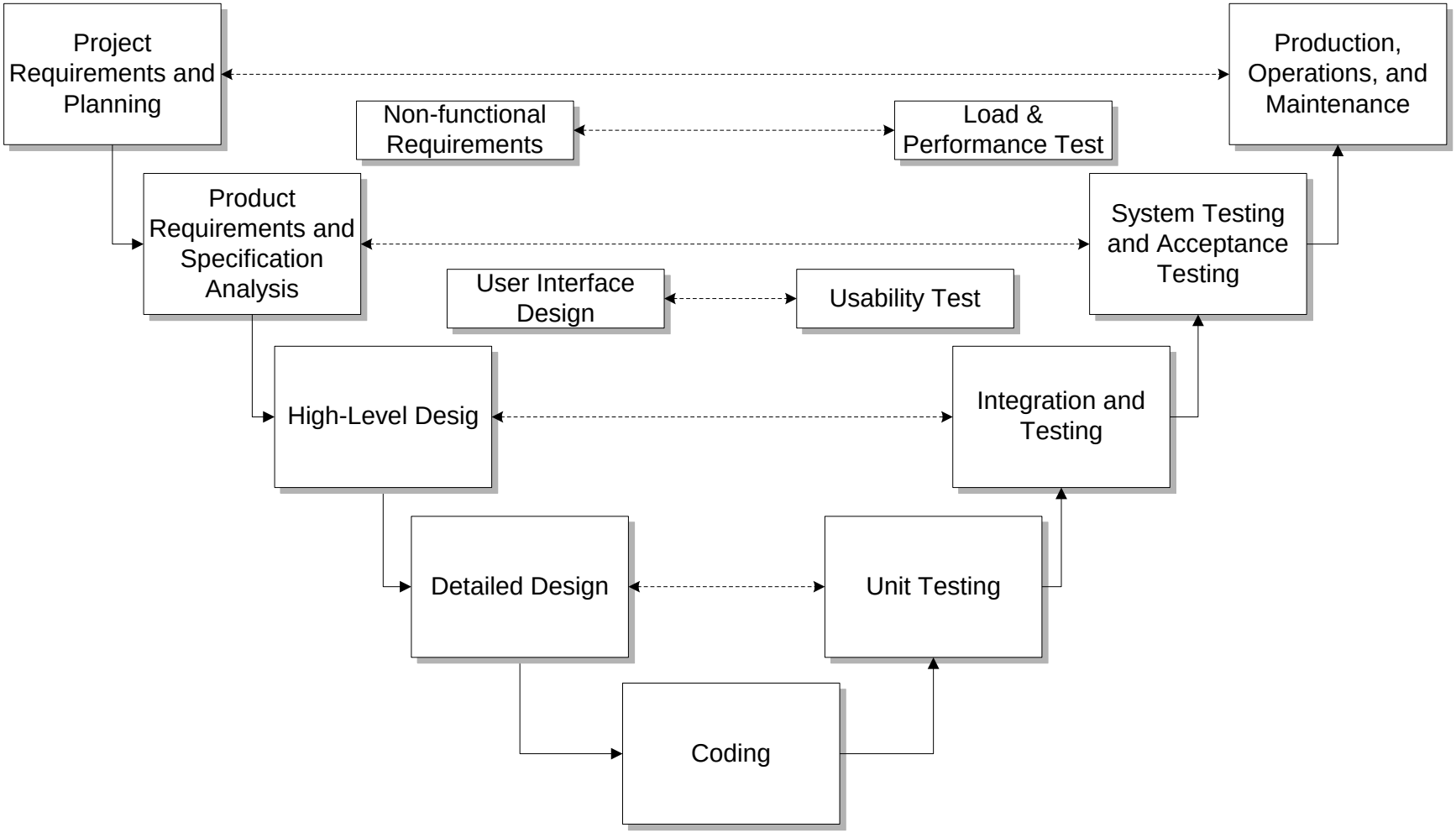
- Software equivalent of “scrap” in manufacturing



Sources of Defects



V Process Model



Project Testing Flow

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

Stopping 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)

White-Box Testing

- 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)
  - Acid tests for browsers compatibility to Web Standards
    - http://en.wikipedia.org/wiki/Category: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

External Testing 2/3

- 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

External Testing 3/3

- 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

Automated Testing

- 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

Load & Stress Testing 2/2

- Metrics
  - Minimal acceptable response time
  - Minimal acceptable number of concurrent users
  - Minimal acceptable downtime
- Vendors: High-End
  - Borland Silk Performer
    - http://www.borland.com/products/silkperformer/
  - HP LoadRunner
    - http://www8.hp.com/us/en/software-solutions/software.html?compURI=1175451
      http://en.wikipedia.org/wiki/LoadRunner
  - Empirix
    - http://www.empirix.com/

Performance Metrics

- Source: Athens Consulting Group

Bad	Good
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

Other Testing

- 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

Test Metrics

- 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

Defect Metrics

- 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
  - Mantis - http://www.mantisbt.org/
  - Bugzilla - http://www.bugzilla.org/
  - TestTrack Pro - http://www.seapine.com/ttpro.html
  - Rational ClearCase - http://www-01.ibm.com/software/awdtools/clearcase/
  - 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

Defect Tracking

- 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

Defect Metrics

- 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

Defect Rates

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

Test Environments

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

Hardware Environments

- 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)

Miscellaneous

- 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
  - Allowing system to run “longer” period of time
  - Variation of stress testing

Miscellaneous

- "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

Optional readings

- McConnell: Chapters 17-19 (very short ones)
- Schwalbe: 6 “Project Cost Management” (175-184), 9 “Project Communication Management”, 15 “Controlling”

Questions?