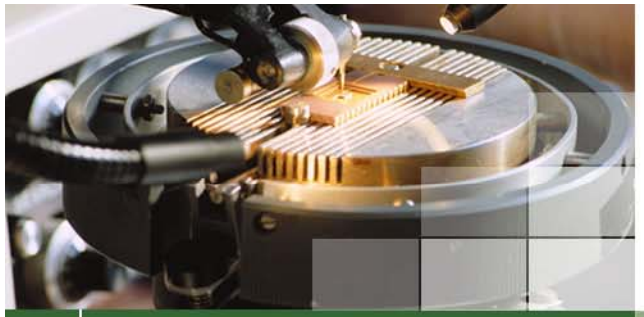


POLITECNICO DI MILANO

Dipartimento di
Elettronica e Informazione

Session 10

Integration & Testing

Emanuele Della Valle

http://home.dei.polimi.it/dellavalle

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

Session 8 Review

- Development Management
  - People dimension
  - Capability Maturity Model
  - Requirements (most critical activity)

People dimension

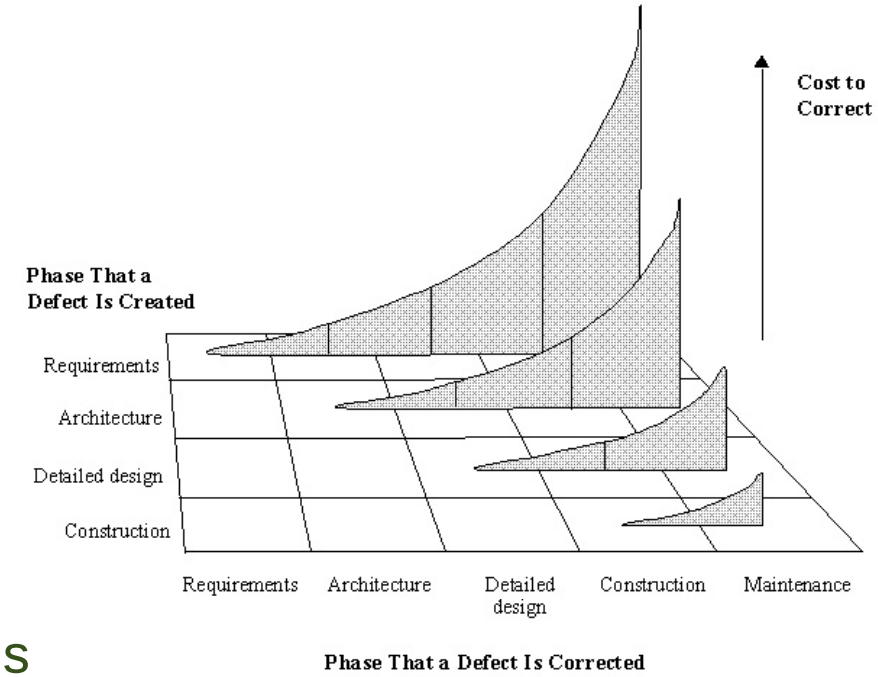
- Roles
- Staffing profile, roll-on and roll-off
- Team Models
  - Business Team
    - flexible
  - Chief-Programmer Team
    - Good for creative and tactical execution projects
  - “Shunkworks” Team
    - Good for creative projects
  - SWAT Team
    - Good for tactical execution projects
- Team size
- Hiring
- Tools
  - Responsibility Assignment Matrix
  - Skill Matrix

Capability Maturity Model

- software process framework
- 5 ‘maturity’ levels
  - Initial, Repeatable, Defined, Managed and Optimizing
- CMM Level 2 functions include
  - Requirements Management
  - Software QA
  - Configuration Management

Requirements

- most critical activity
- Potential tug-of-war
- Functional vs. non-functional
- Requirements Gathering Techniques
  - Interviews
  - Document Analysis
  - Brainstorming
  - Requirements Workshops
  - Prototyping
  - Use Cases
  - Storyboards



Validation vs. Verification

- Validation
  - Are we building the right product?
- Verification
  - Are we building the product right?
- Quality Assurance is about verification

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
  - SRR, CDR, etc.

If 99.9% Were Good Enough

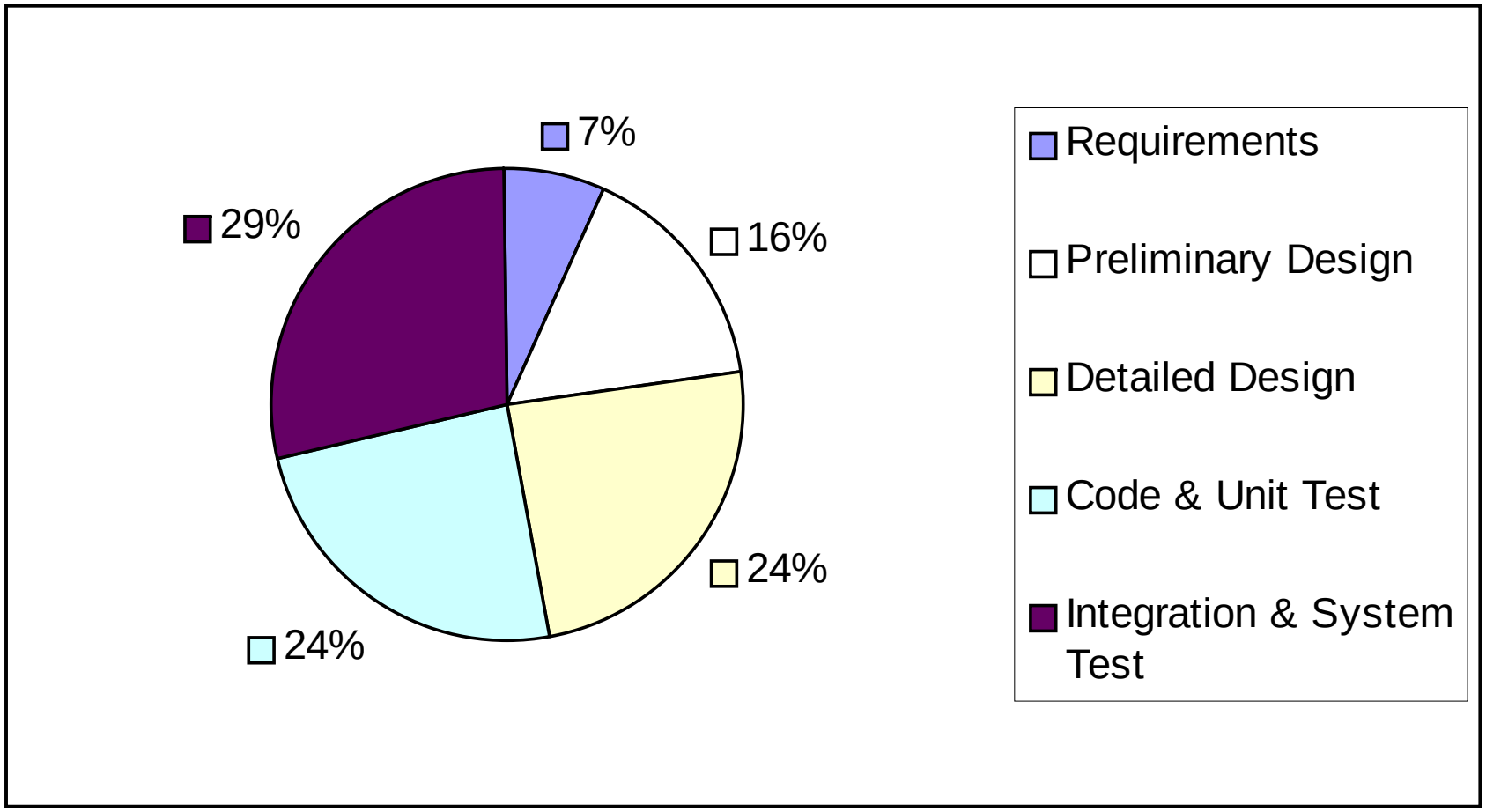
- 9,703 checks would be deducted from the wrong bank accounts each hour
- 27,800 pieces of mail would be lost per hour
- 3,000,000 incorrect drug prescriptions per year
- 8,605 commercial aircraft takeoffs would annually result in crashes

Futrell, Shafer, Shafer, “Quality Software Project Management”, 2002

Quality Assurance

- QA or SQA (Software Quality Assurance)
- Good QA comes from good process
- A CMM Level 2 function
- 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

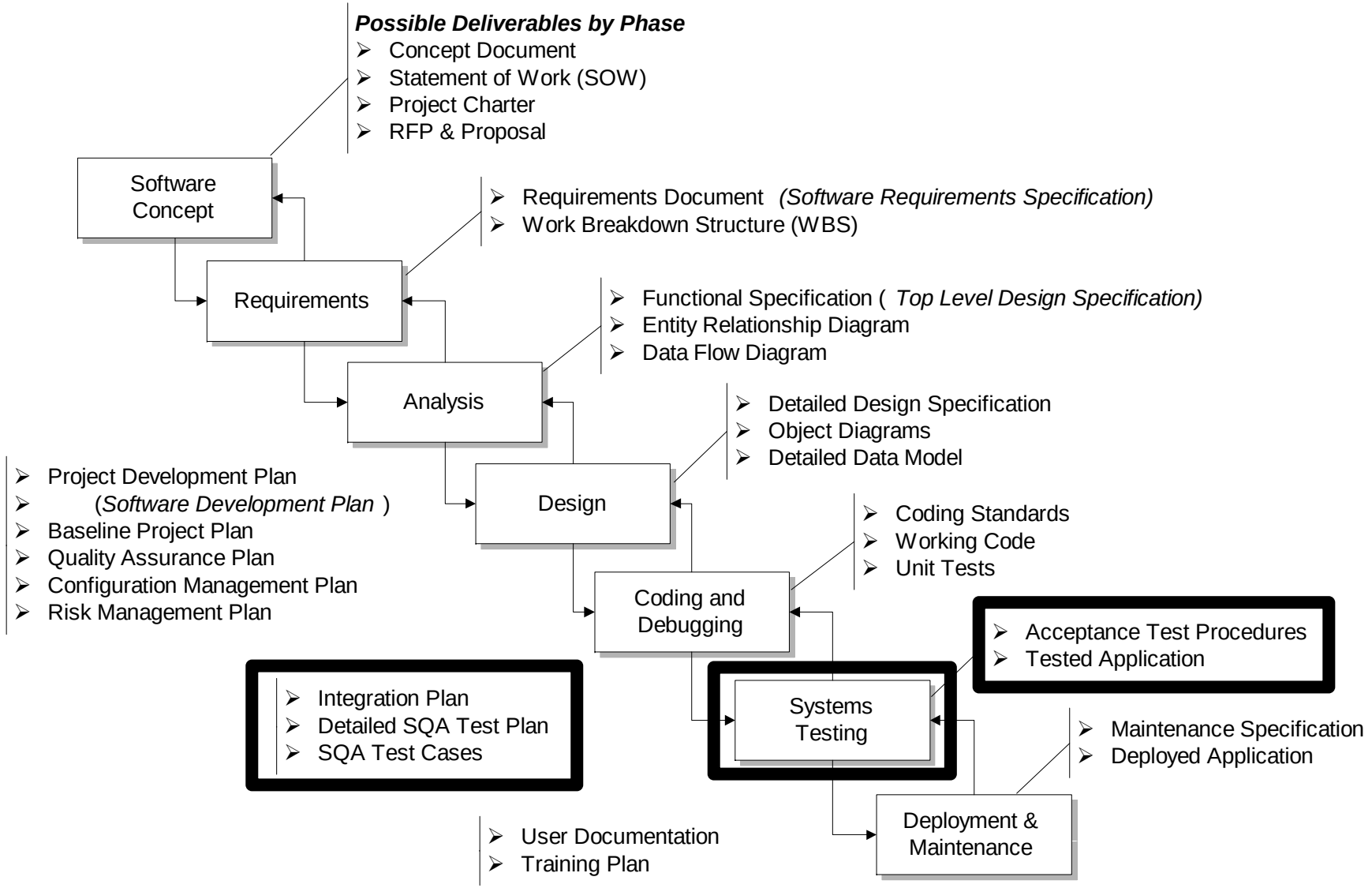
Development Costs



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 dev. 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
  - http://www.cio.energy.gov/documents/csr_sqa_plan.pdf
    - Even use the IEEE 730 standard
      - http://ieeexplore.ieee.org/iel4/5838/15568/00720573.pdf

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

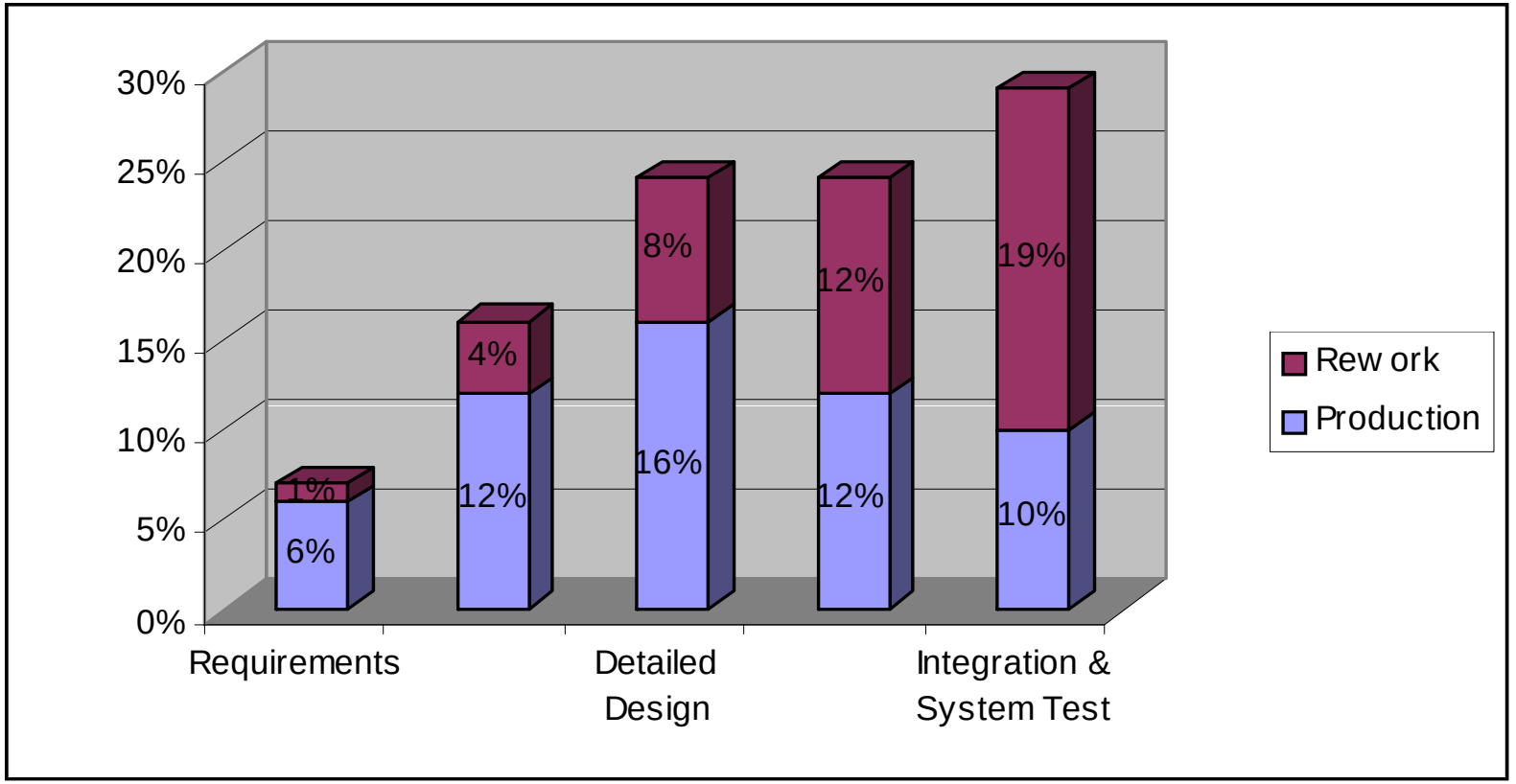
- Exercising computer program with predetermined inputs
- Comparing the actual results against the expected results
- Testing is a form of sampling
- Cannot absolutely prove absence of defects
- All software has bugs. Period.
- Testing is not debugging.

Test Cases

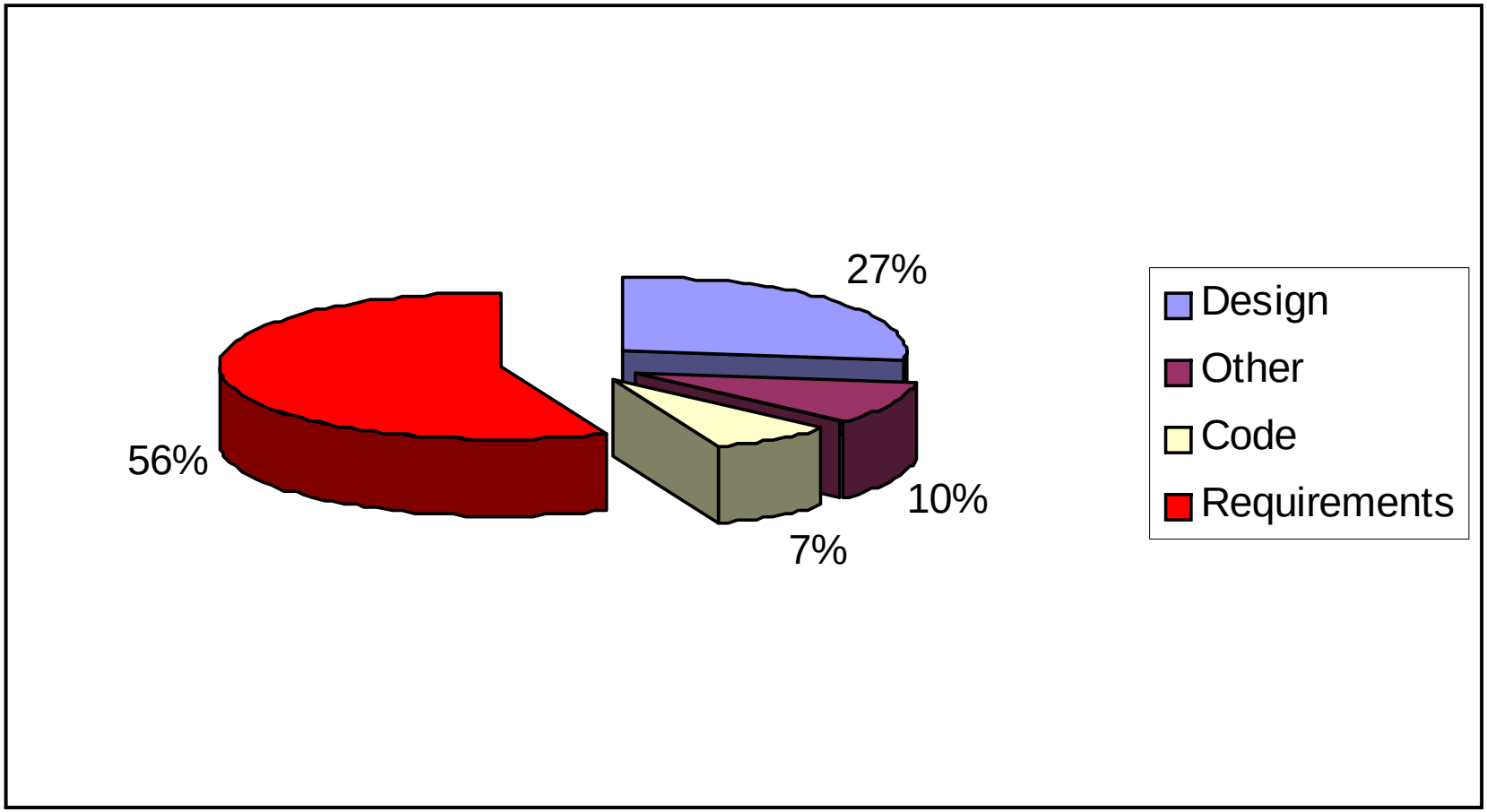
- Key elements of a test plan
- May include scripts, data, checklists
- May map to a Requirements Coverage Matrix
  - A traceability tool
  - See http://en.wikipedia.org/wiki/Traceability_matrix

Rework

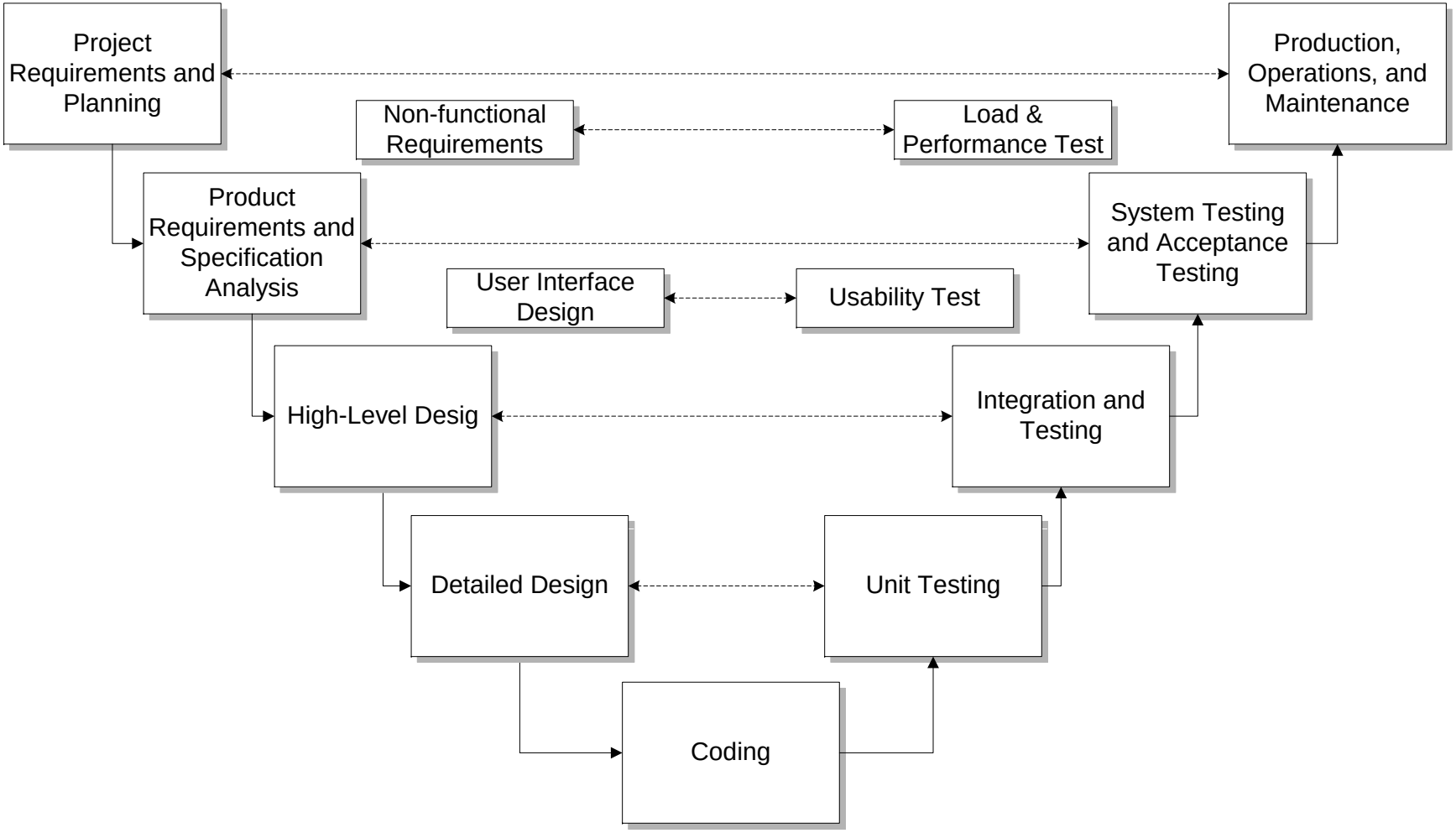
- Software equivalent of “scrap” in manufacturing



Sources of Defects



V Process Model



Project Testing Flow

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

Test Scripts

- Two meanings
  1. Set of step-by-step instructions intended to lead test personnel through tests
     - List of all actions and expected responses
  2. Automated test script (program)

Stopping Testing

- When do you stop?
- Rarely are all defects “closed” by release
- Shoot for all Critical/High/Medium defects
- 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
  - CMM Level 3 activity

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
  - Segue by Borlan
    - http://www.segue.com
  - Mercury (acquired by HP and renamed LoadRunner)
    - https://h10078.www1.hp.com/cda/hpms/display/main/hpms_content.jsp?zn=bto&cp=1-11-126-17^8_4000_100__
    - 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

Web Site Testing 1/2

- 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

Web Site Testing 2/2

- Commercial Tools: Load Test & Site Management
  - Mercury Interactive
    - SiteScope, SiteSeer
  - Segue
- Commercial Subscription Services
  - Keynote Systems
- Monitoring Tools
  - http://www.networkworld.com/reviews/2000/webmgt2result.jsp?_tablename=webmgt2
- Availability: More “Nines” = More $’s
  - Must balance QA & availability costs vs. benefits

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
  - 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

Homework 4

- Deadlines
  - FINAL version 25.6.2010
  - (optionally) DRAFT version 28.5.2010
- Content
  - A base line Gantt diagram of you project describing
    - Tasks
    - Milestones
    - Durations
    - Links
    - Successors/predecessors
    - **Resource allocation to tasks**
    - **Meaningful Staffing profile**
    - **Resource leveling**
- Submission procedures as for previous homeworks

Optional readings

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

Questions?